CHEMICAL PLANT ADMINISTRATIVE RECORD FILE

DOE/OR/21548-344
CONTRACT NO. DE-AC05-86OR21548

ADMINISTRATIVE RECORD FILE SYSTEM MANAGEMENT PLAN

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

JANUARY 1993 **REV. 0**

SUPERSEDED

U.S. Department of Energy
Oak Ridge Field Office
Weldon Spring Site Remedial Action Project

MK-FERGUSON A MORRISON KNUDSEN COMPANY	
Weldon Spring Site Remedial Action Project Contract No. DE-AC05-86OR21548	Rev. No. 0
PLAN TITLE: Administrative Record File System Management Plan	

APPROVALS

Department Manager — Date: 1-26-93

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Weldon Spring Site Remedial Action Project

Administrative Record File System Management Plan

Revision 0

January 1993

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U.S. DEPARTMENT OF ENERGY
Oak Ridge Field Office
Under Contract DE-AC05-86OR21548

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1 INTRODUCTION

The requirement for the Administrative Record is established under Section 113 of the *Comprehensive Environmental Response, Compensation, and Liability Act* of 1980 (CERCLA), as amended by the *Superfund Amendments and Reauthorization Act* of 1986. Section 113(k)(1) of CERCLA and Subpart I of the *National Oil and Hazardous Substance Pollution Contingency Plan* (EPA 1992) require the establishment of an Administrative Record upon which the selection of a response action is based.

The Administrative Record (AR) is a body of documents that "forms the basis" for the selection of a particular response action at a site. Documents that are included in the AR are relevant documents that were relied upon in selecting the response action, including documents that contain alternatives or options that were considered, but were ultimately rejected.

1.1 Purpose

The CERCLA Administrative Record serves a dual purpose. The record documents the decision for the selection of a response action, and the record serves as a vehicle for public participation in the selection of the response action. Judicial review of any issue concerning the adequacy of a response selection is limited to the record. For purposes of administrative and judicial review, the record contains documents that reflect the participation of the public and the DOE's consideration of the public's concerns.

1.2 Public Participation

Section 113(k) of CERCLA requires that the public have the opportunity to participate in developing the Administrative Record for response selection. Section 117 of CERCLA also includes provisions for public participation in the remedial action selection process.

2 WSSRAP ADMINISTRATIVE RECORD

In accordance with *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) the *National Oil and Hazardous Substance Polution Contingency Plan*, and the *Final Guidance on Administrative Records for Selecting Comprehensive Environmental Response, Compensation and Liability Act Response Actions* (EPA 1990), a simple and comprehensive system has been developed for establishing and maintaining the Administrative Record and record files for the Weldon Spring Site Remedial Action Project (WSSRAP) response actions. This system permits the WSSRAP to achieve the judicial review and public participation goals of the Administrative Record by the most efficient and practical means possible.

The administrative record file (ARF) should be distinguished from the administrative record (AR). The ARF refers to the documents as they are being compiled. Until a response action decision has been selected, there is no complete AR for that decision. Thus to avoid creating the impression that an AR is complete at any time prior to the final decision, the set of documents compiled for the response action is referred to as the administrative record file rather than the administrative record.

2.1 Responsibility for the Administrative Record

The overall responsibility for the establishment of the Administrative Record rests with the lead agency, which is the Department of Energy (DOE) at WSSRAP. The Project Management Contractor (PMC) for the DOE then compiles the WSSRAP AR/ARFs and maintains the Administrative Record File System (ARFS). The responsibility for long-term maintenance lies with the DOE as explained in Section 5.

2.2 Objective

The objective of establishing the WSSRAP Administrative Record File System is to provide a system of maintaining concise records that contains the events, studies, data, and other pertinent information documenting the decision process upon which WSSRAP removal and remedial actions are based.

2.3 Scope

This plan applies to all WSSRAP personnel using and/or reviewing documents which are part of the ARFS.

This plan supports procedure RC-8, *Administrative Record Development and Management*.

This plan will be reviewed annually and maintained according to procedure RC-45a/3, *Document Hierarchy Procedure*.

The ARFS comprises Administrative Record and Administrative Record files and the database used to track and compile documents for inclusion into the record file.

Administrative Record File System - provides a systemic approach for the overall scope, work, preparation, and maintenance of the WSSRAP Administrative Record and Administrative Record files.

Database - An electronic method in dBase IV of cataloging and indexing documents included in the AR/AFRs.

2.4 Administrative Record Coordinator

The ARC has the primary responsibility for coordinating the development and maintenance of the ARFS. The system established at the WSSRAP to maintain and implement the Administrative Record requirements includes the following activities:

- Managing the AR master file and copies.
- Creating, maintaining and distributing the administrative records indexes.
- Submitting the administrative record indexes to DOE on a quarterly basis.
- Ensuring availability of the Administrative Record to the public.

- Coordinating with the Administrative Record Committee to ensure that all relevant new documents and correspondences are reviewed by the committee for inclusion/exclusion into the proper Administrative Record file. The AR committee periodically meets to review documents for inclusion in the ARF and consists of the ARC and assistant, and a representative of the Environmental Documentation/ Conceptual Design Department.

- Ensuring that sampling and testing data, quality control and quality assurance documentation, and Chain of Custody Forms would be available for public inspection.

2.5 Administrative Record Requirements

The following sources and authorities mandate the establishment and maintenance of an administrative record.

CERCLA (42 USC Section 9601 et seq.)

- Section 9613 (k), Administrative Record and participation procedures.
- Section 9617 Public Participation.

National Oil and Hazardous Substance Pollution Contingency Plan (40 CFR 300)

- Community Relations provisions in Parts 300.155, 300.415(m), 300.430(c) and (f)(3) and (6) and 300.435(c).

- Administrative Record for Selection of Response Action provisions in Subpart I (300.800 - 300.825).

OSWER Directive No.9833.3A-1 (December 1990)

- *Final Guidance on Administrative Records for Selection of CERCLA Response Actions.*

Federal Facility Agreement (January 1992)

- If requested, a copy of each AR document will be provided to the U.S. Environmental Protection Agency (EPA).

- An index of documents in the AR file will be provided to the EPA on a quarterly basis.

- The above records and documents will be preserved 10 years beyond Federal Facility Agreement (FFA) determination.

3 WSSRAP ADMINISTRATIVE RECORD FILE

The Weldon Spring Site Remedial Action Project (WSSRAP) Administrative Record File System contains the following five separate files:

- Quarry Bulk Wastes Administrative Record (complete).
- Chemical Plant Area Administrative Record File.
- Quarry Residuals/Groundwater Administrative Record File.
- Site Ground Water Administrative Record File (future).
- Interim Response Actions Administrative Record File.

The Quarry Bulk Wastes Administrative Record file is complete. The *Record of Decision* was signed March 1991, and subsequently included in the Quarry Bulk Wastes Administrative Record. This record is now complete, and documents may not be added or deleted from the Quarry Bulk Wastes Administrative Record. The Chemical Plant Area Administrative Record file has been established for the chemical plant area remedial action; it will be complete when the Record of Decision is finalized. The Quarry Residuals/Groundwater Administrative Record file and Site Ground Water Administrative Record file will be established for their respective remedial actions. The Interim Response Actions (IRA) Administrative Record contains the documentation for all removal actions at the WSSRAP. The IRAs are contained in one Administrative Record rather than in separate records for each IRA, at the request of the U.S. Environmental Protection Agency (EPA) Region VII.

3.1 Compilation

The administrative record file (ARF) for a new response action is made available to the public at the time the remedial investigation/feasibility study (RI/FS) work plan for a remedial action or the engineering evaluation/cost analysis (EE/CA) for a removal action is made available to the public. However, the compilation of a WSSRAP ARF begins during the remedial investigation process to ensure that all documents are captured. Documents that would be included in a future ARF are compiled in an "unofficial", pre-public file until the RI/FS work plan is complete.

A time-critical removal action is a removal action for which a period of less than 6 mo exists before on-site removal activities must be initiated (EPA 1990). The administrative record

file for these actions is made available for public inspection no later than 60 days after the initiation of an on-site removal activity. If possible, the record file is made available earlier.

A non-time-critical removal action is a removal action for which a planning period of at least 6 mo exists before on-site removal activities must be initiated [40 CFR 300.415(b)(4)]. The administrative record file for a non-time-critical removal action is made available for public inspection when the engineering evaluation/cost analysis is made available for public comment.

3.2 Content of the Administrative Record

3.2.1 Remedial Actions

According to the *Final Guidance* (EPA 1990), documents such as those listed below should be included in the AR for a remedial action. The term "documents" covers a variety of documents, such as letters of correspondence, data reports, plans, newspaper articles and notices, as well as *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) documents. Documents included in the WSSRAP AR/ARFs for remedial actions do contain the following documents, as appropriate.

- Preliminary Assessment/Site Investigation Reports.
- Remedial Investigation/Feasibility Study (RI/FS) Work Plan.
- Amendments to the final work plan.
- Sampling and Analysis Plan (SAP) consisting of a Quality Assurance Project Plan (QAPP) and a Field Sampling Plan.
- Sampling data: data verified during the RI/FS, or any data collected for previous actions such as removal actions which were considered or relied on in selecting the remedial action. Unvalidated data is included only if relied on in the absence of validated data.
- Chain Of Custody Forms.

- Data Summary Sheets.
- Data submitted by the public.
- Technical studies performed for the site (may be included as technical literature in the reference listing of the AR file).
- Memoranda on site-specific or issue-specific policy decisions. Examples include memoranda on off-site disposal availability, special coordination needs, applicable or relevant and appropriate requirements (to the extent not in the RI/FS), cost effectiveness, and utilization of permanent solutions and alternative treatment technologies.
- Risk evaluation/endangerment assessment and underlying documentation (i.e., WSSRAP Baseline Risk Assessment).
- Remedial Investigation/Feasibility Study (as available for public comment and as final, if different).
- Proposed plan.
- Guidance documents.
- Technical literature.
- Community Relations Plan.
- Newspaper articles showing general community awareness.
- Public notices (i.e., notices of availability of information, notices of meeting, and notices of opportunities to comment).
- Documentation of informal public meetings.
- Public comments.

- Transcripts of formal public meetings.
- Responses to significant comments.
- Responses to comments from the State and Other Federal agencies.
- Documentation of State involvement (documentation of the request and response on applicable and/or relevant and appropriate requirements (ARARs) Section 121(f)(1)(G) *Notices and Responses*, a statement of the State's position on the proposed plan, opportunity to concur in the selected remedy.)
- Agency for Toxic Substances and Disease Registry Health Assessments Reports.
- Natural Resource Trustee notices and responses, findings of fact, final reports, and natural resource damage assessments.
- Record of Decision (ROD) (including Responsiveness Summary).
- Explanations of significant differences and underlying information.
- Amended ROD and underlying information.
- Index.

3.2.2 Removal Actions

According to the *Final Guidance* (EPA 1990), documents such as those listed below should be included in the administrative record for a removal action. The WSSRAP AR/ARFs contains the following documents, as appropriate.

- Preliminary Assessment/Site Investigation Reports.
- Sampling Plan.

- Sampling data: verified data obtained for the removal action, or any data collected for previous actions, such as other response actions which are considered or relied on in selecting the removal action. Unvalidated data is included only if relied on in the absence of validated data.

- Chain Of Custody Forms.

- Engineering Evaluation/Cost Analysis (EE/CA).

- Technical studies performed for the site (may be included as technical literature in the reference listing of the AR file).

- Risk evaluation/endangerment assessment and underlying documentation (i.e., WSSRAP Baseline Risk Assessment).

- Data submitted by the public.

- Memoranda on site-specific or issue-specific policy decisions. Examples include memoranda on off-site disposal availability, compliance with other environmental statutes, special coordination needs.

- Guidance documents.

- Technical literature.

- Community Relations Plan.

- Newspaper articles showing general community awareness.

- Public notices (i.e., notices of availability of information, notices of meeting, and notices of opportunities to comment).

- Documentation of public meetings.

- Public comments.

- Transcripts of formal public meeting.
- Responses to significant comments.
- Responses to comments from the State and other Federal agencies.
- Documentation of State involvement.
- Agency for Toxic Substances and Disease Registry Health Assessments Reports.
- Natural Resource Trustee notices and responses, findings of fact, final reports, and natural resource damage assessments.
- EE/CA Approval Memorandum.
- Action Memorandum or Response Action Decision Document.
- Amended Action Memorandum or Amended Response Action Decision Document.
- Other documents which embody the decision for selection of a removal action.
- Index.

The ARFs include only numeric revision documents (i.e., Revision 0, Revision 1, etc.) for the preceding documents. Drafts (or portions of drafts) and internal memorandums are incorporated into the record only in the following instances:

- If a draft document or internal memorandum is the basis for a response decision, the draft document or internal memorandum is placed in the record file. This may occur if (a) the draft contains factual information which was relied upon but is not included in a final document, (b) a final document does not exist, or (c) a final document did not exist when the response decision was made.
- If a draft document or internal memorandum is circulated by the U.S. Department of Energy (DOE) to other persons (e.g., Federal/State agencies or the general

public), who then submit comments that the decision maker considers or relies upon when making a response action decision, relevant portions of the draft document or the memorandum and comments on that document, are included in the record file.

- If a draft document or internal memorandum explains or conveys decisions on the procedures for selecting the remedy or substantive aspects of a proposed or selected remedy (e.g., the scope of a site investigation or the identification of potential applicable and/or relevant and appropriate requirements [ARARs], the document is placed in the record file, even though the document was signed by a person other than the DOE, and generated long before the decision document was signed.

3.3 Special Documents

According to the *Final Guidance* (EPA 1990), certain documents that are included in the AR file do not have to be maintained in the ARFs. Documents in this category must be included in the AR index or referenced in an AR document included in the record file. Exceptions are described for each special category as follows:

- Chain of custody -- These forms may be left in the original storage location. Chain of custody may be viewed by the public by appointment.

- Data packages.

- Computer models and technical databases --The software is available on site for public inspection.

- Privileged Documents -- These documents can be maintained in the confidential portion of the file located in the Document Control. The title and location of the information, as well as a short description of the information and the reason for the privilege, is maintained by the Administrative Record Coordinator. Currently WSSRAP has no privileged documents.

- Confidential documents -- See Privileged Documents

- Guidance documents -- The guidance documents that comprise the *Compendium of CERCLA Response Selection Guidance Documents Users Manual* (EPA 1988) are located at the EPA Region VII office. The compendium list is included in the WSSRAP AR/ARFs.

- Publicly available documents -- Documents that not site-specific and are publicly available need not be physically located in the ARF, if the documents are referenced in the index to the ARF.

3.4 Post-Decision Information

In general, documents generated or received after signing the decision document are kept in a post-decision document file. This file is not part of the administrative record file and is maintained in a separate file.

However, documents kept in the post-decision document file may be added to the record file when:

- A decision document does not address, or reserves a portion of the decision to be made at a later date, e.g., a decision document that does not resolve the type of treatment technology. In such cases, these documents are added to the record file which forms the basis of the unaddressed or reserved portion of the decision.

- There is a significant change in the selected response action. Changes that result in a significant difference to a basic feature of the selected remedial action (e.g., timing, ARARs), with respect to scope, performance, or cost are addressed in an explanation of significant differences.

- The changes are so significant that they fundamentally alter the very nature or basis of the overall response action and require an amended decision document.

- Comments containing significant information are submitted by interested persons after the close of the public comment period. Documents meeting this criteria are included in the record file, along with the DOE's responses to the significant

comment (whether or not such information results in a change to the selected decision.

- The DOE holds public comment periods after the selection of the response action.

4 WSSRAP ADMINISTRATIVE RECORD FILE SYSTEM

The Weldon Spring Site Remedial Action Project (WSSRAP) Administrative Record File System (ARFS) was developed to select, catalogue, index, and file documents that are incorporated into an Administrative Record File (ARF). The system includes administrative record (AR) document file numbering, instructions for completing database document information, data entry of this information, and generation of the index.

A User's Guide is available (Appendix D) for use by the public and the WSSRAP staff in the Reading Room. The Guide simply explains the Administrative Record requirements and the WSSRAP Administrative Record files.

4.1 Document Selection

The selection process involves the identification of documents for review by the Administrative Record Coordinator (ARC). This selection process is performed on a monthly basis. During a public comment period, the selection process may take place as documents are generated. In this selection process the ARC shall:

- **Review** the incoming and outgoing DOE correspondence logs and the WSSRAP Reference Library Listing of documents printed by Document Control.

- **Select** documents from the DOE logs and Reference Library Listing, and produce the Administrative Record Document Tracking Log (Appendix C) for these documents.

- **Request** copies of the above selected documents for review.

- **Request** AR committee review of documents for which inclusion in an ARF is uncertain.

- **Catalogue** documents approved by the ARC/AR committee by using the AR Document Concurrence/Input Form (see Appendix C).

The AR Document Selection Flowchart (Appendix C) describes the flow of the document selection process from reviewing logs to inclusion of documents in the ARFs.

4.2 Index Generation

Once the document is approved, the document information is added to the index, and the document is placed in the appropriate ARF. The index contains the document information as data fields in the computerized system, as explained in the Document Information and dBase Field (Appendix C). Appendix C also contains an example of the index entry for a document. The index is used to verify that the information entered in the database is correct and it can be used as a cursory review of documents. The current version of the index is kept in the AR file, and is considered a draft index until the Record of Decision is completed and the administrative record is finalized.

The AR document file numbering system is a unique collection of numbers for each document identified in the AR files. Each document is given an unique number for identification and easy retrieval from the files. Below is an explanation of the numbering system:

EXAMPLE: DOCUMENT NUMBER C-100-101-1.01

C - One digit alpha designation to identify to which ARF the document belongs. In this case, C belongs to the Chemical Plant ARF.

100 - Three digit numeric designation for the identification of which general section in the table of contents the document belongs.

101 - Three digit numeric designation for the specific section in which the document belongs.

1.01 - Three digit (with decimal) numeric designation for the sequential number assigned the document. The number is assigned according to the chronological order of the documents in that specific section.

4.3 Technical Literature Review

References listed in primary documents (i.e., Engineering Evaluation/Cost Analysis [EE/CA], Remedial Investigation/Feasibility Study [RI/FS], Baseline Risk Assessment, Proposed Plan) are reviewed as technical literature for inclusion in the ARF. The references are cataloged in the database. Certain non-site-specific references that are publicly available are not required to be placed in the AR. All other references are collected and processed into the ARF under the Technical Sources section of the Table of Contents.

5 RECORD PRESERVATION

The *Federal Facility Agreement* (FFA) (pg. 27) requirements for the preservation of the Weldon Spring Site Remedial Action Project (WSSRAP) Administrative Records as follows:

> "The DOE shall, without regard to any document retention policy to the contrary, preserve during the duration of this Agreement and for a minimum of ten (10) years after its termination, all records and documents in its possession, custody or control which relate in any way to hazardous substances generated, stored, treated or disposed of on the site, the release or threatened release of hazardous substances from the site or work performed pursuant to this Agreement. After this ten-year period has lapsed, DOE shall notify U.S. EPA at least sixty (60) calendar days prior to the destruction of any such document. DOE shall, as directed by U.S. EPA, either provide to U.S. EPA the documents or copies of such documents or retain them for an additional time period specified by U.S. EPA."

6 LOCATION

The Weldon Spring Site Remedial Action Project (WSSRAP) Administrative Record files (ARFs) are located on site at 7295 Highway 94 South, St. Charles, Missouri. One copy of the AR/ARF is located in the WSSRAP Public Reading Room. It provides the community and local officials easy access to the AR/ARF. The master file copy is considered the official file copy and is maintained in fireproof, locking filing cabinets in the Compliance Department. The keys to the master file are kept and controlled by the Compliance Department. Both the Community Relations Department and the Compliance Department hold keys to the file cabinets and bookcases in the Public Reading Room. Both sets of files (the master file copy and the Reading Room copy) are to be kept locked at all times unless being used. Only authorized WSSRAP individuals (Community Relations Department and the ARC) are allowed entry of the Reading Room AR files. Only the Administrative Record Coordinator (ARC) is authorized to gain entry to the master file copy.

In the future, another copy of the ARF may be located at the Kisker Branch Library (in the Government Section), of the St. Charles County Library System which is in Saint Charles, Missouri. The library may be more accessible to the general public than the Reading Room. The address of the Kisker Branch Library is 1000 Kisker Road, Saint Charles, Missouri.

7 REFERENCES

U.S. Environmental Protection Agency, 1988. *Administrative Records Central Compendium of Guidance Documents*. Proposed by the Hazardous Waste Division, Superfund Branch. October.

U. S. Environmental Protection Agency, 1990, *Final Guidance on Administrative Records for Selection of CERCLA Response Actions*, OSWER Directive No. 9833.3A-1, Washington, D. C., December.

U. S. Environmental Protection Agency, 1992, *National Oil and Hazardous Substance Pollution Contingency Plan*, Title 40 Code of Federal Regulations Part 300, Washington, D. C., July.

U.S. Environmental Protection Agency Region VII, 1992. *First Amended Federal Facility Agreement, In the Matter of the United States Department of Energy's Weldon Spring Site, St. Charles, MO*. Docket No. CERCLA-VII-85-F-0057.

PROCEDURES

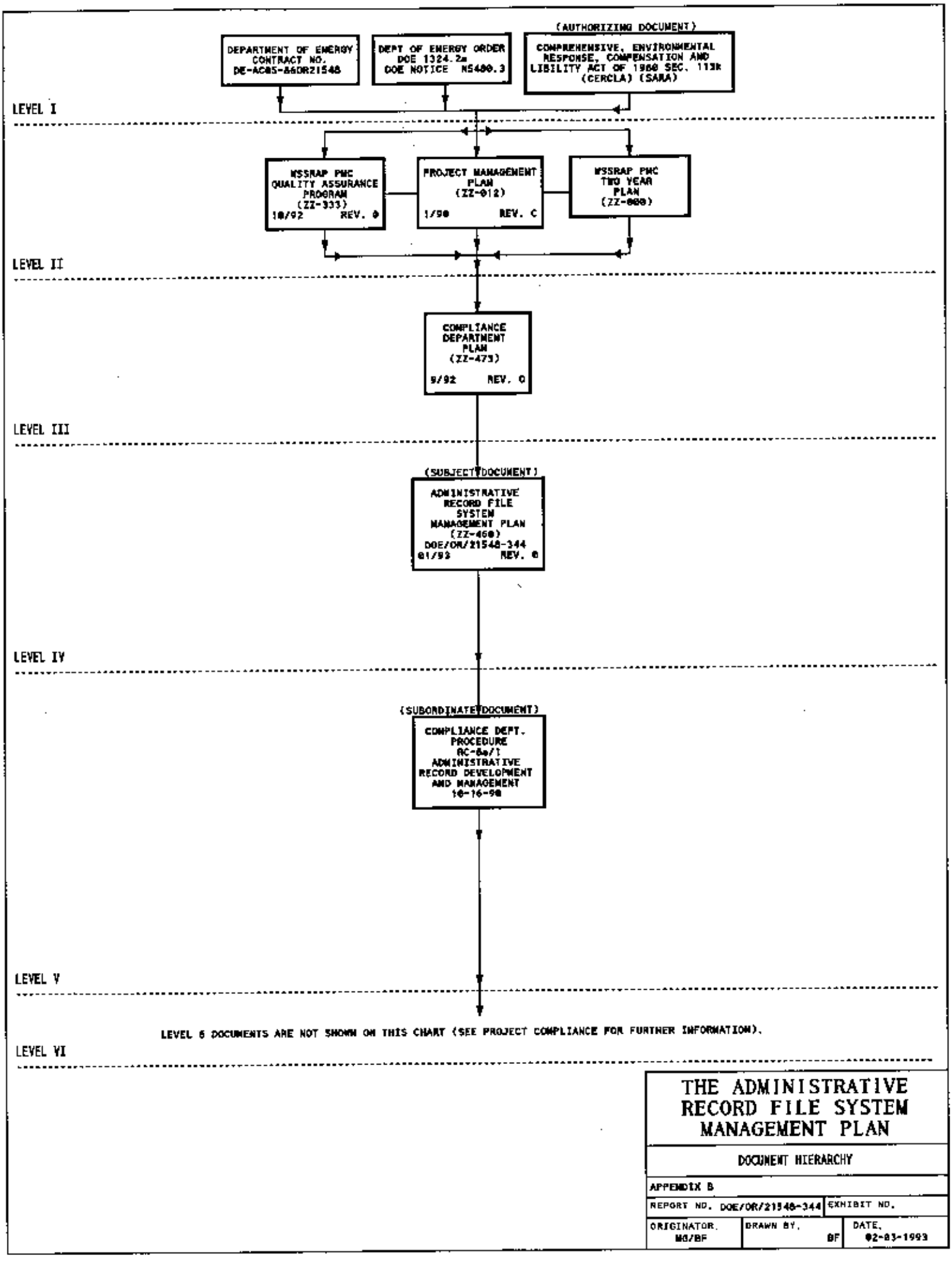
RC-45a/1 *Document Hierarchy*

APPENDIX A
Acronyms

ACRONYMS

AR	Administrative Record
ARC	Administrative Record Coordinator
ARF	Administrative Record File
ARFS	Administrative Record File System
ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation,and Liability Act of 1980 (42 USC Section 9601 et seq.)
CFR	Code of Federal Regulations
DOE	United States Department of Energy
EPA	United States Environmental Protection Agency
FFA	Federal Facilities Agreement
QBWAR	Quarry Bulk Wastes Administrative Record
RI/FS	Remedial Investigation/Feasibility Study
WSSRAP	Weldon Spring Site Remedial Action Project

APPENDIX B
Document Hierarchy Flow Chart


(AUTHORIZING DOCUMENT)
DEPARTMENT OF ENERGY CONTRACT NO. DE-AC05-86OR21548
DEPT OF ENERGY ORDER DOE 1324.2a DOE NOTICE N5480.3
COMPREHENSIVE, ENVIRONMENTAL RESPONSE, COMPENSATION AND LIBILITY ACT OF 1980 SEC. 113k (CERCLA) (SARA)
LEVEL I
WSSRAP PMC QUALITY ASSURANCE PROGRAM (ZZ-333) 10/92 REV. 0
PROJECT MANAGEMENT PLAN (ZZ-012) 1/90 REV. C
WSSRAP PMC TWO YEAR PLAN (ZZ-000)
LEVEL II
COMPLIANCE DEPARTMENT PLAN (ZZ-473) 9/92 REV. 0
LEVEL III
(SUBJECT DOCUMENT)
ADMINISTRATIVE RECORD FILE SYSTEM MANAGEMENT PLAN (ZZ-460) DOE/OR/21548-344 01/93 REV. 0
LEVEL IV
(SUBORDINATE DOCUMENT)
COMPLIANCE DEPT. PROCEDURE AC-6a/1 ADMINISTRATIVE RECORD DEVELOPMENT AND MANAGEMENT 10-16-90
LEVEL V
LEVEL 6 DOCUMENTS ARE NOT SHOWN ON THIS CHART (SEE PROJECT COMPLIANCE FOR FURTHER INFORMATION).
LEVEL VI
THE ADMINISTRATIVE RECORD FILE SYSTEM MANAGEMENT PLAN
DOCUMENT HIERARCHY
APPENDIX B
REPORT NO. DOE/OR/21548-344
EXHIBIT NO.
ORIGINATOR. MS/BF
DRAWN BY. BF
DATE. 02-03-1993

APPENDIX C
Administative Record Document
Selection and Identification Forms

APPENDIX C

DOCUMENT INFORMATION & DBASE FIELDS

Document Number: The numbers of the first and last page of each document or correspondence.

Document Date: The date identified on the document.

Document Title: The full title of the document.

Attachments: Attachments or enclosures attached to a document (e.g., designs, maps, etc.).

Document Type: This field describes the form of the document (e.g., report, notice, letter, etc.)

Author/Recipient: Names and organizations of the parties exchanging information.

Section: The section from the table of contents into which the document is placed.

INDEX INFORMATION

****

CHEMICAL PLANT ADMINISTRATIVE RECORD INDEX

****

DOCUMENT NO: C-100-102-1.01 **DOCUMENT DATE:** 11/01/79

DOCUMENT TITLE: U.S. ENVIRONMENTAL PROTECTION AGENCY REGION VII; POTENTIAL HAZARDOUS WASTE SITE FORM: IDENTIFICATION AND PRELIMINARY ASSESSMENT FOR WELDON SPRINGS CHEMICAL PLANT (BUILDINGS, LANDS, ASH PONDS AND RAFFINATE PITS).

DOCUMENT TYPE: FORM

SECTION: 102 PA/SI REPORTS

AUTHOR: EPA **RECIPIENT:** EPA

FILE NO.: C-100-102-1.01 **# OF PAGES:** 20

Weldon Spring Site Remedial Action Project

DOCUMENT CONCURRENCE/INPUT FORM

Document Date: _____

Document Title: _____

_____

_____

AR Document File No: _____ Number of pages _____

Document Type: _____ Section: _____

Author: _____ Recipient: _____

Location File: _____ DCN/DIN: _____
(which AR file) (i.e., ZZ-200/0001233)

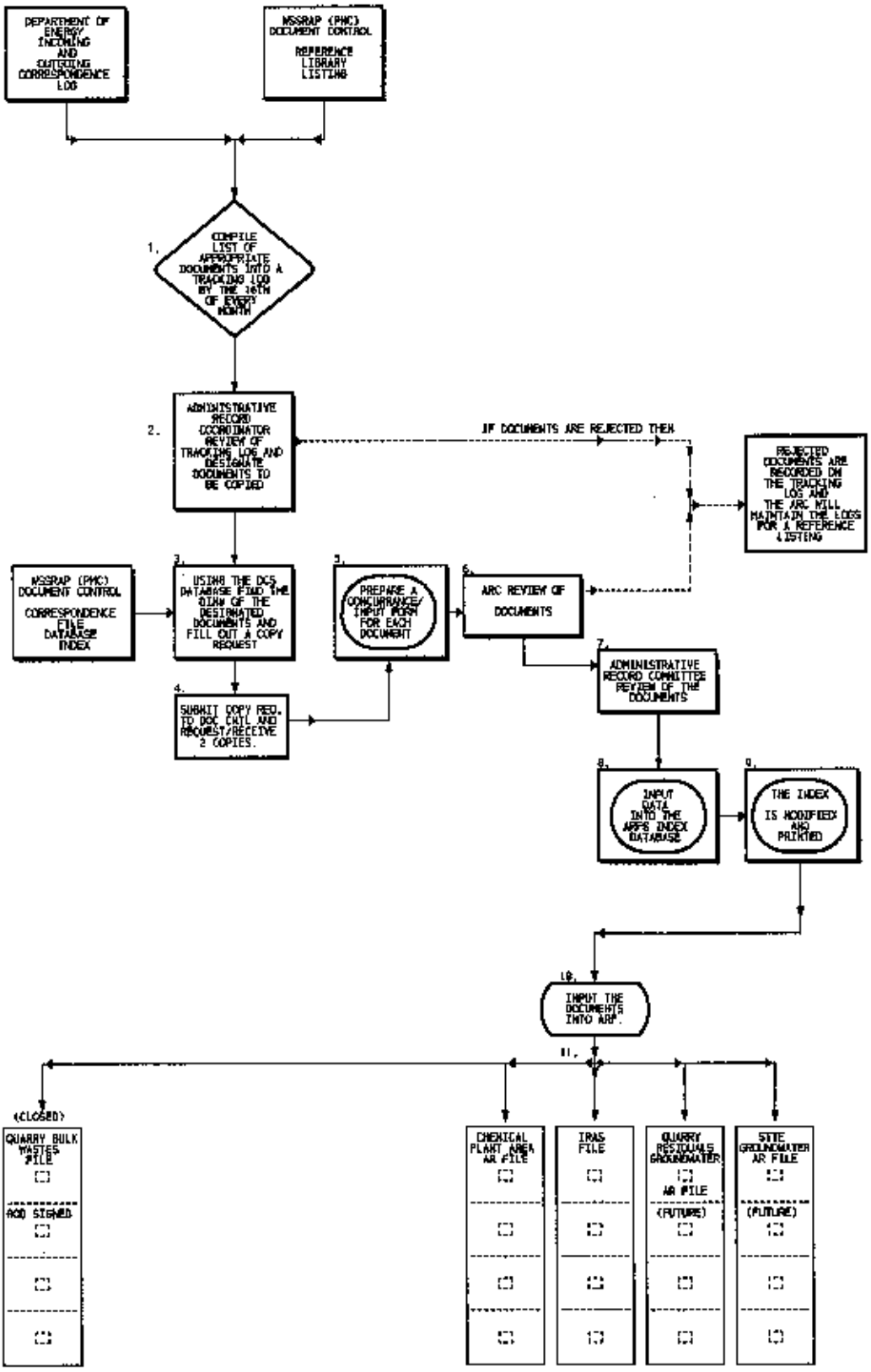
Approvals

_____ _____
Administrative Record Coordinator Date

_____ _____
ED/CD Department Manager Date

Notes

ADMINISTRATIVE DOCUMENT SELECTION PROCESS FLOWCHART



APPENDIX D
Administrative Record User's Guide

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1 INTRODUCTION

The Weldon Spring Site Remedial Action Project (WSSRAP) Administrative Records are managed in accordance with Section 113(j) and (k) of the *Comprehensive Environmental Response Compensation and Liability Act* (CERCLA), as amended by the *Superfund Amendments and Reauthorization Act of 1986*; Subpart I of the *National Oil and Hazardous Substance Pollution Contingency Plan* (NCP) (EPA 1992); and the U.S. Environmental Protection Agency OSWER Directive 9833.3A-1, *Final Guidance on Administrative Records for Selection of CERCLA Response Actions* (EPA 1990).

The purpose of this User's Guide is to facilitate the use of the WSSRAP Administrative Record files by the public or the WSSRAP staff. The Guide explains the breakdown of the Administrative Record files and how and where to find specific information. A site representative, either a Community Relations Specialist or the Administrative Record Coordinator (or designee), will be present during public inspection of the Administrative Records in order to facilitate public use of the record files and to answer questions about the record or the site.

Prior to viewing the Administrative Record files, the log book must be signed, including all pertinent information.

2 WSSRAP ADMINISTRATIVE RECORDS

The purpose of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Administrative Record (AR) is two-fold: first, to accurately document the basis for response actions, since any judicial review is limited to the Administrative Record, and second, to provide a vehicle for public participation in the selection of response actions.

Cleanup of the Weldon Spring site is being conducted as CERCLA remedial and removal actions. A separate administrative record must be compiled for each remedial action. The Weldon Spring Site Remedial Action Project (WSSRAP) removal actions are filed in one Administrative Record. The following is a list of the current and future WSSRAP Administrative Records:

Quarry Bulk Waste Excavation and Removal (complete)
Chemical Plant Area
Quarry Residuals/Groundwater (future)
Site Groundwater (future)
Interim Removal Actions

The Administrative Record for the Quarry Bulk Waste Removal has been completed. (Administrative Records are considered complete when the decision document for that response action is approved.) The Administrative Record for the chemical plant area is in the process of being compiled; it will be completed when the Record of Decision is finalized. Remedial investigations have not yet begun for the quarry residuals/groundwater or site groundwater, and therefore, Administrative Record files for these will be established and made available for public inspection when the Remedial Investigation/Feasibility Study (RI/FS) work plans are approved.

One AR file has been established that includes all WSSRAP interim response or removal actions (IRAs). The following is the current listing of WSSRAP removal actions contained in the IRA AR file:

- IRA 1 Electrical Transformers
- IRA 2 Ash Pond/Isolation Dike
- IRA 4 Army Property 7
- IRA 6 Overhead Piping/Asbestos Removal

- IRA 7 Containerized Chemicals
- IRA 8 Electrical Pole/Line Removal
- IRA 9 Debris Consolidation
- IRA 10 Building 409 Dismantling
- IRA 11 Building 401 Dismantling
- IRA 15 Non-Process Building Dismantling (Task 1)
- IRA 16 Non-Process Building Dismantling (Task 2)
- IRA 17 Water Tower Removal
- IRA 18 Process Building Dismantling
- IRA 20 Site Water Treatment Plant
- IRA 21 Quarry Water Treatment Plant

2.1 Location of the Administrative Record

Section 113(k)(1) of CERCLA requires that the Administrative Record be available to the public "at or near the facility at issue." Duplicates of the record file may be kept at any other location. The WSSRAP Administrative Records are available in the WSSRAP Public Reading Room for public review during business hours, i.e., Monday through Friday from 8am to 4:30 pm. Appointments are preferred.

Information repositories have been established at local libraries, so that the public can view documents at their convenience. The repositories contain various documents and information on WSSRAP activities, e.g., sampling data, informational bulletins, CERCLA/ National Environmental Policy Act (NEPA) documents. However, official copies of the WSSRAP Administrative Records have not been established at any of the repositories.

3 CONTENTS

3.1 Types of Documents

WSSRAP AR files are comprised of various types of documents. Examples of AR documents are correspondence, reports, information bulletins, public notices (newspaper), and decision documents. The documents are compiled and added to the AR files as they are generated and issued.

3.2 Index

A computerized index of each administrative record file is maintained as part of the record. This index contains basic information about the document, i.e., the AR document file number, title, issue date, author, recipient, and the physical location. The AR document file number found in the index is assigned to all documents as they are added to the AR files and are assigned based on the table of contents section. A copy of the index is also sent to EPA Region VII, on a quarterly basis.

3.3 Locating Documents

Specific AR documents can be located by either browsing the files or using the index. Appendix B contains the instructions on how to find a document in the administrative record files.

4 COPYING

The Weldon Spring Site Remedial Action Project (WSSRAP) Administrative Records (AR) are made available to the public for review. Documents comprising any AR file may not be removed from the Reading Room by the public. Authorized personnel may temporarily remove documents from the Reading Room for copying purposes only.

Copies of AR documents may be obtained by request to the authorized site representative. Copies of less than 20 pages may be obtained immediately. Copies of more than 20 pages, or large documents, may require more time. Turn-around time for copying large amounts would be determined on a case-by-case basis. A copying fee of $.20 per page may be charged.

5 GLOSSARY

Administrative Record Coordinator - Person assigned the responsibilities of establishing and maintaining the WSSRAP Administrative Records.

Administrative Record - A body of documents that is considered or relied upon to form the basis for the selection of a response action.

Administrative Record File - The body of documents that will constitute the Administrative Record for a response action once the record of decision is finalized.

Administrative Record File System - The system developed for the process of selecting, cataloging, indexing, and filing of documents constituting the Administrative Record.

Remedial Action - A permanent remedy taken in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release so that the hazardous substance(s) does not migrate to cause substantial danger to present or future public health or welfare or the environment.

Removal Action - A short-term, immediate action taken to remove a release of hazardous substances into the environment. Removal actions may be performed as part of a remedial action.

5.1 Acronyms

AR	Administrative Record
ARF	Administrative Record File
ARFS	Administrative Record File System
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980 (42 USC 9601 et seq.)
CFR	Code of Federal Regulations
EE/CA	Engineering Evaluation/Cost Analysis
IRA	Interim Response Actions
NEPA	National Environmental Policy Act
ROD	Record of Decision

RI/FS	Remedial Investigation/Feasibility Study
WSSRAP	Weldon Spring Site Remedial Action Project

6 REFERENCES

U. S. Environmental Protection Agency, 1990, *Final Guidance on Administrative Records for Selection of CERCLA Response Actions*, OSWER Directive No. 9833.3A-1, Washington, D. C., December.

U. S. Environmental Protection Agency, 1992, *National Oil and Hazardous Substance Pollution Contingency Plan*, Title 40 Code of Federal Regulations Part 300, Washington, D. C., July.

APPENDIX A
Examples of the
Table of Contents for the
Chemical Plant Administrative Record Index
and the
Interim Response Action Administrative Record Index

TABLE OF CONTENTS

SECTION NUMBER	SECTION TITLE
100	**SITE IDENTIFICATION**
101	Background Information
102	Preliminary Assessments and Site Investigation Reports
200	**REMEDIAL INVESTIGATION**
201	Sampling and Analysis Plans
202	Sampling and Analysis Data - Chain of Custody Forms
203	Work Plans
204	Remedial Investigation Quality Assurance Plan
205	Remedial Investigation Reports
300	**FEASIBILITY STUDY**
301	ARAR Determinations
302	Feasibility Study Reports
303	Proposed Plans
400	**RECORD OF DECISION**
401	Record of Decision
402	Amendments to Record of Decision
403	Explanations of Significant Differences
500	**STATE INVOLVEMENT**
501	State ARAR Correspondence
502	State Comments

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SECTION NUMBER	SECTION TITLE
600	**HEALTH ASSESSMENTS**
601	Agency for Toxic Substances and Disease Registry Health Assessments
700	**NATURAL RESOURCE TRUSTEES**
701	Notices to Trustees
800	**PUBLIC PARTICIPATION**
801	Comments and Responses
802	Community Relations Plan
803	Public Notice(s) (Availability of the Administrative Record File, Availability of the Proposed Plan, Public Meetings).
804	Public Meeting Transcripts
805	Documentation of Other Public Meetings
806	Fact Sheets
807	Responsiveness Summary
808	Late Comments
900	**TECHNICAL SOURCES AND GUIDANCE DOCUMENTS**
901	EPA Guidance Documents
902	Technical Sources

INTERIM RESPONSE ACTION Administrative Record INDEX

TABLE OF CONTENTS

SECTION NUMBER	SECTION TITLE
100	IRA 01 ELECTRICAL TRANSFORMERS
101	Sampling and Analysis Plans
102	Sampling and Analysis Data/Chain of Custody Forms
103	Engineering Evaluations/Cost Analysis
104	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
105	Amendments to Decision Document
200	IRA 02 ASH POND/ISOLATION DIKE
201	Sampling and Analysis Plans
202	Sampling and Analysis Data/Chain of Custody Forms
203	Engineering Evaluations/Cost Analysis
204	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
205	Amendments to Decision Document
300	IRA 04 ARMY PROPERTY # 7
301	Sampling and Analysis Plans
302	Sampling and Analysis Data/Chain of Custody Forms
303	Engineering Evaluations/Cost Analysis
304	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
305	Amendments to Decision Document

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SECTION NUMBER	SECTION TITLE
400	IRA 06 OVERHEAD PIPING/ASBESTOS REMOVAL
401	Sampling and Analysis Plans
402	Sampling and Analysis Data/Chain of Custody Forms
403	Engineering Evaluations/Cost Analysis
404	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
405	Amendments to Decision Document
500	IRA 07 CONTAINERIZED CHEMICALS
501	Sampling and Analysis Plans
502	Sampling and Analysis Data/Chain of Custody Forms
503	Engineering Evaluations/Cost Analysis
504	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
505	Amendments to Decision Document
600	IRA 08 ELECTRICAL POLE/LINE REMOVAL
601	Sampling and Analysis Plans
602	Sampling and Analysis Data/Chain of Custody Forms
603	Engineering Evaluations/Cost Analysis
604	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
605	Amendments to Decision Document
700	IRA 09 DEBRIS CONSOLIDATION
701	Sampling and Analysis Plans
702	Sampling and Analysis Data/Chain of Custody Forms

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SECTION NUMBER	SECTION TITLE
703	Engineering Evaluations/Cost Analysis
704	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
705	Amendments to Decision Document
800	IRA 10 BUILDING 409 DISMANTLING
801	Sampling and Analysis Plans
802	Sampling and Analysis Data/Chain of Custody Forms
803	Engineering Evaluations/Cost Analysis
804	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
805	Amendments to Decision Document
900	IRA 11 BUILDING 401 DISMANTLING
901	Sampling and Analysis Plans
902	Sampling and Analysis Data/Chain of Custody Forms
903	Engineering Evaluations/Cost Analysis
904	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
905	Amendments to Decision Document
1000	IRA 15 NON-PROCESS BUILDING DISMANTLING (TASK 1)
1001	Sampling and Analysis Plans
1002	Sampling and Analysis Data/Chain of Custody Forms
1003	Engineering Evaluations/Cost Analysis
1004	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
1005	Amendments to Decision Document

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SECTION NUMBER	SECTION TITLE
1100	IRA 16 NON-PROCESS BUILDING DISMANTLING (TASK 2)
1101	Sampling and Analysis Plans
1102	Sampling and Analysis Data/Chain of Custody Forms
1103	Engineering Evaluations/Cost Analysis
1104	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
1105	Amendments to Decision Document
1200	IRA 17 WATER TOWER REMOVAL
1201	Sampling and Analysis Plans
1202	Sampling and Analysis Data/Chain of Custody Forms
1203	Engineering Evaluations/Cost Analysis
1204	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
1205	Amendments to Decision Document
1300	IRA 18 PROCESS BUILDINGS DISMANTLING
1301	Sampling and Analysis Plans
1302	Sampling and Analysis Data/Chain of Custody Forms
1303	Engineering Evaluations/Cost Analysis
1304	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
1305	Amendments to Decision Document
1400	IRA 20 SITE WATER TREATMENT PLANT
1401	Sampling and Analysis Plans
1402	Sampling and Analysis Data/Chain of Custody Forms

TABLE OF CONTENTS (Continued)

SECTION NUMBER	SECTION TITLE
1403	Engineering Evaluations/Cost Analysis
1404	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
1405	Amendments to Decision Document
1500	**IRA 21 QUARRY WATER TREATMENT PLANT**
1501	Sampling and Analysis Plans
1502	Sampling and Analysis Data/Chain of Custody Forms
1503	Engineering Evaluations/Cost Analysis
1504	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document
1505	Amendments to Decision Document
1600	**IRA PUBLIC PARTICIPATION COMMUNITY RELATIONS**
1601	Comments and Responses
1602	Community Relations Plan
1603	Public Notice(s) (Availability of the Administrative Record File, Availability of the Proposed Plan, Public Meetings).
1604	Public Meeting Transcripts
1605	Fact Sheets
1606	Responsiveness Summary
1607	Late Comments
1700	**TECHNICAL SOURCES AND GUIDANCE DOCUMENTS**
1701	EPA Guidance Documents
1702	Technical Sources

APPENDIX B
How to Find a Document in the Administrative Record Files

1. If you know the Document Title.

   a. Go to the index section listed chronologically by section.
   b. Find the Administrative Record (AR) document number next to the correct title.
   c. Go to the file cabinet with the AR document file number or section number in the table of contents in each AR folder.
   d. Turn to the tab with the AR document file number or section number on it.
   e. Inside the file folder is the list of documents (in order) contained in the file folder.

2. If you know the Document Date.

   a. Go to the index section listed chronologically by date.
   b. Find the AR document file number.
   c. Go to the file cabinet with the AR document file number or section number in the table of contents in each AR folder.
   d. Turn to the tab with the AR document file number or section number on it.
   e. Inside the file folder is the list of documents (in order) contained in the file folder.

3. If you know the remedial action.

   a. Find the remedial action unit code number from the table of contents on each file folder.
   b. Go to the index section listed by AR document numbers.
   c. Go to the AR document numbers beginning with (each unit 1st letter) (i.e. C"= chemical plant).
   d. Find the complete AR document number of the document you want.
   f. Go to the file cabinet with the AR document number on the outside label.
   g. Turn to the AR document within the folder.

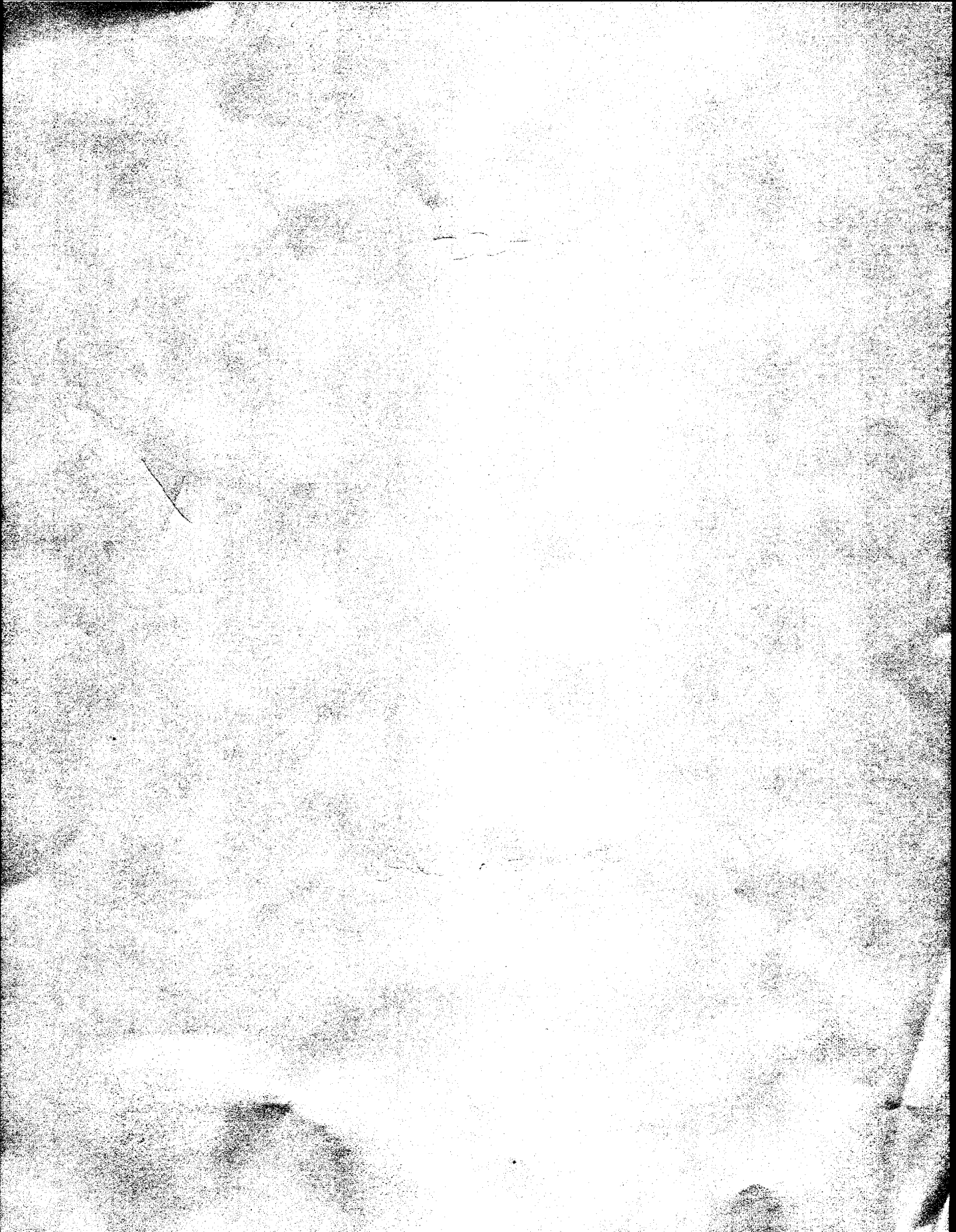
4. If you know the removal action.

   a. Find the removal action unit code number from the table of contents on each file folder.

b. Go to the index section listed by AR document number.

c. Go to the file cabinet with the AR document number in the table of contents inside the AR file folder.

d. Turn to the AR document in the AR file.



CHEMICAL PLANT ADMINISTRATIVE RECORD INDEX

DOCUMENT NUMBER	TITLE	AUTHOR	RECEIPIENT	DATE	TYPE	SECTION
C-100-101-1.01	ACKNOWLEDGEMENT OF NOTIFICATION AND REGISTRATION OF A HAZARDOUS WASTE SITE ACTIVITY	MDNR	DOE	02/04/87	LETTER	101 BACKGROUND INFORMATION
C-100-101-1.02	LETTER OF NOTIFICATION TO THE COMMISSION ABOUT WSSRAP SITE CLEANUP	DOE	MDNR	05/15/87	LETTER	101 BACKGROUND INFORMATION
C-100-101-1.03	FORMER USES OF THE UNIVERSITY OF MISSOURI AGRICULTURAL EXTENSION CENTER, WELDON SPRING, MISSOURI	DOE	FHS DIST.	03/24/89	LETTER	101 BACKGROUND INFORMATION
C-100-101-1.04	ACKNOWLEDGEMENT OF NOTIFICATION AND REGISTRATION OF HAZARDOUS WASTE ACTIVITY	MDNR	PMC	09/11/89	LETTER	101 BACKGROUND INFORMATION
C-100-102-1.01	U.S. EPA REGION VII POTENTIAL HAZARDOUS WASTE SITE FORM: IDENTIFICATION AND PRELIMINARY ASSESSMENT WSCP (BUILDINGS, LANDS ASH POND, AND RAFFINATE PITS)	EPA	DOE	11/01/79	FORM	102 PA/SI REPORTS
C-100-102-1.02	U.S. EPA REGION VII POTENTIAL HAZARDOUS WASTE SITE FORM: IDENTIFICATION AND PRELIMINARY ASSESSMENT WSCP (RAFFINATE PITS)	EPA	DOE	11/01/79	FORM	102 PA/SI REPORTS
C-100-102-1.03	U.S. EPA REGION VII POTENTIAL HAZARDOUS WASTE SITE FORM: IDENTIFICATION AND PRELIMINARY ASSESSMENT WSCP (BUIDLINGS, LAND AND ASH	EPA	DOE	11/01/79	FORM	102 PA/SI REPORTS

DOCUMENT NUMBER	TITLE	AUTHOR	RECEIPIENT	DATE	TYPE	SECTION
	POND)					
C-100-102-1.04	U.S. EPA REGION VII POTENTIAL HAZARDOUS WASTE SITE FORM: IDENTIFICATION AND PRELIMINARY ASSESSMENT; 1) SITE INFO & ASSESSMENT FOR WSS RAFFINATE PITS; 2) WASTE INFO; 3) HAZARDOUS CONDITION/INCIDENTS	EPA	DOE	03/20/86	FORM	102 PA/SI REPORTS
C-100-102-1.05	U.S. EPA REGION VII AND MNDR FORM: COMBINED NOTIFICATION OF HAZARDOUS WASTE ACTIVITY FORM FOR WSSRAP	DOE	EPA/MDNR	01/01/87	FORM	102 PA/SI REPORTS
C-200-201-1.01	PLAN FOR DETERMINATION OF BIOLOGICAL UPTAKE OF RADIONUCLIDES AND NITROAROMATICS IN SPECIES IN THE FOOD PATHWAYS AT THE WSS	PMC	DOE	06/22/87	REPORT	201 SAMPLING/ANALYSIS PLAN
C-200-201-1.02	WORKPLAN FOR THE DETERMINATION OF BIOLOGICAL UPTAKE OF WSS CONTAMINANTS BY SPECIES IN FOOD PATHWAYS	DOE	ADDRESSEES	09/16/87	REPORT	201 SAMPLING/ANALYSIS PLAN
C-200-201-1.03	PLAN FOR THE SAMPLING AND ANALYSIS OF LAKE AND STREAM SEDIMENTS INFLUENCED BY THE WSCP DRAINAGE; DOE/OR/21548-006	DOE	ADDRESSEES	11/01/87	REPORT	201 SAMPLING/ANALYSIS PLAN
C-200-201-1.04	CHEMICAL SOIL INVESTIGATION SAMPLING PLAN FOR THE WSCP/RAFFINATE PITS; REV. 1, DOE/OR/21548-013	DOE	ADDRESSEES	05/01/88	REPORT	201 SAMPLING/ANALYSIS PLAN

DOCUMENT NUMBER	TITLE	AUTHOR	RECEIPIENT	DATE	TYPE	SECTION
C-200-201-1.05	WASTE ASSESSMENT RAFFINATE PIT SAMPLING PLAN WSS; REV. 1, DOE/OR/21548-010	DOE	ADDRESSEES	05/01/88	REPORT	201 SAMPLING/ANALYSIS PLAN
C-200-201-1.07	HYDROGEOLOGICAL INVESTIGATIONS SAMPLING PLAN: REV. 0, DOE/OR/21548-020	DOE	ADDRESSEES	11/01/88	REPORT	201 SAMPLING/ANALYSIS PLAN
C-200-201-1.08	PLAN FOR MONITORING RADIONUCLIDE EMISSIONS OTHER THAN RADON AT WSS CRITICAL RECEPTORS: REV. 0, DOE/OR/21548-127	DOE	ADDRESSEES	05/01/90	REPORT	201 SAMPLING/ANALYSIS PLAN
C-200-201-1.09	ENVIRONMENTAL DATA ADMINISTRATION PLAN; REV. 0, DOE/OR/21548-229	DOE	ADDRESSEES	05/01/90	REPORT	201 SAMPLING/ANALYSIS PLAN
C-200-201-1.10	AGRICULTURAL SAMPLING PLAN; REV. 0, DOE/OR/21548-229	DOE	ADDRESSEES	09/01/91	REPORT	201 SAMPLING/ANALYSIS PLAN
C-200-201-1.11	AGRICULTURAL SAMPLING PLAN; REV. 0, DOE/OR/21548-248	DOE	ADDRESSEES	12/01/91	REPORT	201 SAMPLING/ANALYSIS PLAN
C-200-201-1.12	ENVIRONMENTAL MONITORING PLAN FOR CALENDAR YEAR 1992; REV. 1, DOE/OR/21548-237	DOE	ADDRESSEES	01/01/92	REPORT	201 SAMPLING/ANALYSIS PLAN
C-200-201-1.13	SAMPLING PLAN FOR DETERMINATION OF HYDRAULIC PROPERTIES OF UNDISTURBED SOILS IN THE WELDON SPRING DISPOSAL FACILITY STUDY AREA; REV. 1, DOE/OR/21548-164	DOE	ADDRESSEES	10/01/92	REPORT	201 SAMPLING/ANALYSIS PLAN
C-200-202-1.01	PHASE I CHEMICAL SOIL	DOE	ADDRESSEES	06/01/88	REPORT	202 SAMPLING/ANALYSIS DATA

DOCUMENT NUMBER	TITLE	AUTHOR	RECEIPIENT	DATE	TYPE	SECTION
	INVESTIGATION DATA REPORT FOR THE WSCP RAFFINATE PITS; DOE/OR/21548-016					
C-200-202-1.02	RADIOLOGICAL AND CHEMICAL UPTAKE BY EDIBLE PORTIONS OF SELECTED BIOTA AT THE WSS; REV. 0, DOE/OR/21548-044	DOE	ADDRESSEES	08/01/89	REPORT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.03	AQUIFER CHARACTERISTICS DATA REPORT FOR THE WSCP/RAFFINATE PITS AND VICINITY PROPERTIES; REV. 0, DOE/OR/21548-122	DOE	ADDRESSEES	11/01/90	REPORT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.04	WSSRAP ANNUAL SITE ENVIRONMENTAL REPORT 1989, DOE/OR/21548-129	DOE	PUBLIC	11/01/90	REPORT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.05	QUARTERLY ENVIRONMENTAL DATA SUMMARY 3RD QUARTER 1990; REV. 0, DOE/OR/21548-161	DOE	PUBLIC	01/01/91	REPORT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.06	QUARTERLY ENVIRONMENTAL DATA SUMMARY 4TH QUARTER 1990; REV. 0, DOE/OR/21548-183	DOE	PUBLIC	03/01/91	REPORT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.07	QUARTERLY ENVIRONMENTAL DATA SUMMARY 1ST QUARTER 1991; REV. 0, DOE/OR/21548-202	DOE	ADDRESSEES	06/01/91	REPORT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.08	WSSRAP ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990; DOE/OR/21548-193	DOE	PUBLIC	09/01/91	REPORT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.09	QUARTERLY ENVIRONMENTAL DATA SUMMARY 2ND QUARTER 1991; REV. 0,	DOE	ADDRESSEES	09/01/91	REPORT	202 SAMPLING/ANALYSIS DATA

DOCUMENT NUMBER	TITLE	AUTHOR	RECEIPIENT	DATE	TYPE	SECTION
	DOE/OR/21548-226					
C-200-202-1.10	QUARTERLY ENVIRONMENTAL DATA SUMMARY 3RD QUARTER 1991; REV. 0, DOE/OR/21548-257	DOE	ADDRESSEES	12/01/91	REPORT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.11	CHEMICAL PLANT SITE REMEDIAL INVESTIGATION/FEASIBILITY STUDY DATA VALIDATION REPORT; REV. 0, DOE/OR/21548-256	DOE	ADDRESSEES	02/01/92	REPORT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.12	QUARTERLY ENVIRONMENTAL DATA SUMMARY 4TH QUARTER 1991; REV. 0, DOE/OR/21548-275	DOE	ADDRESSEES	03/01/92	REPORT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.13	QUARTERLY ENVIRONMENTAL DATA SUMMARY 1ST QUARTER 1992; REV. 0, DOE/OR/21548-299	DOE	ADDRESSEES	06/01/92	REPORT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.14	QUARTERLY ENVIRONMENTAL DATA SUMMARY 2ND QUARTER 1992; REV. 0, DOE/OR/21548-337	DOE	ADDRESSEES	09/01/92	REPORT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.15	SITE SOIL PERMEABILITY DATA	DOE	MDNR	12/02/92	LETTER/DAT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.16	SUMMARIES OF ANALYTICAL DATA ON 60 PRIVATE DRINKING WATER WELLS IN THE VICINITY OF THE WSS; SUBMITTED BY MDOH	MDNR	DOE	01/08/92	LETTER/DAT	202 SAMPLING/ANALYSIS DATA
C-200-202-1.17	QUARTERLY ENVIRONMENTAL DATA SUMMARY 3RD QUARTER 1992; REV. 0, DOE/OR/21548-364	DOE	ADDRESSEES	12/01/92	REPORT	202 SAMPLING/ANALYSIS DATA

DOCUMENT NUMBER	TITLE	AUTHOR	RECEIPIENT	DATE	TYPE	SECTION
C-200-202-1.18	QUARTERLY ENVIRONMENTAL DATA SUMMARY 4TH QUARTER 1992; REV. 0, DOE/OR/21548-364	DOE	ADDRESSEES	03/12/93	REPORT	202 SAMPLING/ANALYSIS DATA
C-200-203-1.01	WORKPLAN FOR THE RI/FS-EIS FOR THE WSSRAP; DOE/OR/21548-033	DOE	ADDRESSEES	08/01/88	REPORT	203 WORK PLAN
C-200-204-1.01	REMEDIAL INVESTIGATION QUALITY ASSURANCE PROGRAM PLAN; REV. 0, DOE/OR/21548-011	DOE	ADDRESSEES	12/01/88	REPORT	204 RI QUALITY ASSURANCE QAPP
C-200-204-1.02	U.S. EPA REGION VII RESPONSIVENESS SUMMARY COMMENTS REMEDIAL INVESTIGATION QUALITY ASSURANCE PROGRAM PLAN	EPA	DOE	04/06/88	REPORT	204 RI QUALITY ASSURANCE QAPP
C-200-204-1.03	ENVIRONMENTAL QUALITY ASSURANCE PROJECT PLAN; REV. 0, DOE/OR/21548-352	DOE	ADDRESSEES	10/01/92	REPORT	204 RI QUALITY ASSURANCE QAPP
C-200-205-1.01	HYDROGEOLOGICAL CHARACTERIZATION REPORT FOR WSCP; DOE/OR/21548-137	DOE	ADDRESSEES	07/01/87	REPORT	205 RI REPORTS
C-200-205-1.02	CHEMICAL SOIL INVESTIGATION REPORT FOR THE WSCP/RAFFINATE PITS, PHASE II; REV. 0, DOE/OR/21548-061	DOE	ADDRESSEES	08/01/89	REPORT	205 RI REPORTS
C-200-205-1.03	WASTE ASSESSMENT RADIOLOGICAL CHARACTERIZATION OF THE WSS RAFFINATE PITS; REV. 0, DOE/OR/21548-062	DOE	ADDRESSEES	08/01/89	REPORT	205 RI REPORTS
C-200-205-1.04	WASTE ASSESSMENT CHEMICAL	DOE	ADDRESSEES	08/01/89	REPORT	205 RI REPORTS

DOCUMENT NUMBER	TITLE	AUTHOR	RECEIPIENT	DATE	TYPE	SECTION
	CHARACTERIZATION OF THE WSS RAFFINATE PITS; REV. 0, DOE/OR/21548-092					
C-200-205-1.05	PHASE I SPRING AND SEEP REPORT; REV. 0, DOE/OR/21548-045	DOE	ADDRESSEES	08/01/89	REPORT	205 RI REPORTS
C-200-205-1.06	REMEDIAL INVESTIGATIONS FOR QUARRY BULK WASTES; DOE/OR/21548-066	DOE	PUBLIC	12/01/89	REPORT	205 RI REPORTS
C-200-205-1.07	CHEMICAL PLANT GEOTECHNICAL INVESTIGATIONS; REV. 0, DOE/OR/21548-158	DOE	ADDRESSEES	12/01/90	REPORT	205 RI REPORTS
C-200-205-1.08	REMEDIAL INVESTIGATIONS FOR THE CHEMICAL PLANT AREA OF THE WSS; REV. 0, DOE/OR/21548-074; VOL. I AND II	DOE	PUBLIC	11/20/92	REPORT	205 RI REPORTS
C-200-205-1.09	MODELING GROUNDWATER FLOW AT THE CHEMICAL PLANT AREA OF THE WSS	DOE	PMC	04/14/93	LETTER	205 RI REPORTS
C-201-201-1.06	GEOPHYSICAL/GEOTECHNICAL INVESTIGATION SAMPLING PLAN; REV. 1, DOE/OR/21548-014	DOE	ADDRESSEES	07/01/88	REPORT	201 SAMPLING/ANALYSIS PLAN
C-300-301-1.01	STORAGE OF PCB WASTE AT THE WSS BEYOND ALLOWABLE TIME LIMITS - 40 CFR 761.65 (a)	DOE	EPA	12/06/89	LETTER	301 ARAR DETERMINATION
C-300-301-1.02	STORAGE OF LAND DISPOSAL RESTRICED WASTE	DOE	EPA	03/30/92	LETTER	301 ARAR DETERMINATION
C-300-301-1.03	QUARRY ASBESTOS REMOVAL AND STORAGE	DOE	EPA	03/24/92	LETTER	301 ARAR DETERMINATION

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C-300-301-1.04	REQUEST FOR ARAR WAIVER OF NESHAP REQUIREMENT FOR QUARRY ASBESTOS REMOVAL	DOE	EPA	07/23/92	LETTER	301 ARAR DETERMINATION
C-300-302-1.01	WELDON SPRING RAFFINATE PITS: EVALUATION OF CEMENT-BASED GROUTS AS A STABILIZATION OPTION	ORNL	DOE	06/01/89	REPORT	302 FEASIBILITY STUDY REPORTS
C-300-302-1.02	VITRIFICATION TECHNOLOGIES FOR WELDON SPRING RAFFINATE SLUDGES AND CONTAMINATED SOILS PHASE 2 REPORT: SCREENING OF ALTERNATIVES	PNL	DOE	11/01/89	REPORT	302 FEASIBILITY STUDY REPORTS
C-300-302-1.03	FEASIBILITY STUDY FOR MANAGEMENT OF THE BULK WASTES AT THE WELDON SPRING QUARRY; DOE/OR/21548-104	DOE	PUBLIC	02/01/90	REPORT	302 FEASIBILITY STUDY REPORTS
C-300-302-1.04	SITE SUITABILITY DATA ON POTENTIAL LOCATION OF A DISPOSAL FACILITY; DOE/OR/21548-102	PMC	DOE	09/01/91	REPORT	302 FEASIBILITY STUDY REPORTS
C-300-302-1.05	COMMERCIAL DISPOSAL OF DETARTMENT OF ENERGY (BYPRODUCT OF LOW LEVEL) AND MIXED WASTES	DOE	EPA	09/13/91	LETTER	302 FEASIBILITY STUDY REPORTS
C-300-302-1.06	FINAL REPORT STABILIZATION/SOLIDIFICATION TESTING OF RAFFINATE PIT SLUDGES AND NITROAROMATIC SOILS	WTG	PMC	05/01/92	REPORT	302 FEASIBILITY STUDY REPORTS
C-300-302-1.07	DISPOSAL FACILITY GEOTECHNICAL CHARACTERIZATION REPORT MKES; REPORT NO.	MKSF	PMC	10/01/92	REPORT	302 FEASIBILITY STUDY REPORTS

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	384OR-7005-0					
C-300-302-1.08	FEASIBILITY STUDY FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WSS; REV. 0 DOE/OR/21548-148, VOL. 1 - MAIN TEXT	DOE	PUBLIC	11/20/92	REPORT	302 FEASIBILITY STUDY REPORTS
C-300-302-1.09	FEASIBILITY STUDY FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WSS; DOE/OR/21548-148, VOL. II - APPENDIXES	DOE	PUBLIC	11/20/92	REPORT	302 FEASIBILITY STUDY REPORTS
C-300-302-1.10	ENGINEERING ANALYSIS OF REMEDIAL ACTION ALTERNATIVES PHASE I; REV. 0 DOE/OR/21548-269	PMC	DOE	11/20/92	REPORT	302 FEASIBILITY STUDY REPORTS
C-300-302-1.11	ENGINEERING ANALYSIS OF REMEDIAL ACTION ALTERNATIVES PHASE II; REV. 0 DOE/OR/21548-270	PMC	DOE	11/20/92	REPORT	302 FEASIBILITY STUDY REPORTS
C-300-303-1.01	PROPOSED PLAN FOR THE MANAGEMENT OF BULK WASTES AT THE WELDON SPRING QUARRY DOE/OR/21548-105	DOE	PUBLIC	02/01/90	REPORT	303 PROPOSED PLAN
C-300-303-1.02	PROPOSED PLAN FOR THE REMEDIAL ACTION AT THE CHEMICAL PLANT OF THE WELDON SPRING SITE; REV. 0, DOE/OR/21548-160	DOE	PUBLIC	11/20/92	REPORT	303 PROPOSED PLAN
C-300-303-1.03	BIOLOGICAL ASSESSMENT FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE	ANL	DOE	11/20/92	REPORT	303 PROPOSED PLAN
C-400-401-1.01	RECORD OF DECISION FOR	DOE	PUBLIC	09/01/90	DOCUMENT	401 DECISION DOCUMENT

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	THE MANAGEMENT OF THE BULK WASTES AT THE WELDON SPRING QUARRY					
C-400-401-1.02	RECORD OF DECISION FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WSS	DOE	PUBLIC	09/13/93	DOCUMENT	401 DECISION DOCUMENT
C-400-403-1.01	EXPLANATION OF SIGNIFICANT DIFFERENCE FOR THE CHEMICAL PLANT AREA RECORD OF DECISION, REV. 0; DOE/OR/21548-528	DOE	PUBLIC	01/01/96	REPORT	403 EXPLANATION OF SIGNIFICANT
C-500-501-1.01	APPLICABLE RELEVANT AND APPROPRITATE STATE AND FEDERAL REGULATIONS (ARARS)	DOE	MDNR	12/22/86	LETTER	501 STATE ARAR CORRESPONDENCE
C-500-501-1.02	CONCURRENCE OF NO EVIDENCE OF FAULT BENEATH THE WSS	MDNR	DOE	01/08/92	LETTER	501 STATE ARAR CORRESPONDENCE
C-500-501-1.03	REQUEST FOR EXCEPTION FROM THE DEPARTMENT OF TRANSPORTATION (DOT) REGULATIONS FOR PACKAGING AND STORAGE OF HAZARDOUS MATERIAL	DOE	MDNR	04/02/92	LETTER	501 STATE ARAR CORRESPONDENCE
C-500-501-1.04	WAIVER TO STATE REGULATION 10 CSR 25.5.262 (2)(C) 1 DOT REQUIREMENTS DURING STORAGE OF HAZARDOUS WASTE	DOE	MDNR	08/13/92	LETTER	501 STATE ARAR CORRESPONDENCE
C-500-502-1.01	STATE WITHDRAWAL OF PROPOSED SOIL CLEANUP LEVELS	MDNR	ANL	04/01/93	LETTER	502 STATE COMMENTS
C-500-502-1.02	MDNR CONCURRENCE WITH THE	MDNR	DOE	04/30/93	LETTER	502 STATE COMMENTS

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	PREFERRED REMEDY FOR THE WSS					
C-600-601-1.01	BASELINE RISK EVALUATION FOR EXPOSURE TO BULK WASTES AT THE WELDON SPRING QUARRY DOE/OR/21548-065	DOE	PUBLIC	01/08/90	REPORT	601 RISK ASSESSMENT
C-700-701-1.01	NOTIFICATION TO NATURAL RESOURCES TRUSTEES 40 CFR 300.135 SUBPART G - TRUSTEES FOR NATURAL RESOURCES	DOE	MDNR	04/10/91	LETTER	701 NOTICES TO TRUSTEES
C-700-701-1.02	NOTIFICATION TO NATURAL RESOURCES TRUSTEES 40 CFR 300.135 SUBPART G - TRUSTEES FOR NATURAL RESOURCES	DOE	DOI	04/10/91	LETTER	701 NOTICES TO TRUSTEES
C-800-801-1.01	RESPONSE TO CONCERN ABOUT SAFETY OF THE EPA DIRECTED CHARACTERIZATION PROGRAM	DOE	CO.	11/17/86	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.02	KEEPING INFORMED ON CURRENT ACTIVITIES AT THE WSSRAP	DOE	CO.	04/30/87	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.03	ST. CHARLES CO. COMMISSION COMMENTS ON RI/FS WORKPLAN	CO. COMMISSION	DOE	12/08/88	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.04	RESPONSE TO ST. CHARLES COMM. LETTER OF 12/8/88	DOE	CO.	02/09/89	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.05	ST. CHARLES COUNTAIANS AGAINST HAZARDOUS WASTE ON RI/FS-EIS	GRONEWALD	DOE	12/16/92	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.06	REVISED LETTER - QUESTIONS AND COMMENTS	L. AYYAGARI	DOE	01/01/93	LETTER	801 COMMENTS AND RESPONSES

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C-800-801-1.07	COMMENTS ON THE PROPOSED PLAN FOR TREATMENT AND FINAL DISPOSAL OF WASTE AT WSS	D. BROWN	DOE	02/12/93	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.08	RI/FS-EIS COMMENTS	D. MARTIN	DOE	02/16/93	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.09	RI/FS-EIS COMMENTS	E. JUDD	DOE	02/18/93	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.10	COMMENTS AND QUESTIONS REFERENCING THE BASELINE ASSESSMENT, RI/FS STUDY DOCUMENTS DEVELOPED FOR THE WSSRAP	W. VAUGHN	DOE	02/19/93	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.11	COMMENTARY ON THE PROPOSED FINAL STORAGE FOR THE WSSRAP WASTES	M. HALLIDAY	DOE	02/20/93	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.12	COMMENTS ON THE RI/FS-EIS	M. SANTEE	DOE	02/20/93	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.13	COMMENTS ON THE RI/FS-EIS	L. AYYAGARI	DOE	02/23/93	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.14	REVIEW OF RI/FS-EIS FOR REMEDIAL ACTION AT THE WSS	G. GUNN	DOE	02/26/93	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.15	RESPONSE TO BIOLOGICAL ASSESSMENT CONCERNING CLEANUP ACTIVITIES AT WSCP	D. FREDERICK	DOE	03/16/93	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.16	PUBLIC COMMENTS ON THE PROPOSED PLAN	B. MORGAN	PMC	04/09/93	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.17	RESPONSE TO LETTER CONCERNING BIOLOGICAL ASSESSMENT FOR REMEDIAL ACTION AT WSCP	R. WILLIAMS	DOE	12/31/92	LETTER	801 COMMENTS AND RESPONSES
C-800-801-1.18	WELDON SPRING VILLAGE BOARD MEETING LETTER	A. WANSING	DOE	01/04/93	LETTER	801 COMMENTS AND RESPONSES

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C-800-802-1.01	COMMUNITY RELATIONS PLAN; REV. 6, DOE/OR/21548-009	DOE	PUBLIC	09/01/92	REPORT	802 COMMUNITY RELATIONS PLAN
C-800-803-1.01	PUBLIC INFORMATION MEETING ON WSSRAP RI/FS AND IRAS	DOE	PUBLIC	02/11/88	PRESS	803 PUBLIC NOTICE
C-800-803-1.02	PUBLIC INFORMATION MEETING ON WSSRAP TO DISCUSS RI/FS AND IRAS	ST. CHARLES	PUBLIC	02/26/93	PRESS	803 PUBLIC NOTICE
C-800-803-1.03	PUBLIC MEETING TO DISCUSS RI/FS	ST. L POST	PUBLIC	02/24/88	ARTICLE	803 PUBLIC NOTICE
C-800-803-1.04	PUBLIC INFORMATION MEETING RI/FS AND IRAS	DOE	PUBLIC	02/25/88	NOTICE	803 PUBLIC NOTICE
C-800-803-1.05	PUCLIC SERVICE ANNOUNCEMENT FOR PUBLIC INFORMATION MEETING TO DISCUSS RI/FS FOR WSSRAP - APPEARED ON KMOX AM RADIO, KCLC RADIO, ST. CHARLES CABLE.	DOE	PUBLIC	02/25/88	NOTICE	803 PUBLIC NOTICE
C-800-803-1.06	NOTICE OF PUBLIC HEARING SCHEDULED FOR NOVEMBER 22, 1988	ST CHARLES	PUBLIC	11/16/88	NOTICE	803 PUBLIC NOTICE
C-800-803-1.07	ANNOUNCEMENT OF PUBLIC HEARING TO BE HELD	DOE	ADDRESSEES	11/22/88	LETTER	803 PUBLIC NOTICE
C-800-803-1.08	INVITATION TO ATTEND PUBLIC MEETING	DOE	MDNR	11/22/88	LETTER	803 PUBLIC NOTICE
C-800-803-1.09	PUBLIC INFORMATION MEETING NOTICE FOR RI/FS-EIS WORKPLAN AND IRAS	ST. CHARLES	PUBLIC	12/02/88	NOTICE	803 PUBLIC NOTICE
C-800-803-1.10	PUBLIC INFORMATION	ST. CHARLES	PUBLIC	12/04/88	NOTICE	803 PUBLIC NOTICE

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	MEETING AT THE WSS SCHEDULED FOR DECEMBER 6, 1988 ON RI/FS-EIS WORKPLAN AND IRAS					
C-800-803-1.11	PUBLIC INFORMATION MEETING ON RI/FS-EIS WORKPLAN AND IRAS	ST. CHARLES	PUBLIC	12/06/88	NOTICE	803 PUBLIC NOTICE
C-800-803-1.12	PUBLIC SERVICE ANNOUNCEMENT OF PUBLIC MEETING DATED 12/6/88 RELEASE ON KMOX-AM AND KCLC RADIO AND CABLE TV	DOE	PUBLIC	12/06/88	ANNOUNCEME	803 PUBLIC NOTICE
C-800-803-1.13	AVAILABLITY OF THE ADMINISTRATIVE RECORD	ST. CHARLES	PUBLIC	02/15/89	NOTICE	803 PUBLIC NOTICE
C-800-803-1.14	AVAILABLITY OF THE ADMINISTRATIVE RECORD	ST. CHARLES	PUBLIC	02/15/89	NOTICE	803 PUBLIC NOTICE
C-800-803-1.15	AVAILABLITY OF THE ADMINISTRATIVE RECORD	ST. CHARLES	PUBLIC	02/19/89	NOTICE	803 PUBLIC NOTICE
C-800-803-1.16	ATTENTION FRANCIS HOWELL SCHOOL DISTRICT RESIDENTS	ST. CHARLES	PUBLIC	02/03/93	ANNOUNCEME	803 PUBLIC NOTICE
C-800-803-1.17	EXTENSION OF COMMENT PERIOD LETTER	DOE	ADDRESSEES	01/01/93	LETTER	803 PUBLIC NOTICE
C-800-803-1.18	PUBLIC ANNOUNCEMENT DOE EXTENDS COMMENT PERIOD	ST. CHARLES	PUBLIC	01/24/93	ANNOUNCEME	803 PUBLIC NOTICE
C-800-803-1.19	PUBLIC HEARING SCHEDULE ON PLAN TO BURY WASTES	ST. LOUIS POST	PUBLIC	12/12/92	ARTICLE	803 PUBLIC NOTICE
C-800-803-1.20	NEWS REPORT HEARING SET ON CLEANUP DISPOSAL PLANS	ST. CHARLES	PUBLIC	12/14/92	ARTICLE	803 PUBLIC NOTICE
C-800-803-1.21	PUBLIC NOTICE ON AVAILABLITY OF EE/CA FOR MANAGEMENT OF IMPOUNDED SURFACE WATERS AT THE	DOE	PUBLIC	07/27/90	NOTICE	803 PUBLIC NOTICE

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	CHEMICAL PLANT					
C-800-803-1.22	PUBLIC MEETING NOTICE FOR COMMENTS ON EE/CA FOR IMPOUNDED SURFACE WATER AT THE CHEMICAL PLANT	DOE	PUBLIC	07/27/90	NOTICE	803 PUBLIC NOTICE
C-800-803-1.23	PUBLIC HEARING WILL DISCUSS TREATING OF CHEMICAL PLANT TAINTED WATER	ST. CHARLES	PUBLIC	07/29/90	ARTICLE	803 PUBLIC NOTICE
C-800-804-1.01	TRANSCRIPTS OF THE 12/6/88 PUBLIC MEETING AT LINDENWOOD COLLEGE ST. CHARLES, MO. DOE/OR/21548-072	DOE	ADMIN REC	06/08/89	TRANSCRIPT	804 PUBLIC MTG TRANSCRIPTS
C-800-804-1.02	U.S. DOE WSSRAP AT THE COLUMNS BANQUET AND CONFERENCE CENTER	S. MCGRAW	ADMIN REC	12/16/92	TRANSCRIPT	804 PUBLIC MTG TRANSCRIPTS
C-800-805-1.01	NOTICE OF WORKSHOP TO DISCUSS TREATMENT TECHNOLOGIES	ST. CHARLES	PUBLIC	08/06/91	NOTICE	805 DOCUMENT OF PUBLIC MTGS
C-800-805-1.02	DOE OFFERING A LOOK AT THE WS CLEANUP SITE	ST. LOUIS POST	PUBLIC	09/17/91	NOTICE	805 DOCUMENT OF PUBLIC MTGS
C-800-805-1.03	PUBLIC TO GET LAST LOOK AT WELDON SPRING URANIUM PLANT	ST. CHARLES	PUBLIC	09/18/91	NOTICE	805 DOCUMENT OF PUBLIC MTGS
C-800-805-1.04	PUBLIC CAN TOUR THE OLD CHEMICAL PLANT	ST. CHARLES	PUBLIC	09/18/91	NOTICE	805 DOCUMENT OF PUBLIC MTGS
C-800-805-1.05	INVITATION TO A RISK ASSESSMENT WORKSHOP	DOE	ADDRESSEES	06/19/92	LETTER	805 DOCUMENT OF PUBLIC MTGS
C-800-805-1.06	DISCUSSIONS SET JUNE 30TH ON CHEMICAL PLANT	ST. CHARLES	PUBLIC	06/27/92	ARTICLE	805 DOCUMENT OF PUBLIC MTGS
C-800-805-1.07	MEETING WITH ST. CHARLES	DOE	ADMIN REC	03/19/93	MEETING	805 DOCUMENT OF PUBLIC MTGS

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	COUNTIANS AGAINST HAZARDOUS WASTE TO DISCUSS RI/FS-EIS COMMENTS					
C-800-806-1.01	HISTORY OF THE WELDON SPRING SITE	DOE	PUBLIC	01/01/87	FACT SHEET	806 FACT SHEET
C-800-806-1.02	WATER QUALITY STUDIES DISTRIBUTED AT 2/25/88 PUBLIC MEETING	DOE	PUBLIC	02/25/88	FACT SHEET	806 FACT SHEET
C-800-806-1.03	A HANDOUT ON THE WELDON SPRING SITE: DESCRIPTION AND ANALYSIS OF THE HAZARDOUS AND TOXIC MATERIALS PRESENT ON THE WSS	DOE	PUBLIC	02/01/88	BOOKLET	806 FACT SHEET
C-800-806-1.04	SUPERFUND FACTS, DISTRIBUTED AT THE PUBLIC MEETING HELD 2/25/88	DOE	PUBLIC	02/01/88	FACTSHEET	806 FACT SHEET
C-800-806-1.05	WSSRAP UPDATE	DOE	PUBLIC	02/01/89	BOOKLET	806 FACT SHEET
C-800-806-1.06	WSSRAP UPDATE	DOE	PUBLIC	01/01/90	BOOKLET	806 FACT SHEET
C-800-806-1.07	WSSRAP UPDATE	DOE	PUBLIC	06/01/92	BOOKLET	806 FACT SHEET
C-800-806-1.08	WSSRAP UPDATE	DOE	PUBLIC	02/01/93	BOOKLET	806 FACT SHEET
C-800-806-1.09	WSSRAP UPDATE	DOE	PUBLIC	09/01/93	BOOKLET	806 FACT SHEET
C-800-807-1.01	RESPONSE TO QUESTIONS RAISED CONCERNING THE RI/FS-EIS WORKPLAN	DOE	M. GARVEY	02/27/89	LETTER	807 RESPONSIVENESS SUMMARY
C-800-807-1.02	RESPONSIVENESS SUMMARY FOR THE RI/FS FOR MANAGMENT OF BULK WASTES AT THE WELDON SPRING QUARRY DOE/OR/21548-135	DOE	PUBLIC	08/01/90	REPORT	807 RESPONSIVENESS SUMMARY

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C-800-807-1.03	RESPONSES TO COMMENTS ON RI/FS-EIS FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA	DOE	PUBLIC	05/01/93	REPORT	807 RESPONSIVENESS SUMMARY
C-900-901-1.01	COMPENDIUM OC CERCLEA RESPONSE SELECTION GUIDANCE DOCUMENTS USERS MANUAL	EPA	ADMIN	05/01/89	MANUAL	901 GUIDANCE DOCUMENTS
C-900-902-1.01	CHEMICAL PLANT ADMINISTRATIVE RECORD TECHNICAL REFERENCE LISTING	DOE	PUBLIC	11/01/92	REPORT	902 TECHNICAL SOURCES

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1101	Sampling and Analysis Plans
1102	Sampling and Analysis Data/Chain of Custody Forms
1103	Engineering Evaluations/Cost Analysis
1104	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document (RADD)
1105	Amendments to Decision Document
1200	IRA #17 WATER TOWER REMOVAL
1201	Sampling and Analysis Plans
1202	Sampling and Analysis Data/Chain of Custody Forms
1203	Engineering Evaluations/Cost Analysis
1204	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document (RADD)
1205	Amendments to Decision Document
1300	IRA #18 PROCESS BUILDINGS DISMANTLING
1301	Sampling and Analysis Plans
1302	Sampling and Analysis Data/Chain of Custody Forms
1303	Engineering Evaluations/Cost Analysis
1304	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document (RADD)
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1400	IRA #20 SITE WATER TREATMENT PLANT
1401	Sampling and Analysis Plans
1402	Sampling and Analysis Data/Chain of Custody Forms
1403	Engineering Evaluations/Cost Analysis
1404	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document (RADD)
1405	Amendments to Decision Document

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

1500	IRA #21 QUARRY WATER TREATMENT PLANT
1501	Sampling and Analysis Plans
1502	Sampling and Analysis Data/Chain of Custody Forms
1503	Engineering Evaluations/Cost Analysis
1504	Engineering Evaluations/Cost Analysis Approval or Remedial Action Decision Document (RADD)
1505	Amendments to Decision Document

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

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1601	Comments and Responses
1602	Community Relations Plan
1603	Public Notice(s) (Availability of the Administrative Record File, Availability of the Proposed Plan, Public Meetings).
1604	Public Meeting Transcripts
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1606	Fact Sheets
1607	Responsiveness Summary
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1700	TECHNICAL SOURCES AND GUIDANCE DOCUMENTS
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The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

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SAMPLING AND ANALYSIS DATA AND BORING LOGS

The records cited in entry numbers 1 through 4 may be reviewed, by appointment only, at the Weldon Spring Site Remedial Action Project, Saint Charles, Missouri.

1. Chain of Custody Forms (1986 - Present)

2. Sampling Data (1940 - 1986)

3. Sampling Data (1986 - Present)

4. Boring Logs

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

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IN THIS LISTING DOCUMENTS, PLANS, REPORTS, ETC., ARE LISTED ALPHABETICALLY BY THE FIRST LETTER OF TITLE

ADDITIONAL COPIES LOCATED AT DCC TABLE

REFERENCE LIBRARY LISTING

BG	BIBLIOGRAPHIES
BL	BASELINE DOCUMENTS
BZ	BIOLOGY/ZOOLOGY
CM	CONFERENCE NOTES/MEETING MINUTES
DD	DECONTAMINATION/DECOMMISSIONING
EN	ENGINEERING
EV	ENVIRONMENT
GE	GEOLOGY/GEOCHEMICAL/GEOTECHNICAL
GR	GENERAL REFERENCE
HG	HYDROLOGY
HP	HEALTH PHYSICS
KU	KEEPING UP OLD AND NEW DOCUMENTS
LN	LINERS
PM	PROJECT MANAGEMENT
QY	QUARRY
RG	REGULATIONS
RP	RAFFINATE PITS
SE	SOCI-ECONOMICS
WM	WASTE MANAGEMENT
YY	PUBLIC READING ROOM
ZZ	REPORTS/PLANS

ACCRONYMS

ANL	ARGONNE NATIONAL LABORATORY
BNI	BECHTEL NATIONAL, INC.
DOA	DEPT. OF THE ARMY
DOE	DEPT. OF ENERGY
DOI	DEPT. OF INTERIOR
LBL	LAWRENCE BERKELY LABORATORY
MCW	MALLINCKRODT CHEMICAL WORKS
NLO	NATIONAL LEAD CO. OF OHIO
ORAU	OAK RIDGE ASSOCIATED UNIVERSITIES
ORNL	OAK RIDGE NATIONAL LABORATORY
ORO	OAK RIDGE OPERATIONS
RETA	RYCKMAN, EDGERLEY, TOMLINSON & ASSOC.
SAI	SCIENCE APPLICATIONS, INC.
UCC	UNION CARBIDE CORP.
WSCP	WELDON SPRING CHEMICAL PLANT
WSQ	WELDON SPRING QUARRY
WSSRAP	WELDON SPRING SITE REMEDIAL ACTION PROJECT
WSSS	WELDON SPRING STORAGE SITE
EE/CA	ENGINEERING EVALUATION/COST ANALYSIS
RI/FS	REMEDIAL INVESTIGATION/FEASIBILITY STUDY
RS	RESPONSIVENESS SUMMARY

WSSRAP Reference Library

WSSRAP DE-AC05-86OR21548
MK-Ferguson
Contract: 3589

Alphabetical Listing

Report Date: 09/07/93

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
PM	38	(FIS/SGL) CHART OF ACCOUNTS & RELATED CODES		OCT 1989		
MP	63	10 CFR PART 834 RADIATION PROTECTION OF THE PUBLIC AND THE ENVIRONMENT INCLUDED: BEST AVAILABLE TECHNOLOGY (BAT) GUIDANCE MANUAL (APPLICATION OF BAT FOR LIQUID EFFLUENT RELEASES AT U.S. DOE FACILITIES) SEPT 90 (SECOND DRAFT)	DOE	01-10-91		DRAFT
CN	14	1987 INTERNATIONAL DECOMMISSIONING SYMPOSIUM PROCEEDINGS	WESTINGHOUSE HANFORD CO.	10-87		
CN	25	1989 DOE MODEL CONFERENCE, OCTOBER 2-6, 1989	DOE	10-89		
ZZ	343	1990 WELDON SPRING ANNUAL PCB REPORT	DOE/OR/21548-207	JUNE 91	REV. 0	
BG	8	1990-1991 CATALOG OF AMERICAN NATIONAL STANDARDS	ANSI	1990-1991		ALSO 1988 CATALOG
EV	19	1991 RADIATION MONITORING REPORT SUMMRY OF RADIATION MONITORING DATA RELATED TO ST. LOUIS AREA RADIOACTIVE WASTE SITES	MO. DEPT. OF NAT. RESOURCES	09/11/91		
ZZ	434	1991 WELDON SPRING SITE ANNUAL PCB REPORT	DOE/OR/21548-318	JUNE 92	REV. 0	
RG	146	1992 MOBILE SITE WATER TREATMENT SYSTEM (MSWTS) OPERATING LOG	MK-WELDON SPRINGS	1992		
ZZ	499	1992 NESHAPS ANNUAL REPORT FOR THE WELDON SPRING SITE	DOE/OR/21548-405	JUN. 1993	REV. 1	
ZZ	501	1992 WELDON SPRING SITE ANNUAL PCB REPORT	DOE/OR/21548-407	JUN. 1993	REV. 0	
RG	141	1993 ANNUAL BOOK OF ASTM STANDARDS SECTION 4	ASTM	1993		PERM CHECK OUT L KLINGMULLER
EN	69	90% DESIGN REPORT LAND DISPOSAL FACILITY ALTERNATIVE COVER ASSESSMENT	JEG, INC.	10/07/91		
PM	71	A BRIEFING ON NIAGARA FALLS STORAGE SITE WELDON SPRING SITE	ISFM	MAR. 1982		
GR	53	A CATOLOG OF HAZARDOUS AND SOLID WASTE PUBLICATIONS	EPA	7-89		
GR	202	A COMPENDIUM OF SUPERFUND FIELD OPERATIONS METHODS	EPA	DEC. 1987		PERM. CHECK OUT TO J. BOGNAR
RG	39	A COMPENDIUM OF SUPERFUND FIELD OPERATIONS METHODS	EPA	12-87		
PM	30	A COMPENDIUM OF SUPRERFUND FIELD OPERATIONS METHODS: VOLS. 1 & 2	EPA	08-87		
EV	86	A FIELD GUIDE TO EASTERN TREES EASTERN UNITED STATES AND CANADA	GEORGE A. PETRIDES	1988		PERM. CHECK OUT TO M. THOMAS
EV	84	A FIELD GUIDE TO REPTILES AND AMPHIBIANS EASTERN AND CENTRAL NORTH AMERICA	ROGER CONANT & JOSEPH COLLINS	1991		PERM. CHECK OUT TO M. THOMAS
EV	83	A FIELD GUIDE TO THE BIRDS A COMPLETELY NEW GUIDE TO ALL THE BIRDS OF EASTERN AND CENTRAL NORTH AMERICA	ROGER TORY PETERSON	1980		PERM. CHECK OUT TO M. THOMAS
EV	85	A FIELD GUIDE TO THE MAMMALS NORTH AMERICA NORTH OF MEXICO	WILLIAM HENRY BURT	1976		PERM. CHECK OUT TO M. THOMAS
EV	82	A FIELD GUIDE TO WILDFLOWERS NORTHEASTERN AND NORTHCENTRAL NORTH AMERICA	ROGER TORY PETERSON/M. MCKENNY	1968		PERM. CHECK OUT TO M. THOMAS
ZZ	233	A FIELD STUDY DESIGNED TO SELECT THE IN-SITU INSTRUMENT MOST USEFUL FOR ESTIMATING URANIUM CONTAMINATION IN SOIL	JEG - S. GREEN	12/24/87	DRAFT	
MP	33	A GUIDE TO REDUCING RADIATION EXPOSURE TO AS LOW AS REASONABLY ACHIEVABLE (ALARA)	DOE	APRIL 80		
PM	43	A HAZRISK PROJECT EVALUATION OF WELDON SPRING	INDEPENDENT PROJ. ANALYSIS, IN	FEB 91		PRELIMINARY DRAFT
RG	33	A MANUAL FOR IMPLEMENTING RESIDUAL RADIOACTIVE MATERIAL GUIDELINES	DOE	06-89		
RG	51	A MANUAL FOR IMPLEMENTING RESIDUAL RADIOACTIVITY GUIDELINES	ANL/ORNL/LANL/BPNL	09-30-85		PERM. CHECK OUT TO J REITINGER
PM	83	A PHASE I CULTURAL RESOURCES SURVEY AND EVALUATION	TRIAD RESEARCH			PERM CHECK OUT TO B.

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		OF THE WELDON SPRING QUARRY SITE REMEDIAL ACTION PROJECT AREA, ST. CHARLES COUNTY, MO A CULTURAL RESOURCES MANAGEMENT STUDY CONDUCTED FOR THE US DOE	SERVICES			GOLDKAMP
PM	97	A PHASE I SURVEY & EVALUATION OF THE PROPOSED SITE WATER TREATMENT PLANT EFFLUENT PIPELINE PROJECT AREA	TRIAD RESEARCH SERVICES	MAY 92		
PM	88	A PHASE I SURVEY AND EVALUATION OF A PROPOSED BORROW AREA FOR THE WELDON SPRING SITE REMEDIAL ACTION PROJECT, ST. CHARLES COUNTY, MISSOURI A CULTURAL RESOURCE MANAGEMENT STUDY CONDUCTED FOR THE DEPT.OF ENERGY	TRIAD RESEARCH SERVICES	JAN. 1992		
PM	55	A PHASE I SURVEY AND EVALUATION OF THE PROPOSED WELDON SPRING QUARRY TO WELDON SPRING CHEMICAL PLANT SITE BULK WASTE HAULAGE ROAD PROJECT AREA A CULTURAL RESOURCE MGMT. STUDY CONDUCTED FOR THE US DOE	TRIAD RESEARCH SERVICES	12-15-90		
BZ	5	A RAPID METHOD FOR DETERMINING NANOGRAM QUANTITIES OF URANIUM IN URINE USING THE KINETIC PHOSPHORESCENCE ANALYZER	DOE / IDAHO			
GE	36	A READER ON EARTHQUAKE HAZARD REDUCTION IN THE CENTRAL UNITED STATES	U.S. GEOLOGICAL SURVEY			
GR	189	A REVIEW OF OCCUPATIONAL SAFETY AND HEALTH ISSUES RELEVANT TO THE ENVIRONMENTAL RESTORATION PROGRAM: SELECTED CASE HISTORIES & ASSOCIATED ISSUES	BATTELLE	OCT. 1992		
GR	57	A REVIEW OF REMEDIATION CONTRACTING PRACTICES	ORNL	5-26-89		
RG	35	A REVIEW OF SOME REGULATORY ISSUES & RELATED TECHNICAL CONCERNS AFFECTING THE ON-SITE REMEDIAL ACTION ALTERNATIVE AT WELDON SPRING	MKE			
WM	31	A SUMMARY AND ANALYSIS OF THE PROPOSED STANDARDS FOR THE DISPOSAL OF SEWAGE SLUDGE	ORNL	4-13-89		
PM	48	ACCOMPLISHMENTS REPORT FOR COST CONTROL ACTIVITIES	MARTIN MARIETTA	5-15-87		
GR	8	ACCOUNTING FOR GOVERNMENT CONTRACTS COST ACCOUNTING STANDARDS	MATHEW BENDER	JULY 91		
HP	66	ACCURACY AND DETECTION LIMITS FOR BIOASSAY MEASUREMENTS IN RADIATION PROTECTION STATISTICAL CONSIDERATIONS	NRC	APRIL 86		
EN	25	ACI DETAILING MANUAL - 1988	AMERICAN CONCRETE INSTITUTE	1988		
ZZ	256	ADDENDUM TO ENGINEERING EVALUATION/COST ANALYSIS FOR THE PROPOSED MANAGEMENT OF 15 NONPROCESS BUILDINGS (15 SERIES) AT THE WELDON SPRING SITE CHEMICAL PLANT, WELDON SPRING, MO	DOE/OR/21548-135	AUGUST 90	DRAFT	ANL (JULY 90 INCLUDED) DOE-071
EN	27	ADDENDUM TO THE DESIGN REPORT FOR THE INTERIM WASTE CONTAINMENT FACILITY AT THE NIAGARA FALLS STORAGE SITE: LONG-TERM CONTAINMENT OPTION	BNI	10-86		
ZZ	387	ADDENDUM TO THE SITE REMEDIAL INVESTIGATION REPORT	DOE/OR/21548-272	MARCH 92	REV. D	
ZZ	136	ADDITIONAL ASBESTOS SAMPLING	08-18-87			IRA #6
RG	26	ADMINISTRATIVE GUIDANCE FOR REMOVAL PROGRAM USE OF ALTERNATIVES TO LAND DISPOSAL	EPA	01-18-87	N/A	(DRAFT)
RG	50	ADMINISTRATIVE GUIDANCE FOR REMOVAL PROGRAM USE OF ALTERNATIVES TO LAND DISPOSAL (DRAFT)	EPA	05-18-87		
ZZ	460	ADMINISTRATIVE RECORD FILE SYSTEM MANAGEMENT PLAN	DOE/OR/21548-344	JAN. 1993	REV. 0	
RG	78	ADMINISTRATIVE RECORDS CENTRAL COMPENDIUM OF GUIDANCE DOCUMENTS	EPA	OCT 1988		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
RG	8	AEC REGULATORY GUIDE	USAEC	06-74	N/A	
PM	14	AEC/ERDA - WELDON SPRING RADIOACTIVE WASTE MANAGEMENT PLAN	NLO	-73/07-77	N/A	(DRAFT THRU REV.4)
HP	10	AERIAL RADIOLOGICAL SURVEY OF THE AREA SURROUNDING THE ABANDONED QUARRY NEAR THE WSCP	EG&G	04-82	34	(DATE OF SURVEY -
HP	2	AERIAL RADIOLOGICAL SURVEY OF THE WSCP	EG&G	04-76	56	(DATE OF SURVEY -
HP	3	AERIAL RADIOLOGICAL SURVEY OF THE WSCP	EG&G	01-77	53	(DATE OF SURVEY -
GR	92	AFFIRMATIVE ACTION PROGRAM PLAN	MORRISON KNUDSEN CORP.			
YY	19	AGENDA OF PUBLIC INFORMATION MEETING	02-25-88	02-25-88		PUBLIC PART
ZZ	115	AGRIGULTURAL SAMPLING PLAN	DOE/OR/21548-229	DEC. 1992	REV. 1	
RG	122	AIR PATHWAY ANALYSIS EMISSION RATE FACTORS REPORT #5121-R-758-0	MKES	NOV. 1992	REV. 0	
ZZ	425	AIR SAMPLERS RELOCATION & INSTALLATION 1992 HEALTH AND SAFETY PLAN WP323	PMC	JUNE 92	REV. 0	
GR	229	AIR WAYBILL HANDBOOK	INT. AIR TRANSPORTATION ASSOC.	SEP. 1992		PERM. CHECK OUT TO B. CURIA
HP	87	AIRDOS-EPA: A COMPUTERIZED METHODOLOGY FOR ESTIMATING ENVIRONMENTAL CONCENTRATIONS AND DOSE TO MAN FROM AIRBORNE RELEASES OF RADIONUCLIDES	EPA	DEC. 1979		
GR	44	ALABAMA ARMY AMMUNITION PLANT REMEDIAL INVESTIGATION FINAL REPORT	ENVIRON. SCIENCE & ENG., INC.	07-86		
GR	204	ALTERNATE CONCENTRATION LIMIT GUIDANCE PART 1 ACL POLICY & INFORMATION REQUIREMENTS (INTERIM FINAL)	EPA	JULY 1987		PERM. CHECK OUT TO J. BOGNAR
ZZ	121	ALTERNATE SPOILS AREA RUBBLE AND SOIL MANAGEMENT PLAN	DOE/OR/21548-235	SEPT 91	REV. A	NOT YET RECEIVED
EV	51	AMBIENT MONITORING GUIDELINES FOR PREVENTION OF SIGNIFICANT DETERIORATION (PSD)	EPA	05-87		
RG	92	AMENDMENT TO THE NTIONAL OIL AND HAZARDOUS SUBSTANCES CONTINGENCY PLAN: GUIDANCE ON PROCEDURES FOR PLANNING AND IMPLEMENTING OFF-SITE RESPONSE ACTION	MARTIN MARIETTA	5-24-91		
RG	131	AMERICAN NATIONAL STANDARD RADIATION PROTECTION INSTRUMENTATION TEST & CALIBRATION	ANSI	MAY 1978		
PM	62	AMERUM MANAGEMENT & ORGANIZATION SELF-ASSESSMENT	DOE OAK RIDGE	OCT. 91		
GR	31	AN ANALYSIS OF REGULATORY AND TECHNICAL ISSUES AFFECTING THE DESIGN OF THE DISPOSAL CELL AND WASTEWATER TREATMENT OPTIONS AT THE WSSRAP	MKE			
HP	76	AN APPROACH FOR TESTING ATTAINMENT OF SOIL BACKGROUND STANDARDS AT SUPERFUND SITES	NTIS	AUG 90		
GR	40	AN ARCHAEOLOGICAL SURVEY OF THE LITTLE FEMME OSAGE/RIVER HILLS AREA & THE LOUTRE RIVER VALLEY: A MULTIVARIATE APPROACH TO ENVIRONMENT & SITE DISTRIBUTIONS	D. HAAS	1978		
BZ	4	AN INTRODUCTION TO THE BIOLOGICAL SYSTEMS OF THE ST. LOUIS AREA	MO BOTANICAL GARDENS			
GR	100	ANALYSIS & EVALUATION OF PUMPING TEST DATA	G.P. KRUSEMAN	1991		PERM. CHECK OUT TO KLINGMULLER
PM	90	ANALYSIS OF FINDINGS FROM THE FIRST SIXTEEN TIGER TEAM ASSESSMENT	DOE	MAY 1991		
HG	2	ANALYSIS OF POTENTIAL GROUNDWATER CONTAMINATION IN THE VICINITY OF THE WELDON SPRING RAFFINATE PITS SITE (PRELIMINARY DRAFT & FINAL REPORT)	ANL	83/84	14/N/A	
HG	42	ANALYSIS OF WATERS FROM MONITORING & SUPPLY WELLS IN PROXIMITY T O WELDON SPRING MISSOURI FOR	DA	09&10-89		

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		NITROAROMATIC COMPOUNDS				
ZZ	91	ANALYTICAL SUPPORT SERVICES FOR CHEMICAL AND RADIOCHEMICAL ANALYSIS		AUG 89		
ZZ	71	ANNUAL ENVIRONMENTAL MONITORING REPORT 1988	DOE/OR/21548-079	JUNE 89	REV. 0	
ZZ	35	ANNUAL ENVIRONMENTAL MONITORING REPORT, WELDON SPRING, MO CY1987	DOE/OR/21548-015	04-88		ALSO INCLUDED: 1986
ZZ	319	ANNUAL SITE ENVIRONMENTAL REPORT	DOE/OR/21548-193	SEP 91	REV. 1	RESPONSIVENESS SUMMARY INCL.
ZZ	221	ANNUAL SITE ENVIRONMENTAL REPORT 1989	DOE/OR/21548-129	NOV. 90	REV. 1	
ZZ	318	ANNUAL WASTE REDUCTION ACTIVITIES REPORT	DOE/OR/21548-189	MARCH 91	REV. 0	
ZZ	393	ANNUAL WASTE REDUCTION REPORT	DOE/OR/21548-278	MARCH 92	REV. 0	
RG	10	APPLICABILITY OF THE NATIONAL ENVIRONMENTAL POLICY ACT TO REMEDIAL ACTIONS AT ORNL	ORNL	1987	N/A	
RG	94	APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) FOR THE SAND SPRINGS SUPERFUND SITE SOURCE CONTROL OPERABLE UNIT	ERM-SOUTHERN, INC	MAY 10,89		
ZZ	368	APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR DESIGN AND CONSTRUCTION ACTIVITIES AT WELDON SPRING SITE	DOE/OR/21548-254	AUG. 1992	REV. A	
HP	68	APPLICATION OF RADON REDUCTION METHODS	EPA	AUG 88		
WH	36	APPLICATION OF THE OBSERVATIONAL METHOD TO REMEDIATION OF HAZARDOUS WASTE SITES	CHEM HILL	4-89		
HG	61	APPLIED HYDROGEOLOGY SECOND EDITION	C.W. FETTER	1988		PERM. CHECK OUT TO KLINGMULLER
EV	64	APPRAISAL OF THE UNUSUAL OCCURANCE REPORTING SYSTEMS AT THE ADVANCED TEST REACTOR AND THE IDAHO CHEMICAL PROCESSING PLANT	DOE	5-89		
EN	63	APPRAISAL OF WSSRAP ENGINEERING DESIGN ACTIVITIES JANUARY 7-9, 1991	MK-SAN FRANSISCO	FEB 91		FINAL REPORT
PM	81	APPRAISAL PLAN ENVIRONMENTAL, SAFETY AND HEALTH, AND QUALITY ASSURANCE APPRAISAL OF THE WELDON SPRING SITE	DOE OAK RIDGE FIELD OFFICE	MAR2-6,92		
PM	112	APPRAISAL PLAN ENVIRONMENT, SAFETY & HEALTH, AND QUALITY ASSURANCE APPRAISAL OF THE WELDON SPRING SITE	DOE - OAK RIDGE	MAY 1993	DRAFT	
GR	11	AQUA PURA REQUIUM?	BOLLMEIER,M.	12-84	N/A	
HG	59	AQUATIC BIOLOGICAL MONITORING 1992 SUBCONTRACT DOCUMENTS WP305 FINAL DESIGN FOR CONSTRUCTION	MK FERGUSON WELDON SPRING SITE			
ZZ	322	AQUATIC BIOLOGICAL SCREENING INVESTIGATION		APRIL 91	REV. A	(WORK PLAN)
HG	14	AQUIFER ANALYSIS	NAWA	1987	N/A	
ZZ	250	AQUIFER CHARACTERISTICS DATA REPORT FOR THE WELDON SPRING SITE CHEMICAL PLANT/RAFFINATE PITS AND VICINITY PROPERTIES	DOE/OR/21548-122	NOV 90	REV. 0	
KU	16	AQUIFER RESTORATION - STATE OF THE ART	NOYES PUBLICATIONS (NP)	1986		
ZZ	63	ARMY VICINITY PROPERTY NO. 7 POST-REMEDIAL ACTION REPORT	DOE/OR/21548-043	09-88	REV. 0	
ZZ	143	ARMY VICINITY PROPERTY NO. 7 POST-REMEDIAL ACTION REPORT	09-07-88			IRA #4
ZZ	168	ASBESTOS & CHEMICAL CHARACTERIZATION REPORT FOR NON-PROCESS RELATED BUILDINGS & EQUIPMENT	DOE/OR/21548-070	04-90	REV. E	
ZZ	404	ASBESTOS BULK SAMPLING AND AIR SAMPLING RESULTS	PMC	08/86		
ZZ	94	ASBESTOS CONTAINING MATERIALS - BUILDING 409	02-08-88			IRA #10
ZZ	96	ASBESTOS CONTAINING MATERIALS - BUILDING 401	12-24-87			IRA #11
EV	26	ASBESTOS CONTENT OF PIPE INSULATION ON OUTDOOR OVERHEAD UTILITIES AT THE WSCP	MEYER, KIRK, MKF, JEG	02-87	N/A	

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ZZ	81	ASBESTOS CONTENT OF PIPE INSULATION ON OUTDOOR OVERHEAD UTILITIES AT THE WSCP	02-03-87			IRA #6
ZZ	137	ASBESTOS SAMPLING	08-06-87			IRA #6
GR	30	ASBESTOS SAMPLING MANUAL	OSHA	08-86		
ZZ	138	ASBESTOS SAMPLING RESULTS	08-04-87			IRA #6
ZZ	441	ASBESTOS STORAGE AREA OPERATIONS PLAN	DOE/OR/21548-324	JULY 92	REV. 0	
ZZ	372	ASH POND CONTAMINATED SPOIL STAGING AREA DEVELOPMENT PLAN	DOE/OR/21548-258	FEB. 1992	REV. 0	
ZZ	146	ASH POND ISOLATION DIKE CHEMICAL CHARACTERIZATION DATA	04-05-88			IRA #2
ZZ	466	ASH POND OPERATIONAL PLAN	DOE/OR/21548-354	JAN. 1993	REV. 0	
ZZ	108	ASH POND RUBBLE AND SOIL MANAGEMENT PLAN	DOE/OR/21548-222	AUG 91	REV. 1	
ZZ	207	ASSESSMENT OF ASH POND ISOLATION PROJECT EFFECTIVENESS	DOE/OR/21548-109	02/90	REV. 0	
EN	9	ASSESSMENT OF ENGINEERING OPTIONS FOR THE WSQ LOW-LEVEL RADIOACTIVE WASTE DISPOSAL	LBL	09-81	36	
DD	11	ASSESSMENT OF FOREIGN DECOMMISSIONING TECHNOLOGY WITH POTENTIAL APPLICATION TO U.S. DECOMMISSIONING NEEDS	BATTELLE	SEPT 87		
HP	34	ASSESSMENT OF GRAND JUNCTION COVER SYSTEMS: 1987 FIELD MEASUREMENTS	DOE	02-88		
EN	37	ASSESSMENT OF INTERNATIONAL TECHNOLOGIES FOR SUPERFUND APPLICATIONS	EPA	09-88		
LN	7	ASSESSMENT OF SYNTHETIC MEMBRANE SUCCESSES & FAILURES AT WASTE STORAGE & DISPOSAL SITES	US DEPT. OF COMMERCE	08-85	N/A	
GR	35	ASSESSMENT OF THE ASSUMPTION OF NORMALITY (EMPLOYING INDIVIDUAL OBSERVED VALUES)	AMERICAN NATIONAL STANDARDS	10-73		
PM	31	ASSESSMENT OF THE DOE LEADING UNUSUAL OCCURRENCE FOR CY 1983 - 1987	DOE	09-88		
EV	46	ASSESSMENT OF WSCP	DOA	03-76	57	
EV	17	ASSISTANT MANAGER, ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT SELF ASSESSMENT IMPLEMENTATION PLANS	DOE	JUNE 1991		
EV	113	ASTM STANDARDS ON GROUND WATER & VADOSE ZONE INVESTIGATIONS	ASTM	1992		PERM. CHECK OUT TO J. MEIER
RG	82	ATOMIC ENERGY ACT OF 1954	CONGRESS	AUG. 90		
GR	134	AUDIT STANDARDS A COMPARATIVE ANALYSIS	WALTER WILLBORN	1987		PERM. CHECK OUT TO P. CATE
GR	73	AUGUST A. BUSCH MEMORIAL WILDLIFE AREA LAKES 34 AND 35	MODNR	1986		5 DIFF. BOOKS
ZZ	469	AUTOMATED DATA PROCESSING EQUIPMENT STATEMENT OF STRATEGY	DOE/OR/21548-353	DEC. 1992	REV. 1	
GR	3	AUTOMATIC DATA PROCESSING TASK FORCE (ADPTF) REVIEW OF DOE FIELD OFFICE, OAK RIDGE (OR) INTERNAL AUTOMATION STRATEGY	ORO	JUNE 91		
GR	128	AUTOMATIC SPRINKLER SYSTEMS HANDBOOK 5TH EDITION	NFPA	1991		PERM. CHECK OUT TO C. WALTERS
BL	27	AVIFAUNA BASELINE STUDIES AT THE LOS MEDANOS WIPP SITE, SOUTHEASTERN NEW MEXICO	UNIVERSITY OF NEW MEXICO			
GR	183	BABCOCK & WILCOX CYCLONE FURNACE VITRIFICATION TECHNOLOGY APPLICATIONS ANALYSIS REPORT	EPA	AUG. 1992		
GR	34	BARE-PLOT ANALYSIS AS A TOOL FOR DIAGNOSING IMPEDIMENTS TO REVEGETATION AT SURFACE COAL MINES	C. C. REITH AND L. D. POTTER	10-85		
EN	17	BASELINE ASSESSMENT FOR THE CHEMICAL PLANT AREA OF THE WSS	ANL	MAY 91		WORKING DRAFT - DO NOT CITE
ZZ	189	BASELINE ASSESSMENT FOR THE CHEMICAL PLANT AREA	DOE/OR/21548-091	NOV. 1992		

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REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		OF THE WELDON SPRING SITE				
BL	5	BASELINE CHANGE PROPOSAL (BCP 006) SUBJECT: QUARRY RESIDUAL CHARACTERIZATION PHASE I	PMC	OCT. 91	REV. 0	
BL	1	BASELINE CHANGE PROPOSAL (BCP002) SUBJECT: BUSINESS RISK INSURANCE COST INCLUSION		OCT 1991	REV. 1	
BL	2	BASELINE CHANGE PROPOSAL (BCP003) SUBJECT: PENSION/ESOP COST INCLUSION	PMC	OCT. 1991	REV. 1	
BL	3	BASELINE CHANGE PROPOSAL (BCP004) SUBJECT: DATA PROCESSING/ TELECOMMUNICATIONS/ARTEMIS COST INCLUSION	PMC	OCT. 1991	REV. 1	
BL	4	BASELINE CHANGE PROPOSAL (BCP005) SUBJECT: SITE SURVEYING	PMC	OCT. 1991	REV. 1	
BL	6	BASELINE CHANGE PROPOSAL (BCP007) REV. 0 MK-FERGUSON FEE COST ADJUSTMENT	PMC	OCT 91	REV. 0	
BL	7	BASELINE CHANGE PROPOSAL (BCP008) SUBJECT: RAFFINATE PIT STABILIZATION	PMC	OCT 91	REV. 0	
BL	8	BASELINE CHANGE PROPOSAL (BCP009) SUBJECT: RISK AND UNCERTAINTY REVISION	PMC	OCT 91	REV. 0	
ZZ	163	BASELINE RISK EVALUATION FOR EXPOSURE TO BULK WASTES AT THE WELDON SPRING QUARRY, WELDON SPRING, MO	DOE/OR/21548-065	01-90	REV. 0	ANL (DRAFT)
HP	30	BASIC PRINCIPLES FOR OCCUPATIONAL RADIATION MONITORING	INTERN'L ATOMIC ENERGY AGENCY	1987		
GR	90	BASIC RADIATION TECHNOLOGY 2ND EDITION	PACIFIC RADIATION CORP	04/91	2ND EDIT	
ZZ	440	BATCH LEACH TEST SAMPLING PLAN	DOE/OR/21548-326	JULY 92	REV. 0	
BL	12	BCP 011 BASELINE CHANGE PROPOSAL SUBJECT: PARALLEL CSS/VIT SITE CONCEPTUAL DESIGN REPORT	PMC	APRIL 92	REV. 0	
BL	15	BCP 016 BASELINE CHANGE PROPOSAL SUBJECT: PMC WELL FIELD CONTINGENCY PLAN	PMC	JUNE 92	REV. 0	
BL	17	BCP 018 BASELINE CHANGE PROPOSAL SUBJECT: MKES PI BASELINE ERROR CORRECTION	PMC	JUNE 92	REV. 0	
BL	16	BCP 023 BASELINE CHANGE PROPOSAL SUBJECT: SITE WATER TREATMENT PLANT EFFLUENT PIPELINE	PMC	JUNE 92	REV. 0	
BL	21	BCP 059A BASELINE CHANGE PROPOSAL SUBJECT: WORK PACKAGE Z35 ADMINISTRATION BUILDING ANNEX	PMC	SEPT 1992	REV. 0	
BL	11	BCP010 BASELINE CHANGE PROPOSAL SUBJECT: U.S.G.S. WELLFIELD CONTINGENCY ALTERNATIVES AND BACKGROUND WATER QUALITY IN MISSOURI RIVER ALLUVIUM	PMC	JAN. 1992	REV. 0	
BL	13	BCP014 BASELINE CHANGE PROPOSAL SUBJECT: UTILIZATION OF CLAYMAX	MKFW	APRIL 92	REV. 0	
BL	19	BCP022 BASELINE CHANGE PROPOSAL SUBJECT: PROJECT INTEGRATION STAFFING & RECORD OF DECISION DELAY PROPOSAL	PMC	AUG 1992	REV. 0	
BL	18	BCP024 - BASELINE CHANGE PROPOSAL SUBJECT: CHEMICAL PLANT BLDG. DISMANTLING	PMC	JUNE 92	REV. 0	
BL	23	BCP055 BASELINE CHAGE PROPOSAL SUBJECT: OTHER PARTICIPANTS & ROD SLIP IMPACTS	PMC	OCT. 1992	REV. 0	
BL	26	BCP056 BASELINE CHANGE PROPOSAL SUBJECT: NON ROD SLIP WORK PACKAGES	PMC	DEC. 1992	REV. 1	
BL	25	BCP057 BASELINE CHANGE PROPOSAL SUBJECT: CONTINGENCY AND RISK AND UNCERTAINTY	PMC	NOV. 1992	REV. 0	
BL	24	BCP51 ABBREVIATED BASELINE CHANGE PROPOSAL SUBJECT: CATEGORY "A" DESIGN WORK PACKAGE 100% ENGINEERING/PMB UPDATE	PMC	OCT. 1992	REV. 0	
BL	20	BCP59A BASELINE CHANGE PROPOSAL SUBJECT: WORK	PMC	SEPT 1992	REV. 0	

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		PACKAGE 235 ADMINISTRATION BUILDING ANNEX				
BL	22	BCP61 ABBREVIATED BASELINE CHANGE PROPOSAL SUBJECT: BUILDING #409 SLAB REMOVAL & PARKING LOT	PMC	SEPT 1992	REV. 0	
GR	228	BEST VALUE PROCUREMENT	FEDERAL PUBLICATIONS INC.	JUN. 1993		PERM. CHECK OUT TO M. LEWIS
BG	1	BIBLIOGRAPHIC CITATIONS PERTINENT TO THE WSS	ORNL	08-85	91	
GR	17	BILATERAL EXCHANGE INFORMATION FROM THE FEDERAL REPUBLIC OF GERMANY (FRG)	DOE	12-86	N/A	
GR	97	BIODEGRADATION OF HAZARDOUS WASTE USING WHITE ROT FUNGUS: PROJECT PLANNING AND CONCEPT DEVELOPMENT DOCUMENT	PACIFIC NORTHWEST LABORATORY	NOV. 1990		
ZZ	443	BLDG. REMOVAL PACKAGE 2; OPERATIONAL READINESS REVIEW PLAN	DOE/OR/21548-327	AUG. 1992	REV. 0	
KU	30	BOOK OF LISTS FOR REGULATED HAZARDOUS SUBSTANCES	GOVT. INSTITUTES, INC.	1993		PERM. CHECK OUT TO T. UHLMEYER
HG	63	BOREHOLE GEOPHYSICS APPLIED TO GROUNDWATER INVESTIGATIONS	W. SCOTT KEYS	1989		PERM. CHECK OUT TO KLINGMULLER
LN	9	BOTTOM LINER PERFORMANCE IN DOUBLE-LINED LANDFILLS & SURFACE IMPOUNDMENTS	EPA	04-87		
YY	72	BRIEFING MATERIAL RE: WATER TREATMENT EE/CA FOR 01-05 & 06-89 MEETINGS WITH LOCAL OFFICIALS IN ST. LOUIS/ST. CHARLES COUNTIES	01-89	01-89		
ZZ	165	BUILDING 401 DISMANTLEMENT INTERIM RESPONSE ACTION, WP058, JOB SAFETY ANALYSIS	DOE/OR/21548-067	04-89	REV. 0	IRA #11
ZZ	215	BUILDING 434 CLOSURE PLAN	DOE/OR/21548-117	MAY 90	REV. 0	
ZZ	235	BUILDING 434 MODIFICATION OF EXISTING SCOPE OF WORK	MK-F	11-89		
ZZ	463	BUILDING DEMOLITION WASTE ANALYSIS PLAN	DOE/OR/21548-345	OCT. 1992	REV. 0	
ZZ	344	BUILDING REMOVAL METHODS POLICY FOR CHEMICAL PLANT STRUCTURES		APRIL 91	REV. B	
ZZ	413	BUILDING REMOVAL PACKAGE 1 OPERATION READINESS REVIEW PLAN	DOE/OR/21548-298	JUNE 1992	REV. 0	
ZZ	41	BUILDINGS CHARACTERIZATION SAMPLING PLAN WITH APPENDIX	DOE/OR/21548-021	04-88	REV. 0	
ZZ	312	BUILDINGS CHARACTERIZATION WORK PLAN	DOE/OR/21548-185	APRIL 91	REV. 0	
ZZ	218	BUILDINGS RADIOLOGICAL CHARACTERIZATION REPORT	DOE/OR/21548-120	4/90	REV. 0	
DD	7	CANONSBURG, URANIUM MILL TAILINGS SITE, REMEDIAL ACTION COMPLETION REPORT	MK-F	10-86		
GR	221	CAPABILITIES	KEVRIC CO.	APR. 1993		
GR	93	CASCADE IMPACTOR SAMPLING & DATA ANALYSIS	AM. INDUSTRIAL HYGIENE ASSOC.	1986		
WM	39	CATALOG OF CERCLA APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) - FACT STEETS	DOE	JULY 90		
GR	4	CATALOGUE OF ON-SITE FILES AT WSCP OXIDES TO MASSIVE URANIUM METALS	RETA	06-77	83	
EN	48	CDR FOR FACILITIES CAPABILITY ASSURANCE PROGRAM	MARTIN MARIETTA	11-88		
EN	46	CDR FOR IMPROVE POWER SUPPLY / DISTRIBUTION SYSTEM PHASE II	MARTIN MARIETTA	11-88		
EN	42	CDR PROCESS INVENTORY CONTROL SYSTEM	MARTIN MARIETTA	6-86		
ZZ	422	CDR - SECOND DELIVERABLE COMPARISON PROTOCOLS AND SELECTION METHODOLOGY FOR ALTERNATIVE COVERS, PERIMETER ENCAPSULATION SYSTEMS AND TOP COMPONENTS FOR CSS AND VIT CELLS	PMC	JULY 1992	REV. B	
RG	11	CERCLA AS AMENDED BY SARA	USC	1986	N/A	
RG	41	CERCLA COMPLAINCE/ENFORCEMENT GUIDANCE MANUAL POLICY COMPENDIUM	EPA	11-85		

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RG	73	CERCLA COMPLIANCE WITH OTHER LAWS MANUAL: DRAFT GUIDANCE	EPA	08-88		
RG	86	CERCLA COMPLIANCE WITH OTHER LAWS MANUAL: PART II. CLEAN AIR ACT AND OTHER ENVIRONMENTAL STATUTES AND STATE REQUIREMENTS	EPA	AUG 89		
RG	126	CERCLA COMPLIANCE WITH OTHER LAWS MANUAL	EPA	AUG. 1988	DRAFT	PERM. CHECK OUT TO J. BOGNAR
ZZ	83	CHANGES TO THE PLAN FOR RADIOLOGICAL SURVEY & RELEASE METHODS FOR THE POWER POLE REMOVAL PROJECT	01-13-88			IRA #8
EN	12	CHARACTERIZATION & ASSESSMENT & ANALYSIS OF PROPOSED ENGINEERING OPTIONS FOR THE WSQ LOW-LEVEL RADIOACTIVE WASTE DISPOSAL SITE - VOL. I	BGA	12-83	20	
EN	13	CHARACTERIZATION & ASSESSMENT & ANALYSIS OF PROPOSED ENGINEERING OPTIONS FOR THE WSQ LOW-LEVEL RADIOACTIVE WASTE DISPOSAL SITE - VOL. II	BGA	12-83	21	
PM	6	CHARACTERIZATION & ASSESSMENT FOR THE WSQ LOW-LEVEL RADIOACTIVE WASTE STORAGE SITE	BGA	09-84	12	
ZZ	158	CHARACTERIZAT'ON OF CHEMICAL & RADIOLOGICAL CONTAMINATION IN LAKE & STREAM SEDIMENTS ON PROPERTIES SURROUNDING THE WELDON SPRING SITE	DOE/OR/21548-060	08-89	REV. 0	
HG	55	CHARACTERIZATION OF THE HANFORD SITE AND ENVIRONS	BATTELLE	03-91		
EN	35	CHARACTERIZATION PLAN FOR WSCP	BNI	06-86		
ZZ	49	CHARACTERIZATION REPORT FOR IRA #3 MATERIAL STAGING AREA	DOE/OR/21548-029	11-87	REV. 0	
ZZ	48	CHARACTERIZATION REPORT FOR THE ASH POND ISOLATION DIKE IRA	DOE/OR/21548-028	09-87	REV. 0	IRA #2
ZZ	44	CHARACTERIZATION REPORT IRA #13 ARMY RESERVE PROPERTY VICINITY PROPERTY NO. 2	DOE/OR/21548-024	09-87	REV. 0	IRA #13
ZZ	45	CHARACTERIZATION REPORT IRA #13 ARMY RESERVE PROPERTY VICINITY PROPERTY NO. 3	DOE/OR/21548-025	09-87	REV. 0	IRA #13
ZZ	42	CHARACTERIZATION REPORT IRA #5 A. A. BUSCH & WELDON SPRING WILDLIFE AREA LOCATIONS 3, 4, 5, & 8	DOE/OR/21548-022	05-88	REV. 0	IRA #5
GR	215	CHARACTERIZING HETEROGENEOUS WASTE: METHODS & RECOMMENDATIONS (MARCH 26-28, 1991)	NTIS	FEB. 1992		PERM. CHECK OUT TO D. HIXSON
RP	3	CHEMICAL ANALYSIS OF PONDS 3 & 4 AT WELDON SPRING W/ADDENDUM	ORNL	12/79-	41	
ZZ	46	CHEMICAL CHARACTERIZATION IRA #13 ARMY RESERVE PROPERTY VICINITY PROPERTY NOS. 1, 2, 3, & 7	DOE/OR/21548-026	12-87	REV. 0	IRA #13
EN	16	CHEMICAL CHARACTERIZATION REPORT FOR THE WELDON SPRING QUARRY	BNI	08-87	N/A	DE-AC05-810R20722
EV	31	CHEMICAL CHARACTERIZATION REPORT FOR THE WELDON SPRING QUARRY	BNI	08-87	N/A	
WM	58	CHEMICAL FIXATION AND SOLIDIFICATION OF HAZARDOUS WASTES	CONNER, J	1990		
GR	194	CHEMICAL PLANT ADMINISTRATIVE RECORD INDEX	PMC	DEC. 1992		
ZZ	22	CHEMICAL PLANT CONCEPTUAL DESIGN REPORT	DOE/OR/21548-002	03-89	REV. A	
GR	126	CHEMICAL PLANT SITE ENTRANCE IMPROVEMENTS CONCEPTUAL ANALYSIS OF ENTRANCE REPORT	ZAMBRANA CONSULTANTS	4/10/92	DRAFT	
ZZ	370	CHEMICAL PLANT SITE REMEDIAL INVESTIGATION/FEASIBILITY STUDY DATA VALIDATION REPORT	DOE/OR/21548-256	FEB. 1992	REV. 0	
ZZ	303	CHEMICAL PLANT SITE RI/FS DATA VALIDATION REPORT		JAN 91	REV. A	
ZZ	33	CHEMICAL SOIL INVESTIGATION PLAN FOR THE WELDON SPRING CHEMICAL PLANT/RAFFINATE PITS	DOE/OR/21548-013	05-88	REV. 1	
ZZ	159	CHEMICAL SOIL INVESTIGATION REPORT FOR THE WELDON SPRING CHEMICAL PLANT/RAFFINATE PITS - PHASE II	DOE/OR/21548-061	08-89	REV. 0	

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GR	9	CHRONOLOGICAL LISTING OF SIGNIFICANT EVENTS AT WSCP	MO. DEPT. OF CONSERVATION	6/84	70	
HG	45	CHRONOLOGY OF USAEHA INVOLVEMENT IN WELDON SPRINGS GROUDWATER EXPLOSIVES MONITORING		12-4-89		PREPARED FOR USATHAMA BRIEFING
BZ	10	CLASSIFICATION OF WETLANDS & DEEPWATER HABITATS OF THE UNITED STATES	U.S. DEPT. OF COMMERCE	DEC. 1979		PERM. CHECK OUT TO J. HERRON
RG	13	CLEAN AIR ACT	USC	07-81	N/A	
RG	115	CLEAN AIR ACT HANDBOOK - A PRACTICAL GUIDE TO COMPLIANCE	CLARK BOARDMAN CO.	1991		PERM. CHECKOUT TO DOUG STEFFEN
WM	8	CLEANUP PROCEDURES AT THE NEVADA TEST SITE AND AT OTHER RADIOACTIVE CONTAMINATED SITES INCLUDING REPRESENTATIVE COSTS OF CLEANUP AND TREATMENT OF CONTAMINATED AREAS	ORNL	09-87		
GR	187	CLIPPER PROGRAMMING	OLIVER & SHELDON	1992		PERM CHECK OUT TO M. SHAWKEY
ZZ	167	CLOSURE PLAN - DRUM STORAGE AREA	DOE/OR/21548-069	03-89	REV. 0	
WM	11	CODISPOSAL OF DIMINIMUS LEVELS OF LOW-LEVEL RADIOACTIVE WASTE AND SANITARY WASTE	GEORGIA INSTITUTE OF TECH.	02-86		
GR	2	COMBINED PUBLICATIONS	MCW			SEE GR-9001 THRU GR-9007
EN	57	COMMENT RESOLUTION: RESPONSES TO REVIEW COMMENTS ON THE EE/CA FOR THE PROPOESED MANAGEMENT OF CONTAMINATED WATER IN THE WELDON SPRING RAFFINATE PITS				WORKING DRAFT DATED FEB. 1990
CM	11	COMMENTS WELDON SPRING DEIS SECTION A: LETTERS	ANL	03-88		
CM	12	COMMENTS AND RESPONSES WELDON SPRING DEIS SECTIONS B AND C	ANL	03-88		
YY	63	COMMENTS OF NANCY BECKER, EASTERN DIST. COMMISSIONER, ST. CHARLES COUNTY COMMISSION, 12-06-88 PUBLIC MEETING	12-08-88	12-08-88		
HG	15	COMMENTS ON PROPOSED EPA TITLE I GROUND WATER PROTECTION STANDARDS	PROVIDED BY DOE	09/24/87		
ZZ	112	COMMUNITY RELATIONS CRISIS PLAN	DOE/OR/21548-225	SEPT 91	REV. A	NOT YET RECEIVED
ZZ	486	COMMUNITY RELATIONS DEPARTMENT PLAN	DOE/OR/21548-367	JAN. 1993	REV. 0	
PM	102	COMMUNITY RELATIONS IN SUPERFUND: A HANDBOOK	EPA	JAN. 1992		
ZZ	29	COMMUNITY RELATIONS PLAN	DOE/OR/21548-009	SEPT 1992	REV. 6	
SE	1	COMMUNITY RELATIONS PLAN-WSS	DOE	06-85	95	
HP	27	COMPARISON OF RADON & RADON-DAUGHTER GRAB SAMPLES OBTAINE DURING THE WINTER & SUMMER	DOE	08-87		
EV	60	COMPARISON OF SURFACE METEOROLOGICAL DATA REPRESENTATIVES FOR WELDON SPRING TRANSPORT AND DISPERSION MODELING ANALYSIS	ANL	JUNE 89		
GR	62	COMPARISON OF SURFACE METEOROLOGICAL DATA REPRESENTATIVENESS FOR THE WELDON SPRING TRANSPORT AND DISPERSION MODELING ANALYSIS	ANL	6-89		
WM	6	COMPARISON OF THREE WASTE LEACHING TESTS	EPA	07-79		
RG	77	COMPENDIUM OF CERCLA RESPONSE SELECTION GUIDANCE DOCUMENTS- USERS MANUAL	EPA	MAY 1989		
RG	74	COMPENDIUM OF MAJOR U.S. RADIATION PROTECTION STANDARDS & GUIDES: LEGAL & TECHNICAL FACTS	ORAU	89?		
PM	116	COMPENDIUM OF SUPERFUND PROGRAM PUBLICATIONS	EPA	NOV. 1991		PERM. CHECK OUT TO W. ANDERSON
HG	9	COMPILATION & PRELIMINARY INTERPRETATION OF HYDROLOGIC DATA FOR THE WELDON SPRING RADIOACTIVE WASTE DISPOSAL SITES - A PROGRESS REPORT	USGS/DOI	1986	N/A	
EV	96	COMPILATION OF AIR POLLUTANT EMISSION FACTORS VOL.	EPA	SEPT 85		PERM. CHECK OUT TO

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		1: STATIONARY POINT & AREA SOURCES (SUPPLIMENT A,B,C,D)				T. FRENCH
EV	107	COMPILATION OF EPA'S SAMPLING & ANALYSIS METHODS	LAWRENCE H. KEITH	1992		PERM. CHECK OUT TO L. PHILLIPS
ZZ	151	COMPLETED CHAIN-OF-CUSTODY FORMS				ADMIN FILE (EF)
ZZ	232	COMPLIANCE ASSESSMENT RELATIVE TO NON-FEDERALLY PERMITTED RELEASES OF NONRADIOACTIVE CERCLA HAZARDOUS SUBSTANCES AT THE WELDON SPRING SITE	PMC			
ZZ	447	COMPLIANCE DEPARTMENT PLAN	DOE/OR/21548-331	MAR. 1993	REV. 1	
ZZ	461	COMPLIANCE DEPARTMENT TRAINING PLAN	DOE/OR/21548-356	NOV. 1992	REV. 0	
ZZ	476	COMPLIANCE SURVEILLANCE PLAN	DOE/OR/21548-347	FEB. 1993	REV. 0	
GR	207	COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, & LIABILITY ACT	ORNL	JAN. 1993	REV. 12	
ZZ	364	CONCENTRATION RATIOS OF RADIONUCLIDES IN THE U-238, U-235, AND TH-232 DECAY SERIES	DOE/OR/21548-250	SEPT 1992	REV. 0	
GR	166	CONCEPT FOR DEVELOPING, DESCRIBING, ANALYZING AND IMPLEMENTING ENVIRONMENTAL RESTORATION (ER) ALTERNATIVES	U.S. DOE	AUG. 1992	DRAFT	
ZZ	268	CONCEPTUAL DESIGN REPORT ON THE QUARRY BULK WASTE MANAGEMENT PROGRAM TECHNICAL INFORMATION	DOE/OR/21548-145	APRIL 91	REV. 0	VOL. I(APRIL) AND VOL. II(FEB)
ZZ	295	CONCEPTUAL DESIGN SUPPORTING STUDIES WORK PLAN	DOE/OR/21548-182	MARCH 91	REV. 0	
ZZ	511	CONCEPTUAL SITE TREATMENT PLAN FOR THE WELDON SPRING SITE	DOE/OR/21548-417	AUG. 1993	REV. A	
ZZ	468	CONDUCT OF OPERATIONS MANUAL	DOE/OR/21548-357	OCT. 1992	REV. C	
CM	2	CONFERENCE NOTES #CN-147, REV. 1, TRANSITION PLANNING FOR TURNOVER TO THE WSCP BY THE DOA TO THE DOE	BNI	07-85	75	
CM	3	CONFERENCE NOTES #CN-148, TRANSITION PLANNING FOR TURNOVER OF THE WSCP BY THE DOA TO THE DOE	BNI	07-85	71	
ZZ	442	CONFIGURATION MANAGEMENT DOCUMENT TREE	DOE/OR/21548-325	MAY 92	REV. 0	NOT YET RECEIVED
ZZ	349	CONFIGURATION MANAGEMENT PLAN	DOE/OR/21548-212	NOV. 1991	REV. 3	
ZZ	1	CONFIGURATION MANAGEMENT PLAN (BASELINE & CHANGE CONTROL PLAN)		02-23-87	REV. 0	
GR	75	CONSTRUCTION AND CHARACTERIZATION OF THE TL/TH THORIUM CALIBRATION PADS	UNC GEOTECH	SEPT.1987		RECEIVED OCT. 1987
GR	74	CONSTRUCTION AND TESTING OF A BLOWER-DOOR ASSEMBLY FOR REGULATIO N OF AIR PRESSURE WITHIN STRUCTURES	UNC GEOTECH	SEPT.1987		RECEIVED OCT. 16, 1987
ZZ	228	CONSTRUCTION DATA IRA #5 AND #13 AUGUST A. BUSCH AND WELDON SPRING WILDLIFE AREAS SPECIFICATIONS	MK-F/JEG	8-88		
RG	149	CONSTRUCTION DELAY CLAIMS SECOND EDITION	BRAMBLE & CALLAHAN	1987		PERM. CHECK OUT TO M. LEWIS
PM	57	CONSTRUCTION DIRECT AND INDIRECT COST DEFINITIONS AND PROJECT MANAGEMENT, CONSTRUCTION MANAGEMENT, PROJECT SUPPORT COST DEFINITIONS		MAY 30 90		
RG	148	CONSTRUCTION INDUSTRY INSURANCE HANDBOOK	DEUTSCH, KERRIGAN & STILES	1991		PERM. CHECK OUT TO M. LEWIS
GR	231	CONSTRUCTION LOST-TIME INJURIES: THE U.S. ARMY CORPS OF ENGINEERS DATA BASE 1984-1988	U.S. DEPT. OF LABOR	DEC. 1992		
CM	22	CONSTRUCTION QA FOR HAZARDOUS WASTE LAND DISPOSAL FACILITIES (PUBLIC COMMENT DRAFT)	EPA	10-85		
ZZ	70	CONSTRUCTION SAFETY & HEALTH MANAGEMENT PROGRAM	DOE/OR/21548-050	04-87	REV. 0	
GR	139	CONSTRUCTION SCHEDULING: PREPARATION, LIABILITY, AND CLAIMS	JOHN WILEY & SONS	1991		PERM. CHECKOUT TO MARK LEWIS
GR	178	CONSTRUCTION SCHEDULING: PREPARATION, LIABILITY, & CLAIMS	JOHN WILEY & SONS, INC.	1992		
ZZ	144	CONSTRUCTION STAGING AREA CHARACTERIZATION				

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RG	147	CONSTRUCTION SURETY AND BONDING HANDBOOK	GORDON HUNT	1990		PERM. CHECK OUT TO M. LEWIS
ZZ	140	CONTAINERIZED CHEMICAL INVENTORY		06-12-87		IRA #7
HG	75	CONTAMINANT HYDROGEOLOGY	FETTER	1993		PERM. CHECK OUT TO J. PIER
GR	117	CONTAMINATED REMOVAL FROM PUBLIC WATER SYSTEMS	HOUCK	1985		
GR	115	CONTAMINATED SURFACE SOILS IN-PLACE TREATMENT TECHNIQUES	SIMS	1986		PERM. CHECK OUT TO G. SCHMIDT
ZZ	105	CONTAMINATED WATER TREATMENT PLAN	DOE/OR/21548-219	AUG 91	REV. 0	(NOT YET RECEIVED)
GE	7	CONTAMINATION OF GROUND & SURFACE WATERS BY LIQUID WASTES FROM THE WELDON SPRING ORDNANCE WORKS	FISHEL & WILLIAMS	01-44	N/A	
ZZ	504	CONTINUOUS IMPROVEMENT DEPARTMENT PLAN	DOE/OR/21548-394	JUL. 1993	REV. 0	
PM	25	CONTRACT PERFORMANCE MEASUREMENT REPORTING AND BASELINE MANAGEMENT	DOE	06-84		
GR	109	CONTRACTOR PUCHASING SYSTEM REVIEW ANNUAL OBSERVATIONS REPORT AND STATISTICAL SUMMARY FY 1991	U.S. DOE			
PM	104	CONTRACTOR PURCHASING SYSTEM REVIEW	DOE OAK RIDGE	JAN. 1993	REV. 0	
HG	21	CONTROL OF THE SOIL WATER BALANCE BY SAGEBRUSH & THREE PERENNIAL GRASSES IN A COLD-DESERT ENVIRONMENT	J.E. ANDERSON/R. S. NOWAK	09-87		
RG	99	COORDINATION, CLEARANCE AND APPROVAL OF DoD DATA ACQUISITION DOCUMENTS	DEPARTMENT OF DEFENSE			
CH	17	CORE LIBRARY FACILITY MEETING	MDNR	03-03-88		
ZZ	411	CORRECTIVE ACTION PLAN: FUNCTIONAL APPRAISAL 1992	DOE/OR/21548-297	MAY 1992	REV. 0	
ZZ	506	CORRECTIVE ACTION PLAN: FUNCTIONAL APPRAISAL 1993	DOE/OR/21548-414	JUL. 1993	REV. 0	
PM	84	COST & SCHEDULE CONTROL SYSTEMS CRITERIA FOR CONTRACT PERFORMANCE MEASUREMENT IMPLEMENTATION GUIDE	DOE	JAN. 1986		DOE/MA-0203
PM	26	COST AND SCHEDULE CONTROL SYSTEMS CRITERIA FOR CONTRACT PERFORMANCE MEASUREMENT SYSTEMS REVIEW/SURVEILLANCE GUIDE	DOE	06-86		DOE/MA-0229
EN	56	COST ENGINEERING PRIMER	MK			
EN	49	COST ESTIMATE DOCUMENTATION DRAFT ENGINEERING ANALYSIS OF ALTERNATIVES REPORT		12/11/90		
GR	214	COST ESTIMATE FOR EXCAVATION & TRANSPORTATION OF VICINITY PROPERTY SOILS	MK-BOISE	NOV. 1992	REV. 0	
EV	71	COST ESTIMATING HANDBOOK FOR ENVIRONMENTAL RESTORATION	EM-CAT	APRIL 90		
WM	49	COST ESTIMATING RELATIONSHIPS FOR ENVIRONMENTAL CLEANUP PROJECTS AT U.S. DOE FACILITIES	PEI ASSOCIATES, INC	FEB. 90		
PM	120	CRITERIA FOR EVALUATION OF OPERATIONAL EMERGENCY PLANS	U.S. DOE	FEB. 1993		
RG	48	CRITERIA FOR IDENTIFYING AREAS OF VULNERABLE HYDROGEOLOGY UNDER THE RESOURCE CONSERVATION & RECOVERY ACT. GUIDANCE MANUAL FOR HAZARDOUS WASTE LAND TREATMENT, STORAGE & DISPOSAL	EPA	07-86		
RG	71	CRITERIA FOR PREPARATION AND EVALUATION OF RADIOLOGICAL EMERGENCY RESPONSE PLANS AND PREPAREDNESS IN SUPPORT OF NUCLEAR POWER PLANTS	N.R.C.	3-87	REV. 1	FINAL REPORT INCLUDED AT END
ZZ	211	CURRENT AND PLANNED USAGE OF THE ON-SITE LABORATORY AT THE WSSRAP	DOE/OR/21548-113	MARCH 90	REV. 0	
ZZ	421	DAM SAFETY OPERATIONS EMERGENCY PREPAREDNESS PLAN	DOE/OR/21548-306	DEC. 1992	REV. 1	
ZZ	509	DAM SAFETY OPERATIONS MANUAL	DOE/OR/21548-386	JUL. 1993	REV. 0	
GR	230	DANGEROUS GOODS REGULATIONS	INT. AIR	1993		PERM. CHECK OUT TO

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
			TRANSPORTATION ASSOC.			B. CURIA
EN	97	DATA QUALITY OBJECTIVES FOR REMEDIAL RESPONSE ACTIVITIES - EXAMPLE SCENARIO: RI/FS ACTIVITIES AT A SITE WITH CONTAMINATED SOILS & GROUNDWATER	EPA	MAR. 1987		PERM. CHECK OUT TO J. BOGNAR
RG	18	DATA QUALITY OBJECTIVES FOR REMEDIAL RESPONSE ACTIVITIES	EPA	03-87		DEVELOPMENT PROCESS
GR	219	DATA SUMMARY AND COMPARISON TASK 961 WSSRAP/FEMP DATA REVIEW AND COMPARISON	MK-BOISE	MAR. 1993	REV. 0	
ZZ	209	DATA VALIDATION SCOUTING COMMITTEE SUMMARY REPORT	DOE/OR/21548-111	03/90	REV. 0	
ZZ	187	DATA VALIDATION WORK PLAN	DOE/OR/21548-089	06-89	REV. B	
GR	98	DCHSD: A DUAL-CONTINUUM, THREE-DIMENSIONAL, GROUND-WATER FLOW CODE FOR UNSATURATED, FRACTURED, POROUS MEDIA	GRAM, INC/APPLIED PHYSICS, INC	FEB. 1991		PERM. CHECK OUT TO G. VALETT
ZZ	90	DEBRIS CONSOLIDATION	ANL UNDATED			IRA #9 EE/CA
ZZ	410	DECISION MAKING CRITERIA FOR DECONTAMINATION OF DEMOLITION MATERIALS		MAY 1992	REV. A	
DD	21	DECOMMISSIONING HANDBOOK	U.S. DEPT. OF COMMERCE (NTIS)	NOV 80		
GR	65	DECONTAMINATION DEVELOPMENT AND EVALUATION OF PROCESS OPTIONS				
DD	12	DECONTAMINATION REPORT (WSOW HISTORICAL REPORT)	E.S. HANNAN	1944		ORDNANCE DEPARTMENT
DD	25	DECONTAMINATION STUDY REPORT	JACOBS ENGINEERING	NOV. 1992	REV. 0	
KU	18	DECONTAMINATION TECHNIQUES FOR BUILDING, STRUCTURES AND EQUIPMENT	NOYES DATA CORPORATION (NDC)	1987		
DD	24	DECONTAMINATION: DEVELOPMENT & EVALUATION OF PROCESS OPTIONS	JACOBS ENGINEERING	NOV. 1992	REV. 0	
DD	5	DEFENSE DECONTAMINATION AND DECOMMISSIONING (D&D) PROGRAM OVERVIEW	DOE	01/01/88		
EV	62	DEGRADATION OF PINK WATER COMPOUNDS IN SOIL - TNT, RDX, HMX	U.S. ARMY	1/85		FINAL REPORT 1984
CM	6	DEIS COMMENTS RECEIVED BY DOE	VARIOUS	04-87	N/A	
RG	7	DEMINIMUS URANIUM WASTE DISPOSAL CURRENT SITUATION	NRC	10-81	N/A	
DD	20	DEMOLITION AND DECONTAMINATION PROCEDURES FOR EXISTING TNT LINES AT WELDON SPRING, MO.	FRUIN-COLNON CONTRACTING CO.	3-7-55		
WM	30	DENITRIFICATION OF ACID WASTES FROM URANUIM PURIFICATION PROCESSES	ORNL	11-21-75		
GR	169	DEPARTMENT OF ENERGY CALL FOR PRINTING & PUBLISHING THREE-YEAR SITE PLANS	U.S. DOE	AUG. 1992		
WM	26	DEPARTMENT OF ENERGY HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM: AN OVERVIEW	MARTIN MARIETTA ENERGY SYSTEMS			
WM	41	DEPARTMENT OF ENERGY MODEL WASTE MINIMIZATION AND POLLUTION PREVENTION AWARENESS PLAN SUMMARY OF THE DOE-IG REPORT ON DOE WASTE REDUCTION PROGRAMS	MARTIN MARIETTA	NOV 90		INCLUDED: ANALYSIS
RG	106	DEPARTMENT OF ENERGY STANDARD FOR THE PERFORMANCE TESTING OF EXTREMITY DOSIMETRY	DOE	MAY 1991	REV. 4	DRAFT
GE	18	DERIVATION OF SITE-SPECIFIC SOIL GUIDELINES FOR WELDON SPRING VICINITY PROPERTIES, U.S. ARMY RESERVE PROPERTY (DRAFT)	ANL	01-86		
HP	24	DERIVATION OF SOIL GUIDELINES FOR WELDON SPRING VICINITY PROPERTIES	ANL	01-86	N/A	
EN	45	DESIGN CRITERIA FOR A-E PACKAGE REPLACE WOODEN BUILDINGS FACILITIES CAPABILITY ASSURANCE PROGRAM	MARTIN MARIETTA	6-87		
EN	14	DESIGN CRITERIA FOR FUSRAP & SFMP, REV. 1	DOE/ORO	02-86	N/A	
ZZ	297	DESIGN CRITERIA FOR MISSOURI STATE HIGHWAY 94 AND WELDON SPRING CHEMICAL PLANT SITE ENTRANCE	DOE/OR/21548-238	SEPT 91	REV. 0	

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		IMPROVEMENTS				
EN	88	DESIGN CRITERIA FOR MODULAR OFFICES	DOE/ORO	JULY 92	REV. A	
ZZ	13	DESIGN CRITERIA MANUAL FOR DISPOSAL CELL CONCEPTUAL DESIGN		JULY 1989	DRAFT	
ZZ	415	DESIGN CRITERIA TBP TANK COVERS	DOE/OR/21548-300	JUNE 1992	REV. 0	
ZZ	420	DESIGN CRITERIAL FOR THE SITE WATER TREATMENT PLANT EFFLUENT PIPELINE	DOE/OR/21548-305	JUNE 1992	REV. 0	
GR	195	DESIGN DEVELOPMENT STRATEGIES FOR PERFORMANCE - ORIENTED PACKAGINGS	WESTINGHOUSE HANFORD CO.	JUNE 1992		
RP	1	DESIGN MEMORANDUM FOR 12M CUBIC FOOT RAFFINATE PIT-AEC PLANT WELDON SPRING	MCW	01-64	61	
EN	21	DESIGNING VEGETATION COVERS FOR LONG-TERM STABILIZATION OF URANIUM MILL TAILINGS	NRC	03-84		
HP	6	DETAILED WALK-THROUGH HEALTH & SAFETY SURVEY OF WSCP/HEALTH & SAFETY REPORT #2	RETA	07-77	79	
HP	39	DETECTING BURIED RADIUM CONTAMINATION USING SOIL-GAS & SURFACE- FLUX RADON MEASUREMENTS	UNC	06-88		
EN	18	DETERMINATION OF MAXIMUM EARTHQUAKE FOR WELDON SPRING DISPOSAL FACILITY	JACOBS ENGINEERING GROUP	1987		
GR	198	DETERMINATION OF MAXIMUM EARTHQUAKE FOR WELDON SPRING DISPOSAL FACILITY	JACOBS ENGINEERING	NOV. 1992	REV. 0	
HG	49	DETERMINING SOIL RESPONSE ACTION LEVELS BASED ON POTENTIAL CONTAMINANT MIGRATION TO GROUND WATER: A COMPENDIUM OF EXAMPLES	USEPA	10-89		
DD	10	DEVELOPMENT OF NOVEL DECONTAMINATION TECHNIQUES FOR CHEMICAL AGENTS (GB, VX, HD) CONTAMINATED FACILITIES - PHASE I IDENTIFICATION & EVALUATION OF NOVEL DECONTAMINATION CONCEPTS	DOA	02-83		
RG	150	DIFFERING SITE CONDITION CLAIMS	CUSHMAN & TORTORELLO	1992		PERM. CHECK OUT TO M. LEWIS
EV	40	DIRECTORY OF ENVIRONMENTAL INFORMATION SOURCES	GOVERNMENTS INSTITUTES, INC.	08-88		
KU	5	DIRECTORY OF TESTING LABORATORIES	ASTM	1988		
HP	79	DISCOVER AIHA'S PUBLICATIONS IN OCCUPATIONAL AND ENVIRONMENTAL HEALTH AND SAFETY	AM. INDUSTRIAL HYGIENE ASSOC	1991		
ZZ	166	DISMANTLEMENT OF BUILDING 409 INTERIM RESPONSE ACTION, WP022, JOB SAFETY ANALYSIS	DOE/OR/21548-068	04-89	REV. 0	IRA #10
ZZ	101	DISMANTLING OF BUILDING 401				IRA #11 EE/CA
ZZ	95	DISMANTLING OF BUILDING 409	ANL UNDATED			IRA #10 EE/CA
ZZ	4	DISPOSAL FACILITY CONCEPTUAL DESIGN REPORT		04-01-87	REV. 0	
ZZ	231	DISPOSAL FACILITY ENGINEERING REPORT	MK-F/JEG	9-89	REV. A	
ZZ	451	DISPOSAL FACILITY SITING DEMONSTRATION PROPOSAL	DOE/OR/21548-335	MAY 1991	REV. A	
ZZ	323	DISPOSAL FACILITY SITING STUDY REPORT	MKES DOC. #5121-772-0	APRIL 91	REV. 0	
ZZ	25	DISPOSAL FACILITY SITING WORK PLAN	DOE/OR/21548-005	11-87	DRAFT	
EV	53	DISPOSAL OF HANFORD DEFENSE HIGH-LEVEL, TRANSURANIC AND TANK WASTES	DOE	12/87		FINAL EIS
EV	21	DOA ENVIRONMENTAL MONITORING REPORTS	DOA	77-85	92	
HP	35	DOCUMENTATION ON CURRENTLY OPERATING LOW-LEVEL RADIOACTIVE WASTE TREATMENT SYSTEMS	DOE	11-87		
YY	70	DOE ANNOUNCEMENT IN ST. CHARLES JOURNAL RE: AVAILABILITY OF ADMINISTRATIVE RECORD	02-15-89	02-15-89		
YY	71	DOE ANNOUNCEMENT IN ST. CHARLES JOURNAL RE: AVAILABILITY OF ADMINISTRATIVE RECORD	02-19-89	02-19-89		
YY	69	DOE ANNOUNCEMENT IN ST. CHARLES POST RE: AVAILABILITY OF ADMINISTRATIVE RECORD	02-15-89	02-15-89		

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ZZ	458	DOE CONTINGENCY BASELINE	DOE/OR/21548-342	SEPT 1992	REV. 0	(NOT YET RECEIVED)
ZZ	408	DOE DIRECTIVES	DOE/OR/21548-295	JUNE 1991	REV. A	FILE IN BL-020
GR	104	DOE FIRE PROTECTION RESOURCE MANUAL: DOE "MODEL" FIRE PROTECTION PROGRAM NUCLEAR FIRE SAFETY CRITERIAL JUNE, 1991 DRAFT SUMMARY OF FIRE PROTECTION PROGRAMS OF US DOE CY 88 AND 89STANDARD ON FIRE PROTECTION FOR PORTABLE STRUCTURES AUG 79	DOE			
PM	65	DOE LDR STRATEGY REPORT FOR RMW	DOE	SEPT 89		
CM	24	DOE MODEL CONFERENCE PROCEEDINGS - VOLS. 1 THRU 5	DOE	10/03-88		
PM	114	DOE PERFORMANCE INDICATORS GUIDANCE DOCUMENT	DOE	DEC. 1992		
PM	119	DOE REAL PROPERTY A YEARLY STATISTICAL HANDBOOK FISCAL YEAR 1992	U.S. DOE			
GR	24	DOE REMEDIAL ACTION ACTIVITIES IN MISSOURI	DOE/ORO	03-86	N/A	
YY	64	DOE RESPONSE TO N. BECKER, ESTERN DIST. COMMISSIONER, ST. CHARLES COUNTY COMMISSION	02-09-88	02-09-88		
DD	6	DOE SCRAP METAL RECOVERY DEMONSTRATION PROJECT PHASE I REPORT VOLUME 1	BABCOCK & WILCOX	7-30-87		
RG	120	DR/2000 SPECTROPHOTOMETER PROCEDURES MANUAL	HACH CO.	1988		
GR	103	DRAFT BASELINE RISK ASSESSMENT WELDON SPRING ORDNANCE WORKS, WELDON SPRING MISSOURI	INTERNATIONAL TECHNOLOGY CORP.	DEC 11,91		
GR	107	DRAFT COMMUNITY RELATIONS PLAN WELDON SPRING ORDINANCE WORKS WELDON SPRING, MISSOURI	IT CORPORATION	DEC 1991		
GR	95	DRAFT CONCEPTUAL PROGRAM PLAN FOR THE WELDON SPRING ORDNANCE WORKS WELDON SPRING, MO	ITC	NOV. 1991		
GR	55	DRAFT CONTINGENCY PLAN FOR FRANCES HOWELL SENIOR HIGH SCHOOL FOR POTENTIAL EMERGENCY RESPONSE ACTIVITIES ARISING FROM THE WELDON SPRING SITE REMEDIAL ACTION PROJECT				
ZZ	243	DRAFT CSCSC COMPLIANCE REPORT	MK-F	5-89		
ZZ	257	DRAFT DEBRIS CONSOLIDATION PHASE I, RAILROAD TRACK REMOVAL PHASE I HEALTH AND SAFETY PLAN	DOE/OR/21548-137	8-90		(NOT YET RECEIVED)
EV	16	DRAFT ENVIRONMENTAL AUDIT OF THE WSSRAP	DOE	APRIL 91		
EV	23	DRAFT ENVIRONMENTAL IMPACT STATEMENT	DOE	02-87		INCLUDED: DRAFT 7-86
GR	220	DRAFT FEASIBILITY STUDY WELDON SPRING ORDNANCE WORKS	IT-CORP	APR. 1993		
ZZ	307	DRAFT FEDERAL FACILITY AGREEMENT IMPLEMENTATION PLAN	DOE/OR/21548-351	JULY 92	REV. 1A	
GR	88	DRAFT GOSIP TRANSITION STRATEGY	DOE	11-19-90		(GW-ST-008)
PM	47	DRAFT GUIDELINES FOR THE CONDUCT OF OPERATIONS AT DOE FACILITIES	DEPARTMENT OF ENERGY	01/90		
LN	12	DRAFT MINIMUM TECHNOLOGY GUIDANCE ON DOUBLE LINER SYSTEMS FOR LANDFILLS AND SURFACE IMPOUNDMENTS--DESIGN, CONSTRUCTION, AND OPERATION		APRIL 87		
ZZ	301	DRAFT ON-SITE DISPOSAL STUDY	DOE/OR/21548-173	JAN 91	REV. A	
PM	42	DRAFT REMEDIAL INVESTIGATION WELDON SPRING ORDNANCE WORKS	IT CORPORATION	AUG 91		
EV	57	DRAFT RESPONSIVENESS SUMMARY FOR THE QUARRY RI REPORT		03/16/90		
ZZ	255	DRAFT RESPONSIVENESS SUMMARY FOR THE REMEDIAL INVESTIGATION/ FEASIBILITY STUDY FOR MANAGEMENT OF BULK WASTES AT WELDON SPRING QUARRY, WELDON SPRING, MO	DOE/OR/21548-135	6-90		ANL (FILED IN WM-035)
GR	81	DRAFT ROADMAP METHODOLOGY DOCUMENT	DOE	03-25-91		INCL: 10-01-90
GR	138	DRAFT TECHNICAL MEMORANDUM #1 DEVELOPMENT OF REMEDIAL ALTERNATIVES WELDON SPRING ORDNANCE WORKS	IT CORP	JUNE 92		

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GR	85	DRAFT U.S. GOSIP TRANSITION PLAN	DOE (GW-PN-005) D/C SHELF	11-19-90		INCLUDED:5-4-90,7-31 -90 - FILE
ZZ	358	DRAFT WORK PLAN FOR THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY - ENVIRONMENTAL ASSESSMENT FOR THE QUARRY RESIDUALS OPERABLE UNIT AT THE WELDON SPRING SITE	DOE/OR/21548-243	JUN 1993		
KU	29	DRILL OR EXERCISE CONTROLLER MANUAL	U.S. DOE			
KU	32	DRILL OR EXERCISE EVALUATOR MANUAL	DOE			
RG	93	DRINKING WATER REGULATIONS UNDER THE SAFE DRINKING WATER ACT	EPA	DEC 1990		
HP	82	DRUM HANDLING MANUAL FOR HAZARDOUS WASTE SITES	NDC	1987		PERM CHECK OUT TO M. NELSON
GR	64	DRYING (MECHANICAL & THERMAL) DEVELOPMENT AND EVALUATION OF PROCESS OPTIONS				
HG	34	DYE TRACING TECHNIQUES USED TO DETERMINE GROUND WATER FLOW IN A CARBONATE AQUIFER SYSTEM NEAR ELIZABETHTOWN, KY	DOI	1988		
RG	104	ECOLOGICAL ASSESSMENT OF HAZARDOUS WASTE SITES: A FIELD & LABORATORY REFERENCE	EPA	MARCH 89		
ZZ	365	ECOLOGICAL CHARACTERIZATION SAMPLING PLAN FOR QUARRY RESIDUAL AREA	DOE/OR/21548-251	NOV 91	REV A	
ZZ	3	ECOLOGICAL EVALUATION FOR THE SITE WATER TREATMENT PLANT EFFLUENT PIPELINE ROUTE	DOE/OR/21548-286	JAN. 1993	REV. 0	
QY	6	ECOLOGICAL FIELD SURVEY OF THE PROPOSED QUARRY HAUL ROAD WSS		7/91		
EV	111	ECOLOGICAL MONITORING PROGRAM AT THE WASTE ISOLATION PILOT PLANT FIRST SEMIANNUAL REPORT	U.S. DOE	JAN. 1985		
WM	37	ECONOMICAL AND SAFE DISPOSAL OF T.N.T WASTE WATERS AT WELDON SPRING ORDNANCE WORKS	GREELY AND HANSEN	7-42		
GE	31	EFFECT OF FREEZING AND THAWING ON UMTRA COVERS A SPECIAL STUDY FINDING	DOE	10-88		
HG	22	EFFECTS OF VEGETATION AND SOIL- SURFACE COVER TREATMENTS ON THE HYDROLOGIC BEHAVIOR OF LOW-LEVEL WASTE TRENCH CAPS	LOS ALAMOS NATIONAL LAB	?		
GR	224	EFFLUENT INFORMATION SYSTEM (EIS)/ONSITE DISCHARGE INFORMATION SYSTEM (ODIS) 1990 (& 1991) EXECUTIVE SUMMARY	INEL	APR. 1993		
ZZ	127	ELECTRICAL POWER LINE & POLE REMOVAL COMPLETION REPORT	05-24-88			IRA #8
ZZ	58	ELECTRICAL POWER LINE & POLE REMOVAL RADIOLOGICAL SURVEY COMPLETION REPORT	DOE/OR/21548-038	02-89	REV. 2	IRA #8
GR	26	ELECTRICAL SAFETY MANUAL	DOE	MAY 1991		
WM	54	EM PEIS WASTE MANAGEMENT DESCRIPTION OF WM ALTERNATIVES & ANALYTICAL METHODOLOGY		AUG. 1992		
ZZ	132	EMERGENCY PLAN - METCALF AND ASSOCIATES, INC.	WP056	09-30-88		IRA #7
ZZ	32	EMERGENCY PLANS & PROCEDURES FOR THE WELDON SPRING SITE REMEDIAL ACTION PROJECT	DOE/OR/21548-012	06-88	REV. 3	
ZZ	109	EMERGENCY PREPAREDNESS PLAN	DOE/OR/21548-223	MAR. 1993	REV. 1A	FILED IN ZZ-378
ZZ	330	EMERGENCY RESPONSE MANUAL	DOE/OR/21548-196	FEB. 1993	REV. 2	FILED IN ZZ-378
ZZ	496	EMISSIONS ESTIMATE FOR THE QUARRY WATER TREATMENT PLANT	DOE/OR/21548-403	MAY 1993	REV. A	
ZZ	497	EMISSIONS ESTIMATE FOR THE SITE WATER TREATMENT PLANT	DOE/OR/21548-404	MAY 1993	REV. A	
RG	31	ENFORCEMENT ACTIONS UNDER RCRA & CERCLA AT FEDERAL FACILITIES	EPA	01-88		
ZZ	290	ENGINEERING ANALYSIS OF REMEDIAL ACTION	DOE/OR/21548-269/270	DEC. 1992	REV. 0	BOTH DOCUMENTS ARE

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		ALTERNATIVES PHASE I/II WORKING DRAFT				AT REV. 0
ZZ	310	ENGINEERING ASSESSMENT REPORT HIGHWALLS STABILITY - WSQ	DOE/OR/21548-181	MARCH 91	REV. 0	
ZZ	477	ENGINEERING DEPARTMENT PLAN	DOE/OR/21548-360	FEB. 1993	REV. 0	
ZZ	289	ENGINEERING DESIGN PLAN	DOE/OR/21548-165	JAN. 1992	REV. 0	
EN	67	ENGINEERING DESIGN REVIEW	HYDRO-PURE	10/18/90		
EN	33	ENGINEERING EVALUAION/COST ANALYSIS GUIDANCE FOR REMOVAL AC	CAMP DRESSER & MCKEE & WESTON	10-08-86		
EN	15	ENGINEERING EVALUATION OF ALTERNATIVES FOR THE DISPOSITION OF THE WELDON SPRING RAFFINATE PITS SITE W/ADDENDUM	BNI	04-84/85	18/6	
EN	10	ENGINEERING EVALUATION OF WASTE DISPOSAL OPTIONS AT WSQ	SAI	12-81	35	
EN	71	ENGINEERING EVALUATION/COST ANALYSIS & ADDENDUM FOR THE MAN & 15 NONPROCESS BUILDINGS (15 SERIES) AT THE WELDON SPRING CHEMICAL PLANT, WELDON SPRING, MO. -- ENVIRONMENTAL ASSESSMENT	U.S. DOE	NOV. 1991		
EN	30	ENGINEERING EVALUATION/COST ANALYSIS FOR AN EXPEDITED RESPONSE CONTAMINATION SITE	CAMP DRESSER & MCKEE, INC.	05-16-86		
EN	59	ENGINEERING EVALUATION/COST ANALYSIS FOR THE PROPOSED MANAGEMENT (15 SERIES) AT THE WELDON SPRING SIT	DOE/OR/21548-071 (ANL)	MAY 89		
ZZ	61	ENGINEERING EVALUATION/COST ANALYSIS FOR PROPOSED REMOVAL A RAFFINATE PITS/CHEMICAL PLANT	DOE/OR/21548-041	08-88	ANL	(EF)
ZZ	169	ENGINEERING EVALUATION/COST ANALYSIS FOR PROPOSED MANAGEMEN SERIES) AT WELDON SPRING CHEMICAL PLANT,	DOE/OR/21548-071	05-89	IRA #17	FILED: EN-059
ZZ	179	ENGINEERING EVALUATION/COST ANALYSIS FOR PROPOSED MANAGEMEN SERIES) AT WELDON SPRING CHEMICAL PLANT	DOE/OR/21548-081	05-89	ANL	(EF)
ZZ	204	ENGINEERING EVALUATION/COST ANALYSIS FOR THE PROPOSED MANAG IMPOUNDED AT THE WELDON SPRING CHEMICAL	DOE/OR/21548-106	7-90	ANL	RAFF. PITS(SEE SUPERCEDED CPY)
ZZ	282	ENGINEERING EVALUATION/COST ANALYSIS FOR THE PROPOSED MANAG THE WELDON SPRING SITE CHEMICAL PLANT	DOE/OR/21548-159	MAY 1991		
PM	21	ENGINEERING EVALUATION/COST ANALYSIS GUIDANCE FOR NON-TIME-CRITICAL REMOVAL ACTIONS	EPA	06-87		(DRAFT)
RG	37	ENGINEERING EVALUATION/COST ANALYSIS GUIDANCE FOR NON-TIME-CRITICAL REMOVAL ACTIONS				PROVIDED BY ANL
ZZ	59	ENGINEERING EVALUATION/COST ANALYSIS PROPOSED MANAGEMENT OF SPRING QUARRY	DOE/OR/21548-039	01-89	ANL	IRA #21
ZZ	418	ENGINEERING QUALITY ASSURANCE PLAN	DOE/OR/21548-303	JUNE 1992	REV. B	(NOT YET RECEIVED)
EV	52	ENVIRONMENT, SAFETY AND HEALTH COMPLIANCE REPORT FOR THE WSSRAP	MK-BOISE / JEG-DENVER	FEB 91		
EV	69	ENVIRONMENT, SAFETY AND HEALTH, AND QUALITY ASSURANCE (ESH&QA) FUNCTIONAL APPRAISAL OF THE WELDON SPRING SITE REMEDIAL ACTION PROJECT	DOE-ORO	MAY 1993		INCL. OCT. 15-26, 1990, 3-6-92
EV	75	ENVIRONMENT, SAFETY, AND HEALTH INFORMATION NETWORK: MANAGEMENT PLAN AND REQUIREMENTS DOCUMENT	DOE	2-20-91		
EV	88	ENVIRONMENT, SAFETY, AND HEALTH NEEDS OF THE U.S. DEPARTMENT OF ENERGY	DOE	DEC. 1988		VOL. 2: SITE SUMMARIES
EV	12	ENVIRONMENTAL AIR MONITORING REPORT FOURTH QUARTER, 1983	SHELL ENG.	01-84	01/19	
ZZ	286	ENVIRONMENTAL ASSESSMENT	DOE	NOV. 1990	REV. 0	
EV	25	ENVIRONMENTAL ASSESSMENT - WELDON SPRING RAFFINATE PITS STABILIZATION	NLO	09-74	N/A	

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ZZ	342	ENVIRONMENTAL AUDIT ACTION PLAN	DOE/OR/21548-206	JAN. 1992	REV. 1	
EV	18	ENVIRONMENTAL AUDIT WSSRAP	DOE	JUNE 91		
EV	114	ENVIRONMENTAL AUDITING	NEWTON	NO DATE		PERM. CHECK OUT TO D. TAYLOR
EV	89	ENVIRONMENTAL BIOTECHNOLOGY FOR WASTE TREATMENT	PLENUM PRESS, NEW YORK	1991	VOL. 41	PERM. CHECK OUT TO S. MURRAY
EV	91	ENVIRONMENTAL BOOKS FOR BUSINESS PROFESSIONALS	GOVERNMENT INSTITUTES	1992		PERM CHECK OUT TO M. GILBERT
EV	65	ENVIRONMENTAL COMPLIANCE ASSESSMENT FINDINGS FOR WSSRAP	ORNL	12-19-90		FINAL
EV	81	ENVIRONMENTAL COMPLIANCE ASSESSMENT FINDING FOR WSSRAP	ENVIRONMENTAL SCIENCE DIVISION	DEC 19,90		
EV	112	ENVIRONMENTAL DATA ACQUISITION AT THE WAST ISOLATION PILOT PLANT: A CHRONOLOGICAL DESCRIPTION AND JUSTIFICATION MATRIX	IT CORP	JUNE 1985		
ZZ	217	ENVIRONMENTAL DATA ADMINISTRATION PLAN	DOE/OR/21548-119	AUG. 1993	REV. 3	
EV	33	ENVIRONMENTAL DOCUMENTATION PROCESS FOR REMEDIAL ACTION AT THE WELDON SPRING SITE	DOE	09-28-87		""BLUE BOOK""
EV	99	ENVIRONMENTAL GUIDANCE FOR DEVELOPMENT OF CULTURAL RESOURCE MANAGEMENT PLANS	DOE	FEB. 92		
EV	72	ENVIRONMENTAL GUIDANCE PROGRAM REFERENCE BOOKS HAZARDOUS MATERIALS TRANSPORTATION ACT	DOE	FEB 1990		
EV	116	ENVIRONMENTAL IMPLEMENTATION GUIDE FOR RADIOLOGICAL SURVEY PROCEDURES	DOE	NOV. 1992	DRAFT	
EV	104	ENVIRONMENTAL LAW HANDBOOK ELEVENTH EDITION (2 BOOKS ORDERED, ONE FOR A. SISSON & ONE FOR N. KELLAR)	GOVT. INSTITUTES, INC.	MARCH 91		CHECK OUT TO SISSON & KELLAR
KU	31	ENVIRONMENTAL LAW INDEX TO CHEMICALS	C.C. LEE, Ph.D.	1993		PERM. CHECK OUT TO T. UHLMEYER
PM	85	ENVIRONMENTAL MANAGEMENT TECHNICAL CENTER MONTHLY REPORT	DOE	JUN. 1993		MONTHLY REPORT
EV	11	ENVIRONMENTAL MONITORING OF THE DOE OWNED SURPLUS FACILITY WSS	BNI	11-83	23	
ZZ	201	ENVIRONMENTAL MONITORING PLAN	DOE/OR/21548-103	FEB 90	REV. 1	
ZZ	302	ENVIRONMENTAL MONITORING PLAN	DOE/OR/21548-174	FEB 91	REV. 0	
ZZ	124	ENVIRONMENTAL MONITORING PLAN FOR CALENDAR YEAR 1992	DOE/OR/21548-237	JAN. 1992	REV. 1	
ZZ	472	ENVIRONMENTAL MONITORING PLAN FOR CALENDAR YEAR 1993	DOE/OR/21548-349	JUN. 1992	REV. 1	
EV	6	ENVIRONMENTAL MONITORING PROGRAM FOR DOE WELDON SPRING, MO SITE	NLO	08-81	37	
ZZ	152	ENVIRONMENTAL MONITORING PROGRAM PLAN	DOE/OR/21548-054	08-87	REV. 1	
EV	9	ENVIRONMENTAL MONITORING REPORT SECOND QUARTER, 1983 & REV. 1	SHELL ENG.	7-83/2-84	1/27	
EV	10	ENVIRONMENTAL MONITORING REPORT THIRD QUARTER, 1983	SHELL ENG.	10-83	1/24	
EV	27	ENVIRONMENTAL MONITORING REPORTS 1959 THRU 1965	MCW	1959-1965	N/A	
HP	56	ENVIRONMENTAL PROTECTION AGENCY'S RADIOACTIVITY STANDARDS INVENTORY AND DISTRIBUTION PROGRAM	EPA			
EV	80	ENVIRONMENTAL PROTECTION DIVISION ENVIRONMENTAL INCIDENT TRAINING MANUAL	ORO	FEB 91	REV. 3	
ZZ	193	ENVIRONMENTAL PROTECTION PROGRAM IMPLEMENTATION PLAN	DOE/OR/21548-095	OCT. 1992	REV. 4	
ZZ	354	ENVIRONMENTAL QUALITY ASSURANCE PROGRAM PLAN	DOE/OR/21548-240	NOV. 91	REV. 0	
ZZ	465	ENVIRONMENTAL QUALITY ASSURANCE PROJECT PLAN	DOE/OR/21548-352	JUL. 1993	REV. 1	
EV	117	ENVIRONMENTAL RADON	PLENUM	1987		PERM. CHECK OUT TO

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
						G. SCHMIDT
EV	55	ENVIRONMENTAL REGULATORY GUIDE FOR RADIOLOGICAL EFFLUENT MONITORING AND ENVIRONMENTAL SURVEILLANCE	DOE	JAN 91		
KU	4	ENVIRONMENTAL REMEDIATION '91	DOE	SEP. 1991		
EV	102	ENVIRONMENTAL RESTORATION	INEL			
EV	37	ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT SITE-SPECIFIC PLAN FOR THE OAK RIDGE RESERVATION	DOE	SEPT 91		
EV	38	ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT SITE-SPECIFIC PLAN FOR DOE FIELD OFFICE, OR (FUSRAP)	DOE	SEPT 91		
EV	98	ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT; OFFICE OF TECHNOLOGY DEVELOPMENT; INTEGRATED DEMONSTRATION/PROGRAMS FACTS BOOK	MAZWRAP	APRIL 92		
EV	118	ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT SAFETY AND HEALTH FIVE-YEAR PLAN FISCAL YEARS 1995-1999 SECTION 1 - SAFETY AND HEALTH (S&H)-PLANNING FOR THE CLEANUP		JUN. 1993	DRAFT	
EV	119	ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT SAFETY AND HEALTH FIVE-YEAR PLAN FISCAL YEARS 1995-1999 SECTIONS 2 & 3 - LANDLORD SITE AND OPERATIONS OFFICE SUMMARIES		JUN. 1993	DRAFT	
KU	19	ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT SITE-SPECIFIC PLAN FOR OAK RIDGE OPERATIONS OFFICE	U.S. DEPARTMENT OF ENERGY	JAN. 1990		
PM	127	ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT PROGRAM REVIEW	DOE- OAK RIDGE	JUL. 1990		
WM	21	ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT FIVE-YEAR PLAN FY 92-96	DOE	6-90		
ZZ	195	ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT SITE-SPECIFIC PLAN FOR OAK RIDGE OPERARTIONS OFFICE WELDON SPRING SITE REMEDIAL ACTION PROJECT	DOE/OR/21548-097	JUNE 1991	REV. 2	
ZZ	438	ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT FY 1993 SITE-SPECIFIC PLAN FOR FIELD OFFICE - OAK RIDGE	DOE/OR/21548-322	AUG. 1992	REV. 2	
EV	78	ENVIRONMENTAL RESTORATION AND WASTE MGMT. PROGRAM QUALITY ASSURANCE PLAN PART I	PAI CORP.	DEC 91		
EV	79	ENVIRONMENTAL RESTORATION AND WASTE MGMT. QA PROGRAM TRAINING PROCEDURES	PAI CORP			
PM	61	ENVIRONMENTAL RESTORATION CURRENT AWARENESS BULLETIN	ORNL	MAY 1993		
WM	48	ENVIRONMENTAL RESTORATION PROGRAM WASTE MINIMIZATION AND POLLUTION PREVENTION AWARENESS PROGRAM PLAN	MARTIN MARIETTA	SEPT. 91		ES/ER/TM-21
EV	110	ENVIRONMENTAL RESTORATION REGULATORY OVERVIEW FOR LAND AND SURPLUS PLANNING	EM-43	SEPT 1992		
RG	25	ENVIRONMENTAL REVIEW REQUIREMENTS FOR REMOVAL ACTIONS	EPA	02-10-87	N/A	(DRAFT)
RG	43	ENVIRONMENTAL REVIEW REQUIREMENTS FOR REMOVAL ACTIONS	EPA	04-87		
ZZ	475	ENVIRONMENTAL SAFETY & HEALTH DEPARTMENT PLAN	DOE/OR/21548-362	FEB. 1993	REV. 0	
ZZ	6	ENVIRONMENTAL SAFETY AND HEALTH PLAN	DOE/OR/21548-172	FEB 92	REV. 2	
ZZ	459	ENVIRONMENTAL SAMPLE TRACKER USERS MANUAL	DOE/OR/21548-343	SEPT 1992	REV. 0	
WM	53	ENVIRONMENTAL SAMPLING FOR HAZARDOUS WASTES	SCHMEITZER & SANTOLUCITO			PERM CHECKOUT TO D. HIXSON
ZZ	142	ENVIRONMENTAL, SAFETY AND HEALTH PLAN FOR REMOVAL OF THREE PARTIALLY BURIED BARRELS ON VICINITY				

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		PROPERTY NO. 5 ON WELDON SPRING WILDLIFE AREA				
HG	39	EPA GROUND WATER HANDBOOK	EPA / GOV. INSTITUTES, INC.			
ZZ	149	EPA REFERENCE GUIDANCE DOCUMENTS ARE AVAILABLE AT EPA REGION VII, 726 MINNESOTA AVENUE, KANSAS CITY, KANSAS 66101				EPA GUIDANCE (EF)
DD	1	ERDA - WELDON SPRING/WELDON SPRING DECOMMISSIONING STUDY	NLO	06-75	59	
DD	2	ERDA - WELDON SPRING/WELDON SPRING DECOMMISSIONING STUDY - QUARRY SUPPLEMENT	NLO	09-75	58	
WM	18	ERDA-NIAGARA FALLS RADIOACTIVE WASTE MANAGEMENT PLAN	NLO	06-16-75		
RG	102	ERGONOMICS PROGRAM MANAGEMENT GUIDELINES FOR MEATPACKING PLANTS	U.S. DEPT. OF LABOR	1990		
GR	38	EROSION PROTECTION OF URANIUM TAILINGS IMPOUNDMENTS	NRC	09-86		
ZZ	304	ES&H COMPLETION REPORT FOR BUILDING 401	DOE/OR/21548-175	JULY 91	REV. 1	
ZZ	315	ES&H DEPARTMENT CHARTER	PMC	APRIL 90		
WM	12	ESTABLISHMENT OF CRITERIA FOR THE UNCONDITIONAL RELEASE OF THE SHIPPINGPORT ATOMIC POWER STATION SITE	GENERAL ELECTRIC COMPANY	1988		
PM	18	ESTIMATING & COST CONTROL MANUAL FOR CONSTRUCTION PROJECTS	DOE	04-81	N/A	
GE	26	ESTIMATION OF EARTHQUAKE EFFECTS ASSOCIATED WITH A GREAT EARTHQUAKE IN THE NEW MADRID SEISMIC ZONE	DOI	1983		GEOLOGICAL SURVEY
RP	5	EVALUATION OF ALTERNATIVES FOR STABILIZING LOW-LEVEL WASTES LOCATED AT THE WELDON SPRING RAFFINATE PITS	BNI	11-84	9	
BZ	1	EVALUATION OF BIOLOGICAL HEALTH HAZARDS FROM ACCUMULATED BIRD DROPPINGS AT WSCP	RETA	10-77	80	
GE	15	EVALUATION OF GEOLOGIC MATERIALS TO LIMIT BIOLOGICAL INTRUSION INTO LOW-LEVEL RADIOACTIVE WASTE DISPOSAL SITES	LOS ALAMOS NATIONAL LABORATORY	09-86		
HG	74	EVALUATION OF GROUND-WATER EXTRACTION REMEDIES: PHASE II (VOLS. I, II & III)	EPA	FEB. 1992		PERM. CHECK OUT TO J. BOGNAR
GR	69	EVALUATION OF PHYSICAL SEPARATION TECHNIQUES FOR THE TREATMENT OF CONTAMINATED SOILS		NOV. 1992	REV. 0	
ZZ	500	EVALUATION OF RADCON EMANATION DURING RAFFINATE SLUDGE DREDGING AND PROCESSING	DOE/OR/21548-384	MAY 1993	REV. A	
ZZ	180	EVALUATION OF RADON EMISSIONS & POTENTIAL CONTROL REQUIREMENTS	DOE/OR/21548-082	JAN 90	REV. 2	
GR	118	EVALUATION OF REMEDIAL ACTION UNIT OPERATIONS AT HAZARDOUS WASTE DISPOSAL SITES	EHRENFELD/BASS	1984		
GR	60	EVALUATION OF THE U.S. DOE'S OCCUPATIONAL SAFETY AND HEALTH PROGRAM FOR IT'S GOVERNMENT-OWNED CONTRACTOR - OPERATED FACILITIES	DEPT. OF LABOR	DEC 1990		
GR	68	EVALUTATION OF ROTARY KILN AND FLUIDIZED BED INCINERATION TECHNOLOGIES FOR THE TREATMENT OF CONTAMINATED SOILS AND SLUDGES				
GR	177	EXCAVATION AROUND FOUNDATIONS TREATABILITY STUDY WORK PLAN WELDON SPRING ORDNANCE WORKS	IT CORPS.	SEPT 1992		
GE	14	EXCERPT FROM D'APPOLONIA REPORT: SOIL ATTENUATION STUDY, CRANDON PROJECT, CRANDON, WISCONSIN				
LN	10	EXCERPT FROM: EPRI REPORT CHEMICAL ATTENUATION RATES, COEFFICIENTS, & CONSTANTS IN LEACHATE MIGRATION	EPRI			

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
PM	82	EXECUTIVE COURSE FUNDAMENTALS FOR DOE OPERATIONS	DOE			
BL	28	EXECUTIVE SUMMARY BASELINE CHANGE PROPOSAL SUBJECT: WSSRAP BSELINE VALIDATION/ESAAB REVIEW	PMC	JAN. 1993	REV. 1	ALSO REV. 0
GR	22	EXPANSION PROGRAM AT ST. LOUIS AREA/PROJECT HISTORY & COMPLETION REPORT	DOE	10-60	N/A	
KU	6	EXPERIMENTAL STATISTICS	M.G. NATRELLA	AUG. 1963		
QY	1	EXPLOSIVE HAZARD REVIEW FOR THE WELDON SPRING SITE REMEDIAL ACTION PROJECT QUARRY EXCAVATION	HERCULES INC.	JUNE 90		
RG	125	EXPOSURE FACTORS HANDBAG	EPA	JULY 1989		PERM. CHECK OUT TO J. BOGNAR
EV	74	EXPOSURE FACTORS HANDBOOK	U.S. EPA	MAY 89		
GR	174	EXTREMITY MONITORING: CONSIDERATIONS FOR USE, DOSIMETER PLACEMENT, & EVALUATION	PACIFIC NORTHWEST LABORATORY	NOV. 1985		
ZZ	237	F.Y. 1991 BUDGET REQUEST		APRIL 89		ALSO FY1990 BUDGET REQUEST
EN	47	FACILITIES CAPABILITY ASSURANCE PROGRAM	MARTIN MARIETTA	11-88		
GR	42	FACILITIES RENOVATION REPORT FOR PROPOSED EDUCATIONAL CENTER	R.G.MCMAHON & ASSOC., INC.	12-16-74		
YY	55	FACT SHEET: FUNDING AURHTORIZATION FOR WSSRAP IN FISCAL YEAR 1987	11-04-86	11-04-86		PUBLIC PART
YY	54	FACT SHEET: HISTORY OF THE WELDON SPRING SITE	01-87	01-87		PUBLIC PART
YY	21	FACT SHEET: INTERIM RESPONSE ACTION UPDATE	12-06-88	12-06-88		PUBLIC PART
YY	43	FACT SHEET: INTERIM RESPONSE ACTIONS	09-87	09-87		PUBLIC PART
YY	73	FACT SHEET: PROPOSED MANAGEMENT OF CONTAMINATED WATER IN WELDON SPRING QUARRY	01-05-89	01-05-89		
GE	45	FACT SHEET: RISK ASSESSMENT GUIDANCE FOR SUPERFUND: VOL. 1 HUMAN HEALTH EVALUATION MANUAL (PART A)	EPA	APRIL 90		
YY	31	FACT SHEET: SUPERFUND FACTS	02-88	02-88		PUBLIC PART
YY	33	FACT SHEET: SUPERFUND FACTS	02-88	02-88		PUBLIC PART
YY	25	FACT SHEET: UPDATE OF THREE IRA'S	10-88	10-88		PUBLIC PART
YY	34	FACT SHEET: WATER QUALITY STUDIES	02-88	02-88		PUBLIC PART
DD	23	FACTORS RELEVANT TO THE DECOMMISSIONING OF URANIUM MINING AND MILLING FACILITIES	INTERNATIONAL ATOMIC ENERGY AG	NOV. 1991		
RG	112	FAR FEDERAL ACQUISITION REGULATION AS OF FEBRUARY 1, 1992	COMMERCE CLEARING HOUSE, INC.	1992		PERM. CHECK OUT TO L. MEDLIN
GE	28	FATE AND TRANSPORT OF CONTAMINANTS IN THE VADOSE ZONE	MICHAEL E. BEDAN	08-24-89		
ZZ	202	FEASIBILITY STUDY FOR MANAGEMENT OF THE BULK WASTES AT THE WELDON SPRING QUARRY, WELDON SPRING, MISSOURI	DOE/OR/21548-104	FEB 90	REV. 0	PUBLISHED BY ANL
EN	60	FEASIBILITY STUDY FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE	DOE/OR/21548-148	OCT. 1990		WORKING DRAFT
ZZ	271	FEASIBILITY STUDY FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE	DOE/OR/21548-148	NOV. 1992		FILED IN EN-060 (ANL DOC.)
EN	58	FEASIBILITY STUDY FOR THE WELDON SPRING SITE, WELDON SPRING, MO	ANL	SEPT 90		WORKING DRAFT
ZZ	227	FEASIBILITY STUDY/ENVIRONMENTAL ASSESSMENT FOR THE WELDON SPRING QUARRY BULK WASTE REMEDIAL ACTION		FEB. 1990	DRAFT	FILED IN ZZ-202
EV	100	FEDERAL AGENCY ENVIRONMENTAL ROUNDTABLE	EPA	APRIL 92		
GR	145	FEDERAL AGENCY POLLUTION ABATEMENT PLAN - SYSTEM REFERNCE MANUAL	DOE			
PM	92	FEDERAL CONTRACT MANAGEMENT A MANUAL FOR THE CONTRACT PROFESSIONAL VOLS. 1 - 3	MATTHEW BENDER	1992		PERM. CHECK OUT TO M. LEWIS
EV	70	FEDERAL ENVIRONMENTAL REPORTING REQUIREMENTS	DOE	MAY 90		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		HANDBOOK				
PM	19	FEDERAL FACILITY AGREEMENT (EPA/DOE/CERCLA)	EPA	JAN 91		INCLUDED 04-86, 08-90
ZZ	416	FEDERAL FACILITY AGREEMENT QUARTERLY REPORT	DOE/OR/21548-301	JUNE 1992	REV. A	
ZZ	446	FEDERAL FACILITY AGREEMENT QUARTERLY REPORT THIRD QUARTER FISCAL YEAR 1992	DOE/OR/21548-330	AUG. 1992	REV. 0	
ZZ	464	FEDERAL FACILITY AGREEMENT QUARTERLY REPORT FOURTH QUARTER FISCAL YEAR 1992	DOE/OR/21548-355	NOV. 1992	REV. 1	
ZZ	474	FEDERAL FACILITY AGREEMENT QUARTERLY REPORT FIRST QUARTER FISCAL YEAR 1993	DOE/OR/21548-373	JAN. 1993	REV. 0	
ZZ	493	FEDERAL FACILITY AGREEMENT QUARTERLY REPORT SECOND QUARTER FISCAL YEAR 1993	DOE/OR/21548-398	APR. 1993	REV. 0	
ZZ	510	FEDERAL FACILITY AGREEMENT QUARTERLY REPORT THIRD QUARTER 1993	DOE/OR/21548-413	AUG. 1993	REV. 0	
YY	2	FEDERAL REPOSITORIES/SPENCER CREEK BRANCH LIBRARY	08-22-88	08-22-88		PUBLIC PART
GR	18	FEDERAL REPUBLIC OF GERMANY (FRG) DOCUMENT ON EXPLOSIVE DEMOLITION	DOE	12-86	N/A	
RG	14	FEDERAL WATER POLLUTION CONTROL ACT / CLEAN WATER ACT / WATER QUALITY ACT OF 1987	USC	1987	N/A	
HP	42	FIELD CALIBRATION FACILITIES FOR ENVIRONMENTAL MEASUREMENT OF RADIUM, THORIUM, & POTASSIUM	DOE	08-86		
GE	48	FIELD INVESTIGATION OF HAZARDOUS WASTES AT WELDON SPRING TRAINING AREA ST. CHARLES COUNTY, MISSOURI	CAMBELL DESIGN GROUP	APR. 1987		
PM	13	FIELD OPERATION MANUAL FOR WSS	BNI	08-85	N/A	
HG	36	FIELD OPERATIONS PLAN (FOP) - SURFACE & SUBSURFACE HYDROLOGY INVESTIGATION, SPRING 1987, CHEROKEE COUNTY, KS (APPENDIX A)	CH2M HILL	03-87		
ZZ	512	FIELD SAMPLE TRACKER (FST) USER MANUAL	DOE/OR/21548-402	AUG. 1993	REV. 0	
GR	33	FIELD STUDY OF GRAVEL ADMIX, VEGETATION, & SOIL WATER INTERACTIONS: A 1987 STATUS REPORT	DOE	03-88		
HP	41	FIELD STUDY OF INDOOR AVERAGE RADON-DAUGHTER ESTIMATION METHODS	DOE	08-86		
RP	14	FINAL DRAFT POSITION PAPER ARARS FOR WSSRAP CHEMICAL PLANT/RAFFINATE PITS AREA	DAMES & MOORE	6-5-89		
GR	136	FINAL FEASIBILITY STUDY WORK PLAN WELDON SPRING ORDNANCE WORKS	IT CORP	APRIL 92		
EN	34	FINAL REMEDIAL INVESTIGATION REPORT - REMEDIAL INVESTIGATION/FEASIBLITY STUDY	ECOLOGY & ENVIRONMENT, INC.	12-17-85		
GR	149	FINAL REMEDIAL INVESTIGATION REPORT WELDON SPRING ORDNANCE WORKS, WELDON SPRING, MO	IT CORP.	NOV. 1992		
GR	29	FINAL REPORT ASBESTOS MODELING STUDY	EPA	03-88		
GE	47	FINAL REPORT GEOMORPHOLOGICAL ASSESSMENT THE WELDON SPRING SITE REMEDIAL ACTION PROJECT	ROCKAWAY, JOHN D.	MAY 1993		
GR	208	FINAL REPORT ON THE INSTALLATION OF LINING SYSTEM AT THE UNITED STATES DEPARTMENT OF ENERGY WELDON SPRING REMEDIAL ACTION PROJECT EQUALIZATION BASIN ST. CHARLES, MISSOURI GEOSYNTHETICS CONSTRUCTION QUALITY ASSURANCE	I-CORP INTERNATIONAL, INC.	MAR. 1993		LOCATED ON SHELF W/ DOE ORDERS
GR	216	FINAL REPORT ON THE INSTALLATION OF LINING SYSTEM AT THE UNITED STATES DEPARTMENT OF ENERGY WELDON SPRING REMEDIAL ACTION PROJECT EFFLUENT PONDS 1 & 2 ST. CHARLES, MO GEOSYNTHETIC CONSTRUCTION QUALITY ASSURANCE	I-CORP INTERNATIONAL, INC.	APR. 1993		LOCATED ON SHELF W/ DOE ORDERS
RP	16	FINAL REPORT STABILIZATION/SOLIDIFICATION TESTING OF RAFFINATE PIT SLUDGES & NITROAROMATIC SOILS	WASTE TECH. GROUP, INC.	05-08-92		
GR	77	FINAL REPORT TO THE SECRETARY OF ENERGY	DOE	AUG 1990		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		IMPLICATIONS OF THE BEIR V REPORT TO THE DEPARTMENT OF ENERGY				
WM	25	FINDING OF NO SIGNIFICANT IMPACT (FONSI), FLOODPLAIN STATEMENT OF FINDINGS, PROPOSED MANAGEMENT OF CONTAMINATED WATER AT THE WELDON SPRING QUARRY, WELDON SPRING, MISSOURI	DEPARTMENT OF ENERGY	NOV 90		INCLUDED 02/90
HP	90	FIRE PROTECTION GUIDE TO HAZARDOUS MATERIALS 10TH EDITION	NFPA	1991		PERM. CHECK OUT TO J. DILLALO
ZZ	444	FIRE PROTECTION PROGRAM MANUAL	DOE/OR/21548-328	JULY 92	REV. C	NOT YET RECEIVED
ZZ	391	FIRE PROTECTION REPORT 1991	DOE/OR/21548-276	MAY 1992	REV. 1	
ZZ	479	FIRE PROTECTION REPORT 1992	DOE/OR/21548-383	MAR. 1993	REV. 0	
ZZ	431	FIRST AMENDED FEDERAL FACILITIES AGREEMENT IN THE MATTER OF THE UNITED STATES DEPARTMENT OF ENERGY'S WELDON SPRING SITE, ST. CHARLES, MISSOURI	DOE/OR/21548-315			NOT YET RECEIVED
HG	38	FIRST ANNUAL REPORT ON THE SHALLOW GROUNDWATER INVESTIGATIONS AT WELDON SPRING, MO	MDNR	1988		ATTACHED SECOND ANNUAL 1989
EV	108	FLORA OF MISSOURI (THREE PARTS)	UMI	1992		PERM. CHECK OUT TO J. HERRON
LN	2	FLUE GAS CLEANING SLUDGE LEACHATE/LINER COMPATIBILITY INVESTIGATION	GEOTECHNICAL LABORATORY	08/79	N/A	
PM	44	FMPC ROADMAP VOLUME 1 & 2	WESTINGHOUSE MATERIALS CO/OHIO	1-31-91		PRE-DECISIONAL DRAFT
HP	32	FORMERLY UTILIZED MED/AEC SITES REMEDIAL ACTION PROGRAM	DOE	09-79		
EV	67	FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM ENVIRONMENTAL COMPLIANCE ASSESSMENT CHECKLISTS	ORNL	8-18-89		
ZZ	437	FREEZE PROTECTION SELF-ASSESSMENT	DOE/OR/21548-321	JULY 92	REV. A	NOT YET RECEIVED
GR	16	FUEL FOR THE ATOMIC AGE - COMPLETION REPORT-URANIUM PROCESSING OPERATIONS 1942-1967	FLEISHMAN-HILLIARD, INC.	09-67	N/A	
GR	146	FUNCTION ANALYSIS - SYSTEMATIC IMPROVEMENT OF QUALITY AND PERFORMANCE	KANEO AKIYAMA	1989		PERM. CHECKOUT TO GENE VALETT
EV	66	FUNDAMENTALS OF RADIATION PROTECTION	RADIATION SAFETY ASSOCIATES	?		
ZZ	236	FY '89 MID-YEAR REVIEW	DOE	APRIL 89		ALSO INCLUDES 1988 & SITE TOUR
ZZ	412	FY '92 MID-YEAR REVIEW		MAY 14,92		
PM	11	FY 1989 BUDGET AND REPORTING (B&R)/ORGANIZATION CROSSWALK, B&R CLASSIFICATION CODES, AND CONTROL AND REPORTING LEVELS	DOE	7-7-88		
ZZ	110	FY 1992 APPROPRIATION PRIORITY SCORING SYSTEM REVIEW		SEPT 1991	REV. 1	
ZZ	374	FY 1992 BUDGET SUBMITTAL ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT (EM) DECONTAMINATION AND DECOMMISSION DIVISION		MARCH 90		
ZZ	321	FY 1993 BUDGET PRIORITY SCORING SYSTEM REVIEW		FEB 91		
ZZ	336	FY 1993 PROJECT VALIDATION		JUNE 91		ALSO FY92 FILED HERE
ZZ	482	FY 1995 BUDGET REQUEST DOE/ORO SUBMITTAL	PMC	FEB. 1993		
ZZ	258	FY 89 YEAR END REVIEW ,AND FY 90 YEAR END REVIEW	PMC	NOV 90		ALSO FY88 FILED HERE
ZZ	177	FY 90 BUDGET - REVISION A	MK-FERGUSON	10-1-89	REV. A	
PM	123	FY 91 BUDGET	PMC	OCT. 1990		
GR	175	GENERAL RECORDS SCHEDULE TRANSMITTAL #2	NATIONAL ARCHIVES & RECORDS	OCT. 1989		
RG	130	GENERAL SAFETY STANDARD FOR INSTALLATIONS USING NON-MEDICAL X-RAY AND SEALED GAMMA-RAY SOURCES, ENERGIES UP TO 10 MeV	U.S. DEPT. OF COMMERCE	MAY 1974		
ZZ	47	GENERIC TECHNICAL SPECIFICATIONS VICINITY	DOE/OR/21548-027	03-88	REV. A	

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		PROPERTIES REMEDIATION				
GE	37	GEOCHEMICAL DATA FOR THE WELDON SPRING CHEMICAL PLANT SITE AND VICINITY PROPERTY, ST. CHARLES COUNTY, MISSOURI--1989-1990	U.S. GEOLOGICAL SURVEY	89-90		
GE	34	GEOCHEMICAL DATA FOR THE WELDON SPRING TRAINING AREA AND VICINITY PROPERTY, ST. CHARLES COUNTY, MISSOURI--1990-92	USGS	1993		
GE	6	GEOCHEMICAL INFORMATION FOR SITES CONTAMINATED WITH LOW-LEVEL RADIOACTIVE WASTES: III - WSSS	ORNL	02-85	8	
HG	76	GEOHYDROLOGY, EXTENT OF CONTAMINATION, AND SIMULATION OF GROUND-WATER FLOW AT THE WELDON SPRING CHEMICAL PLANT SITE AND VICINITY PROPERTY, ST. CHARLES, MISSOURI - 1987-90	KLEESCHULTE, MICHAEL J.	1993		
GE	10	GEOLOGIC APPRAISAL OF SETTLEMENT PITS, WELDON SPRING ORDNANCE WORKS	MOYLAN,J.E. & ELSER,L.G.	10-67	N/A	
GE	12	GEOLOGIC FIELD REFERENCE MANUAL WSCP CHARACTERIZATION	BECHTEL	1986		
GE	38	GEOLOGIC INDICATORS OF SUBSIDENCE AND COLLAPSE IN KARST TERRAIN IN MISSOURI PHASE III REPORT ASSESSMENT OF DISPOSITION ALTERNATIVES	MDNR	JAN 21 76		2ND RPT- MAY 1978 BY R.E.T.A
GE	5	GEOLOGIC REPORT - WELDON SPRING RAFFINATE PIT SITE	BNI	11-84	10	
ZZ	50	GEOLOGICAL CROSS-SECTION MATERIAL STAGING AREA	DOE/OR/21548-030	05-88	REV. 0	
GE	30	GEOPHYSICAL INVESTIGATION SPECIFICATION 3589-SC-WP028 WELDON SPRING CHEMICAL PLANT APPENDICES A-F	GEOTECHNOLOGY SERVICES	12-9-88		FINAL DRAFT, VOLUME II
GE	17	GEOPHYSICAL INVESTIGATION, SPECIFICATION 3589-SC-WP028, WELDON SPRING CHEMICAL PLANT	GEOTECHNOLOGY SERVICES, INC.	12-09-88		FINAL REPORT
GE	2	GEOPHYSICAL MEASUREMENTS - US DOE RAFFINATE PIT SITE - WELDON SPRING, MO	WESTON GEOPHYSICAL	03-83	30	
WM	4	GEOPHYSICAL TECHNIQUES FOR SENSING BURIED WASTES & WASTE MIGRATION	US DEPT. OF COMMERCE	06-84	N/A	
ZZ	34	GEOPHYSICAL/GEOTECHNICAL INVESTIGATION SAMPLING PLAN	DOE/OR/21548-014	07-88	REV. 1	
GR	150	GEOSCIENCES WORKSHOP	COMMUNITY RELATIONS	JULY 92		
SE	4	GEOSCIENCES WORKSHOP AGENDA AND INFORMATIONAL PACKET	WSSRAP	02/21/91		
GE	25	GEOTECHNICAL EVALUATION PROPOSED DISPOSAL CELL SITE WSSRAP WELDON SPRING, MO	DAMES & MOORE	10-89		
GE	35	GEOTECHNICAL INVESTIGATION ST. CHARLES COUNTY WATER TANK	GROUND ENGINEERING, INC.	7-90		
ZZ	320	GEOTECHNICAL INVESTIGATION SAMPLING PLAN	DOE/OR/21548-190	APRIL 91	REV. 0	
GE	11	GEOTECHNICAL REPORT - FIELD INVESTIGATION OF HAZARDOUS WASTES AT WSTA	CAMPBELL DESIGN GROUP	04-87	N/A	
GE	33	GEOTECHNICAL REQUIREMENTS FOR DRILLING, MONITOR WELLS, DATA ACQUISITION, AND REPORTS	DEPT. OF ARMY	03/87		
EN	61	GEOTEXTILE ENGINEERING MANUAL				COURSE TEXT
GR	83	GOSIP CATEGORY: HARDWARE AND SOFTWARE STANDARDS SUBCATEGORY: COMPUTER NETWORK PROTOCOLS	DOE	08-24-88		(FIPS PUB 146) D/C SHELF
GR	87	GOSIP - THE COMPLETE PROCUREMENT GUIDE	DOE			(D/C SHELF)
GR	86	GOSIP USERS GUIDE	DOE (PB90-11212) D/C SHELF	AUG 89		INCLUDED: #2 11-89 - FILE
GR	84	GOSIP VERSION 2.0	DOE	OCT 90		(D/C SHELF) ALSO IN FILE
HG	20	GROUND WATER MONITORING PROGRAM ST. CHARLES COUNTY WELDON SPRING WELL FIELD	SOIL CONSULTANTS, INC.	03-88		
EN	54	GROUND-WATER FLOW AND SOLUTE TRANSPORT MODELING	ANL	8-22-89		ATTACHED DOC. DATE

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		NEEDS FOR THE WS RI/FS PROPOSED CONTINUATION STUDIES FOR THE WELDON SPRING QUARRY				7-5-89
HG	73	GROUND-WATER MICROBIOLOGY & GEOCHEMISTRY	FRANCIS H. CHAPELLE	1993		(PERM. CHECK OUT TO J. CARMAN)
HG	17	GROUND-WATER PROTECTION STRATEGY	EPA	08-84		
HG	62	GROUNDWATER	R. ALLAN FREEZE/JOHN A. CHERRY	1979		PERM. CHECK OUT TO RHETA SMITH
KU	15	GROUNDWATER BIBLIOGRAPHY - THIRD EDITION	WATER INFORMATION CENTER, INC.	1983		
ZZ	214	GROUNDWATER CLASSIFICATION	DOE/OR/21548-116	04-90	REV. 0	
HG	6	GROUNDWATER HYDROLOGY INVESTIGATION - WELDON SPRING, MO VOLS. I, II, III	LAYNE WESTERN CO., INC.	01-86	N/A	
HG	71	GROUNDWATER MONITORING REPORT FIRST YEARLY SAMPLING ROUND	IT-CORP	APR. 1993		
ZZ	220	GROUNDWATER PROTECTION PROGRAM MANAGEMENT PLAN	DOE/OR/21548-123	JUL. 1992	REV. 3	
HG	5	GROUNDWATER STUDY - WSS	LAYNE WESTERN CO., INC.	09-85	N/A	
HG	72	GROUNDWATER TREATMENT TECHNOLOGY	EVAN K. NYER	1992		PERM. CHECK OUT TO J. CARMAN
RG	134	GSI REGULATORY REFERENCE UPDATE SERVICE 49 CFR PARTS 106-180 SPRING - 93 EDITION	GSI & LABELMASTER	DEC. 1992		PERM CHECK OUT TO L. PHILLIPS
GR	197	GTGS VERSION 3.12 MANUAL UPDATE PACKAGE (ALSO INCLUDES DISK)	GTGS	NO DATE		PERM CHECK OUT TO L KLINGMULLE
RG	47	GUIDANCE DOCUMENT FOR CLEANUP OF SURFACE TANK & DRUM SITES	EPA	05-85		
RG	140	GUIDANCE DOCUMENT FOR COMPLIANCE WITH DOE ORDER 5000.3B	MK-F	MAR. 1993	REV. A	
HG	67	GUIDANCE DOCUMENT FOR PROVIDING ALTERNATE WATER SUPPLIES	EPA	FEB. 1988		PERM. CHECK OUT TO J. BOGNAR
RG	129	GUIDANCE FOR APPLICANTS FOR STATE WELLHEAD PROTECTION PROGRAM ASSISTANCE FUNDS UNDER THE SAFE DRINKING WATER ACT	EPA	JUNE 1987		PERM. CHECK OUT TO J. BOGNAR
RG	32	GUIDANCE FOR CONDUCTING REMEDIAL INVESTIGATIONS AND FEASIBILITY STUDIES UNDER CERCLA	EPA	10-88		INTERIM FINAL (3-88 INCLUDED)
RG	127	GUIDANCE FOR CONDUCTING REMEDIAL INVESTIGATIONS & FEASIBILITY STUDIES UNDER CERCLA (INTERIM FINAL)	EPA	OCT. 1988		PERM. CHECK OUT TO J. BOGNAR
RG	124	GUIDANCE FOR DATA USABILITY IN RISK ASSESSMENT	EPA	JUNE 1992		
RG	91	GUIDANCE FOR FEDERAL FACILITIES ON RELEASE NOTIFICATION REQUIREMENTS UNDER CERCLA AND SARA TITLE III	EPA	NOV 1990		
RG	17	GUIDANCE FOR PREPARATION OF COMBINED WORK/QUALITY ASSURANCE PROJECT PLANS FOR ENVIRONMENTAL MONITORING	EPA	05-84		
RG	132	GUIDANCE FOR PREPARATION OF SAFETY ANALYSIS REPORTS FOR NONREACTOR FACILITIES & OPERATIONS	DOE-OAK RIDGE	NOV. 1992	REV. 2	
RG	70	GUIDANCE MANUAL FOR DOE COMPLIANCE WITH THE NEPA & RELATED FEDERAL ENVIRONMENTAL STATUTES	NEPA	10-88		NEPA COMPLIANCE GUIDE (DRAFT)
RG	44	GUIDANCE ON IMPLEMENTATION OF THE "CONTRIBUTE TO REMEDIAL PERFORMANCE" PROVISION	EPA	04-87		
RG	76	GUIDANCE ON PREPARING SUPERFUND DECISION DOCUMENTS: THE PROPOSED PLAN THE RECORD OF DECISION EXPLANATION OF SIGNIFICANT DIFFERENCES THE RECORD OF DECISION AMENDMENT	EPA	07/89		INTERIM FINAL
HG	41	GUIDANCE ON REMEDIAL ACTIONS FOR CONTAMINATED GROUNDWATER AT SUPERFUND SITES	EPA	12-88		
PH	66	GUIDANCE ON REMEDIAL ACTIONS FOR SUPERFUND SITES	EPA	AUG 90		

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		WITH PCB CONTAMINATION				
RG	1	GUIDANCE ON REMEDIAL INVESTIGATIONS UNDER CERCLA/GUIDANCE ON FEASIBILITY STUDIES UNDER CERCLA	EPA	06-85	N/A	
RG	9	GUIDANCE ON THE DEFIN. & IDENTIFICATION OF COMMERCIAL MIXED LOW-LEVEL RAD. & HAZ. WASTE/COMBINED NRC-EPA GUIDELINES FOR DISPOSAL OF MIXED LOW-LEVEL RAD. & HAZ. WASTE/JOINT NRC-EPA GUIDANCE ON A CONCEPTUAL DESIGN APPROACH FOR COMMERCIALMIXED LOW-LEVEL RAD	NRC & EPA	01-87	N/A	
RG	107	GUIDE FOR CONDUCTING TREATABILITY STUDIES UNDER CERCLA INTERIM FINAL	EPA	DEC. 1989		
RG	136	GUIDE FOR DOE REVIEW OF CONTRACTOR OCCUPATIONAL MEDICAL PROGRAMS	DOE	APR. 1991		
RG	116	GUIDE FOR PERFORMANCE OF DOE CONTRACTOR PURCHASING SYSTEM REVIEWS (CPSR)	U.S. DOE	OCT. 1990		
EV	115	GUIDE TO ENVIRONMENTAL ANALYTICAL METHODS	GENIUM PUBLISHING CORP.	1992		PERM. CHECK OUT TO J. EVERETT
HP	52	GUIDE TO SAMPLING AIRBORNE RADIOACTIVE MATERIALS IN NUCLEAR FACILITIES	AMERICAN NATIONAL STANDARD	2-19-69		
RG	22	GUIDE TO THE DISPOSAL OF CHEMICALLY STABILIZED & SOLIDIFIED WASTE	EPA	09-82		
RG	79	GUIDELINES FOR CONTRACT CULTURAL RESOURCE SURVEY REPORTS AND PROFFESSIONAL QUALIFICATIONS	MoDNR	1-86		
RG	6	GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE	NRC	07-82	N/A	
RG	128	GUIDELINES FOR DELINEATION OF WELLHEAD PROTECTION AREAS	EPA	JUNE 1987		PERM. CHECK OUT TO J. BOGNAR
HG	18	GUIDELINES FOR GROUND-WATER CLASSIFICATION UNDER THE EPA GROUND-WATER PROTECTION STRATEGY	EPA	11-86		
PM	53	GUIDELINES FOR STRATEGIC PLANNING	DOE	JULY 91		
ZZ	328	GURU VERSION 1 USERS MANUAL	DOE/OR/21548-195	NOV. 1992	REV. 1	
HG	57	HANDBOOK FOR SAMPLING AND SAMPLE PRESERVATION OF WATER AND WASTEWATER	EPA	SEPT. 82		
HP	60	HANDBOOK FOR THE DEPARTMENT OF ENERGY LABORATORY ACCREDITATION PROGRAM FOR PERSONNEL DOSIMETRY SYSTEMS	DOE	12-86		
RG	114	HANDBOOK OF LABORATORY SAFETY 3RD EDITION	CRC PRESS	1991		PERM. CHECK OUT TO S. STUMNE
GR	116	HANDBOOK OF LAND TREATMENT SYSTEMS FOR INDUSTRIAL AND MUNICIPAL WASTES	REED/CRITES	1984		
RG	144	HANDBOOK OF RCRA GROUND-WATER MONITORING CONSTITUENTS CHEMICAL PHYSICAL PROPERTIES (40 CFR PART 264, APPENDIX 9)	EPA	SEP. 1992		
GR	210	HANDBOOK OF RCRA GROUNDWATER MONITORING CONSTITUENTS, CHEMICAL & PHYSICAL PROPERTIES (40 CFR PART 264, APPENDIX 9)	EPA	SEPT 1992		PERM. CHECK OUT TO A. GIBSON
YY	35	HANDOUT: A DESCRIPTION & ANALYSIS OF THE HAZARDOUS & TOXIC MATERIALS PRESENT ON THE WELDON SPRING SITE	02-88	02-88		PUBLIC PART
ZZ	401	HAZARD ASSESSMENT & CONTINGENCY PLAN FOR THE RELEASE OF UNTREATED QUARRY WATER	DOE/OR/21548-288	APRIL 92	REV. A	(NOT YET RECEIVED)
ZZ	69	HAZARD COMMUNICATION PROGRAM	DOE/OR/21548-049	AUG 1992	REV. 1	
RG	65	HAZARD COMMUNICATION STANDARD INSPECTION MANUAL	OSHA	03-89		
GR	156	HAZARDOUS CHEMICALS DESK REFERENCE 2ND EDITION (FOUR (4) BOOKS RECEIVED)	RICHARD R LEWIS, SR	1991		PERM CHECKOUT TO C. PROCTOR

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HP	96	HAZARDOUS CHEMICALS DESK REFERENCE THIRD EDITION	RICHARD J. LEWIS, SR.	1993		PERM. CHECK OUT TO B. FOX
ZZ	455	HAZARDOUS MATERIAL STORAGE PROGRAM PLAN	DOE/OR/21548-339	OCT. 1992	REV. 0	
KU	13	HAZARDOUS SOLID WASTE TESTING: FIRST CONFERENCE	ASTM	1983		
KU	3	HAZARDOUS WASTE & HAZARDOUS MATERIALS	NORMAN BEECHER	WINTER 87		
WM	45	HAZARDOUS WASTE CHEMISTRY, TOXICOLOGY AND TREATMENT	STANLEY E. MANAHAN	1990		SIGN OUT: M.E. NELSON (COMPL)
RG	4	HAZARDOUS WASTE LAND TREATMENT	BNI	04-83	N/A	
HP	86	HAZARDOUS WASTE MEASUREMENTS	M. SIMMONS	1991		PERM. CHECK OUT TO D. MIXSON
WM	43	HAZARDOUS WASTE MINIMIZATION	HARRY M. FREEMAN	1990		
ZZ	348	HEALTH & SAFETY GUIDEBOOK	DOE/OR/21548-211	AUG. 1992	REV. 1	
PM	101	HEALTH & SAFETY PLAN (HASP) USER'S GUIDE	EPA	MARCH 92		
EN	19	HEALTH-HAZARD EVALUATION DETERMINATION REPORT RADFORD ARMY AMMUNITION PLANT HERCULES INC., RADFORD, VIRGINIA	NTIS	09-80		
EN	20	HEALTH HAZARD EVALUATION REPORT OLIN CHEMICAL CO. MOUNDSVILLE, WEST VIRGINIA	NTIS	08-82		
HP	61	HEALTH PHYSICS MANUAL OF GOOD PRACTICES FOR URANIUM FACILITIES	IDAHO NATIONAL ENGINEERING LAB	JUNE 90		
HP	5	HEALTH PHYSICS PLAN & IMPLEMENTING PROCEDURES FOR THE WELDON SPRING SURVEY & ALTERNATIVES ASSESSMENT	RETA	07-77	86	
GR	222	HEALTHY MISSOURIANS 2000 VOLUME I	MO DEPT. OF HEALTH	NOV. 1992		
ZZ	88	HEARING CONSERVATION PROGRAM PLAN	DOE/OR/21548-293	DEC. 1992	REV. 1	
GR	12	HISTORICAL NUCLEAR MATERIALS BALANCE REPORT FOR THE FORMER AEC-OWNED WSCP	DOE/ORO	07-86	N/A	
HP	91	HUMAN LEAD EXPOSURE	NEEDLEMAN, H. L.	1992		PERM CHECK OUT TO R. GANAPATHY
EN	62	HYDRAULIC DESIGN OF STILLING BASINS AND ENERGY DISSPATORS	DOI			
GR	176	HYDRAULIC SCOURING OF PIPELINE TREATABILITY STUDY WORK PLAN WELDON SPRING ORDNANCE WORKS	IT CORPS.	SEPT 1992		
HG	19	HYDROGEOLOGIC & GEOCHEMICAL STUDIES OF SELECTED NATURAL RADIOISOTOPES & BARIUM IN GROUNDWATER IN ILLINOIS	ILLINOIS DEPT. OF ENERGY AND	05-83		
ZZ	40	HYDROGEOLOGIC INVESTIGATIONS SAMPLING PLAN	DOE/OR/21548-020	11-88	REV 0	
ZZ	24	HYDROGEOLOGIC INVESTIGATIONS WORK PLAN	DOE/OR/21548-004	11-87	DRAFT	
ZZ	28	HYDROGEOLOGIC INVESTIGATIONS WORK PLAN ABBREVIATED SUBMITTAL: PUMPING, OBSERVATION, & DEEP MONITORING WELLS	DOE/OR/21548-008	01-88	DRAFT	
HG	53	HYDROGEOLOGIC REPORT ENVIROCARE WASTE DISPOSAL FACILITY SOUTH CLIVE, UTAH	BINGHAM ENVIRONMENTAL	05-17-91		
HG	10	HYDROGEOLOGICAL CHARACTERIZATION REPORT FOR WSCP (DRAFT)	BNI	02-87	N/A	
HG	11	HYDROGEOLOGICAL CHARACTERIZATION REPORT FOR WSCP (DRAFT)	BNI	06-87	N/A	
HG	12	HYDROGEOLOGICAL CHARACTERIZATION REPORT FOR WSCP (FINAL)	BNI	07-87	N/A	
ZZ	119	HYDROGEOLOGICAL SAMPLING PLAN QUARRY RESIDUALS WSSRAP	DOE/OR/21548-233	DEC. 91	REV. B	
HG	65	HYDROGEOLOGY THE GEOLOGY OF NORTH AMERICA VOLUME O-2	ROSENSHEIN/SEABER	1988		PERM. CHECK OUT TO J. CARMAN
HG	13	HYDROLOGIC DATA FOR THE WELDON SPRING RADIOACTIVE WASTE-DISPOSAL SITES, ST. CHARLES COUNTY, MO 1984 - 1986	USGS/DOI	84-86	N/A	
HG	16	HYDROLOGY & WATER QUALITY AT THE WELDON SPRING	DOI	1987		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		RADIOACTIVE WASTE- DISPOSAL SITES, ST. CHARLES COUNTY MISSOURI				
MG	43	IMPACT OF PROPOSED WSSRAP WATER TREATMENT PLANT SITEWORK ON FLOOD ELEVATIONS IN LITTLE FEMME OSAGE CREEK	HORNER & SHIFRIN, INC.	3/90		
KU	26	IMPLEMENTATION MANUAL (HMIS) HAZARDOUS MATERIALS INDENTIFICATION SYSTEM REVISED	LABELMASTER	1981		PERM. CHECK OUT TO T. PAZ
GR	164	IMPLEMENTATION MANUAL FOR APPLICATION OF BEST-AVAILABLE TECHNOLOGY PROCESSES FOR RADIONUCLIDES IN LIQUID EFFLUENTS	U.S. DOE	JUNE 1992		
RG	123	IMPLEMENTATION PLAN FOR THE CLEAN AIR ACT AMENDMENTS OF 1990	MARTIN MARIETTA	JAN. 1992		
PM	100	IMPLEMENTATION PLAN FOR THE PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR THE DOE ENVIRONMENATL RESTORATION & WASTE MANAGEMENT PROGRAM	U.S. DOE	JULY 1992		
EV	61	IN SITU TREATMENT OF S-3 PONDS	OAK RIDGE-Y12	9-16-85		
DD	17	IN-SITU EXTRACTION/IMMOBILIZATION OF HEAVY METALS AND RADIONUCLIDES IN SOILS	NUCLEAR ASSURANCE CORP.	12-14-87		
GR	63	IN-SITU LEACHING DEVELOPMENT AND EVALUATION OF PROCESS OPTIONS				
EN	92	IN-SITU LEACHING: DEVELOPMENT & EVALUATION OF PROCESS OPTIONS	JACOBS ENGINEERING	NOV. 1992	REV. 0	
YY	3	INCIDENT REPORT (SWIMMING IN QUARRY)	07-23-87	07-23-87		PUBLIC PART
PM	89	INDEPENDENT COST ESTIMATE FOR WELDON SPRING SITE REMEDIAL ACTION PROJECT WELDON SPRING, MO. INDEPENDENT COST ESTIMATING CONTRACT WITH DOE FINAL REPORT	FOSTER WHEELER USA CORPORATION	JAN. 1992		VOLUMES 1 AND 2
GR	47	INDUSTRIAL & HAZARDOUS WASTE MANAGEMENT FIRMS 1989	ENVIRON. INFO., LTD.	1989		
YY	29	INFORMATION BROCHURE PREPARED FOR 05-23-88 SITE TOUR OF MISSOURI STATE LEGISLATURE	05-23-88	05-23-88		PUBLIC PART
GE	29	INFORMATION FOR GEOLOGICAL SOCIETY OF AMERICA	DOE	11-10-89		
ZZ	279	INFORMATION MANAGEMENT SYSTEM PLAN	DOE/OR/21548-156	AUG 91	REV. 1	
WM	28	INFORMATION SYSTEMS SURVEY VOLUME I WASTE TRACKING SYSTEMS	MANAGEMENT SYSTEMS LAB.	9-89		
YY	40	INFORMATIONAL MATERIAL DISTRIBUTED AS PART OF WSSRAP SITE TOUR FOR FRANCIS HOWELL SCHOOL BOARD	10-10-87	10-10-87		PUBLIC PART
YY	36	INFORMATIONAL MATERIAL FOR WSSRAP SITE TOUR FOR MOPIRG	01-14-88	01-14-88		PUBLIC PART
YY	74	INFORMATIONAL MATERIAL PRESENTED TO U.S. CONGRESSMAN HAROLD VOLKMER, SITE VISIT OF 01-06-89	01-06-89	01-06-89		
YY	41	INFORMATIONAL MATERIALS DISTRIBUTED ON WSSRAP SITE TOUR CONDUCTED FOR ASSOCIATION OF MISSOURI GEOLOGISTS	09-25-87	09-25-87		PUBLIC PART
ZZ	56	INITIAL ASSESSMENT OF THE EFFECT OF DROUGHT CONDITIONS ON CONTAMINANT MIGRATION FROM THE WELDON SPRING QUARRY	DOE/OR/21548-036	11-88	REV. 0	
RG	96	INPUFF 2.0 - A MULTIPLE SOURCE GAUSSIAN PUFF DISPERSION ALGORITHM. USERS GUIDE	EPA	AUG 86		
RG	98	INPUFF: A SINGLE SOURCE GAUSSIAN PUFF DISPERSION ALGORITHM. USERS GUIDE	EPA	10/84		
RG	100	INSPECTION AND ACCEPTANCE OF TECHNICAL DATA PACKAGES	DEPARTMENT OF DEFENSE			
GR	130	INSPECTION, TESTING & MAINTENANCE OF SPRINKLER SYSTEMS NFPA 13A 1987 EDITION	NFPA	1987		PERM. CHECK OUT TO C. WALTERS
EN	50	INSTALLATION ASSESSMENT OF WS TRAINING AREA ST.	U.S. ARMY	4-77		

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		CHARLES, MD				
GR	131	INSTALLATION OF SPRINKER SYSTEMS NFPA 13 1991 EDITION	NFPA	1991		PERM. CHECK OUT TO C. WALTERS
EV	2	INSTALLATION RESTORATION AT WSCP - ENVIRONMENTAL IMPACT ASSESSMENT	DOA	11-76	54	
PM	79	INSTRUCTIONS FOR GENERATING INPUTS FOR THE FY1994 APPLICATION OF THE DOE ENVIRONMENTAL RESTORATION PRIORITY SYSTEM	APPLIED DECISION ANALYSIS, INC	DEC. 1991	REV. 0	
RG	83	INTEGRATING NEPA AND CERCLA REQUIREMENTS DURING RESPONSES AT DOE FACILITIES	ORNL	JULY 90		
EN	55	INTEGRATION OF REMEDIAL DESIGN (RD) WITH AN ONGOING RI/FS: THE FERNALD EXPERIENCE	MARTIN MARIETTA	3-90		
BG	9	INTEGRATION OF THE RI/FS WITH THE RD/RA	MICHAEL J. HARTNETT / EPA			
ZZ	7	INTER-BUILDING INSULATION SAMPLING PLAN	11-86			
RG	81	INTERIM GUIDANCE ON ADMINISTRATIVE RECORDS FOR THE SELECTION OF CERCLA RESPONSE ACTIONS	USEPA	4-6-89		DRAFT
RG	36	INTERIM GUIDANCE ON POTENTIALLY RESPONSIBLE PARTY PARTICIPATION IN REMEDIAL INVESTIGATIONS & FEASIBI	EPA	05-88		
PM	20	INTERIM GUIDELINES & SPECIFICATIONS FOR PREPARING QUALITY ASSURANCE PROJECT PLANS	EPA	12-80		
HP	25	INTERIM INDOOR RADON AND RADON DECAY PRODUCT MEASUREMENT PROTOCOL	EPA	04-86	N/A	
BZ	3	INTERIM METHODS FOR THE SAMPLING AND ANALYSIS OF PRIORITY POLLUTANTS IN SEDIMENTS AND FISH TISSUES	EPA	10/80		
HP	43	INTERIM REPORT ON TEST CELL MONITORING	BECHTEL	JAN 91		
PM	15	INTERIM WORK PLAN FOR THE WELDON SPRING SITE REMEDIAL ACTION PROJECT	DOE/ORO	07-86	N/A	
HP	51	INTERNAL DOSE ASSESSMENT AND CONTROL		SEPT 87		
ZZ	356	INTERNAL DOSIMETRY PROGRAM TECHNICAL BASIS MANUAL	DOE/OR/21548-241	NOV. 1991	REV. 0	
EV	14	INTRODUCTION TO ENVIRONMENTAL LAWS & REGULATIONS FOR THE WELDON SPRING REMEDIAL ACTION PROGRAM	DOE	6-4,5 91		
EV	90	INVESTIGATION OF CONTAMINATED WASTE SHIPMENTS TO ROLLINS ENVIRONMENTAL SERVICES BATON ROUGE, LOUISIANA	DOE/ORO-974	JULY 1991		
GR	180	INVESTIGATION OF CUMULATIVE TRAUMA OCCUPATIONAL ILLNESS	MARTIN MARIETTA	FEB. 1992		FINAL DRAFT
GR	28	JAPAN ATOMIC ENERGY RESEARCH INSTITUTE ANNUAL REPORT	JAPAN ATOMIC ENERGY RESEARCH	03-87		
ZZ	178	JOB SAFETY ANALYSIS FOR CONTAINERIZED CHEMICAL SAMPLING, CONSOLIDATION, & REMOVAL INTERIM RESPONSE ACTION, WP056	DOE/OR/21548-086	05-89	REV. 0	IRA #7
GR	27	JPDR WORKSHOP	JAPAN ATOMIC ENERGY RESEARCH	02-88		
ZZ	508	JUSTIFICATION FOR RELEASE OF THE SITE WATER TREATMENT PLANT AREA FROM 'CONTROLLED AREA' STATUS	DOE/OR/21548-412	JUL. 1993	REV. 0	
ZZ	276	LABORATORY CAPABILITY REPORT	DOE/OR/21548-153	DEC 1990		(NOT YET RECEIVED)
ZZ	311	LABORATORY CHEMICAL HYGIENE PLAN	DOE/OR/21548-184	JAN 91	REV. 0	
EN	23	LABORATORY SOILS TESTING	DOA	11-30-70		ENGINEER MANUAL
BZ	13	LABORATORY TESTING OF SLUDGE SAMPLES	CHEN-NORTHERN, INC.			
GE	3	LABORATORY TESTING OF SOILS - WSSS	MCCLELLAND	07-83	25	(SUPERCEDED REPORT)
EV	45	LAKE AND STREAM SEDIMENT SAMPLING SPECIFICATION - FINAL REPORT	GEOTECHNOLOGY	12-88		INCLUDED IS ADDENDUM REPORT
KU	21	LASALLE ELECTRICAL UTILITIES SOIL AND GROUNDWATER	ECOLOGY AND ENV.	03/31/89		

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		REMEDIATION PHASE II CONSTRUCTION VOLUME II DIVISIONS 2 TO 16	ENG. OF ILL.			
HP	77	LEACHATE PLUME MANAGEMENT	NTIS	OCT 85		
YY	8	LETTER TO CONCERNED PARTIES FROM RODNEY R. NELSON RE: PUBLIC MEETING OF 12-06-88	11-22-88	11-22-88		PUBLIC PART
YY	6	LETTER TO DR. FREDERIC BRUNNER, DIRECTOR, STATE OF MISSOURI DEPT. OF NATURAL RESOURSES FROM RODNEY R. NELSON ANNOUNCING PUBLIC MEETING OF 12-06-88	11-22-88	11-22-88		PUBLIC PART
GR	91	LIFE SAFETY CODE HANDBOOK	NATIONAL FIRE PROTECTION ASSOC	1991		SIGN OUT: T. HEUER (SAFETY)
RG	23	LIGHT-WATER-REACTOR SAFETY FUEL SYSTEMS RESEARCH PROGRAMS: QUARTERLY PROGRESS REPORT VOLS. I THRU 4	ANL	1984		
YY	1	LINDA KOEHLER - ASBESTOS DISPOSAL AT J&Z LANDFILL IN WRIGHT CITY	08-24-88			PUBLIC PART
YY	4	LINDENWOOD COLLEGE MEETING RE: RI/FS-EIS WORK PLAN, INTERIM RESPONSE ACTIONS UPDATE	12-06-88	12-06-88		PUBLIC PART
PM	59	LINE ITEM PROJECT REVIEW & REPORTING USERS MANUAL	MARTIN MARIETTA ENERGY SYSTEM	02-08-91		
LN	8	LINER MATERIALS EXPOSED TO HAZARDOUS & TOXIC WASTES	EPA	11-84		
LN	4	LINING OF WASTE IMPOUNDMENT AND DISPOSAL FACILITIES	EPA	03-83	N/A	
CM	4	LIST OF ATTENDEES FOR THE WSSRAP SITE TOUR & PREPROPOSAL CONFERENCE	DOE	08-85	94	
PM	8	LONG-TERM MANAGEMENT OF EXISTING RADIOACTIVE MATERIAL IN THE VICINITY OF WELDON SPRING, MO - IMPLEMENTATION PLAN FOR THE ENVIRONMENTAL IMPACT STATEMENT	DOE	05-85	5	
HP	36	LONG-TERM PROTECTION OF URANIUM MILL TAILINGS	DOE	04-84		
ZZ	363	LOW PERMEABILITY BORROW INVESTIGATIONS GEOTECHNICAL INVESTIGATION SAMPLING PLAN	DOE/OR/21548-249	JAN. 92	REV. 0	
WM	20	LOW-LEVEL WASTE MANAGEMENT HANDBOOK SERIES ENVIRONMENTAL MONITORING FOR LOW-LEVEL WASTE DISPOSAL SITES	EG&G	9-89		
EV	63	MANAGEMENT APPRAISAL OF ENVIRONMENT, SAFETY, HEALTH AND QUALITY ASSURANCE ACTIVITIES OF THE WELDON SPRING SITE REMEDIAL ACTION PROJECT	DOE	2/90		
PM	93	MANAGEMENT AUDITS THE ASSESSMENT OF QUALITY MANAGEMENT SYSTEMS 2ND EDITION	A.J. SAYLE	1988		PERM. CHECK OUT TO A. GALLEGOS
PM	51	MANAGEMENT CONTROL SYSTEM SIMPLIFICATIONS AND "REDLINED" PROCEDURES	WILLIAM B. POORE & CO.	5-26-89		
BZ	2	MANAGEMENT OF BIRD & BAT MANURE	AEHA	01-85	N/A	
EN	98	MANAGEMENT OF BUILDING MATERIALS & DEBRIS VALUE ENGINEERING STUDY RESULTS (REPORT #3840-R-5400)	MK-SAN FRANCISCO	AUG. 1991	REV. 0	
ZZ	8	MANAGEMENT PLAN		07-87	REV. 1	(EF)
ZZ	488	MANAGEMENT PLAN FOR WP186 QUARRY BULK WASTE REMOVAL AND HAULING/TSA OPERATIONS AND MAINTENANCE	DOE/OR/21548-366	MAR. 1993	REV. 0	
GR	142	MANAGEMENT TEAMS - WHY THEY SUCCEED OR FAIL	R. MEREDITH BELBIN	1981		PERM. CHECKOUT TO GENE VALETT
PM	63	MANAGER'S FY 1991 ASSURANCE MEMORANDUM TO THE SECRETARY	DOE OAK RIDGE	OCT. 1991		
ZZ	216	MANUAL FOR CATEGORIZATION, NOTIFICATION & REPORTING OF 5000.3A OCCURRENCES	DOE/OR/21548-118	MARCH 92	REV. A	
HP	70	MANUAL OF ANALYTICAL METHODS FOR RADIOBIOASSAY	LOS ALAMOS NATIONAL LAB.	JULY 83		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
MG	46	MANUAL OF WATER WELL CONSTRUCTION PRACITCES	DEPT. OF COMMERCE	1977		
MP	62	MATERIAL SAFETY DATA SHEETS PHASE I AND II CONTAINERIZED CHEMICALS LOCATED IN BUILDING 434 RCRA/TSCA STORAGE AREA WSSRAP		9-90		
ZZ	285	MATERIAL STAGING AREA GEOTECHNICAL REPORT	DOE/OR/21548-162	DEC 1990	REV. 1	(NOT YET RECEIVED)
ZZ	252	MATERIAL STAGING AREA HEALTH AND SAFETY PLAN	DOE/OR/21548-132	JULY 90	REV. A	
EV	28	MATERIAL TEST REPORT/SLUDGE SAMPLING & TESTING SERVICES - WELDON SPRING RAFFINATE PITS	ESE	83/84	N/A	
MP	69	MEASUREMENTS FOR THE SAFE USE OF RADIATION PROCEEDINGS OF AN NBS ANNIVERSARY SYMPOSIUM (75TH)	U.S. DEPT. OF COMMERCE	NOV 1976		
ZZ	429	MEMORANDUM OF UNDERSTANDING	DOE/OR/21548-313	FEB. 1985	REV. 0	NOT YET RECEIVED
PM	7	MEMORANDUM OF UNDERSTANDING BETWEEN THE DOE & DOA CONCERNING TRANSFER OF CUSTODY & ACCOUNTABILITY FOR, & FUNDING OF REMEDIAL ACTIONS AT THE WSCP	OFFICE OF TERMINAL WASTE DISP.	02-85	7	
GR	67	METAL MELTING DEVELOPMENT AND EVALUATION OF PROCESS OPTIONS				
EN	90	METAL MELTING: DEVELOPMENT & EVALUATION OF PROCESS OPTIONS	JACOBS ENGINEERING	NOV. 1992	REV. 0	
EV	32	METHODS FOR ASSESSING ENVIRONMENTAL IMPACTS OF A FUSRAP PROPERTY-CLEANUP/INTERIM-STORAGE REMEDIAL ACTION	ANL	81/82	N/A	
GR	173	METHODS FOR CHEMICAL ANALYSIS OF WATER & WASTES - REVISED MARCH 1983	EPA	MARCH 83		
GR	203	METHODS FOR DETERMINING THE LOCATION OF ABANDONED WELLS	EPA	JAN. 1984		PERM. CHECK OUT TO J. BOGNAR
RG	103	METHODS FOR EVALUATING THE ATTAINMENT OF CLEANUP STANDARDS VOL. 1 : SOILS & SOLID MEDIA	EPA	FEB 1989		
RG	108	METHODS FOR MEASURING THE ACUTE TOXICITY OF EFFLUENTS TO FRESHWATER AND MARINE ORGANISMS (THIRD EDITION)	EPA	03/85	3RD EDIT	
RG	55	METHODS MANUAL FOR THE NATIONAL SURFACE WATER SURVEY PROJECT - PHASE I	EPA	02-84		
ZZ	329	MID YEAR 1991 MAY 16 AND 17, 1991	PMC	MAY 91		
GE	27	MIGRATION OF EXPLOSIVES IN SOIL	NSWC	12-82		
MP	48	MILDOS - A COMPUTER PROGRAM FOR CALCULATING ENVIRONMENTAL RADIATION DOSES FROM URANIUM RECOVERY OPERATIONS	PACIFIC NORTHWEST LAB FOR NRC	04-81		
EV	50	MILDOS-AREA: AN ENHANCED VERSION OF MILDOS FOR LARGE-AREA SOURCES	ANL	06-89		
LN	6	MINIMUM TECHNOLOGY GUIDANCE ON DOUBLE LINER SYSTEMS FOR LANDFILLS AND SURFACE IMPOUNDMENTS - DESIGN, CONSTRUCTION & OPERATION-2ND VER.	US DEPT. OF COMMERNCE	05-85	N/A	
RG	28	MISSOURI CLEAN WATER LAW	STATE OF MISSOURI	06-15-73	N/A	
GR	79	MISSOURI EIGHTY-SIXTH GENERAL ASSEMBLY FIRST REGULAR SESSION 1991 SUBJECT INDEX HOUSE AND SENATE BILLS AND JOINT RESOLUTIONS	HOUSE OF REPS. COMPUTER SERVIC	FEB 8, 90		
EV	92	MISSOURI ENVIRONMENTAL LAW HANDBOOK	GOVERNMENT INSTITUTES, INC.	MARCH 90		PERM CHECK OUT TO M. GILBERT
GE	20	MISSOURI GEOLOGY PRESENTS THE ULTIMATE CHALLENGE FOR HAZARDOUS WASTE DISPOSAL	M. BOLLMEIER	07-84		
RG	3	MISSOURI HAZARDOUS WASTE MANAGEMENT LAW/MISSOURI HAZARDOUS WASTE MANAGEMENT REGULATIONS 10CSR25	MDNR	10-86	N/A	
RG	29	MISSOURI REGISTER	STATE OF MISSOURI	10488	N/A	
RG	117	MISSOURI STANDARD SPECIFICATIONS FOR HIGHWAY CONSTRUCTION	MO. HIGHWAY & TRANSPORTATION	1990		PERM CHECK OUT TO DON FERGUSON
GR	10	MISSOURI'S COMMERCIAL VEHICLE REGULATIONS		1991		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
ZZ	17	MKE SUPPLEMENTAL SITE CHARACTERIZATION		12-86	DRAFT	
ZZ	394	MOBILE SUMP WATER TREATMENT SYSTEM OPERATION PLAN	DOE/OR/21548-279	JUNE 92	REV. 0	
ZZ	406	MOBILE SUMP WATER TREATMENT SYSTEM OPERATIONS & MAINTENANCE MANUAL	DOE/OR/21548-292	JUNE 92	REV. 0	(TWO (2) VOLUMES)
ZZ	407	MOBILE SUMP WATER TREATMENT SYSTEM PREOPERATIONAL TEST PROCEDURE	DOE/OR/21548-294	MAY 92	REV. 0	
ZZ	403	MOBILE WASTEWATER TREATMENT SYSTEM PRE-OPERATIONAL TEST	DOE/OR/21548-290	APRIL 92	REV. A	(NOT YET RECEIVED)
GR	23	MODEL GUIDE SPECIFICATIONS - ASBESTOS ABATEMENT IN BUILDINGS	NIBS	07-86	N/A	
HG	70	MODELING GROUNDWATER FLOW AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE	ANL	OCT. 1992		
GR	205	MODELING REMEDIAL ACTIONS AT UNCONTROLLED HAZARDOUS WASTE SITES	EPA	APR. 1985		PERM. CHECK OUT TO J. BOGNAR
GR	199	MODELING VERTICAL & HORIZONTAL SOLUTE TRANSPORT FOR THE WELDON SPRING SITE REMEDIAL ACTION PROJE	ANL	NOV. 1992		
PM	39	MODERN ENGINEERING & CONSTRUCTION MANAGEMENT SYSTEMS FOR THE MK PROFESSIONAL	MK-F	10-89		
ZZ	247	MODIFICATION M008 PROPOSAL FOR EQUITABLE ADJUSTMENT EXECUTIVE REVIEW	MK-FERGUSON	7/9/90		
RG	15	MONITORING FOR COMPLIANCE WITH DECOMMISSIONING TERMINATION SURVEY CRITERIA	NRC	06-81	N/A	
GR	72	MONITORING WATERLINE INSTALLATION THROUGH ARCHAEOLOGICAL SITES 23SC81 AND 23SC83 WELDON SPRING QUARRY REMEDIAL ACTION PROJECT ST. CHARLES COUNTY, MISSOURI	TRIAD RESEARCH SERVICES	9-10-90		
ZZ	335	MONITORING WELL HYDRAULIC CONDUCTIVITY TESTING PLAN FOR THE WSQ	DOE/OR/21548-201	JULY 91	REV. 0	
RG	60	MULTI-MEDIA COMPLIANCE INSPECTION MANUAL	EPA	10-87		
RG	42	N.R.C. REGULATION GUIDES	NRC			
EN	6	NATURAL DISASTERS REPORT - WSCP SURVEY & ASSESSMENT	RETA	05-78	48	
RG	145	NEC HANDBOOK 1993 (ALSO INCLUDES NATIONAL ELECTRICAL CODE 1993)	NFPA	1992		PERM. CHECK OUT TO J. ATCHISON
GR	182	NEW LABADIE FLY ASH BASIN: HYDRAULIC & LEACHING PROPERTIES OF SOILS, FLY ASHES, AND LIME-STABILIZED MIXTURES	BATTELLE	JAN. 1992		
RG	45	NFPA 232 - STANDARD FOR THE PROTECTION OF RECORDS	NATIONAL FIRE PROT. ASSOC.	1986		
GR	129	NFPA 72 INSTALLATION, MAINTENANCE, AND USE OF PROTECTIVE SIGNALING SYSTEMS 1990 EDITION	NFPA	08/17/92		PERM. CHECK OUT TO C. WALTERS
PM	24	NIAGARA FALLS STORAGE SITE INTERIM REMEDIAL ACTIONS 1982 - 1986 (CASE STUDY)	BECHTEL	82 - 86		
EV	59	NITRIC ACID DISPOSAL BY RECYCLE AND BIOLOGICAL DENITRIFICATION	OAK RIDGE-Y12	3-31-81		
RG	142	NON COMPLIANCE REPORTING REQUIREMENTS FOR THE TN, KY, & OH AND FEDERAL REGULATIONS FOR THE CLEAN WATER ACT & HAZARDOUS WASTE REGULATIONS	PEER CONSULTANTS	FEB. 1993		
RG	58	NPDES COMPLIANCE INSPECTION MANUAL	EPA	09-88		
RG	69	NPDES PERMIT HANDBOOK	GOV. INSTITUTES, INC.	04-89		
ZZ	448	NPDES STORM WATER PERMIT APPLICATION PHASE I SAMPLING REPORT	DOE/OR/21548-332	SEPT 1992	REV. 0	
ZZ	419	NPDES STORM WATER PERMIT APPLICATION SAMPLING PLAN	DOE/OR/21548-304	JUNE 1992	REV. 0	
ZZ	376	NQA-1, 1989 SUPPLEMENTS & APPENDIXES (ALSO INCLUDES NQA-2-1989 EDITION)	DOE/OR/21548-260	OCT. 1992		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
PM	1	NRC LICENSE APPLICATION FOR SOURCE MATERIAL LICENSE FOR POSSESSION OF SOURCE AND SPECIAL NUCLEAR MATERIAL PRESENT AS CONTAMINATION AT WSCP	DOA ARRCOM	04-77	52	
RG	34	NRC RULES & REGULATIONS PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION	NRC	12-31-87		
BG	2	NUCLEAR FACILITY DECOMMISSIONING & SITE REMEDIAL ACTION / A SELECTED BIBLIOGRAPHY - VOLUMES 1-13	ORNL	SEP. 1992		
EV	76	NUCLEAR SAFETY AND HEALTH COUNTERFEIT AND SUBSTANDARD PRODUCTS ARE A GOVERNMENTWIDE CONCERN	GENERAL ACCOUNTING OFFICE	OCT 90		
CM	7	OAK RIDGE MODEL CONFERENCE	ORNL	02-87	N/A	
PM	67	OAK RIDGE OPERATIONS FIELD OFFICE REPORT 1991 THROUGH 2ND QUARTER	EG&G IDAHO, INC.	SEPT 1991		
PM	91	OAK RIDGE OPERATIONS FIELD OFFICE REPORT 1991 THROUGH 4TH QUARTER	EG&G	2/27/92		
GR	71	OAK RIDGE OPERATIONS FIRE PREVENTION AND PROTECTION POLICIES 6TH EDITION - 1989	DOE	1989		
ZZ	409	OCCUPATIONAL EXPOSURE TO BLOODBORNE PATHOGENS-EXPOSURE CONTROL PLAN	DOE/OR/21548-296	MAY 1992	REV. 0	
RG	101	OCCUPATIONAL INJURY AND PROPERTY DAMAGE SUMMARY	U.S. DOE	JAN-SEP91		
ZZ	457	OFF-SITE ENGINEERING SUPPORT (DETAILED STUDY OF OFF-SITE ENGINEERING - WSSRAP PROJECT) PERFORMED JUL	DOE/OR/21548-341	AUG. 1992	REV. 0	CI #20
EV	43	OFF-SITE ENVIRONMENTAL MONITORING REPORTS (VARIOUS QUARTERLY & ANNUAL REPORTS)	MCW	1959-1965		
GR	200	OFF-SITE POPULATION RADIOLOGICAL DOSE & RISK ASSESSMENT FOR POTENTIAL AIRBURNE EMISSIONS FROM THE WELDON SPRING SITE	ANL	NOV. 1992		
ZZ	309	OFF-SITE RELEASE GUIDANCE FOR DEMOLITION RUBBLE AND DEBRIS FROM THE WSSRAP CHEMICAL PLANT AND QUARRY	DOE/OR/21548-205	DEC. 91	REV. 1A	
ZZ	305	OFF-SITE TRANSPORT AND DISPOSAL OPTIONS STUDY	DOE/OR/21548-176	NOV. 1992	REV. 0	
PM	95	OFFICE OF SELF ASSESSMENT ADMINISTRATIVE PROCEDURE OSA-AP-3 OSA PROGRESS ASSESSMENTS OF FIELD OFFICE ACTIVITIES	DOE OAK RIDGE FIELD OFFICE	MAY 92	REV. 0	
ZZ	118	ON-SITE CONTAMINATED RUBBLE AND SOIL MANAGEMENT REQUIREMENTS	DOE/OR/21548-232	OCT 91	REV. 1	
ZZ	340	ON-SITE TRANSPORTATION MANUAL FOR HAZARDOUS MATERIAL	DOE/OR/21548-244	JAN. 1993	REV. 1	
GR	154	OPEN HOUSE	COMMUNITY RELATIONS	JULY 92		
PM	94	OPERABLE UNIT 1 QUARTERLY REVIEW		MAY 92		
EN	32	OPERABLE UNIT FEASIBILITY STUDY PROTECTION OF PUBLIC WATER SUPPLY (DRAFT)	CH2M HILL	04-03-86		
EV	58	OPERATION AND MICROBIOLOGY OF BIOLOGICAL DENITRIFICATION SYSTEM FOR TREATING HIGHLY CONCENTRATED NITRATE WASTES	OAK RIDGE-Y12	5-16-80		
ZZ	396	OPERATION PLAN FOR THE WELDON SPRING QUARRY WATER TREATMENT PLANT	DOE/OR/21548-281	JUNE 1992	REV. 0	
ZZ	240	OPERATIONAL ENVIRONMENTAL, SAFETY AND HEALTH PLAN FOR THE WELDON SPRING QUARRY WATER TREATMENT PLANT AND BULK WASTE REMOVAL	DOE/OR/21548-126	5/90	REV. A	DRAFT
ZZ	388	OPERATIONAL PLAN MATERIAL STAGING AREA	DOE/OR/21548-273	JUNE 92	REV. 0	
ZZ	326	OPERATIONAL PLAN MATERIAL STAGING AREA PHASE I	DOE/OR/21548-192	MAY 1991	REV. 0	
GR	105	OPERATIONAL READINESS PROCESS READINESS REVIEW TEAM WORKSHOP	MARTIN MARIETTA	10/21/91		
ZZ	9	OPERATIONAL READINESS REVIEW PLAN		09-05-86	REV. 0	
ZZ	103	OPERATIONAL SCENARIO FOR WASTE REMOVAL,	PMC			

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		TRANSPORTATION AND RECLAMATION (TASK 814)				
EN	70	OPERATIONAL STRATEGY FOR THE TOXIC SUBSTANCE CONTROL ACT (TSCA) INCINERATOR	IT/MCGILL PCS	10/23/91		DRAFT REPORT
GR	56	OPERATOR'S MANUAL MODEL D-80/MD-80 - CUTTER		04-01-91		
GR	141	ORG PLUS ADVANCED USER'S GUIDE	IBM VERSION	MAY 91		PERM. CHECKOUT TO KATIE VOELL
RG	62	OSHA FIELD OPERATIONS MANUAL	OSHA	10-87		
RG	64	OSHA INDUSTRIAL HYGIENE TECHNICAL MANUAL	OSHA	05-88		
RG	63	OSHA SYSTEMS SAFETY INSPECTION GUIDE	OSHA	02-89		
RG	90	OSWER DIRECTIFE 9285.5-1	EPA			OFFICE OF EMERG.&REMEDIAL RESP
ZZ	162	OVERHEAD PIPING & SUPPORT REMOVAL INTERIM RESPONSE ACTION, WP017 , JOB SAFETY ANALYSIS	DOE/OR/21548-064	02-89	REV. 0	IRA #6
GE	22	OVERVIEW OF EARTHQUAKE HAZARD REDUCTION IN THE CENTRAL UNITED STATES	US GEOLOGICAL SURVEY USDI			
PM	58	OWNERSHIP REPORT, DEED, EASEMENT, PROPERTY SURVEY (PROVIDED FOR HAUL ROAD SURFACE OWNERSHIP)	ST. CHARLES CO. TITLE SERVICES			ORIGINAL IN ADMIN LEGAL FILES
EV	36	PATHWAY ANALYSIS MODELS USED FOR ASSESSMENT OF FORTY-FIVE WASTE SITE AREAS AT THE SAVANNAH RIVER PLANT	DU PONT	1987		
HP	49	PAVAN: AN ATMOSPHERIC DISPERSION PROGRAM FOR EVALUATING DESIGN BASIS ACCIDENTAL RELEASES OF RADIOACTIVE MATERIALS FROM NUCLEAR POWER STATIONS	PACIFIC NORTHWEST LAB FOR NRC	11-82		
ZZ	196	PCB ANNUAL REPORT - 1988	DOE/OR/21548-098	1988	REV. 0	
ZZ	254	PCB ANNUAL REPORT 1989	DOE/OR/21548-134	JAN 90		
ZZ	99	PCB SURVEY REPORT - BUILDING 401	12-87			IRA #11 (EMPTY FILE)
ZZ	93	PCB SURVEY REPORT - BUILDING 409	02-88			IRA #10
GR	21	PED: PRESSURIZED ELECTROOSMOTIC DEWATERING	HEATH,L.W.	1985	N/A	
GR	140	PERFORMANCE INDICATOR FOR 1ST QUARTER CY-1992	DOE OAK RIDGE FIELD OFFICE	JULY 92		PERM. CHECKOUT TO STEVE GREEN
ZZ	116	PERFORMANCE INDICATOR REPORT FOR 2ND QUARTER 1991	DOE/OR/21548-230	OCT 91	REV. 0	
ZZ	339	PERFORMANCE INDICATORS FOR 1ST QUARTER CY-1992	DOE/OR/21548-204	JUNE 92		
ZZ	507	PERFORMANCE INDICATORS FOR FIRST QUARTER CALENDAR YEAR 1993	DOE/OR/21548-415	JUL. 1993	REV. 0	
ZZ	367	PERFORMANCE INDICATORS FOR FOURTH QUARTER CALENDAR YEAR 1992	DOE/OR/21548-252	MAR. 1993		QUARTERLY
RG	143	PERFORMANCE OBJECTIVES & CRITERIA FOR TECHNICAL SAFETY APPRAISALS AT DEPARTMENT OF ENERGY FACILITIES & SITES	DOE	JUN. 1990		
WM	9	PERFORMANCE OBJECTIVES FOR DISPOSAL OF LOW-LEVEL RADIOACTIVE WASTES ON THE OAK RIDGE RESERVATION	ORNL	07-87		
HP	75	PERFORMANCE TESTING OF RADIOBIOASSAY LABORATORIES: IN-VITRO MEASUREMENTS PILOT STUDY REPORT	BATTELLE	DEC 84		
RG	121	PERFORMANCE-ORIENTED PACKAGING - A GUIDE TO IDENTIFYING, PROCURING, AND USING PROCUREMENT & USE OF PACKAGING USING HM-181 REGULATIONS	WESTINGHOUSE HANFORD CO.	SEPT 1992		
ZZ	11	PERMITTING PLAN		09-86	DRAFT	
PM	52	PERSONAL PROPERTY MANAGEMENT REVIEW	DOE	5-15-89		FINAL REPORT
ZZ	54	PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS MANUAL	DOE/OR/21548-034	APRIL 92	REV. 3	
GR	50	PERSONNEL EXPERTISE AND RESOURCE LISTING (PEARL)	DOE	FEB. 1993		
RG	49	PETITIONS TO DELIST HAZARDOUS WASTES	EPA	04-85		
ZZ	36	PHASE I CHEMICAL SOIL INVESTIGATION DATA REPORT FOR WSCP/WSRP	DOE/OR/21548-016	01-88		
EN	31	PHASE I REMEDIAL INVESTIGATION REPORT - CHEROKEE COUNTY, GALENA SUBSITE (FINAL DRAFT)	EPA	04-23-86		
ZZ	65	PHASE I SPRING AND SEEP REPORT (PHASE I SPRING	DOE/OR/21548-045	08-89	REV. 0	

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		AND SEEP SAMPLIN G PLAN)				
EV	54	PHASE I SURVEY & EVALUATION OF THE WSQ POTABLE WATERLINE PROJECT & PHASE II TESTING OF ARCHAEOLOGICAL SITES 23SC80, 23SC81 & 23S C83, ST. CHARLES COUNTY, MO	TRIACE RESEARCH SERVICES	10-05-89		
EN	52	PHASE I SURVEY AND EVALUATION OF THE PROPOSED WELDON SPRING QUARRY STOCKPILE	TRIAD RESEARCH	5/18/90		
ZZ	314	PHASE I WASTE CONTAINER ASSESSMENT WORK PLAN	DOE/OR/21548-188	NOV. 1991	REV. 1	
ZZ	205	PHASE II CHEMICAL CONSOLIDATION WORK PLAN	DOE/OR/21548-107	OCT. 90	REV. 1	
ZZ	176	PHASE II GROUNDWATER QUALITY ASSESSMENT FOR THE WELDON SPRING SITE, CHEMICAL PLANT, RAFFINATE PITS & SURROUNDING VICINITY PROPERTIES	DOE/OR/21548-078	09-89	REV. 0	
EN	3	PHASE II TECHNICAL REPORT: NARRATIVE SECTION	RETA	12-77	49	
GR	54	PHASE II TESTING & EVALUATION OF ARCHAEOLOGICAL SITE 23SC21, ST. CHARLES COUNTY, MO	TRIAD RESEARCH SERVICES	07-31-89		
EN	5	PHASE III REPORT: ASSESSMENT OF DISPOSITION ALTERNATIVES	RETA	05-78	47	
EN	65	PHASE III TESTING AND EVALUATION OF 23SC108, 23SC744 AND 23SC745, PROPOSED WSQ TO WSCP SITE BULK WASTE HAULAGE ROAD PROJECT AREA	TRIAD RESEARCH SERVICES	APRIL 91		
ZZ	244	PLAN FOR DETERMINATION OF BIOLOGICAL UPTAKE OF RADIONUCLIDES AND NITROAROMATICS IN SPECIES IN THE FOOD PATHWAYS AT THE WSS	MK-F	6-22-87	DRAFT	
ZZ	126	PLAN FOR ESTIMATING THE AVERAGE URANIUM CONCENTRATION OF THE WELDON SPRING CHEMICAL PLANT OVERHEAD PIPING INSULATION	DOE/OR/21548-052	01-89	REV. 0	IRA #1
ZZ	324	PLAN FOR MEETING THE REQUIREMENTS OF 40 CFR 61 FOR RADIONUCLIDE OTHER THAN RADON EMISSIONS AT WSS CRITICAL RECEPTORS		FEB 90		DRAFT
ZZ	241	PLAN FOR MONITORING RADIONUCLIDE EMISSIONS OTHER THEN RADON AT THE WELDON SPRING SITE CRITICAL RECEPTORS	DOE/OR/21548-127	JUNE 92	REV. 1	
ZZ	171	PLAN FOR RADIOLOGICAL SURVEY & RELEASE METHOD FOR CHEMICAL PLANT OVERHEAD PIPING & SUPPORTS	DOE/OR/21548-073	03-89	REV. 0	IRA #6
ZZ	26	PLAN FOR THE SAMPLING & ANALYSIS OF LAKE & STREAM SEDIMENTS INFLUENCED BY THE WELDON SPRING CHEMICAL PLANT DRAINAGE	DOE/OR/21548-006	11-87		
ZZ	494	PLAN FOR WORKING IN CONFINED SPACES	DOE/OR/21548-397	MAY 1993	REV. 0	
ZZ	248	PLANNING, ANALYSIS & CONTROLS SELF ASSESSMENT	PMC	APRIL 92		
RG	66	PLANS & SCHEDULES FOR IMPLEMENTATION OF U.S. NUCLEAR REGULATORY COMMISSION RESPONSIBILITIES UNDER THE LOW-LEVEL RADIOACTIVE WASTE POLICY AMENDMENTS ACT OF 1985 (P.L. 99-240)	NRC	08-87		
ZZ	360	PMC BASELINE EXECUTION PLAN	DOE/OR/21548-246	JUNE 92	REV. 0	CI #19
ZZ	10	PMC TRANSITION/RELOCATION PLAN		08-22-86		
ZZ	436	PMC WORK BREAKDOWN STRUCTURE DICTIONARY	DOE/OR/21548-320	SEPT 1992	REV. 1	CI #22
PM	64	POLICY INFORMATION BULLETIN NO. 91-27 APPLICATION OF DOE DIRECTIVES TO AWARDS OF DOE PROCUREMENT CONTRACTS. FINANCIAL ASSISTANCE, AND SALES CONTRACTS AND APPLICATION OF DOE DIRECTIVES TO MANAGEMENT AND OPERATING (M&O) CONTRACTS	DOE OAK RIDGE	06/14/91		
GE	9	POSSIBLE USE OF QUARRY AT M.C.W. WELDON SPRING FOR THE DISPOSAL OF URANIUM CONTAMINATED BUILDING DEBRIS & RUBBLE & RESIDUES CONTAINING THORIUM AND URANIUM	RICHARDSON, A.M. (USCGS)	06/11-60	N/A	ALSO GR0045
GR	45	POSSIBLE USE OF QUARRY AT MALLINCKRODT CHEMICAL	R.M. RICHARDSON	1960		ALSO GE009

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		WORKS, WELDON SPRING, MO, FOR THE DISPOSAL OF URANIUM CONTAMINATED BUILDING DEBRIS & RUBBLE & RESIDUES CONTAINING THORIUM & URANIUM				
ZZ	361	POTENTIAL RADIUM - 226 AND THORIUM REMEDIAL ACTION STANDARDS FOR THE WELDON SPRING SITE	DOE/OR/21548-247	DEC. 91	REV. A	
ZZ	117	POTENTIAL APPLICABLE OF RELEVANT AND APPROPRIATE REQUIREMENTS FOR RADIOLOGICAL EXPOSURE FROM THE WELDON SPRING SITE LAND DISPOSAL FACILITY	DOE/OR/21548-231	SEPT 91	REV. 0	NOT YET RECEIVED
HP	19	POTENTIAL RADIOLOGICAL IMPACTS ASSOCIATED WITH THE RELEASE OF CONTAMINATED WATER FROM THE WELDON SPRING ASH POND & BURGERMEISTER SPRING	ANL	NL	N/A	
HG	27	PRACTICAL GUIDE FOR GROUND-WATER SAMPLING	EPA	09-85		
HG	66	PRACTICAL HANDBOOK OF GROUND-WATER MONITORING	LEWIS PUBLISHERS	1991		PERM. CHECK OUT TO M. QUINONEZ
HP	53	PRACTICE FOR OCCUPATIONAL RADIATION EXPOSURE RECORDS SYSTEMS		3-14-66		
HG	50	PREDICTING THE FATE AND TRANSPORT OF ORGANIC COMPOUNDS IN GROUNDWATER		6-90		
RP	6	PRELIMINARY ANALYSIS OF CONTAINMENT MIGRATION FOR THE WELDON SPRING RAFFINATE PIT SITE	BNI	06-85	72	
HP	45	PRELIMINARY CHARACTERIZATION & ASSESSMENT OF THE WELDON SPRING L OW-LEVEL RADIOACTIVE WASTE DISPOSAL SITE, WELDON SPRING, MO	LBL	09-80		
GR	7	PRELIMINARY DRAFT: RADIOLOGICAL, HYDROGEOLOGICAL, GEOCHEMICAL, & GEOPHYSICAL ASSESSMENT OF THE WSQ DISPOSAL SITE	LBL	1/80	40	
DD	18	PRELIMINARY EVALUATION OF COSTS FOR DECONTAMINATING URANIUM SOIL CONTAMINATION TO VARIOUS LEVELS AND ASSOCIATED RADIOLOGICAL DOSES FROM RESIDUAL RADIOACTIVITY AT THE U.S. DEPARTMENT OF ENERGY WELDON SPRING SITE	DAMES & MOORE	3-89		
HG	1	PRELIMINARY INVESTIGATION OF GROUNDWATER OCCURRENCES IN THE WELDON SPRING AREA	DOI	12-51	64	
HP	1	PRELIMINARY RADIOLOGICAL SURVEY OF THE WSCP	BRL	04-76	55	
WM	19	PRELIMINARY REVIEW OF THE SITE SUITABILITY OF SCHUYLKILL METALS CORP. LEAD SMELTER SLAG LANDFILL	W. H. FULLER, UNIV. OF AZ	02-87		
HP	9	PRELIMINARY RISK ASSESSMENT OF THE WELDON SPRING ROCK QUARRY	SAI	09-79	43	
ZZ	219	PRELIMINARY SITE DEVELOPMENT PLAN	DOE/OR/21548-121	04-90	REV. 0	
HP	74	PRELIMINARY STUDY OF URANIUM OXIDE DISSOLUTION IN SIMULATED LUNG FLUID	LOS ALAMOS NAT. LAB	JAN 85		
GR	58	PREPAR - A USER-FRIENDLY PREPROCESSOR TO CREATE AIRDOS-EPA INPUT DATA SETS	ORNL	AUG. 1984		
EV	87	PREPARATION OF SOIL SAMPLING PROTOCOL: TECHNIQUES AND STRATEGIES	ENVIRONMENTAL RESEARCH CENTER	MAY 1983		
HP	73	PREPRECISION MEASUREMENT AND CALIBRATION STATISTICAL CONCEPTS AND PROCEDURES	NTIS	FEB 1969		
HG	47	PRESCRIBED PROCEDURES FOR MEASUREMENT OF RADIOACTIVITY IN DRINKING WATER	EPA	08/1980		
HP	54	PRESCRIBED PROCEDURES FOR MEASUREMENT OF RADIOACTIVITY IN DRINKING WATER	EPA	08-80		
YY	50	PRESS RELEASE RE: ANNOUNCEMENT OF CHANGE IN LOCATION FOR THE PUBLIC HEARING ON THE DEIS	03-16-87	03-16-87		PUBLIC PART
YY	27	PRESS RELEASE RE: ANNOUNCING PUBLIC MEETING OF 09-15-87	09-03-87	09-03-87		PUBLIC PART
YY	61	PRESS RELEASE RE: DEIS TO BE MAILED BY END OF	02-24-87			PUBLIC PART

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		WEEK				
YY	57	PRESS RELEASE RE: DOE PUBLISHES TWO NEW REPORTS ON WELDON SPRING CHEMICAL PLANT	07-17-86	07-17-86		PUBLIC PART
YY	60	PRESS RELEASE RE: DOE PUBLISHES WATER QUALITY PHASE I ASSESSMENT REPORT	12-30-87	12-30-87		PUBLIC PART
YY	62	PRESS RELEASE RE: DOE PUBLISHES WATER QUALITY PHASE I ASSESSMENT REPORT	12-30-87			PUBLIC PART
YY	76	PRESS RELEASE RE: DOE TO FUND INDEPENDENT WELL MONITORING FOR WSSRAP	03-24-89	03-24-89		
YY	75	PRESS RELEASE RE: GROUNDWATER MONITORING PROGRAM RESULTS EVALUATION FOR ST. CHARLES COUNTY WELL FIELD	03-16-89	03-16-89		
YY	51	PRESS RELEASE RE: LINDENWOOD COLLEGE TO HOST DEIS HEARING ON WELDON SPRING	03-02-87	03-02-87		PUBLIC PART
YY	53	PRESS RELEASE RE: LINDENWOOD COLLEGE TO HOST DEIS HEARING ON WELDON SPRING	03-02-87	03-02-87		PUBLIC PART
YY	26	PRESS RELEASE RE: PCB'S REMOVED FROM WELDON SPRING SITE	09-06-88	09-06-88		PUBLIC PART
YY	44	PRESS RELEASE RE: PLANNED INTERIM RESPONSE ACTIONS	09-03-87	09-03-87		PUBLIC PART
YY	52	PRESS RELEASE RE: PUBLIC AVAILABILITY OF WSSRAP DEIS AND ANNOUNCEMENT OF 03-13-87 & 03-14-87 PUBLIC INFORMATION MEETINGS	02-24-87	02-24-87		PUBLIC PART
YY	32	PRESS RELEASE RE: PUBLIC MEETING OF 02-25-88	02-11-88	02-11-88		PUBLIC PART
YY	48	PRESS RELEASE RE: RELEASE OF PRELIMINARY RESULTS FROM WEL MONITORING PROGRAM AT WELDON SPRING SITE	04-14-87	04-14-87		PUBLIC PART
YY	56	PRESS RELEASE RE: RODNEY R. NELSON NAMED DOE SITE MANAGER FOR WSSRAP	09-12-86	09-12-86		PUBLIC PART
YY	28	PRESS RELEASE RE: SAMPLING, CONSOLIDATION, AND DISPOSAL OF CONTAINERIZED CHEMICALS AT THE WELDON SPRING SITE	08-88	08-88		PUBLIC PART
YY	46	PRESS RELEASE RE: NO NITROAROMATICS, INCLUDING TNT AND 2,6 DNT IN SIX WELLS NEAR WELDON SPRING SITE	05-04-87	05-04-87		PUBLIC PART
YY	39	PRESS RELEASE: ADMINISTRATION BUILDING DISMANTLING CONTRACT AWARD	10-07-88	10-07-88		PUBLIC PART
YY	47	PRESS RELEASE: ANNOUNCING EXTENSION OF PUBLIC COMMENT PERIOD FOR DEIS COMMENTS	04-17-87	04-17-87		PUBLIC PART
YY	45	PRESS RELEASE: ISSUANCE OF REVISED DEIS	05-87	05-87		PUBLIC PART
YY	37	PRESS RELEASE: PUBLIC AVAILABILITY OF ASH POND EE/CA	11-09-87	11-09-87		PUBLIC PART
YY	38	PRESS RELEASE: PUBLIC AVAILABILITY OF FOUR IRA WORK PLANS & COMMENT PERIOD	10-16-87	10-16-87		PUBLIC PART
YY	24	PRESS RELEASE: PUBLIC AVAILABILITY OF RI/FS-EIS WORK PLAN FOR THE WSSRAP	11-09-88	11-09-88		PUBLIC PART
YY	23	PRESS RELEASE: PUBLIC INFORMATION MEETING OF 12-06-88	11-21-88	11-21-88		PUBLIC PART
EV	106	PRINCIPLES OF ENVIRONMENTAL SAMPLING	AMERICAN CHEMICAL SOCIETY	1988		PERM. CHECK OUT TO L. PHILLIPS
PM	73	PRINTING AND PUBLISHING ACTIVITIES THREE-YEAR PLAN FY 1991 - FY 1993	DOE	FEB. 1990		
PM	80	PRIORITY INPUT PROGRAM FOR PRIORITY SYSTEM SCORING AND REPORTING	APPLIED DECISION ANALYSIS, INC	DEC. 1991		USER'S GUIDE
GE	23	PROBABILISTIC ESTIMATES OF MAXIMUM ACCELERATION AND VELOCITY IN ROCK IN THE CONTIGUOUS UNITED STATES	DOI	1982		GEOLOGICAL SURVEY
EV	35	PROBABLE MAXIMUM PRECIPITATION ESTIMATES, U. S.	DOA	06-78		(INCLUDES VOL. 52 -

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		EAST OF THE 105TH MERIDAN VOL. 51				
RG	88	PROCEDURE MANUAL ESTIMATION OF AVERAGE INDOOR RADON-DAUGHTER CONCENTRATIONS USING FILTERED ALPHA-TRACK METHOD	UNC GEOTECH	APRIL 88		
HP	44	PROCEDURES FOR SAMPLING RADIUM-CONTAMINATED SOILS	DOE	10-85		
HG	35	PROCEDURES FOR THE COLLECTION & PRESERVATION OF GROUNDWATER & SURFACE WATER SAMPLES & FOR THE INSTALLATION OF MONITORING WELLS	DOE	10-85		
DD	13	PROCEEDINGS OF A MEETING ON TEACEABILITY FOR IONIZING RADIATION MEASUREMENTS HELD AT NATIONAL BUREAU OF STANDARDS, GAITHERSBURG, MD, ON MAY 8-9, 1980	NTIS	FEB 82		
ZZ	331	PROCEEDINGS OF THE GEOSCIENCES WORKSHOP	DOE/OR/21548-197	FEB 21,91		
CM	26	PROCEEDINGS OF THE WORKSHOP ON THE MANAGEMENT OF URANIUM-BEARING WASTES, POLLARD AUDITORIUM, OAK RIDGE, TN	ORNL	5-12-88		
WM	22	PROCEEDINGS OF THE WORKSHOP ON THE MANAGEMENT OF URANIUM-BEARING WASTES, POLLARD AUDITORIUM, OAK RIDGE, TN	ORNL	05-12-88		
HP	46	PROCESS DESCRIPTION & RESULTANT RADIOLOGIC CONTAMINATION FROM OPERATIONS OF THE AEC - WSCP 1956-1967	NLO	10-76		
WM	10	PROCESS DESIGN MANUAL SLUDGE TREATMENT & DISPOSAL	EPA	09-79		
RP	7	PROCESSING RADIOACTIVE WASTES & URANIUM MILL TAILINGS FOR SAFE ECOLOGICALLY-ACCEPTABLE DISPOSAL (STABILIZATION TECHNIQUE)	MANCHAK,F.	05-82	N/A	
GR	132	PROCUREMENT QUALITY CONTROL 4TH EDITION AMERICAL SOCIETY FOR QUALITY CONTROL VENDOR-VENDEE TECHNICAL COMMITTEE	BOSSERT J.L.	1988		PERM. CHECK OUT TO P. CATE
ZZ	148	PRODUCTIVITY IMPROVEMENT PROGRAM PLAN	DOE/OR/21548-053		REV.0	
PM	103	PROFESSIONAL ENVIRONMENTAL MANAGEMENT & AUDITING	BOWMAN	1992		PERM. CHECK OUT TO D. TAYLOR
ZZ	261	PROGRAM DOCUMENTATION PLAN	DOE/OR/21548-139	8-90	REV. 0	
PM	117	PROGRAM PERFORMANCE ASSESSMENT OF DOE & DOE CONTRACTOR MANAGEMENT OF OCCUPATIONAL INJURY AND ILLNESS RECORDKEEPING AND REPORTING EXECUTIVE SUMMARY	DOE	JUN. 1992		
PM	118	PROGRAM PERFORMANCE ASSESSMENT OF DOE & DOE CONTRACTOR MANAGEMENT OF OCCUPATIONAL INJURY AND ILLNESS RECORDKEEPING AND REPORTING OAK RIDGE FIELD OFFICE	DOE	JUN. 1992		
DD	3	PROGRAM PLAN FOR THE DECONTAMINATION & DISPOSITION OF WSCP	ROCKWELL INTL.	09-79	42	
PM	34	PROGRAM PLAN FY 1989 - SURPLUS FACILITIES MANAGEMENT PROGRAM	DOE	11-88		
KU	7	PROGRESS & IMPROVEMENTS IN LABORATORY RESEARCH PILOT PLANT DEVELOPMENT PRODUCTION TECHNOLOGY				
GR	218	PROHIBITION ON THE PLACEMENT OF BULK LIQUID HAZARDOUS WASTE IN LANDFILLS - STATUTORY INTERPRETIVE GUIDANCE -	EPA	JUN. 1986		
ZZ	308	PROJECT BASELINE	DOE/OR/21548-180	MAY 1991	REV. 1	
PM	16	PROJECT CHARTER FOR WSSRAP	DOE	05-86	N/A	
PM	113	PROJECT CONTROL SYSTEM GUIDELINES IMPLEMENTATION REFERENCE MANUAL	DOE	DEC. 1992	DRAFT	PERM CHECK OUT TO M. ANKROM
ZZ	449	PROJECT MANAGEMENT CONTRACTOR QUALITY ASSURANCE PROGRAM	DOE/OR/21548-333	SEPT 1992	REV. 0	

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
ZZ	68	PROJECT MANAGEMENT PLAN	DOE/OR/21548-048	1-90	REV. C	DRAFT
PM	111	PROJECT MANAGER'S PROGRESS REPORT	DOE	DEC. 1992		
ZZ	426	PROJECT PLAN FOR WELDON SPRING SITE REMEDIAL ACTION PROJECT	DOE/OR/21548-310	AUGUST 91	REV. 3	FILED IN PM-017
PM	17	PROJECT PLAN FOR WSSRAP	DOE	MAY 91	REV. 3	
ZZ	12	PROJECT PROCUREMENT PLAN		08-86	REV. 0	
ZZ	194	PROPERTY MANAGEMENT PLAN	DOE/OR/21548-096	MARCH 92	REV. 3	
DD	8	PROPOSAL FOR DECONTAMINATION OF LATTY AVENUE STORAGE SITE	RETA	05-72		
ZZ	259	PROPOSAL FOR EQUITABLE ADJUSTMENTS CONSEQUENT TO DOE ORDER 5400.1 (GENERAL ENVIRONMENTAL PROTECTION PROGRAM)	MK-F	JUNE 90		
HP	88	PROPOSAL FOR EQUITABLE ADJUSTMENTS DOE ORDER 5000.3A OCCURRENCE REPORTING AND PROCESSING OF OPERATIONS INFORMATION	PHC	JUNE 92		
GR	171	PROPOSAL FOR EQUITABLE ADJUSTMENTS FEDERAL FACILITY AGREEMENT	MK-FERGUSON	AUG. 1992		
GR	99	PROPOSAL FOR EQUITABLE ADJUSTMENTS PCB MATERIALS ON SUBSTATION 411	MKFW & JEGW	DEC. 1991		
GR	112	PROPOSAL FOR EQUITABLE ADJUSTMENTS QUARTERLY ENVIRONMENTAL DATA SUMMARY REPORT	MKFW & JEGW	MARCH 92		
GR	170	PROPOSAL FOR EQUITABLE ADJUSTMENTS SEN-15-90 & DOE ORDER 5440.1D REVISED NEPA COMPLIANCE PROCEDURES	MK-FERGUSON	AUG. 1992		
EN	82	PROPOSAL FOR EQUITABLE ADJUSTMENTS VALUE ENGINEERING	MKFW AND JEGW	JAN. 1992		DRAFT
EN	28	PROPOSAL FOR FORMERLY UTILIZED SITE REMEDIAL ACTION PROGRAM ENGINEERING EVALUATIONS	FOR BACON & DAVIS UTAH, INC.	12-21-79		
EV	42	PROPOSAL FOR FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM ENVIRONMENTAL ANALYSES	FORD BACON & DAVIS UTAH, INC.	12-18-79		
ZZ	223	PROPOSAL FOR INSURANCE MODIFACTION	MK-F	12-89		
ZZ	55	PROPOSED INTERIM RESPONSE ACTION #13 ARMY VICINITY PROPERTIES	DOE/OR/21548-035	08-88	REV. 0	IRA #13
ZZ	52	PROPOSED INTERIM RESPONSE ACTION #3 MATERIAL STAGING AREA	DOE/OR/21548-032	07-88	REV. 0	IRA #3
ZZ	57	PROPOSED INTERIM RESPONSE ACTION #5 AUGUST A. BUSCH & WELDON SPRING WILDLIFE AREA VICINITY PROPERTIES	DOE/OR/21548-037	08-88	REV. 0	IRA #5
ZZ	60	PROPOSED IRA: CONSTRUCTION ASH POND ISOLATION SYSTEM AT WELDON SPRING SITE	DOE/OR/21548-040	05-88	ANL	IRA #2
ZZ	251	PROPOSED MATERIAL STAGING AREA CHARACTERIZATION REPORT	DOE/OR/21548-131	AUGUST 90	REV. A	
PM	33	PROPOSED PLAN FOR INTERIM MANAGEMENT OF DIOXIN-CONTAMINATED SOIL STOUT POTRION OF THE MINKER/STOUT/ROMAINE CREEK SITE	EPA	08-87		
PM	40	PROPOSED PLAN FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE	DOE/OR/21548-160 (ANL)	SEP 91		PRELIMINARY WORKING DRAFT
QY	2	PROPOSED PLAN FOR THE MANAGEMENT OF BULK WASTES AT THE WELDON SPRING QUARRY, WELDON SPRING, MISSOURI	DOE/OR/21548-105 (ANL)	FEB 90		
ZZ	203	PROPOSED PLAN FOR THE MANAGEMENT OF BULK WASTES AT THE WELDON SPRING QUARRY	DOE/OR/21548-105	02-90	ANL	FILED: QY-002
ZZ	283	PROPOSED PLAN FOR THE REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE	DOE/OR/21548-160	NOV. 1992		WORK. DRAFT (FILED: PM-40)
RG	38	PROPOSED REVISIONS TO THE NATIONAL CONTINGENCY PLAN	DOE	02-88		
RG	16	PROPOSED RULEMAKING EXEMPTION FROM LICENSING REQUIREMENTS FOR SMELTED ALLOYS CONTAINING	NRC	10-80	N/A	

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
WH	5	RESIDUAL TECHNETIUM-99 & LOW-ENRICHED URANIUM PROPOSED SAMPLING & ANALYTICAL METHODOLOGIES FOR ADDITION TO TEST METHODS FOR EVALUATING SOLID WASTE PHYSICAL/CHEMICAL METHODS SW-846 (2ND EDITION)	EPA	1984	N/A	
EN	89	PROPOSED WORK PLAN & COST PROPOSAL FOR PERFORMING THE EPA MENTOD 9090 TESTS OF THE GUNDLE 60-MIL HDPE GEOMEMBRANE WITH THE WASTE LIQUID FROM THE QUARRY WTP SITE	MATRECON (H. HAXO)	JAN. 1993		ORIG. GIVEN TO J. WILLIAMS
KU	12	PROTECTION OF PUBLIC WATER SUPPLIES FROM GROUND-WATER CONTAMINATION	NOYES DATA CORPORATION (NDC)	1987		
GR	76	PROTOCOL FOR THE ESTIMATION OF AVERAGE INDOOR RADON-DAUGHTER CONCENTRATIONS SECOND EDITION	UNC GEOTECH	MAY 1988		RECEIVED JUNE 1988
PM	98	PROTOCOLS FOR CONDUCTING ENVIRONMENTAL MANAGEMENT AUDITS	U.S. DOE	JULY 1992	DRAFT	
GR	1	PUBLIC AFFAIRS PLAN FOR SURVEY & ASSESSMENT OF WSCP	DOA	NONE	87	
SE	2	PUBLIC AFFAIRS PLAN FOR SURVEY & ASSESSMENT OF WELDON SPRING CHEMICAL PLANT, ST. CHARLES, MO	DOA	1977		
CM	20	PUBLIC COMMENT DRAFT FEASIBILITY STUDY - TIMES BEACH SITE, TIMES BEACH, MO	EPA	12-14-86		
CM	18	PUBLIC COMMENT DRAFT OPERABLE UNIT FEASIBILITY STUDY - ROMAINE CREEK PORTION OF THE MINKER/STOUT/ROMAINE CREEK SITE, IMPERIAL, MO	BLACK & VEATCH	07-08-87		
CM	19	PUBLIC COMMENT DRAFT OPERABLE UNIT FEASIBILITY STUDY - STOUT PORTION OF THE MINKER/STOUT/ROMAINE CREEK SITE, IMPERIAL, MO	BLACK & VEATCH	07-08-87		
YY	68	PUBLIC NOTICE IN MESSENGER TRIBUNE ANNOUNCING 02-13 & 14-89 PUBLIC MEETINGS	02-08-89	02-08-89		ATTACHED TO LTR. 118 & 119 D/O
YY	66	PUBLIC NOTICE IN ST. CHARLES JOURNAL ANNOUNCING 12-06-88 PUBLIC MEETING	12-08-88	12-02-88		
YY	67	PUBLIC NOTICE IN ST. CHARLES JOURNAL ANNOUNCING 12-06-88 PUBLIC MEETING	12-04-88	12-04-88		
YY	30	PUBLIC NOTICE OF 02-25-88 PUBLIC MEETING	02-25-88	02-25-88		PUBLIC PART
YY	42	PUBLIC NOTICE OF 09-15-87 PUBLIC MEETING	09-87	09-87		PUBLIC PART
YY	22	PUBLIC NOTICE OF 12-06-88 PUBLIC INFORMATION MEETING	12-06-88	12-06-88		PUBLIC PART
YY	49	PUBLIC NOTICE OF PUBLIC HEARING OF 04-10-87 AT HOLLENBECK JUNIOR HIGH	04-87	04-87		PUBLIC PART
YY	59	PUBLIC NOTICE RE: PUBLIC INFORMATION MEETINGS OF 03-13 & 14-87	03-87	03-87		PUBLIC PART
YY	7	PUBLIC SERVICE ANNOUNCEMENT - PUBLIC MEETING OF 12-06-88	12-06-88	12-06-88		PUBLIC PART
YY	9	PUBLIC SERVICE ANNOUNCEMENT - PUBLIC MEETING AT FRANCIS HOWELL HIGH SCHOOL	02-25-88	02-25-88		PUBLIC PART
YY	17	PUBLIC SERVICE ANNOUNCEMENT OF PUBLIC HEARING TO RECEIVE COMMENTS ON THE DRAFT EIS	04-10-87	04-10-87		PUBLIC PART
YY	65	PUBLIC SERVICE ANNOUNCEMENT OF WASRAP PUBLIC MEETING OF 09-15-87	07-09-87	07-09-87		
RG	56	QUALITY ASSURANCE HANDBOOK FOR AIR POLLUTION MEASUREMENT SYSTEMS: VOL. III. STATIONARY SOURCES SPECIFIC METHODS	EPA	08-88		
RG	95	QUALITY ASSURANCE HANDBOOK FOR AIR POLLUTION MEASUREMENT SYSTEMS VOL. III - AMBIENT AIR SPECIFIC METHODS	EPA	MAY 1977		SIGN OUT: R. MEDORA (ES&H)
ZZ	435	QUALITY ASSURANCE MANAGEMENT POLICY	DOE/OR/21548-319	JUNE 92	REV. A	NOT YET RECEIVED

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
GR	70	QUALITY ASSURANCE MANUAL	METATRACE, INC.	JULY 87		
HP	58	QUALITY ASSURANCE MANUAL FOR THE DEPARTMENT OF ENERGY LABORATORY ACCREDITATION PROGRAM FOR PERSONNEL DOSIMETRY SYSTEMS	DOE	2/87		
ZZ	131	QUALITY ASSURANCE PLAN FOR CONTAINERIZED WASTE HANDLING - METCALF AND ASSOCIATES, INC.	WP056			IRA #7
RG	54	QUALITY ASSURANCE PLAN FOR THE NATIONAL SURFACE WATER SURVEY PROJECT - PHASE I	EPA	02-83		
RG	139	QUALITY ASSURANCE PROGRAM FOR DOE FACILITIES	MK		REV. 0	
ZZ	20	QUALITY ASSURANCE PROGRAM PLAN		03-29-91	REV. 4	
RG	97	QUALITY ASSURANCE PROGRAM REQUIREMENTS FOR NUCLEAR FACILITIES	AMER. SOCIETY OF MECHAN. ENGIN	89		1986 EDITION
HP	55	QUALITY ASSURANCE PROJECT PLAN FOR ANALYTICAL SUPPORT SERVICES FOR THE CHEMICAL ANALYSIS OF SAMPLES FROM THE WSSRAP	MAXWELL	12-7-90		
EN	87	QUALITY ENGINEERING HANDBOOK	PYZDEK & BERGER	1992		PERM. CHECK OUT TO P. CATE
BZ	7	QUANTITAVE BASES FOR DEVELOPING A UNIFIED INDEX OF HARM	INT'L COMMISSION ON RAD PROTEC	1985		
ZZ	484	QUARRY BULK WASTE REMOVAL AND HAULING/TEMPORARY STORAGE AREA OPERATIONS & MAINTENANCE OPERATIONAL READINESS REVIEW PLAN	DOE/OR/21548-381	FEB. 1993	REV. 0	
GR	152	QUARRY BULK WASTE REMOVAL ROD; COMMUNITY RELATIONS ACTIVITIES	COMMUNITY RELATIONS	JULY 92		
ZZ	14	QUARRY CONCEPTUAL DESIGN REPORT		04-87	REV. 1	
ZZ	334	QUARRY CONSTRUCTION STAGING AREA & WATER TREATMENT PLANT SITE REMEDIAL ACTION CHARACTERIZATION REPORT	DOE/OR/21548-200	SEPT 91	REV. 0	
ZZ	111	QUARRY DETECTION MONITORING WELLS COMPLETION REPORT WP166	DOE/OR/21548-224	SEPT 91	REV. 0	
EN	75	QUARRY FLEXIBLE LINER INVESTIGATION AND ASSESSMENT OF TITLE III CONSTRUCTION INSPECTION PROGRAM	MKES SAN FRANCISCO	JAN. 1992	REV. 0	REPORT # 3840R-344-00
ZZ	270	QUARRY GEOTECHNICAL REPORT	DOE/OR/21548-147	11-90	REV. 0	
ZZ	114	QUARRY HAUL ROAD ECOLOGICAL SURVEY	DOE/OR/21548-228	SEPT 1992	REV. 1	
ZZ	306	QUARRY HAUL ROAD HASP WP213	DOE/OR/21548-177	FEB 91		(NOT YET RECEIVED)
GR	161	QUARRY HAUL ROAD PHYSICAL RISK ASSESSMENT TASK 353	M.E. BRONSTAD	AUG. 1992	REV. 0	REPORT #3840-Q:EN-R-08-3149 -00
ZZ	192	QUARRY PRELIMINARY ENGINEERING REPORT	DOE/OR/21548-094	JAN. 1990	REV. 2	
ZZ	327	QUARRY RESIDUAL RI/FS SCOPING DOCUMENT	DOE/OR/21548-194	OCT 91	REV. 0	
ZZ	347	QUARRY RESIDUALS GROUNDWATER WELL SAMPLING PLAN	DOE/OR/21548-210	JULY 91	REV. 0	
ZZ	483	QUARRY RESIDUALS SAMPLING PLAN	DOE/OR/21548-382	MAY 1993	REV. B	
ZZ	278	QUARRY STAGING AND WATER TREATMENT PLANT AREA HEALTH AND SAFETY PLAN		MARCH 90	REV. 0	
ZZ	379	QUARRY STAGING AREA MONITORING WELLS COMPLETION REPORT WP238	DOE/OR/21548-262	MARCH 92	REV. 0	
ZZ	423	QUARRY WATER TREATMENT PLANT OPERATIONS & MAINTENANCE MANUAL	DOE/OR/21548-308	MAR. 1993	REV. 1	
ZZ	505	QUARRY WATER TREATMENT PLANT VENDOR DOCUMENTATION	DOE/OR/21548-399	APR. 1993	REV. 0	LOCATED WITH TECH. LIBRARY
QY	5	QUARRY WATER TREATMENT STUDY WELDON SPRING QUARRY	HORNER & SHIFRIN	8-28-90		
ZZ	498	QUARTERLY ENVIRONMENTAL DATA SUMMARY - 1993	DOE/OR/21548-400	MAY 1993	REV. 0	
ZZ	481	QUARTERLY ENVIRONMENTAL DATA SUMMARY - FOURTH QUARTER 1992	DOE/OR/21548-379	MAR. 1993	REV. 0	
ZZ	453	QUARTERLY ENVIRONMENTAL DATA SUMMARY - SECOND QUARTER 1992	DOE/OR/21548-337	SEPT 1992	REV. 0	
ZZ	470	QUARTERLY ENVIRONMENTAL DATA SUMMARY - THIRD	DOE/OR/21548-364	DEC. 1992	REV. 0	

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		QUARTER 1992				
ZZ	337	QUARTERLY ENVIRONMENTAL DATA SUMMARY FIRST QUARTER 1991	DOE/OR/21548-202	JUNE 91	REV. 0	
ZZ	414	QUARTERLY ENVIRONMENTAL DATA SUMMARY FIRST QUARTER 1992	DOE/OR/21548-299	JUNE 1992	REV. 0	
ZZ	316	QUARTERLY ENVIRONMENTAL DATA SUMMARY FOURTH QUARTER 1990	DOE/OR/21548-183	MARCH 91	REV. 0	
ZZ	390	QUARTERLY ENVIRONMENTAL DATA SUMMARY FOURTH QUARTER 1991	DOE/OR/21548-275	MARCH 92	REV. 0	
ZZ	263	QUARTERLY ENVIRONMENTAL DATA SUMMARY QUARTERS 1 AND 2, 1990	DOE/OR/21548-141	SEPT 90	REV. 0	
ZZ	113	QUARTERLY ENVIRONMENTAL DATA SUMMARY SECOND QUARTER 1991	DOE/OR/21548-226	SEPT 91	REV.0	
ZZ	371	QUARTERLY ENVIRONMENTAL DATA SUMMARY THIRD QUARTER 1991	DOE/OR/21548-257	DEC. 91	REV. 0	
ZZ	284	QUARTERLY ENVIRONMENTAL DATA SUMMARY, THIRD QUARTER 1990	DOE/OR/21548-161	JAN 91	REV. 0	
HG	69	QUARTERLY GROUNDWATER MONITORING FOURTH REPORT	IT CORP.	JAN. 1993		
HP	89	QUARTERLY GROUNDWATER MONITORING THIRD REPORT	IT CORP.	OCT. 1992		
HG	48	QUARTERLY REPORT ST. CHARLES COUNTY WELL FIELD MONITORING PROJECT	ST. CHAS. CO. WATER DEPT.	JUN. 1993		QUARTERLY
ZZ	294	QY REMEDIATION COMPLETION REPORT	DOE/OR/21548-168	JAN 91	REV. 0	(NOT YET RECEIVED)
EV	109	RADCON, RADIUM & URANIUM IN DRINKING WATER	COTHERN & REBERS	1990		(PERM. CHECK OUT TO J. BOGNAR)
HP	94	RADIATION EXPOSURES FOR DOE AND DOE CONTRACTOR EMPLOYEES - 1989	DOE	DEC. 1992		
HP	31	RADIOACTIVE MATERIAL IN THE WEST LAKE LANDFILL	NRC	02-88		
WM	16	RADIOACTIVE WASTE MANAGEMENT PLAN	NLP	06-74		
WM	14	RADIOACTIVE WASTE MANAGEMENT PLAN - ERDA-NIAGARA FALLS	NLO	06-30-76		
WM	38	RADIOACTIVE WASTE SITES RADIATION MONITORING REPORT	MoDNR	7-10-90		
ZZ	87	RADIOACTIVITY CONTAINED WITHIN POWER POLES	10-01-87			IRA #8
HP	81	RADIOACTIVITY IN CONSUMER PRODUCTS	U.S. DEPT. OF COMMERCE	AUG. 1978		
HP	72	RADIOCHEMICAL ANAYTICAL PROCEDURES FOR ANALYSIS OF ENVIRONMENTAL SAMPLES	EPA	MARCH 79		
HP	29	RADIOLOGIC CHARACTERIZATION OF THE WELDON SPRING REMEDIAL ACTION SITE	DOE/ID/12584-22	02/88		
HP	22	RADIOLOGICAL & CHEMICAL CHARACTERIZATION REPORT FOR WSCP - APPENDIX A, BLDG. 201 VOL.1 / 2 APPENDICES B & C, BLDGS. 301 & 403 APPENDIX D, BLDG. 404 APPENDICES E & F, BLDGS 405A/405B	BNI	11-86	N/A	
ZZ	66	RADIOLOGICAL & CHEMICAL CHARACTERIZATION REPORT FOR THE PLANNED QUARRY CONSTRUCTION STAGING AREA & WATER TREATMENT PLANT	DOE/OR/21548-046	03-89	REV. 1	IRA #22
ZZ	64	RADIOLOGICAL & CHEMICAL UPTAKE EDIBLE PORTIONS OF SELECTED BIOTA AT THE WELDON SPRING SITE	DOE/OR/21548-044	08-89	REV. 0	
ZZ	210	RADIOLOGICAL AND CHEMICAL COMPLETION REPORT FOR OVERHEAD PIPING REMOVAL	DOE/OR/21548-112	03/90	REV. 0	
ZZ	78	RADIOLOGICAL CHARACTERIZATION OF ARMY VICINITY PROPERTY NO. 7	07-14-87			IRA #4
ZZ	206	RADIOLOGICAL COMPLETION REPORT FOR BUILDING 409	DOE/OR/21548-108	01/90	REV. 0	
ZZ	226	RADIOLOGICAL SAMPLING AND MEASUREMENT RESULTS FOR THE NON-PROCESS RELATED BUILDINGS AND EQUIPMENT		FEB 1989	REV. D	DRAFT

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
ZZ	145	RADIOLOGICAL SAMPLING RESULTS AND NEEDS FOR THE SOUTHEAST DIVERSION DIKE INTERIM RESPONSE ACTION	01-05-88			IRA #2
ZZ	62	RADIOLOGICAL SOIL CHARACTERIZATION FOR THE WSCP & RAFFINATE PITS SITE	DOE/OR/21548-042	11-88	REV. A	
ZZ	85	RADIOLOGICAL SURVEY & RELEASE METHODS FOR CHEMICAL PLANT POWER POLES & ELECTRIC LINES	11-17-87			IRA #8
ZZ	38	RADIOLOGICAL SURVEY & RELEASE PLAN FOR BUILDING 401	DOE/OR/21548-018	04-88		IRA #11
ZZ	39	RADIOLOGICAL SURVEY & RELEASE PLAN FOR BUILDING 409	DOE/OR/21548-019	04-88		IRA #10
ZZ	37	RADIOLOGICAL SURVEY & RELEASE PLAN FOR OVERHEAD PIPING/SUPPORTS & ASBESTOS	DOE/OR/21548-017	04-88		IRA #6
HP	17	RADIOLOGICAL SURVEY - US ARMY RESERVE PROPERTY - WSS	ORAU	01/86	N/A	
ZZ	213	RADIOLOGICAL SURVEY AND RELEASE PLAN FOR MARSHALLING YARD RAILROAD TRACKS BEING REMOVED FOR THE NATIONAL MUSEUM OF TRANSPORTATION	DOE/OR/21548-115	04/90	REV. 0	
ZZ	249	RADIOLOGICAL SURVEY AND RELEASE PLAN FOR RAILROAD TRACKS LOCATED ON THE QUARRY HAUL ROAD	DOE/OR/21548-130	6-90	REV.0	
ZZ	275	RADIOLOGICAL SURVEY AND RELEASE PLAN FOR THE BUILDING SITE OF THE ADMINISTRATION ANNEX BUILDING, COK	DOE/OR/21548-152	FEB 91	REV. 1	
ZZ	80	RADIOLOGICAL SURVEY AND RELEASE PLAN(S) FOR BUILDINGS 409, 401, AND THE OVERHEAD PIPING/SUPPORTS & A		03-30-88		IRA 10,11,6
ZZ	86	RADIOLOGICAL SURVEY OF CHEMICAL PLANT ELECTRICAL POLES	08-06-87			IRA #8
HP	18	RADIOLOGICAL SURVEY OF THE A. A. BUSCH & WELDON SPRING WILDLIFE AREAS - WSS	ORAU	04/86	N/A	
ZZ	74	RADIOLOGICAL SURVEY OF THE PCB-CONTAINING TRANSFORMERS	04-15-87			IRA #1
HP	40	RADIOLOGICAL SURVEY OF THE WEST LAKE LANDFILL ST. LOUIS COUNTY, MISSOURI	NRC	05-82		
HP	23	RADIOLOGICAL SURVEY OF THE WSCP	DOA	10-69	N/A	
HP	47	RADIOLOGICAL SURVEY OF VISTRON CORPORATION, LIMA, OH	ORAU	08-83		
ZZ	97	RADIOLOGICAL SURVEY ON THE ROOF OF BUILDING 401	07-27-87			IRA #11 (EF)
ZZ	92	RADIOLOGICAL SURVEY REPORT	09-30-87			IRA #10
ZZ	73	RADIOLOGICAL SURVEY REPORT FOR THE TRANSFORMERS AT THE WSS	09-28-87			IRA #1
HP	11	RADIOLOGICAL SURVEY REPORT FOR THE WELDON SPRING RAFFINATE PITS SITE	BNI	08-84	13	
ZZ	98	RADIOLOGICAL SURVEY REPORT FOR THE WELDON SPRING CHEMICAL PLANT STEAM PRODUCTION FACILITY	09-17-87			IRA #11 (EF)
HP	16	RADIOLOGICAL SURVEY REPORT FOR THE WSQ	BNI	08-85	2	
PH	23	RADIOLOGICAL, CHEMICAL, AND HYDROGEOLOGICAL CHARACTERIZATION PLAN FOR THE ST. LOUIS DOWNTOWN SITE	BECHTEL	02/88		
BZ	6	RADIUM BIOACCUMULATION IN TROUT	COLORADO STATE UNIVERSITY	11-30-80		
HP	93	RADON AND ITS DECAY PRODUCTS IN INDOOR AIR	MAZAROFF & NERO	1988		PERM. CHECK OUT TO G. SCHMIDT
ZZ	454	RADON COMPLIANCE ASSESSMENT AND IMPLEMENTATION PLAN	DOE/OR/21548-338	JAN. 1993	REV. 0	
HP	64	RADON SMPLING AT WSS INCLUDED: RADIOLOGICAL SURVEY OF THE WSCP (FILED IN HP-023)	NLO	6-3-77		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
ZZ	480	RAFFINATE PIT 4 CHARACTERIZATION WORK PLAN	DOE/OR/21548-378	MAR. 1993	REV. 0	
ZZ	15	RAFFINATE PITS CONCEPTUAL DESIGN REPORT		05-87	REV. 1	
ZZ	120	RAFFINATE PITS FLOOD INUNDATION STUDY REPORT	DOE/OR/21548-234	SEPT 91	REV. 0	
GR	184	RAFFINATE SLUDGE DREDGING & DEWATERING STUDY	MKES	NOV. 1992	REV. 0	
RP	10	RAFFINATE SLUDGE DREDGING AND DEWATERING STUDY	MK-E	03-90	DRAFT	REPORT #5121-R:GR-R-05-0748 -00
EV	77	RAFT OF SELF ASSESSMENT PROGRAM PLAN	ORO	FEB 91		
PM	50	RAIOLOGICAL SITE ASSESSMENT PROGRAM MANPOWER EDUCATION, RESEARCH AND TRAINING OAK RIDGE ASSOCIATED UNIVERSITIES OAK RIDGE ASSOCIATED UNIVERSITIES OAK RIDGE, TENNESSEE 37831-0117	DOE	JAN 86		FINAL REPORT
LN	1	RATIONALE FOR SELECTING A NATURAL CLAY LINER SYSTEM AT THE PROPOSED NFSS AND WSRP WASTE MANAGEMENT FACILITIES	BNI	05-85	4	
EN	22	RATIONALE FOR SELECTION OF GEOMEMBRANE POLYMER TYPE AND THICKNESS, GLOUCESTER COUNTY SOLID WASTE COMPLEX, PHASE II ENGINEERING DEISGN	CAMP DRESS & MCKEE, INC.	03-88		
RG	110	RCRA (RESOURCE CONSERVATION AND RECOVERY ACT) FACILITY INVESTIGATION (RFI) GUIDANCE VOLUMES I AND II / VOLUMES III AND IV	NTIS	MAY 1989		
RG	138	RCRA CORRECTIVE ACTION MANUAL VOLUME I	THOMPSON PUBLISHING GROUP	1993		PERM CHECK OUT TO D. STEFFEN
RG	119	RCRA GROUND WATER MONITORING TECHNICAL ENFORCEMENT GUIDANCE DOCUMENT (TEGD) 2 BOOKS ORDERED	NWWA/EPA SERIES	SEPT 1986		PERM CHECKOUT TO L KLINGMULLER
HG	68	RCRA GROUND-WATER MONITORING TECHNICAL ENFORCEMENT GUIDANCE DOCUMENT	EPA	SEPT 1986		PERM. CHECK OUT TO J. BOGNAR
LN	3	RCRA GUIDANCE DOCUMENT: LANDFILL DESIGN, LINER SYSTEMS & FINAL COVER	EPA	07-82	N/A	
RG	2	RCRA ORIENTATION MANUAL	EPA	01-86	N/A	
CM	28	RCRA SUBPART S CORRECTIVE ACTION INFORMATION MEETING	RADIAN CORP.	MAY 1993		
ZZ	384	READINESS REVIEW PLAN FOR BUILDINGS 201 AND 301 DEMOLITION	DOE/OR/21548-267	APR. 1992	REV. 0	
ZZ	399	READINESS REVIEW PLAN FOR THE QUARRY BULK WASTE REMOVAL AND TEMPORARY STORAGE AREA OPERATION	DOE/OR/21548-284	APRIL 92	REV. A	(NOT YET RECEIVED)
ZZ	380	READINESS REVIEW PLAN FOR THE QUARRY WATER TREATMENT FACILITY	DOE/OR/21548-263	JAN. 92	REV. 0	
HG	23	RECHARGE AT THE HANFORD SITE: STATUS REPORT	DOE	11-87		
GE	41	RECOMMENDATIONS TO THE NRC FOR SOIL COVER SYSTEMS OVER URANIUM MILL TAILINGS AND LOW-LEVEL RADIOACTIVE WASTES (IDENTIFICATION AND RANKING OF SOILS EXPERIMENT STATION)	U.S. ARMY ENG. WATERWAYS EXPER	JAN 91	VOL. 1	
GE	42	RECOMMENDATIONS TO THE NRC FOR SOIL COVER SYSTEMS OVER URANIUM MILL TAILINGS AND LOW-LEVEL RADIOACTIVE WASTES (LABORATORY AND FIELD TESTS FOR SOIL COVERS)	U.S. ARMY ENG. WATERWAYS EXPER	JAN 91	VOL. 2	
ZZ	478	RECORD OF DECISION FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE	DOE/OR/21548-376	AUG. 1993		
WM	34	RECORD OF DECISION FOR THE MANAGEMENT OF THE BULK WASTES AT THE WELDON SPRING QUARRY, WELDON SPRING,	ANL	9-90	REV. 0	
ZZ	433	RECORD OF DECISION FOR THE MANAGEMENT OF THE BULK WASTES AT THE WELDON SPRING QUARRY	DOE/OR/21548-317	SEPT. 90		NOT YET RECEIVED
PM	121	RECORDS MANAGEMENT SECOND EDITION	SUSAN DIAMOND	1991		PERM CHECK OUT TO L. KOEHMSTED

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
GR	13	RECREATIONAL USE OF WELDON SPRING WILDLIFE AREA 1989 - 1990	MO. DEPT. OF CONSERVATION	JUNE 91		
RG	89	REGULATORY ALTERNATIVES FOR GROUNDWATER COMPLIANCE FOR THE DEPARTMENT OF ENERGY'S UMTRA PROJECT ALTERNATE CONCENTRATION LIMITS SUPPLEMENTAL STANDARDS ANDINSTITUTIONAL CONTROLS		MAY 1990	DRAFT	
ZZ	265	REGULATORY COMPLIANCE DEPARTMENT FISCAL YEAR 1990 DEPARTMENT PLAN	PMC	FEB 90	REV. A	
ZZ	147	RELEASE OF TRANSFORMERS FROM THE WSS	12-29-87			IRA #1
RG	52	REMEDIAL ACTION & WASTE TECHNOLOGY PROGRAMS - KEY APPLICABLE OR RELEVANT ENVIRONMENTAL REGULATIONS & SUMMARY OF HOW THE PROJECTS ARE MEETING THE REQUIREMENTS	MKF/BNI/DOE/ANL	12-88		
WM	57	REMEDIAL ACTION AT WASTE DISPOSAL SITES	EPA	MAR. 1982		PERM. CHECK OUT TO J. BOGNAR
BG	3	REMEDIAL ACTION CONTACTS DIRECTORY	DOE	05-86		
GR	48	REMEDIAL ACTION CONTACTS DIRECTORY 1991	ORNL	JUN. 1991		
EN	39	REMEDIAL ACTION COSTING PROCEDURES MANUAL	JRB ASSOC.	10-87		
PM	29	REMEDIAL ACTION PROGRAM CURRENT AWARENESS BULLETIN	ORNL	MARCH 92		DECEMBER - JANUARY 1991
CM	10	REMEDIAL ACTION PROGRAMS ANNUAL MEETING (MEETING NOTES)	DOE	04/87		
CM	16	REMEDIAL ACTION PROGRAMS ANNUAL MEETING	DOE	04-87		
KU	17	REMEDIAL ACTION TECHNOLOGY FOR WASTE DISPOSAL SITES - SECOND EDITION	NOYES DATA CORPORATION (NDC)	1986		
ZZ	355	REMEDIAL ACTION WORK PLAN FOR FISCAL YEAR 1992	DOE/OR/21548-239	OCT. 91	REV. A	(NOT YET RECEIVED)
GR	37	REMEDIAL ACTIONS AT THE FORMER CLIMAX URANIUM COMPANY URANIUM MILL SITE, GRAND JUNCTION, CO	DOE	12-86		
ZZ	325	REMEDIAL DESIGN WORK PLAN FOR THE QUARRY BULK WASTE MANAGEMENT PROGRAM	DOE/OR/21548-191	MAY 91	REV. 0	
RG	27	REMEDIAL INVESTIGATION AND FEASIBILITY STUDY GUIDANCE MANUAL	HSCD & WORK GROUP REVIEW COPY	07-24-87	N/A	(DRAFT)
ZZ	164	REMEDIAL INVESTIGATION FOR QUARRY BULK WASTES	DOE/OR/21548-066	12/89	REV. 1	
ZZ	172	REMEDIAL INVESTIGATION FOR THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE	DOE/OR/21548-074	NOV. 1992		VOLUMNE I AND II
ZZ	31	REMEDIAL INVESTIGATION QUALITY ASSURANCE PROGRAM PLAN	DOE/OR/21548-011	12-88	REV. 0	
PM	22	REMEDIAL INVESTIGATION/FEASIBILITY STUDY WITH OPTIONAL DESIGN AT THE WELDON SPRING TRAINING AREA	MKE	07-87		
ZZ	345	REMOVAL ACTION DECISION DOCUMENT FOR MANAGEMENT OF CONTAMINATED STRUCTURES AT THE WSCP	DOE/OR/21548-208	JULY 91	REV. 0	
ZZ	273	REMOVAL ACTION DECISION DOCUMENT FOR THE MANAGEMENT OF 15 NON- PROCESS BLDGS. (15 SERIES) AT THE WELDON SPRING CHEMICAL PLANT	DOE/OR/21548-151	NOV 1990	DRAFT	
ZZ	274	REMOVAL ACTION DECISION DOCUMENT MANAGMENT OF THE CONTAMINATED WATER IMPOUNDED AT THE WELDON SPRING CHEMICAL PLANT	DOE/OR/21548-150	NOV 1990	DRAFT	
ZZ	287	REMOVAL OF OIL-FILLED EQUIPMENT ELECTRICAL SUBSTATION 411 HEALTH AND SAFETY PLAN	PMC	DEC 1990	REV. A	(NOT YET RECEIVED)
ZZ	77	REMOVAL OF PCB TRANSFORMERS				EE/CA
EN	40	REMOVAL OF URANIUM FROM DRINKING WATER BY ION EXCHANGE & CHEMICA L CLARIFICATION	EPA / NM STATE UNIV.	09-87		
GR	119	REMOVAL OF VOLATILE ORGANIC CHEMICALS FROM POTABLE WATER TECHNOLOGIES AND COSTS	ES&E	1986		
KU	22	REPORT OF COST AND SCHEDULE CONTROL SYSTEMS CRITERIA (CSCSC) COMPLIANCE REVIEW	WILLIAM B. POORE & CO.	05/26/89		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
PM	9	REPORT OF EXCESS REAL PROPERTY	DOA	06-85	88	
GE	8	REPORT OF FOUNDATION INVESTIGATION AEC - WELDON SPRING	CORPS OF ENGINEERS	02-54	N/A	
HG	54	REPORT OF GROUNDWATER MODELING ENVIROCARE WASTE DISPOSAL FACILITY SOUTH CLIVE, UTAH	BINGHAM ENVIRONMENTAL	05-31-91		
YY	80	REPORT OF TELECON: DELLI-BOVI WITH ANNE BAITTINGER OF BROOKHAVE NATIONAL LABORATORY	03-24-89	03-27-89		
YY	91	REPORT OF TELECON: DELLI-BOVI WITH BOB KOENIG, WASHINGTON BUREAU, ST. LOUIS POST-DISPATCH	03-30-89	03-30-89		
YY	86	REPORT OF TELECON: DELLI-BOVI WITH DALE DUNIVAN'S VOCATIONAL AGRICULTURAL CLASS, FRNACIS HOWELL HIGH SCHOOL	03-29-89	03-29-89		
YY	84	REPORT OF TELECON: DELLI-BOVI WITH DARYL ROBERTS, BUREAU CHIEF - MDH AND NANCY PALLARDY, AREA RESIDENT	03-27-89	03-27-89		
YY	85	REPORT OF TELECON: DELLI-BOVI WITH DONALD HARBOUR, ENSCO ENVIRONMENTAL SERVICES, INC. AND ROY BLANKLEY, ENVIRONMENTAL AND ENERGY SYSTEMS, INC.	03-29-89	03-29-89		
YY	81	REPORT OF TELECON: DELLI-BOVI WITH JIM BOONE, JR. OF MERRMAC SCHOOL	03-27-89	03-27-89		
YY	89	REPORT OF TELECON: DELLI-BOVI WITH JOE HAUSER, CHLORINATION UNLIMITED	03-30-89	03-30-89		
YY	92	REPORT OF TELECON: DELLI-BOVI WITH JOHN SCHLATTER, BECHTEL	04-04-89	04-04-89		
YY	78	REPORT OF TELECON: DELLI-BOVI WITH MARY HALLIDAY, PRESIDENT OF SCCAHW AND LARRY LANGUISH AND HERBIE MUSCHANEY, AREA RESIDENTS	03-23-89	03-23-89		
YY	87	REPORT OF TELECON: DELLI-BOVI WITH MEREDITH BOLLMEIER, SCCAHW	03-29-89	03-29-89		
YY	90	REPORT OF TELECON: DELLI-BOVI WITH MEREDITH BOLLMEIER, SCCAHW AND ROY KLEIN, R. KLEIN INDUSTRIES	03-30-89	03-30-89		
YY	79	REPORT OF TELECON: DELLI-BOVI WITH NINA KNIGHT AND NANCY PALLARDY, AREA RESIDENTS	03-24-89	03-24-89		
YY	88	REPORT OF TELECON: DELLI-BOVI WITH ROD LANDERS, AREA RESIDENT	03-30-89	03-30-89		
YY	77	REPORT OF TELECON: DELLI-BOVI/McCRACKEN/HAMMOND WITH AVEL/MEDLER	03-23-89	03-23-89		
ZZ	135	REPORT OF THE BULK ASBESTOS SAMPLING EFFORT CONDUCTED ON MAY 7, 1987	11-10-87			
GR	61	REPORT OF THE INVESTIGATION OF THE ACCIDENT OF THE MOUND PLANT APRIL 11, 1987	DOE ALBUQUERQUE OPS OFFICE	AUGUST 87		
GR	223	REPORT OF THE TASK GROUP ON ELECTRICAL SAFETY OF DEPARTMENT OF ENERGY FACILITIES	DOE	JAN. 1993		
EV	30	REPORT ON CHILDHOOD LEUKEMIA IN ST. CHARLES COUNTY (1970-1983)	MO DEPT OF HEALTH	07-86	N/A	
ZZ	392	REPORT ON DISPOSAL FACILITY ALTERNATIVE CONCEPTUAL FEATURES	DOE/OR/21548-277	MARCH 92	REV. 1	
HG	7	REPORT ON GROUNDWATER MONITORING WELL REHABILITATION & RADIOLOGICAL CHARACTERIZATION DRILLING, WSQ	BNI	12-85	N/A	
GR	191	REPORT ON MINIMUM CRITERIA TO ASSURE DATA QUALITY		DEC. 1989		
GR	5	REPORT ON PRELIMINARY GEOLOGICAL, HYDROLOGICAL & RADIOLOGICAL SURVEY AT WSQ DURING 1976 & 1977	NLO	12-78	N/A	
ZZ	43	REPORT ON RADIOLOGICAL FINDINGS & RECOMMENDATIONS	DOE/OR/21548-023	10-87	REV. 0	IRA #13

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		REGARDING ARMY RESERVE PROPERTY VICINITY PROPERTY NO. 1				
MG	8	REPORT ON WATER BALANCE STUDIES FROM 1983 TO 1985 - WELDON SPRING RAFFINATE PITS SITE	BNI	03-86	N/A	
GR	206	REPORTABLE OCCURRENCES THROUGH 4TH QUARTER CY-1992 SUMMARY	DOE OAK RIDGE	JAN. 1993		
ZZ	298	REPROCESSING THE RAFFINATE PIT SLUDGES AT THE WELDON SPRING SITE	DOE/OR/21548-169	NOV. 1992	REV. 0	
DD	4	REQUEST FOR PROPOSALS/STUDY FOR DECOMMISSIONING THE AEC/WELDON SPRING SITE AND QUARRY	NLO	09-11-74	N/A	
RG	53	RESEARCH & DEVELOPMENT - INTERIM METHODS FOR THE SAMPLING & ANAL YSIS OF PRIORITY POLLUTANTS IN SEDIMENTS & FISH TISSUE	EPA	08-77		
EN	64	RESEARCH DESIGN FOR PHASE III DATA RECOVERY PROGRAM AT PRE- HISTORIC ARCHAEOLOGICAL SITE 23SC744, BULK WASTE HAULAGE ROAD PROJECT	TRIAD RESEARCH SERVICES	APRIL 91		
MP	71	RESL ANALYTICAL CHEMISTRY BRANCH PROCEDURES MANUAL	RADIOLOG. & ENV. SCIENCES LAB	1982		
RG	40	RESOURCE CONSERVATION & RECOVERY ACT COMPLIANCE/ENFORCEMENT GUIDANCE MANUAL POLICY COMPENDIUM	EPA	01-85		
RG	59	RESOURCE CONSERVATION & RECOVERY ACT INSPECTION MANUAL	EPA	01-89		
ZZ	129	RESPIRATOR PROGRAM - METCALF AND ASSOCIATES, INC.	WP056			IRA #7
ZZ	155	RESPIRATORY PROTECTION PROGRAM PLAN	DOE/OR/21548-057	01-92	REV. 1	
MP	80	RESPIRATORY PROTECTION: A MANUAL AND GUIDELINE	AM. INDUSTRIAL HYGIENE ASSOC.	1991		SECOND EDITION
ZZ	300	RESPONSE TO OAK RIDGE OFFICE APPRAISAL OF ENVIRONMENTAL SAFETY AND HEALTH AND QUALITY ASSURANCE PROCEDURES AT WSSRAP	DOE/OR/21548-171	MAY 91	REV. 1	
ZZ	485	RESPONSES TO COMMENTS ON THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY-ENVIRONMENTAL IMPACT STATEMENT FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE (NOVEMBER 1992) (ALSO INCLUDES RESPONSIVENESS SUMMARY FOR THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY-ENVIRONMENTAL IMPACT STATEMENT FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE; AND RESPONSES TO COMMENTS ON THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY-ENVIRONMENTAL IMPACT STATEMENT FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE)	DOE/OR/21548-387	APR. 1993		(RESPONSES TO COMMENTS APR.93)
ZZ	503	RESPONSES TO LABOR ISSUES RAISED AT THE DECEMBER 16, 1992 PUBLIC MEETING	DOE/OR/21548-393	JUN. 1993	REV. 0	
YY	58	RESPONSES TO MAJOR ISSUES RAISED IN COMMENTS ON THE DRAFT EIS	08-88	08-88		PUBLIC PART
PM	46	RESPONSIVENESS SUMMARY FOR THE ENGINEERING EVALUATION/ COST ANALYSIS FOR THE PROPOSED MANAGEMENT OF CONTAMINATED WATER IN THE WELDON SPRING QUARRY	DOE/OR/21548-146 (ANL)	06/89		
WM	35	RESPONSIVENESS SUMMARY FOR THE REMEDIAL INVESTIGATION/ FEASIBILITY STUDY FOR THE MANAGEMENT OF THE BULK WASTES AT THE WELDON SPRING QUARRY, WELDON SPRING, MO.	DOE/OR/21548-135 (ANL)	6-90		
ZZ	280	RESPONSIVENESS SUMMARY FOR THE REMEDIAL	DOE/OR/21548-157	DEC. 1990		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		INVESTIGATION REPORT				
RP	8	RESULTS OF ADDITIONAL TESTING OF THE RAFFINATE PITS AT WSS	BNI	08-86	N/A	
ZZ	82	RESULTS OF ASBESTOS SAMPLES ANALYZED FOR RADIOACTIVITY	12-01-87			IRA #6
HP	15	RESULTS OF MOBILE GAMMA SCANNING ACTIVITIES IN WELDON SPRING, MO	ORNL	06-85	69	
ZZ	76	RESULTS OF RADIOLOGICAL ANALYSIS OF PCB TRANSFORMER OIL	03-20-87			IRA #1
PM	3	RESULTS OF WELDON SPRING TECHNICAL SUPPORT FOR FY 1980	UCC	11-80	39	
EV	56	RESULTS OF WSSRAP DATA REVIEW	JACOBS ENGINEERING GROUP	02/14/90	N/A	
DD	9	REVIEW OF DECONTAMINATION TECHNIQUES IN RELATION TO DECOMMISSIONING	NORTHERN RESEARCH LAB	12-87		
HG	25	REVIEW OF GROUND-WATER FLOW AND TRANSPORT MODELS IN THE UNSATURATED ZONE	NRC	11-82		
RG	20	REVIEW OF INTERIM GUIDANCE ON COMPLIANCE WITH ARARs	USEPA	5-29-87		
GR	165	REVIEW OF OFF-SITE SERVICES BCP ESTIMATED	PMC			
ZZ	84	REVIEW OF RADIOLOGICAL GUIDELINES FOR THE RELEASE OF THE WOODEN POLES FROM THE WSS	11-11-87			IRA #8
ZZ	72	REVIEW OF RADIOLOGICAL SURVEY OF PCB CONTAINING TRANSFORMERS	08-21-87			IRA #1
ZZ	100	REVIEW OF THE REPORT ON RADIOLOGICAL SURVEY OF BUILDING 401	08-21-87			IRA #11 (EF)
ZZ	139	REVISED ASBESTOS MONITORING DATA	09-29-87			IRA #6
GR	168	REVISED COMMUNITY RELATIONS PLAN WELDON SPRING ORDNANCE WORKS WELDON SPRING, MO	IT CORP.	SEPT 1992		
GR	226	REVISED ROADMAP METHODOLOGY DOCUMENT	US DOE	MAY 1993		
PM	12	RFP FOR A PROJECT MANAGEMENT CONTRACTOR FOR WSSRAP/QUESTIONS & ANSWERS RECEIVED DURING SITE TOUR	DOE	08-85	93	
EV	97	RISK ASSESSMENT GUIDANCE FOR SUPERFUND VOLUME I: HUMAN HEALTH EVALUATION MANUAL (PARTS A, B, & C)	EPA	MARCH 91		PERM. CHECKOUT TO R. FERGUSON
HP	57	RISK ASSESSMENT GUIDANCE FOR SUPERFUND VOLUME I: HUMAN HEALTH EVALUATION MANUAL	EPA	9-29-89		INTERIM FINAL
RG	133	RISK ASSESSMENT GUIDANCE FOR SUPERFUND VOLUME I HUMAN HEALTH EVALUATION MANUAL (PART A, PART B, AND PART C)	EPA	DEC. 1989		PERM CHECK OUT TO J. BENNETT
EV	47	RISK ASSESSMENT METHODOLOGY - DRAFT EIS FOR PROPOSED NESHAPS FOR RADIONUCLIDES, VOL. 1/RISK ASSESSMENTS, VOL. 2/ECONOMIC ASSESSME NT, VOL. 3 (BACKGROUND INFORMATION DOCUMENT)	EPA	02-89		
ZZ	471	ROADMAP ADDENDUM	DOE/OR/21548-371	DEC. 1992 REV. A APR. 1993		
GR	225	ROADMAP DEVELOPMENT GUIDANCE DOCUMENT				
GR	36	ROOT LENGTHS OF PLANTS ON LOS ALAMOS NATIONAL LABORATORY LANDS	LOS ALAMOS NATIONAL LAB	01-87		
ZZ	267	RS FOR EE/CA FOR PROPOSED MANAGEMENT OF CONTAMINATED WATER IMPOUNDED AT THE WSCP AREA	DOE/OR/21548-144	JAN 91		
ZZ	269	RS FOR EE/CA FOR PROPOSED MGMT. OF CONTAMINATED WATER IN WSQ	DOE/OR/21548-146	JUNE 89		FILED IN PM-046
HP	85	RTECS REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES VOLUMES 1-5 ALSO VOLUME 3A	US DEPT. OF HEALTH & HUMAN RES	1985-1986		PERM CHECK OUT TO L. PHILLIPS
KU	8	RULES AND REGULATIONS OF THE MISSOURI DAM AND RESERVOIR SAFETY COUNCIL	MDNR	1985		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
RG	85	S-3 PONDS (T-004) SUMMARY OF CLOSURE UNDER RULES GOVERNING HAZARDOUS WASTE MANAGMENT IN TENNESSEE	MARTIN MARIETTA	8-88		
EN	68	SAFE WORK PLAN FOR WELDON SPRING SITE TSA TRAIN 1 SITE WATER TREATMENT PLANT	RESOURCE TECHNOLOGIES GROUP	10-10-91	REV. 0	
RG	105	SAFE WORK PLAN FOR WELDON SPRING SITE TSA TRAIN 1 SITE WATER TREATMENT PLANT	RESOURCE TECHNOLOGIES GROUP	SEP 10,91	REV. 0	
ZZ	452	SAFETY ANALYSIS DOCUMENTATION FOR THE QUARRY BULK WASTE REMOVAL, TSA, MSA, BUILDING DISMANTLEMENTS, & BUILDING 434	DOE/OR/21548-336	AUG. 1992	REV. A	(NOT YET RECEIVED)
GR	163	SAFETY ANALYSIS REPORT UPDATE PROGRAM HAZARD SCREENING APPLICATION GUIDE	MARTIN MARIETTA	JUNE 1992		
GR	162	SAFETY ANALYSIS REPORT UPDATE PROGRAM OVERVIEW & PHASE I IMPLEMENTATION	MARTIN MARIETTA	AUG. 1991		
ZZ	130	SAFETY AND HEALTH PLAN - CONTAINERIZED WASTE HANDLING	WP056	10-17-88		IRA #7
ZZ	299	SAFETY ASSESSMENT FOR THE WSQ WATER TREATMENT PLANT	DOE/OR/21548-170	MAY 1992	REV. 2	
WM	7	SAFETY ASSESSMENT OF ALTERNATIVES TO SHALLOW-LAND BURIAL OF LOW-LEVEL RADIOACTIVE WASTE VOLUME II: ENVIRONMENTAL CONDITIONS AFFECTING RELIABILITY OF ENGINEERED BARRIERS	NRC	09-87		
ZZ	487	SAFETY DEPARTMENT PLAN	DOE/OR/21548-388	FEB. 1993	REV. 0	
PM	41	SAFETY PERFORMANCE PROFILE OAK RIDGE OPERATIONS	INEL	DEC 90		
ZZ	173	SAFETY PLAN FOR FEDERAL & STATE REGULATORY AGENCY SITE INSPECTORS	DOE/OR/21548-075	03-89	REV. A	
GR	188	SAMPLING & ANALYSIS PLAN FOR PERFORMANCE TESTING OF THE WELDON SPRING SITE WATER TREATMENT PLANT TSA TRAIN 1	RTG	DEC. 1992		
RG	57	SAMPLING & CHEMICAL ANALYSIS QUALITY ASSURANCE PROGRAM FOR U.S. ARMY TOXIC & HAZARDOUS MATERIALS AGENCY (USATHAMA)	DOA	04-82		
EV	68	SAMPLING AND ANALYSES TO SUPPORT EXCAVATION OF BLUE LAGOON SEDIMENT BUILD-UP OAK RIDGE Y-12 PLANT OAK RIDGE, TN	MARTIN MARIETTA	11-88		
EV	4	SAMPLING DESIGN AND STATISTICAL METHODS FOR ENVIORNMENTAL BIOLOGISTS	UNIVERS. OF WESTERN ONTARIO	1979		
HP	14	SAMPLING OF ASH POND OUTFALL AT WSCP	BNI	05-85	74	
ZZ	288	SAMPLING PLAN FOR DETERMINATION OF HYDRAULIC PROPERTIES OF UNDISTURBED SOILS IN THE WELDON SPRING DISPOSAL FACILITY STUDY AREA	DOE/OR/21548-164	MAR. 1993	REV. 2	
ZZ	313	SAMPLING PLAN FOR POTENTIALLY PCB-CONTAMINATED SOILS	DOE/OR/21548-186	APRIL 91	REV. 0	
ZZ	386	SAMPLING PLAN FOR QUARRY AND SITE WATER TREATMENT PLANT EFFLUENT PONDS	DOE/OR/21548-271	MAY 1992	REV. 2	
ZZ	5	SAMPLING PLAN FOR VOLUMETRIC PCB CONCRETE CONTAMINATION	DOE/OR/21548-287	MAY 92	REV. 0	
ZZ	445	SAMPLING PLAN FOR WATER TREATMENT PLANTS WASTE STREAMS WP140/144/316	DOE/OR/21548-329	AUG. 1992	REV. 0	
GE	21	SAMPLING SOILS FOR 137CS USING VARIOUS FIELD-SAMPLING VOLUMES	LOS ALAMOS NAT'L LAB	10-81		
GR	155	SAX'S DANGEROUS PROPERTIES OF INDUSTRIAL MATERIALS EIGHTH EDITION (VOLUMES I, II & III)	RICHARD J LEWIS, SR	1992		PERM CHECK OUT TO C. PROCTOR
KU	9	SCIENCE	AMERICAN ASSOC. FOR ADV. SCIEN	APR. 1987		
EN	73	SCOPE OF WORK WORK PACKAGE 257 PACKAGE 2 BUILDING REMOVAL	MKFW AND JEGW	OCT. 1991	REV. 1	

WSSRAP DE-AC05-86OR21548
MK-Ferguson
Contract: 3589

Alphabetical Listing

Report Date: 09/07/93

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
ZZ	341	SCOPING DOCUMENT FOR THE PREPARATION OF THE SITE OPERABLE UNIT CONCEPTUAL DESIGN REPORT	DOE/OR/21548-307	OCT. 1992	REV. 2	
DD	14	SCRAP METAL PROGRAM PHASE I DECONTAMINATION DEMONSTRATION PROJECT	BECHTEL	JAN 88		
ZZ	277	SCREENING LEVEL CHARACTERIZATION OF ELECTRICAL SUBSTATION 411	DOE/OR/21548-154	NOV. 1990	REV.0	
GR	217	SECOND MISCELLANEOUS SAMPLING REPORT WELDON SPRING ORDNANCE WORKS WELDON SPRING, MO	IT-CORP	MAR. 1993		
YY	18	SECTION B: PUBLIC HEARING TRANSCRIPT COMMENTS / SECTION C: RESPONSES	04-10-87	04-10-87		PUBLIC PART
EV	44	SEDIMENT SAMPLING QUALITY ASSURANCE USER'S GUIDE	ENVIRONMENTAL RESEARCH CENTER	JUL. 1985		EPA/600/4-85-048
EN	96	SEEPAGE, DRAINAGE, & FLOW NETS	CEDERGREN, H.R.	1989		
GE	39	SEISMOTECTONICS OF THE CENTRAL UNITED STATES	DEPT. OF EARTH AND ATMOSPHERE			
RG	84	SELECTED TEXT OF ATOMIC ENERGY ACT EXECUTIVE ORDERS AND OTHER LAWS OF GENERAL INTEREST TO SAFEGUARDS AND SECURITY OFFICERS	TECHNICAL SUPPORT ORGANIZATION	9-88		
PM	99	SELF ASSESSMENT GUIDANCE DOCUMENT	DOE	DEC. 1992		
ZZ	490	SELF-ASSESSMENT PROGRAM IMPLEMENTATION PLAN	DOE/OR/21548-385	MAR. 1993	REV. A	
GR	179	SEPARATION OF CONSTRUCTION DEBRIS TREATABILITY STUDY REPORT WELDON SPRING ORDNANCE WORKS	IT CORP.	FEB. 1993		
GR	49	SERVICE CONTRACT ACT DIRECTORY OF OCCUPATIONS	US DEPT OF LABOR	07-86		
PM	27	SERVICE CONTRACT ACT DIRECTORY OF OCCUPATIONS	U.S. DEPT. OF LABOR	07-86		
HG	51	SHALLOW GROUNDWATER INVESTIGATIONS AT WS, MO FINAL REPORT FOR FISCAL YEARS 1988-1990	MDNR	JUNE 91		INCLUDED: DEC 90
WM	23	SHIPMENT MOBILITY/ACCOUNTABILITY COLLECTION (SMAC) SYSTEM	BROWN TRANSPORT CORP.	10/4/88		
GR	52	SHIPMENT OF RADIOACTIVE MATERIALS	DOE			
CM	9	SHIPROCK CASE STUDY 1986 ANNUAL DOE REMEDIAL ACTION PROGRAMS MEETING OAK RIDGE TENNESSEE	DOE	11/86		
BG	4	SIGNIFICANT ACCOMPLISHMENTS DURING TENURE OF SECRETARY WATKINS	ORO	1-31-91		
ZZ	16	SITE CHARACTERIZATION PLAN		04-10-87	REV. 0	
ZZ	502	SITE CONCEPTUAL DESIGN REPORT, VOLUME II TECHNICAL INFORMATION DOCUMENT	DOE/OR/21548-411	JUN. 1993	REV. A	
ZZ	424	SITE CONSOLIDATION TRANSPORTATION ACTIVITY MANUAL	DOE/OR/21548-309	OCT. 1992	REV. 0	
ZZ	351	SITE DEVELOPMENT PLANNING - SITE DEVELOPMENT PLAN DOCUMENT	DOE/OR/21548-214	JULY 1991	REV. 0	
ZZ	352	SITE DEVELOPMENT PLANNING - TECHNICAL SITE INFORMATION DOCUMENT	DOE/OR/21548-215	JULY 1991	REV. 0	
PM	56	SITE DEVELOPMENT PLANNING HANDBOOK	BOOZ, ALLEN & HAMILTON, INC.	JAN 81		
GR	80	SITE DEVELOPMENT PLANNING HANDBOOK (INCLUDING SUPPLEMENT)	DOE	JAN 1981		
ZZ	246	SITE FS-EIS MANAGEMENT PLAN	MK-F/JEG	1-90	REV.A	
PM	106	SITE ROD SLIP & DOE DIRECTIVES IMPACT PROPOSAL FOR EQUITABLE ADJUSTMENT VOLUME III - APPENDIX	PMC	FEB. 1993	REV. 0	
PM	109	SITE ROD SLIP & DOE DIRECTIVES IMPACT PROPOSAL FOR EQUITABLE ADJUSTMENT VOLUME II - TECHNICAL	PMC	FEB. 1993	REV. 0	
PM	110	SITE ROD SLIP & DOE DIRECTIVES IMPACT PROPOSAL FOR EQUITABLE ADJUSTMENT VOLUME II - COST	PMC	FEB. 1993	REV. 0	
PM	105	SITE ROD SLIP & DOE DIRECTIVES IMPACT VOLUME II	MKES	JAN. 1993	REV. 0	
PM	107	SITE ROD SLIP & DOE DIRECTIVES IMPACT VOLUME I	MKES	JAN. 1993	REV. 0	
PM	108	SITE ROD SLIP & DOE DIRECTIVES IMPACT VOLUME I	JEG	FEB. 1993	REV. 0	
ZZ	18	SITE SECURITY PLAN	DOE/OR/21548-199	OCT. 1992	REV. 1	

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
ZZ	200	SITE SUITABILITY DATA ON POTENTIAL LOCATION OF A DISPOSAL FACILITY: COLLAPSE POTENTIAL AND PERMEABILITY	DOE/OR/21548-102	SEP 91	REV. 2	COMMENTS INCLUDED
ZZ	19	SITE SURVEILLANCE & MAINTENANCE PLAN		01-09-87	REV. 0	
GR	43	SITE TOUR FOR WSSRAP	DOE	1985		
MU	27	SITE TREATMENT PLAN GUIDANCE DOCUMENTS		AUG. 1993		PERM. CHECK OUT TO T. UHLMEYER
ZZ	450	SITE WATER TREATMENT PLANT TRAIN NO. 1 OPERATIONAL READINESS REVIEW PLAN	DOE/OR/21548-334	JAN. 1993	REV. 0	
GR	66	SIZE REDUCTION DEVELOPMENT AND EVALUATION OF PROCESS OPTIONS				
EN	95	SIZE REDUCTION: DEVELOPMENT & EVALUATION OF PROCESS OPTIONS	JACOBS ENGINEERING	NOV. 1992	REV. 0	
GR	185	SIZING OF BUILDING MATERIALS & STRUCTURES STUDY	MKES	OCT. 1992	REV. 0	
WM	17	SLOPE STABILITY FAILURE INVESTIGATION: LANDFILL UNIT B-19, PHASE I-A, KETTLEMAN HILLS, CA	UNIV. OF CALIF. - BERKELEY	07-88		
GR	101	SLURRY BIODEGADATION	NTIS	SEPT 1990		PERM CHECK OUT TO D. STEFFEN
BZ	11	SMALL MAMMAL POPULATION ANALYSIS FOR THE WELDON SPRING SITE REMEDIAL ACTION PROJECT	BETHEL & ALLEN	NO DATE		
ZZ	362	SMALL MAMMAL SAMPLING PLAN	DOE/OR/21548-248	AUG. 1992	REV. 1	
GR	120	SMALL WATER SYSTEM TREATMENT COSTS	GUMERMAN/BURRIS/HANSEN	1986		
ZZ	353	SOCIAL LAND - USE SAMPLING PLAN FOR THE WELDON SPRING QUARRY RESIDUALS PROJECT	DOE/OR/21548-217	SEPT 91	REV. 0	
EN	24	SOIL PROPERTIES, CLASSIFICATION, & HYDRAULIC CONDUCTIVITY TESTING DRAFT TECHNICAL RESOURCE DOCUMENT FOR PUBLIC COMMENT	EPA	03-84		
ZZ	395	SOIL SAMPLING PLAN FOR COLUMN LEACH TESTS AND TCLP ANALYSIS	DOE/OR/21548-280	MAY 1992	REV. 0	
GR	19	SOIL SAMPLING QUALITY ASSURANCE USER'S GUIDE	UNLV	05-84	N/A	
GE	43	SOIL SAMPLING QUALITY ASSURANCE USERS GUIDE	ENVIRONMENTAL RESEARCH CENTER	MARCH 89		
GE	13	SOIL SURVEY OF ST. CHARLES COUNTY MISSOURI	U.S. DEPT. OF AGRICULTURE	05-82		
EN	86	SOIL VAPOR EXTRACTION TECHNOLOGY REFERENCE HANDBOOK	TOM A. PEDERSEN & JAMES CURTIS	FEB. 1991		PERM CHECK OUT TO B. GOLDKAMP
GR	96	SOLIDIFICATION/STABILIZATION MECHANISMS & APPLICATIONS GULF COAST HAZARDOUS SUBSTANCE RESEARCH CENTER	LAMAR UNIVERSITY	FEB 1990		2ND ANNUAL SYMPOSIUM
HP	50	SOLUBILITY CLASSIFICATION OF AIRBORNE URANIUM PRODUCTS COLLECTED AT THE PERIMETER OF THE ALLIED CHEMICAL PLANT, METROPOLIS, IL	NRC / PNL	05-80		
HP	67	SOLUBILITY CLASSIFICATION OF AIRBORNE URANIUM PROJECTS FROM LWR-FUEL PLANTS	NRC	AUG 80		
ZZ	397	SOUTHEAST DRAINAGE FLOW STUDY COMPLETION REPORT	DOE/OR/21548-282	MARCH 92	REV. A	(NOT YET RECEIVED)
ZZ	293	SOUTHEAST DRAINAGE FLOW STUDY SAMPLING PLAN	DOE/OR/21548-167	SEP 91	REV. 1	
ZZ	186	SPECIAL STUDIES PHASE II REPORT - THERMAL TREATMENT OF SOILS/SEDIMENTS, SLUDGES, & COMBUSTIBLE DEBRIS AT THE WELDON SPRING SITE	DOE/OR/21548-088	05-89	REV. A	
ZZ	185	SPECIAL STUDIES PHASE II REPORT - DRYING/DEWATERING OF RAFFINATE PIT SLUDGES AT THE WELDON SPRING SI	DOE/OR/21548-087	NOV. 1992	REV. 1	
GR	196	SPECIAL STUDIES PHASE II REPORT ON SLAGGING INCINERATION	JACOBS ENGINEERING	NOV. 1992	REV. 0	
LN	11	SPECIAL STUDIES PROGRAM: GEOMEMBRANE FINAL REPORT	DOE	07-88		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		CONTRACT NO. DE-AC04-82AL14086				
EN	94	SPECIAL STUDY PHASE II REPORT - METAL MELTING TECHNOLOGY, INCLUDING SIZE REDUCTION BEFORE MELTING, FOR RADIOACTIVELY CONTAMINATED METAL AT THE WELDON SPRING SITE	JACOBS ENGINEERING	NOV. 1992	REV. 0	
ZZ	181	SPECIAL STUDY PHASE II REPORT - REPROCESSING THE RAFFINATE PIT SLUDGES AT THE WELDON SPRING SITE	DOE/OR/21548-083	DEC 1990		
EN	93	SPECIAL STUDY PHASE II REPORT - STABILIZATION OF THE RAFFINATE PIT SLUDGES AT THE WELDON SPRING SITE	JACOBS ENGINEERING	NOV. 1992	REV. 0	
ZZ	182	SPECIAL STUDY PHASE II REPORT - STABILIZATION OF THE RAFFINATE P IT SLUDGES AT THE WELDON SPRING SITE	DOE/OR/21548-084	05-89	REV. A	
EN	91	SPECIAL STUDY PHASE II REPORT - THERMAL TREATMENT OF SOILS/SEDIMENTS, SLUDGES, AND COMBUSTIBLE DEBRIS AT THE WELDON SPRING SITE	JACOBS ENGINEERING	NOV. 1992	REV. 0	
ZZ	183	SPECIAL STUDY PHASE II REPORT - VERIFICATION TECHNOLOGIES FOR RAFFINATE PIT SLUDGES & CONTAMINATED SOILS AT THE WELDON SPRING SITE	DOE/OR/21548-085	05-89	REV. A	
ZZ	184	SPECIAL SUTDIES PHASE II REPORT - METAL MELTING TECHNOLOGY, INCLUDING SIZE REDUCTION BEFORE MELTING, FOR RADIOACTIVELY CONTAMINATED METAL AT THE WELDON SPRING SITE	DOE/OR/21548-086	05-89	REV. A	
ZZ	157	SPECIFICATION FOR CHARACTERIZATION OF COAL CHUTES IN BUILDING 401	DOE/OR/21548-059	01-89	REV. 0	IRA #11
ZZ	128	SPECIFICATION FOR CONTAINERIZED WASTE HANDLING, TRANSPORT AND DISPOSAL 3589-056 REV. 2	3589-056	FEB 88	REV. 2	IRA #7
ZZ	79	SPECIFICATION FOR VICINITY PROPERTIES, ARMY PROPTERTY #7	3589-SC-WP055			IRA #4
DD	19	SPECIFICATIONS FOR CONSTRUCTION OF A 400,000 GALLON ELEVATED STEEL WATER TANK AND WATER MAIN IN ST. CHARLES COUNTY, MO	WVP CORPORATION	?		
RG	46	SPECIFICATIONS FOR STRUCTURAL CONCRETE FOR BUILDINGS	AMERICAN CRETE INSTITUTE	1988		
ZZ	27	SPILL PREVENTION, CONTROL & COUNTERMEASURE PLAN	DOE/OR/21548-007	07-89	REV. 0	
ZZ	400	ST. CHARLES CO. WELL FIELD SUMMARY OF ALTERNATIVES FOR CONTINGENCY PLANS	DOE/OR/21548-285	MAY 92	DRAFT	
GR	113	ST. CHARLES COUNTY WELL FIELD SUMMARY OF ALTERNATIVES FOR CONTINGENCY PLANS	ZAMBRANA CONSULTANTS, INC.	MARCH 92		DOE/OR/21548-285
YY	11	ST. CHARLES JOURNAL - PUBLIC INFORMATION MEETING OF 02-25-88 ANNOUNCEMENT	02-21-88	02-21-88		PUBLIC PART
YY	14	ST. CHARLES JOURNAL RE: ANNOUNCEMENT OF PUBLIC INFORMATION MEETING OF 03/13 & 14/87	03-08-87	03-08-87		PUBLIC PART
YY	12	ST. CHARLES JOURNAL RE: AVAILABILITY OF INFORMATION & COMMENT DUE DATE ON INITIAL FOUR IRA'S	10-21-87	10-21-87		PUBLIC PART
YY	5	ST. CHARLES JOURNAL RE: PLANNED 12-16-88 PUBLIC MEETING	11-16-88	11-16-88		PUBL PART
YY	10	ST. CHARLES POST - PUBLIC MEETING 02-25-88	02-24-88	02-24-88		PUBLIC PART
YY	15	ST. CHARLES POST RE: ANNOUNCEMENT OF PUBLIC INFORMATION MEETING OF 03-13 & 14-87	03-13-87	03-13-87		PUBLIC PART
YY	13	ST. CHARLES POST RE: PLANS FOR WELDON SPRING CLEANUP MADE AVAILABLE FOR REVIEW	10-20-87	10-20-87		PUBLIC PART
YY	20	ST. CHARLES POST RE: UPCOMING 02-25-88 PUBLIC MEETING TO DISCUSS THE WSSRAP RI/FS	02-24-88	02-24-88		PUBLIC PART
YY	16	ST. LOUIS POST DISPATCH RE: ACCOUNT OF	02-25-87	02-25-87		PUBLIC PART

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		AVAILABILITY OF WSSRAP DEIS				
WM	42	STABILIZATION AND SOLIDIFICATION OF HAZARDOUS WASTES	EDWIN F. BARTH	1990		SIGN OUT: F.J. SPITTLER (ENG)
GR	212	STABILIZATION FATAL FLAW ANALYSIS REPORT NO. 5121R-400-0	MK-BOISE	NOV. 1992	REV. 0	
RP	17	STABILIZATION/SOLIDIFICATION TESTING OF RAFFINATE PITS SLUDGES AND NITROAROMATIC SOILS	WASTE TECHNOLOGIES GROUP, INC.	MAY 92		
ZZ	338	STABILIZATION/SOLIDIFICATION/DEWATERING SAMPLING PLAN	DOE/OR/21548-203	MAY 1991	REV. 0	
ZZ	208	STANDARD FOR CONDUCT OF OPERATIONS AT THE WSSRAP	DOE/OR/21548-110	FEB. 1992	REV. 1	
HP	59	STANDARD FOR THE PERFORMANCE TESTING OF PERSONNEL DOSIMETRY SYSTEMS	DOE	12/86		
HP	78	STANDARD FOR THE PERFORMANCE TESTING OF EXTRMITY DOSIMETRY	DOE	MAY 91	REV. 4	
WM	52	STANDARD HANDBOOK OF ENVIRONMENTAL ENGINEERING	ROBERT A. CORBITT	1990		PERM CHECKOUT TO L. PHILLIPS
WM	44	STANDARD HANDBOOK OF HAZARDOUS WASTE TREATMENT AND DISPOSAL	HARRY M. FREEMAN	1989		
WM	51	STANDARD HANDBOOK OF HAZARDOUS WASTE TREATMENT AND DISPOSAL	HARRY M. FREEMAN	1989		PERM CHECKOUT TO L. PHILLIPS
RG	135	STANDARD INDUSTRIAL CLASSIFICATION MANUAL	NATIONAL TECH. INFO. SERVICE	1987		PERM. CHECK OUT TO W. ANDERSON
WM	55	STANDARD METHODS FOR EXAMINATION OF WATER AND WASTEWATER	A.E. GREENBERG, L.S. CLESCERI	1992	18 EDIT.	PERM. CHECK OUT TO L. PHILLIPS
LN	5	STANDARD NUMBER 54 - FLEXIBLE MEMBRANE LINERS	NSF	11-83	N/A	
GR	25	STANDARDIZED PROCEDURES FOR PLANTING VEGETATION ON COMPLETED SANITARY LANDFILLS	RUTGERS UNIVERSITY	07-83	N/A	
HG	56	STATISTICAL ANALYSIS OF GROUND-WATER MONITORING DATA AT RCRA FACILITIES - INTERIM FINAL GUIDANCE	EPA	FEB 89		
GE	44	STATISTICAL ANALYSIS OF GROUNDWATER MONITORING DATA AT RCRA FACILITIES	EPA	APRIL 89		
ZZ	402	STATISTICAL ANALYSIS PLAN FOR GROUNDWATER AND SURFACE DATA (DATA TREND ANALYSIS, OUTLIER TESTING GEOSTATISTICS)	DOE/OR/21548-289	APRIL 92		(NOT YET RECEIVED)
HP	12	STATUS REPORT ON SURVEYS OF WELDON SPRING VICINITY PROPERTIES	ORAU	09-84	89	
HG	77	STEVENS WATER RESOURCES PRODUCTS				
ZZ	106	STORMWATER CONTROL PLAN	DOE/OR/21548-220	AUG 91	REV. 0	(NOT YET RECEIVED)
ZZ	405	STORMWATER RUN OFF SAMPLING PLAN	DOE/OR/21548-291	MAY 1992	REV. 0	
GR	186	STRALEY'S PROGRAMMING WITH CLIPPER 5.0	STEVEN J. STRALEY	1991		PERM CHECK OUT TO M. SHAWKEY
HP	4	STUDY OF RADIOACTIVE WASTE STORAGE AREAS AT ERDA-WSS	NLO	04-77	51	
ZZ	224	STYLE GUIDE	DOE/OR/21548-178	APR. 1993	REV. 3C	
ZZ	198	SUBCONTRACT FINAL REPORT FOR DEMOLITION OF BUILDING 401	DOE/OR/21548-100	12-89	REV. 0	
GR	159	SUMMARY OF COMMENTS GIVEN TO THE U.S. DEPT. OF ENERGY IN PUBLIC WORKSHOPS	BARRY LAWSON, ASSOC., INC.	MAY 1992		
GR	167	SUMMARY OF COMMENTS GIVEN TO THE U.S. DEPARTMENT OF ENERGY IN PUBLIC WORKSHOPS		NO DATE		
EN	81	SUMMARY OF FIRE PROTECTION PROGRAMS OF THE UNITED STATES DEPARTMENT OF ENERGY CALENDAR YEARS 1988 & 1989	OFFICE OF THE ASSIST. SEC.	10/91		
GR	46	SUMMARY OF HEALTH PROTECTION PRACTICES	MCW	1965		
KU	20	SUMMARY OF PUMPING TEST RESULTS AND EVALUATION WELLS 1, 2, AND 3 WELDON SPRINGS, MISSOURI	EARTH SCIENTIST, INC.	11/17/89		

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GR	209	SUMMARY OF TIGER TEAM ASSESSMENT & TECHNICAL SAFETY APPRAISAL RECURRING CONCERNS (OPERATIONS AREA)	INEL	JAN. 1993		
HG	3	SUMMARY OF WATER TRACING EXPERIMENTS AT WELDON SPRING COMPLEX	GEOLOGY & LAND SURVEY	11-83	22	
ZZ	212	SUMMARY OF WSSRAP DATA VALIDATION PROGRAM	DOE/OR/21548-114	MARCH 90	REV. A	DRAFT
GR	153	SUPER EE/CA; COMMUNITY RELATIONS ACTIVITIES	COMMUNITY RELATIONS	JULY 92		
GR	201	SUPERFUND EXPOSURE ASSESSMENT MANUAL	EPA	APR. 1988		PERM. CHECK OUT TO J. BOGNAR
PM	115	SUPERFUND FEDERAL - LEAD REMEDIAL PROJECT MANAGEMENT HANDBOOK	NTIS	DEC. 1986		PERM. CHECK OUT TO W. ANDERSON
PM	35	SUPERFUND HANDBOOK	ERT/SIDLEY & AUSTIN	04-87		
PM	36	SUPERFUND II: A NEW MANDATE	BNA	1987		
PM	32	SUPERFUND MANUAL	GOVERNMENT INSTITUTES, INC.	05-88		
HP	92	SUPERFUND PUBLIC HEALTH EVALUATION MANUAL	EPA	OCT. 1986		PERM. CHECK OUT TO J. BOGNAR
RG	19	SUPERFUND PUBLIC HEALTH EVALUATION MANUAL	EPA	10-86		
RG	87	SUPERFUND REMEDIAL DESIGN AND REMEDIAL ACTION GUIDANCE	NTIS	JUNE 86		
RG	24	SUPERFUND REMOVAL PROCEDURES REV. 2	EPA	08-84	N/A	
EN	44	SUPPLEMENTAL COST & SCHEDULE INFORMATION FOR PROCESS INVENTORY CONTROL SYSTEM	MARTIN MARIETTA	6-86		
ZZ	491	SUPPLEMENTARY SOIL SAMPLING PLAN	DOE/OR/21548-395	MAR. 1993	REV. A	
GR	127	SUPPORT STUDY #14 LAND DISPOSAL FACILITY ALTERNATIVE COVER ASSESSMENT	JEG	APRIL 92		
GR	147	SUPPORTING STUDY #45; DISPOSAL CELL PERFORMANCE ASSESSMENT ANNOTATED OUTLINE AND FIGURES ROADMAP	PMC	JULY 92	REV. B	
EN	85	SUPPORTING STUDY NO. 13 LEACHATE COLLECTION AND REMOVAL SYSTEM DESIGN CRITERIA ASSESSMENT FOR THE WELDON SPRING SITE REMEDIAL ACTION PROJECT PROPOSED LAND DISPOSAL FACILITY	MK-ENVIRONMENTAL BOISE	JAN. 1992	REV. 0	
ZZ	122	SUPPORTING STUDY NO. 3A - PERMEABILITY TESTING		09-19-91	REV. 1	
ZZ	292	SUPPORTING STUDY NO. 41 - PREPROCESSING TREATMENT		SEPT 91	REV. 0	
HP	38	SURFACE INVESTIGATION DRAFT REPORT FOR WELDON SPRING TRAINING AREA	DOA	03-88		
HG	64	SURFACE WATER HYDROLOGY THE GEOLOGY OF NORTH AMERICA VOLUME O-1	WOLMAN/RIGGS	1990		PERM. CHECK OUT TO J. CARMAN
ZZ	107	SURFACE WATER MANAGEMENT PLAN	DOE/OR/21548-221	JUNE 92	REV. 0	
EN	29	SURVEY & ASSESSMENT OF WSCP, ST. CHARLES, MO	DOA	08-77		
EN	1	SURVEY PLAN CONSIDERATIONS REPORT	RYCKMAN, EDGERLEY, TOMLINSON	JUNE 1977		
HP	13	SURVEY PLAN FOR THE RADIOLOGICAL CHARACTERIZATION OF THE WSQ	BNI	10-84	11	
ZZ	141	SURVEY REPORT FOR THE BUSCH AND WELDON SPRING WILDLIFE AREA LOCATIONS 3, 4, 5, AND 8		04-28-88		
EN	4	SYNOPSIS OF ELECTRICAL POWER FOR PHASE II SURVEY	RETA	01-78	81	
RG	75	TECH/OPS LANDAUER, INC. GENERAL QUALITY ASSURANCE MANUAL REV. 4	TECH/OPS LANDAUER, INC.	8-1-90	REV. 4	
BL	9	TECHNICAL BASELINE DOCUMENT PMC STATEMENT OF WORK	PMC	MAY 92	REV. 2	
ZZ	359	TECHNICAL BASELINE DOCUMENT PMC STATEMENT OF WORK	DOE/OR/21548-245	MAY 1992	REV. 2	FILE IN BL-009; CI #18
CM	13	TECHNICAL EXCHANGE MEETING ON PASSIVE RADON MONITORING	DOE	09-21-87		
RG	5	TECHNICAL GUIDANCE DOCUMENT: CONSTRUCTION QUALITY ASSURANCE FOR HAZARDOUS WASTE LAND DISPOSAL	EPA	10-86	N/A	

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		FACILITIES				
EN	43	TECHNICAL INFORMATION DOCUMENT PROCESS INVENTORY CONTROL SYSTEM	MARTIN MARIETTA	6-30-86		
GR	172	TECHNICAL INSTRUCTIONS FOR THE SAFE TRANSPORT OF DANGEROUS GOODS BY AIR 1993-1994 EDITION (3 COPIES RECEIVED & GIVEN FOR PERM. CHECK OUT TO BRENT CURIA)	ICAO	1992		PERM. CHECK OUT TO B. CURIA
EN	53	TECHNICAL MEASUREMENTS CENTER MONTHLY REPORT	UNC GEOTECH			MONTHLY
WM	40	TECHNICAL POSITION ON WASTE FORM	U.S. NUCLEAR REGULATORY COMM.	JAN 91	REV. 1	
GR	15	TECHNICAL PROPOSAL - PHASE IV: A MODEL FOR QUANTITATIVE DECISION- MAKING	RETA	06-78	N/A	
HP	7	TECHNICAL PROPOSAL FOR PHASE II HEALTH & SAFETY PLAN	RETA	09-77	76	
PM	37	TECHNICAL PROPOSAL FOR PHASE II: PHASE II COST & SCHEDULE	RETA	09-77		
EN	2	TECHNICAL PROPOSAL FOR PHASE II: BUILDING SURVEY PLAN WELDON SPRING CHEMICAL PLANT SURVEY AND ASSESSMENT	RETA	SEPT 1977		
GR	39	TECHNICAL PROPOSAL FOR PHASE II: BUILDING SURVEY PLAN, WSCP SURVEY & ASSESSMENT	RYCKMAN/EDGERLEY/TOM LINSON	09-77		
EV	3	TECHNICAL PROPOSAL FOR PHASE II: ENVIRONMENTAL SURVEY PLAN & SUPPLEMENT	RETA	08/09-77	84/77	
ZZ	150	TECHNICAL SOURCES UTILIZED IN GENERATING THE VARIOUS WSSRAP REPORTS AND PLANS ARE LISTED IN EACH DOCUMENT AS REFERENCES. THESE PEFERENCES ARE AVAILABLE AT LOCAL LIBRARIES AND/OR FROM THE RESPECTIVE PUBLISHER.				TECH SOURCES (EF)
EN	38	TECHNOLOGICAL APPROACHES TO THE CLEANUP OF RADIOLOGICALLY CONTAMINATED SUPERFUND SITES	EPA	08-88		
RG	30	TECHNOLOGICAL APPROACHES TO THE CLEANUP OF RADIOLOGICALLY CONTAMINATED SUPERFUND SITES APPENDIX A APPLICABLE LAWS, REGULATIONS & GUIDANCE	EPA	12-87		
SE	3	TECHNOLOGIES WORKSHOP - WSSRAP		08/08/91		
GR	111	TECHNOLOGY NEEDS ASSESSMENT CROSSWALK REPORT	CHEM-NUCLEAR GEOTECH, INC.	AUG. 1992	DRAFT	
EN	36	TECHNOLOGY SCREENING GUIDE FOR TREATMENT OF CERCLA SOILS AND SLUDGES	EPA	09-88		
GR	151	TECHNOLOGY WORKSHOP	COMMUNITY RELATIONS	JULY 92		
ZZ	153	TEMPORARY ASPHALT CONCRETE PAVEMENT - SPECIFICATION SECTION 02548 - STANDARD SPECIFICATION	DOE/OR/21548-055	01-09-89	REV. 0	
ZZ	156	TEMPORARY EROSION CONTROL	DOE/OR/21548-058	04-13-89	REV. 0	STANDARD SPEC. SP: 2279
ZZ	161	TEMPORARY STORAGE AREA CHARACTERIZATION REPORT	DOE/OR/21548-063	JAN 90	REV. 1	
ZZ	473	TEMPORARY STORAGE AREA OPERATION PLAN	DOE/OR/21548-369	JUN. 1993	REV. 0	
ZZ	492	TEMPORARY STORAGE AREA SAMPLING AND CHARACTERIZATION PLAN	DOE/OR/21548-396	APR. 1993	REV. 0	
GR	181	TEST & EVALUATION DOCUMENT FOR DOT SPECIFICATION 7A TYPE A PACKAGING	WESTINGHOUSE HANFORD CO.	JUNE 1992		
RG	137	TEST METHODS FOR EVALUATING SOLID WASTE (VOLUME Ic: LABORATORY MANUAL PHYSICAL/CHEMICAL METHODS)	EPA	NOV. 1986		
KU	24	TEST METHODS FOR EVALUATING SOLID WASTE, PHYSICAL/CHEMICAL METHODS, SW-846, 3RD EDITION	U.S. GOVT. PRINTING OFFICE			PERM. CHECK OUT TO B DONALDSON
HP	65	TEST PLANS AND SPECIFICATIONS FOR IN SITU PERMEABILITY TESTING PROGRAM AT THE WSS	DANIEL B. STEPHENS & ASSOC.	JAN 91		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
GR	110	TEST REPORT EXPLOSIVITY TESTING OF STABILIZED TNT CONTAMINATED SOIL SAMPLES	HERCULES INCORPORATED	FEB. 1992		
HP	95	TESTING TO DETERMINE RELATIONSHIP BETWEEN EXPLOSIVE CONTAMINATED SLUDGE COMPONENTS AND REACTIVITY	ARTHUR D. LITTLE, INC.	JAN. 1987		
KU	28	THE 100 MOST FREQUENTLY CITED OSHA CONSTRUCTION STANDARDS IN 1991: A GUIDE FOR THE ABATEMENT OF THE TOP 25 ASSOCIATED PHYSICAL HAZARDS	U.S. DEPT. OF LABOR	FEB. 1993		PERM. CHECK OUT TO K. JENKINS
CM	15	THE 7TH ANNUAL DOE MODEL CONFERENCE ON WASTE MGMT. & ENVIRONMENTAL RESTORATION OCT. 14-17, 1991	DOE OAK RIDGE	OCT. 91		
GR	114	THE CHEMISTRY OF CEMENT AND CONCRETE	F.M. LEA	1971		PERM. CHECK OUT TO G. SCHMIDT
EV	94	THE CLEAN AIR ACT AMENDMENTS OF 1990: STATUTORY REQUIREMENTS AND KEYWORD INDEX	MCCOY AND ASSOC., INC.	1991		PERM. CHECK OUT TO T. UHLMEYER
KU	2	THE CLEAN WATER ACT AMENDMENTS OF 1987	ENVIRONMENT REPORTER	SEP. 1987		
RG	113	THE COMPLETE GUIDE TO THE HAZARDOUS WASTE REGULATIONS SECOND EDITION	T.P. WAGNER	1991		PERM. CHECK OUT TO S. STUMNE
ZZ	369	THE CONFIGURATION OF THE WELDON SPRING SITE REMEDIAL ACTION PROJECT	DOE/OR/21548-255	12/01/91	REV 0	MINI GUIDE TO MANAGING
HG	37	THE CONTAMINATION OF GROUND & SURFACE WATERS BY LIQUID WASTES FROM THE WELDON SPRING ORDANCE WORKS, MISSOURI	DOI	01-44		
WM	56	THE DISPERSAL & IMPACT OF SALT FROM SURFACE STORAGE PILES AT WIPP	IT CORP	NO DATE		
GY	3	THE EFFECT OF A ZERO-CONCENTRATION SINK ON CONTAMINANT TRANSPORT AND REMEDIAL-ACTION DESIGNS FOR THE WELDON SPRING QUARRY, WELDON SPRING, MO.	ANL	APRIL 90		
HG	26	THE EFFECTS OF A PERTURBED SOURCE ON CONTAMINANT TRANSPORT NEAR THE WELDON SPRING QUARRY	ANL	03-89		
GE	16	THE GEOLOGY OF A PORTION OF THE WELDON SPRING QUADRANGLE	WASHINGTON UNIVERSITY	06-56		
GR	143	THE HAZARDOUS WASTE CONSULTANT VOLUME 10, ISSUE 4	McCOY AND ASSOCIATES, INC.	JULY 92		PERM. CHECKOUT TO MARY GILBERT
HP	97	THE HEALTH PHYSICS AND RADIOLOGICAL HEALTH HANDBOOK	B. SHLEIEN	1992		PERM. CHECK OUT TO M. SIZEMORE
KU	23	THE LABOR REQUIREMENTS OF THE SERVICE CONTRACT ACT	FEDERAL PUBLICATIONS INC.	FEB. 1993		PERM CHECK OUT TO A. SISSON
RG	67	THE LOW-LEVEL WASTE HANDBOOK: A USER'S GUIDE TO THE LOW-LEVEL RADIOACTIVE WASTE POLICY AMENDMENTS ACT OF 1985	M. BROWN (NATL GOVENORS' ASS.)	11-86		
GR	157	THE MERCK INDEX ELEVENTH EDITION	MERCK & CO., INC.	1989		PER CHECKOUT TO C. PROCTOR
RG	68	THE MISSOURI SAFE DRINKING WATER ACT & THE MISSOURI PUBLIC DRINKING WATER REGULATIONS	MDNR	09-88		
GR	102	THE NATIONAL ELECTRICAL CODE - 1990 HANDBOOK	M. EARLEY, R. MURRAY, J CALOGG	1989		PERM CHECK OUT TO P. CATE
RG	118	THE PURCHASING HANDBOOK FIFTH EDITION	NATIONAL ASSOC. OF PURCHASING	1993		PERM. CHECK OUT TO M. LEWIS
GR	133	THE QUALITY AUDIT A MANAGEMENT EVALUATION TOOL	C.A. MILLS	1989		PERM. CHECK OUT TO P. CATE
GR	51	THE RESOURCES OF ST. CHARLES COUNTY, MISSOURI LAND, WATER, AND MINERALS	MDNR	04/77		
KU	1	THE UNITED STATES GOVERNMENT MANUAL 1990/91 CENSUS 1790	MARTHA GIRARD	JUL. 1990		
CM	21	THE WELDON SPRING SITE REMEDIAL ACTION PROJECT	DOE	03-13-86		
PM	77	THE WELDON SPRING SITE WSSRAP FY92 ADS	DOE	NOV 29,89		

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		PRESENTATION TO OAK RIDGE OPERATIONS				
EV	95	THE WILD MAMMALS OF MISSOURI	SCHWARTZ	1981		PERM. CHECK OUT TO M. THOMAS
EV	13	THIRD QUARTER AIR MONITORING REPORT FOR WELDON SPRING, MO	BNI	10-28-83		
RG	12	TOXIC SUBSTANCES CONTROL ACT	USC	10-76	N/A	
RG	61	TOXIC SUBSTANCES CONTROL ACT INSPECTION MANUAL	EPA	10-82		
PM	60	TRAFFIC STUDY FOR WSSRAP	HORNER & SHIFRIN, INC.	MAY 91	REV. 0	
ZZ	174	TRANSCRIPT OF: 02-13-89 MoDNR NPDES HEARING ON DOE DISCHARGE PERMIT	DOE/OR/21548-076	6-89		
ZZ	175	TRANSCRIPT OF: 02-14-89 MoDNR NPDES HEARING ON DOE DISCHARGE PERMIT	DOE/OR/21548-077	6-89		
ZZ	170	TRANSCRIPT OF: THE 12-06-88 PUBLIC MEETING - LINDENWOOD COLLEGE	DOE/OR/21548-072	06-89		
ZZ	262	TRANSCRIPT OF: THE AUGUST 16, 1990 PUBLIC MEETING ST. CHARLES, MO. FOR THE NPDES PERMIT SITE WATER TREATMENT	DOE/OR/21548-140	AUG. 90		
ZZ	266	TRANSCRIPT OF: THE MARCH 29, 1990 PUBLIC MEETING WENTZVILLE, MO FOR THE: QUARRY WASTE REMOVAL PROPOSED PLAN	DOE/OR/21548-143	MARCH 90		
CM	5	TRANSCRIPT: DEIS PUBLIC HEARING	PERRY REPORTING	04-87	N/A	
CM	1	TRANSCRIPT: WELDON SPRING SCOPING MEETING	CONCANNON & JAEGER	03-84	73	
ZZ	75	TRANSFORMER SAMPLING FOR PCB FLUIDS	04-17-87			IRA #1
DD	26	TRANSPORT OF CHEMICAL CONTAMINANTS IN KARST TERRANES: OUTLINE AND SUMMARY	MALCOLM S. FIELD	JUL. 1989		(PERM. CHECK OUT TO J. PIER)
GR	135	TRANSPORTATION INFORMATION RESOURCE MANUAL		FEB. 92		PERM. CHECK OUT TO L. PHILLIPS
WM	50	TRANSPORTATION OF HAZARDOUS WASTE MATERIALS (SECOND EDITION)	KENWORTHY/SNOW/DALY	APRIL 92		PERM. CHECKOUT TO BRENT CURIA
WM	46	TRANSPORTATION OUTREACH PROGRAM PLAN	DOE	AUG 91		
GR	121	TREATABILITY MANUAL VOLUME I TREATABILITY DATA	EPA	FEB. 1983		
GR	122	TREATABILITY MANUAL VOLUME II INDUSTRIAL DESCRIPTIONS	EPA	SEPT. 81		
GR	123	TREATABILITY MANUAL VOLUME III TECHNOLOGY FOR CONTROL/REMOVAL OF POLLUTANTS	EPA	SEPT. 81		
GR	124	TREATABILITY MANUAL VOLUME IV COST ESTIMATING	EPA	APRIL 83		
GR	125	TREATABILITY MANUAL VOLUME V SUMMARY	EPA	SEPT. 81		
EN	66	TREATMENT PROCESS DESIGN REPORT FOR WELDON SPRING SITE TSA TRAIN 1 SITE WATER TREATMENT PLANT	RESOURCE TECH. GROUP INC.	09/06/91		
EV	41	TRINITROTOLUENE HEALTH ADVISORY	EPA	01-89		
EV	103	U.S. ARMY TOXIC AND HAZARDOUS MATERIALS AGENCY INSTALLATION RESTORATION PROGRAM: REMEDIAL INVESTIGA	BIANG, BENIOFF, DAVIS & EDDY	JUNE 88		
RG	109	U.S. DEPARTMENT OF ENERGY CONSTRUCTION SAFETY MANUAL BUILDING BLOCKS OF CONSTRUCTION SAFETY	LOS ALAMOS NATIONAL LAB.	06/04/91	DRAFT	
ZZ	428	U.S. DEPARTMENT OF ENERGY FIELD WORK PROPOSAL, WORK PACKAGE NO. ANL 061-00-93, WORK PROPOSAL NO. 01	DOE/OR/21548-312	APRIL 92		NOT YET RECEIVED
PM	72	U.S. DEPARTMENT OF ENERGY GRAND JUNCTION PROJECTS OFFICE CAPABILITIES AND FACILITIES	DOE			
GR	82	U.S. DOE GOVERNMENT OPEN SYSTEMS INTERCONNECTION PROFILE PROCEDURES AND GUIDELINES (GOSIP)	DOE (GW-PN-007) D/C SHELF	04-05-91		INCLUDED: GW-PN-004,5,6 - FILE
PM	49	U.S. DOE GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL AT FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM AND REMOTE SURPLUS FACILITIES	DOE	3-87	REV. 2	ENCLOSURE 1

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		MANAGEMENT PROGRAM SITES				
RG	80	U.S. DOE GUIDELINES FOR RESIDUAL RADIOACTIVITY AT FUSRAP AND REMOTE SFMP SITES	DOE	8-16-85		
PM	96	U.S. DOE RADIOLOGICAL CONTROL MANUAL	U.S. DOE SECRETARY FOR ES&H	JUNE 92		
DO	28	U.S. ENVIRONMENTAL PROTECTION AGENCY'S STRATEGY FOR GROUND WATER QUALITY MONITORING AT HAZARDOUS WASTE LAND DISPOSAL FACILITIES LOCATED IN KARST TERRANES	EPA	NOV. 1988		(PERM. CHECK OUT TO J. PIER)
RG	72	UNDERGROUND STORAGE TANK POLICY	DOE (PEER)	7-26-89		
WM	32	UNDERGROUND STORAGE TANK POLICY	PEER	7-26-89		
GR	227	UNDERSTANDING OVERHEAD IN GOVERNMENT CONTRACTS	FEDERAL PUBLICATIONS INC.	FEB. 1993		PERM. CHECK OUT TO M. LEWIS
PM	68	UNITED STATES DEPARTMENT OF ENERGY WELDON SPRING SITE REMEDIAL ACTION PROJECT PRESENTATION TO: DEPARTMENT OF THE ARMY	DOE WELDON SPRING	NOV. 2,90		
EV	1	UNIVERSITY OF MO WELDON SPRING MASTER PLAN - ENVIRONMENT IMPACT ASSESSMENT	MOK ASSOC.	09-76	N/A	
ZZ	191	UNKNOWN	DOE/OR/21548-093	08-89	REV. 0	(EF)
HP	26	URAINUM REFERENCE MATERIALS	DOE	07-87		
WM	29	USE OF INCENTIVES TO SITE LOW-LEVEL RADIOACTIVE WASTE FACILITIES		4-90		
EV	48	USEPA CONTRACT LABORATORY PROGRAM - STATEMENT OF WORK FOR ORGANICS ANALYSIS MULTI-MEDIA MULTI-CONCENTRATION	EPA	07-87		
GR	78	USER'S GUIDE FOR THE SHIPMENT MOBILITY/ACCOUNTABILITY COLLECTION	DOE			
GR	148	USER'S GUIDE FOR THE SHIPMENT MOBILITY/ACCOUNTABLE COLLECTION	DOE	JUNE 92		
HG	52	USERS GUIDE VERSION 3.2 TO THE GROUND WATER NETWORK OF THE NATIONAL GROUND WATER INFORMATION CENTER	NAT. GROUND WATER INFO. CENTER	6-10-91		
HP	84	USP XXII NF XVII 6 SUPPLEMENTS ATTACHED	US PHARMACOPEIAL CONVENTION,	JAN 1, 90		PERM. CHECK OUT TO L. PHILLIPS
RP	4	UTILITY OF RAFFINATE PITS AT WELDON SPRING, MO FOR THE CONTAINMENT OF RADIOACTIVE CONTAMINANTS	ORNL	08-82	32	UPDATED 12-82
RG	21	VALIDATION OF METHODS FOR EVALUATION RADON-FLUX ATTENUATION THROUGH EARTHEN COVERS	NRC	10-84		
HP	28	VALIDATION OF THE PROMPT ALPHA-TRACK METHOD	DOE	08-87		
GR	193	VALIDATION OF THE SAMPLING SCHEDULE IN THE RADIOLOGICAL BASELINE PROGRAM FOR THE WIPP PROJECT: A STATISTICAL ARGUMENT	IT CORP.	AUG. 1985		
ZZ	346	VEGETATIVE DEBRIS SAMPLING PLAN	DOE/OR/21548-209	SEPT 91	REV. 0	
GR	59	VERIFICATION AND CERTIFICATION PROTOCOL FOR REMOTE SITES DECONTAMINATED UNDER THE SURPLUS FACILITIES MANAGEMENT PROGRAM	DOE	1-31-86		
ZZ	134	VERIFICATION OF RELEASED MATERIALS	03-03-88			IRA #6
GE	40	VERIFICATION SURVEY OF BUILDING 409 WSSRAP	ORAU	APRIL 91		FINAL REPORT
ZZ	89	VERIFICATIONS OF RELEASED MATERIALS - LOAD NOS. 1 - 18	01-04-88			
ZZ	21	VICINITY PROPERTIES CONCEPTUAL DESIGN REPORT	DOE/OR/21548-001	04-89	REV. A	
GR	213	VITRIFICATION COST STUDY INCLUDING A REVIEW OF PACIFIC NORTHWEST LABORATORY'S VITRIFICATION TECHNOLOGIES FOR WELDON SPRING RAFFINATE SLUDGE AND CONTAMINATED SOILS PHASE II REPORT, SCREENING OF ALTERNATIVES	MK-BOISE	NOV. 1992	REV. 0	

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GR	211	VITRIFICATION FATAL FLAW ANALYSIS REPORT NO. 5121R-403-0	MK-BOISE	NOV. 1992	REV. 0	
RP	11	VITRIFICATION TECHNOLOGIES FOR WELDON SPRING RAFFINATE SLUDGES AND CONTAMINATED SOILS PHASE 2 REPORT: SCREENING OF ALTERNATIVES	BATTELLE	11-89		
RP	12	VITRIFICATION TECHNOLOGIES FOR WELDON SPRING RAFFINATE SLUDGES AND CONTAMINATED SOILS PHASES I REPORT: DEVELOPMENT OF ALTERNATIVES	BATTELLE	12-88		
DD	27	VULNERABILITY OF KARST AQUIFER TO CHEMICAL CONTAMINATION	EPA	NOV. 1988		(PERM. CHECK OUT TO J. PIER)
WM	33	WASTE ACCEPTANCE PLAN AND ANALYTICAL PROTOCOL FOR THE K-1435 TOXIC SUBSTANCE CONTROL ACT INCINERATOR	DOE	10-1-86	0	
ZZ	242	WASTE ANALYSIS PLAN	DOE/OR/21548-128	AUG. 1992	REV. 4	
WM	27	WASTE ANALYSIS PLANS A GUIDANCE MANUAL	EPA	11-84		
ZZ	190	WASTE ASSESSMENT CHEMICAL CHARACTERIZATION OF THE WELDON SPRING SITE RAFFINATE PITS	DOE/OR/21548-092	08-89	REV. 0	
ZZ	160	WASTE ASSESSMENT RADIOLOGICAL CHARACTERIZATION OF THE WELDON SPRING SITE RAFFINATE PITS	DOE/OR/21548-062	08-89	REV. 0	
ZZ	30	WASTE ASSESSMENT: RAFFINATE PIT SAMPLING PLAN, WELDON SPRING SITE	DOE/OR/21548-010	05-88	REV. 1	
EN	26	WASTE CONTAINMENT DESIGN REPORT FOR THE NIAGARA FALLS STORAGE SITE	DOE	06-84		
GR	20	WASTE CONTAINMENT DESIGN REPORT FOR THE NFSS & ADD. 1 / LONG-TERM CONTAINMENT OPTION	BNI	6-84/10-8	N/A	
KU	14	WASTE DISPOSAL EFFECTS ON GROUND WATER	PREMIER PRESS	19800		
ZZ	495	WASTE INVENTORY TRACKING SYSTEM (WITS) USER MANUAL	DOE/OR/21548-389	MAY 1993	REV. 0	
WM	1	WASTE MANAGEMENT '87 VOL. 1 GENERAL INTEREST	ANS	03-87	N/A	
WM	2	WASTE MANAGEMENT '87 VOL. 2 HIGH-LEVEL WASTE	ANS	03-87	N/A	
WM	3	WASTE MANAGEMENT '87 VOL. 3 LOW-LEVEL WASTE	ANS	03-87	N/A	
ZZ	154	WASTE MANAGEMENT IMPLEMENTATION PLAN	DOE/OR/21548-056	03-89	REV. 0	
ZZ	188	WASTE MANAGEMENT PLAN	DOE/OR/21548-090 (INACTIVE)	07-90	REV. B	FILED: ZZ291 DOE/OR/21548-166
ZZ	272	WASTE MANAGEMENT TRAINING PLAN	DOE/OR/21548-149	FEB 92	REV. 2	
ZZ	291	WASTE MANAGMENT PLAN	DOE/OR/21548-166	FEB. 1993	REV. 4	INCL. REV A&B DOE/OR/21548-090
WM	47	WASTE MINIMATION AND POLLUTION PREVENTION AWARENESS PLAN	BNI	JUNE 91		
ZZ	238	WASTE MINIMIZATION POLLUTION PREVENTION AWARENESS PLAN	DOE/OR/21548-124	MAY 91	REV. 1	CONTROLLED DOCUMENT
ZZ	430	WASTE QUANITIES QUARTERLY REPORT: 4/1/92 - 6/30/92	DOE/OR/21548-314	APRIL 92		NOT YET RECEIVED
ZZ	467	WASTE SAMPLING & ANALYSIS PLAN FOR CHEMICAL PLANT ROOFING	DOE/OR/21548-348	NOV. 1992	REV. 0	
GR	32	WASTE SITE CLOSURE DEMONSTRATION ANNUAL PROGRESS REPORT	ENVIRONMENTAL SCIENCE GROUP	10-87		
GR	106	WATER AND WASTE LABORATORY	HAZEN RESEARCH, INC	JULY 1990	REV. 2	
EV	24	WATER BALANCE REPORT FOR THE WELDON SPRING RAFFINATE PITS	SHELL ENG.	10-85	N/A	
HG	32	WATER QUALITY CRITERIA FOR 2,4,6-TRINITROTOLUENE (TNT)	ORNL	08-87		
HG	31	WATER QUALITY CRITERIA FOR 2,4-DINITROTOLUENE AND 2,6-DINITROTOLUENE	ORNL	08-87		
HG	28	WATER QUALITY CRITERIA FOR HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE	ORNL	06-86		
HG	29	WATER QUALITY CRITERIA FOR NITROCELLULOSE	ORNL	06-86		

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MK-Ferguson
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Alphabetical Listing

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MG	30	WATER QUALITY CRITERIA FOR NITROGLYCERIN	ORNL	07-86		
MG	33	WATER QUALITY CRITERIA FOR WHITE PHOSPHORUS	ORNL	08-87		
ZZ	23	WATER QUALITY PHASE I ASSESSMENT REPORT	DOE/OR/21548-003	12-87		
GE	19	WATER RESOURCES OF THE ST. LOUIS AREA, MO	MO GEO & US GEO SURVEY	1974		
MG	78	WATER-QUALITY DATA FOR THE MISSOURI RIVER AND MISSOURI RIVER ALLUVIUM NEAR WELDON SPRING, ST. CHARLES COUNTY, MISSOURI--1991-92	U.S. GEOLOGICAL SURVEY	1993		OPEN-FILE REPORT 93-109
GE	24	WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN MISSOURI, FISCAL YEAR 1989	U.S. GEOLOGICAL SURVEY	1989		
GR	158	WEBSTER'S II - NEW RIVERSIDE UNIVERSITY DICTIONARY	RIVERSIDE PUBLISHING CO.			PERM CHECKOUT TO C. TIBURZI
HP	37	WELDON SPRING CHEMICAL PLAN SURVEY & ASSESSMENT	DOA	06-78		FINAL REPORT
ZZ	197	WELDON SPRING CHEMICAL PLANT BUILDINGS	DOE/OR/21548-099	DEC 89	REV. A	
ZZ	260	WELDON SPRING CHEMICAL PLANT UNDERGROUND STORAGE TANK SAMPLING PLAN	DOE/OR/21548-138	NOV. 90	REV. 0	
ZZ	427	WELDON SPRING CONTRACT DOE NO. DE-AC05-86OR21548, MK CONTRACT NO. 3589	DOE/OR/21548-311	MAY 1986		NOT YET RECEIVED
HP	8	WELDON SPRING DOSE CALCULATIONS	ORNL	09-78	45	
GR	41	WELDON SPRING EEA ADDENDUM - ALTERNATIVE #3A, ACCELERATE QUARRY WORK, RFE #106 (ESTIMATES FOR REMEDIAL ACTION)	BNI	84		
EN	51	WELDON SPRING ENGINEERING ANALYSIS OF ALTERNATIVES	MK-E	DEC 1990	REV. A	
HP	20	WELDON SPRING HISTORICAL DOSE ESTIMATE	ANL	07-86	N/A	
PM	45	WELDON SPRING ORDNANCE WORKS COMPLETION REPORT				PROVIDED FROM ARMY FILES
ZZ	199	WELDON SPRING QUARRY BOREHOLE LOGS AND WELL COMPLETION DIAGRAMS	DOE/OR/21548-101	01-90	REV. 0	
ZZ	432	WELDON SPRING QUARRY CONCEPTUAL DESIGN REPORT	DOE/OR/21548-316	APRIL 87	REV. 1	NOT YET RECEIVED
ZZ	381	WELDON SPRING QUARRY ENVIRIONMENTAL MONITORING INVESTIGATIONS SAMPLING PLAN	DOE/OR/21548-264	AUG. 1992	REV. 0	
ZZ	332	WELDON SPRING QUARRY HAUL ROAD CHARACTERIZATION REPORT	DOE/OR/21548-198	AUG 91	REV. 0	
ZZ	239	WELDON SPRING QUARRY HAUL ROUTE CHEMICAL CHARACTERIZATION SAMPLING PLAN	DOE/OR/21548-125	7/90	REV. 0	
ZZ	317	WELDON SPRING QUARRY POND, ASH POND, AND SITE PROCESS SEWER NPDES OUTFALL 0001 SURFACE WATER SAMPLING PLAN	DOE/OR/21548-187	MARCH 91	REV. 0	
ZZ	333	WELDON SPRING QUARRY RESIDUAL WORK PLAN	DOE/OR/21548-216	APRIL 91	REV. A	
ZZ	357	WELDON SPRING QUARRY RESIDUALS CONTAMINANT INVESTIGATIONS SAMPLING PLAN	DOE/OR/21548-242	DEC. 91	REV. B	
WM	15	WELDON SPRING RADIOACTIVE WASTE MANAGEMENT PLAN	NLO	06-21-73		
RP	2	WELDON SPRING RAFFINATE PITS & QUARRY TASK FORCE REPORT	HILT,J.M.	06-67	60	
PM	10	WELDON SPRING REMEDIAL ACTION (FROM A.N.S. MEETING 06-11-85)	DOE	06-85	03	
BZ	12	WELDON SPRING REMEDIAL ACTION PROJECT 1992 AQUARTIC BIOLOGICAL MONITORING - WP305 FINAL REPORT	ENVIRONMENTAL SCIENCE & ENG.	APR. 1993		
ZZ	398	WELDON SPRING SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1991	DOE/OR/21548-283	JULY 1992	REV. 1	
ZZ	489	WELDON SPRING SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1992	DOE/OR/21548-372	JUN. 1993	REV. 0	
ZZ	377	WELDON SPRING SITE NORTHWEST QUADRANT PLAN	DOE/OR/21548-261	FEB. 1992	REV. 0	
CM	8	WELDON SPRING SITE PUBLIC FORUM	MK-F	10-87		
CM	27	WELDON SPRING SITE REMEDIAL ACTION PROJECT PUBLIC	SANDY MCGRAW	DEC. 1992		

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		HEARING THURSDAY DECEMBER 16, 1992				
EN	79	WELDON SPRING SITE REMEDIAL ACTION PROJECT WSSRAP DISPOSAL FACILITY DUST CONTROL METHODS AND CRITERIA STUDY	MK ES BOISE	DEC. 1991	REV. C	(3840R-799-C)
GE	46	WELDON SPRING SITE REMEDIAL ACTION PROJECT WSSRAP QUARRY HAUL ROAD RISK ASSESSMENT REPORT	MK CLEVELAND	APR 3, 91	DRAFT	REPORT #5121-R-315-B
LN	13	WELDON SPRING SITE REMEDIAL ACTION PROJECT QUARRY FLEXIBLE MEMBRANE LINER (FML) INVESTIGATION	LOCKWOOD GREENE ENG., INC.	DEC 20,91		DRAFT
PM	124	WELDON SPRING SITE REMEDIAL ACTION PROJECT (WSSRAP) BASIS OF COST ESTIMATE		APR. 1987		
PM	125	WELDON SPRING SITE REMEDIAL ACTION PROJECT (WSSRAP) COST ESTIMATE REVIEW CHEMICAL PLANT GROUND WATER RECLAMATION	FOSTER WHEELER USA CORP.	DEC. 1987	REV. 2	
HG	4	WELDON SPRING SITE REVIEW AND ASSESSMENT OF WATER RELATED ISSUES AND INVESTIGATIONS	OZARK UNDERGROUND LAB	02-84	N/A	
EN	74	WELDON SPRING SITE WATER TREATMENT PLANT TRAIN NO. 1 OPERATION PLAN	MKFW AND JEGW	NOV. 1991	REV. A	DIN # 12877
ZZ	439	WELDON SPRING SITE WATER TREATMENT PLANT EFFLUENT PIPELINE CHARACTERIZATION	DOE/OR/21548-323	JULY 1992	REV. 0	
WM	24	WELDON SPRING SPECIAL STUDIES PHASE II REPORT ON SLAGGING INCENERATION	JEG	2/90		DRAFT
EN	41	WELDON SPRING TRAINING AREA DRAFT RI REPORT - VOL. 1, 2, & 3 WITH SECOND ADDENDUM	DA / INTERN'L TECH. CORP.	06-89		SECOND ADDENDUM - 5/90
EV	49	WELDON SPRING TRAINING AREA SURFACE INVESTIGATION (FINAL REPORT)	US ARMY CORPS OF ENGINEERS	11-88		
RP	9	WELDON SPRING, MO, RAFFINATE PITS 1,2,3, & 4: PRELIMINARY GROUT DEVELOPMENT SCREENING STUDIES FOR IN SITU WASTE IMMOBILAZATION	ORNL	04-87		
KU	10	WELDON SPRING: A PROPOSAL FOR A REGIONAL ENVIRONMENTAL EDUCATION CENTER	RPDG	JAN. 1977		
GE	32	WELDON SPRINGS SITE REMEDIAL ACTION PROJECT LABORATORY TEST RESULTS	CHEN-NORTHERN, INC.	01-31-89		
ZZ	456	WELL FIELD CONTINGENCY PLAN	DOE/OR/21548-340	NOV. 1992	REV. 0	
HG	44	WELL HYDRAULICS INTERPRETATION PROGRAM (WHIP) VERSION 3.22 USERS MANUAL	HYDRO GEO CHEM INC.	JULY 1988		SIGN OUT: J. CARMAN (ES&H)
EV	34	WEST VIRGINIA ORDNANCE WORKS: ENDANGERMENT ASSESSMENT FOR SEWERLINES, THE TNT MANUFACTURING AREA, & THE BURNING GROUNDS FINAL REPORT	U.S. ARMY	06-86		
BZ	9	WETLANDS	SCHOOL OF NATURAL RESOURCES	1986		PERM. CHECK OUT TO M. THOMAS
QY	8	WHITE PAPER - QUARRY HAUL ROAD SAFETY ENHANCEMENTS (TASK 353; DRAFT)	MKFB	JULY 92	REV. B	
GR	160	WHITE PAPER QUARRY HAUL ROAD SAFETY ENHANCEMENTS TASK 353	MK-BOISE	JULY 1992	REV. 0	REPORT #3840R-351-0
ZZ	385	WHOLE-EFFLUENT TOXICITY (WET) TESTING SAMPLE FOR QUARRY AND SITE WATER TREATMENT PLANT EFFLUENT PONDS	DOE/OR/21548-268	FEB. 1992	DRAFT	(NOT YET RECEIVED)
GR	137	WILDEN M4 CHAMP DIRECTIONS FOR INSTALLATION AND MAINTENANCE		JUNE 87		
BZ	8	WILDLIFE TOXICOLOGY	VAN NOSTRAND REINHOLD NY, NY			PERM. CHECK OUT TO M. THOMAS
GR	190	WIPP BIOLOGY PROGRAM CHAPTER 9 STATISTICAL ANALYSIS AND DATA MANAGEMENT	CONCEPTS DEVELOPMENT INCORP.	NOV. 80		
ZZ	234	WORK BREAKDOWN STRUCTURE DICTIONARY	DOE/OR/21548-179	05-05-91	REV. 2	
PM	4	WORK FLOW CHART - WSCP	BNI	03-83	31	
ZZ	133	WORK PLAN CONTAINERIZED WASTE HANDLING- METCALF	WP056	09-30-88		IRA #7

WSSRAP DE-AC05-860R21548
MK-Ferguson
Contract: 3589

Alphabetical Listing

Report Date: 09/07/93

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
PM	70	WSSRAP QUARTERLY CONTRACTORS REPORT	DOEW	SEPT 1991		
PM	76	WSSRAP QUARTERLY REVIEW MEETING		JAN 22,87		
ZZ	462	WSSRAP RADIOLOGICAL CONTROL MANUAL	DOE/OR/21548-346	JAN. 1993	REV. 0	
ZZ	102	WSSRAP REFERENCE DOCUMENT LIBRARY INDEX				
KU	25	WSSRAP REFERENCE MATERIAL FOR MANAGEMENT APPRAISAL - VOL. 1 AND VOL. 2		02/01/90		
ZZ	389	WSSRAP ROADMAP	DOE/OR/21548-274	MAY 1992	REV. A	
EV	22	WSSRAP TNT CONTAMINATION	DOE	01-86	N/A	
PM	74	WSSRAP VALIDATION REVIEW FY 1991 *INCLUDED-FY 1989 AND FY 1990*	DOE	APRIL 89		
GE	4	WSSS 1982 - 1983 GEOLOGIC CHARACTERIZATION	BNI	07-83	N/A	
EN	11	WSSS, SITE SEISMICITY & DESIGN EARTHQUAKE CONSIDERATIONS	BNI	07-83	26/28	
WM	13	Y-12 DEVELOPMENT DIVISION TECHNICAL PROGRESS REPORT - PART 7 WASTE PROCESS DEVELOPMENT & PROCESS IMPROVEMENTS	UNION CARBIDE CORP.	07-01-79		
GR	192	YEAR 2000 MASTER PLAN ST. CHARLES COUNTY, MO	SCC PLANNING DEPT.	APRIL 90		

Total Number of Documents Printed: 1,764

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
		AND ASSOCIATES, INC.				
ZZ	375	WORK PLAN FOR DETERMINATION OF BIOLOGICAL UPTAKE OF WSS CONTAMINANTS BY SPECIES IN FOOD PATHWAYS	MKFW AND JEGW	SEPT 87		
ZZ	350	WORK PLAN FOR HYDROLOGICAL INVESTIGATIONS NEAR MW-1011, WSQ AREA	DOE/OR/21548-213	AUG 1991	REV. 0	
ZZ	253	WORK PLAN FOR IN SITU PERMEABILITY TESTING OF OVERBURDEN SOILS	DOE/OR/21548-133	JUNE 90	A	
EV	39	WORK PLAN FOR THE EXHUMATION, EXAMINATION, & CHARACTERIZATION OF BURIED MATERIALS AT THE SOUTH DUMP AREA & THE NORTH & WEST PORTION OF THE ASH POND	MKF AND JEG	NOV. 1991		
ZZ	373	WORK PLAN FOR THE EXHUMATION, EXAMINATION & CHARACTERIZATION OF BURIED MATERIALS AT THE SOUTH DUMP AREA & THE NORTH & WEST PORTION OF THE ASH POND	DOE/OR/21548-259	JAN. 1992	REV. 0	
ZZ	225	WORK PLAN FOR THE MOVEMENT OF RCRA/RSCA AND OTHER MATERIALS TO BUILDING 434		DEC 1989		
ZZ	53	WORK PLAN FOR THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY - ENVIRONMENTAL IMPACT STATEMENT FOR THE WELDON SPRING SITE, WELDON SPRING, MISSOURI	DOE/OR/21548-033	08-88	REV. 0	
HG	24	WORK PROGRESSION PLAN (DRAFT)/DRILLING, MONITORING WELL INSTALLATION AND SAMPLING PLAN/DATA MANAGEMENT PLAN WELDON SPRING TRAINING AREA RI/FS WELDON SPRING, MO/SITE SPECIFIC HEALTH & SAFETY PLAN/QUALITY CONTROL PLAN (DRAFT)	IT CORP.	02-88		
ZZ	417	WORKSTATION SHORTAGES & PROPOSED SOLUTIONS	DOE/OR/21548-302	MAY 1992	REV. 0	(NOT YET RECEIVED)
ZZ	51	WP-100 SPECIFICATION FOR BUILDINGS & EQUIPMENT CHARACTERIZATION	DOE/OR/21548-031	06-88	REV. 0	
RP	13	WS RAFFINATE PITS: EVALUATION OF CEMENT-BASED GROUTS AS A STABILIZATION OPTION	ORNL FOR MARTIN MARIETTA	JUNE 1989		
HP	21	WSCP GROUND SURVEY SUMMARY	EG&G	12-77	50	
EN	7	WSCP SURVEY & ASSESSMENT	RETA	06-78	46	
PH	2	WSCP SURVEY & ASSESSMENT PHASE III: TECHNICAL, COST, & SCHEDULE PROPOSAL	RETA	01-78	82	
EN	8	WSQ - ENGINEERING EVALUATION PROGRAM PLAN	SAI	07-81	N/A	
EV	29	WSS ANNUAL SITE ENVIRONMENTAL MONITORING REPORT FOR CY-1985	BNI	09-86	N/A	
GR	6	WSS BACKGROUND REPORT	AEROSPACE CORP.	5/79	44	
EV	15	WSS ENVIRONMENTAL AIR MONITORING REPORT FOR CY-1983	BNI	06-84	15	
EV	5	WSS ENVIRONMENTAL MONITORING REPORT FOR CY-1981	BNI	1981	38	
EV	7	WSS ENVIRONMENTAL MONITORING REPORT FOR 1979 & 1980	MLO	04-82	33	
EV	8	WSS ENVIRONMENTAL MONITORING REPORT FOR CY-1982	BNI	05-83	29	
EV	20	WSS ENVIRONMENTAL MONITORING REPORT FOR CY-1984	BNI	07-85	N/A	
PH	5	WSS PROJECT MANAGEMENT PLAN AND INFORMATION SUPPLEMENT	DOE/ORO	10-85	REV.1	SUPERCEDED
ZZ	229	WSSRAP DEPARTMENT OF ENERGY CONTRACT NO. DE-AC05-860R21548				
PH	126	WSSRAP BASE LINE	MK-FERGUSON	MAR. 1987	REV. 0	
ZZ	2	WSSRAP BASELINE DELIVERABLES (EM-40 BASELINE IMPLEMENTATION)	PMC	APRIL 92	REV. 1	
ZZ	67	WSSRAP BASELINE RISK ASSESSMENT PROTOCOL DOCUMENT	DOE/OR/21548-047	10-88	REV. 0	
ZZ	123	WSSRAP BUILDINGS CHARACTERIZATION CHEMICAL CHARACTERIZATION REPORT	DOE/OR/21548-236	OCT 91	REV. 0	

REF	SEQ	DOCUMENT TITLE	AUTHOR	DOCUMENT DATE	R.R. NUMBER	REMARKS
PM	54	WSSRAP CATEGORIZATION OF EMERGENCY AND NON-EMERGENCY INCIDENTS		11-27-90		
EN	72	WSSRAP CHEMICAL PLANT PROPOSAL FOR ENGINEERING SERVICES BUILDING DISMANTLEMENT AND DEMOLITION WP257	MKE BOISE	OCT. 1991	REV. 0	
ZZ	264	WSSRAP CHEMICAL PLANT GEOTECHNICAL INVESTIGATIONS APPENDICIES A,B,C & D INCLUDED	DOE/OR/21548-142 (INACTIVE)	9-90	DRAFT	FILED: ZZ281 DOE/OR/21548-158
ZZ	281	WSSRAP CHEMICAL PLANT GEOTECHNICAL INVESTIGATIONS APPENDICIES A,B,C & D INCLUDED	DOE/OR/21548-158	DEC. 1990	REV. 0	INCL. DRAFT DOE/OR/21548-142
ZZ	366	WSSRAP CHEMICAL PLANT SURFACE WATER AND EROSION CONTROL REPORT	DOE/OR/21548-253	OCT. 1991	REV. 0	
ZZ	125	WSSRAP CHEMICAL SOIL DATA REPORT TO SUPPORT INTERIM RESPONSE ACTIONS, CONSTRUCTION STAGING AREA AND ADMINISTRATION BUILDING	DOE/OR/21548-051	FEB. 1989	REV. 0	
PM	28	WSSRAP CONTAMINATED WATER TREATMENT QUARRY AND RAFFINATE PITS FINAL FEASIBILITY REPORT	MKE	03-87		
DD	22	WSSRAP COST ESTIMATE REVIEW DISPOSAL FACILITY	FOSTER WHEELER USA CORP	DEC 10,87		
PM	78	WSSRAP COST ESTIMATE REVIEW EXECUTIVE SUMMARY	FOSTER WHEELER USA CORP	DEC 30,87		
QY	7	WSSRAP COST ESTIMATE REVIEW QUARRY SITE	FOSTER WHEELER USA CORP	DEC 3,87		
RP	15	WSSRAP COST ESTIMATE REVIEW RAFFINATE PITS	FOSTER WHEELER USA CORP	DEC 3, 87		
HP	83	WSSRAP COST ESTIMATE REVIEW VICINITY PROPERTIES	FOSTER WHEELER USA CORP	DEC 10,87		
ZZ	230	WSSRAP DATABASE ACCURACY REPORT	JEG	10-31-89		
ZZ	245	WSSRAP DECONTAMINATION STUDY REPORT		MAY 90		
EN	77	WSSRAP DISPOSAL FACILITY ANNOTATED OUTLINE CDR TASK 727 CHEMICAL SOLIDIFICATION/STABILIZATION	MK BOISE	DEC. 1991	REV. A	REPORT NO. 3840R-7032-A
EN	78	WSSRAP DISPOSAL FACILITY CDR VITRIFICATION STUDY DESIGN BASIS MEMORANDUM	MK BOISE	DEC. 1991	REV. 0	
MG	60	WSSRAP DISPOSAL FACILITY DESIGN BASIS MEMORANDUM CDR TASK 730 DEWATERING	MK BOISE	DEC. 1991	REV. A	
GR	108	WSSRAP DISPOSAL FACILITY DESIGN STORM CRITERIA ASSESSMENT	MK-ENVIRONMENTAL, BOISE	JAN. 1992	REV. 0	
ZZ	296	WSSRAP DOCUMENT CONTROL SYSTEM CORRESPONDENCE FILE		JUNE 1991	REV. 2	
ZZ	378	WSSRAP EMERGENCY MANAGEMENT PLAN DOCUMENTS: EMERGENCY PREPAREDNESS PLAN (DOE/OR/21548-223) EMERGENCY RESPONSE MANUAL (DOE/OR/21548-196)	PMC			TRANSMITTED 1/16/92
ZZ	222	WSSRAP ENGINEERING REVIEW	MK-F/JEG	6-10-88		
KU	11	WSSRAP FY 87 YEAR END REVIEW FY 88/89 PLANS	PMC	OCT. 1987		
ZZ	104	WSSRAP GUIDE TO OUTSIDE AGENCY HAZARDOUS MATERIAL INCIDENT NOTIFICATIONS	DOE/OR/21548-218	JAN. 1992	REV. 1	
GR	94	WSSRAP HVAC ASSESSMENT PHASE I	MKF ST. LOUIS	NOV 25,91		
PM	122	WSSRAP MONTHLY CONTRACTORS REPORT	PMC	APR. 1990		
PM	69	WSSRAP MONTHLY ENGINEERING REPORT	MK-FERGUSON	JAN. 1992		WSSRAP 3589
BL	10	WSSRAP PMC BASELINE EXECUTION PLAN	DOE/OR/21548-246	JUNE 92	REV. A	
PM	75	WSSRAP PROGRAM REVIEW	MK-FERGUSON	DEC 21,87		
ZZ	382	WSSRAP PROGRESS PHOTOGRAPHS AND BRIEFING MATERIAL VOLUME I	DOE/OR/21548-265	JAN. 92	REV. 1	FILED IN TECH. LIBRARY
ZZ	383	WSSRAP PROGRESS PHOTOGRAPHS AND BRIEFING MATERIAL VOLUME II	DOE/OR/21548-266	JAN. 92	REV. 1	FILED IN TECH. LIBRARY
EN	84	WSSRAP QUARRY BULK WASTE REMOVAL AND HAULING/ TSA OPERATIONS AND MAINTENANCE TECHNICAL SPECIFICATIONS SUMMARY OF WORK SECTION 01010	MK-E BOISE	JAN 1992	REV. B	

CHEMICAL PLANT ADMINISTRATIVE RECORD FILE

ARFS FILE # C-100-1

TABLE OF CONTENTS

SECTION	SECTION TITLE
100	SITE IDENTIFICATION
101	Background Information

DOCUMENT NUMBERS	DOCUMENT TITLE
C-100-101-1.01	ACKNOWLEDGMENT OF NOTIFICATION AND REGISTRATION OF A HAZARDOUS WASTE SITE ACTIVITY
C-100-101-1.02	LETTER OF NOTIFICATION TO THE COMMISSION ABOUT WSSRAP SITE CLEANUP
C-100-101-1.03	FORMER USES OF THE UNIVERSITY OF MO AGRICULTURAL EXTENSION
C-100-101-1.04	ACKNOWLEDGEMENT OF NOTIFICATION AND REGISTRATION OF HAZARDOUS WASTE ACTIVITY

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

CHEMICAL PLANT ADMINISTRATIVE RECORD FILE

ARFS FILE # C-100-1

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SECTION	SECTION TITLE
100	SITE IDENTIFICATION
102	Preliminary Assessments and Site Investigation (PA/SI) Reports

DOCUMENT NUMBERS	DOCUMENT TITLE
C-100-102-1.01	ID AND PRELIMINARY ASSESSMENT OF WSCP/LANDS BLDGS, ASH POND, RP
C-100-102-1.02	ID AND PRELIMINARY ASSESSMENT OF WSCP/LANDS/RP/VP
C-100-102-1.03	ID AND PRELIMINARY ASSESSMENT OF WSCP/LANDS
C-100-102-1.04	ID AND PRELIMINARY ASSESSMENT OF WSCP
C-100-102-1.05	ID AND PRELIMINARY ASSESSMENT OF WSCP

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

CHEMICAL PLANT 101

CHEMICAL PLANT
100-1.01

JOHN ASHCROFT
Governor

FR[redacted]ICK A. BRUNNER
Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF ENVIRONMENTAL QUALITY
P.O. Box 176
Jefferson City, MO 65102

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation,
and Historic Preservation

6

February 4, 1987

Mr. R. R. Nelson
Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, TN 37831

Re: Acknowledgment of Notification and Registration of Hazardous Waste Activity

Dear Generator:

This is to acknowledge that you have filed hazardous waste activity forms for the installation located at the address shown in the box below to comply with Section 260.380 of the Missouri Hazardous Waste Management Law and Section 3010 of the Resource Conservation and Recovery Act (RCRA). The identification numbers must be included on all hazardous waste manifest documents for transporting hazardous wastes; on all reports that generators of hazardous waste are required to maintain, and reports that owners and operators of hazardous waste treatment, storage and disposal facilities must file with the State of Missouri and the Federal EPA; on all applications for a state and federal hazardous waste permit; and other required hazardous waste management reports and documents.

Installation	Weldon Spring Chemical Plt
Site Address	Highway 94 Weldon Spring MO
Missouri Generator I.D. Number	- - - - - -
EPA I.D. Number	MO6210022830

Sincerely,

DIVISION OF ENVIRONMENTAL QUALITY

Kenneth Purvis, Jr.

Kenneth Purvis, Jr.
Environmental Specialist
Waste Management Program

KP:ss

Enclosure

M-K FERGUSON CO.
RECEIVED
AUG 1 1989
WSSRAP CONTRACT 3589

CHEMICAL PLANT
101-1.02

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

May 15, 1987

Missouri Emergency Response Commission
ATTN: Jim Long
Missouri Department of Natural Resources
Jefferson City, Missouri 65102

Dear Mr. Long:

This letter is intended to serve as the notification to your Commission as required by the Superfund Amendments and Reauthorization Act of 1986, Title III Sec. 302 (C). Our facility is located near Weldon Spring, Missouri, about 30 miles west of St. Louis. It is surrounded by large tracts of land owned by the federal government and the state of Missouri. The site was used by the U.S. Department of the Army from 1941 to 1944 for the production of explosives. In 1957, a 220-acre portion of the site was released to the U.S. Atomic Energy Commission, which used the site for processing of uranium and thorium concentrates from 1957 to 1966. The site is comprised of four areas: raffinate pits, chemical plant, quarry, and vicinity properties. The raffinate pits and chemical plant are on adjoining land about 2 miles southwest of the junction of Missouri Route 94 and U.S. Route 40/61. The raffinate pits and chemical plant areas are accessed from Route 94. The quarry is located in a comparatively remote area about 4 miles south-southwest of the raffinate pits area; the quarry is also accessed from State Route 94. The contaminated vicinity properties are located in the proximity of these three areas.

DOE is presently preparing documentation for cleanup of the site in accordance with the National Environmental Policy Act (NEPA). Actual cleanup work will begin when that process is completed. In support of the NEPA process a containerized chemical inventory will be made and detailed site characterization work will be performed. We are not sure that Sec. 302 would apply to this facility since it is not an operating facility, however, we will keep you informed of our characterization findings and will cooperate with decisions on applicability of the 302 requirements.

If you have any questions please contact myself or Ken Lawver at 314-441-8978.

Sincerely,

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

CE-541:Lawver

CHEMICAL PLANT
101-1.03

March 24, 1989

Dr. Wanda McDaniel, Superintendent
Francis Howell School District
7001 Highway 94 South
St. Charles, Missouri 63303

Dear Dr. McDaniel:

FORMER USES OF THE UNIVERSITY OF MISSOURI AGRICULTURAL EXTENSION CENTER, WELDON SPRING, MISSOURI

According to a U. S. Army Toxic and Hazardous Material 1977 report the facilities at the former University of Missouri Agricultural Extension Center was constructed as a part of the Weldon Spring Ordnance Works in 1941. The buildings were the "Box Factory" which produced boxes for the explosives to be packed in. The packing of the boxes apparently occurred in a series of buildings located in the explosives production areas to the west of the Extension Center.

The Box Factory was transferred to the University of Missouri in 1949. The University used the facilities for storage of materials used at their experimental farm prior to and during the operation of their extension office. The experimental farm operated until 1978 when 7200 acres were sold to the Missouri Department of Conservation. The Extension Center operated until 1988.

The Department of Army transferred land to the Atomic Energy Commission in 1954 for construction of a uranium feed materials plant which converted processed ore into uranium metal until 1966. During this time, the University operated the Extension Center. No radioactive materials were taken onto or stored at the Extension Center. In 1985-86 Oak Ridge Associated Universities performed a detailed radiological survey of the area surrounding the uranium processing facility. This survey included the roads, rail line and fenced perimeter of the Extension Center. No elevated levels of radiation were observed and, based on the use of the property, no additional studies were required.

CONCURRENCES

RTG SYMBOL
INITIALS/SIG.
DATE

RTG SYMBOL
INITIALS/SIG.
DATE

RTG SYMBOL
INITIALS/SIG.
DATE

RTG SYMBOL
INITIALS/SIG.
DATE

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DATE

RTG SYMBOL
INITIALS/SIG.
DATE

The Extension Center is located uphill of all Ordnance Works and uranium processing facilities and therefore could not receive run-off from these areas.

If you have any additional questions please call.

Sincerely,

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

CE-541:KDLawver:852:mw:3/23/89: (c:ExtCentr.Ltr.)

CONCURRENCES

RTG SYMBOL	CE-541
INITIALS/SIG.	KDLawver
DATE	3/24/89
RTG SYMBOL	CE-541
INITIALS/SIG.	RRNelson
DATE	3/24/89
RTG SYMBOL	
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(7-73)

OFFICIAL FILE COPY

CHEMICAL PLANT
101-1.04

JOHN ASHCROFT
Governor

G. TRACY MEHAN III
Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation, and Historic Preservation

DIVISION OF ENVIRONMENTAL QUALITY
P.O. Box 176
Jefferson City, MO 65102

September 11, 1989

Bill Goldkamp
Weldon Spring Chemical Plant Site
7295 Hwy. 94 South
St. Charles, MO 63303

Re: Acknowledgment of Notification and Registration of Hazardous Waste Activity

Dear Generator:

This is to acknowledge that you have filed hazardous waste activity forms for the installation located at the address shown in the box below to comply with Section 260.380 of the Missouri Hazardous Waste Management Law and Section 3010 of the Resource Conservation and Recovery Act (RCRA). The identification numbers must be included on all hazardous waste manifest documents for transporting hazardous wastes; on all reports that generators of hazardous waste are required to maintain, and reports that owners and operators of hazardous waste treatment, storage and disposal facilities must file with the State of Missouri and the Federal EPA; on all applications for a state and federal hazardous waste permit; and other required hazardous waste management reports and documents.

Installation	Weldon Spring Chemical Plant Site
Site Address	7295 Hwy. 94 South St. Charles, MO 63303
Missouri Generator I.D. Number	012183
EPA I.D. Number	MO6210022830

Sincerely,

DIVISION OF ENVIRONMENTAL QUALITY

Kenneth Purvis

Kenneth Purvis, Jr.
Environmental Specialist
Waste Management Program

KP:rlh

RECEIVED
SEP 12 1989

MENT NUMBER: ___

CHEMICAL PLANT
102

CHEMICAL PLANT
102-1.01

U. S. ENVIRONMENTAL PROTECTION AGENCY

REGION VII

POTENTIAL HAZARDOUS WASTE SITE

IDENTIFICATION AND PRELIMINARY ASSESSMENT

This form is completed for each potential hazardous waste site to help set priorities for site inspections. The information submitted on this form is based on available records and may be updated on subsequent forms as a result of additional inquiries and on-site inspections.

SITE IDENTIFICATION

Site number 000000050
(to be assigned by Headquarters)

Site Name Weldon Springs Chemical Plant (Building [illegible])

Street (or other identifier) Mo. 94 2 miles S. of U.S. 40

City, State, Zip

County Name St. Charles County, Missouri

Owner/Operator (if known) Kansas City Engineering District, U.S. Army Corps of Engineers and Technical Services Div., Department of Energy

Telephone

/X/ Federal /__/ State /__/ County
/__/ Municipal /__/ Private /__/ Unknown

FTS 626-[illegible]

Site Description Former DNT-TNT plant; Former Uranium Feed Materials Product Plant.

How Identified (i.e. Citizen's complaints, OSHA Citations, etc.) Date Identified

Decontamination and Decommission Operations Jan. 1968

Principal State Contact Robert Robinson Telephone 314-751-3241

Fill in pages 2-5 of this form as completely as possible. Then indicate the preliminary assessment in the boxes below:

PRELIMINARY ASSESSMENT

Apparent Seriousness of Problem /__/ High /__/ Medium /X/ Low /__/ None /__/ Un

/X/ No action needed - ~~no hazard~~

/_/ Immediate site inspection needed Tentatively Scheduled for _____
Will be performed by _____

/_/ Site inspection needed Tentatively Scheduled for _____
Will be performed by _____

/_/ Site inspection needed - low priority

File this form in the Regional Hazardous Waste Log File and submit a copy to:
Site Tracking System
Hazardous Waste Enforcement Task Force
U. S. Environmental Protection Agency
401 M Street SW (EN335)
Washington, D. C. 20460

Prepared by [illegible]

Telephone FTS. 758 [illegible]

Date [illegible] 1979

Form 1-GPS Revised 10/16/79

DOCUMENT NU

SITE INFORMATION

/_/ ACTIVE — Those industrial or municipal sites which are being used for waste treatment, storage, or disposal on a continuing basis, even if infrequently.

/X/ INACTIVE — Those sites which no longer receive wastes.

/_/ OTHER — Specify: _____
Those sites resulting from incidents like "midnight dumping" where no regular or continuing use of the site for waste disposal has occurred.

GENERATOR ON SITE No /X/ Yes /_/ If yes, specify generator's SIC Code /_/_/_/_/

Area of Site 219 Acres

If apparent seriousness of site is high, specify coordinates
Latitude /3/8/ /3/0/ /_/_/ (deg / min / sec) Longitude /9/0/_/ /3/7/ (deg / min)

Are there buildings on the site No /_/ Yes /X/ If yes, specify 8 major 36 minor

CHARACTERIZATION OF SITE ACTIVITY

Check off the appropriate activities below:

/_/ TRANSPORTER	/X/ STORER	/_/ TREATOR	/X/ DISPOSER
/_/ Rail	/_/ Pile	/_/ Filtration	/_/ Landfill
/_/ Ship	/X/ Surface Impoundment	/_/ Incineration	/_/ Landfarm
/_/ Barge	/_/ Drums	/_/ Volume Reduct	/X/ Open Dump
/_/ Truck	/X/ Tank, Above Ground	/_/ Recycling/ Recovery	/_/ Surface Impoundment
/_/ Pipeline	/_/ Tank, Below Ground	/_/ Chem/Phys Treatment	/_/ Midnight Dumping
/_/ Other _____	/X/ Other Contaminated Buildings and Equipment	/_/ Biological Treatment	/_/ Incineration
		/_/ Waste Oil Reprocessing	/_/ Underground Injection
		/_/ Solvent Recovery	
		/_/ Other	/_/ Other

Specify details of site activities as needed:

_____

_____

_____

_____

_____

_____

WASTE RELATED INFORMATION

WASTE TYPE:

/__/ UNKNOWN /X/ LIQUID /X/ SOLID /__/ SLUDGE /__/ GAS

WASTE CHARACTERISTICS:

/__/ UNKNOWN /__/ CORROSIVE /__/ IGNITABLE /X/ RADIOACTIVE /__/ HIGHLY V
/X/ TOXIC /__/ REACTIVE /__/ INERT /X/ FLAMMABL
/__/ OTHER SPECIFY_____

WASTE CATEGORIES:

Are records of wastes available? Specify items such as manifests, inventories, etc:

Partial. Stored at DOE Technical Services (Oak Ridge Engineers) and on-site.

Estimated amount of waste by category:

SLUDGE	OIL	SOLVENTS	CHEMICALS	SOLIDS	OTHER
_____ amt & unit	less than 1000 gallons amt & unit	_____ amt & unit	unknown amt & unit	6 million (cubic feet amt & unit	20 million gallons amt & unit
/__/ Paint, Pigments	/X/ Oily Wastes	/__/ Halogenated Solvents	/__/ Acids	/__/ Flyash	/__/ Lab,Pha
/__/ Metals Sludges	/__/ Other Hexone Contaminated with Uranium	/__/ Non-halogntd Solvents	/__/ Pickling Liquors	/__/ Asbestos	/__/ Hospita
/__/ POTW		/__/ Other _____	/__/ Caustics	/__/ Milling	/__/ Radioac
/__/ Alum Sldg			/__/ Pesticides	/__/ Mine Tailngs	/__/ Municip
/__/ Other _____			/__/ Dyes/Inks	/__/ Ferrous	/__/ Other Specify Radium Contaminated Water _____
			/__/ Cyanides	/__/ Non-ferr	
			/__/ Phenols	/X/ Other Raffinates	
			/__/ Halogens		
			/__/ PCB		
			/__/ Metal Solvents		
			/X/ Other Uranium oxides & fluorides in buildings		

LIST SUBSTANCES OF GREATEST CONCERN WHICH MAY BE ON THE SITE: (Place in descending order of

Raffinate Pits

Uranium Uranium Uranium and Decay Products

TNT/DNT Thorium

Water contaminated with Radium

WASTE RELATED INFORMATION (continued)

Additional comments or narrative description of situation known or reported to exist at the site

Armament Command U.S. Army, Rock Island Arsenal ordered by NRC to produce Decontamination and Decommission Plan for Buildings by Nov. 15 1979. DOE plans to seek NPDES permit to discharge 15,000,000 gallons 10 pc/l water from Raffinate Pits into Missouri River.

HAZARD DESCRIPTION

	POTENTIAL HAZARD Check Off	ALLEGED INCIDENT Check Off	DATE OF INCIDENT month/day/yr	REMARKS
No hazard	/__/			
Human Health	/X/	/__/		
Non-worker Injury/Exposure	/__/	/__/		
Worker Injury	/__/	/__/		
Contamination of Water Supply	/__/	/__/		
Contamination of Food Chain	/__/	/__/		
Contamination of Ground Water	/__/	/__/		
Contamination of Surface Water	/__/	/__/		
Damage to Flora/Fauna	/__/	/__/		
Fish Kill	/__/	/__/		
Contamination of Air	/__/	/__/		
Noticeable Odors	/__/	/__/		
Contamination of Soil	/X/	/__/		
Property Damage	/__/	/__/		
Fire or Explosion	/__/	/__/		
Spills/Leaking Containers/Runoff/ Standing Liquids	/X/	/__/		20 million gallons Radium Contaminated water in Raffinate Pits.
Sewer, Storm Drain Problems	/__/	/__/		
Erosion Problems	/__/	/__/		
Inadequate Security	/__/	/__/		
Incompatible Wastes	/__/	/__/		
Midnight Dumping	/__/	/__/		
Other - Specify_____	/__/	/__/		

ACTIONS TAKEN OR PLANNED

PERMIT INFORMATION

List all Applicable Permits held by the site:

/__/ NPDES Permit /__/ SPCC Plan /__/ State Permit - Specify_____

/__/ Air Permits /__/ Local Permit /__/ RCRA Transporter

/__/ RCRA Storer /__/ RCRA Treator /__/ RCRA Disposer

/X/ Other - Specify NRC permit SMB 1314, 1977 to U.S. Army

In Compliance /__/ Yes /__/ No /__/ Unknown with respect to _____
Regulation Name/Number

PAST REGULATORY ACTIONS

/__/ None

/X/ Yes If yes, summarize: NRC amended permit in May 1979 to require Building Decontamination & Decommission Plan by Nov. 15 1979

INSPECTION ACTIVITY (Past or on-going)

	Date of Past Action	Performed by (EPA/State)	Describe:
/__/ None			
/X/ Yes - Specify:			
_____	Nov. 1975	ERDA	Aerial Radiological Survey
_____	March 1976	Army	Assessment of Weldon Spring Chemical Plant
_____	1975	ERDA	Weldon Spring Decommissioning Study

REMEDIAL ACTIVITY (Past or on-going)

/__/ None

/X/ Yes - Specify:

_____	Nov. 15	1979	DoD plan for Buildings by Army
_____	planned	_____	Sale of Raffinate and wastes for reprocessing, by DOE
_____	_____	_____	_____

Based on the information on pages 2 through 5, fill out the Preliminary Assessment information on the first page of this form.

CHEMICAL PLANT
102-1.02

U. S. ENVIRONMENTAL PROTECTION AGENCY

REGION ___

POTENTIAL HAZARDOUS WASTE SITE

SITE INSPECTION REPORT

SITE IDENTIFICATION

Site number 000000050
(obtain from Headquarters)

Site Name Weldon Springs Chemical Plant (Buildings, Land, Ash Pond and Raffinate Pits)

Street (or other) identifier) Mo. 94 2 miles S. of U.S. 40

City, State, Zip

County Name St. Charles County, Missouri

Operator of Site U.S. Army 169 Armament Command FTS 367-6132 Telephone

Street Buildings and Land

City, State, Zip Rock Island Arsenal, Illinois 61301

Owner of Realty Kansas City Engineering District 816-374-3450 Telephone
(if different from operator of site)

City, State, Zip U.S. Army Corps of Engineers

Site Description Former DNT-TNT Plant; Former Uranium Feed Materials Production Plant

Ownership /X/ Federal /__/ State /__/ County
/__/ Municipal /__/ Private

Fill in pages 2 through 13 of this form as completely as possible. Then use the information on this form to develop a Tentative Disposition.

Estimate date of Tentative Disposition unknown

Apparent seriousness of problem /__/ High /__/ Medium /X/ Low /__/ None

File this form in its entirety in the regional Hazardous Waste Log File. Be sure to include all appropriate supplemental forms in the file. Submit a copy of the forms to:

Site Tracking System
Hazardous Waste Enforcement Task Force
U. S. Environmental Protection Agency
401 M Street SW (EN335)
Washington, D. C. 20460

Prepared by Richard Kaufman

Telephone 374-3307

Date Nov. 1, 1979

Form 2-GPS Revised 10/18/79

INSPECTION INFORMATION

Principal Inspector: DOE & US Army / Contractor EG&G — US Army Toxic & Hazardous Materials Agency, Aberdeen, MD; 301-671-3424

Organization — Title — Area Code and Telephone

INSPECTION PARTICIPANTS

Names			
Organization			
Telephone			

SITE REPRESENTATIVES INTERVIEWED (Corporate Officials, Workers, Residents)

Names	E. L. Keller		
Title/Telephone	Director, Technical Services, DOE FTS 626-[illegible]		
Address	P O B E	Oak Ridge, Tennessee 378 30	
Names	Andrew W. Anderson		
Title/Telephone	U.S. Army	Toxic and Hazardous Materials Agency 301-671-3424	
Address	Aberdeen	Proving Ground	Maryland 21010

GENERATOR INFORMATION (List sources of waste)

Names			
Telephone	TNT/DNT	U.S. Army	
Address	Uranium/Thorium	AEC/ERDA	
Waste Type Generated			

TRANSPORTER/HAULER INFORMATION

Names	US Army		
Telephone	AEC/ERDA		
Address			
Waste Type Transported			

If waste is processed on site and also shipped to other sites, identify off-site facilities used for disposal:

Names	planned disposal of Rattlesnake Pit solid waste		
Telephone	to Cotter Corporation,	Canon City, Colorado	
Address			

INSPECTION INFORMATION (Continued)

Date of Inspection _____ Time of Inspection _____

Access gained by /__/ Permission /__/ Warrant
(Credentials must be shown in all cases)

Weather _____

SAMPLING INFORMATION

Check off the types of samples taken and indicate where they have been sent e.g. regional lab, other EPA lab, contractor, etc. and estimate when the results will be available

SAMPLE TYPE	COLLECTED	REMARKS	ESTIMATE DATE THAT RESULTS WILL BE AVAILABLE
Groundwater	/__/ Yes		
Surface Water	/X/ Yes	Excess Radium detected in water from past	
Waste	/__/ Yes	Raffinate Pits - 10 to 200 pc/l	
Air	/__/ Yes		
Runoff	/__/ Yes		
Spill	/__/ Yes		
Soil	/X/ Yes	TNT/DNT contamination found in PPD	
Vegetation	/__/ Yes		
Other_____	/__/ Yes		

FIELD MEASUREMENTS TAKEN (E.g. radioactivity, explosivity, PH, etc.)

Type	Location of Measurements	Results
Radiological Survey	Aerial	Nov. 1975 - residual radioactivity over background detected
Radiological Survey	Soil	March 1976 - residual radioactivity over background detected

Photos Taken /X/ Ground /X/ Aerial

Photos in custody of In Assessment Study of Site, March 1976, US Army. EPA Kansas City, HAZMAT [illegible]

Site Mapped /X/ Yes

Location of Maps

Latitude /3/8/ /3/0/ /__/__/ deg min sec

Longitude /9/0/__/ /3/7/ /__/__/ deg min sec

SITE INFORMATION

/_/ ACTIVE — Those industrial or municipal sites which are being used for waste treatment, storage, or disposal on a continuing basis, even if infrequently.

/X/ INACTIVE — Those sites which no longer receive wastes.

/_/ OTHER — Specify: _____
Those sites resulting from incidents like "midnight dumping" where no regular or continuing use of the site for waste disposal has occurred.

GENERATOR ON SITE No /X/ Yes /_/ If yes, specify generator's SIC Code /_/_/_/_/

Area of Site 219 Acres

Are there buildings on the site No /_/ Yes /X/ If yes, specify 8 major 36 minor

CHARACTERIZATION OF SITE ACTIVITY

Check off one or more of the activities below:

/_/ TRANSPORTER	/X/ STORER	/_/ TREATOR	/X/ DISPOSER
/_/ Rail	/_/ Pile	/_/ Filtration	/_/ Landfill
/_/ Ship	/X/ Surface Impoundment	/_/ Incineration	/_/ Landfarm
/_/ Barge	/_/ Drums	/_/ Volume Reduct	/X/ Open Dump
/_/ Truck	/X/ Tank, Above Ground	/_/ Recycling/ Recovery	/_/ Surface Impoundment
/_/ Pipeline	/_/ Tank, Below Ground	/_/ Chem/Phys Treatment	/_/ Midnight Dumping
/_/ Other _____	/X/ Other Contaminated Building and Equipment	/_/ Biological Treatment	/_/ Incineration
		/_/ Waste Oil Reprocessing	/_/ Underground Injection
		/_/ Solvent Recovery	
		/_/ Other	/_/ Other

SUPPLEMENTAL FORMS

If the site falls within any of the categories listed below, supplemental forms must be filled out. Indicate which supplemental forms you have filled out and attached to this form:

/_/ Storage	/_/ Incineration	/_/ Landfill
/X/ Surface Impoundment	/_/ Deep Well	/_/ Chem/Bio/Phys Treatment
/_/ Landfarm	/_/ Open Dump	/_/ Transporter
/_/ Recyclor/Reclaimer		

WASTE RELATED INFORMATION

WASTE TYPE: /X/ LIQUID /X/ SOLID /__/ SLUDGE /__/ GAS

WASTE CHARACTERISTICS:

/__/ CORROSIVE /__/ IGNITABLE /X/ RADIOACTIVE /__/ HIGH

/X/ TOXIC /__/ REACTIVE /__/ INERT /X/ FLA

/__/ OTHER SPECIFY _____

WASTE CATEGORIES:

Are records of wastes available? Specify items such as manifests, inventories, etc:

Partial. Stored at DOE Technical Services (Oak Ridge Tennessee) and on-site.

Estimated amount of waste by category and specify details below:

SLUDGE	OIL	SOLVENTS	CHEMICALS	SOLIDS	OTHER
_____	less than 1000 gallons	_____	unknown	6 million	20 mill
amt & unit	amt & unit	amt & unit	amt & unit	amt & unit cubic feet	amt &
/__/ Paint, Pigments	/X/ Oily Wastes	/__/ Halogenated Solvents	/__/ Acids	/__/ Flyash	/__/ La
/__/ Metals Sludges	/__/ Other	/__/ Non-halogntd Solvents	/__/ Pickling Liquors	/__/ Asbestos	/__/ Ho
/__/ POTW	Hexane Contaminated with Uranium	/__/ Other	/__/ Caustics	/__/ Milling	/__/ Ra
/__/ Alum Sldg		_____	/__/ Pesticides	/__/ Mine Tailngs	/__/ Mu
/__/ Other			/__/ Dyes/Inks	/__/ Ferrous	/__/ Ot
_____			/__/ Cyanides	/__/ Non-ferr	Sp
			/__/ Phenols	/X/ Other	Rad
			/__/ Halogens	Raffinates	Contami
			/__/ PCB		Water
			/__/ Metal Solvents		
			/X/ Other		
			Uranium Oxides and Fluorides in Buildings		

LIST SUBSTANCES OF GREATEST CONCERN WHICH ARE ON THE SITE: (place in descending orde

	Substance	Form (Solid, Liq, Vapor)	Toxicity (High, Med, Low, None)	CAS Number	Amount and Unit
1	Uranium	Solid	Medium	7440-61-1	150 tons in Raf pits + Content in [illegible]
2	Thorium	Solid	High	7440-29-1	75 tons
3	Radium	liquid	High	none	unknown
4	TNT	Solid	High	118-96-7	unknown
5	DNT	solid		25321-14-6	unknown
6	Nitrates	liquid	Low		
7					
8					

HAZARD DESCRIPTION

FIELD EVALUATION	HAZARD DESCRIPTION	REMARKS
Check below if "yes"		
/X/	Human Health Hazards	
/__/	Non-Worker Injury/Exposure	
/__/	Worker Injury/Exposure	
/__/	Contamination of Water Supply	
/__/	Contamination of Food Chain	

HAZARD DESCRIPTION

FIELD EVALUATION	HAZARD DESCRIPTION	REMARKS
Check below if "yes"		
/__/	Contamination of Ground Water	
/__/	Contamination of Surface Water	
/__/	Damage to Flora/Fauna	
/__/	Fish Kill	
/__/	Contamination of Air	

HAZARD DESCRIPTION

FIELD EVALUATION	HAZARD DESCRIPTION	REMARKS
Check below if "yes"		
/__/	Noticeable Odors	
/X/	Contamination of Soil	
/__/	Property Damage	
/__/	Fire or Explosion	
/X/	Spills/Leaking Containers/Runoff (Standing Liquid)	

HAZARD DESCRIPTION

FIELD EVALUATION	HAZARD DESCRIPTION	REMARKS
Check below if "yes"		
/__/	Sewer, Storm Drain problems	
/__/	Erosion Problems	
/__/	Inadequate Security	
/__/	Incompatible Wastes	
/__/	Midnight Dumping	

HAZARD DESCRIPTION

FIELD EVALUATION	HAZARD DESCRIPTION	REMARKS
Check below if "yes"		
/__/	Other - Specify	

POPULATION DIRECTLY AFFECTED BY SITE:

	Approximate number of People Affected	Within unit Area	Approximate Number of Buildings Affected	Distance to Site
In residential areas	240			2 miles
In commercial or industrial areas	Road Maintenance unknown		1	½ mile
In publicly travelled areas	unknown			Highway 4 adjacent
Public Use Areas (Parks, Schools, etc.)	School 2000 Park unknown		1	½ mile adjacent

WATER AND HYDROLOGICAL DATA

Depth to Groundwater Minimum 60' beneath Direction of Flow Localized

Groundwater use in vicinity Rattlesnake Pike unknown Potential yield of Aquifer Unknown

Distance to Drinking Water Supply 3 miles to nearest known well Direction to Drk Wtr Suppl South

Type of Drinking Water supply /__/ Non-Community < 15 connections /X/ Community (Town of St. Charles County wa >15 connections

/__/ Surface Water /__/ Well

List all drinking water wells within 1/4 mile radius of site:

Well	Depth	Location (proximity to population/buildings)	Non-Community
		Unknown	/__/
			/__/
			/__/
			/__/
			/__/

Receiving Waters /__/ Sewers /X/ Streams/Rivers

Name Missouri and Mississippi Rivers /__/ Lakes/Reservrs /__/ Other

Specify use and classification of receiving waters Navigable Streams

SOIL AND VEGETATION DATA

Location of Site is in:

/__/ Known Fault Zone

/__/ Karst Zone

/__/ 100 Year Floodplain

/__/ Wetland

/__/ A Regulated Floodway

/__/ Critical Habitat

/__/ Recharge Zone or Sole Source Aquifer

TYPE OF GEOLOGICAL MATERIAL OBSERVED

/X/ Overburden	/X/ Bedrock (specify)	/__/ Other (specify)
/__/ Sand	Limestone	
/X/ Clay		
/__/ Gravel		

SOIL PERMEABILITY

/__/ Unknown

/__/ Very High (100000-1000 ft/day)

/__/ High (1000-10 ft/day)

/__/ Moderate (10 to .1 ft/day)

/__/ Low (.1 to .001 ft/day)

/X/ Very Low (.001 to .00001 ft/day)

Recharge Area /__/ Yes /X/ No Comments: Under valley side hills

Discharge Area /X/ Yes /__/ No Comments: 3 small streams cross surface

Slope (estimate % of slope) unknown Specify direction of slope, condition of slope, etc.

Other Geological Data See U.S. Army Assessment study, March 1976

PERMIT INFORMATION

List all Applicable Permits held by the site:

Permit Type (E.g. RCRA, State, NPDES, etc)	Issuing Agency	Permit Number	Date Issued	Expirtn date	In Complian Yes	In Complian No
Radioactive Material Storage	NRC	SMB 1314	1977		/_/	/X/
					/_/	/_/
					/_/	/_/
					/_/	/_/
					/_/	/_/
					/_/	/_/

PAST REGULATORY OR ENFORCEMENT ACTIONS

/__/ None

/X/ Yes If yes, summarize: NRC amended permit in May 1977 to require Buildings Decontamination and Decommission Plan by Nov. 15 1979

Based on the information on pages 2 through 13, fill out the projected date of the Tentative Disposition on the first page of this form.

SUPPLEMENTAL FORM

SURFACE IMPOUNDMENTS

Answer and Explain as Necessary:

1. Type of Impoundment 4 Ruthenate Pits
   1 Ash Pit
2. Stability/Condition of Imbankments: Slide observed on
   repaired on Pit #4 in 1975
3. Evidence of Site Instability (Erosion, Settling, Sink Holes, etc.)
   Yes ( ) No (X)
4. Evidence of Disposal of Ingnitable or Reactive Waste
   Yes ( ) No (X)
5. Waste Compatible with Impoundment Yes (X) No ( )
6. Records Checked for the Contents and Location of Each Surface Impoundment Yes (X) No ( )
7. Impoundment has Liner System Yes ( ) No (X)
   Integrity of Liner System Checked Yes ( ) No ( )
   Findings: _____
8. Soil Structure and Substructure Clay over limestone
9. Monitoring Wells Yes (X) No ( )
10. Length, Width and Depth Combined estimated surface area greater than 100 acres
11. Calculated Volumetric Capacity unknown
12. Percent of Capacity Remaining unknown
13. Estimate Freeboard: unknown
14. Solids Deposition Yes (X) No ( )
15. Dredging Disposal Method _____
16. Other Equipment _____

CHEMICAL PLANT
102-1.03

U. S. ENVIRONMENTAL PROTECTION AGENCY

REGION VII

POTENTIAL HAZARDOUS WASTE SITE

TENTATIVE DISPOSITION

SITE IDENTIFICATION

Site number _____

Site Name Weldon Springs Chemical Plant (Buildings, Land, Ash Pond and Raffinate Pits)

Street Mo. 94 2 miles S. of U.S. 40

City, State, Zip St. Charles County, Missouri

TENTATIVE DISPOSITION

	Check Off	Action Agency EPA	State	Local	Private
1) NO ACTION NEEDED - NO HAZARD	/__/				
2) INVESTIGATIVE ACTION(S) NEEDED If yes, fill in Page 2	/__/	/__/	/__/	/__/	/__/
3) REMEDIAL ACTION NEEDED If yes, fill in page 3	/X/ Army or DoE	/__/	/__/	/__/	/__/
4) ENFORCEMENT ACTION NEEDED If yes, specify whether the case will be primarily managed by the EPA or the State.	/__/	/__/	/__/		
		/__/	/__/		

Rationale for disposition: _____

Indicate the estimated date of Final Disposition: unknown

If a Case Development Plan is necessary, indicate the estimated date on which the Plan will be developed: _____

File this form in the regional Hazardous Waste Log File and submit a copy to:

Site Tracking System
Hazardous Waste Enforcement Task Force
U. S. Environmental Protection Agency
401 M Street SW (EN335)
Washington, D. C. 20460

Prepared by Richard Kaufman

Telephone FTS 758-3307

Date Nov 1 1979

Form 2 SDS Revised 10/19/79

EPA

POTENTIAL HAZARDOUS WASTE SITE
IDENTIFICATION AND PRELIMINARY ASSESSMENT

REGION: VII | SITE NUMBER (To be assigned by HQ): MO

NOTE: This form is completed for each potential hazardous waste site to help set priorities for site inspection. The information submitted on this form is based on available records and may be updated on subsequent forms as a result of additional inquiries and on-site inspections.

GENERAL INSTRUCTIONS: Complete Sections I and III through X as completely as possible before Section II *(Preliminary Assessment)*. File this form in the Regional Hazardous Waste Log File and submit a copy to: U.S. Environmental Protection Agency; Site Tracking System; Hazardous Waste Enforcement Task Force *(EN-335)*; 401 M St., SW; Washington, DC 20460.

I. SITE IDENTIFICATION

A. SITE NAME: Raffinate Pits — Weldon Springs Chemical Plant

B. STREET *(or other identifier)*: Mo. 94, 2 miles S. of U.S. 40

C. CITY: St. Charles

D. STATE: MO

E. ZIP CODE:

F. COUNTY NAME: St. Charles

G. OWNER/OPERATOR *(If known)*

1. NAME: Technical Services Department, U.S. D.O.E.

2. TELEPHONE NUMBER: FTS: 626-0947

H. TYPE OF OWNERSHIP

[X] 1. FEDERAL [ ] 2. STATE [ ] 3. COUNTY [ ] 4. MUNICIPAL [ ] 5. PRIVATE [ ] 6. UNKNOWN

I. SITE DESCRIPTION

Former Uranium Feed Material Plant, raffinate pits.

J. HOW IDENTIFIED *(i.e., citizen's complaints, OSHA citations, etc.)*

Decommissioning Study

K. DATE IDENTIFIED *(mo., day, & yr.)*: Jan. 1968

L. PRINCIPAL STATE CONTACT

1. NAME: Robert Robinson

2. TELEPHONE NUMBER: 314/751-3241

II. PRELIMINARY ASSESSMENT *(complete this section last)*

A. APPARENT SERIOUSNESS OF PROBLEM

[ ] 1. HIGH [ ] 2. MEDIUM [X] 3. LOW [ ] 4. NONE [ ] 5. UNKNOWN

B. RECOMMENDATION

[X] 1. NO ACTION NEEDED *(no hazard)*

DOE exerting efforts for timely remedial actions

[ ] 2. SITE INSPECTION NEEDED
a. TENTATIVELY SCHEDULED FOR:
b. WILL BE PERFORMED BY:

[ ] 2. IMMEDIATE SITE INSPECTION NEEDED
a. TENTATIVELY SCHEDULED FOR:
b. WILL BE PERFORMED BY:

[ ] 4. SITE INSPECTION NEEDED *(low priority)*

C. PREPARER INFORMATION

1. NAME: W.L. Brinck

2. TELEPHONE NUMBER: FTS: 758-3307

3. DATE *(mo., day, & yr.)*: Nov. 1, 1979

III. SITE INFORMATION

A. SITE STATUS

[ ] 1. ACTIVE *(Those industrial or municipal sites which are being used for waste treatment, storage, or disposal on a continuing basis, even if infrequently.)*

[X] 2. INACTIVE *(Those sites which no longer receive wastes.)*

[ ] 3. OTHER *(specify)*: *(Those sites that include such incidents like "midnight dumping" where no regular or continuing use of the site for waste disposal has occurred.)*

B. IS GENERATOR ON SITE?

[X] 1. NO [ ] 2. YES *(specify generator's four-digit SIC Code)*:

C. AREA OF SITE *(in acres)*: 52

D. IF APPARENT SERIOUSNESS OF SITE IS HIGH, SPECIFY COORDINATES

1. LATITUDE *(deg.-min.-sec.)*: 38/30/--

2. LONGITUDE *(deg.-min.-sec.)*: 90/37/--

E. ARE THERE BUILDINGS ON THE SITE?

[ ] 1. NO [X] 2. YES *(specify)*: 1 minor

T2070-1 (10-79)

DOCUMENT

IV. CHARACTERIZATION OF SITE ACTIVITY

Indicate the major site activity(ies) and details relating to each activity by marking 'X' in the appropriate boxes.

	A. TRANSPORTER		B. STORER		C. TREATER		D. DISPOSER
	1. RAIL		1. PILE		1. FILTRATION		1. LANDFILL
	2. SHIP	X	2. SURFACE IMPOUNDMENT		2. INCINERATION		2. LANDFARM
	3. BARGE		3. DRUMS		3. VOLUME REDUCTION		3. OPEN DUMP
	4. TRUCK		4. TANK, ABOVE GROUND		4. RECYCLING/RECOVERY	X	4. SURFACE IMPOUNDMENT
	5. PIPELINE		5. TANK, BELOW GROUND		5. CHEM./PHYS. TREATMENT		5. MIDNIGHT DUMPING
	6. OTHER (specify):		6. OTHER (specify):		6. BIOLOGICAL TREATMENT		6. INCINERATION
					7. WASTE OIL REPROCESSING		7. UNDERGROUND INJECTIO
					8. SOLVENT RECOVERY		8. OTHER (specify):
					9. OTHER (specify):		

E. SPECIFY DETAILS OF SITE ACTIVITIES AS NEEDED

V. WASTE RELATED INFORMATION

A. WASTE TYPE

☐ 1 UNKNOWN ☒ 2. LIQUID ☐ 3. SOLID ☒ 4. SLUDGE ☐ 5. GAS

B. WASTE CHARACTERISTICS

☐ 1 UNKNOWN ☐ 2. CORROSIVE ☐ 3. IGNITABLE ☒ 4 RADIOACTIVE ☐ 5 HIGHLY VOLATILE
☐ 6 TOXIC ☐ 7 REACTIVE ☐ 8 INERT ☐ 9 FLAMMABLE

☐ 10. OTHER (specify):

C. WASTE CATEGORIES

1. Are records of wastes available? Specify items such as manifests, inventories, etc. below.

Partial, stored at DOE Technical Services, Oak Ridge, Tenn.

2. Estimate the amount (specify unit of measure) of waste by category; mark 'X' to indicate which wastes are present.

a. SLUDGE	b. OIL	c. SOLVENTS	d. CHEMICALS	e. SOLIDS	f. OTHER
AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT $.6 \times 10^6$	AMOUNT 2×10^7
UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE ft^3	UNIT OF MEASU gallons
☐ (1) PAINT, PIGMENTS	☒ (1) OILY WASTES	☒ (1) HALOGENATED SOLVENTS	☒ (1) ACIDS	☒ (1) FLYASH	☒ (1) LABORAT PHARMAC
☐ (2) METALS SLUDGES	☐ (2) OTHER (specify):	☐ (2) NON-HALOGNTD SOLVENTS	☐ (2) PICKLING LIQUORS	☐ (2) ASBESTOS	☐ (2) HOSPITAL
☐ (3) POTW		☐ (3) OTHER (specify):	☐ (3) CAUSTICS	☐ (3) MILLING/ MINE TAILINGS	☐ (3) RADIOACT
☐ (4) ALUMINUM SLUDGE			☐ (4) PESTICIDES	☐ (4) FERROUS SMLTG. WASTES	☐ (4) MUNICIPA
☐ (5) OTHER (specify):			☐ (5) DYES/INKS	☐ (5) NON-FERROUS SMLTG. WASTES	☒ (5) OTHER (sp
			☐ (6) CYANIDE	☒ (6) OTHER (specify): Raffinates containing Uranium and Thorium	Radium Contamina Water
			☐ (7) PHENOLS		
			☐ (8) HALOGENS		
			☐ (9) PCB		
			☐ (10) METALS		
			☐ (11) OTHER (specify)		

V. WASTE RELATED INFORMATION (continued)

3. LIST SUBSTANCES OF GREATEST CONCERN WHICH MAY BE ON THE SITE (place in descending order of hazard).

Raffinate Pits - Uranium and Daughter Products in Sludge, Thorium in sludge, Radium contaminated water.

4. ADDITIONAL COMMENTS OR NARRATIVE DESCRIPTION OF SITUATION KNOWN OR REPORTED TO EXIST AT THE SITE.

ERDA Decommissioning study dated June 1975. Remedial efforts to date have been unsuccessful (political complications).

VI. HAZARD DESCRIPTION

A. TYPE OF HAZARD	B. POTENTIAL HAZARD (mark 'X')	C. ALLEGED INCIDENT (mark 'X')	D. DATE OF INCIDENT (mo., day, yr.)	E. REMARKS
1. NO HAZARD				
2. HUMAN HEALTH	X			
3. NON-WORKER INJURY/EXPOSURE				
4. WORKER INJURY				
5. CONTAMINATION OF WATER SUPPLY				
6. CONTAMINATION OF FOOD CHAIN				
7. CONTAMINATION OF GROUND WATER				
8. CONTAMINATION OF SURFACE WATER				
9. DAMAGE TO FLORA/FAUNA				
10. FISH KILL				
11. CONTAMINATION OF AIR				
12. NOTICEABLE ODORS				
13. CONTAMINATION OF SOIL				
14. PROPERTY DAMAGE				
15. FIRE OR EXPLOSION				
16. SPILLS/LEAKING CONTAINERS/ RUNOFF/STANDING LIQUIDS	X			2×10^7 gal. radium contaminated water.
17. SEWER, STORM DRAIN PROBLEMS				
18. EROSION PROBLEMS				
19. INADEQUATE SECURITY				
20. INCOMPATIBLE WASTES				
21. MIDNIGHT DUMPING				
22. OTHER (specify):				

Continued From Front

VII. PERMIT INFORMATION

A. INDICATE ALL APPLICABLE PERMITS HELD BY THE SITE.

☐ 1. NPDES PERMIT ☐ 2. SPCC PLAN ☐ 3. STATE PERMIT (specify):
☐ 4. AIR PERMITS ☐ 5. LOCAL PERMIT ☐ 6. RCRA TRANSPORTER
☐ 7. RCRA STORER ☐ 8. RCRA TREATER ☐ 9. RCRA DISPOSER
☐ 10. OTHER (specify): DOE plans to seek NPDES permit to discharge 1.5×10^7 gal. of pico curie water from raffinate pits into Missouri River.

B. IN COMPLIANCE?
☐ 1. YES ☐ 2. NO ☐ 3. UNKNOWN

4. WITH RESPECT TO (list regulation name & number):

VIII. PAST REGULATORY ACTIONS

☐ A. NONE ☐ B. YES (summarize below)

IX. INSPECTION ACTIVITY (past or on-going)

☐ A. NONE ☒ B. YES (complete items 1,2,3, & 4 below)

1. TYPE OF ACTIVITY	2. DATE OF PAST ACTION (mo., day, & yr.)	3. PERFORMED BY: (EPA/State)	4. DESCRIPTION
	Nov. 1975	ERDA	Aerial Radiological Survey
	1975	ERDA	Weldon Spring Decommissioning Study

X. REMEDIAL ACTIVITY (past or on-going)

☐ A. NONE ☒ B. YES (complete items 1, 2, 3, & 4 below)

1. TYPE OF ACTIVITY	2. DATE OF PAST ACTION (mo., day, & yr.)	3. PERFORMED BY: (EPA/State)	4. DESCRIPTION
	proposed	DOE	Sale of raffinate pit wastes for reprocessing.

NOTE: Based on the information in Sections III through X, fill out the Preliminary Assessment (Section II) information on the first page of this form.

CHEMICAL PLANT
102-1.04

POTENTIAL HAZARDOUS WASTE SITE
IDENTIFICATION AND PRELIMINARY ASSESSMENT

REGION: VII

SITE NUMBER (To be assigned by EPA): 64 MO0000025

NOTICE: This form is completed for each potential hazardous waste site to help set priorities for site inspection. The information described on this form is based on available records and may be updated on subsequent forms as a result of additional inquiries and on-site inspections.

GENERAL INSTRUCTIONS: Complete Sections I and III through X as completely as possible before Section II (*Preliminary Assessment*). File this form in the Regional Hazardous Waste Log File and submit a copy to: U.S. Environmental Protection Agency; Site Tracking System; Hazardous Waste Enforcement Task Force (*EN-335*); 401 M St., SW; Washington, DC 20460.

I. SITE IDENTIFICATION

A. SITE NAME: Weldon Springs Chemical Plant (Buildings, Land, and Ash Pond)

B. STREET (*for other identifier*): MO. 94, 2 mi. S. of U.S. 40

C. CITY: St. Charles

D. STATE: MO

E. ZIP CODE:

F. COUNTY NAME: St. Charles

G. OWNER/OPERATOR (*if known*)

1. NAME: Kansas City Engineering District
U.S. Army Corps of Engineers

2. TELEPHONE NUMBER: 816/374-3450

H. TYPE OF OWNERSHIP

[X] 1. FEDERAL [ ] 2. STATE [ ] 3. COUNTY [ ] 4. MUNICIPAL [ ] 5. PRIVATE [ ] 6. UNKNOWN

I. SITE DESCRIPTION: Former DNT-TNT plant, Former Uranium Feed Materials Plant, (Buildings, land and Ash Pond)

J. HOW IDENTIFIED (*i.e., citizen's complaints, OSHA citations, etc.*): Decontamination and Decommission Operations

K. DATE IDENTIFIED (*mo., day, & yr.*): January 1968

L. PRINCIPAL STATE CONTACT

1. NAME: Robert Robinson

2. TELEPHONE NUMBER: 314/751-3241

II. PRELIMINARY ASSESSMENT (*complete this section last*)

A. APPARENT SERIOUSNESS OF PROBLEM

[ ] 1. HIGH [ ] 2. MEDIUM [X] 3. LOW [ ] 4. NONE [ ] 5. UNKNOWN

B. RECOMMENDATION

[X] 1. NO ACTION NEEDED (*no hazard*)
DOD Activities will probably be sufficient

[ ] 2. IMMEDIATE SITE INSPECTION NEEDED
a. TENTATIVELY SCHEDULED FOR:
b. WILL BE PERFORMED BY:

[ ] 3. SITE INSPECTION NEEDED
a. TENTATIVELY SCHEDULED FOR:
b. WILL BE PERFORMED BY:

[ ] 4. SITE INSPECTION NEEDED (*low priority*)

C. PREPARER INFORMATION

1. NAME: W.L. Brinck

2. TELEPHONE NUMBER: FTS: 758-3307

3. DATE (*mo., day, & yr.*): Nov. 1, 1979

III. SITE INFORMATION

A. SITE STATUS

[ ] 1. ACTIVE (*Those industrial or municipal sites which are being used for waste treatment, storage, or disposal on a continuing basis, even if infrequently.*)

[X] 2. INACTIVE (*Those sites which no longer receive wastes.*)

[ ] 3. OTHER (*specify*): (*Those sites that include such incidents like "midnight dumping" where no regular or continuing use of the site for waste disposal has occurred*)

B. IS GENERATOR ON SITE?

[X] 1. NO [ ] 2. YES (*specify generator's four-digit SIC Code*):

C. AREA OF SITE (*in acres*): 168

D. IF APPARENT SERIOUSNESS OF SITE IS HIGH, SPECIFY COORDINATES

1. LATITUDE (*deg.-min.-sec.*): 38/30/--

2. LONGITUDE (*deg.-min.-sec.*): 90/37/--

E. ARE THERE BUILDINGS ON THE SITE?

[ ] 1. NO [X] 2. YES (*specify*): 8 major, 36 minor

T2070-2 (10-79)

Continue On Rev

DOCUMENT NUMBER

IV. CHARACTERIZATION OF SITE A [illegible] TY

Indicate the major site activity(ies) and details relating to each activity by marking 'X' in the appropriate boxes.

A. TRANSPORTER	B. STORER	C. TREATER	D. DISPOSER
	X		X
	1. PILE	1. FILTRATION	1. LANDFILL
	2. SURFACE IMPOUNDMENT	2. INCINERATION	2. LANDFARM
	X 3. DRUMS	3. VOLUME REDUCTION	X 3. OPEN DUMP
	X 4. TANK, ABOVE GROUND	4. RECYCLING/RECOVERY	4. SURFACE IMPOUNDMEN
	5. TANK, BELOW GROUND	5. CHEM./PHYS. TREATMENT	5. MIDNIGHT DUMPING
6. OTHER (specify):	X 6. OTHER (specify): Contaminated Buildings and Equipment	6. BIOLOGICAL TREATMENT	6. INCINERATION
		7. WASTE OIL REPROCESSING	7. UNDERGROUND INJECT
		8. SOLVENT RECOVERY	8. OTHER (specify):
		9. OTHER (specify):	

E. SPECIFY DETAILS OF SITE ACTIVITIES AS NEEDED

V. WASTE RELATED INFORMATION

A. WASTE TYPE

X 1. UNKNOWN X 2. LIQUID X 3. SOLID 4. SLUDGE 5. GAS

B. WASTE CHARACTERISTICS

1. UNKNOWN 2. CORROSIVE 3. IGNITABLE X 4. RADIOACTIVE 5. HIGHLY VOLATILE
X 6. TOXIC 7. REACTIVE 8. INERT X 9. FLAMMABLE

10. OTHER (specify):

C. WASTE CATEGORIES

1. Are records of wastes available? Specify items such as manifests, inventories, etc. below.

Records on-site but may not be readily retrievable

2. Estimate the amount (specify unit of measure) of waste by category; mark 'X' to indicate which wastes are present.

a. SLUDGE	b. OIL	c. SOLVENTS	d. CHEMICALS	e. SOLIDS	f. OTHE
AMOUNT	AMOUNT < 1000 Gal.	AMOUNT	AMOUNT Unknown	AMOUNT	AMOUNT
UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEAS
X (1) PAINT, PIGMENTS	X (1) OILY WASTES	X (1) HALOGENATED SOLVENTS	X (1) ACIDS	X (1) FLYASH	X (1) LABORA PHARMA
(2) METALS SLUDGES	X (2) OTHER (specify): Hexane Contaminated with Uranium	(2) NON-HALOGNTD SOLVENTS	(2) PICKLING LIQUORS	(2) ASBESTOS	(2) HOSPITA
(3) POTW		(3) OTHER (specify)	(3) CAUSTICS	(3) MILLING/ MINE TAILINGS	(3) RADIOAC
(4) ALUMINUM SLUDGE			(4) PESTICIDES	(4) FERROUS SMLTG. WASTES	(4) MUNIC P
(5) OTHER (specify):			(5) DYES/INKS	(5) NON-FERROUS SMLTG. WASTES	(5) OTHER (
			(6) CYANIDE	(6) OTHER (specify):	
			(7) PHENOLS		
			(8) HALOGENS		
			(9) PCB		
			(10) METALS		
			X (11) OTHER (specify): Uranium oxides & fluorides		

Continue On Pa

Continued From Page 2

V. WASTE RELATED INFORMATION (continued)

3. LIST SUBSTANCES OF GREATEST CONCERN WHICH MAY BE ON THE SITE (place in descending order of hazard).

Uranium, Tanks and drums containing unknown substances contaminated with uranium, TNT/DNT

4. ADDITIONAL COMMENTS OR NARRATIVE DESCRIPTION OF SITUATION KNOWN OR REPORTED TO EXIST AT THE SITE.

A contractor report dated May 1978 to DOD gives extensive details of site conditions and presents control alternatives. Armament command, U.S. Army, Rock Island Arsenal ordered to produce Decontamination and Decommission Plan by Nov. 15, 19

VI. HAZARD DESCRIPTION

A. TYPE OF HAZARD	B. POTENTIAL HAZARD (mark 'X')	C. ALLEGED INCIDENT (mark 'X')	D. DATE OF INCIDENT (mo., day, yr.)	E. REMARKS
1. NO HAZARD				
2. HUMAN HEALTH	X			
3. NON-WORKER INJURY/EXPOSURE				
4. WORKER INJURY				
5. CONTAMINATION OF WATER SUPPLY				
6. CONTAMINATION OF FOOD CHAIN				
7. CONTAMINATION OF GROUND WATER				
8. CONTAMINATION OF SURFACE WATER				
9. DAMAGE TO FLORA/FAUNA				
10. FISH KILL				
11. CONTAMINATION OF AIR				
12. NOTICEABLE ODORS				
13. CONTAMINATION OF SOIL	X			
14. PROPERTY DAMAGE				
15. FIRE OR EXPLOSION				
16. SPILLS/LEAKING CONTAINERS/ RUNOFF/STANDING LIQUIDS	X			
17. SEWER, STORM DRAIN PROBLEMS	X			
18. EROSION PROBLEMS				
19. INADEQUATE SECURITY				
20. INCOMPATIBLE WASTES				
21. MIDNIGHT DUMPING				
22. OTHER (specify)				

Continue On Reverse

Continued From Front

VII. PERMIT INFORMATION

A. INDICATE ALL APPLICABLE PERMITS HELD BY THE SITE.

☐ 1. NPDES PERMIT ☐ 2. SPCC PLAN ☐ 3. STATE PERMIT *(specify)*:

☐ 4. AIR PERMITS ☐ 5. LOCAL PERMIT ☐ 6. RCRA TRANSPORTER

☐ 7. RCRA STORER ☐ 8. RCRA TREATER ☐ 9. RCRA DISPOSER

☒ 10. OTHER *(specify)*: NRC Permit SMB 1314, 1977 to U.S. Army

B. IN COMPLIANCE?

☐ 1. YES ☐ 2. NO ☒ 3. UNKNOWN

4. WITH RESPECT TO *(list regulation name & number)*:

VIII. PAST REGULATORY ACTIONS

☐ A. NONE ☒ B. YES *(summarize below)*

NRC amended permit in May 1979 to require Building Decontamination and Decommission Plan by Nov. 15, 1979.

IX. INSPECTION ACTIVITY *(past or on-going)*

☐ A. NONE ☐ B. YES *(complete items 1,2,3, & 4 below)*

1. TYPE OF ACTIVITY	2. DATE OF PAST ACTION *(mo., day, & yr.)*	3. PERFORMED BY: *(EPA/State)*	4. DESCRIPTION
	Nov. 1975	ERDA	Aerial Radiological Survey
	May 1978	Army	Assessment of Disposition Alternatives

X. REMEDIAL ACTIVITY *(past or on-going)*

☐ A. NONE ☒ B. YES *(complete items 1, 2, 3, & 4 below)*

1. TYPE OF ACTIVITY	2. DATE OF PAST ACTION *(mo., day, & yr.)*	3. PERFORMED BY: *(EPA/State)*	4. DESCRIPTION
	Nov. 15, 1979	Army	Building Decontamination and Decommission

NOTE: Based on the information in Sections III through X, fill out the Preliminary Assessment *(Section II)* information on the first page of this form.

EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 1 - SITE INFORMATION AND ASSESSMENT

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
MO	2216090005

II. SITE NAME AND LOCATION

01 SITE NAME (Legal, common, or descriptive name of site)	02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER
Weldon Spring Raffinate Pits Site	MO. HWY 94, 2 miles south of U.S HWY 40

03 CITY	04 STATE	05 ZIP CODE	06 COUNTY	07 COUNTY CODE	08 CONG DIST
St. Charles	MO		St. Charles		

09 COORDINATES LATITUDE	LONGITUDE
38° 42' __.W	90° 44' __.W

10 DIRECTIONS TO SITE (Starting from nearest public road)
Take U.S. HWY 40 West from St. Louis, Approx. 13 miles to Missouri HWY. 94, Head south on HWY. 94, approx. 2 miles. Site is located on north side of 94.

III. RESPONSIBLE PARTIES

01 OWNER (If known)	02 STREET (Business, mailing, residential)
Department of Energy (DOE)	

03 CITY	04 STATE	05 ZIP CODE	06 TELEPHONE NUMBER
			( )

07 OPERATOR (If applicable and different from owner)	08 STREET (Business, mailing, residential)
Mallinckrodt Chemical Works/ Atomic Energy Commission	

09 CITY	10 STATE	11 ZIP CODE	12 TELEPHONE NUMBER
			( )

13 TYPE OF OWNERSHIP (Check one)
☐ A. PRIVATE ☒ B. FEDERAL: Department of Energy (DOE) (Agency name) ☐ C. STATE ☐ D. COUNTY ☐ E. MUNICIPAL
☐ F. OTHER: _____ (Specify) ☐ G. UNKNOWN

14 OWNER-OPERATOR NOTIFICATION ON FILE (Check all that apply)
☐ A. RCRA 3001 DATE RECEIVED: __/__/__ (MONTH DAY YEAR) ☐ B. UNCONTROLLED WASTE SITE (CERCLA 103 c) DATE RECEIVED: __/__/__ (MONTH DAY YEAR) ☐ C. NONE

IV. CHARACTERIZATION OF POTENTIAL HAZARD

01 ON SITE INSPECTION
☐ YES DATE __/__/__ (MONTH DAY YEAR)
☐ NO

BY (Check all that apply)
☐ A. EPA ☐ B. EPA CONTRACTOR ☐ C. STATE ☐ D. OTHER CONTRACTOR
☐ E. LOCAL HEALTH OFFICIAL ☐ F. OTHER: _____ (Specify)
CONTRACTOR NAME(S): _____

02 SITE STATUS (Check one)
☐ A. ACTIVE ☒ B. INACTIVE ☐ C. UNKNOWN

03 YEARS OF OPERATION
1958 (BEGINNING YEAR) | 1965 (ENDING YEAR) ☐ UNKNOWN

04 DESCRIPTION OF SUBSTANCES POSSIBLY PRESENT, KNOWN, OR ALLEGED
Wastes present onsite include Raffinate sludges from uranium and thorium processing operations, including uranium and thorium decay products and radium contaminated water. Also onsite are solid rubble and debris from destruction of the Weldon Spring Chemical Plant.

05 DESCRIPTION OF POTENTIAL HAZARD TO ENVIRONMENT AND/OR POPULATION
Wastes have been found to be low level radioactive. Sludges and waters are contained in unlined pits constructed directly in native soils. Several small areas of soil outside the pits have shown gamma levels above background.

V. PRIORITY ASSESSMENT

01 PRIORITY FOR INSPECTION (Check one. If high or medium is checked, complete Part 2 - Waste Information and Part 3 - Description of Hazardous Conditions and Incidents)
☐ A. HIGH (Inspection required promptly) ☐ B. MEDIUM (Inspection required) ☒ C. LOW (Inspect on time available basis) ☐ D. NONE (No further action needed, complete current disposition form)

VI. INFORMATION AVAILABLE FROM

01 CONTACT	02 OF (Agency/Organization)	03 TELEPHONE NUMBER
Files	EPA Region VII	( )

04 PERSON RESPONSIBLE FOR ASSESSMENT	05 AGENCY	06 ORGANIZATION	07 TELEPHONE NUMBER	08 DATE
Terry J. Shedd	~~EPA~~ SUPERFUND	TAT 17	(816) 221-1722	03 / 20 / 86 (MONTH DAY YEAR)

EPA FORM 2070-12 (7-81)

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APR 24 1986
SITE LOG

DOCUMENT NUMBE

EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 2 - WASTE INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
MO	2210090005

II. WASTE STATES, QUANTITIES, AND CHARACTERISTICS

01 PHYSICAL STATES (Check all that apply)

- [X] A. SOLID
- [ ] B. POWDER, FINES
- [X] C. SLUDGE
- [X] E. SLURRY
- [X] F. LIQUID
- [ ] G. GAS
- [ ] D. OTHER (Specify)

02 WASTE QUANTITY AT SITE (Measures of waste quantities must be independent)

- TONS
- CUBIC YARDS: 220,000
- NO. OF DRUMS

03 WASTE CHARACTERISTICS (Check all that apply)

- [X] A. TOXIC
- [ ] B. CORROSIVE
- [X] C. RADIOACTIVE
- [ ] D. PERSISTENT
- [ ] E. SOLUBLE
- [ ] F. INFECTIOUS
- [ ] G. FLAMMABLE
- [ ] H. IGNITABLE
- [ ] I. HIGHLY VOLATILE
- [ ] J. EXPLOSIVE
- [ ] K. REACTIVE
- [ ] L. INCOMPATIBLE
- [ ] M. NOT APPLICABLE

III. WASTE TYPE

CATEGORY	SUBSTANCE NAME	01 GROSS AMOUNT	02 UNIT OF MEASURE	03 COMMENTS
SLU	SLUDGE low radiation	220,000	cu. yards	
OLW	OILY WASTE			
SOL	SOLVENTS			
PSD	PESTICIDES			
OCC	OTHER ORGANIC CHEMICALS			
IOC	INORGANIC CHEMICALS			
ACD	ACIDS			
BAS	BASES			
MES	HEAVY METALS			

IV. HAZARDOUS SUBSTANCES (See Appendix for most frequently cited CAS Numbers)

01 CATEGORY	02 SUBSTANCE NAME	03 CAS NUMBER	04 STORAGE DISPOSAL METHOD	05 CONCENTRATION	06 MEASURE OF CONCENTRATION
SLU	Raffinate sludges from uranium & thorium processing, decay products, and water contaminated with radium. Pit #4 also contains drums & solid rubble from destruction of the Weldon Spring Chemical Plant	Ra-226	Surface impairment	460 ± 130	pCi/g dry
		Ra-228		850 ± 85	"
		TH-232		120 ± 20	"
		TH-230		24,000 ± 1,000	"
		U-238		710 ± 70	"
		U-234		810 ± 80	"
		U-235		40 ± 5	"

V. FEEDSTOCKS (See Appendix for CAS Numbers)

CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER	CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER
FDS			FDS		
FDS			FDS		
FDS			FDS		
FDS			FDS		

VI. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

Radiological Survey Report for the Weldon Spring Raffinate Pits Site, Weldon Spring, Missouri – Bechtel National, Inc., August 1984.

EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
MO	2210090005

II. HAZARDOUS CONDITIONS AND INCIDENTS

01 ☒ A. GROUNDWATER CONTAMINATION — 02 ☐ OBSERVED (DATE: _____) — ☒ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: 61,400 — 04 NARRATIVE DESCRIPTION

Some nitrates have been detected in ground water. May not be attributable to Raffinate Pits, but to the former Weldon Spring Chemical Plant site.

01 ☐ B. SURFACE WATER CONTAMINATION — 02 ☐ OBSERVED (DATE: _____) — ☒ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

NONE DIRECTLY ATTRIBUTABLE TO THE RAFFINATE PITS SITE HAS BEEN OBSERVED.

01 ☒ C. CONTAMINATION OF AIR — 02 ☐ OBSERVED (DATE: _____) — ☒ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: Unknown — 04 NARRATIVE DESCRIPTION

Walkover gamma surveys have detected gross CPM gamma levels in excess of background (approx. 6,000 counts/min.) is several localized spots. Potential contamination of airways onsite.

01 ☐ D. FIRE EXPLOSIVE CONDITIONS — 02 ☐ OBSERVED (DATE: _____) — ☒ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

NONE OBSERVED, BUT POTENTIAL MAY BE PRESENT DUE TO TNT AND DNT CONTAMINATION DETECTED AT ADJACENT CHEMICAL PLANT, AND TRAINING AREA SITES.

01 ☐ E. DIRECT CONTACT — 02 ☐ OBSERVED (DATE: _____) — ☐ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

Site is enclosed by a 7 ft high security fence. In addition, each pit is enclosed by a smaller interior fence.

01 ☒ F. CONTAMINATION OF SOIL — 02 ☐ OBSERVED (DATE: _____) — ☒ POTENTIAL — ☐ ALLEGED
03 AREA POTENTIALLY AFFECTED: Unknown (ACRES) — 04 NARRATIVE DESCRIPTION

Wastes are contained in unlined impoundments directly in native soils. Potential for migration of contaminants into surrounding soils. Walkover gamma surveys, bore holes gamma logs, and surface soil samples have shown radionuclide levels exceeding background levels in several localized spots.

01 ☒ G. DRINKING WATER CONTAMINATION — 02 ☐ OBSERVED (DATE: _____) — ☒ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: 61,400 — 04 NARRATIVE DESCRIPTION

None observed attributable to the Raffinate Pits Site, but location and construction of pits (unlined) present some potential.

01 ☐ H. WORKER EXPOSURE/INJURY — 02 ☐ OBSERVED (DATE: _____) — ☐ POTENTIAL — ☐ ALLEGED
03 WORKERS POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

No workers onsite

01 ☒ J. POPULATION EXPOSURE/INJURY — 02 ☐ OBSERVED (DATE: _____) — ☒ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: ~3,000 — 04 NARRATIVE DESCRIPTION

Francis Howell high school is located within one mile east of the site. Potential exists for exposure to radiological contaminants via airways. In addition, Army Reserve/National Guards personnel are in the Training Area, west of the site.

EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
MO	2210090005

II. HAZARDOUS CONDITIONS AND INCIDENTS (Continued)

01 ☒ J. DAMAGE TO FLORA — 02 ☐ OBSERVED (DATE: _____) ☒ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION
None observed, but proximity of wild-life areas to site presents a potential for adverse impact to area flora.

01 ☒ K. DAMAGE TO FAUNA — 02 ☐ OBSERVED (DATE: _____) ☒ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION (Include name(s) of species)
None observed, but proximity of wildlife areas (Busch Wildlife Area, and Weldon Spring Wildlife area) presents potential for adverse impact to area fauna. Bald Eagle is known to inhabit and nest along the Missouri River

01 ☒ L. CONTAMINATION OF FOOD CHAIN — 02 ☐ OBSERVED (DATE: _____) ☒ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION
The proximity of water bodies from which fish are caught presents a potential for contamination of food chain in the event of a release of contaminants from the site.

01 ☒ M. UNSTABLE CONTAINMENT OF WASTES (Spills, runoff, standing liquids, leaking drums) — 02 ☐ OBSERVED (DATE: _____) ☒ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: Unknown — 04 NARRATIVE DESCRIPTION
Sludges are contained in open, unlined impoundments constructed in native soil. Potential for emigration of contaminants into surrounding soils.

01 ☐ N. DAMAGE TO OFFSITE PROPERTY — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION
None Documented

01 ☐ O. CONTAMINATION OF SEWERS, STORM DRAINS, WWTPs — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION
None Documented

01 ☐ P. ILLEGAL/UNAUTHORIZED DUMPING — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION
None Documented

05 DESCRIPTION OF ANY OTHER KNOWN, POTENTIAL, OR ALLEGED HAZARDS
None Documented

III. TOTAL POPULATION POTENTIALLY AFFECTED: ~3,000

IV. COMMENTS
Water samples collected from the St. Charles County well field have shown radionuclide levels within exceptable levels. However, it may not be attributable to the Weldon Spring sites.

V. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)
- Hazard Ranking System analysis prepared for the Weldon Spring Chemical Plant (including Raffinate Pits); by NUS Corporation, 7/3/85
- Radiological Survey Report for the Weldon Spring Raffinate Pits Site, Bechtel Natl., Inc. - 8/84
- Assessment of the Weldon Spring Chemical Plant, Dept. of the Army, 3/1/76

CHEMICAL PLANT
102-1.05

Form Approved. OMB No. 2050-0028. Expires 2-28-93
OSA No. 0246-R6 (7)

Please print or type with ELITE font (12 characters per inch) in the unshaded areas only.

5

EPA / MoDNR

COMBINED NOTIFICATION OF HAZARDOUS WASTE ACTIVITY

Send to: Missouri Department of Natural Resources, Waste Management Program, P.O. Box 176, Jefferson City, MO 65102

For Official Use Only

Comments

Installation's EPA ID Number	Approved	Date Received (yr. mo. day)
MOG21092281330		

I. Name of Installation: WELDON SPRING SITE REMEDIAL ACTION PROJECT

II. Installation Mailing Address

Street or P.O. Box: Route 2 Highway 94 South

City or Town: St. Charles | State: MO | ZIP Code: 63303

III. Location of Installation

Street or Route Number: Route 2 Highway 94 South

City or Town: St. Charles | State: MO | ZIP Code: 63303

IV. Installation Contact

Name and Title (last, first, and job title): Rodney Nelson | Phone Number (area code and number): 314 441 8978

V. Ownership

A. Name of Installation's Legal Owner: DOE Dept of Energy | B. Type of Ownership (enter code): FC

VI. Type of Regulated Waste Activity (Mark 'X' in the appropriate boxes. Refer to instructions.)

A. Hazardous Waste Activity

- [X] 1a. Generator
- [ ] 1b. Less than 1,000 kg/mo.
- [ ] 2. Transporter
- [ ] 3. Treater/Storer/Disposer
- [ ] 4. Underground Injection
- [ ] 5. Market or Burn Hazardous Waste Fuel (enter 'X' and mark appropriate boxes below)
  - [ ] a. Generator Marketing to Burner
  - [ ] b. Other Marketer
  - [ ] c. Burner

B. Used Oil Fuel Activities

- [ ] 6. Off-Specification Used Oil Fuel (enter 'X' and mark appropriate boxes below)
  - [ ] a. Generator Marketing to Burner
  - [ ] b. Other Marketer
  - [ ] c. Burner
- [ ] 7. Specification Used Oil Fuel Marketer (or On-site Burner) Who First Claims the Oil Meets the Specification

VII. Waste Fuel Burning: Type of Combustion Device (enter 'X' in all appropriate boxes to indicate type of combustion device(s) in which hazardous waste fuel or off-specification used oil fuel is burned. See instructions for definitions of combustion devices.)

- [ ] A. Utility Boiler
- [ ] B. Industrial Boiler
- [ ] C. Industrial Furnace

VIII. Mode of Transportation (transporters only — enter 'X' in the appropriate box(es))

- [ ] A. Air
- [ ] B. Rail
- [ ] C. Highway
- [ ] D. Water
- [ ] E. Other (specify)

IX. First or Subsequent Notification

Mark 'X' in the appropriate box to indicate whether this is your installation's first notification of hazardous waste activity or a subsequent notification. If this is not your first notification, enter your installation's EPA ID Number in the space provided below.

- [ ] A. First Notification
- [X] B. Subsequent Notification (complete item C)

C. Installation's EPA ID Number: MO 6210022830

Continue on reverse

DOCUMENT NUMBER: _____

ID - For Official Use Only			
C W		T/M	C 1

cription of Hazardous Wastes (continued from front)

A. Wastes from Nonspecific Sources (F-List). Enter the four-digit number from 40 CFR Part 261.31 for each listed hazardous waste from nonspecific sources your installation handles. Below each number, enter monthly generation amount in pounds and frequency code A, B, or C.

WASTE ID #	F002	F005		
AMOUNT AND FREQUENCY	lbs C	lbs C	lbs	lbs

B. Wastes from Specific Sources (K-List). Enter the four-digit number from 40 CFR Part 261.32 for each listed hazardous waste from specific sources your installation handles. Below each number, enter the monthly generation amount in pounds and frequency code A, B, or C.

WASTE ID #				
AMOUNT AND FREQUENCY	lbs	lbs	lbs	lbs

C. Commercial Chemical Product Wastes (U and P Lists). Enter the four-digit number from 40 CFR Part 261.33 for each chemical substance your installation handles which may be a hazardous waste. Below each number, enter monthly generation amount in pounds and frequency A, B, or C.

WASTE ID #	U105	U106	U117	U134
AMOUNT AND FREQUENCY	lbs C	lbs C	lbs C	lbs C

U225
U151
U077
20 lb.

D. (Reserved)

E. Characteristics of Nonlisted Hazardous Wastes. Mark an 'x' in the boxes corresponding to the characteristics of nonlisted hazardous wastes your installation handles. (See 40 CFR Parts 261.21 - 261.24) Below each box that you check, enter the monthly generation amount expressed in pounds and generation frequency code A, B, or C.

	1. Ignitable (D001)	2. Corrosive (D002)	3. Reactive (D003)
AMOUNT AND FREQUENCY	X 31,500 lbs C	X 2000 lbs C	lbs

X 4. Toxic Enter the four-digit number which identifies each characteristic toxic waste. Below each number enter the monthly generation amount and frequency.

	D009			
AMOUNT AND FREQUENCY	80 lbs C	lbs	lbs	lbs

MISSOURI REQUIRED INFORMATION

MO Generator ID Number _____

Principle Business Activity _____

S.I.C. Code (leave blank if uncertain) ☐☐☐☐

Check this box if you generate/accumulate less than a regulated quantity ☐

XI. Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Signature	Name And Official Title(Type Or Print)	Date Signed

HWG — 1A
Continuation Sheet
for
Combined Notification of Hazardous Waste Activity

(See reverse side of this form for specific instructions)

I. Name of Installation _____

II. Location of Installation _____
Street or Route Number

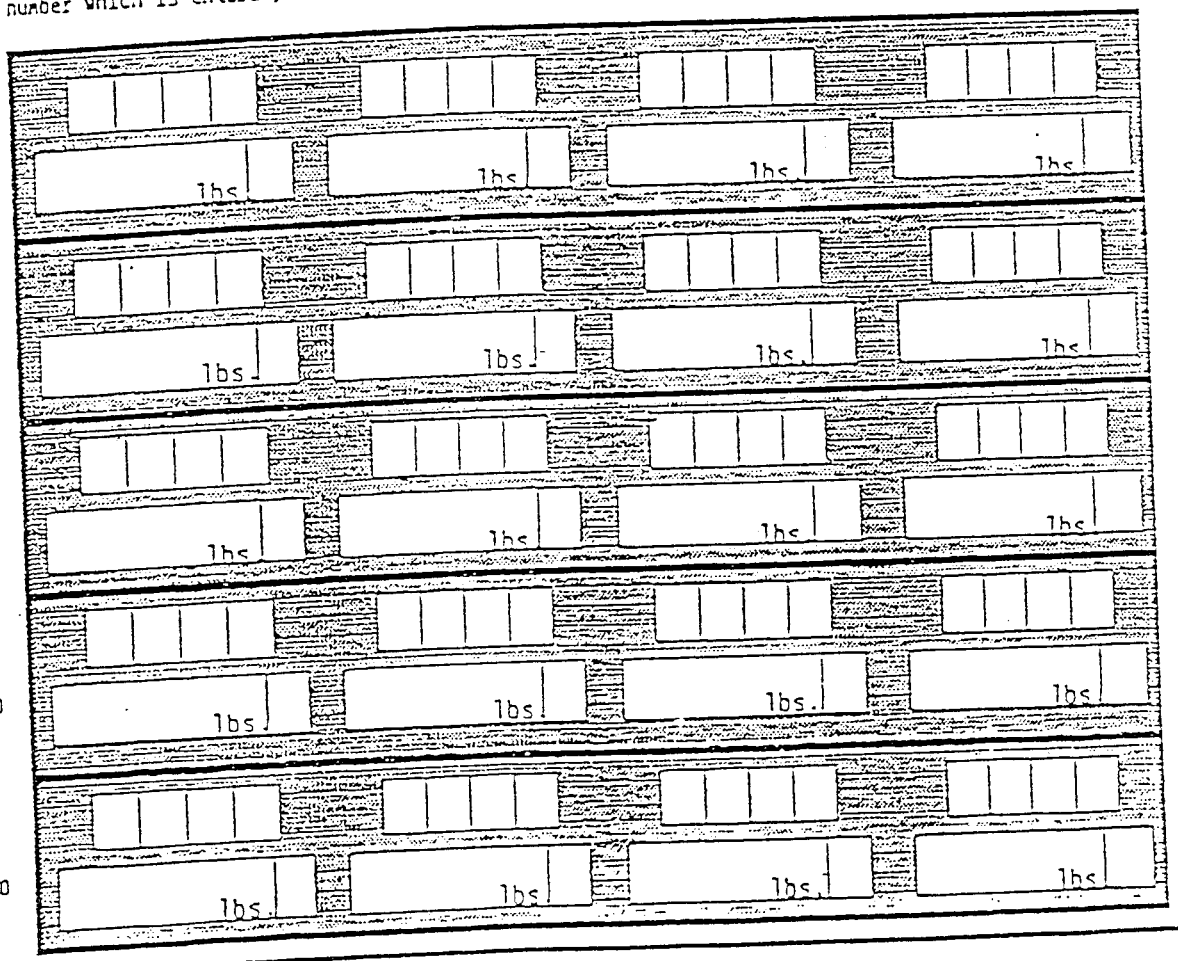
_____
City, State, and Zip Code

III. Identification Numbers If Previously Assigned

EPA # | | | | | | | | | | | | MISSOURI # | | | | | |

IV. Hazardous Waste Description

Enter the four-digit EPA waste number from 40 CFR Part 261 for each additional waste stream. Below each EPA waste number which is entered, enter the monthly generation amount in pounds and frequency code A, B, or C.



V. Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Signature	Name And Official Title(Type Or Print)	Date Signed

Instructions for Completion of HWG — 1A Form

General Instructions — Type or print in black ink. This form is to be used as additional space for "Description of Hazardous Waste" (Item X), of the EPA/DNR Combined Notification of Hazardous Waste Activity form (EPA 8700 —12/MDNR HWG —1), only if additional space is necessary. This form is valid only when attached to a completed EPA 8700 —12/MDNR HWG —1 form.
SPECIAL NOTE: When adding or deleting a waste, a new Combined Notification of Hazardous Waste Activity Form must be completed and submitted. Be certain to accurately reflect all waste streams each time you notify, as the most recent form in our files will be considered as your legal registration.

Item I — Name of Installation — Enter the name of your business or organization as you have on your completed and attached EPA 8700 —12/MDNR HWG —1, item I.

Item II — Location of Installation — Enter the location as you have on your completed and attached EPA 8700 — 12/MDNR HWG —1, item III.

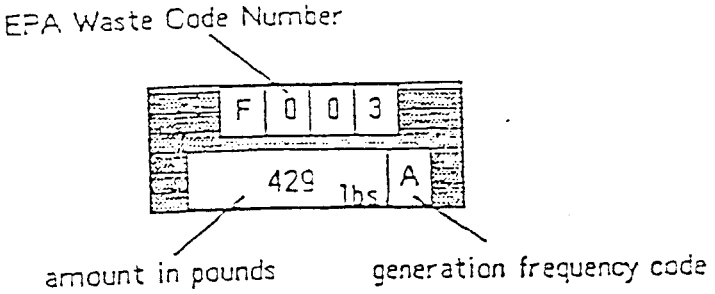
Item III — Identification Numbers — If previously assigned, enter your 12—digit EPA identification number and 5—digit Missouri identification number in the boxes provided.

Item IV — Hazardous Waste Description — Enter the four—digit EPA waste number from 40 CFR Part 261 for each waste stream. Below each EPA waste number which is entered, give the monthly generation rate in pounds and frequency code A, B, or C.

In completing this section use the following generation frequency codes:

A= Continual Generation
B= Intermittent Generation
C= One time only Generation

To assist you in the completion of this section note the following example:



Item V — Certification — This certification must be signed by the owner, operator, or an authorized representative of your installation. An "authorized representative" is a person responsible for the overall operation of the facility, i.e., a plant manager or superintendent, or a person of equal responsibility. *All notifications must include this certification to be complete.*

Instructions for Completion of Combined Notification of Hazardous Waste Activity
Form EPA 8700 -12 / MONR HWG - 1

General Instructions - Type or print in black ink except item XI, "Signature". Leave a blank box between words. If you must use additional sheets, indicate clearly the number of the item on the form to which the information on the separate sheet applies. If you need additional space for item X, attach a completed form DNR HWG-1A (continuation sheet).

SPECIAL NOTE: When adding or deleting a waste, a new Combined Notification of Hazardous Waste Activity form must be completed and submitted. Be certain to accurately reflect all waste streams each time you notify, as the most recent form in our files will be considered your legal registration.

Items I-III - Name, Mailing Address, and Location of Installation - Complete Items I-III. Please note that the address you give for Item III, "Location of Installation", must be a physical address, *not a post office box or route number.* If the mailing address and physical facility location are the same, you can print "Same" in box for Item III.

Item IV - Installation Contact - Enter the name, title, and business telephone number of the person who should be contacted regarding information submitted on this form.

Item V - Ownership

A) Name: Enter the name of the legal owner(s) of the installation, including the property owner. Use additional sheets if necessary to list more than one owner.

B) Type: Using the codes listed below, indicate the legal status of the owner of the facility:

FF=Federally Owned, Federally Operated
FC=Federally Owned, Operated by a Private Contractor to Federal Government
FP=Federally Owned, Privately Operated
PF=Privately Owned, Constructed for Use by The Federal Government and Operated by The Federal Government
PL=Privately Owned, Leased and Operated by The Federal Government
PI=Privately Owned, Indian Land
FI=Federally Owned, Indian Land
C =County
D =District
M =Municipal
P =Private
S =State

Item VI - Type of Regulated Waste Activity

A) Hazardous Waste Activity: Mark the appropriate box(es) to show which hazardous waste activities are going on at this installation.

1) Generator:

a) If you generate a hazardous waste this is identified by characteristic or listed in 40 *CFR* Part 261, mark an "X" in this box.

b) In addition, *if you generate less than 1000 kilograms of non-acutely hazardous waste per calendar month, mark an "X" in this box.*

2) Transporter: If you move hazardous waste by air, rail, highway, or water mark an "X" in this box. All transporters must complete Item VIII. Transporters do not have to complete Item X of this form, but must sign the certification in Item XI. Refer to Part 263 of 40 *CFR* for an explanation of the federal regulations for hazardous waste transporters.

3) Treater/Storer/Disposer: If you treat, store, or dispose of regulated hazardous waste, mark an "X" in this box. You are reminded to contact the Missouri Department of Natural Resources, Waste Management Program, to request Part A of the RCRA permit application. Refer to Parts 264 and 265 of 40 *CFR* for an explanation of the federal regulations for hazardous waste facility owners/operators. Be sure to also check applicable state regulations.

4) Underground Injection: Persons who generate and/or treat, store, or dispose of hazardous waste must place an "X" in this box if an injection well is located at their installation. An injection well is defined as any hole in the ground, including septic tanks, that is deeper than it is wide and that is used for the subsurface placement of fluids.

5) Market or Burn Hazardous Waste Fuel: If you market or burn hazardous waste fuel, place an "X" in this box. Then mark the appropriate boxes to indicate your specific activity. *If you mark "Burner" you must complete Item VII - "Type of Combustion Device".*

Note: Generators are required to notify for waste-as-fuel activities only if they market directly to the burner.

"Other Marketer" is defined as any person, other than the generator marketing his hazardous waste, who markets hazardous waste fuel.

B) Used Oil Fuel Activities

Mark an "X" in the appropriate box(es) below to indicate which used oil fuel activities are taking place at this installation.

6) Off-Specification Used Oil Fuel: If you market or burn off-specification used oil, the place an "X" in this box. Then mark the appropriate boxes to indicate your specific activity. *If you mark "Burner" you must complete Item VII - "Type of Combustion Device".*

Note: Used oil generators are required to notify only if marketing directly to the burner.

"Other Marketer" is defined as any person, other than a generator marketing his or her used oil, who markets used oil fuel.

7) Specification Used Oil Fuel: If you are the first to claim that the used oil meets the specification established in 40 *CFR* Part 266.40(e) and is exempt from further regulation, you must mark an "X" in this box.

Item VII — Waste—Fuel burning. Type of Combustion Device — Enter an "X" in all appropriate boxes to indicate type(s) of combustion devices in which hazardous waste fuel or off—specification used oil fuel is burned. (Refer to definition section for complete description of each device.)

Item VIII — Mode of Transportation — Complete this item only if you are a transporter of hazardous waste. Mark an "X" in each appropriate box to indicate the method(s) of transportation you use.

Item IX — First or Subsequent Notification — Place an "X" in the appropriate box to indicate whether this is your first or a subsequent notification. If you have filed a previous notification, enter your EPA Identification Number in the boxes provided.

Note: When the owner of a facility changes, the new owner must notify of the change even if the previous owner has already received a U.S. EPA Identification Number. Because the U.S. EPA number is "site specific", the new owner will keep the existing ID number. If the facility moves to another location, the owner/operator must notify of this change. In this instance, a new U.S. EPA Identification Number will be assigned, since the facility has changed locations.

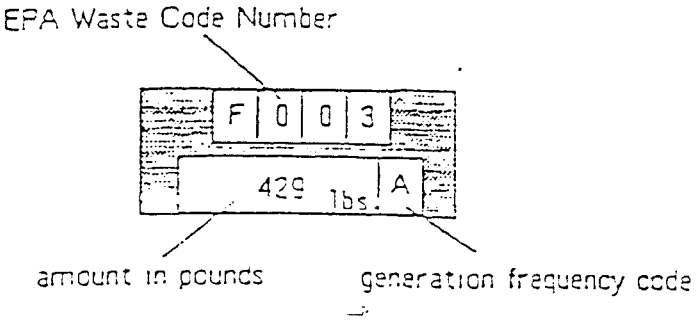
Item X — Description of Hazardous Waste — Only persons involved in hazardous waste activity [Item VI(A)] need to complete this item. Transporters requesting a U.S. EPA Identification Number do not need to complete this item, but must sign the "Certification" in Item XI.

You will need to refer to the federal regulations, Title 40 *CFR* Part 261 in order to complete this section. Part 261 identifies those wastes that EPA defines as hazardous. You must also refer to Missouri chapter 10 CSR 25—4.261 for any additional state listed waste streams.

In completing this section use the following generation frequency codes:

A= Continual Generation
B= Intermittent Generation
C= One time only Generation

To assist you in the completion of this section note the following example:



Section A — If you handle hazardous wastes that are listed in the "nonspecific sources" category in Part 261.31, enter the appropriate 4—digit numbers in the

boxes provided. Below each waste code number, enter the monthly generation rate in pounds, and, the generation frequency code.

Section B — If you handle hazardous wastes that are listed in the "specific industrial sources" category in Part 261.32, enter the appropriate four—digit numbers in the boxes provided. Below each waste code number, enter the monthly generation rate in pounds, and, the generation frequency code.

Section C — If you handle any of the "commercial chemical products" listed as wastes in Part 261.33, enter the appropriate four—digit numbers in the boxes provided. Below each waste code number, enter the monthly generation rate in pounds and, the generation frequency code.

Section D — Disregard, Since EPA has not yet published infectious waste regulations.

Section E — If you handle hazardous wastes which are not listed in any of the categories above, but do possess a hazardous characteristic, you should describe these wastes by their hazardous characteristic. An explanation of each characteristic is found in Part 261.21—261.24. Place an "X" in the box of each characteristic waste that you handle. Below each waste code number, enter the monthly generation rate in pounds and, the generation frequency code.

If you need space for additional waste streams use the Continuation Sheet Form MDNR HWG —1A.

Missouri Required Information

Missouri Generator ID Number — If your business has been previously assigned a 5—digit Missouri Generator Identification Number enter it here.

Principle Business Activity — Enter a description of the activity which best typifies your business, i.e., manufacture steel chairs and related products.

Standard Industrial Classification Number — Enter the 4 — digit standard industrial classification number(s) in order of descending importance.

Generate Less Than 100 kilograms (220 pounds)/month — Check this box if the total of all hazardous waste streams is less than this amount.

Item XI — Certification — This certification must be signed by the owner, operator, or an authorized representative of your installation. An "authorized representative" is a person responsible for the overall operation of the facility, i.e., a plant manager or superintendent, or a person of equal responsibility. *All notifications must include this certification to be complete.*

CHEMICAL PLANT ADMINISTRATIVE RECORD FILE

ARFS FILE # C-201-1

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SECTION	SECTION TITLE
200	REMEDIAL INVESTIGATION (RI)
201	Sampling and Analysis Plans

DOCUMENT NUMBERS	DOCUMENT TITLE
C-200-201-1.01(r)	PLAN FOR DETERMINATION OF BIOLOGICAL UPTAKE OF RADIONUCLIDES AND NITROAROMATICS IN SPECIES IN THE FOOD PATHWAYS AT THE WSS; DRAFT
C-200-201-1.02(r)	WORKPLAN FOR THE DETERMINATION OF BIO UPTAKE OF WSS CONTAMINANTS BY SPECIES IN FOOD PATHWAYS
C-200-201-1.03(r)	PLAN FOR THE SAMPLING AND ANALYSIS OF LAKE AND STREAM SEDIMENTS INFLUENCED BY THE WSCP DRAINAGE
C-200-201-1.04(r)	CHEMICAL SOIL INVESTIGATION SAMPLING PLAN FOR THE WSCP/WSRP

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

CHEMICAL PLANT
201

CHEMICAL PLANT
201-1.01

5496

June 23, 1987

Ms. Katie Biggs
U. S. Environmental Protection
Agency, Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Dear Ms. Biggs:

Enclosed are two copies of the "Plan for Determination of Biological Uptake of Radionuclides and Nitroaromatics in Species in the Food Pathways" and the "Plan for the Sampling of Sediment Influenced by Weldon Spring Chemical Plant Drainage." We intend to discuss these plans at the June 29, meeting with EPA in Kansas City.

Please be prepared to present any comments you may have at that meeting.

Sincerely,

K. D. Lawver
Environmental Engineer
Weldon Spring Site
Remedial Action Project

CE-541:Lawver

Enclosures

CE-541:KDLawver:mb:x36:6/23/87

CONCURRENCES

RTG SYMBOL	INITIALS/SIG.	DATE
CE-541	KDLawver	6/23/87

DOE F 1325.10
(7-79)

OFFICIAL FILE COPY

#5486

June 23, 1987

Mr. David Bedan
Missouri Department of
Natural Resources
205 Jefferson Street
Jefferson City, Missouri 65102

Dear Mr. Bedan:

Enclosed are two copies of the "Plan for Determination of Biological Uptake of Radionuclides and Nitroaromatics in Species in the Food Pathways" and the "Plan for the Sampling of Sediment Influenced by Weldon Spring Chemical Plant Drainage." We intend to discuss these plans at the June 29, meeting with EPA in Kansas City.

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K. D. Lawver
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Weldon Spring Site
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Enclosures

CE-541:KDLawver:mb:x36:6/23/87

CONCURRENCES

RTG SYMBOL	INITIALS/SIG.	DATE
CE-541	KDLawver	6/23/87

DOE F 1325.10
(7-79)

OFFICIAL FILE COPY

5486

June 23, 1987

Dr. John R. Crellin, Chief
Bureau of Environmental Epidemiology
Missouri Department of Health
1730 E. Elm
Jefferson City, Missouri 65102

Dear Dr. Crellin:

Enclosed are two copies of the "Plan for Determination of Biological Uptake of Radionuclides and Nitroaromatics in Species in the Food Pathways" and the "Plan for the Sampling of Sediment Influenced by Weldon Spring Chemical Plant Drainage." We intend to discuss these plans at the June 29, meeting with EPA in Kansas City.

Please be prepared to present any comments you may have at that meeting.

Sincerely,

K. D. Lawver
Environmental Engineer
Weldon Spring Site
Remedial Action Project

CE-541:Lawver

Enclosures

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CONCURRENCES	
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DATE	

DOE F 1325.10
(7-79)

OFFICIAL FILE COPY

PLAN FOR DETERMINATION OF BIOLOGICAL UPTAKE OF RADIONUCLIDES AND NITROAROMATICS IN SPECIES IN THE FOOD PATHWAYS AT THE WSS

DRAFT

PREPARED FOR:

U.S. DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

UNDER CONTRACT NO. DE-AC05-86OR21548

PREPARED BY:

MK-FERGUSON COMPANY

AND

JACOBS ENGINEERING GROUP, INC.

ROUTE 2, HIGHWAY 94 SOUTH

ST. CHARLES, MISSOURI 63303

JUNE 22, 1987

DRAFT

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DRAFT

1.0 INTRODUCTION

The Weldon Spring Site (WSS) is a U.S. Department of Energy (DOE) surplus facility located in St. Charles County, Missouri. This document presents a description of the study plan and work scope to determine and characterize the level of potential human exposure to radionuclides and nitroaromatics from the food pathways at the WSS. This will be accomplished by a statistically significant sampling effort of biota available for human consumption from various locations around and within the WSS. The final report will describe the methods in performing the survey, summarize the results, and discuss their significance. This effort represents the first step in those analyses which are typically performed in an Endangerment Assessment as part of an RI/FS process under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

The analysis of the food pathway for the surrounding populations is necessary in assessing the risks to human health from pathway ingestion of biota living in or near these contaminated sediments and waters. Chemical and radiological exposure in humans and the relevance of data in establishing design and action limits will be reviewed.

The study will combine estimates of average consumption by humans with measured contamination levels in edible tissues for input into a metabolic model. The approach taken will be to measure the actual uptake of edible aquatic and terrestrial biota with a calculation of the uptake from human consumption of contaminated tissue based on assumed ingestion rates.

The sampling program will consist of the collection of approximately forty-one (41) kilograms of sunfish, twenty-seven and one-half (27.5) kilograms of catfish, two and one-half

(2.5) kilograms of minnows, fifteen (15) kilograms of largemouth bass, five (5) kilograms of crappies, and a minimum of eight (8) kilograms of both rabbits and squirrels.

Electrofishing methods will be utilized for the collection of aquatic samples. This method will provide randomness in fish samples. Individual samples weighing approximately less than 50-75 grams will not be kept, assuming these samples would not be kept for consumption by typical members of the public.

Biota samples will consist of small mammals such as rabbits and squirrels. Since the population of these mammals is limited, the traps will be set adjacent or above the areas of contamination. The samples collected will be assumed to live and intake steady or chronic amounts of contaminants.

All samples will be analyzed for total uranium and nitroaromatics. In addition, samples collected from the Raffinate Pits and Quarry Sump will be analyzed for radium-226 and thorium-230. Surface water exiting the site via drainage pathways have elevated amounts of uranium with very small amounts of radium and thorium.

Since certain uranium compounds are soluble and can migrate in soil and water, the spread of contamination is primarily uranium. Uranium is also more soluble than radium and thorium in the body, therefore it is more likely to be present in soft tissues in addition to the bone.

For the nitroaromatics, dinitrotoluenes (DNT) are probable carcinogens and are believed to be more toxic than trinitrotoluenes (TNT). Acute toxicity to human beings has been observed for 2,4,6-TNT. Chronic toxicity has not been observed for any of the nitroaromatic contaminants to human beings. Nitroaromatic contamination has been found in locations where either process lines and buildings stood or in

surface water and drainage locations. All samples will be analyzed for nitroaromatics since TNT and DNT are similar to each other with respect to solubility and properties affecting adsorption.

2.0 SITE HISTORY AND ENVIRONMENTAL SETTING

From 1941 to 1944, the U.S. Department of the Army (DA) operated the Weldon Spring Ordnance Works for production of trinitrotoluene (TNT) and dinitrotoluene (DNT). During this operation, smaller areas of the 17,000-acre site were contaminated by TNT process materials. In the mid-1950's 220-acres of the Ordnance Works property was transferred to the U.S. Atomic Energy Commission (AEC). From 1957 to 1966, the AEC operated a uranium processing facility at the site. During the operation of this Feed Materials Plant, the buildings, equipment, and immediate terrain of the plant (220-acres) became contaminated with radionuclides in the Uranium transformation series.

After closure by the AEC, the Feed Materials Plant was reacquired by the Army in 1967. The Army partially decontaminated the buildings, dismantled some of the equipment, and began converting the facilities to produce herbicides. In 1969, prior to the Chemical Plant (WSCP) becoming operational, the herbicide project was canceled. In 1985, the custody of the WSCP was transferred from the DA to the Department of Energy (DOE). In conjunction with this transfer, the Weldon Spring Site Remedial Action Project (WSSRAP) was created as DOE Major Project Number 182.

Surface water runoff from the north and west sides of the WSCP, as well as potential overflow from an onsite water tower, flow to Ash Pond (Figure 1). Water from Ash Pond travels through an overflow conduit for approximately 100 m, surfaces, and then flows to Lake 35 on the August Busch Wildlife Area, to Schote Creek, Dardenne Creek, and eventually the Mississippi River (Figure 2). Water from Ash Pond also discharges via underground connections to Burgermeister Spring, Lake 34, Dardenne Creek, and eventually the Mississippi River. Since

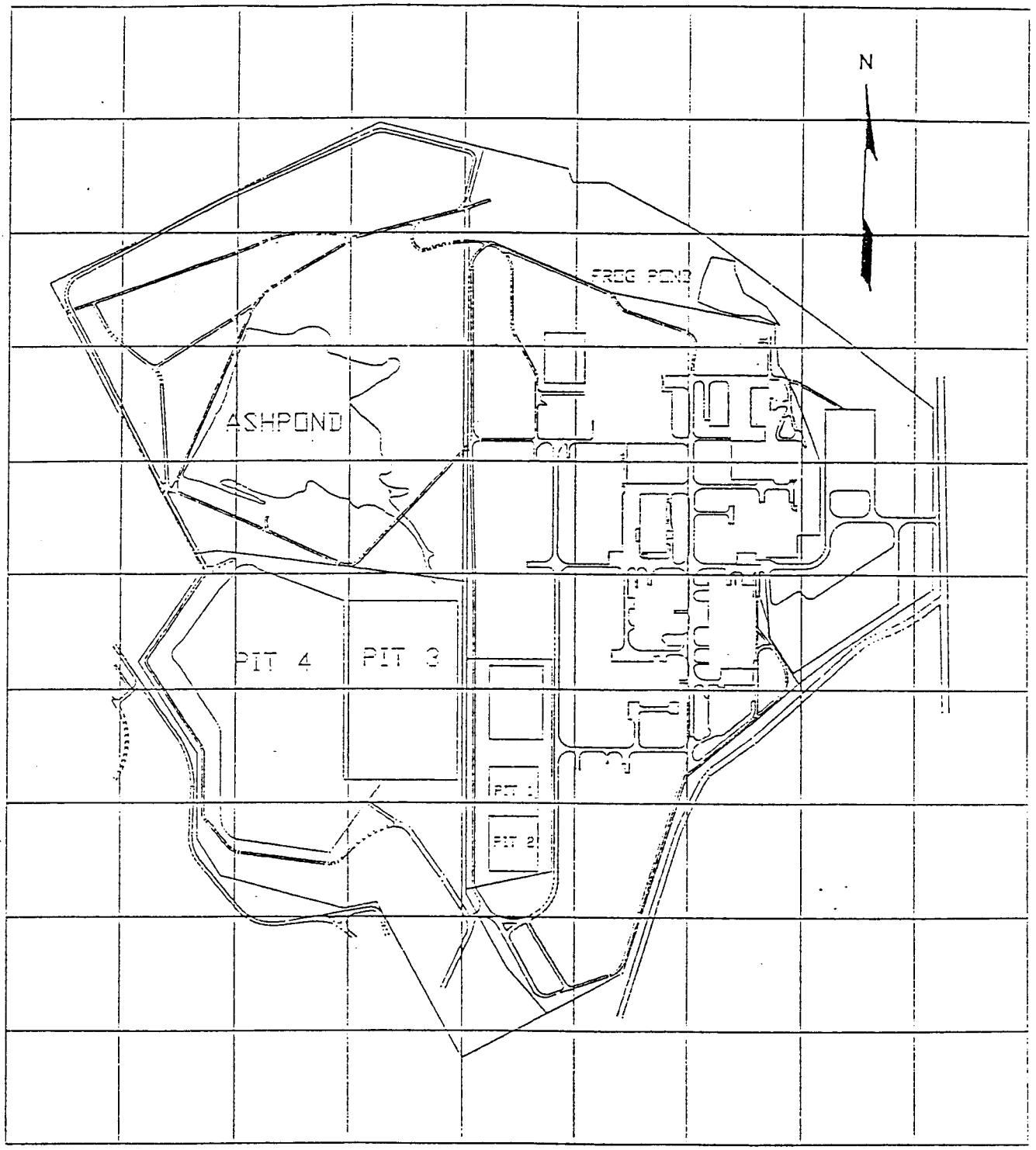

FIGURE 1

MAP OF WSCP/WSRP

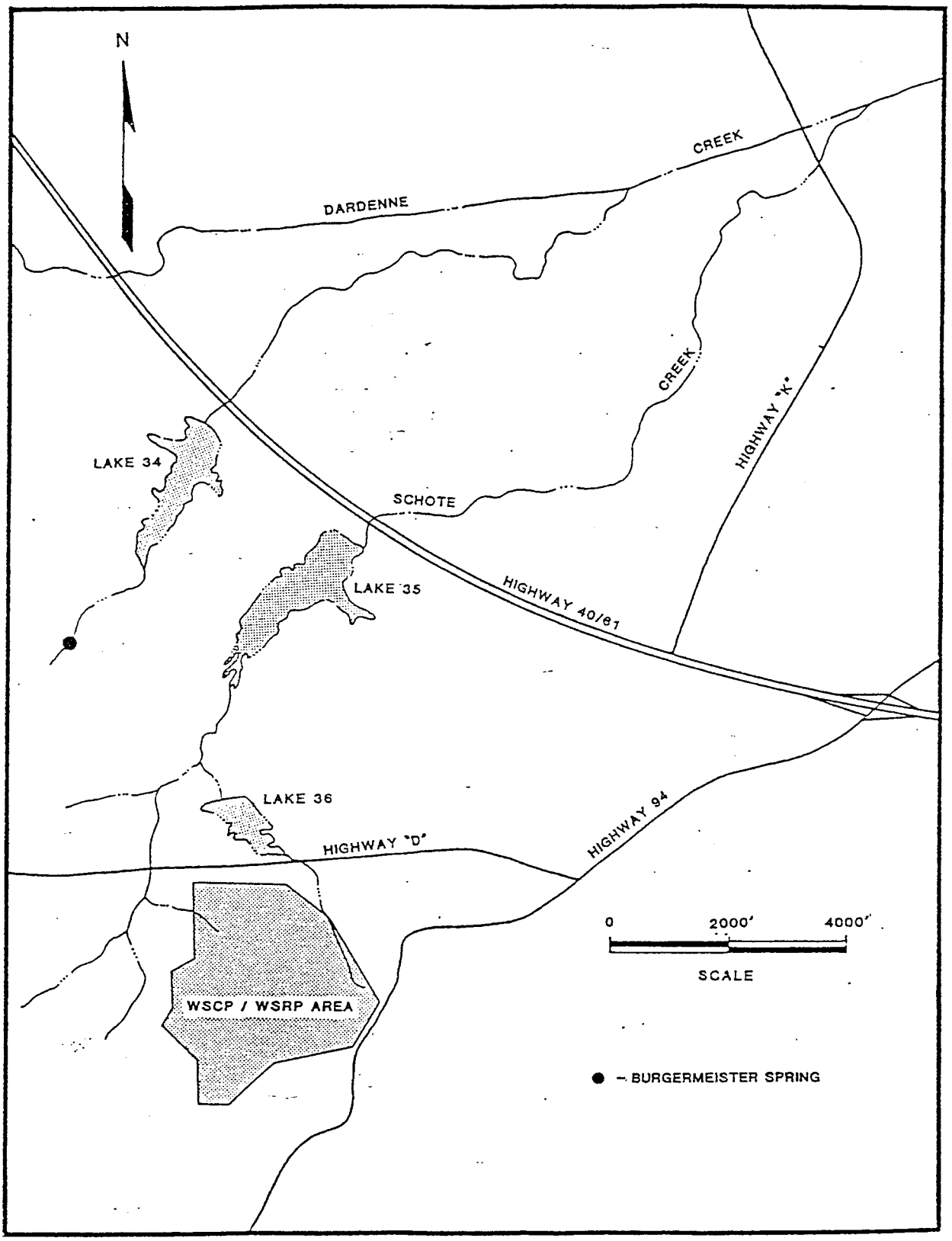

FIGURE 2

MAP OF THE WSCP/WSRP SURROUNDING PROPERTIES

operations in 1967 ceased, the discharge from Ash Pond has become an intermittent stream.

Surface water runoff from the northeast portion of the WSCP drains into Frog Pond. An intermittent stream out of Frog Pond flows north to Lake 36 and then into Lake 35, Schote Creek, Dardenne Creek, and eventually the Mississippi.

On the southeast corner of the WSCP, the outfall of the Imhoff Tank, the former WSCP sanitary sewage system, flows down a drainage ditch to the Missouri River. This drainage contains numerous areas of elevated radionuclides. Currently, flow through the Imhoff Tank results from the infiltration of storm water inflow into the sewer system. Sanitary wastes no longer enter the sewer system.

From 1941 to 1944, the Army used the Weldon Spring Quarry (WSQ) for disposal of rubble contaminated with TNT. The WSQ is approximately 4 miles to the south-southwest of the WSCP. Radioactive wastes were disposed of in the WSQ by the AEC from 1957 to 1966. (Figure 3)

The Femme Osage Slough, located south-southeast of the WSQ, has elevated concentrations of radionuclides (Figure 4). Contaminants are believed to be carried by groundwater movements from the WSQ sump to the slough, eventually reaching the Missouri River.

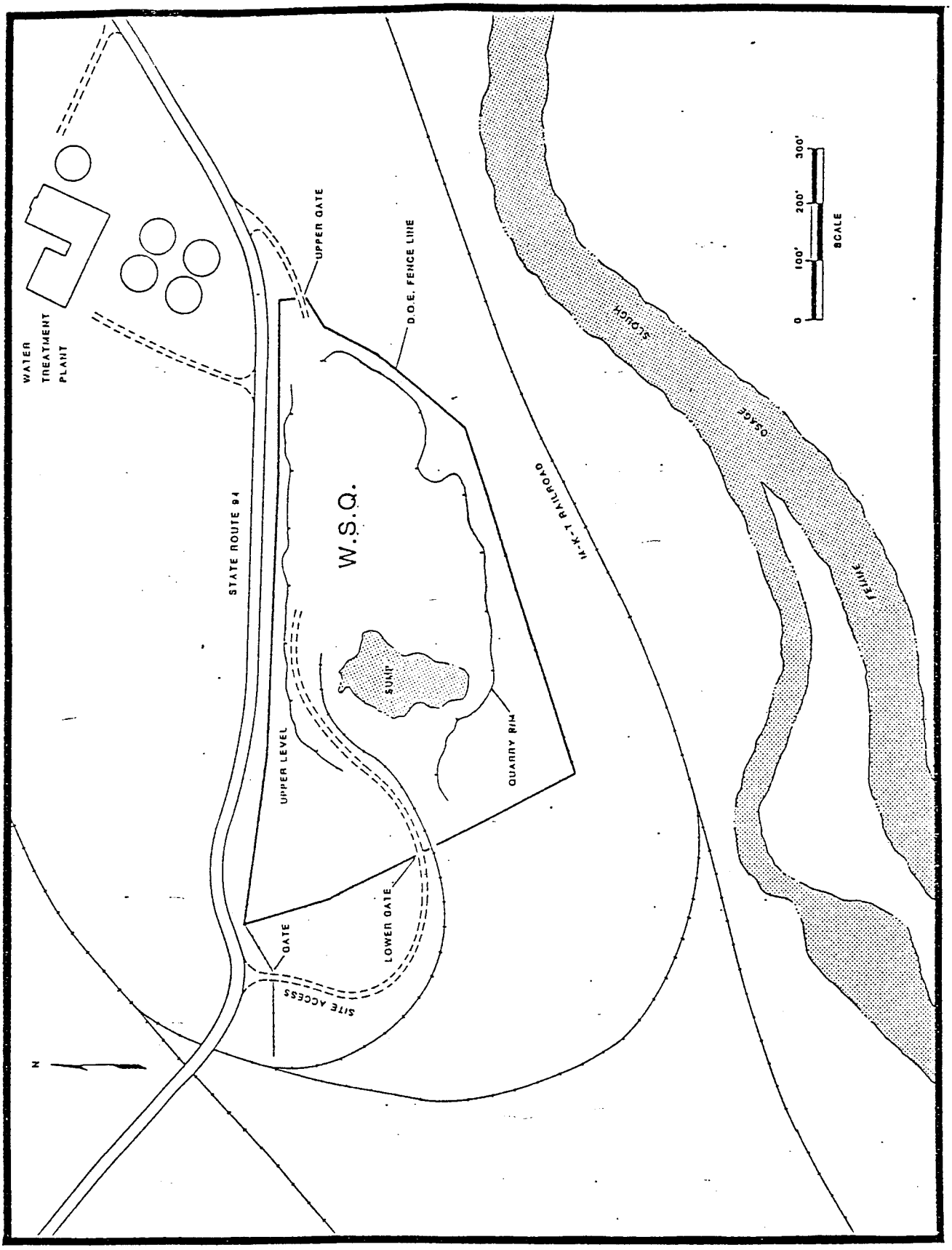

FIGURE 3

MAP OF WSQ

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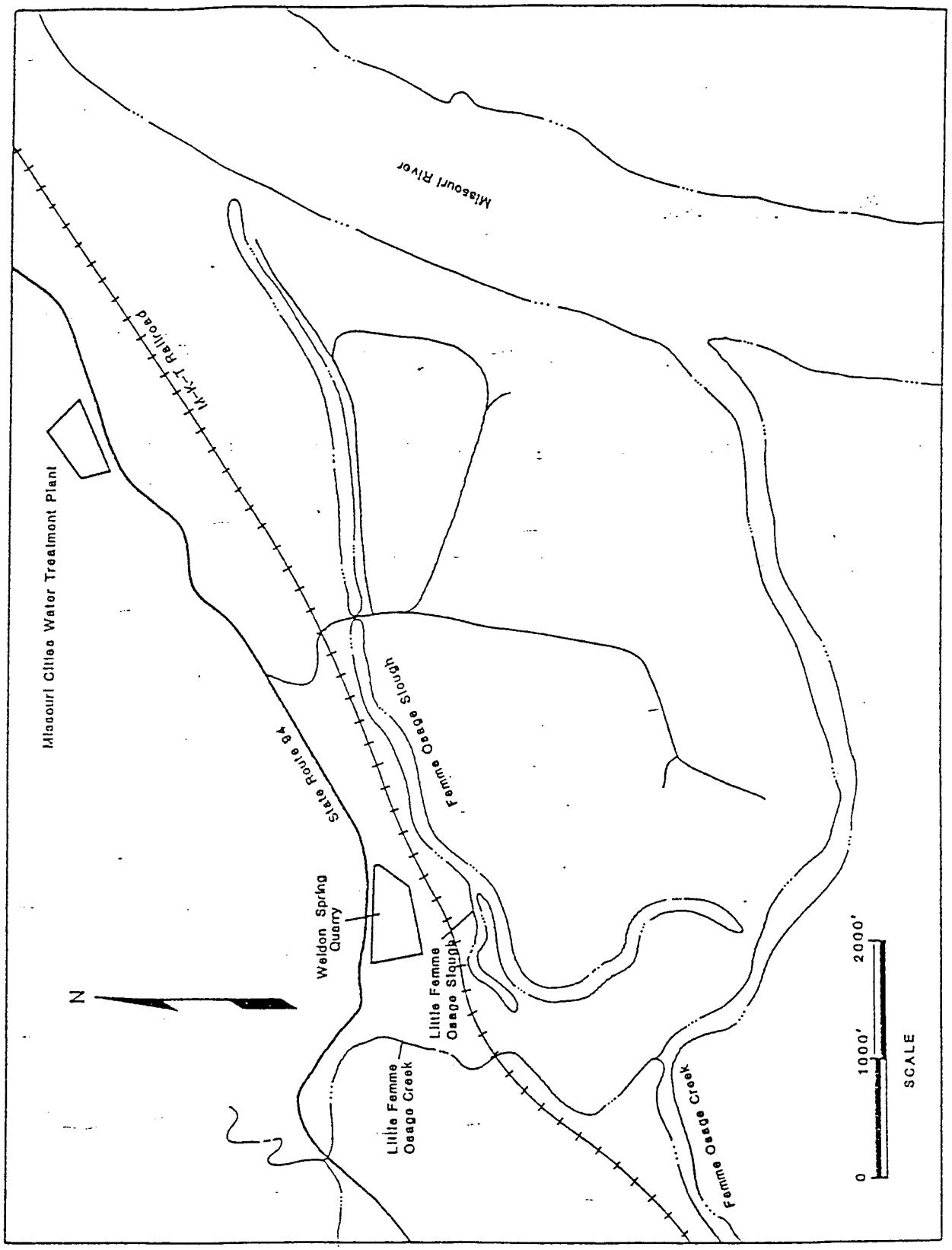

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FIGURE 4

MAP OF WSQ SURROUNDING PROPERTIES

3.0 TECHNICAL DISCUSSION AND BACKGROUND INFORMATION

Lake 35 is located in the Busch Wildlife Area. It is the closest lake receiving effluent from Ash Pond in an unrestricted area. Lake 35 is used for recreational activities such as fishing and boating. Dye tests have shown that water from Ash Pond also discharges via underground connections to Burgermeister Spring. Burgermeister Spring discharges to Lake 34 in the Busch Wildlife Area (Figure 2). At present, there is no recreational use of Burgermeister Spring, but Lake 34 is used for recreational purposes similar to Lake 35. These streams or lakes are not used as drinking water or irrigation sources.

Lake 36, located in the Busch Wildlife Area is the closest lake receiving effluent from Frog Pond in an unrestricted area. Frog Pond discharges via an intermittent stream into Lake 36. Lake 36 is also used for recreational activities such as fishing and boating.

The Femme Osage Slough is located approximately 500-feet SSE of the WSQ sump in an unrestricted area (Figure 3). The sump is believed to be hydraulically connected to the slough. This slough is not used as a source for drinking water or irrigation, but is frequently used for fishing (Figure 4).

Average radioactivity levels in surface and runoff water samples taken from in and around the WSS in 1986 are presented in Table 1. Nitroaromatic concentrations are presented in Table 2. The activity levels in waters decrease rapidly with the increase of distance from site mainly due to dilution by lake waters and/or other water sources.

Important considerations for determining body content of a radionuclide after it is ingested are time and age dependence of the intake. For purposes of the present analysis, it may be

TABLE 1

RADIONUCLIDE CONCENTRATIONS FROM 1986 ENVIRONMENTAL MONITORING DATA.

LOCATION	RADIONUCLIDE CONCENTRATIONS (pCi/l)		
	TOTAL U	Ra-226	Th-230
Lake 34	17	0.28	0.20
Lake 35	11	0.18	0.25
Lake 36	36	0.13	0.18
Frog Pond Outfall	29	0.20	1.37
Ash Pond Outfall	2700	0.10	0.0
Raffinate Pit #3	110	160	3.0
Raffinate Pit #4	1900	77	160
Femme Osage Slough	54	0.31	0.28
Quarry Sump	1240	1.0	1.5
Ash Pond	3000	*	*
Frog Pond	30	0.33	1.37

SOURCE: EMR, 1986.
* Samples not analyzed for this parameter.

TABLE 2

Nitroaromatic Concentrations from March 1987. National Pollutant Discharge Eliminate System (NPDES) Sampling.

LOCATION	Nitroaromatic Concentrations (ug/l)	
	2,4 DNT	2,6 DNT
Frog Pond	<0.2	<0.6
Ash Pond	1.5	<0.6
Raffinate Pit #4	<0.2	<0.6
Burgermeister Spring	<0.2	1.4
SE Drainage (WSCP)	<0.2	0.8

assumed that organ concentrations remain constant at an equilibrium value with a fixed daily intake. The consumption of biota by humans will have the same assumptions applied. Since dietary composition and its source can change, this may lead to an oversimplification. Also, some of the metabolic parameters may change due to age dependence over the course of intake.

The International Commission on Radiological Protection has developed mathematical models which determine body content of a radionuclide after it is ingested. The bone is the major site for uranium, radium, and thorium accumulation. The turnover or half life of some fraction of these is slow, therefore, skeletal cancer will be regarded as the major potential radiobiological effect of ingestion by humans. The metabolism of the biota has the primary effect in these calculations. Unfortunately, most studies focus on relating the metabolic rates to humans rather than different species. There is a wealth of data for metabolism in human beings, so the primary focus will be given to the careful dissection and sample analysis of only food parts from the biota to determine their uptake. From this study, the action levels adopted to control radiological risk are to limit the likelihood of bone cancer induction for the nearby population, though calculations will be based on a hypothetically maximum exposed individual.

The quantitative relationship between uranium intake and kidney damage have been measured in several species. Proximal renal tubule cells are killed by high acute or lower chronic dosages of soluble uranium compounds. The limiting concentration for chronic intake is 120 ug per day. From this level of intake, the toxic effects should be sufficiently low in the kidney. Kidney damage may be expected to occur gradually, above some critical uranium concentration.

The primary site of effect for TNT is the blood system. TNT can cause toxic hepatitis, aplastic anemia, and methemoglobinemia.

The most serious systemic effect of acute TNT poisoning in humans are toxic jaundice and toxic hepatitis. There is growing evidence from research that DNT's are carcinogenic, although the potency of the different isomers in cancer induction has not been well characterized. The acceptable dose for DNT is based on EPA ambient water quality criterion, 0.11 ug/L or 3.2×10^{-6} mg/kg/day.

By comparing actual contaminant levels with these criteria, the actual risks incurred from ingestion of biota tissue containing these nitroaromatics can be estimated. The development of criteria is still based on a variety of conservative assumptions and safety factors so that exceedence of the criteria does not imply that adverse health effects are expected.

4.0 SAMPLE COLLECTION

Biota samples will be collected from locations both on and off the WSS. Locations of fish and small mammal collection areas are shown in Figures 5, 6, 7, and 8. Fish will be collected using electrofishing methods and minnow traps, while small mammals will be collected using live traps. Electrofishing involves the use of a gas powered electric generator to introduce an electric current into the water near the boat. This temporarily stuns fish long enough to be netted and placed in a container in the boat. Electrofishing will be conducted by Missouri Department of Conservation (MDOC) personnel for all sites located on the Busch and Weldon Spring Wildlife Areas. Electrofishing will continue at each site until a sufficient quantity of fish is collected to fulfill the sample requirements. (Table 2)

Four composite samples will be collected at each site. Three of the four composites will be composed of skinned and filleted specimens representing the following fish; largemouth bass, sunfish, and catfish. These three composites will represent only edible portions of fish flesh. In Lake 35, the largemouth bass composite will be replaced by crappie since this lake has an overabundance of crappie and few bass. It is currently being managed with special regulations to reverse this trend. The fourth composite will consist of sunfish that have been cleaned and scaled but not skinned or filleted. This composite will represent fish used to make fishcakes, a common method of preparation for small edible fish.

Approximately 500 grams of fish tissue per composite sample will be required for the laboratory analyses. Fish will be cleaned or filleted, depending on the composite, at the end of each day. Fish flesh samples will be stored in labeled plastic bags and frozen prior to shipment to the lab. At the lab, each composite will be homogenized and extracted as required for the specific analyses to be performed.

Two separate sampling locations have been selected at Lakes 34 and 35 on the Busch Wildlife Area due to the large size of these lakes. The locations are at the inlet and outlet ends of these two lakes. Lakes 36 and 37 will be sampled only at the inlet ends. Lake 37 has been chosen for use as a background location. This lake does not receive runoff from either the WSCP/WSRP or the Army Ordnance Works property.

Two locations will also be sampled in the Femme Osage Slough. The first location is just below the WSQ near the confluence of the Little Femme Osage Slough. The second location is in the eastern end of the Femme Osage Slough on the other side of the access road crossing the Slough (see Figure 8).

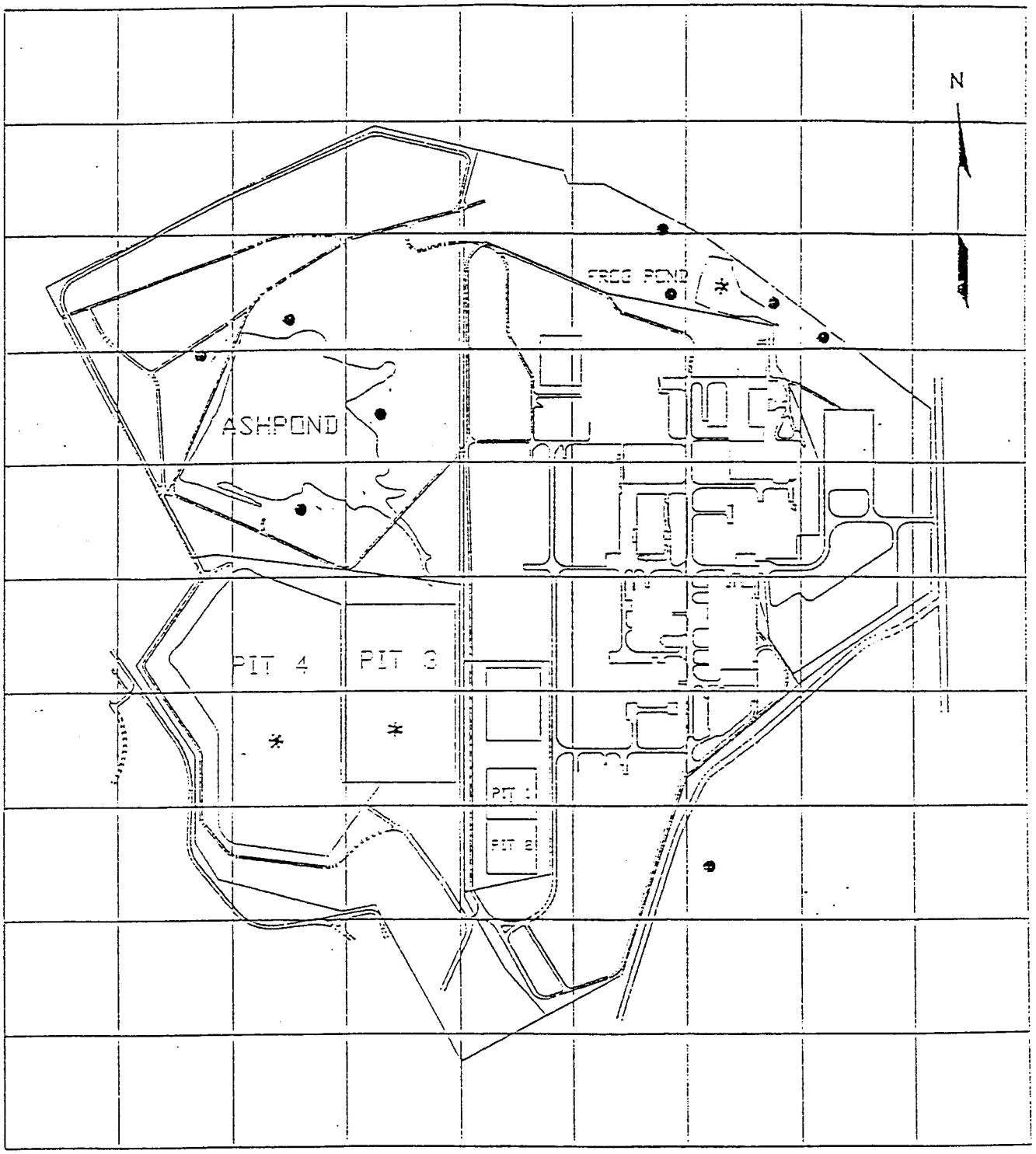

FIGURE 5

MAP OF WSCP/WSRP SAMPLING LOCATIONS

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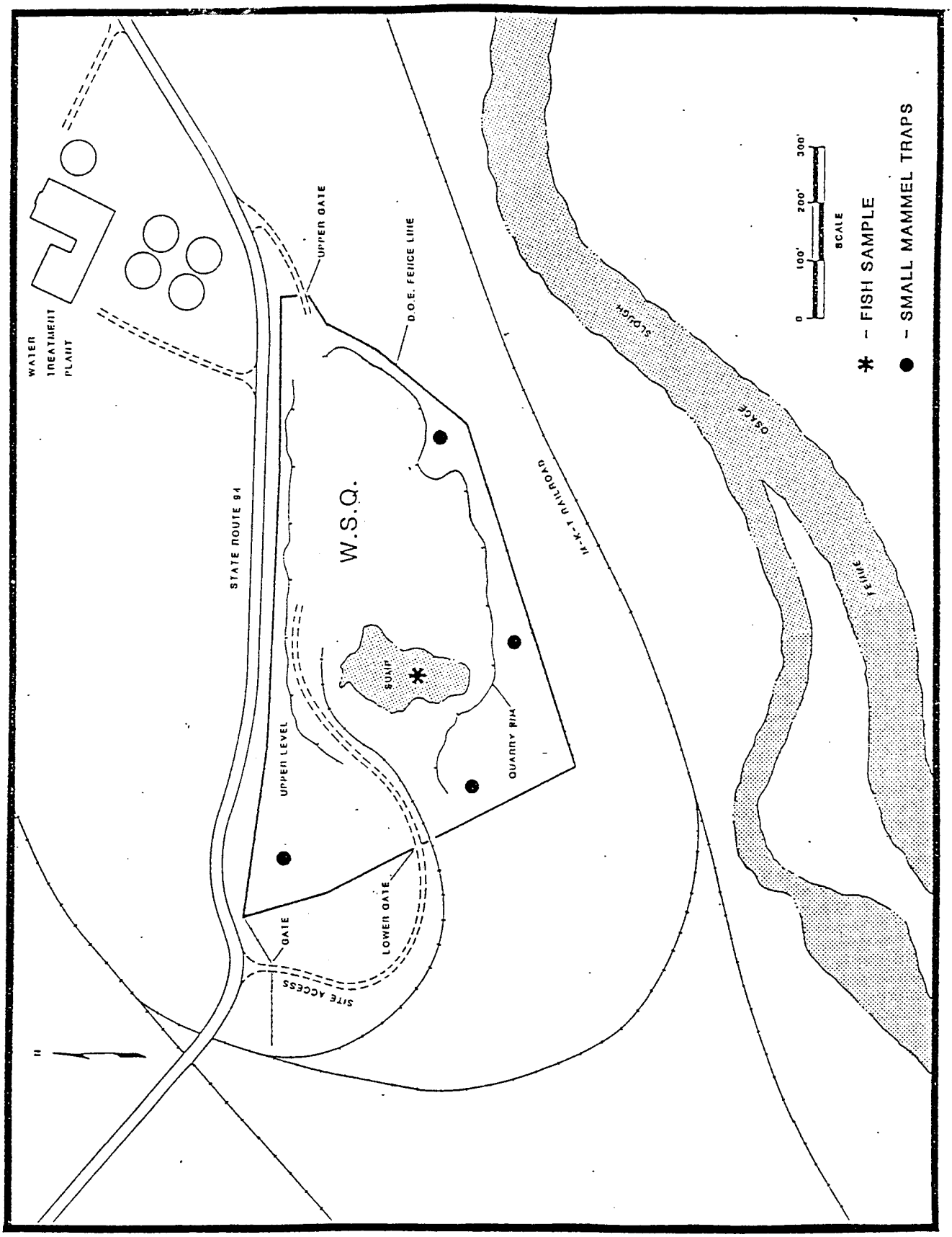

FIGURE 6

WSQ SAMPLING LOCATIONS

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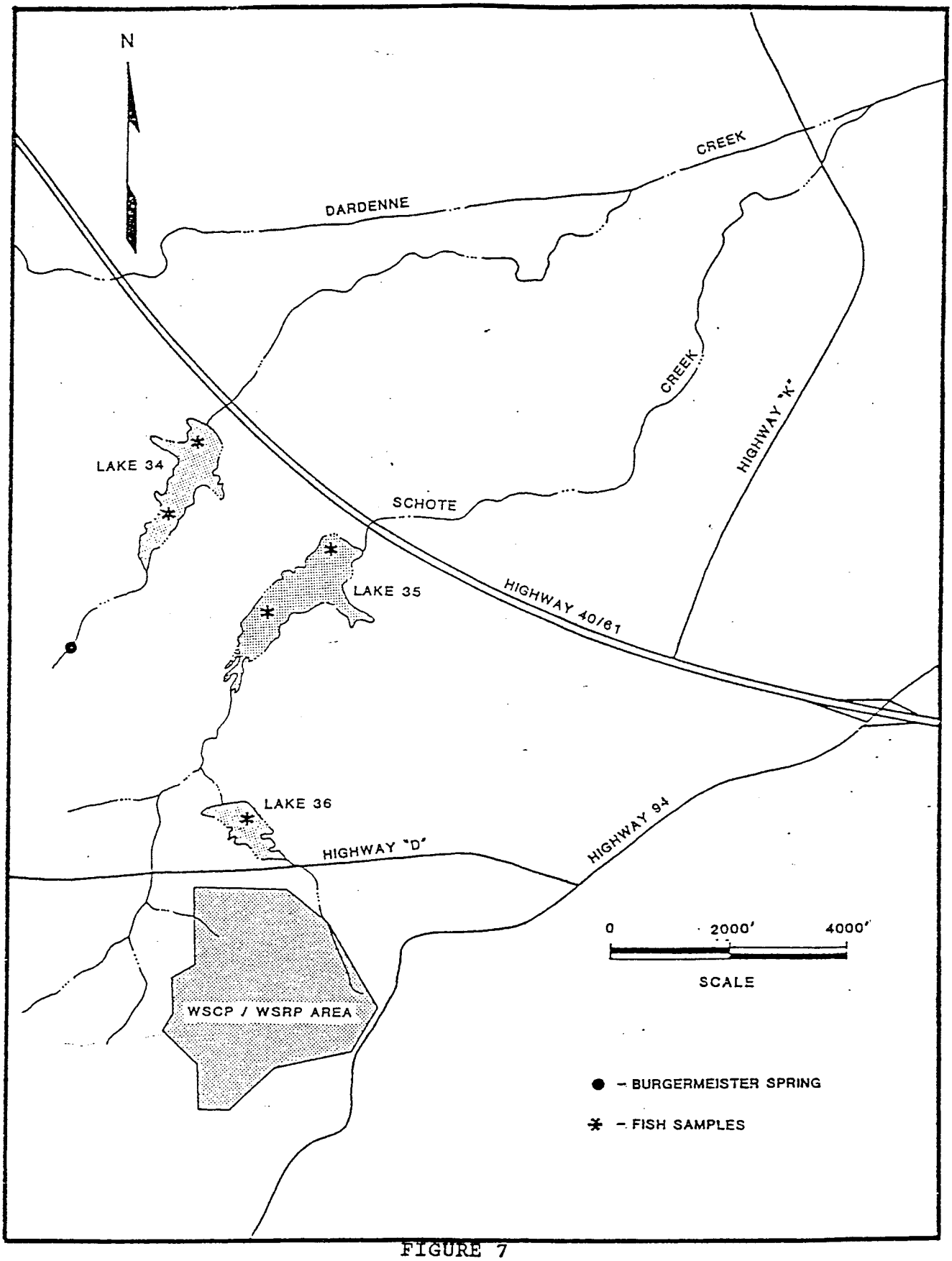

FIGURE 7

WSCP/WSRP SURROUNDING PROPERTIES SAMPLING LOCATIONS

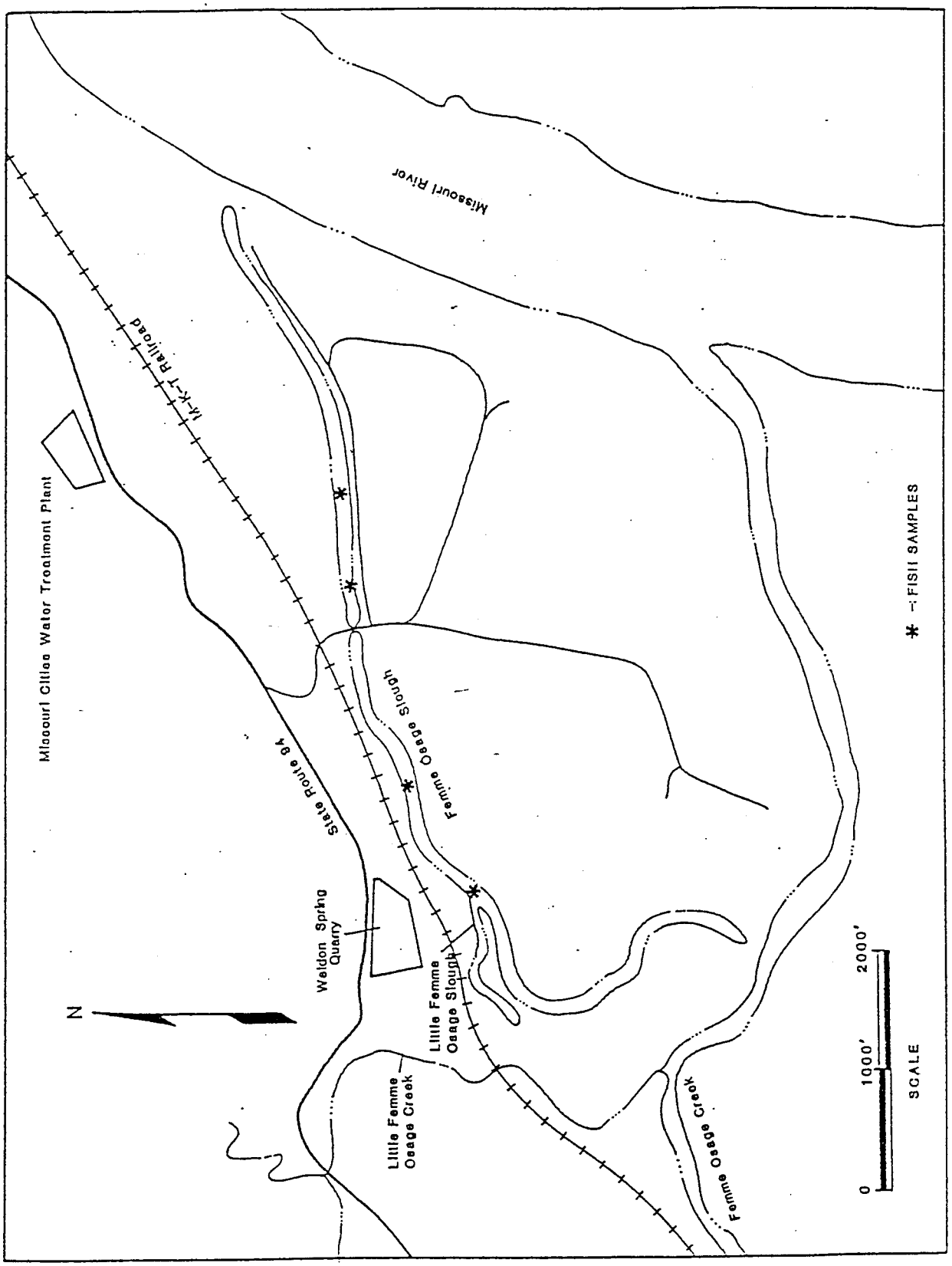

FIGURE 8

MAP OF WSQ SURROUNDING PROPERTIES SAMPLING LOCATIONS

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TABLE 3
DESCRIPTION OF SAMPLES COLLECTED

AREA	SPECIES	MINIMUM AMOUNT OF SAMPLE COLLECTED	MINIMUM AMOUNT OF SAMPLE SUBMITTED
Lake 34	Largemouth bass, fillets	5000 g	(2) 1000 g
	Sunfish, fillets	5000 g	(2) 1000 g
	Catfish, fillets	5000 g	(2) 1000 g
	Sunfish, cleaned	3000 g	(2) 1000 g
Lake 35	Crappie, fillets	5000 g	(2) 1000 g
	Sunfish, fillets	5000 g	(2) 1000 g
	Catfish, fillets	5000 g	(2) 1000 g
	Sunfish, cleaned	3000 g	(2) 1000 g
Lake 36	Largemouth bass, fillets	2500 g	1000 g
	Sunfish, fillets	2500 g	1000 g
	Catfish, fillets	2500 g	1000 g
	Sunfish, cleaned	1500 g	1000 g
Frog Pond	Sunfish, fillets	2500 g	1000 g
	Catfish, fillets	2500 g	1000 g
Raffinate Pit #3	Minnows, whole	2500 g	1000 g
Raffinate Pit #4	Sunfish, fillets	2500 g	1000 g
	Catfish, fillets	2500 g	1000 g
	Sunfish, cleaned	1500 g	1000 g
Femme Osage Slough	Largemouth bass, fillets	5000 g	(2) 1000 g
	Sunfish, fillets	5000 g	(2) 1000 g
	Catfish, fillets	5000 g	(2) 1000 g
	Sunfish, cleaned	3000 g	(2) 1000 g
Quarry Sump	Catfish, fillets	2500 g	1000 g
	Sunfish, fillets	2500 g	1000 g
Lake 37 (Background location)	Sunfish, fillets	2500 g	1000 g
	Catfish, fillets	2500 g	1000 g
	Largemouth bass, fillets	2500 g	1000 g
	Sunfish, cleaned	1500 g	1000 g

SAMPLE TYPES

AREA	SPECIES	MINIMUM AMOUNT OF SAMPLE COLLECTED	MINIMUM AMOUNT OF SAMPLE SUBMITTED
Ash Pond Area	Rabbit	4000 g	1000 g
	Squirrel	4000 g	1000 g
Quarry Area	Rabbit	4000 g	1000 g
	Squirrel	4000 g	1000 g
Frog Pond Area	Rabbit	4000 g	1000 g
	Squirrel	4000 g	1000 g
Imhoff SE Drainage Easement	Rabbit	4000 g	1000 g
	Squirrel	4000 g	1000 g

A total of 48 samples will be submitted.

Locations that will be sampled on-site include Frog Pond, the quarry sump, and Raffinate Pits 3 and 4. Fish are not positively known to occur in these on-site waterbodies. However, sightings have been reported of minnows and possibly sunfish by Project employees. Electrofishing will therefore be utilized in an attempt to obtain samples from these locations. In addition, minnow traps will be set so that a composite sample of whole minnows can be collected if larger fish are unavailable. Some type of fish sample from on-site locations is important since this represents a "worst case" situation of radionuclide uptake.

Small game mammals, such as squirrels and rabbits, will be collected by live traps set at various locations around the Weldon Spring Site. Traps located on the WSCP and WSQ will be focused at boundary areas where animals can migrate on and off site being accessible to hunters. Figure 5 shows the proposed locations where traps will be set in the WSCP area. Figure 6 illustrates the locations for the WSQ area. Figure 7 shows the area in the Weldon Spring Wildlife Area where traps will be set in the vicinity of the southeast drainage easement.

Live traps will be set in the approximate locations shown on the figures where suitable habitat exists. Traps will be baited and checked daily until the sampling effort has been completed. Only small mammals commonly eaten by hunters will be kept. Others, such as opossums and raccoons, will be released unharmed. Animals kept for analysis will be killed using a pellet gun at close range, skinned, and cleaned, so that flesh samples represent only edible portions (Table 2).

Composite samples of each species, rabbit and squirrel, will be collected at four areas: Frog Pond, Ash Pond, Quarry, and the Imhoff (southeast) drainage easement. Each composite will consist of a minimum of 3 individuals. At the Quarry and Imhoff drainage easement locations, rabbits will probably be

difficult to obtain since these locations are densely wooded with little open or brushy habitat suitable for rabbits. Should this be the case, the rabbit composites from these two locations will be deleted.

Small mammal composite samples will be handled similarly as the fish. Composites will be made after skinning and cleaning the animals, stored in labeled plastic bags and frozen prior to shipment to the lab. Chain of Custody records will be utilized for a written record of sampling effort. These records will verify that the samples were not tampered with or altered prior to laboratory analysis.

The laboratory analyses with unit costs are estimated below:

TYPE OF ANALYSIS	UNIT COST	ESTIMATED NUMBER
Total Natural Uranium	120.00	48
Radium-226	200.00	6
Thorium-230	200.00	6
Total Nitroaromatics	300.00	48

Approximately 500 grams (minimum) will be required per sample for the analysis. The analysis for uranium, radium, and thorium should have a lower limit of detectability of 0.01 pCi/g. The level of activity expected to be seen from the offsite lakes will be in this range. Nitroaromatics will have a lower limit of detectability of approximately 0.2-0.5 parts per billion (ppb).

The estimated amount of time required to complete the sampling operation are as follows:

AREA	MAN-HOURS
Lake 34 *	12
Lake 35 *	12
Lake 36 *	12
Lake 37*	12
Frog Pond	12
Raffinate Pit #3	12
Raffinate Pit #4	12
Femme Osage Slough *	24
Quarry Sump	24
Total Man-Hours	132

* Locations will be assisted by MDOC personnel.

Sampling efforts will begin after July 1, 1987. MDOC personnel will be notified well in advance of operation. Small mammal traps will be set after July 1, 1987. Traps will be checked on a daily basis until minimum sample number obtained.

The following is a numbered list of equipment and materials needed for the sampling operation.

1. Small mammal traps (18)
2. Boat or raft for onsite
3. Electroshock apparatus for onsite
4. Small mammal dissection kits
5. Fish filet equipment
6. Sample collection bags
7. Radiation monitoring equipment
8. Life preservers
9. Rubber boots & gloves
10. Rain suits
11. Transport for boat or raft

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12. Sample prep table
13. Waste containers
14. Permits

5.0 DATA ANALYSES

The set of data along with assumptions made on dietary intake will be used to calculate the radiation dose from internally deposited radionuclides. Cumulative risk estimates from lifelong intakes will assume a linear dose-response relationship for cancer induction at environmental levels.

If the biota sampling results in significant findings, routine collection and analysis may be added to the Environmental Monitoring Plan. The radiation dose calculated from edible parts of biota samples and measured data for water concentrations will be compared.

If measured offsite concentrations increase and conditions drastically change in future operations, the need may arise for another study. Sampling efforts in higher radionuclide concentrations located on-site may provide better estimates and determinations for outcomes of such releases.

The DOE radiation dose limit for an unrestricted area is 100 mrem/yr above background for whole body exposure. The DOE Administrative action level is 25 mrem/yr above background. A hypothetical individual consuming such biota from the vicinity of WSS receives internal exposure via the food pathway and by ingestion of contaminated water.

If calculations suggest the radiation dose to an individual is greater than 50 percent of the administrative action level, then a second study for verification of results may be developed.

Available data pertaining to DNT exposure is limited at this time, calculation of an acceptable dosage is extremely difficult. In research, animal studies indicate significant species and strain differences in the excretion of DNT isomers.

The potency of DNT varies in studies, so to assure the protection of public health from carcinogenic effects, a 10^{-6} cancer risk level is generally assumed at the dosage of 6.4×10^{-7} mg/kg/day. With the primary site for TNT being the blood system and liver, studies have provided no evidence of carcinogenicity, so an Allowable Daily Intake (ADI) is used for a no-observed-adverse-effect level (1.4×10^{-3} mg/kg/day). Conclusions from the assessment and subsequent determinations regarding the levels of contamination will be reviewed for actual risks incurred by the exposed population.

DRAFT

6.0 References:

International Commission of Radiological Protection. Publications 23, 26, and 30. Pergamon Press, Elmsford, NY, 1977 and 1978.

Ryckman et.al. WSCP Survey and Assessment. Final Report. Prepared for DOA, Aberdeen Proving Ground, MD, by Ryckman/Edgerley/ Tomlinson and Assoc., St. Louis, MO June 1978.

U.S. Army Toxic and Hazardous Materials Agency. West Virginia Ordnance Works: Endangerment Assessment for Sewerlines, TNT Manufacturing Area, and the Burning Grounds. Aberdeen Proving Ground, MD. June 1986.

Wang, J. et.al. Potential Radiological Impacts Associated with Release of Contaminated Water from the Weldon Spring Ash Pond and Burgermeister Spring. ANL, Argonne, IL 1986.

CHEMICAL PLANT
201-1.02

cc: Kan
1240.2 J. Coyne

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII
726 MINNESOTA AVENUE
KANSAS CITY, KANSAS 66101
July 6, 1987

Mr. Rodney R. Nelson
U.S. Department of Energy
Weldon Spring Site Remedial
Action Project/Office
Route 2, Highway 94, South
St. Charles, Missouri 63303

Dear Mr. Nelson:

Ed Skowronski, ATSDR representative working with EPA, reviewed the Biouptake and Sediment Sampling Plans. His comments are as follows:

1. Plan for the Sampling of Sediment Influenced by Weldon Spring Chemical Plant Drainage.

Table 4-1 - Are some of the sample locations truly background?

5.0 - I would like to see more of the QA/QC procedures detailed in the body of the plan.

6.0 - Who will get a copy of the results? Will we get a chance to input into deciding the necessity for cleanup? This is not clear.

2. Plan for Determination of Biological Uptake of Radionuclides and Nitroaromatics in Species in the Food Pathway at the Weldon Spring Site.

Are there any other contaminants that may be expected to appear in the food pathway at the Weldon Spring Site? Page 14, paragraph 2 - FDA procedures for determining edible portions of fish flesh call for filleted with the skin left on. Page 21 - Frogs have been found at other site to have very high levels of contamination. They should probably be included.

Please call Ed at 913/236-2856 if you have any questions or need further information.

Sincerely yours,

Katie

B. Katherine Biggs
Chief, Environmental Review Branch

cc: Robert Morby
Ed Skowronski
David Bedan

001349
7-10-87

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

September 24, 1987

Ms. Katherine Biggs, Chief
Environmental Review Branch
U. S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Dear Ms. Biggs:

WORK PLAN FOR DETERMINATION OF BIOLOGICAL UPTAKE OF WSS CONTAMINANTS BY SPECIES IN FOOD PATHWAYS

Enclosed are four (4) copies of the subject work plan. The sampling effort may begin as early as September 28, 1987. Comments in your July 6, 1987, letter have been incorporated as applicable.

If you have any questions, please call me or Ken Lawver at (314) 441-8978.

Sincerely,

R. R. Nelson

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

CE-541:Lawver

Enclosure

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

September 24, 1987

Mr. Dave Bedan
Missouri Department of
Natural Resources
Post Office Box 176
Jefferson City, Missouri 65102

Dear Mr. Bedan:

WORK PLAN FOR DETERMINATION OF BIOLOGICAL UPTAKE OF WSS CONTAMINANTS BY SPECIES IN FOOD PATHWAYS

Enclosed are four (4) copies of the subject work plan. The sampling effort may begin as early as September 28, 1987. Comments in your July 6, 1987, letter have been incorporated as applicable.

If you have any questions, please call me or Ken Lawver at (314) 441-8978.

Sincerely,

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

CE-541:Lawver

Enclosure

JOHN ASHCROFT
Governor

[redacted]RICK A. BRUNNER
Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL QUALITY
P.O. Box 176
Jefferson City, MO 65102

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation,
and Historic Preservation

October 26, 1987

Ms. Katie Biggs, Chief
Environmental Review Branch
U.S. Environmental Protection Agency
727 Minnesota Avenue
Kansas City, Kansas 66101

Dear Ms. Biggs:

The Missouri Department of Natural Resources (MDNR) has reviewed four interim response actions which the U.S. Department of Energy (DOE) has proposed for the Weldon Spring site.

These actions are:

1) Removal of overhead piping and asbestos insulation

2) Disposal of containerized chemicals

3) Remedial action on the Army Reserve Property

4) Power line/pole removal.

The MDNR supports the initiation of these actions at this time with the qualifications noted in the October 26, 1987 letter from Dr. Frederick A. Brunner, Director of MDNR, to Mr. Rod Nelson, Weldon Spring Site Manager. Therefore, MDNR approves initiation of these actions but the DOE should initiate discussions with the MDNR regarding the issues raised in Dr. Brunner's letter, specifically:

1) DOE should provide information to MDNR to allow us to determine whether the on-site handling, processing and storage of solid waste is subject to the Missouri Solid Waste Management Law.

2) When an off-site solid waste landfill is selected for the disposal of asbestos or other solid waste, the landifll operator and the DOE must apply for special waste disposal approval.

3) In regard to containerized chemical waste disposal, the subcontractor's work plan should be submitted to MDNR for review, when it is available.

The MDNR has also reviewed the "Work Plan for Determination of Biological Uptake of WSS Contaminants by Species in Food Pathways." MDNR agrees that this study should be immediately initiated. However, we note that deer, turkey, geese and ducks will not be sampled at this time because of their mobility. While we agree that it would be difficult to interpret sampling results from these species, we believe that further thought should be given to determining whether these species, particularly the waterfowl, might be contaminated by feeding on the site. If any methods of making this determination can be devised, we would recommend further studies at that time.

Please contact me if you have any further questions on these matters.

Sincerely,

DEPARTMENT OF NATURAL RESOURCES

David E. Bedan
Weldon Spring Site Work Group Coordinator

DEB/mjb

cc: Ron Kucera
Carolyn deRoos
William C. Ford
Nicholas A. Di Pasquale
Bill Dieffenbach, DOC
John Crellin, DOH
Rod Nelson, U.S. DOE

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

November 6, 1987

Ms. Katherine Biggs, Chief
Environmental Review Branch
U. S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Missouri 66101

Dear Ms. Biggs:

PLAN FOR DETERMINATION OF BIOLOGICAL UPTAKE OF WSS CONTAMINANTS BY SPECIES IN FOOD PATHWAYS

Pursuant to our discussion on November 5, 1987, we will modify the subject plan to include PCB and Metal Analyses for on-site terrestrial mammal samples.

Regarding your question concerning analysis of off-site fish samples for levels of Ra 226 and Th 230 we do not plan to include such sampling at this time. We base this plan on previous findings of no elevated levels of Th 230 in off-site water bodies. The mobility of Ra 226 is similar to Th 230 and, similarly, we would not expect to find elevated levels of this radionuclide in off-site water bodies. We will add in the Biouptake Plan that if elevated levels of RA 226 or Th 230 are discovered during the upcoming lake and stream sediments sampling program then it will be necessary to analyze for these radionuclides on fish samples designed to represent consumption of fishcake (i.e., including bones). Our plan does include analyses for Ra 226 and Th 230 on fish samples from on-site water bodies.

We appreciate EPA's comments and encourage you to call if you have any further questions.

Sincerely,

Stephen H. McCracken
Deputy Project Manager
Weldon Spring Site
Remedial Action Project

cc: J. D. Hammond, MK-Ferguson

cc: R. Nelson
S. McCracken
J. Coyne
File

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII
726 MINNESOTA AVENUE
KANSAS CITY, KANSAS 66101
November 6, 1987

Mr. Rodney R. Nelson
U.S. Department of Energy
Weldon Spring Site Remedial
Action Project/Office
Route 2, Highway 94, South
St. Charles, Missouri 63303

Dear Mr. Nelson:

We have reviewed the revised work plan for determination of biological uptake at the Weldon Spring Site (WSS). Generally, the plan is well written and contains all the necessary elements to reach the stated objectives. We concur with the revised plan and agree you should undertake the sampling as planned. The Missouri Department of Natural Resources (MDNR) also agrees this work should be immediately implemented.

As you prepare the report for this work, there are some items that need more detailed discussion or clarification. These points are addressed in the following comments.

1. It is stated that the data will be used in an Endangerment Assessment under CERCLA, but no reference to a guidance document is given. The specific documents to be used should be referenced.

2. On page 2, reference is made to a "metabolic model," but no reference or other discussion is given concerning the type of model to be used; i.e., computer, pharmacokinetic, etc.

3. The term "uptake" may be erroneously used in this document. What is really being measured are residues of compounds already ingested, distributed, metabolized and/or stored. "Uptake" implies that not only is the exposure quantified but that the metabolic dynamics of the chemicals in question are well understood. We suggest that the term "residue" be used in place of "uptake" to denote that the compounds in tissues are of environmental origin but not to imply that complete information regarding pharmacokinetics under natural conditions are known.

4. The revised work plan does not address on-site sampling for PCBs and metals. Based on our discussion, it is my understanding you plan to conduct these analyses and will send a letter to confirm this.

001853
11-17-87

5. Composite samples made up of cleaned but not filleted fish suggest radium and thorium analysis since the bones would also be present in a fish cake. Your report should address why these anlyses are not included.

6. The difficulty in interpreting the analytical results of nitroaromatic coumpounds in tissue should not necessarily deter you from looking for these compounds. It is correct that biodegradation studies as well as true "uptake" studies appear to be unavailable and recoveries of nitroaromatic compounds may be less than 60 percent. However, the mere presence of nitroaromatics in fish tissues would be of significance. It is suggested that, once the TNT/DNT levels in and around the WSS are sifficiently known, the report evaluate the need for additional biological sampling to analyze tissues for the presence of TNT, DNT and other nitroaromatic residues.

7. The plan cites CLP and other analytical methods; however the plan does not specify any tissue extraction procedures. Also, no analytical laboratory is identified.

If you have any questions regarding these comments, please contact me or Dan Wall.

Sincerely yours,

Katie

B. Katherine Biggs
Chief, Environmental Review Branch

cc: David Bedan, Missouri Department of Natural Resources

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

3589-88-I-DOE-014

January 13, 1988

Ms. Katherine Biggs
United States Environmental
Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Dear Ms. Biggs:

RESPONSIVENESS SUMMARY ON WSS BIOLOGICAL UP-TAKE SAMPLING AND ANALYSIS WORK PLAN

Enclosed is a responsiveness summary to comments in your November 6, 1987 letter. The final report will reflect responses to the comments and no changes will be made to the sampling plan.

If you have any questions, please call.

Sincerely,

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

cc: D. Bedan, MDNR
J. Hammond, MK-Ferguson/Document Control

Responsiveness Summary to Comments on the WSS Biological Up-Take Sampling and Analysis Work Plan - Reference: Letter from K. Biggs to R.R. Nelson dated 11/06/87.

Comment No. 1:

It is stated that the data will be used in baseline risk assessment under CERCLA, but no reference to a guidance document is given. The specific documents to be used should be referenced.

Response:

A baseline risk assessment (formerly an Endangerment Assessment) will be conducted to assess the impacts of the no action alternative and the information incorporated into the remedial investigation report. The baseline risk assessment will follow the methodology described in the Superfund Public Health Evaluation Manual.

Comment No. 2:

On page 2, reference is made to a "metabolic model", but no reference or other discussion is given concerning the type of model to be used; i.e., computer, pharmacokinetic, etc.

Response:

Based upon a preliminary review of potential indicator compounds at the WSS, the dominant risk is associated with the ingestion of radiological species. For this reason, the metabolic model used will be that found in the International Commission on Radiological Protection (ICRP) Publications No.'s 23, 26, and 30. All calculations and assumptions will be based on this methodology.

If further evaluation of indicator compounds indicates the need for additional metabolic model(s), the types and rationale for selection of these models will be discussed with EPA before implementation.

Comment No. 3:

The term "uptake" may be erroneously used in this document. What is really being measured are residues of compounds already ingested, distributed, metabolized and/or stored. "Uptake" implies that not only is the exposure quantified, but that the metabolic dynamics of the chemicals in question are well understood. We suggest that the term "residue" be used in place of "uptake" to denote that the compounds in tissues are of environmental origin but not to imply that complete information regarding pharmocokinetics under natural conditions are known.

Response:

The final report will carefully use terms describing the metabolic behavior of the various hazardous substances. The ICRP currently uses the term "uptake" to describe ingestion, distribution and metabolism of radiological species. However, the term "residue" will be incorporated into discussions of compounds in tissue that are of environmental origin in order to not imply complete understanding.

Comment No. 4:

The revised work plan does not address on-site sampling for PCB's and metals. Based on our discussion, it is my understanding you plan to conduct these analyses and will send a letter to confirm this.

Response:

Pursuant to the letter from Stephen McCracken to K. Biggs dated November 6, 1987, analyses for PCBs' and CLP metals for on-site terrestrial mammal samples will be performed. The results will be presented in the final report, however, we do not envision modification and formal reissuance of the work plan document.

Comment No. 5:

Composite samples made up of cleaned but not filleted fish suggest radium and thorium analysis since the bones would also be present in a fish cake. Your report should address why these analyses are not included.

Response:

Previous samples of the surface water in off-site water bodies showed no elevated levels of Ra-226 or Th-230 present. In addition, no elevated levels of Th-230 in sediment from Lakes 34, 35 and 36 and the Femme Osage Slough have been detected in previous preliminary sampling efforts and the mobility of Ra-226 is similar to Th-230. A more intensive Stream and Lake Sediment Sampling Plan is to be initiated in the winter/spring of 1988. Should elevated levels of Ra-226 or Th-230 be discovered during this upcoming program, then the biological uptake plan will be revised to collect and analyze for these radionuclides on fish samples designed to represent consumption of fish cake (i.e., including bones). The current work plan does include analyses for Ra-226 and Th-230 on samples from on-site water bodies.

Comment No. 6:

The difficulty in interpreting the analytical results of nitroaromatic compounds in tissue should not necessarily deter you from looking for these compounds. It is correct that biodegradation studies as well as true "uptake" studies appear to be unavailable and recoveries of nitroaromatics compounds may be less than 60 percent. However, the mere presence of nitroaromatics in fish tissues would be of significance. It is suggested that, once the TNT/DNT levels in and around the WSS are sufficiently known, the report evaluate the need for additional biological sampling to analyze tissues for the presence of TNT, DNT and other nitroaromatic residues.

Response:

Once the nitroaromatic levels in and around the WSS are sufficiently known, the final report will evaluate the need for additional biological sampling to analyze tissues for the presence of these compounds.

Comment No. 7:

The plan cites CLP and other analytical methods; however the plan does not specify any tissue extraction procedures. Also, no analytical laboratory is identified.

Response:

The analytical laboratory which will perform the analyses on samples collected for the biological uptake work plan is metaTrace, in St. Louis, MO. This laboratory has performed the majority of analyses for all determinations made at the WSS in 1987. The laboratory participates in the Contract Lab Program and meets USATHAMA requirements. We would be glad to provide more details on the Quality Assurance and other capabilities of this laboratory at your request.

Tissue extraction procedures are based on guidance provided in the EPA Interim Methods for the Sampling and Analysis of Priority Pollutants in Sediments and Fish Tissue. Modifications to these procedures were made to improve detection limits and percent recovery. These procedures will be cited in the final report.

4728

WORK PLAN FOR DETERMINATION OF BIOLOGICAL UPTAKE OF WSS CONTAMINANTS BY SPECIES IN FOOD PATHWAYS

PREPARED FOR:

U.S. DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

UNDER CONTRACT NO. DE-AC05-86OR21548

PREPARED BY:

MK-FERGUSON COMPANY

AND

JACOBS ENGINEERING GROUP, INC.

ROUTE 2, HIGHWAY 94 SOUTH

ST. CHARLES, MISSOURI 63303

SEPTEMBER 16, 1987

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1.0 INTRODUCTION

The Weldon Spring Site (WSS) is a U.S. Department of Energy (DOE) surplus facility located in St. Charles County, Missouri. This document presents a description of the study plan and scope of work to determine and characterize the level of potential human exposure to radionuclides, polychlorinated biphenyls (PCB's), and EPA-CLP Metals from the food pathways at the WSS. This will be accomplished by a statistically representative sampling effort of biota available for human consumption from various locations around and within the WSS. The final report will describe the methods used in performing the survey, summarize the results, and discuss their significance. This effort is fundamental in providing data used in an Endangerment Assessment as part of an RI/FS process under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

The analysis of the food pathways for the surrounding population is necessary in assessing the risks to human health from pathway ingestion of biota living in or near contaminated sediments and water. Chemical and radiological exposure in humans and the relevance of data in establishing design and action limits will be reviewed.

The study will combine estimates of average consumption by humans with measured contamination levels in edible tissues for input into a metabolic model. The approach taken will measure the actual uptake by edible aquatic and terrestrial biota and then calculate the human uptake from consumption of contaminated tissue based on assumed ingestion rates.

The goal of the sampling is to collect approximately thirty-nine (39) kilograms of sunfish, twenty-eight (28) kilograms of catfish, two (2) kilograms of minnows, sixteen (16) kilograms of largemouth bass, five (5) kilograms of crappies, thirty-two (32) kilograms of frogs, and a minimum of seven (7) kilograms of both rabbits and squirrels.

Electrofishing methods will be utilized for the collection of aquatic samples. This method will provide randomness in fish samples. Individual samples weighing approximately less than 50-75 grams will not be kept, assuming these samples would not be kept for consumption by typical members of the public and uptake would be minimal compared to more adult samples. Frogs will be collected using hand-held nets.

Terrestrial biota samples will consist of small mammals such as rabbits and squirrels. Live traps will be used for the capture of these mammals. Since the population of these

mammals is limited, the traps will be set adjacent or above the areas of contamination. The samples collected will be assumed to live and intake representative amounts of contaminants for populations living near the site(s).

Deer, turkey, geese, and ducks will not be sampled at this time. These animals are very mobile, readily moving on and off the Weldon Spring Site. For this reason, it would be extremely difficult to interpret both positive and negative results since no estimate of the percentage of their time spent on site can be substantiated.

Investigations of offsite radiological migration in soil and water have focused on uranium, due in part to its higher solubility and quantity compared to the other radionuclides present at the WSS. These uranium compounds are also soluble in the body and will incorporate into the soft tissues and bone. Thus, all onsite and offsite samples will be analyzed for uranium.

Surface water outfall sample results from the WSS have background concentrations of radium and thorium. Radium and thorium compounds are insoluble and incorporate primarily in the bone. Therefore, samples from the offsite waterbodies will not be analyzed for radium and thorium because their

uptake in tissue samples are expected to be below detectable levels.

Composite samples collected from the Raffinate Pits, Frog Pond, Quarry Sump, Lake 37, and from small mammals will be analyzed for radium and thorium. Detectable quantities of radium and thorium may exist in the onsite samples due to the higher concentrations of the radionuclides in the waterbodies.

One composite fish sample from each off-site water body will also be analyzed for PCB's and CLP metals. Since the WSCP was operational at a time when PCB's were routinely used, the potential exists for the presence of the contaminants. Many of the old electrical transformers contain PCB's in varying concentrations. In addition, ongoing investigations have indicated PCB's to be present in low concentrations on floors, equipment, and in hydraulic lines at the WSCP. These releases were a result of accidental spills and careless use, not routine releases due to operational procedures.

Draft versions of the Biological Uptake Plan included the analysis of biota samples for nitroaromatics. This was based on the potential for the laboratory to perform such

analyses. Subsequent research indicates the general lack of knowledge about the uptake and bio-degradation and metabolism of nitroaromatic compounds by animals and humans. It would, therefore, be very difficult to interpret analytical results. Second, there is no accepted methodology for analysis of nitroaromatic compounds in tissue. Recovery of target compounds following accepted extraction procedures is expected to be extremely low. In addition, bio-degradation products may not be detected and the lower limits of detection will not be low enough to consistently detect the concentrations anticipated. Therefore, nitroaromatic analyses have been deleted from this plan.

The additional analyses of semi-volatiles were considered, but were discounted for the same factors as discussed for nitroaromatics. Sufficient information concerning uptake, biodegradation and metaboles is inadequate and an acceptable methodology has not been developed.

2.0 SITE HISTORY AND ENVIRONMENTAL SETTING

From 1941 to 1944, the U.S. Department of the Army (DA) operated the Weldon Spring Ordnance Works for production of trinitrotoluene (TNT) and dinitrotoluene (DNT). During this operation, smaller areas of the 17,000-acre site were contaminated by TNT process materials. In the mid-1950's 220-acres of the Ordnance Works property were transferred to the U.S. Atomic Energy Commission (AEC). From 1957 to 1966, the AEC operated a uranium processing facility (Mallinckrodt Chemical Works) at the site. During the operation of this Feed Materials Plant, the buildings, equipment, and immediate terrain of the plant (220-acres) became contaminated with radionuclides in the Uranium transformation series.

After closure by the AEC, the Feed Materials Plant was reacquired by the Army in 1967. The Army partially decontaminated the buildings, dismantled some of the equipment, and began converting the facilities to produce herbicides. In 1969, prior to the Chemical Plant (WSCP) becoming operational, the herbicide project was canceled. In 1985, the custody of the WSCP was transferred from the DA to the Department of Energy (DOE). In conjunction with this transfer, the Weldon Spring Site Remedial Action Project (WSSRAP) was created as DOE Major Project Number 182.

Surface water runoff from the north and west sides of the 220-acre WSCP, as well as potential overflow from an onsite water tower, flow to Ash Pond (Figure 1). Water from Ash Pond travels through an overflow conduit for approximately 100 m, surfaces, and then flows to Lake 35 on the August Busch Wildlife Area, to Schote Creek, Dardenne Creek, and eventually the Mississippi River (Figure 2). Lake 35 is the closest lake receiving effluent from Ash Pond in an unrestricted area. Lake 35 is used for recreational activities such as fishing and boating.

Water from Ash Pond also discharges via underground connections to Burgermeister Spring, Lake 34, Dardenne Creek, and eventually the Mississippi River. At present, there is no recreational use of Burgermeister Spring, but Lake 34 is used for recreational purposes similar to Lake 35. Lakes 34 and 35 are not used as drinking water or irrigation sources. Since operations in 1967 ceased, the discharge from Ash Pond has become an intermittent stream.

Surface water runoff from the northeast portion of the WSCP drains into Frog Pond. An intermittent stream out of Frog Pond flows north to Lake 36. The outfall of Lake 36 discharges into Lake 35, Schote Creek, Dardenne Creek, and eventually the Mississippi River. Lake 36, located in the Busch Wildlife Area is the closest lake receiving effluent from Frog Pond in an unrestricted area. Lake 36 is also

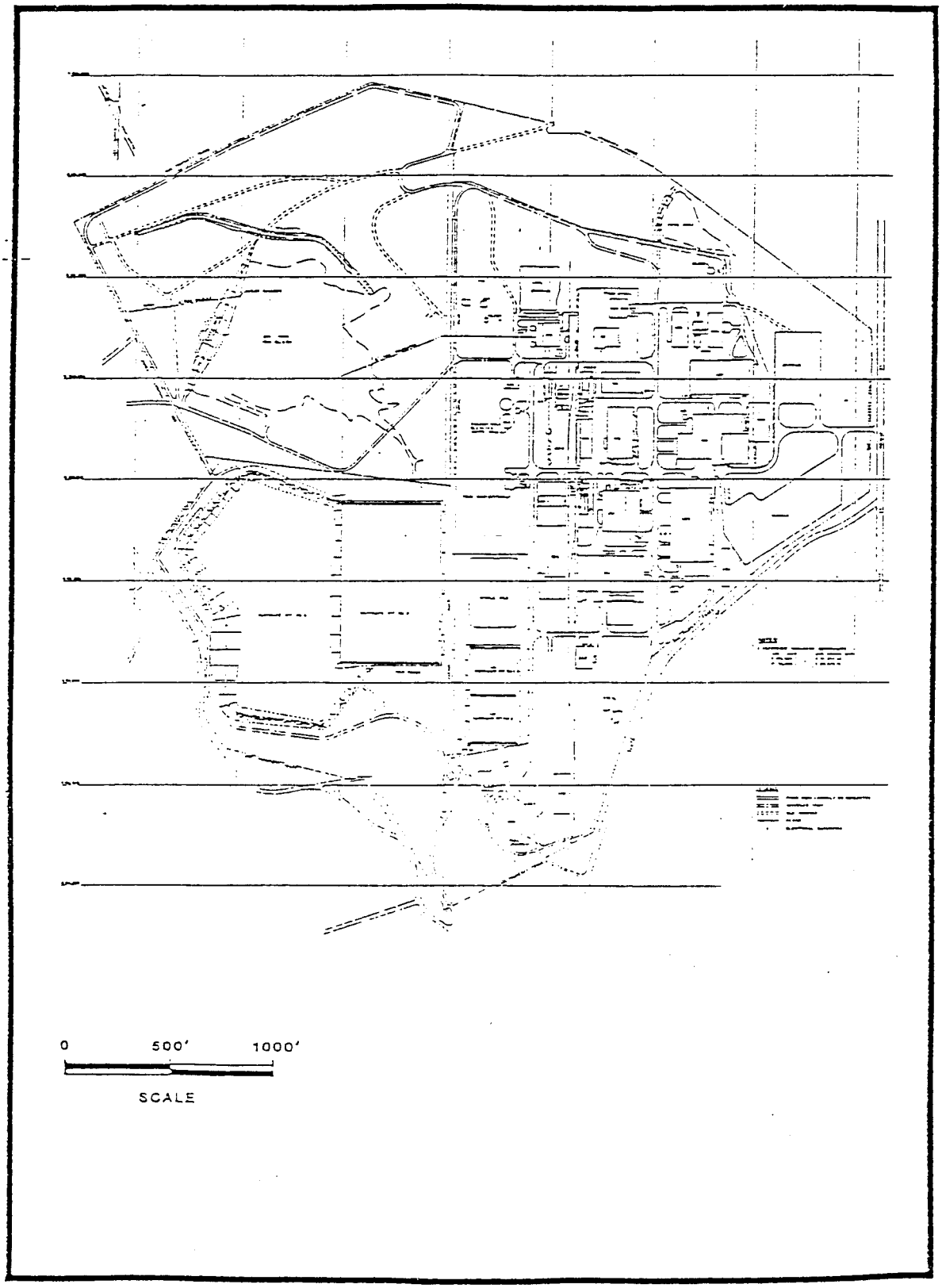

FIGURE 1
MAP OF WSCP/WSRP

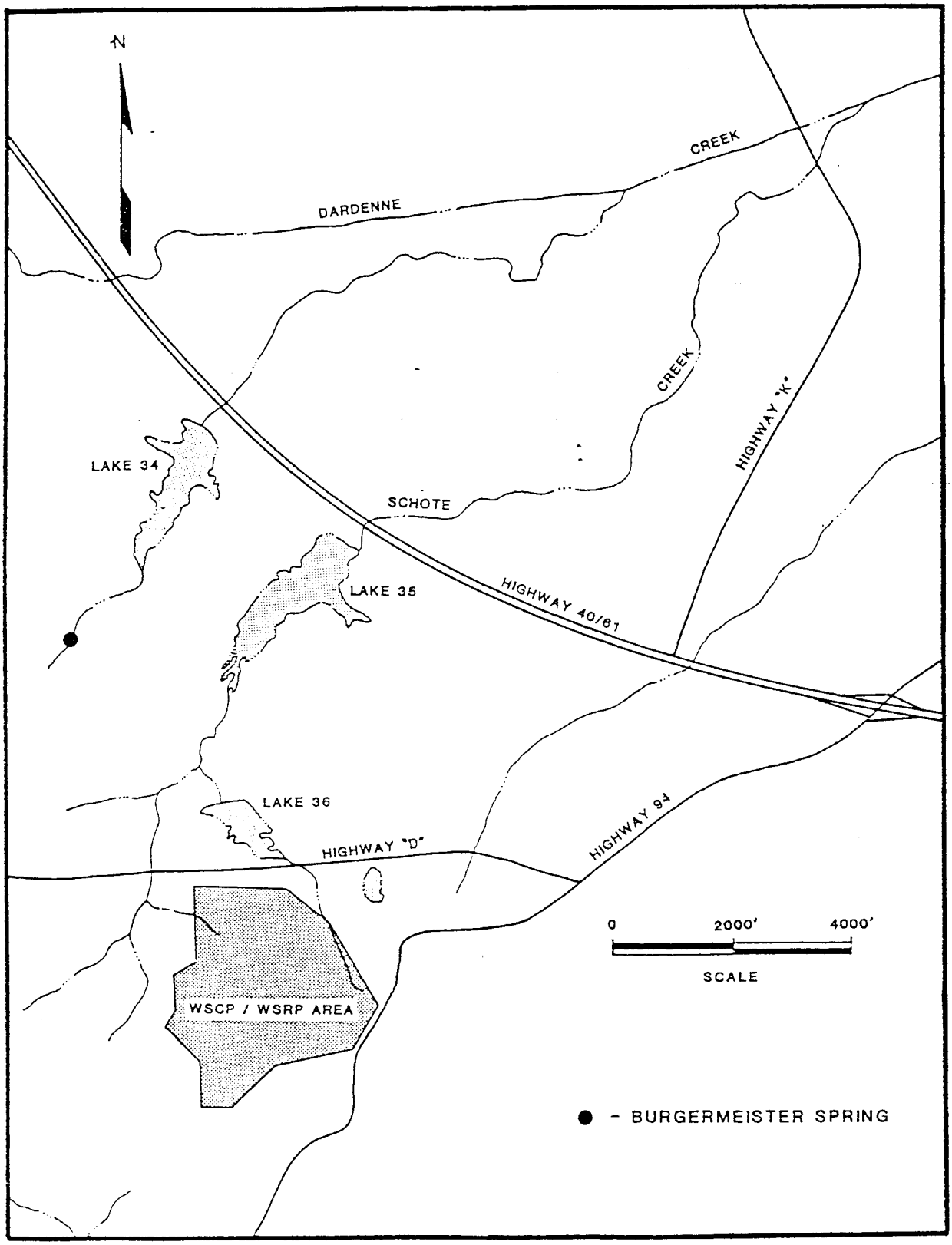

FIGURE 2
MAP OF THE WSCP/WSRP SURROUNDING PROPERTIES

used for recreational activities such as fishing and boating but not as drinking water or irrigation sources.

On the southeast corner of the WSCP, the outfall of the Imhoff Tank, the former WSCP sanitary sewage system, flows down a drainage ditch to the Missouri River. This drainage contains numerous areas of elevated radionuclide concentrations. Currently, flow through the Imhoff Tank results from the infiltration of storm water inflow to the sewer system. Sanitary wastes no longer enter the sewer system.

The Weldon Spring Quarry (WSQ) is approximately 4 miles to the south-southwest of the WSCP. Radioactive wastes were disposed of in the WSQ by the AEC from 1957 to 1966 (Figure 3). The DA also disposed of TNT process wastes into the WSQ. A large portion of the AEC radioactive wastes were from Mallinckrodt Chemical Works' Destrehan Street Feed Plant in St. Louis. Materials from this plant were contaminated with radionuclides in the uranium transformation series.

The Femme Osage Slough is located in the Weldon Spring Wildlife Area, approximately 500-feet SSE of the WSQ sump in an unrestricted area (Figure 3). The sump is believed to be hydraulically connected to the slough. The slough is not used as a source for drinking water or irrigation, but is frequently used for fishing (Figure 4).

Lake 37, located at the western end of the Busch Wildlife Area, will be used as a background location for fish and frog samples. This lake does not receive runoff from either the Army Ordnance Works or the Weldon Spring site and should therefore be free of contaminants. In addition, Lake 37 is generally upwind of the Weldon Spring site and over three miles away.

Average radioactivity levels in surface and runoff water samples taken from in and around the WSS in 1986 are presented in Table 1. These average values are presented in the WSS 1986 Environmental Monitoring Report. The data represents samples taken at quarterly intervals which are then averaged over the entire year. The activity levels in waters will decrease with the increase of distance from site mainly due to dilution by lake waters and/or other water sources.

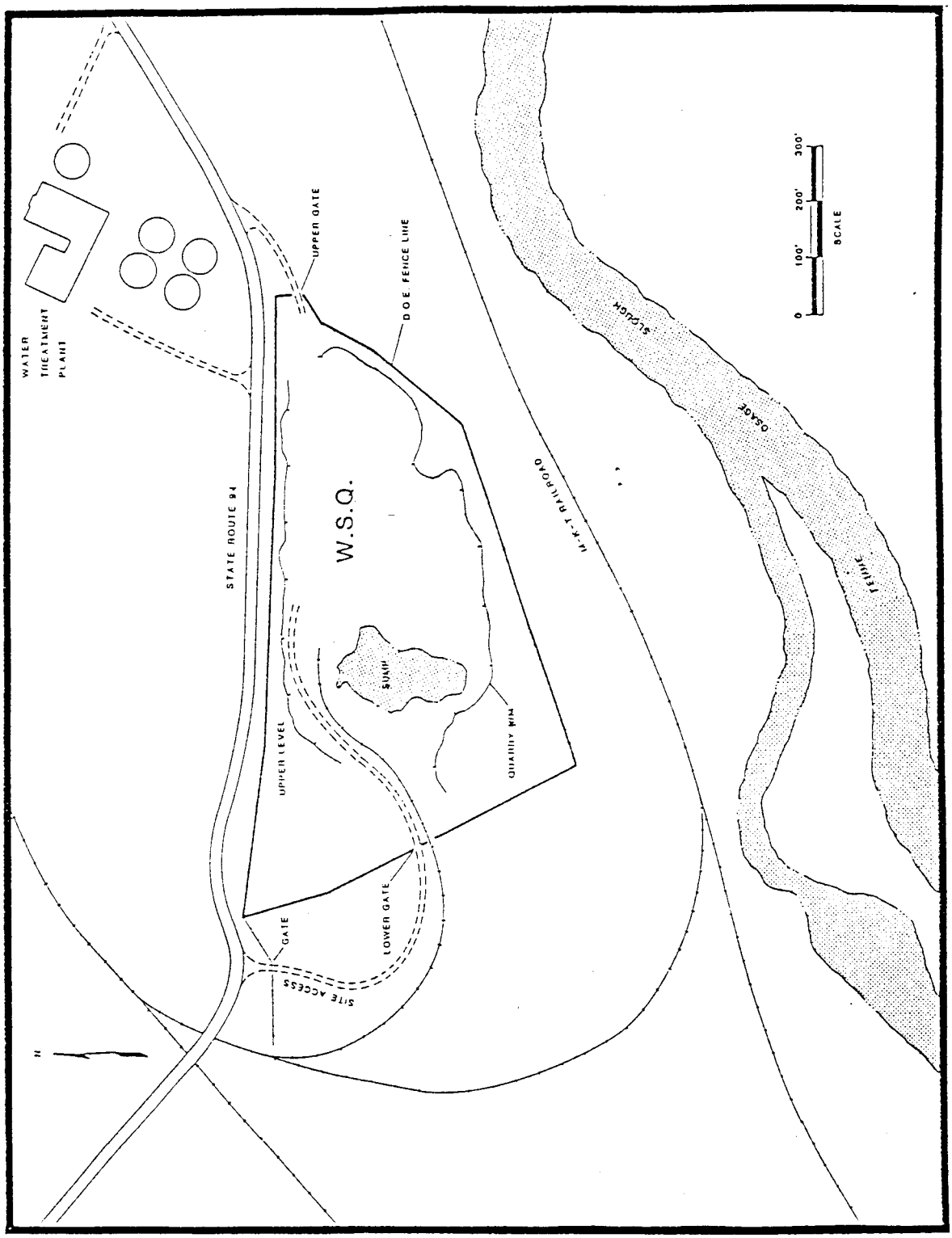

FIGURE 3
MAP OF WSQ

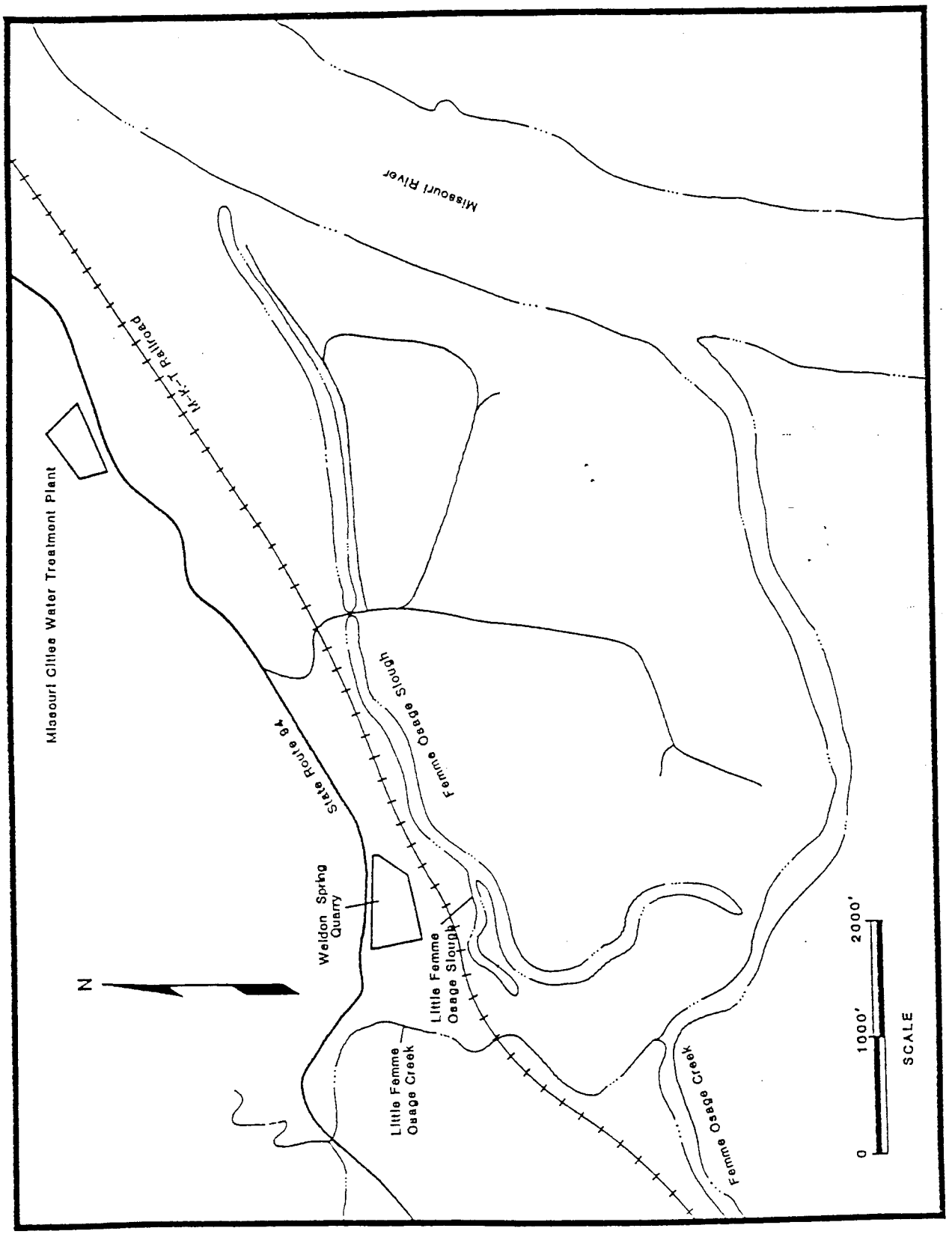

FIGURE 4
MAP OF WSQ SURROUNDING PROPERTIES

TABLE 1

RADIONUCLIDE CONCENTRATIONS FROM 1986 ENVIRONMENTAL MONITORING DATA.

LOCATION	RADIONUCLIDE CONCENTRATIONS (pCi/l)		
	TOTAL U	Ra-226	Th-230
Lake 34	17	0.28	0.20
Lake 35	11	0.18	0.25
Lake 36	36	0.13	0.18
Frog Pond Outfall	29	0.20	1.37
Ash Pond Outfall	2700	0.10	0.0
Raffinate Pit #3	110	160	3.0
Raffinate Pit #4	1900	77	160
Femme Osage Slough	54	0.31	0.28
Quarry Sump	1240	1.0	1.5
Ash Pond	3000	<1.0	<2.0
Frog Pond	30	0.33	1.37

SOURCE: EMR, 1986; 1987

3.0 SAMPLE COLLECTION

Biota samples will be collected from locations both on and off the WSS. Locations of fish, frog, and small mammal collection areas are shown in Figures 5, 6, 7, and 8. Fish will be collected using electrofishing methods and minnow traps, while small mammals will be collected using live traps.

Electrofishing involves the use of a gas powered electric generator to introduce an electric current into the water near the boat. This temporarily stuns fish long enough to be netted and placed in a container in the boat. Electrofishing will be conducted by Missouri Department of Conservation (MDOC) personnel for all sites located on the Busch and Weldon Spring Wildlife Areas. Electrofishing will continue at each site until a sufficient quantity of fish is collected to fulfill the sample requirements. (Table 2)

Five composite samples will be collected, if possible, at each of the offsite locations. Three of the five composites will be composed of filleted specimens representing the following fish; largemouth bass, sunfish, and catfish. These three composites will represent only edible portions of fish tissue. In Lake 35, the largemouth bass composite will be replaced by crappie since this lake has an overabundance of crappie and few bass. It is currently being managed with special regulations to reverse this trend. The fourth composite will consist of sunfish that have

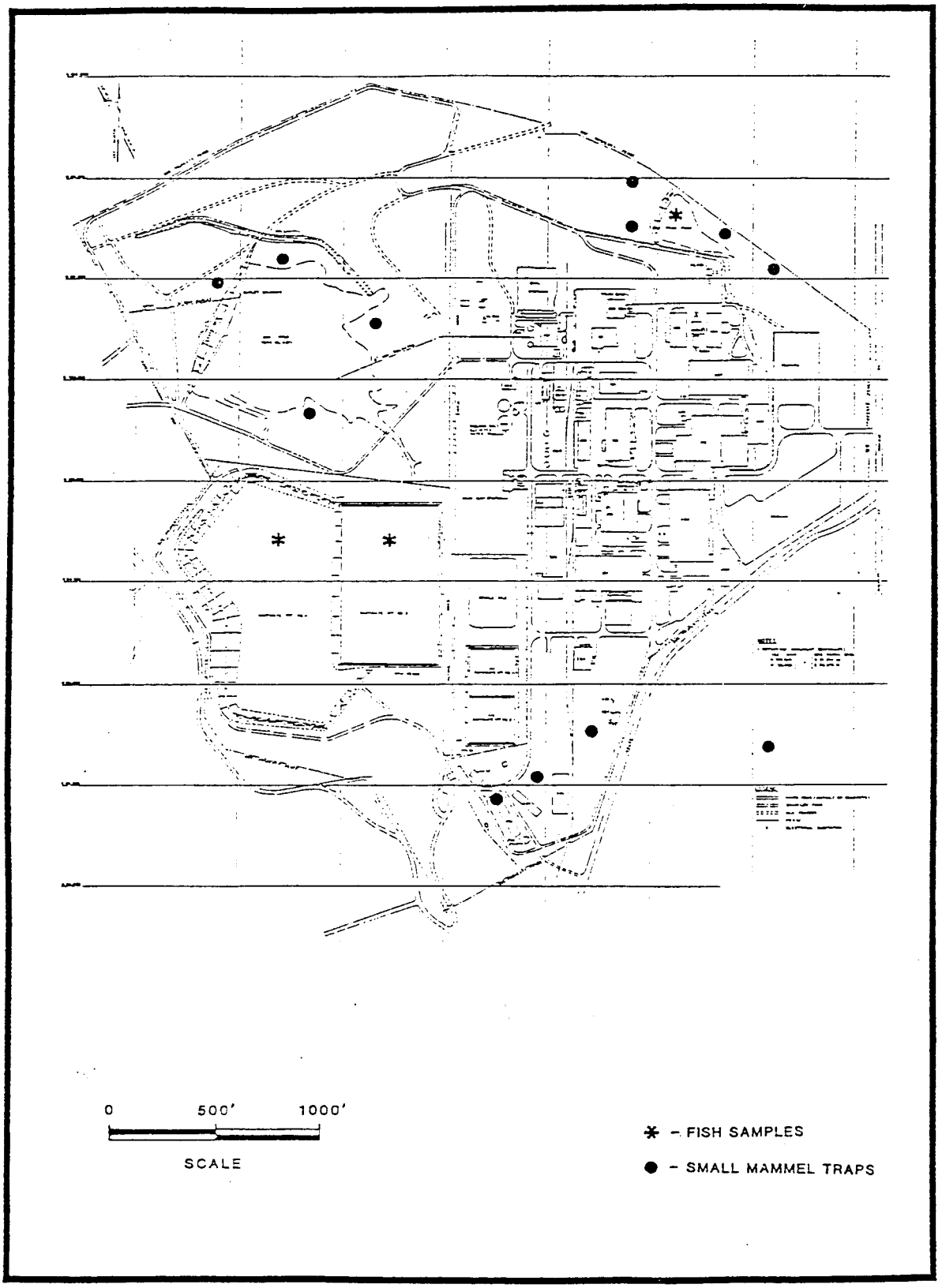

FIGURE 5
MAP OF WSCP/WSRP SAMPLING LOCATIONS

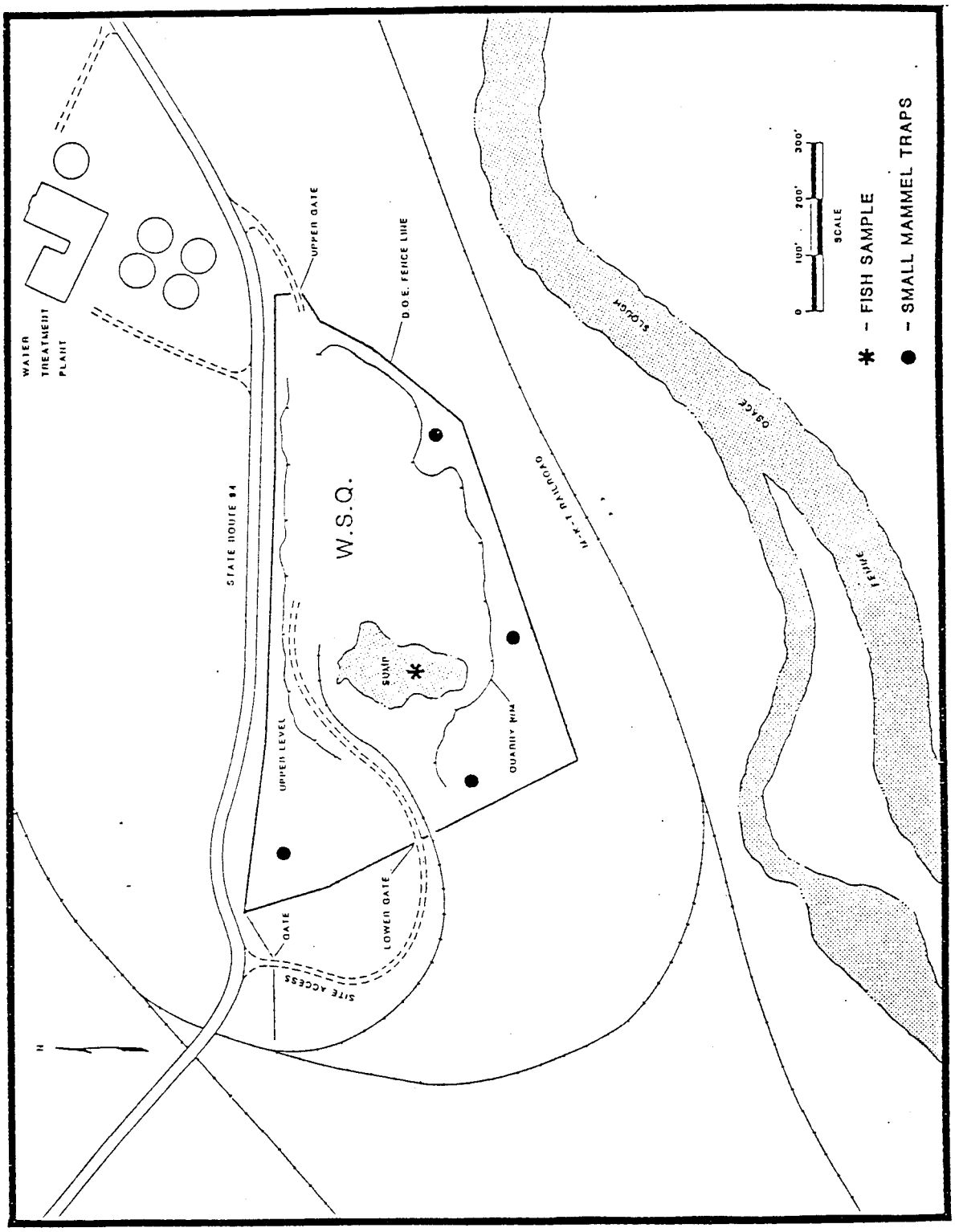

FIGURE 6
WSQ SAMPLING LOCATIONS

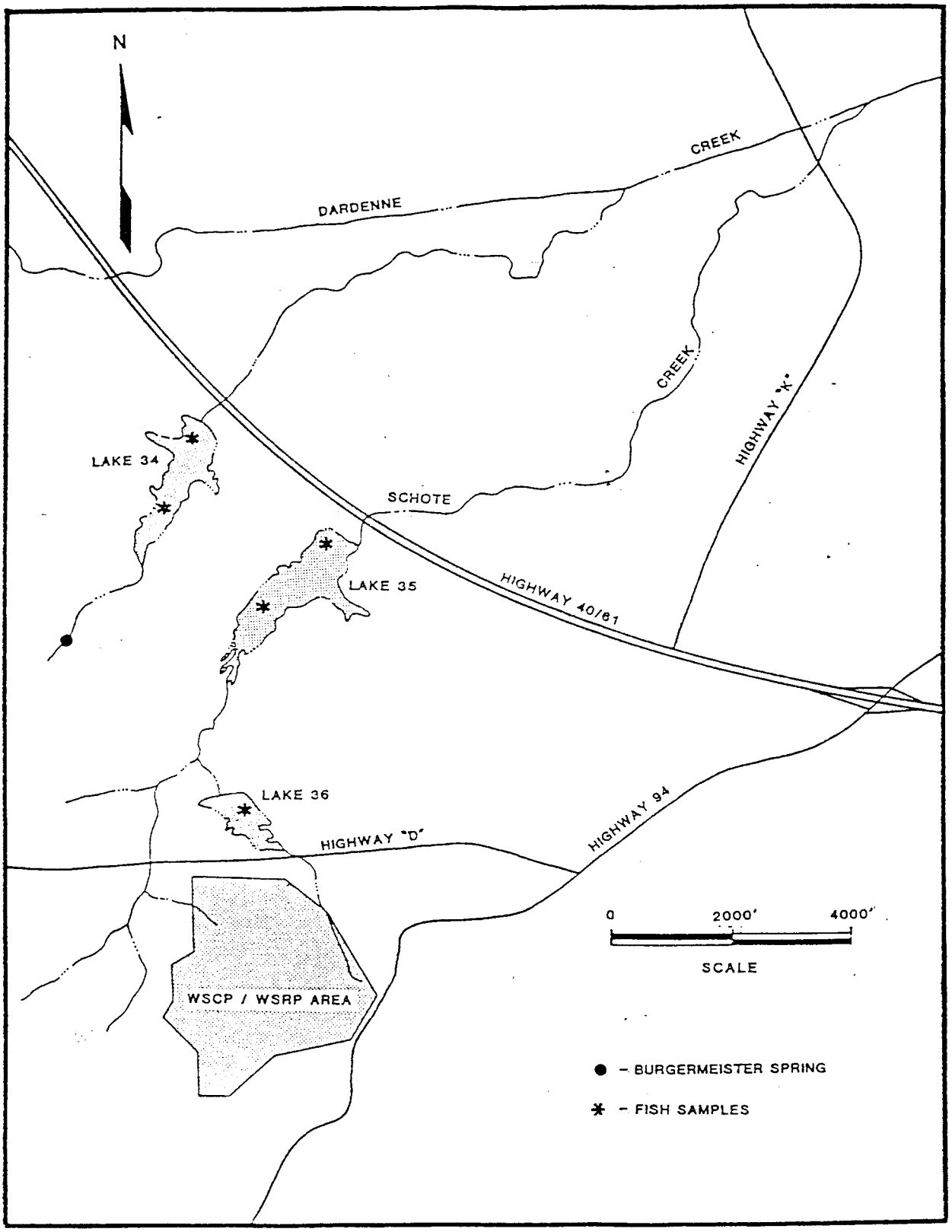

FIGURE 7
WSCP/WSRP SURROUNDING PROPERTIES SAMPLING LOCATIONS

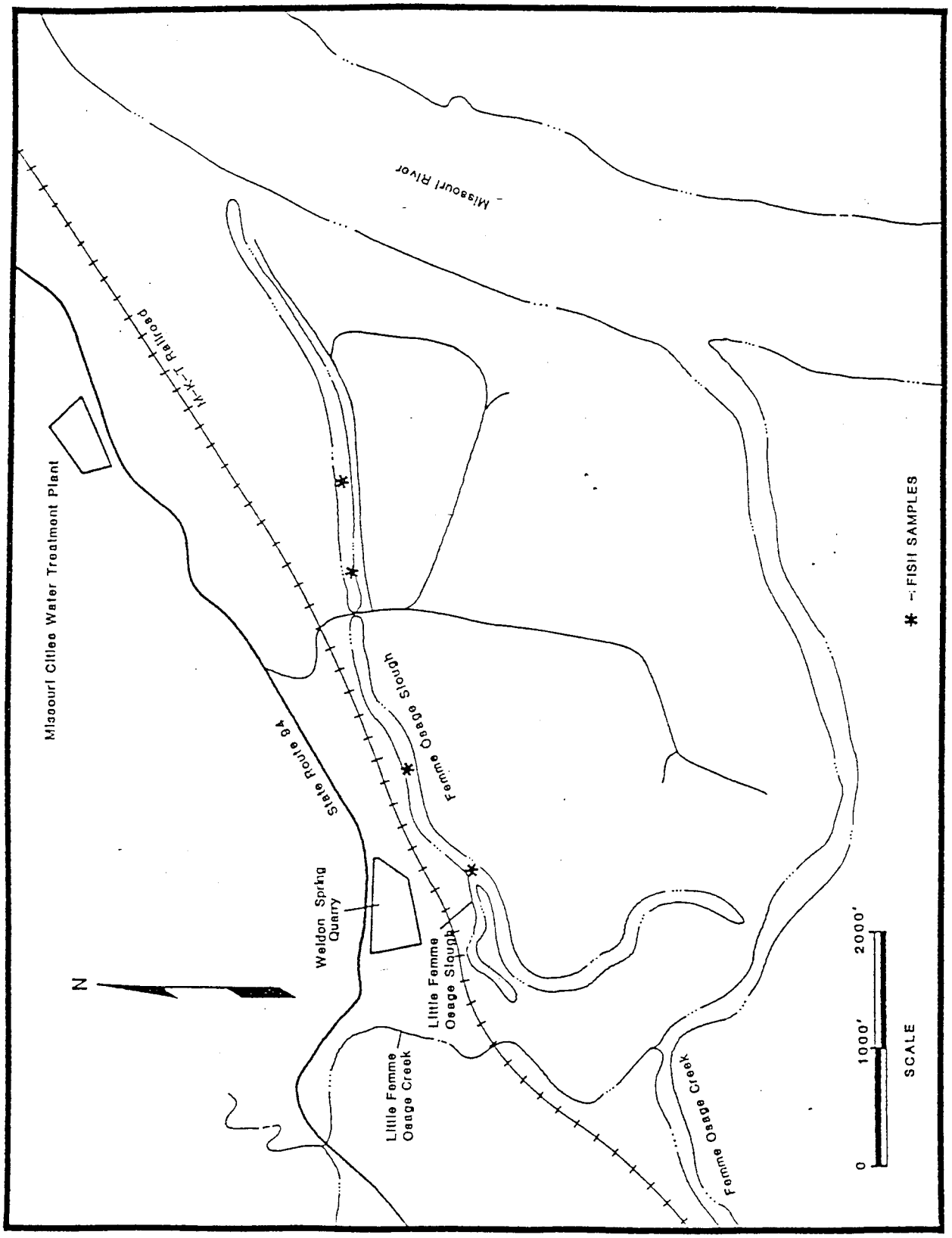

FIGURE 8
MAP OF WSQ SURROUNDING PROPERTIES SAMPLING LOCATIONS

TABLE 2
DESCRIPTION OF SAMPLES COLLECTED

AREA	SPECIES	MINIMUM AMOUNT OF SAMPLE COLLECTED	MINIMUM AMOUNT OF SAMPLE SUBMITTED
Lake 34	Largemouth bass, fillets	(2) 2000 g	(2) 800 g
	Sunfish, fillets	(2) 2000 g	(2) 800 g
	Catfish, fillets	(2) 2000 g	(2) 800 g
	Sunfish, cleaned	(2) 1200 g	(2) 800 g
	Frogs (legs)	3000 g	300 g
	Fish Composite, fillets	(2) 2000 g	(2) 800 g
Lake 35	Crappie, fillets	(2) 2000 g	(2) 800 g
	Sunfish, fillets	(2) 2000 g	(2) 800 g
	Catfish, fillets	(2) 2000 g	(2) 800 g
	Sunfish, cleaned	(2) 1200 g	(2) 800 g
	Frogs (legs)	3000 g	300 g
	Fish Composite, fillets	(2) 2000 g	(2) 800 g
Lake 36	Largemouth bass, fillets	2000 g	800 g
	Sunfish, fillets	2000 g	800 g
	Catfish, fillets	2000 g	800 g
	Sunfish, cleaned	1200 g	800 g
	Frogs (legs)	3000 g	300 g
	Fish Composite, fillets	2000 g	800 g
Frog Pond	Sunfish, fillets	2000 g	800 g
	Catfish, fillets	2000 g	800 g
	Frogs (legs)	5000 g	500 g
Raffinate Pit #3	Minnows, whole	2000 g	800 g
Raffinate Pit #4	Sunfish, fillets	2000 g	800 g
	Catfish, fillets	2000 g	800 g
	Sunfish, cleaned	1200 g	800 g
	Frogs (legs)	5000 g	500 g
Femme Osage Slough	Largemouth bass, fillets	(2) 2000 g	(2) 800 g
	Sunfish, fillets	(2) 2000 g	(2) 800 g
	Catfish, fillets	(2) 2000 g	(2) 800 g
	Sunfish, cleaned	(2) 1200 g	(2) 800 g
	Frogs (legs)	3000 g	300 g
	Fish Composite, fillets	(2) 2000 g	(2) 800 g
Quarry Sump	Catfish, fillets	2000 g	800 g
	Sunfish, fillets	2000 g	800 g
	Frogs (legs)	5000 g	500 g
	Fish Composite, fillets	2000 g	800 g

TABLE 2 (Continued)

AREA	SPECIES	MINIMUM AMOUNT OF SAMPLE COLLECTED	MINIMUM AMOUNT OF SAMPLE SUBMITTED
Lake 37 (Background location)	Sunfish, fillets	2000 g	800 g
	Catfish, fillets	2000 g	800 g
	Largemouth bass, fillets	2000 g	800 g
	Sunfish, cleaned	1200 g	800 g
	Frogs (legs)	5000 g	500 g
	Fish Composite, fillets	2000 g	800 g
Ash Pond Area	Rabbit	1600 g	800 g
	Squirrel	1600 g	800 g
Quarry Area	Rabbit	1600 g	800 g
	Squirrel	1600 g	800 g
Frog Pond Area	Rabbit	1600 g	800 g
	Squirrel	1600 g	800 g
Imhoff SE Drainage Easement	Rabbit	1600 g	800 g
	Squirrel	1600 g	800 g

A total of 65 samples will be submitted.

been cleaned and scaled but not filleted. This composite will represent fish used to make fishcakes, a common method of preparation for small edible fish. The fifth composite sample will be made up of representatives of all species collected, equally represented by weight. These samples will be filleted and analyzed for PCB's and CLP metals.

Locations that will be sampled on-site include Frog Pond, the quarry sump, and Raffinate Pits 3 and 4. While fish have been sited at some onsite surface bodies, it is uncertain that sufficient samples can be collected positively known to occur in these on-site waterbodies. Electrofishing will therefore be utilized in an attempt to obtain samples from these locations. In addition, minnow traps will be set so that a composite sample of whole minnows can be collected if larger fish are unavailable. Some type of fish sample from on-site locations is important since this represents a "worst case" situation of a high radionuclide uptake.

Two separate fish sampling locations have been selected at Lakes 34 and 35 on the Busch Wildlife Area due to the large size of these lakes. The locations are at the inlet and outlet ends of these two lakes. This is being done to see if there is any dilution factor or difference in fish uptake. Higher concentrations might be expected at or near the inlets. Lakes 36 and 37 will be sampled only at the inlet ends. Lake 37 has been chosen for use as a background location. This lake does not receive runoff from either

the WSCP or the DA Ordnance Works abandoned facility.

Two locations will also be sampled in the Femme Osage Slough. The first location is just below the WSQ near the confluence of the Little Femme Osage Slough. The second location is in the eastern end of the Femme Osage Slough on the other side of the access road crossing the Slough (see Figure 8).

4.0 METHODS OF ANALYSIS

Approximately 100 grams of fish tissue per sample will be required for the laboratory analyses per radionuclide. Fish will be cleaned or filleted, depending on the sample, at the end of each day. Fish samples will be stored in labeled plastic bags and frozen prior to shipment to the lab for radionuclide analysis. The composite samples that will be analyzed for PCB's and CLP Metals will be stored in aluminum foil instead of plastic bags. At the laboratory, each composite will be homogenized and extracted as required for the specific analyses to be performed. A summary of the appropriate analysis to be performed on samples are presented in Table 3.

Samples of frogs will be collected from each of the water-body locations. Frogs will be collected using hand-held nets. If this sampling cannot be accomplished in daylight, it will be attempted at night with lights. This method is often used by sportsmen to gig frogs. Frog specimens will be prepared by removing the legs, skinning them, and cutting the meat from the bones. These samples will represent the edible portion of frog tissue. Samples will be bagged, labeled and frozen prior to shipment to the laboratory.

Small game mammals, such as squirrels and rabbits, will be collected by live traps set at various locations around the

Table 3

DESCRIPTION OF SAMPLES COLLECTED AND THE APPROPRIATE ANALYSIS

AREA	SPECIES	TOTAL URANIUM	Ra-226 & Th-230	PCB's & METALS
Lake 34	Largemouth bass, fillets	X		
	Sunfish, fillets	X		
	Catfish, fillets	X		
	Sunfish, cleaned	X		
	Frogs (legs)	X		
	Fish Composite, fillets			X
Lake 35	Crappie, fillets	X		
	Sunfish, fillets	X		
	Catfish, fillets	X		
	Sunfish, cleaned	X		
	Frogs (legs)	X		
	Fish Composite, fillets			X
Lake 36	Largemouth bass, fillets	X		
	Sunfish, fillets	X		
	Catfish, fillets	X		
	Sunfish, cleaned	X		
	Frogs (legs)	X		
	Fish Composite, fillets			X
Frog Pond	Sunfish, fillets	X	X	
	Catfish, fillets	X	X	
	Frogs (legs)	X	X	
Raffinate Pit #3	Minnows, whole	X	X	
Raffinate Pit #4	Sunfish, fillets	X	X	
	Catfish, fillets	X	X	
	Sunfish, cleaned	X	X	
	Frogs (legs)	X	X	
Femme Osage Slough	Largemouth bass, fillets	X		
	Sunfish, fillets	X		
	Catfish, fillets	X		
	Sunfish, cleaned	X		
	Frogs (legs)	X		
	Fish Composite, fillets			X
Quarry Sump	Catfish, fillets	X	X	
	Sunfish, fillets	X	X	
	Frogs (legs)	X	X	
	Fish Composite, fillets			X

Table 3 (Continued)

DESCRIPTION OF SAMPLES COLLECTED AND THE APPROPRIATE ANALYSIS

AREA	SPECIES	TOTAL URANIUM	Ra-226 & Th-230	PCB's & METALS
Lake 37 (Background location)	Sunfish, fillets	X	X	
	Catfish, fillets	X	X	
	Largemouth bass, fillets	X	X	
	Sunfish, cleaned	X	X	
	Frogs (legs)	X	X	
	Fish Composite, fillets			X
Ash Pond Area	Rabbit	X	X	
	Squirrel	X	X	
Quarry Area	Rabbit	X	X	
	Squirrel	X	X	
Frog Pond Area	Rabbit	X	X	
	Squirrel	X	X	
Imhoff SE Drainage Easement	Rabbit	X	X	
	Squirrel	X	X	

Weldon Spring Site. Traps located on the WSCP and WSQ will be focused at boundary areas where animals can migrate on and off site being accessible to hunters. Figure 5 shows the proposed locations where traps will be set in the WSCP area (Frog and Ash Pond). Figure 6 illustrates the locations for the WSQ area.

Live traps will be set in the approximate locations shown on the figures where suitable habitat exists. Traps will be baited and checked daily until the sampling effort has been completed. Only small mammals commonly eaten by hunters will be kept. Others, such as opossums and raccoons, will be released unharmed. Animals kept for analysis will be killed using a pellet gun at close range, skinned, and cleaned, so that tissue samples represent only edible portions.

Each small mammal composite sample will consist of a minimum of 3 individuals. At the WSQ and southeast drainage easement locations, rabbits will probably be difficult to obtain since these locations are densely wooded with little open or brushy habitat suitable for rabbits. Should this be the case, the rabbit composites from these two locations will be deleted.

Small mammal composite samples will be handled in a similar manner as the fish. Composites will be made after skinning and cleaning the animals. The animals will then be stored in

labeled plastic bags and frozen prior to shipment to the lab. Chain of Custody records will be utilized for a written record of the sampling effort. These records will verify that the samples were not tampered with or altered prior to laboratory analysis.

The analysis for uranium, radium, and thorium should have a lower limit of detectability of 0.01 pCi/g. The level of uranium activity in soft tissues is expected to be slightly above this range from the offsite waterbodies. Polychlorinated biphenyls (PCB's) and metals analyses only require 25 and 5 grams for analysis respectively and have a lower limit of detectability in water as listed below:

METALS	DETECTION LEVEL (ug/L or ppb)
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20

PCB'S	DETECTION LEVEL (ug/L or ppb)
PCB-1016	0.5
PCB-1221	0.5
PCB-1232	0.5
PCB-1242	0.5
PCB-1248	0.5
PCB-1254	1.0
PCB-1260	1.0

Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) Test Method 608 will be used to analyze samples for PCB's. This is a gas chromatographic (GC) method applicable to the determination of the compounds listed above.

EPA-CLP method for inorganic analysis based on Caucus Inorganics Protocol will be used to analyze samples for Metals. These metals are determined by inductively coupled plasma emission or Atomic Absorption Spectroscopy.

Uranium will be analyzed per EPA Method 908-ASTN. Radium-226 will be analyzed per EPA Methods 903.0 and 903.1. Thorium-230 will be analyzed per the procedure developed by the EPA Eastern Environmental Radiation Facility (EERF 00/07).

5.0 DATA ANALYSES

The set of data along with assumptions made on dietary intake will be used to calculate the radiation dose from internally deposited radionuclides. Cumulative risk estimates from lifelong intakes will assume a linear dose-response relationship for cancer induction at environmental levels.

Important considerations for determining body content of a radionuclide after it is ingested are time and age dependence of the intake. For purposes of the present analysis, it may be assumed that animal and fish tissue concentrations remain constant at an equilibrium value with a fixed daily intake of contaminant. The consumption of these biota by humans will have the same assumptions applied. Since dietary composition and its source can change, this may lead to a conservative oversimplification. Also, some of the metabolic parameters may change due to age dependence over the course of intake. The present analysis will assume metabolic parameters of reference man (ICRP No. 23).

The International Commission on Radiological Protection has developed mathematical models which determine body content of a radionuclide after it is ingested. The bone is the major site for uranium, radium, and thorium accumulation. The biological turnover or half life of a fraction of these is slow, therefore, skeletal cancer will be regarded as the major

potential radiobiological effect of ingestion by humans. The metabolism of the biota and the concentration of the contaminant in their tissue has the primary effect in these calculations. The primary focus will be given to the careful dissection and sample analysis of only food parts from the biota to determine the biota uptake. There is a wealth of data for the assumptions made on uptake and the metabolism in human beings. From this study, the action levels adopted to control radiological risk are to limit the likelihood of bone cancer induction for the nearby population, though calculations will be based on a hypothetically maximum exposed individual.

The quantitative relationship between uranium intake and kidney damage have been measured in several species of animals. Proximal renal tubule cells are killed by high acute or lower chronic dosages of soluble uranium compounds. The limiting concentration for chronic intake is 110 ug per day (Wrenn, 1985). From this level of intake, the toxic effects should be sufficiently low to nonexistent in the kidney. Kidney damage may be expected to occur gradually above this uranium concentration.

Radiobiological Effects of Uranium

The concentration determined in the fish tissue will be multiplied by 4086 grams per year (USDA, 1986) to give the total activity ingested by a hypothetical individual in a one

year time interval. Using the methodology described in ICRP's 26 and 30, the 50-year committed dose equivalent and effective dose equivalent will be calculated.

Example: The Effective Dose Equivalent for a hypothetically exposed individual who consumes fish tissue contaminated with uranium. Assume 1.0 pCi/g total Uranium in fish tissue is found by laboratory analysis :

Radiobiological Dose (mrem) = (1.0 pCi/g) X (4086 g)
X (1.0E-06 uCi/pCi)
X (0.25 rem/uCi) X (1.0E+03 mrem/rem)
= 1.0 mrem (whole body) or 1.0 E-05 Sv.

Example: The 50-year Committed Dose Equivalent to the bone for a hypothetically exposed individual. Assume 1.0 pCi/g total uranium in fish tissue is found by laboratory analysis:

Radiobiological Dose to Bone (mrem) = (1.0 pCi/g) X (4086 g)
X (1.0 E-06 uCi/pCi) X (4.2 rem/uCi)
X (1.0 E+03 mrem/rem) = 17 mrem (bone) or 1.7E-04 Sv.

The radiosensitive cells in bone have been identified as the endosteal cells and epithelial cells on bone surfaces. For purposes of radiation protection, the number of excess cancer

fatalities for bone cancer is 5 per 10000 individuals per Sievert (Sv) (ICRP No. 26).

Example: Bone cancer risk

Bone cancer fatalities per 10000 exposed individuals =

(1.7 E-04 Sv) X (5 fatalities/Sv)

= 9.0 E-04 fatalities/10000 individuals exposed to this level.

The number of excess cancer fatalities is dependent upon the number of individuals consuming 4086 grams of fish from a contaminated lake. If 100 million individuals caught fish from a lake with this amount of contaminant in the fish tissue, then 9 of these individuals would die of bone cancer.

Chemical Toxicity Effects of Uranium

The concentration determined in the fish tissue will be multiplied by 11.2 grams per day (USDA, 1986)* to give the average intake. Gastrointestinal absorption of uranium as a function of intake will decrease with increases in intake. Therefore, a daily average or chronic intake is used for conservatism in these calculations.

According to recent studies, the fractional gastrointestinal (GI) absorption from the GI tract to the blood is 1.4 percent.

* Rabbit, squirrel and frog - assume 2000 grams per year.

A blood-to-kidney transfer factor of 11 percent (Wrenn, 1985) is assumed, with a 15-day half-time in the kidney. The amount of uranium in the kidney at equilibrium would then be as follows:

$$A_e = (f_1/\ln 2) \times (f_{21})\ (T_1) = (0.014/\ln 2) \times (0.11)(15)$$

$$= 0.033 \text{ or } 3.3 \text{ percent}$$

where: A_e = amount of uranium in the kidney at equilibrium

f_1 = fractional GI absorption from GI tract to blood

f_{21} = fractional transfer from blood to kidney

T_1 = half-time in kidney compartment

Using 0.6 ug/g as the limiting concentration (C_L) in the kidney (below the injury threshold, Wrenn, 1985), a safety factor(S) of 50(NAS-77) and kidney mass (m= 310 g), the limiting daily intake (I_L) would be derived as:

$$I_L = (C_L/S)(A_e/m) = (0.6/50)/(0.033/310)$$

$$= 110 \text{ ug per day}$$

If the measured concentration in the fish tissue is 1.0 pCi/g then the percent of the limiting daily intake would be calculated as:

$$I_L\% = \frac{(C) \times (CF) \times (A) \times 100\%}{I_L}$$

$$= \frac{(1.0 \text{ pCi/g})(0.677 \text{ ug/pCi})\ (11.2 \text{ g}) \times 100\%}{110 \text{ ug}}$$

$$= 7\%$$

where: C = Assumed concentration in fish tissue

CF = Conversion Factor for a mass of natural uranium to its activity

A = Amount of fish tissue ingested daily

I_L = Limiting Daily intake

Nitroaromatic Toxicity Effects

Available data pertaining to DNT and TNT exposure is limited at this time. Animal studies indicate significant species and strain differences in the excretion of DNT isomers. There is growing evidence from research that DNT's are carcinogenic, although the potency of the different isomers in cancer induction is not well characterized. The primary site for TNT toxicity is the blood system and liver. The most serious systemic effects of acute TNT poisoning in humans are toxic jaundice and toxic hepatitis.

The potency of DNT varies in studies, so to assure the protection of public health from carcinogenic effects, a 10^{-6} cancer risk level has been assumed by the EPA at the dosage of 6.4×10^{-7} mg/kg/day. Since studies have provided no evidence of TNT carcinogenicity, an Allowable Daily Intake (ADI) has been used for a no-observed-adverse-effect level at 1.4×10^{-3} mg/kg/day.

By comparing actual contaminant levels with these criteria, the actual risks incurred from ingestion of biota tissue containing these nitroaromatics could be estimated. The development of criteria is still based on a variety of conservative assumptions and safety factors so that no adverse health effects would be expected.

At the WSS, determinations regarding the levels of contamination in water are being reviewed and studied. Again, until the different TNT and DNT isomers are better characterized and the breakdown products in tissues reviewed for carcinogenic effects, contaminant levels in tissues along with the variety of assumptions and safety factors will make the criteria and an acceptable risk far lower than the present day detection limits for these nitroaromatics in tissues.

Discussion

If the biota sampling results in significant findings, routine collection and analysis may be added to the Environmental Monitoring Plan. The radiation dose calculated from edible parts of biota samples and measured data for water concentrations will be compared. The chemical toxicity and percent of Limiting Daily Intake from edible parts will be reviewed. The findings from this program will be summarized and interpreted in the Endangerment Assessment section of the RI/FS.

If measured offsite concentrations increase and conditions change significantly in future operations, the need may arise for additional studies. Sampling efforts at onsite locations with higher radionuclide concentrations may provide better estimates and determinations for outcomes of such releases.

The DOE radiation dose limit for an unrestricted area is 100 mrem/yr above background for whole body exposure. The DOE Administrative action level is 25 mrem/yr above background. A hypothetical individual consuming such biota from the vicinity of WSS would receive internal exposure via the food pathway and by ingestion of contaminated water. If calculations suggest the radiation dose to an individual is greater than 50 percent of the administrative action level, then biological sampling will be included in the Environmental Monitoring Plan based on radiological concerns.

An administrative action limit for chemical toxicity to uranium has not been developed. If calculations suggest the chemical toxicity to an individual is significant, then biological sampling will be included in the Environmental Monitoring Plan based on chemical toxicity concerns.

In the Appendix, Table A-1 lists the estimated costs for laboratory analysis of the samples. An increase in cost is due to a much lower limit of detection required in the analyses of radionuclides. The total number of man-hours required to

complete the sampling, mobilization of equipment, and sample preparation are estimated in Table A-2 in the Appendix. MDOC will be supplying equipment and personnel for the sampling on the Busch Wildlife Area, however, sampling on the WSS will require the use of Project equipment and materials. A list of the necessary equipment and materials needed for the entire sampling operation are listed in Table A-3 in the Appendix.

6.0 References:

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APPENDIX

Table A-1

The Laboratory Analyses With Unit Costs

TYPE OF ANALYSIS	UNIT COST	ESTIMATED NUMBER
Total Natural Uranium	120.00	59
Radium-226	200.00	24
Thorium-230	200.00	24
CLP-Metals	300.00	9
PCB's	150.00	9

Table A-2

Estimated Amount Of Time Required
To Complete The Sampling Operation

AREA	MAN-HOURS
Lake 34 *	24
Lake 35 *	24
Lake 36 *	24
Lake 37 *	24
Frog Pond	24
Raffinate Pit #3	24
Raffinate Pit #4	24
Femme Osage Slough *	36
Quarry Sump	36
Total Man-Hours	240

* Locations will be assisted by MDOC personnel.

Sampling efforts will begin after September 28, 1987. MDOC personnel will be notified well in advance of operation. Small mammal traps will be set after September 28, 1987. Traps will be checked on a daily basis until minimum sample numbers obtained.

Table A-3

Equipment And Materials Needed For The Sampling Operation

1. Small mammal traps (18)
2. Boat or raft for onsite
3. Electroshock apparatus for onsite
4. Small mammal dissection kits
5. Fish filet equipment
6. Sample collection bags
7. Radiation monitoring equipment
8. Life preservers
9. Rubber boots & gloves
10. Rain suits
11. Transport for boat or raft
12. Sample prep table
13. Waste containers
14. Permits

CHEMICAL PLANT
201-1.03

3589-87-I-DOE-222

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

M-K FERGUSON CO.
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WSSRAP CONTRACT 3589

December 11, 1987

Ms. Katherine Biggs, Chief
Environmental Review Branch
U. S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Dear Ms. Biggs:

PLAN FOR THE SAMPLING AND ANALYSIS OF LAKE AND STREAM SEDIMENTS

Enclosed are four copies of the Final Sampling Plan for Lake and Stream Sediments influenced by the Weldon Spring Chemical Plant drainage. All of your July 6, 1987, comments have been incorporated and the sampling effort is scheduled to begin in January 1988.

If you have any questions, please call.

Sincerely,

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosures

cc:
Dave Bedan, MDNR, w/enclosures (4 copies)
Jack Hammond, MK-F, w/o enclosure

DOE/OR/21548-006

United States Department Of Energy

W.S.S.R.A.P.

PLAN FOR THE SAMPLING AND ANALYSIS OF LAKE AND STREAM SEDIMENTS INFLUENCED BY THE WELDON SPRING CHEMICAL PLANT DRAINAGE

NOVEMBER, 1987

WELDON SPRING SITE REMEDIAL ACTION PROJECT

PLAN FOR THE SAMPLING & ANALYSIS OF LAKE & STREAM SEDIMENTS INFLUENCED BY THE WELDON SPRING CHEMICAL PLANT DRAINAGE

NOVEMBER, 1987

PLAN FOR THE SAMPLING & ANALYSIS OF LAKE & STREAM SEDIMENTS INFLUENCED BY THE WELDON SPRING CHEMICAL PLANT DRAINAGE

PREPARED FOR:

UNITED STATES DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE
UNDER CONTRACT NO. DE-AC05-86OR21548

PREPARED BY:

MK-FERGUSON COMPANY
AND
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NOVEMBER, 1987

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1.0 INTRODUCTION

This document presents the Field Sampling and Analysis Plan for the collection of sediments from lakes and streams influenced by drainage from the Weldon Spring Site. The plan describes the scope of activities to be performed by the Project Management Contractor (PMC) and its subcontractors during sediment collection and analysis.

Results of this study and any subsequent sediment investigations will be incorporated into the Site Characterization Report. In addition, the risks associated with any discovered contaminant deposition will be assessed as part of the Environmental Impact Statement.

1.1 Background

A survey of sediments near the Weldon Spring Site will be performed in 1988. Surface drainage from most of the combined Weldon Spring Chemical Plant (WSCP) and Weldon Spring Raffinate Pit (WSRP) areas flows in a northerly direction, toward Lakes 35 and 36 on the August A. Busch Memorial Wildlife Area (Busch Area) (Figure 1.1). The remaining surface drainage flows southward down a drainage easement to the Missouri River, through the Weldon Spring Wildlife Area (WSWA). The drainage easement also carried process and sanitary sewer outfall to the Missouri River.

The 7,000-acre Busch Area and 7,200-acre WSWA are managed by the Missouri Department of Conservation and are open throughout the year to the general public. Several of the intermittent streams draining portions of the WSCP/WSRP areas are losing streams. A portion of this drainage resurfaces at Burgermeister Spring which is upstream from Lake 34 on the Busch Area. Radiological activity above background was detected in the waters of these three lakes at levels ranging from 11 pCi/L to 36 pCi/L (DOE, 1986 Environmental Monitoring Report).

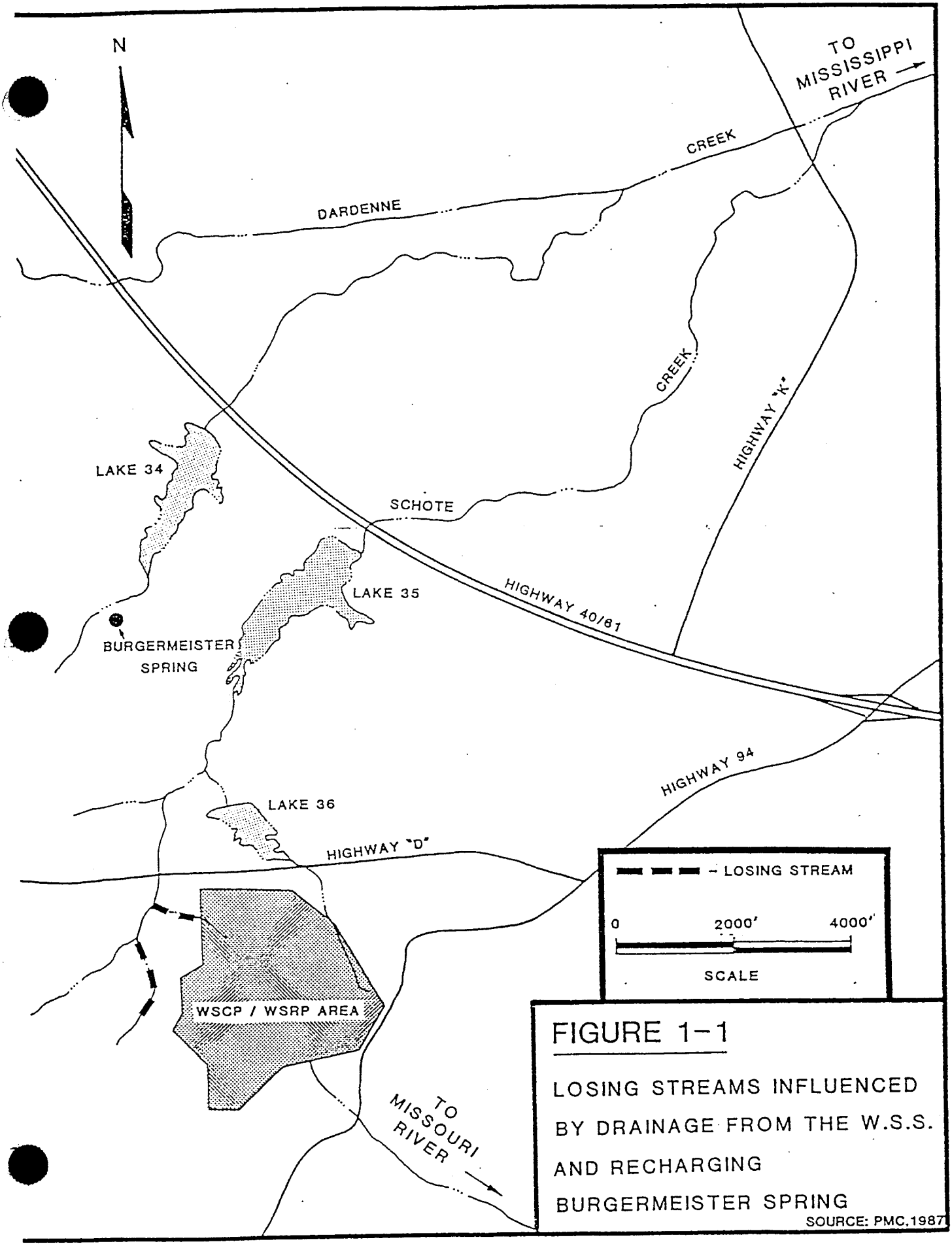


FIGURE 1-1

LOSING STREAMS INFLUENCED BY DRAINAGE FROM THE W.S.S. AND RECHARGING BURGERMEISTER SPRING

SOURCE: PMC,1987

In addition, limited lake and stream sediment sampling conducted in 1986 (ORAU: Radiological Survey of the August A. Busch and Weldon Spring Wildlife Areas.) and in 1978 (Rykman, Edgerly, Tomlinson and Associates: Phase III Report: Assessment of Deposition Alternatives) indicated uranium activity in several lake and stream sediment samples exceeding the remedial action guidelines of 60 pCi/g for U-238 and U-234 respectively. These data suggest that the underlying sediments in these lakes may require remedial action.

In addition, five sediment samples were collected in 1983 from Dardenne Creek by a local citizens group and analyzed for radiological parameters. While analyzed results of these samples technically indicated background levels, the report concludes that samples from downstream of the WSS exhibited higher activity than background. However, insufficient quality control analyses do not allow adequate assessment of the validity of the report's conclusion. In August of 1987, eight sediment samples were collected from the proposed NPDES storm water discharge points around the perimeter of the WSS. Samples were collected from the top 6 inches of sediment from each outfall. The data indicate above background levels of uranium, nitroaromatics and several semi-volatiles related to coal burning.

Nitroaromatics are also known to be present in the soil at the WSCP/WSRP area. Tributary and receiving streams from these areas as well as the drainage easement, also may be contaminated and require investigation. Lakes 35 and 36 drain into Schote Creek which joins Dardenne Creek just east of Highway K. Lake 34 flows directly into Dardenne Creek just west of Highway K. Dardenne Creek, in turn, flows north to the Mississippi River.

1.2 Objectives

The purpose of this activity is to determine the extent and magnitude of potential chemically and radiologically contaminated sediment under off-site streams and surface water bodies. This determination will be performed by the collection and analysis of a significant number of samples to limit uncertainty and achieve a proper level of confidence required to evaluate the no action and various remedial action alternatives. Limited analysis for PCB's, semi-volatiles and metals will also be performed to document any presence of these compounds in sediments compared to background.

The field sampling and analysis activities will comply with all applicable WSSRAP procedures including:

- Soil/Sediment Sampling
- Sample Number
- Chain of Custody
- Sample Packaging and Shipment
- Decontamination

1.3 Overview of Program

This sampling effort will determine the uranium activity and nitroaromatic, PCB's, semi-volatiles, and metals concentrations in lake and stream sediments influenced by the WSS drainage. Areas receiving direct runoff or subsurface recharge will be considered in this study. Based on data from the RETA report and knowledge of the types of materials processed during uranium refinement, radium-226, thorium-230, and thorium-232 activity levels exceeding DOE remedial action guidelines in these sediments are not expected. However, at least 30 percent of all sediment samples collected will be analyzed for these additional radiological parameters.

Stream sediments below the Busch Area Lakes (with the exception of 2 locations) will not be sampled for nitroaromatics, PCB's, semi-volatiles, or metals since contaminated sediment should have settled in the lakes. Since no documentation exists for chemical species in the lake sediments, a single composite sample from each of 3 six inch sediment intervals will be collected. These composites, coupled with results from upstream locations, should confirm the absence of these compounds.

Table 1.1 describes the area, the number of sampling stations, and estimated number of samples, and analysis to be performed on each sample. Samples will be collected from a total of 66 stations.

TABLE 1.1

SUMMARY OF PROPOSED LAKE & STREAM SEDIMENT SAMPLING PROGRAM[1]

AREA	NO. OF SAMPLING STATIONS	TOTAL NUMBER OF SAMPLES[2]	ANALYTICAL PARAMETERS
Lakes 34, 35, & 36	10 (per lake)	90	Uranium
		30	Nitroaromatics
		9	Radium & Thorium
		9 Composites	PCBs, Semi-volatiles, Metals
Lake 37	3	9	Uranium
		3	Nitroaromatics
		3	Radium & Thorium
		1 Composite	PCBs, Semi-Volatiles, Metals
Dardenne Creek & Peruque Creek	12	36	Uranium
		12	Radium & Thorium
Schote Creek	10	30	Uranium
		24	Nitroaromatics
		10	Radium & Thorium
		24	PCBs, Semi-volatiles, Metals
Burgermeister Spring, and Stream	5	15	Uranium
		12	Nitroaromatics
		5	Radium & Thorium
		12	PCBs, Semi-volatiles, Metals
Southeast Drainage Easement	6	18	Uranium
		18	Nitroaromatics
		6	Radium & Thorium
		18	PCBs, Semi-volatiles, Metals

1 - Based on 3 six-inch-interval composites per location
2 - 5% of samples will be submitted for Duplicate Analysis

Source: WSSRAP, 1987.

2.0 SAMPLING PROGRAM

Samples will be collected from several depth intervals at each location. Each interval will be a maximum of six inches thick, beginning with the 0 to 6 inch interval. A minimum of three depth intervals will be collected at each location, if sediments are 18 inches thick and recoverable. Samples will be collected by a subcontractor to the Project Management Contractor (PMC) using a PMC-approved method based on the criteria stated below. Sampling equipment will be thoroughly decontaminated between samples following EPA guidance documents.

After collection, the samples will be packaged and shipped to the subcontractor's laboratory for analysis. Field data shall be recorded on the Sediment Sampling Data Form (Figure 2-1) which records all relevant sample collection data, such as depth of sample, analytical parameters, location diagram, etc. Completed forms will be included in the final data report as an appendix.

The exact sampling methods and procedures will be supplied by the selected subcontractor for approval by the DOE before sampling commencement. In order to avoid limiting competition among potential subcontractors, exact methods have not been defined. However, in the Technical Instructions to potential bidders, EPA procedures, WSSRAP Standard Operating Procedures, and applicable guidance documents have been provided. Bidders have been instructed to propose sampling methods which will comply with both EPA and DOE requirements.

FIGURE 2-1

WELDON SPRING SITE REMEDIAL ACTION PROJECT (WSSRAP)
Route 2, Highway 94 South, St. Charles, Missouri 63303
Phone (314) 441-8086 Telecopy (314) 447-0803

Sediment Sampling Data Form

Sample Number: _____ Date: _____

Location: _____

_____

Personnel: _____ Time: _____

_____

Sample Collection Method: Pipe Post Hole Digger Other

Decon of Sampling Equipment Performed _____

Sample Type: Depth Composite Grab Other _____

Height (Ft) of Water Above Sample

Depth of Sample: _____ to _____ inches

Analysis to be Performed: _____

Location Diagram:

Description of Sample

_____

_____

_____

_____

_____

_____

Sample Container(s) _____ # of Containers _____

Sample Preservation _____

2.1 Sampling Locations

Sampling locations have been selected in both lakes and streams as described below. The rationale for sampling each location is presented in Table 2-1.

2.2 Stream Sampling Locations

Stream sediments will be collected at, or as near as possible to, the marked locations for each stream. Areas of sediment deposition will be sampled preferentially. Depth interval samples will be taken at stream locations to the extent possible, depending on sediment type and depositional environment. Samples from locations near highway crossings will be taken far enough upstream of the crossing to avoid influences from casual private dumping.

2.2.1 Schote Creek

Sediment samples will be collected from 10 locations (SD-4001 to SD-4010) shown on Figure 2-2.

2.2.2 Unnamed Tributary To Dardenne Creek

Five locations (SD-4011 to SD-4015) along the Burgermeister Spring stream will be sampled. The approximate locations are shown in Figure 2-2.

2.2.3 Dardenne Creek

Sediment samples will be collected from 11 locations (SD-4016 to SD-4026) along Dardenne Creek. An additional background sample (SD-4027) will be collected from Peruque Creek. These locations are shown in Figure 2-3.

TABLE 2-1

STREAM SEDIMENT REMEDIAL INVESTIGATIONS

LOCATION NO.	LOCATION DESCRIPTION	SAMPLING RATIONALE
*SD-4001	Inflow to Lake 36 - 100' north of Highway D	Assess sediment prior to entering lake
*SD-4002	Ash Pond drainage 100' west of DOE fence	Assess sediment in outfall stream
*SD-4003	Unnamed tributary to Schote Creek	Establish background conditions
*SD-4004	Unnamed tributary to Schote Creek just south of Army Reserve Training Area	Assess sediment entering Busch Area
*SD-4005	Schote Creek - 200' east of Ahden Knight Memorial Lake	Establish background conditions
*SD-4006	Lake 36 outfall stream north of gravel road	Assess sediment below lake
*SD-4007	Schote Creek - 600' above Lake 35	Assess sediment prior to entering Lake 35
*SD-4008	Schote Creek at Hwy 40-61	Assess sediment below Lake 35
SD-4009	Schote Creek at Weldon Spring Rd.	Assess sediment in populated
area		
SD-4010	Schote Creek at Highway K	Assess sediment below Lake 35
*SD-4011	Stream above Burgermeister Spring	Establish background conditions
*SD-4012	Burgermeister Spring	Assess sediment in source area

TABLE 2-1

STREAM SEDIMENT REMEDIAL INVESTIGATIONS

LOCATION NO.	LOCATION DESCRIPTION	SAMPLING RATIONALE
*SD-4013	Burgermeister Spring Stream midway between Spring & Lake 34	Assess sediment prior to entering lake
*SD-4014	Lake 34 outfall stream at Hwy 40	Assess sediment below Lake 34
SD-4015	Stream at Henning Road	Assess sediment in populated area
SD-4016	Dardenne Creek at Hopewell Road	Establish background conditions
SD-4017	Dardenne Creek at Hwy DD	Establish background conditions
SD-4018	Dardenne Creek at Lake 33	Establish background conditions
SD-4019	Dardenne Creek at Hwy 40	Establish background conditions
SD-4020	Dardenne Creek at Hwy K	Assess Burgermeister Spring stream sediment impact
SD-4021	Dardenne Creek at Schote Creek	Assess combined sediments
SD-4022	Dardenne Creek at Hwy N	Assess sediment conditions
SD-4023	Dardenne Creek at St. Peters Rd.	Assess sediment in populated area
SD-4024	Dardenne Creek at Mexico Road	Assess sediment in populated area
SD-4025	Dardenne Creek at St. Peters	Assess sediment in populated area
SD-4026	Dardenne Creek at Kampville	Assess sediment in populated area

TABLE 2-1

STREAM SEDIMENT REMEDIAL INVESTIGATIONS

LOCATION NO.	LOCATION DESCRIPTION	SAMPLING RATIONALE
SD-4027	Peruque Creek at Hwy 79	Establish background in Mississippi River alluvial stream
*SD-4061	Drainage Easement	Assess sediment in Wildlife Area
*SD-4062	Drainage Easement	Assess sediment in Wildlife Area
*SD-4063	Drainage Easement	Assess sediment in Wildlife Area
*SD-4064	Drainage Easement	Assess sediment in Wildlife Area
*SD-4065	Drainage Easement	Assess sediment in Wildlife Area
*SD-4066	Drainage Easement	Assess sediment in Wildlife Area

Source: WSSRAP, 1987.

*Location to be sampled for nitroaromatics, PCB's, Semi-volatiles, and CLP Metals

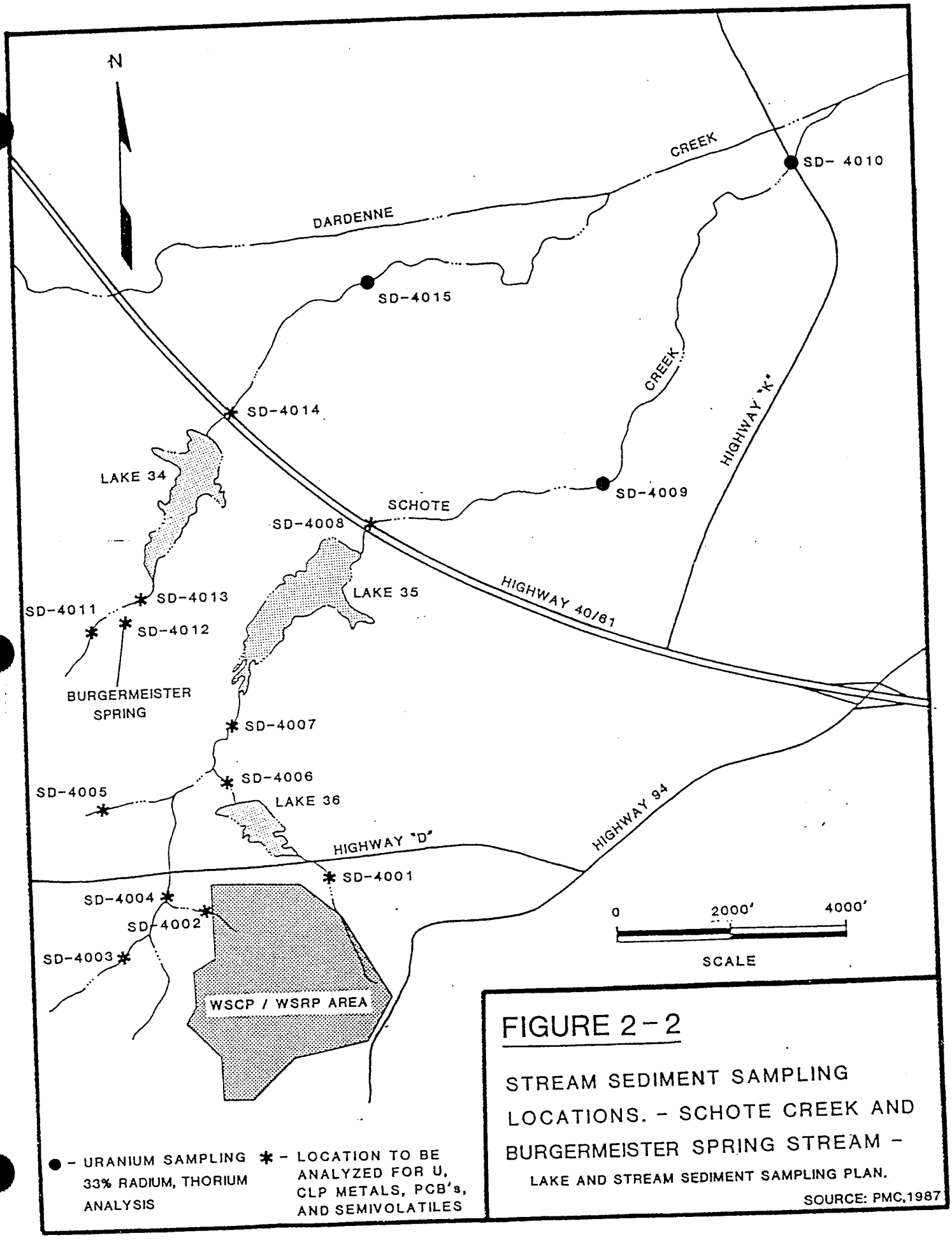
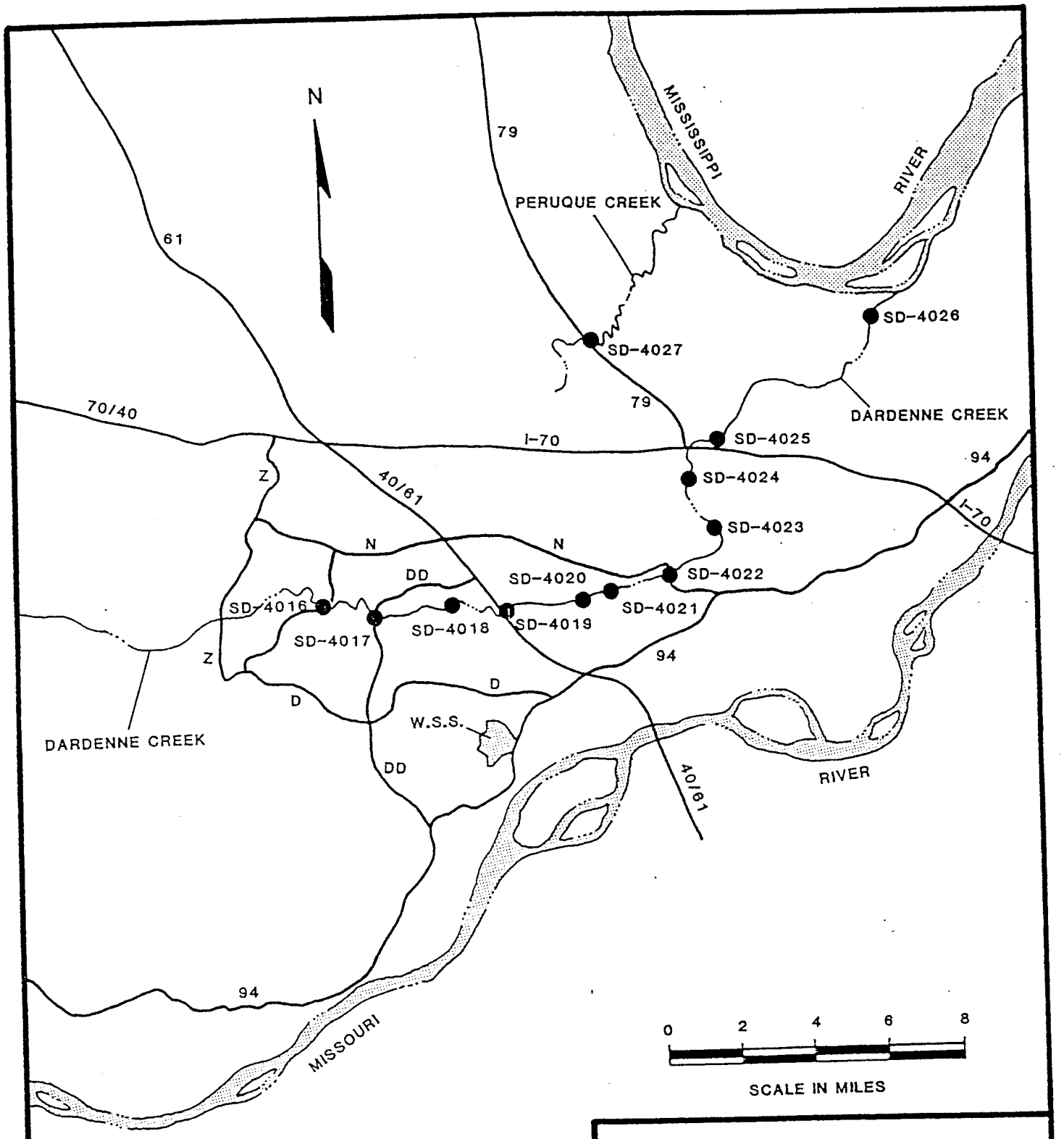


FIGURE 2-2

STREAM SEDIMENT SAMPLING LOCATIONS. - SCHOTE CREEK AND BURGERMEISTER SPRING STREAM -

LAKE AND STREAM SEDIMENT SAMPLING PLAN.

SOURCE: PMC,1987



● - URANIUM SAMPLING LOCATION
33% RADIUM, THORIUM ANALYSIS

FIGURE 2-3

STREAM SEDIMENT SAMPLING LOCATIONS. - DARDENNE CREEK -

LAKE AND STREAM SEDIMENT SAMPLING PLAN.

SOURCE: PMC,1987

2.2.4 Southeast Drainage Easement

Six locations (SD-4061 to SD-4066) along the drainage easement will be sampled. The locations are shown on Figure 2-4.

2.3 Lake Sampling Locations

Samples will be collected from 10 locations in each of the three affected lakes. Three background locations will be sampled in Lake 37 on the Busch Area. The approximate locations within the lakes are shown in Figures 2-5, 2-6, 2-7 and 2-8 for Lakes 34, 35, 36 and 37 respectively. At all locations, measurements of water depth and depth of sediment will be recorded on the Sediment Sampling Data Form (Figure 2-1) during sample collection. All samples will be analyzed for natural uranium. At least three samples per lake will be analyzed for radium-226 and thorium-230. One-third of all lake sediment samples will be analyzed for nitroaromatics. Three composite samples will be prepared from Lake 34, 35 and 36 respectively. One composite sample will be prepared from Lake 37. Each composite will be prepared by combining sediments from three to four sampling locations and sediments from the same sampling interval (i.e. 0-6", 6-12" etc.) Each composite will be analyzed for PCB's, semi-volatiles and metals.

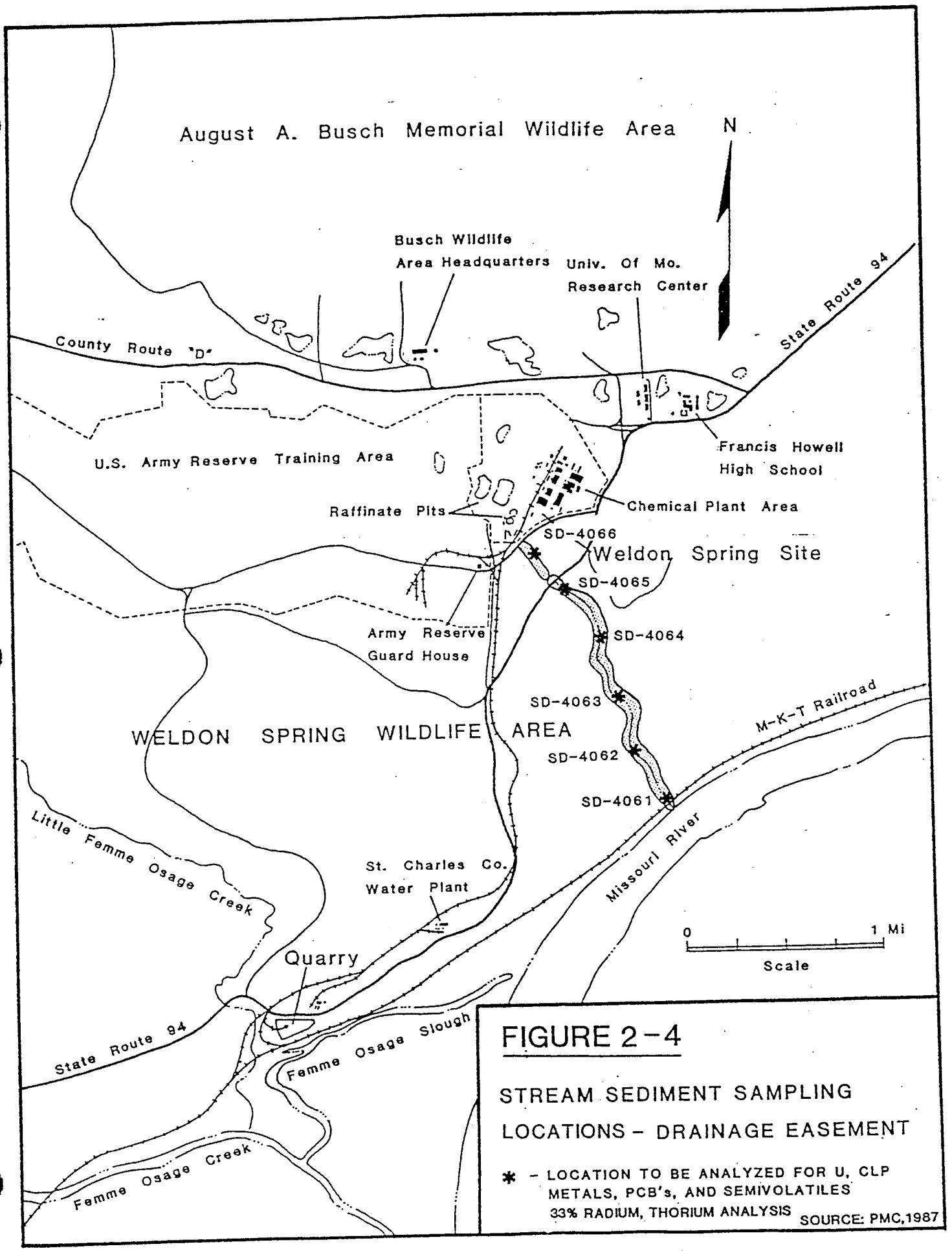


FIGURE 2-4

STREAM SEDIMENT SAMPLING LOCATIONS - DRAINAGE EASEMENT

* - LOCATION TO BE ANALYZED FOR U, CLP METALS, PCB's, AND SEMIVOLATILES
33% RADIUM, THORIUM ANALYSIS

SOURCE: PMC,1987

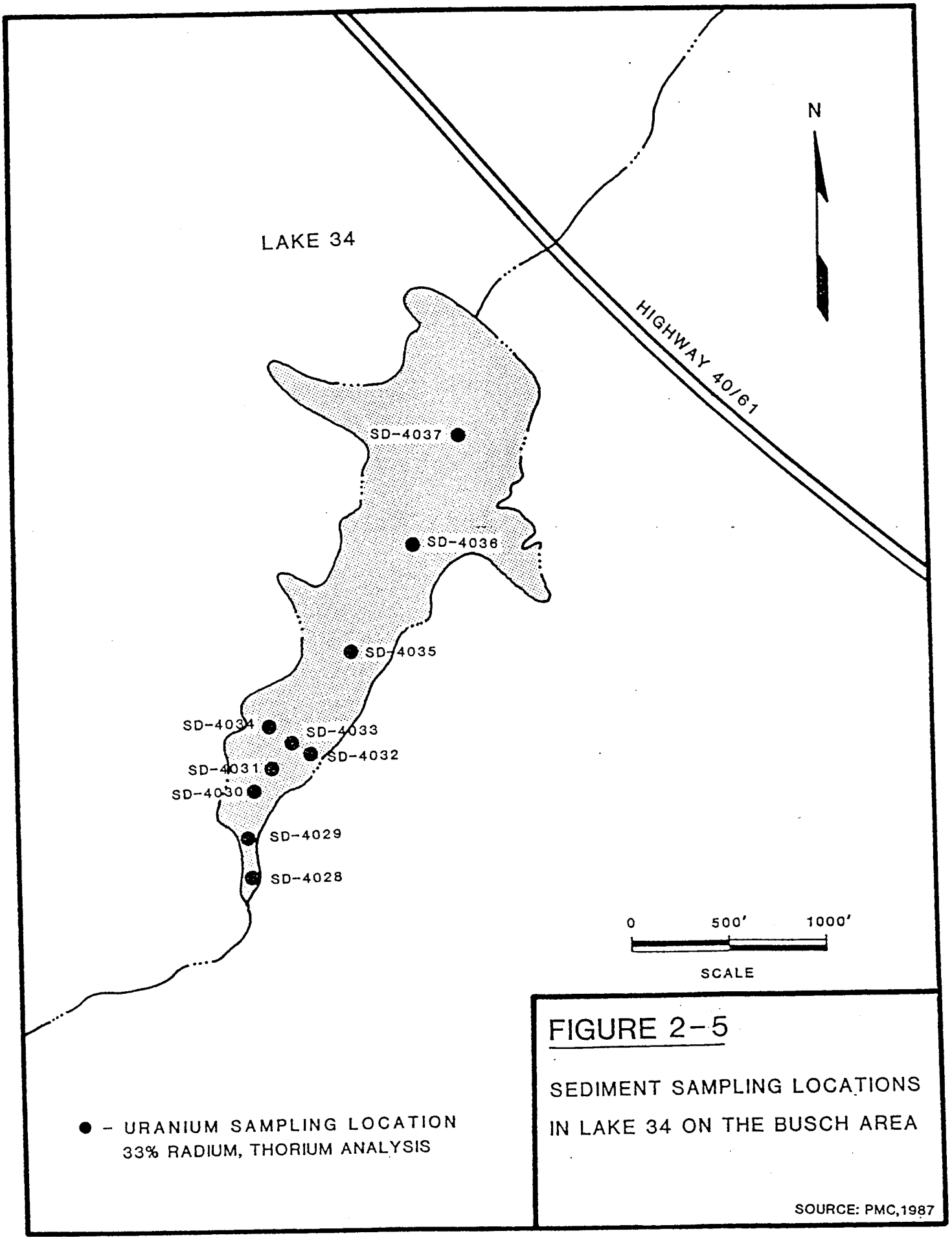


FIGURE 2-5

SEDIMENT SAMPLING LOCATIONS IN LAKE 34 ON THE BUSCH AREA

SOURCE: PMC,1987

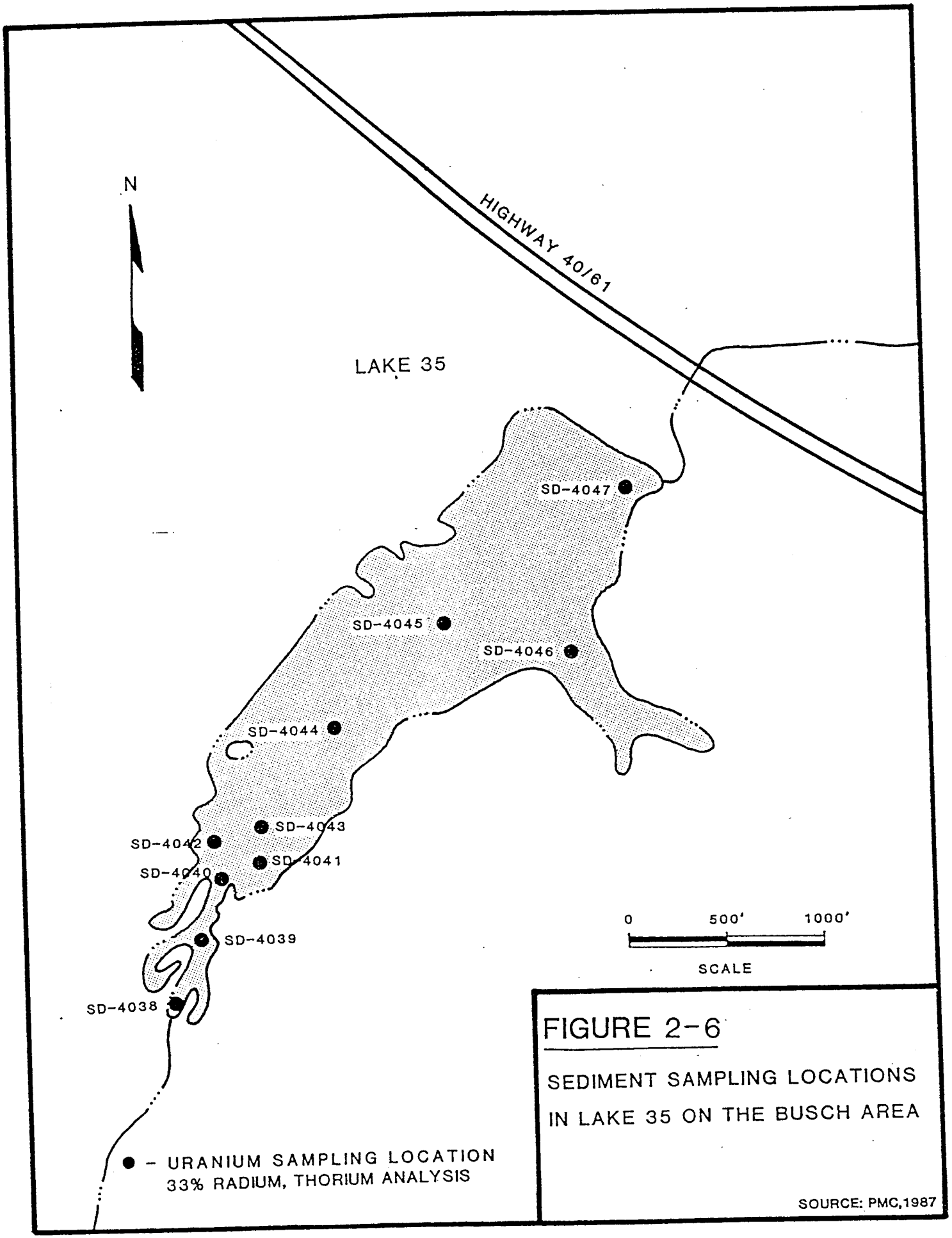


FIGURE 2-6

SEDIMENT SAMPLING LOCATIONS IN LAKE 35 ON THE BUSCH AREA

SOURCE: PMC,1987

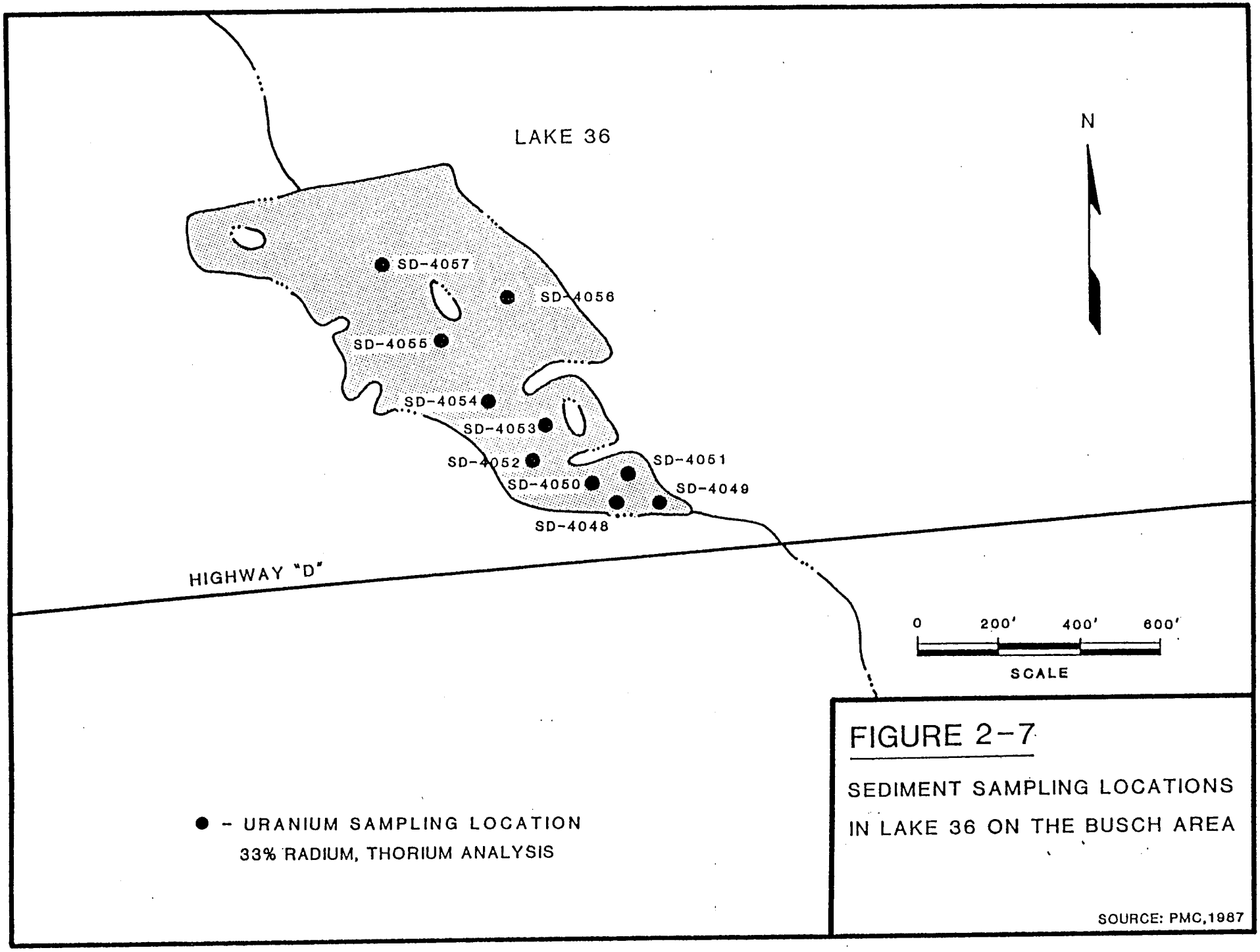
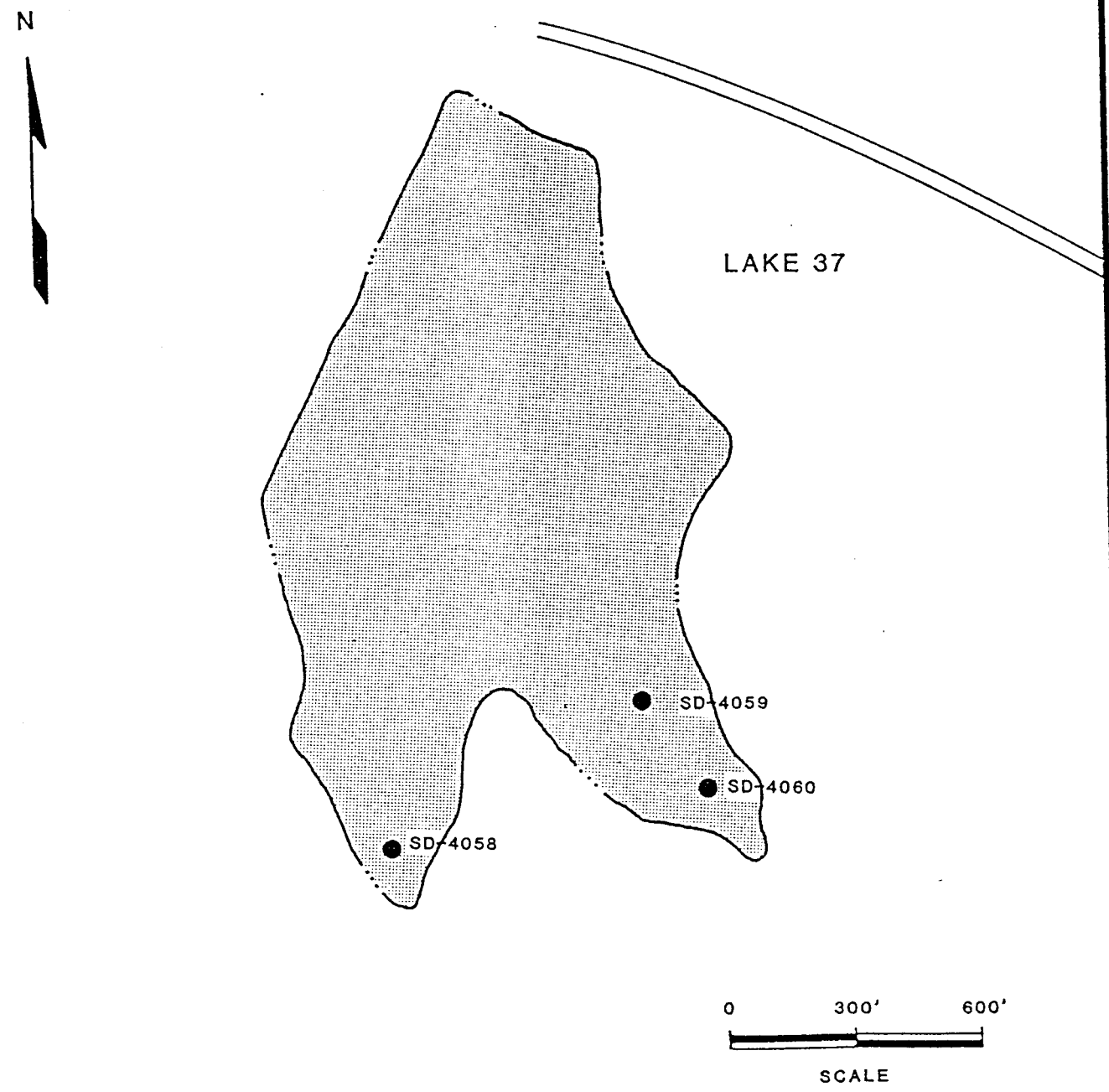


FIGURE 2-7

SEDIMENT SAMPLING LOCATIONS IN LAKE 36 ON THE BUSCH AREA

SOURCE: PMC, 1987



● - URANIUM SAMPLING LOCATION
33% RADIUM, THORIUM ANALYSIS

FIGURE 2-8

SEDIMENT SAMPLING LOCATIONS IN LAKE 37 ON THE BUSCH AREA

SOURCE: PMC,1987

3.0 ANALYTICAL PROCEDURES

Samples will be analyzed as described in Table 1.1. Metals and semi-volatiles analyses will be performed using methodology, chain of custody, and detection limits required in the USEPA Contract Laboratory Program Statement of Work. Nitroaromatic analyses will be performed according to USATHAMA methodology. Radiologic parameters will be determined following the methods and meeting the minimum detection and accuracy limits shown in Table 3-1.

TABLE 3-1

DETECTION LIMITS FOR RADIOLOGICAL PARAMETERS

SPECIES	METHODS	DETECTION LIMITS	ACCURACY * (95% CONFIDENCE LEVEL)
Uranium,Natural	EPA 908/ASTM	5 pCi/g	± 30% at 30 pCi/g
Radium-226	EPA 904	1 pCi/g	± 30% at 5 pCi/g
Thorium-230	EERF 00/07	1 pCi/g	± 30% at 5 pCi/g
Thorium-232	EERF 00/07	1 pCi/g	± 30% at 5 pCi/g

Source: WSSRAP, 1987.

* All activities reported on a dry weight basis.

4.0 QUALITY ASSURANCE

The integrity of all sediment samples shall be maintained in accordance with WSSRAP ES&H Standard Operating Procedure No. 4.01.02 (Chain of Custody). A minimum of 5 percent of the total number of samples shall be duplicates to assess analytical precision.

5.0 DATA DOCUMENTATION

Proper documentation is a fundamental element for quality assurance of this program. All sampling activities including sampling location, identification, sampling techniques and methods, decontamination procedures, and shipment of samples will be extensively documented in the field on a daily basis.

5.1 Sample Collection

Prior to sample collection, the sample location will be checked to verify that the sampling ID code used corresponds to the sampling plan station. For each sample collected, a Sediment Sampling Data Form will be completed. The data form (Figure 2.1) includes the name(s) of the person(s) collecting the sample, the time of collection, the mechanism for sampling, depth of sample, location, and discription of the sample. Sample numbering will be as defined in ES&H WSSRAP SOP 4.01.01 (Environmental Numbering System).

5.2 Chain of Custody

Custody of Samples will be maintained and documented from the time of collection to completion of analysis and reporting of data. Chain of Custody procedures are specified in the ES&H WSSRAP Standard Operating Procedure 4.01.02 (Chain of Custody).

5.3 Field Notebook

All field sampling activities will be documented through written entries into a field notebook. Field activities will be logged in on a daily and event-oriented basis.

Entries will be as detailed as possible so that, at a later date, the reader could reconstruct each event without reliance on the

memories of the field team members.

All field notebooks will be hardbound with numbered pages. Responsibility for note-taking will be assigned to specific field team personnel. Each notebook will be identified by the project-specific information recorded on the front cover:

Project Name:	WSSRAP Lake/Stream Sediment Characterization
Start Date:	
End Date:	
Responsibility:	Name of person to whom the notebook is assigned.

Entries into the notebook will contain a variety of information. At the beginning of each entry, the date, start time, weather, all field personnel present, level of personal protection being used onsite, and the signature of the person making the entry will be entered. The names of property owners approached for access, agency personnel present, and all field sampling team personnel will be recorded in the field notebook.

All measurements made and samples collected will be recorded. All entries will be made in waterproof ink and no erasures will be allowed. If an incorrect entry is made, the information will be crossed out with a single strike mark. Wherever a sample is collected or a measurement is made, a detailed description of the location of the station, which includes compass and distance measurements, shall be recorded. The film roll number and number of photographs taken of the station will also be noted. All equipment used to make measurements will be identified, along with the date of calibration.

5.4 Photographs

Photographs will be taken of each sampling location at the time

of sampling (except lake locations). These photographs will document the position of each location in relation to local surroundings and prominent reference points. Photographs will be taken of groups of soil sampling locations where each location is clearly visible. The frame, roll number and compass heading (e.g., N, NE, NW, etc.) of each picture will be logged into the field sampling notebook along with the other site location information.

In addition to documenting each sampling location with photographs a photographic record also will made of the sediment collected at each location. A reference (such as a ruler) and identification label will be used to identify the sample, depth and physical description of the interval sampled.

6.0 REPORTING REQUIREMENTS

After the analytical results are received from the laboratory, a data report will be prepared to present the findings from this study and to interpret the data. This report will show actual sampling locations, sampling method, field data, and analytical results. It will also be used to make recommendations regarding further sampling and/or continued monitoring. This report will provide information from which a decision can be made regarding the necessity for cleanup of sediment in these surface water bodies.

CHEMICAL PLANT
201-1.04

DOE/OR/21548-013

United States Department Of Energy

WELDON SPRING SITE REMEDIAL ACTION PROJECT CHEMICAL SOIL INVESTIGATION SAMPLING PLAN FOR THE WELDON SPRING CHEMICAL PLANT / RAFFINATE PITS

REV. 1

MAY, 1988

WELDON SPRING SITE REMEDIAL ACTION PROJECT

WELDON SPRING SITE REMEDIAL ACTION PROJECT

CHEMICAL SOIL INVESTIGATION SAMPLING PLAN FOR THE WELDON SPRING CHEMICAL PLANT/RAFFINATE PITS

PREPARED FOR:

U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE
UNDER CONTRACT NO. DE-AC05-86OR21548

PREPARED BY:

MK-FERGUSON COMPANY

AND

JACOBS ENGINEERING GROUP

ROUTE 2, HIGHWAY 94 SOUTH

ST. CHARLES, MISSOURI 63303

MAY, 1988

1.0 INTRODUCTION

1.1 Purpose

The purpose of this Chemical Soil Investigation Sampling Plan is to provide a systematic approach for chemically characterizing soils at the Weldon Spring Chemical Plant/Raffinate Pits (WSCP/WSRP) areas in support of the overall Site Characterization Plan. The Chemical Soil Investigation Sampling Plan is designed to determine the extent and magnitude of chemically contaminated soil, evaluate contaminant migration pathways, document uncontaminated areas, and identify soil contaminant concentrations in qualitative and quantitative terms.

1.2 Scope

This sampling plan reviews historical information, identifies data needs and uses, and outlines sampling and analytical procedures, quality assurance methods, and data documentation and reporting requirements for soil investigations at the Weldon Spring Site (WSS).

The scope of this sampling plan is limited to the chemical characterization of soil contaminants in the 220-acre area of the WSCP/WSRP. The Weldon Spring Quarry (WSQ) and vicinity properties will be addressed as Interim Response Actions (IRAs) and are not included under this plan. This plan is not intended

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to provide a vadose zone characterization or geotechnical information. Radiological soils characterization was completed in 1987, the conclusions of which are summarized in this sampling plan.

The area in and under the raffinate pits is not addressed in this sampling plan. The raffinate pit wastes will be characterized under the Waste Sampling Plan - Raffinate Pits. Any characterization of soil underlying the raffinate pits will be performed following waste removal to avoid risk of leakage from the WSRP. All waste material will be excavated to meet applicable guidelines and standards determined in the Baseline Risk Assessment. The need for chemical characterization of soils underlying the pits will be evaluated upon completion of soils data interpretation.

The need for chemical characterization of soils underlying existing buildings and along process sewer lines will be evaluated based on the results of this investigation. Any required characterization will be performed following removal of buildings and process sewers.

2.0 BACKGROUND

2.1 Site Description

The WSCP/WSRP is located in St. Charles County, Missouri, approximately 30 miles west of St. Louis and 14 miles southwest of St. Charles as shown in Figure 2-1. The site is situated on Missouri State Highway 94, about two miles southwest of the junction of Highway 94 and U.S. Routes 40 and 61. The WSCP/WSRP is surrounded by state and federally owned lands. It is adjoined on the west by the Weldon Spring Training Area (WSTA) and on the east, north and south by Missouri Department of Conservation (DOC) lands.

The communities of Weldon Spring and Weldon Spring Heights are located approximately two miles from WSCP/WSRP with a combined population of 200. A significantly larger population within close proximity of WSCP/WSRP includes the St. Louis metropolitan area with a population exceeding 2.5 million, and St. Charles with a population of over 36,000.

The geology of the area is predominantly clayey and silty soils overlying weathered limestone bedrock. The limestone bedrock contains solution-enlarged joints and fractures. In general, groundwater movement in the area is toward the north.

The best aquifer for potable water is the St. Peter Sandstone,

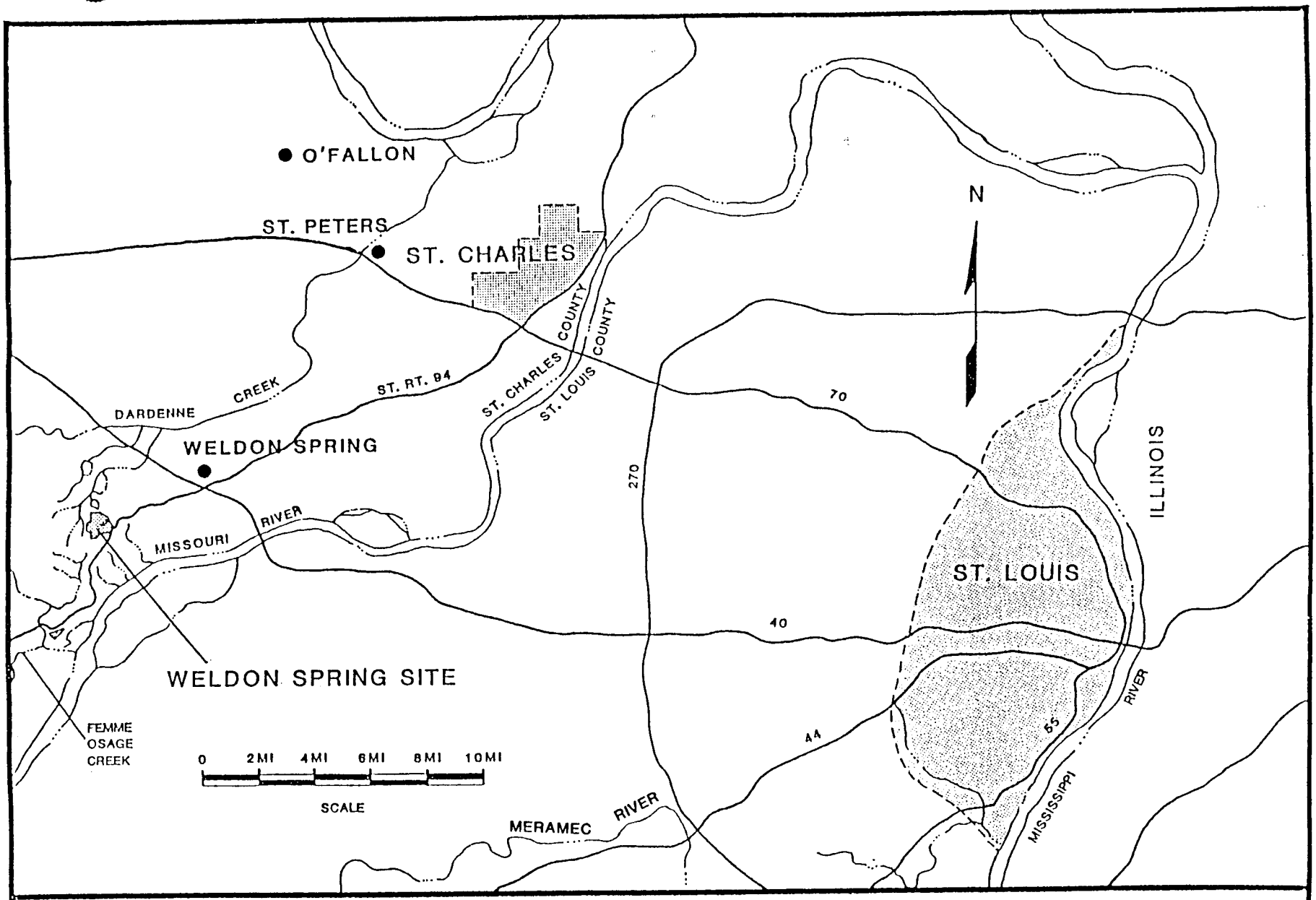

FIGURE 2-1

LOCATION OF THE WELDON SPRING SITE

approximately 600 feet below the surface at WSCP/WSRP. Two other aquifers of significance are the Burlington-Keokuk, about 200 feet thick and 60 feet below the surface, and the Sulfur Springs (Bushberg Sandstone), about 50 feet thick and 400 feet below the surface.

2.2 Site History

The site history, including previous decontamination efforts from 1941 to 1987 is summarized below. A more detailed history of WSS operations is included in Sections 2.2.1 - 2.2.4.

In April of 1941, the Department of the Army (DA) acquired 17,232 acres of land, and from November 1941 through January 1944, Atlas Powder Company operated a trinitrotoluene (TNT) and dinitrotoluene (DNT) explosives production facility known as the Weldon Spring Ordnance Works (WSOW). The 17,232-acre WSOW was closed and declared surplus to Army needs in April 1946. By 1949, all but approximately 2,000 acres had been transferred to the State of Missouri (August A. Busch Memorial Wildlife Area) and the University of Missouri (agricultural land). Except for several small parcels transferred to St. Charles County, the remaining property became the Weldon Spring U.S. Army Reserve and National Guard Training Area (WSTA).

Through a Memorandum of Understanding between the Secretary of the Army and the General Manager for the Atomic Energy Commission

(AEC) in May 1955, 205 acres of the former WSOW were transferred to the AEC for construction and operation of the Weldon Spring Uranium Feed Materials Plant (WSUFMP) to process uranium and thorium ore concentrates. Considerable explosives decontamination was performed by Atlas Powder and the DA prior to WSUFMP construction (DA, 1976).

The WSUFMP processed uranium and thorium ore concentrates from 1957 to 1966 with Mallinckrodt Chemical Works - Uranium Division as the AEC Operating Contractor. This facility consisted of 13 major process buildings and approximately 30 support structures as shown in Figure 2-2. The AEC closed the WSUFMP in December of 1966 when the facility was determined to be in excess of their needs.

On August 7, 1967, the AEC facility was selected as the site for a herbicide production facility, later known as the Weldon Spring Chemical Plant (WSCP). The Army was granted a license from the Nuclear Regulatory Commission (NRC) for the source material that was present as contamination throughout the site. On December 31, 1967, 169 acres of property and improvements were transferred to the Kansas City District-U.S. Corps of Engineers, which was responsible for the design and construction of the herbicide facility. The 52-acre WSRP and the WSQ remained under AEC control.

Decontamination and dismantling operations were initiated in

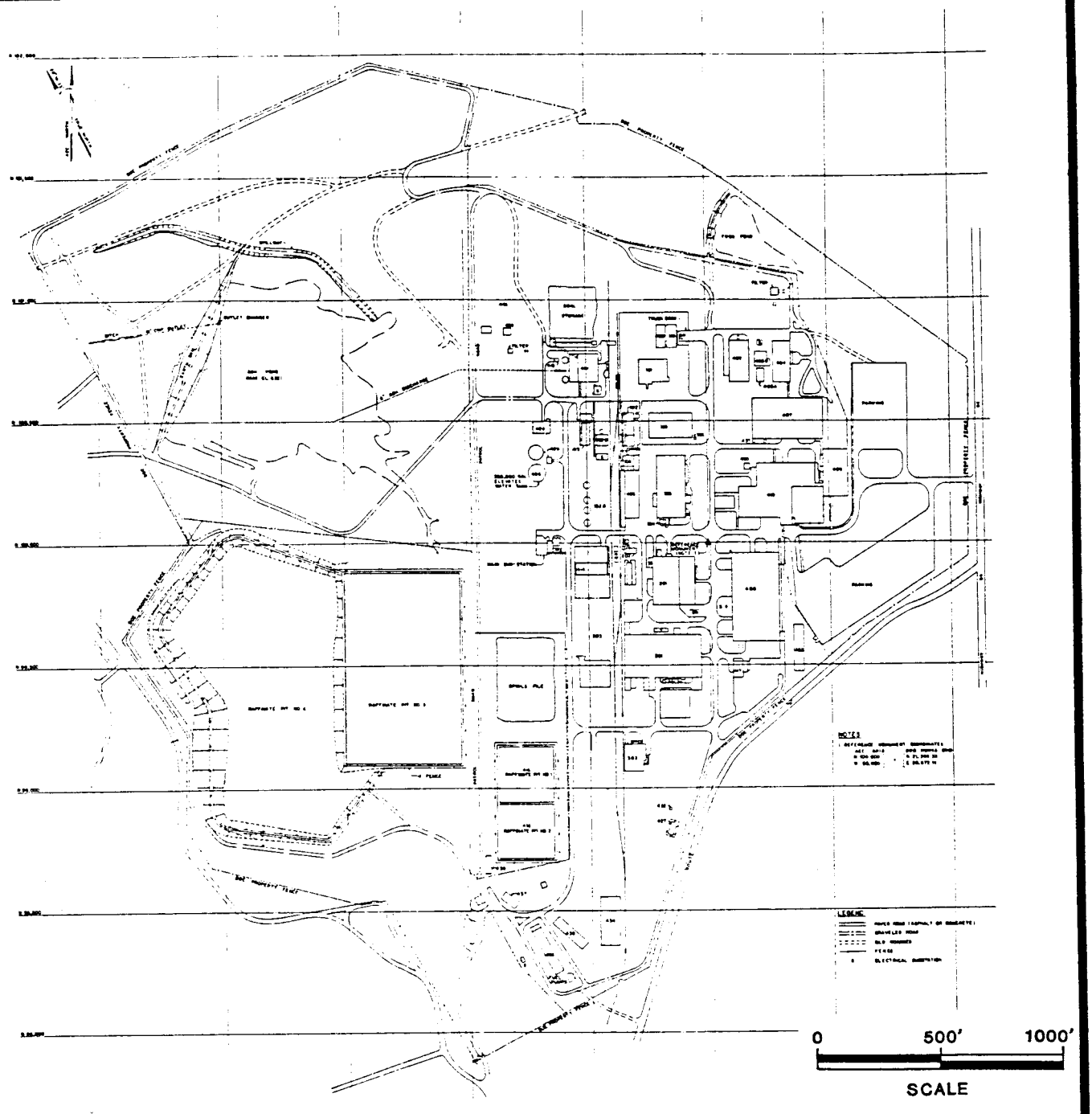

FIGURE 2-2

WSCP / WSRP

January 1968, by Thompson-Stearns-Roger Corporation (TSR), the Army's prime contractor for design and construction of the herbicide facility. Although some progress was made in decontaminating areas required for herbicide production equipment, the project was cancelled in February 1969 due to costs required to meet radiological contamination limits imposed on the facility and to the reduction of the military's requirements for herbicide.

The herbicide project was cancelled before any process equipment was installed for production. The DA retained the responsibility for the land and facilities at the WSCP.

The AEC contracted with National Lead Company of Ohio (NLO) to periodically visit the WSRP to perform environmental monitoring, maintain the pit embankments, and perform maintenance and surveillance tasks as necessary. In October 1981, Bechtel National, Incorporated (BNI), under contract to DOE (successor to AEC), assumed management responsibility for the WSRP and WSQ from NLO.

In November 1984, the DOE was directed by the Office of Management and Budget to assume custody and accountability for the WSCP from the DA. This transfer occurred on October 1, 1985.

In February 1985, DOE proposed designating the control and decontamination of the WSRP, WSCP, and WSQ as a major project.

Designation was effected by DOE Order 4240.1E dated May 14, 1985. A Project Management Contractor (PMC) for the Weldon Spring Site Remedial Action Project (WSSRAP) was selected in February 1986. In July 1986, a DOE Project Office was established on site. The PMC, MK-Ferguson Company, assumed control of the WSS on October 1, 1986.

2.2.1 Weldon Spring Ordnance Works: 1941-1949

The Atlas Powder Company operated the WSOW from November 1941 through January 1944. The complex consisted of 18 TNT and two DNT explosives manufacturing plants which were built within the borders of what is now the WSCP and WSTA. Figures 2-3 and 2-4 display the original WSOW layout and the current ownership, respectively. The first three TNT plants, and a portion of a fourth were built on what is now the WSCP/WSRP. Plate 1, bound at the back of this report, shows the locations of the TNT plants, roads, and process lines relative to the current WSCP/WSRP location.

At peak operation, the WSOW required 48 to 50 million gallons of water per day. In addition to the great quantities of water used for washing and mixing the chemicals, the process of manufacturing TNT and DNT also requires large quantities of nitric and sulfuric acids, and a chemical solution called sellite (sodium sulfite). The huge volume of wastewater generated at the WSOW caused the surface waters to become

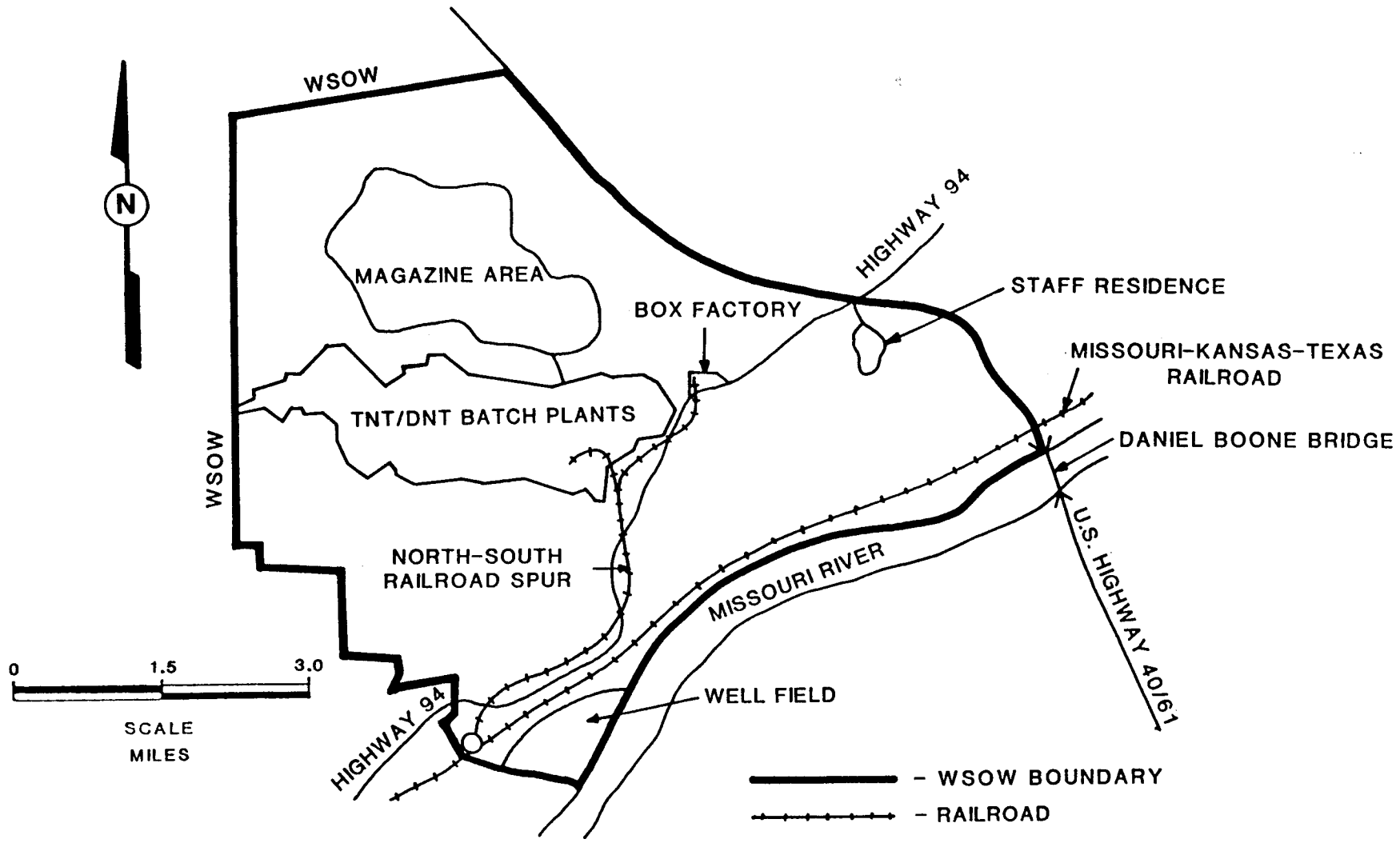

FIGURE 2-3

ORIGINAL WSOW LAYOUT

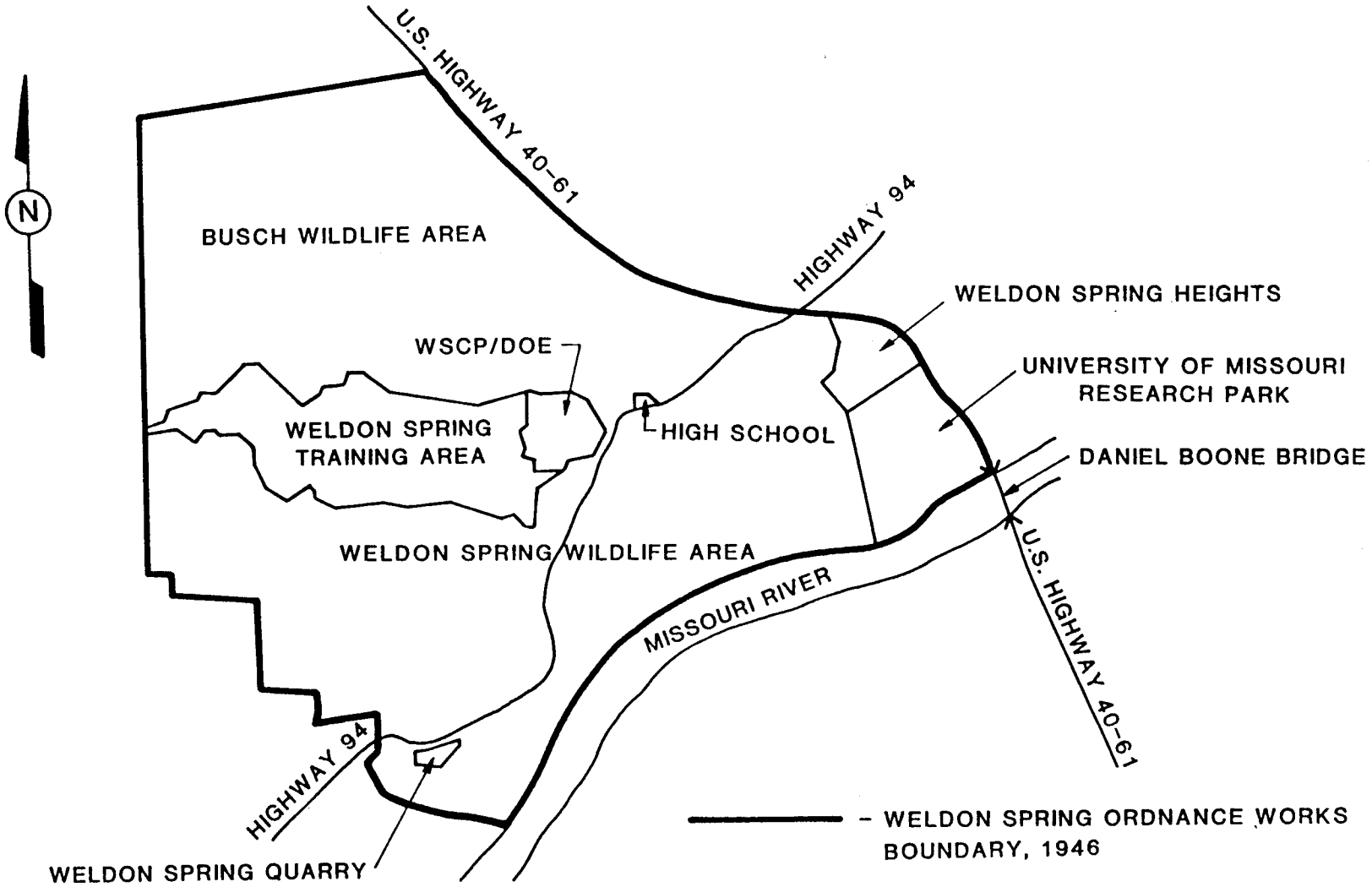

FIGURE 2-4

CURRENT DISPOSITION OF WSOW PROPERTY

polluted with TNT and DNT. Prior to construction of wastewater treatment plants in 1943, wastewater was discharged into seven lagoons for temporary storage. In December 1943, the Army drained and earth-filled four lagoons. The remaining three were drained but not filled at this time (USGS, 1944).

Water and wastewater lines served each batch plant. Separate wastewater lines were used for chemical waste and for sewage. The chemical wastewater lines carried red and yellow wastewater from each batch plant to various locations where the lines terminated. An estimated 66,000 linear feet of wooden wastewater lines were laid at the WSOW. The pipelines were generally made of cypress wood constructed similar to barrels with metal bands for support and were 10 feet or less in length. The lines discharged into wastewater treatment plants used to collect wastes for land disposal.

At the request of the War Department, the USGS conducted an investigation of groundwater and surface water contamination from TNT and DNT waste products. The contamination source was originally believed to be waste lagoons constructed to store wastewater. Subsequent field observations by the USGS revealed that wastewater was also discharged into ditches and streams, and that wastewater lines and catchment tanks frequently overflowed. A 1944 report by Fishel & Williams titled "The Contamination of Ground and Surface Waters by Liquid Wastes from the Weldon Spring Ordnance Works, Missouri," indicates a potential for soil

contamination along wastewater lines, in surface drainages, near production areas, at waste lagoons and wastewater catchment tanks.

The wastewater treatment plants were used to evaporate the wastewater into a sludge. The sludge was then hauled to open burning grounds for incineration. Eight burning grounds were used at WSOW. Seven of these areas are located off of the WSCP. One area, number five of the original eight, is thought to be located within the WSCP area and is shown in Figure 2-5. The WSOW temporarily ceased operations in January 1944, for approximately six months; then the DA reactivated it and operated it until the end of World War II.

Under the reactivation program at the WSOW, equipment in line No. 18 was cannibalized for use in other lines. Lines No. 2 and No. 3 were reassembled, but were never placed in operation. In addition, the WSOW produced a new type of TNT under the reactivation program. In January 1946, an Ordnance Review Board (ORB) was created to determine the disposition of contaminated buildings and equipment at various ordnance plants. In April 1946, the ORB declared the WSOW surplus property and transferred it to the War Assets Administration (WAA) on September 1, 1946. The WAA was organized to dispose of surplus U.S. government property.

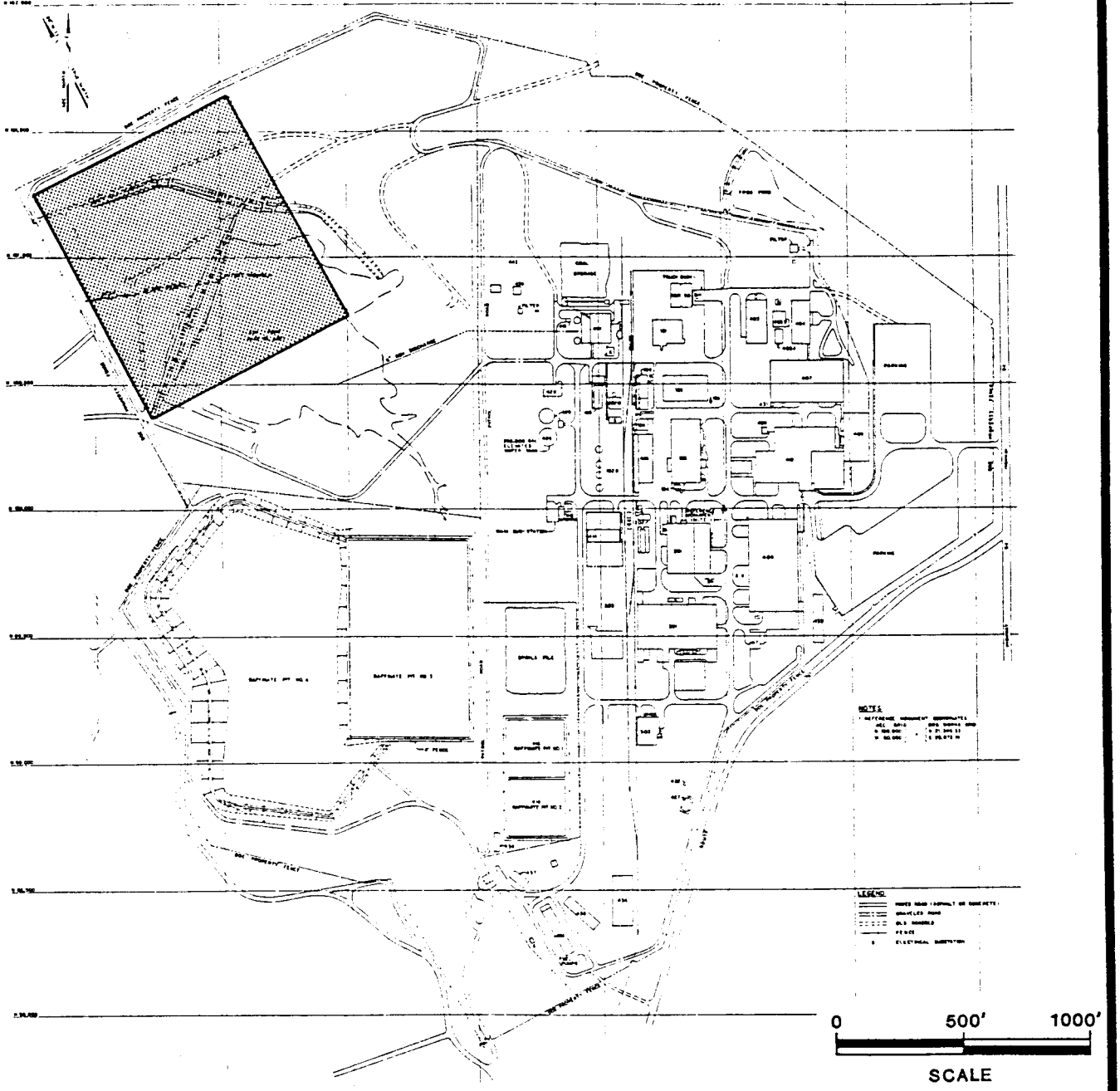

FIGURE 2-5

BURNING GROUND AREA

The first effort to decontaminate the WSOW was made by Atlas Powder Company in 1946. Atlas presumably decontaminated all equipment in accordance with accepted standards for stand-by service. In the fall of 1946, however, several fatalities occurred as a result of using improperly decontaminated equipment. Therefore, the ORB recommended that any processing equipment in direct contact with TNT, DNT or their intermediates be considered hazardously contaminated. In addition, the Board recommended removal of all earth known to be contaminated around processing buildings, catch tanks and similar areas. In 1946, following these recommendations, the Kansas City District of the Army Corps of Engineers removed 3,512 cubic yards of earth, burned 113,005 pounds of hand-picked TNT and 40 tons of TNT and other residues in place. It is not known if the Corps deposited this earth in the magazine area, the quarry, the burning grounds or somewhere else. In addition, many buildings were burned or otherwise destroyed. At the conclusion of this decontamination effort, the Corps published a report entitled: "Survey Covering Salvageable Equipment and Buildings in TNT Area at Weldon Spring Ordnance Works," Kansas City District Corps of Engineers, December 7, 1946 (USATHAMA, 1977). Of the more than 800 buildings comprising the WSOW, the Corps burned or demolished approximately 200 buildings. These 200 buildings were considered contaminated with explosives. It has been discovered much later that many of the 800 buildings at the WSOW contained asbestos insulation. This suggests the possibility of asbestos contamination in the remains of destroyed buildings.

2.2.2 Land Transfers: 1949-1954

In 1949, much of the original WSOW was sold to the public. The University of Missouri received approximately 8,000 acres for agricultural use (southern half of the WSOW). Subsequently, this land was purchased by the Missouri Department of Conservation (DOC)--the present owners. The DOC received about 7,000 acres and created the August A. Busch Memorial Wildlife Area (Busch Area- northern half of WSOW). St. Charles County Public Schools received about 40 acres, where Francis Howell High School now stands. The WAA was the grantor in all these transactions. In 1950, the General Services Administration (GSA), as successors of the WAA, took custodial control of the remaining 2,000 acres at Weldon Spring. The GSA conducted a renovation project to restore some buildings and equipment.

The GSA transferred the remaining 2,000 acres of WSOW land to the DA in July 1954, as part of the National Industrial Plant Reserve.

2.2.3 Uranium Feed Materials Plant: 1954-1966

In 1954, the Atomic Energy Commission (AEC) expressed an interest in using the area for the Weldon Spring Uranium Feed Materials Plant (WSUFMP). The Army agreed to transfer 205 acres to the AEC in 1955. Prior to transfer, decontamination operations were performed. These operations were limited to decontaminating only the 205-acre area transferred to the AEC. As a result of this

decontamination operation, it was assumed that all underground wastewater lines were removed from the WSCP/WSRP to the perimeter of the WSTA fence (USATHMA, 1977).

To ensure complete decontamination of underground process lines, trenches were dug 360 degrees around each foundation to locate any remaining underground lines that might be contaminated. Additional trenching was performed in adjacent areas where there was a potential for underground lines or contaminated residue collection points. Contaminated lines and materials located were removed and destroyed by flashing (burning with a flamethrower). It was discovered that as many as four underground lines remained around certain buildings because broken lines were neither repaired nor removed when bypass lines were installed. The new replacement lines were probably never mapped since production of explosives was top priority while the installation of waste lines was occurring. Large deposits of explosive materials were found in the pipelines that were located and removed in 1955. It was also reported that chunks of TNT, measuring approximately 36 inches in diameter and 18 inches thick, were removed from catch basins. (Campbell, 1986)

Contaminated materials were burned (presumably in the burning grounds area) and conveyed to designated storage areas as noncombustibles. Uncontaminated useful materials such as wood, utility poles and fire hydrants were salvaged for future use. Excess materials were accumulated and later sold as scrap. The

following list indicates the major work items performed (USATHAMA, 1977):

o Structures burned	59
o Structures removed by wrecking	8
o Structures remaining (uncontaminated)	2
o Underground piping removed, linear feet (estimated)	21,500
o Poles and supports removed (estimated)	1,600
o Poles salvaged	815
o Process equipment delivered to U.S. Army, items	33
o Contaminated earth removed, cubic yards (estimated)	28,250
o Concrete foundations removed, cubic yards (estimated)	1,400

The decontamination work above is described in very general terms in an AEC document on site preparation for construction of the WSUFMP (DA, 1976). After decontamination was completed, the DA transferred 205 acres to the AEC in August 1956. This land was to revert back to the DA whenever the AEC operations ceased.

To prepare the site for construction after the decontamination process, extensive cut and fill grading was performed across the site. Plate 2 shows the location of cut and/or fill grading relative to the current WSCP locations and topography.

The AEC contracted with Mallinckrodt Chemical Works to operate the WSUFMP. Operations which produced uranium metal from processed uranium ore began in June 1957, and ceased on December 31, 1966. The plant consisted of numerous buildings and four waste pits, called "raffinate" pits. The AEC also acquired the WSQ located four miles south of the WSCP/WSRP which was used to dispose of radiologically contaminated waste materials.

The WSUFMP, as first constructed, contained only two raffinate pits. The third and fourth pits were constructed in 1958 and 1964, respectively. The pits were used to deposit radioactive process waste from the WSUFMP. The Army transferred another 15 acres to the AEC for construction of the fourth pit. The land was carefully chosen to avoid taking any land contaminated with explosives, avoiding another decontamination operation. All waste pits were elevated to prevent surface drainage from entering the pits. Although the pits are located on the north side of the drainage divide between the Mississippi and Missouri rivers, indicating drainage into the Mississippi River watershed, the pits were designed in such a manner that allowed discharge into the Missouri River watershed, south of the divide. Decant from the pits (supernatant liquid after deposition of raffinate sludge) originally flowed into plant effluent and then to the southeast drainage easement. (When the AEC acquired the land for the WSUFMP in 1956, they obtained a drainage easement for the plant sewer outfall. This easement begins at the southeast corner of the plant and continues to the Missouri River. The DOC

owns the intervening land comprising this sewer outfall, however, the Army has retained control of the easement.)

The WSCP was transferred back to the Army in 1967 after the WSUFMP closed.

2.2.4 Weldon Spring Chemical Plant: 1967-1969

In August 1967, WSCP was selected for a herbicide orange (also known as "Agent Orange") facility because of the immediate need for herbicide in Southeast Asia. The Kansas City District-U.S. Corps of Engineers was responsible for design and construction of the facility and contracted with TSR Corp. for design and construction. The Army received a license to possess the radioactive material present as contamination on the site, but the WSQ and the WSRP remained under AEC control. However, the Army received permission from the AEC to dispose of radiologically contaminated equipment in the quarry and to pump plant waste into Raffinate Pit No. 4 with prior clearance from the AEC (DA, 1976).

In an amendment to the license, the Army specified that levels of radioactivity after decontamination were to be below the approved standards at the time. Due to these limits, the project was delayed and costs increased.

In January 1968, TSR Corporation took occupancy of the WSCP, and by February, decontamination and equipment removal had begun in Buildings 103 and 105 (Figure 2-2). Although progress was made, by January 1969, the estimated costs for completing the project had risen to 293% of the original bid, from approximately $10 million to over $30 million. At the same time, military demands for the herbicide were reduced. As a result, the project was cancelled in February 1969.

During decontamination operations, 20 railcars of stainless piping were shipped to National Lead Company of Ohio and about 900 truckloads containing 6,000 cubic yards of uranium-contaminated material were buried at the quarry. Furthermore, an unknown quantity (something less than 80 railcars) of radioactive material was shipped to Tennessee for reclamation.

2.2.5 Current Status: 1969-1988

Following the cancellation of the herbicide project in 1969, the WSCP remained under DA control and the WSRP was administered by the AEC. Only general maintenance activities such as mowing were performed from 1969 to 1987. Various characterization activities were performed by both the DA and AEC during this time. No decontamination or decommissioning efforts were performed during this period.

2.3 Physical Properties of Soil

Two previous studies at the WSCP/WSRP have established the current understanding of area soils and their physical properties. These studies, performed by Bechtel National in 1983-84 and 1986-87, defined on-site geology at the WSRP and WSCP respectively. The 1983-84 study focused on the 52-acre WSRP area. Soil samples were analyzed for grain size, laboratory hydraulic conductivity and several strength tests. The 1986-87 study evaluated the 169-acre WSCP and incorporated data from the previous report. Additional soil samples were collected and analyzed for liquid and plastic limit, grain size, unit weight, specific gravity, moisture content, centrifuge moisture equivalent, effective cation exchange capacity (CEC) and distribution ratio. Additional soil parameters were calculated including: void ratio, porosity, specific retention, specific yield, saturation and activity.

These studies defined WSCP/WSRP soils and their physical properties. Soils at the WSCP/WSRP area consist of six distinct units:

- Topsoil/Fill
- Loess
- Ferrelview Formation
- Clay Till
- Basal Till
- Residuum

The topsoil/fill unit is the first soil unit encountered on-site. Topsoil ranges in thickness from a few inches up to one foot. Topsoil is typically a dark, organic-rich silty clay to clayey silt. Fill at the WSCP/WSRP is highly variable in nature, ranging from silts and clays to gravel and debris. Up to 26 feet of fill is present in some locations at the WSCP/WSRP. Related to the fill are cut areas. Up to fourteen feet of material was cut from various areas and used as fill for low areas. Cut and fill relationships are displayed in Plate 2.

Loess deposits are present over portions of the site. Their areal distribution is highly variable due to predepositional topography and postdepositional erosion. Loess thickness ranges from 0 to 10 feet.

Underlying the topsoil and/or loess units is the Ferrelview Formation, which consists of orange-yellow to brown silty clay. The Ferrelview Formation developed as a weathering product of the underlying clay till and its lateral extent is controlled by the presence of the till. Figure 2-6 presents an isopach map of the Ferrelview Formation (BNI, 1987). Thickness ranges from 0 to more than 15 feet.

The clay till unit is a glacial till deposited during Kansan glaciation composed of a yellow-brown silty clay with minor

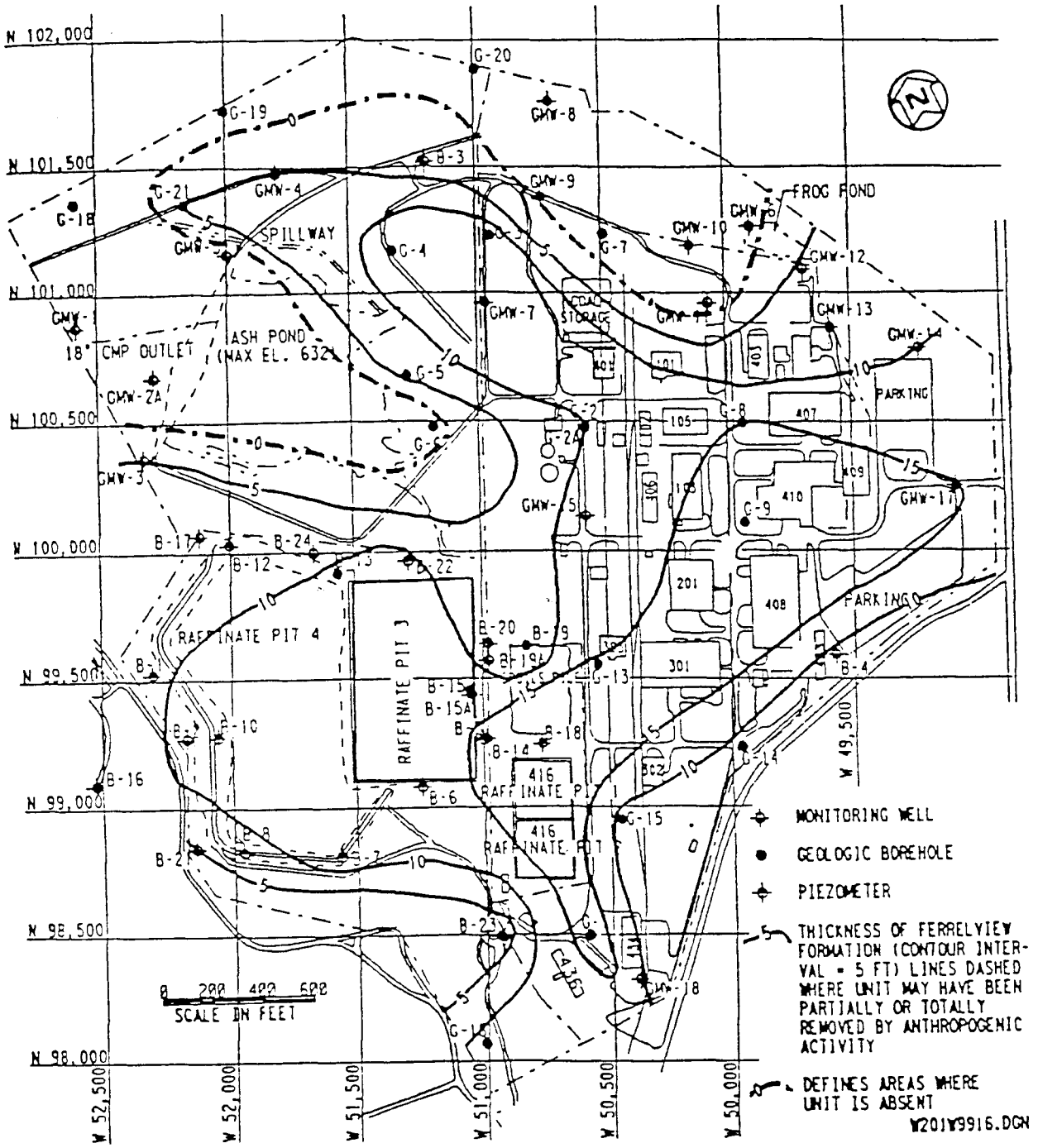

FIGURE 2-6

FERRELVIEW ISOPACH

amounts of sand and gravel. Up to 35 feet of clay till is present beneath the site, with the thickest deposits in the northern portion of the WSCP. Figure 2-7 presents an isopach map of the clay till unit (BNI, 1987).

Underlying the clay till is the basal till unit which contains greater amounts of gravel and angular chert in a clayey silt matrix. The basal till is thinnest (or absent) in areas with higher bedrock elevations. Figure 2-8 displays a basal till isopach map (BNI, 1987).

Residuum is present immediately overlying bedrock and consists of red and yellow clays with substantial quantities of chert. Thickness ranges from 0 to 23 feet for the residuum layer with the thickest deposits present in the Ash Pond area.

The average grain size distributions and Unified Soil Classification System (USCS) description for the soil units above the residium is presented in Table 2-1. Average moisture content (BNI, 1987) is also presented in this table.

Cation exchange capacity (CEC) was measured for both till units and the Ferrelview Formation. CEC values averaged 60.3 meq/100g for the Ferrelview Formation, 69.0 meq/100g for the clay till unit and 29.0 meq/100g for the basal till. The CEC is a measure of the propensity of the soil to exchange cations and retain contaminants. CEC tests indicate that the Ferrelview Formation

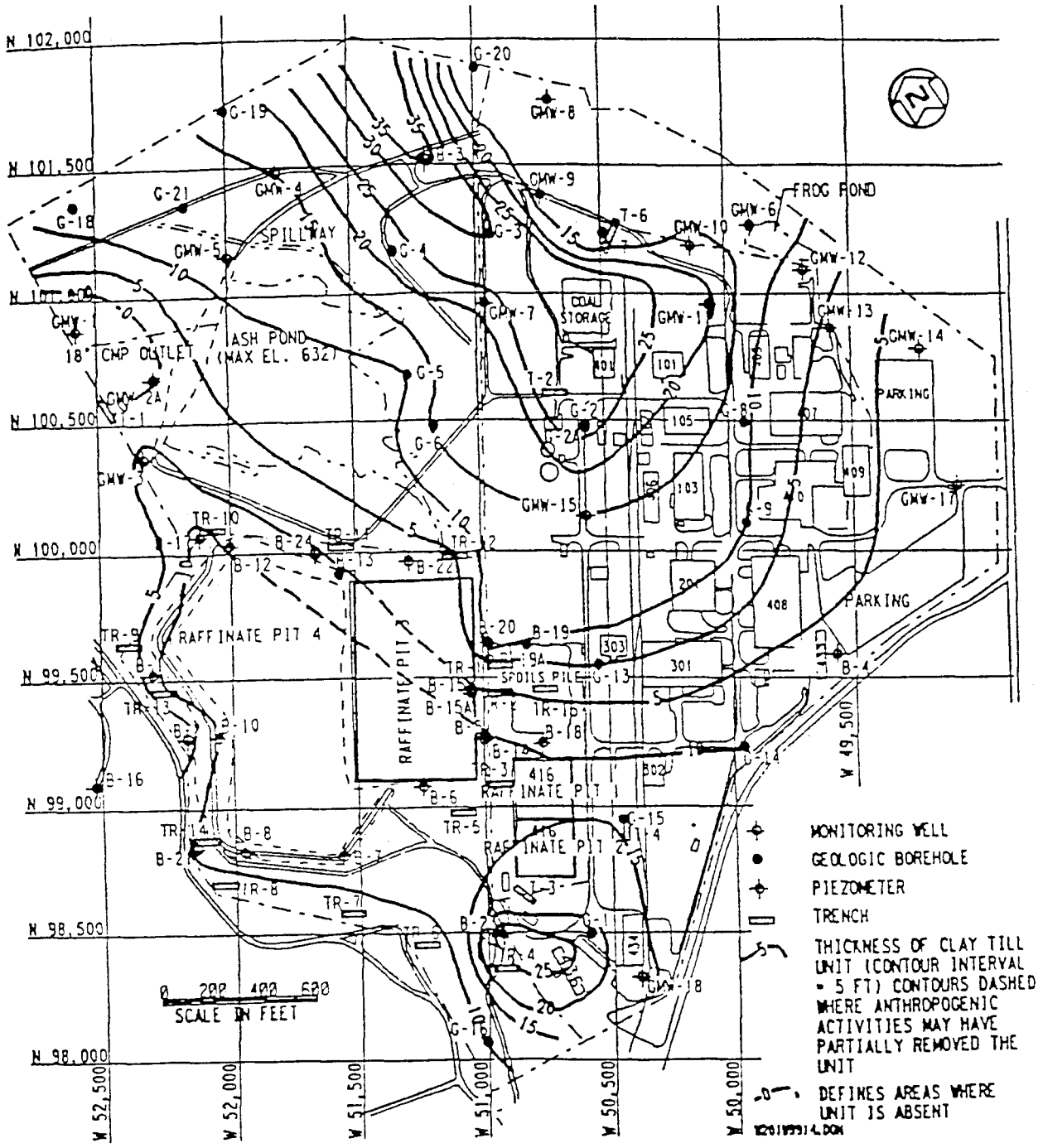

FIGURE 2-7

CLAY TILL ISOPACH

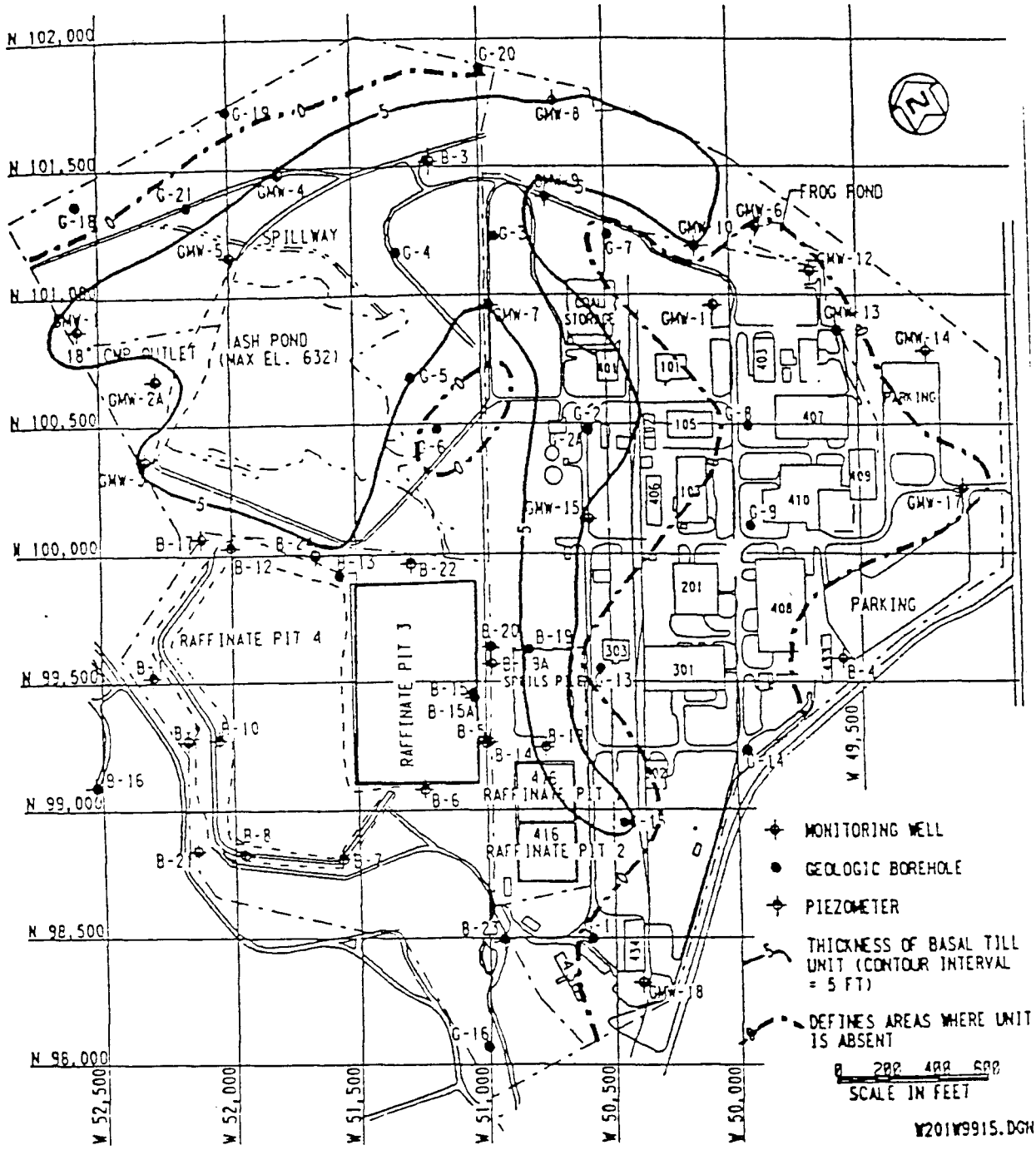

FIGURE 2-8

BASAL TILL ISOPACH

TABLE 2-1

GRAIN SIZE DISTRIBUTION FOR

SOIL UNITS

UNIT	USCS Classification	PERCENTAGE OF GRAIN SIZES GRAVEL	SAND	SILT	CLAY	MOISTURE CONTENT
Loess	CL	0	4.4	64	31.6	N.M.
Ferrelview Formation	CL-CH	2.8	9.8	49.6	39.6	24.7
Clay Till	CL	0.4	22.4	31.7	45.6	19.3
Basal Till	GC-CL	10.7	18.7	39.8	30.8	20.9
Residuum	**					

N.M. - not measured

Compiled from "Hydrogeological Characterization Report For Weldon Spring Chemical Plant," BNI 1987.

** Residuum information not available.

and the clay till are the primary soil units that can retain significant amounts of contaminants.

During the geological characterization of the WSRP performed by Bechtel National in 1983-84, soil samples were collected and analyzed for physical properties such as strength, grain size, and permeability. Since soil strength is of very limited usefulness in assessing contaminant migration, it will not be discussed in this work plan. Geotechnical properties of the soil will be addressed in detail under the Disposal Facility Siting Work Plan.

Laboratory testing indicated soil permeabilities ranging from 10-6cm/sec to 10-9cm/sec. These values are within the expected range for clay soils and clay tills. These values should be viewed as "ideal" conditions. The permeability of a clay soil unit can be increased by a number of factors including desiccation cracks, root penetration, soil jointing and chemical alteration. Individual samples may or may not be indicative of the whole unit.

Overall, natural soils above the residium at the WSCP/WSRP are low plasticity silty clays with a high CEC. They are generally "tight" and do not transmit significant amounts of water to the underlying bedrock. More permeable, preferred migration pathways may exist in the form of desiccation cracks, old borings, etc., and could potentially transmit contamination from source areas

into the groundwater. The residuum unit may also be extremely permeable.

3.0 DATA NEEDS AND USES

Soil investigations at the WSS will be performed to satisfy defined data needs. The data obtained from these investigations, applied in concert with existing data, will be used to identify contamination source areas, determine the extent and magnitude of contamination, evaluate migration pathways and document uncontaminated areas.

Section 3.1 provides information on the possible chemical contamination sources from both the WSOW and the WSUFMP. An assessment of existing chemical soil data is given relative to both operations and is followed by a discussion of data validity and the need for further data collection. Section 3.2 discusses the data needed to further define the extent and magnitude of contamination. Section 3.3 discusses potential migration pathways and the known environmental fate of specific contaminants. Section 3.4 discusses the data needed for documentation of uncontaminated areas.

3.1 Contamination Sources

The WSOW and WSUFMP operations are the two primary sources for soil contamination at the WSCP/WSRP. Since the processes at each of these plants are known, and no other materials are known to have been disposed of on-site, a detailed list of suspected contaminants can be prepared.

3.1.1 Weldon Spring Ordnance Works

WSOW TNT and DNT production consisted of treating liquid toluene with mixed nitric and sulfuric acid.

Three complete TNT production lines, and a portion of a fourth, were originally constructed in the 220-acre portion of the WSOW that later became the WSCP/WSRP. The primary suspected contaminants from WSOW are nitroaromatic residues, nitrate, sulfate, and metals. Table 3-1 lists the chemicals used in TNT and DNT production. Potential source areas include WSOW building locations, old wooden wastewater lines, spill areas, and surface drainages from process buildings.

Plate 1 presents WSOW features superimposed on existing site features.

3.1.1.1 Data Assessment of WSOW Sources

Twenty surface soil samples were taken in 1975 by the U.S. Army Chemical Demilitarization and Installation Restoration (DACDIR) team to provide a general assessment of the residual explosives present on site from previous WSOW operations. The majority of the surface and subsurface sampling points were located in areas suspected of containing the highest level of nitroaromatic contamination on-site, from building foundations, wastewater

TABLE 3-1

CHEMICALS USED IN TNT AND DNT PRODUCTION AT THE WSOW

CHEMICALS	USE(S)
Ammonia	Nitric acid production
Caustic Soda	Neutralize acidic wastewater
Chlorine*	Water treatment
Coal*	Burned for power generation
Fuel Oil	Sulfuric acid concentrating and wastewater treatment
Oleum	Used in TNT lines
Salt*	Power generation
Soda Ash*	Sellite production
Sulphur*	Sellite production
Toluene	TNT lines

*Process located outside of WSCP/WSRP

Source: WSSRAP 1987

lines, or in and around the burning ground area. Sampling locations are provided in Figure 3-1.

The samples were transported to the Battelle-Columbus Laboratories, Columbus, Ohio, for analyses (gas chromatography-electron capture). A known positive sample was also provided to verify analytical detection.

Eight subsurface soil samples (Figure 3-1) were also collected at this time by the St. Louis District - U.S. Corps of Engineers. Seven of these samples were consolidated soil taken from the top three feet of earth. The eighth sample was taken from the interface where the Ash Pond dam construction material meets the original soil surface at a depth of approximately 25 feet below the top of the dam. Ash Pond was constructed for WSUFMP use. These samples were treated identically to previously collected soil samples and were also transported to and analyzed by Battelle-Columbus Laboratories.

Sample analyses were performed by the Battelle-Columbus Laboratories. The analyses were directed toward quantitative determination of 2,6-DNT, 2,4-DNT, and TNT. The analytical results indicated low-level (low ug/kg) contamination of the soil by all three nitroaromatic compounds.

Of the 20 surface soil samples submitted, seven samples (and the known positive sample which was also submitted) were not

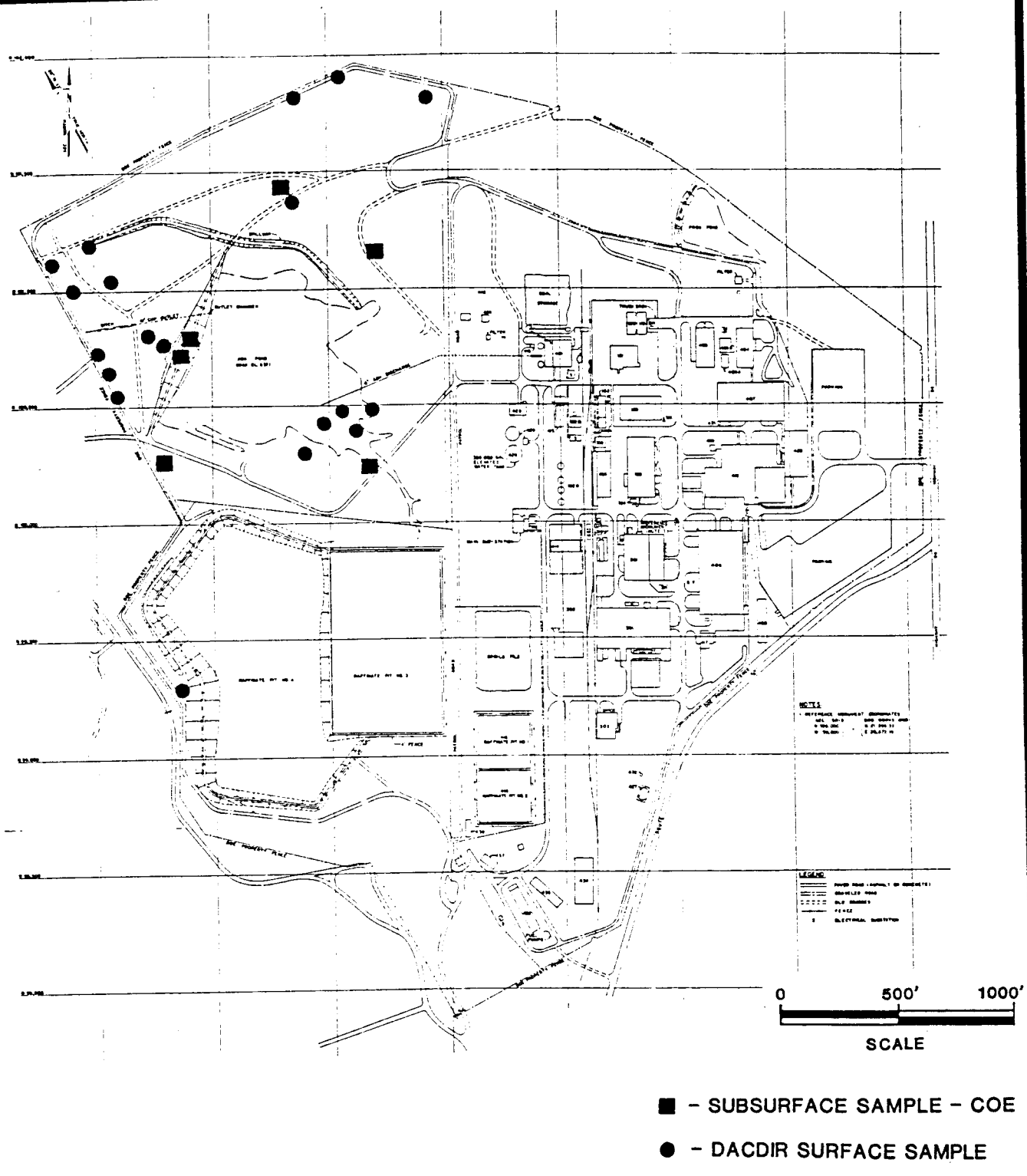

FIGURE 3-1

DACDIR SAMPLING LOCATIONS

analyzed "due to presence of some major interfering material(s) appearing in extracts of these samples." The 13 remaining samples were analyzed for 2,4 DNT, 2,6 DNT and TNT.

For the 2,6 DNT, six samples had non-detectable concentrations, and four samples had tentative identification, but less than the method detection limit of 1.0 ug/kg. The highest level detected in surface soil was 2.9 ug/kg.

For 2,4 DNT, only one sample had non-detectable concentrations, and 2 samples showed tentative identifications, but less than the method detections limit of 2.0 ug/kg. The highest level detected in surface soil was 38.3 ug/kg which was collected in the vicinity of TNT Production Line No. 4, located west of Raffinate Pit No. 4.

For TNT compounds, seven samples had non-detectable levels, and one sample had tentative identification, but was less than the method detection limit of 3.0 ug/kg. The highest TNT level detected was 32.4 ug/kg.

In the eight subsurface soil sampling locations, no interferences were found in the analytical matrixes. Seven of the eight subsurface soil samples were consolidated from the upper 1-3 feet of soil. The remaining subsurface sample was taken from 25 feet below the top of Ash Pond dam at the original WSOW topographic level.

The 2,6 DNT sample results ranged from <1.0 ug/kg to 12.9 ug/kg. For TNT, the sample results ranged from non-detectable to 292 ug/kg. Overall, the highest concentrations of nitroaromatics were identified in the Ash Pond dam (the area of the WSOW burning grounds).

This investigation established the presence of nitrated toluene compounds in WSCP/WSRP soils at concentrations in the lower microgram per kilogram range. Cross trenching operations failed to expose any remaining underground wastewater lines. Comparison of photographs taken during WSUFMP construction to WSOW wastewater lines indicate that WSUFMP construction would have encountered any unexcavated lines. While the analytical results presented do not meet current standards (see data validation discussion), significant deposits of nitroaromatics were not detected. This sampling effort did not incorporate cut and fill relationships between WSOW and WSUFMP topographies (Plate 2). This study concluded that a more extensive effort was required to assure total decontamination and removal of hazardous explosives material.

3.1.1.2 Data Validity and Assessment

Complete Quality Assurance/Quality Control (QA/QC) information is unavailable for the soil sampling efforts performed by the DACDIR in 1975. Limited analytical information is available in the 1976 Assessment of Weldon Spring Chemical Plant (DA, 1976).

The procedures utilized by the Battelle-Columbus Laboratories in 1975 are not consistent with the current semi-volatile analyses for 2,4 DNT and 2,6 DNT identified in SW-846 - Method 8090 for nitroaromatics (9/86) or USEPA Contract Laboratory Program methodology for the determination of extractable semi-volatiles (based on EPA Method 625). The analytical procedures employed also differ from the current USATHAMA High Pressure Liquid Chromotography (HPLC) method.

Furthermore, documentation of sample collection, handling, preservation, storage and transport by the DACDIR and QA procedures performed by Battelle-Columbus laboratories, including precision, accuracy, etc. was not included with the reported data.

The data presented in this report are useful in establishing areas of contamination and contaminant levels. However, the data presented cannot be validated according to the Quality Assurance Project Plan (QAPP) and will not be used in Risk Assessment analyses and/or final soil contamination interpretations. The data will be used to guide WSOW biased sampling.

3.1.2 Weldon Spring Uranium Feed Materials Plant

Uranium processing at the WSUFMP consisted of converting uranium ore concentrates to uranium metal with several intermediate

metallurgical steps. Figures 3-2, 3-3 and 3-4 depict the processing sequence and chemicals used in each stage.

The primary potential contaminants associated with uranium processing include: nitric acid, tributyl phosphate in hexane, ammonia, hydrogen fluoride, magnesium, uranium, radium, thorium and other trace metals. Table 3-2 lists the chemicals used for uranium processing and support operations.

To date, no soils investigation has been conducted specifically for chemicals associated with uranium production. However, in 1987, the DOE conducted a preliminary chemical soil contamination assessment and site investigation (PA/SI).

The preliminary assessment was based on the Phase I Water Quality Assessment. The Water Quality Assessment established baseline groundwater and surface water conditions at the WSS. All existing monitoring wells were sampled for the complete Hazardous Substance List, nitroaromatics, inorganic anions and radionuclides. The Phase I Water Quality Assessment detected the presence of nitrate, sulfate and nitroaromatics in the groundwater. No other organic or inorganic contaminants were observed in the groundwater, implying the lack of significant soil contamination by these compounds. The Phase I Water Quality Assessment was used in developing the Phase I Soil

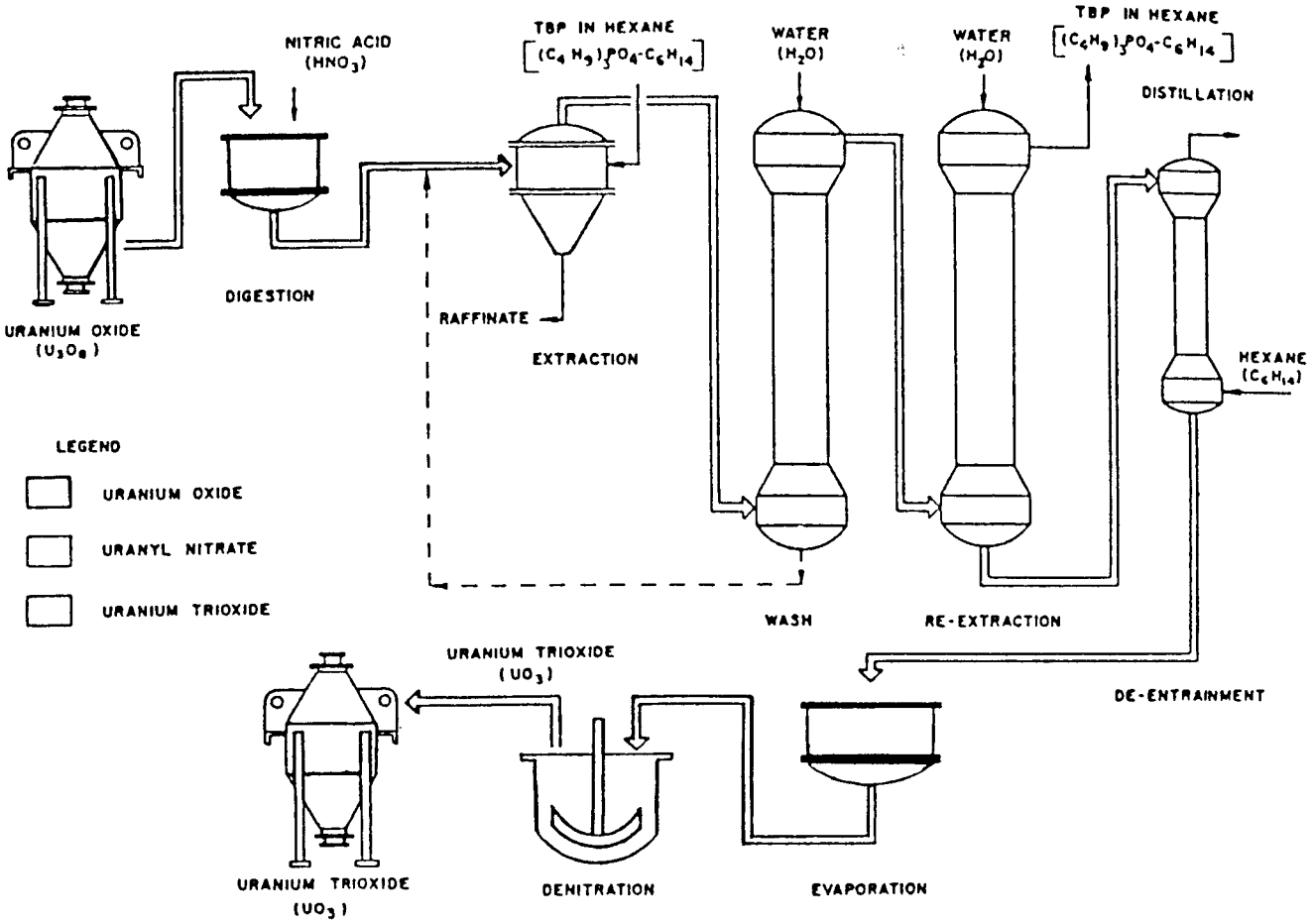

FIGURE 3-2

URANIUM PROCESSING SEQUENCE & CHEMICALS

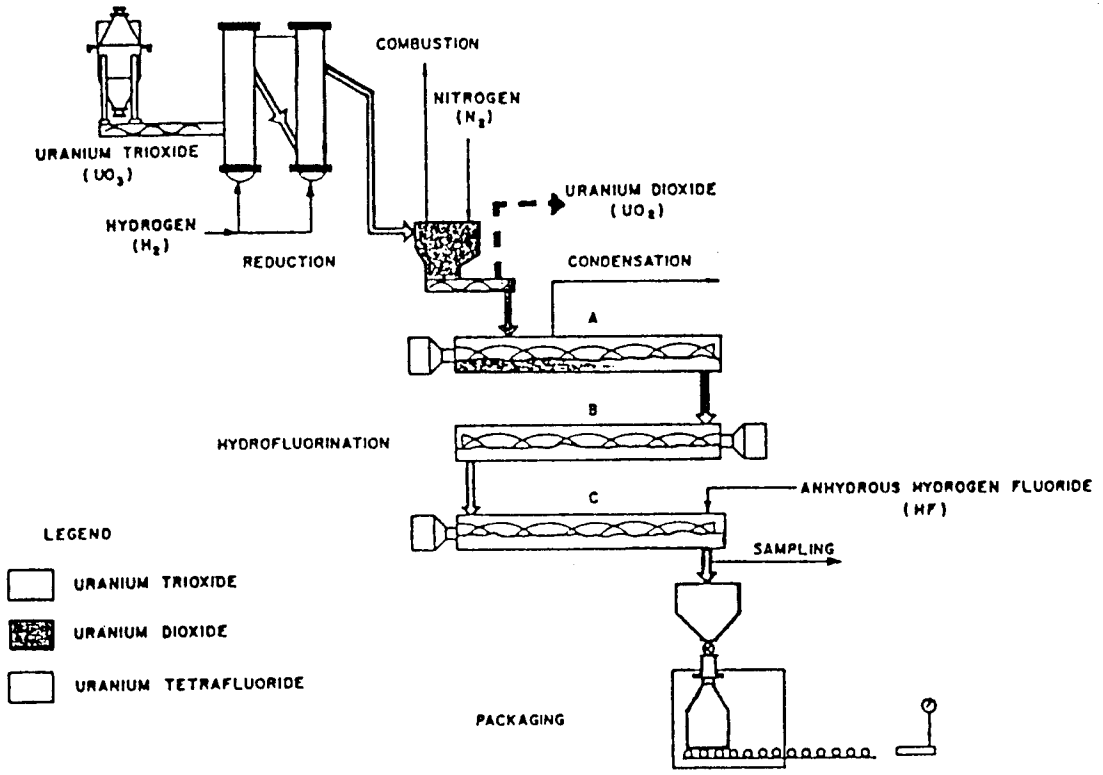

FIGURE 3-3

URANIUM PROCESSING SEQUENCE & CHEMICALS

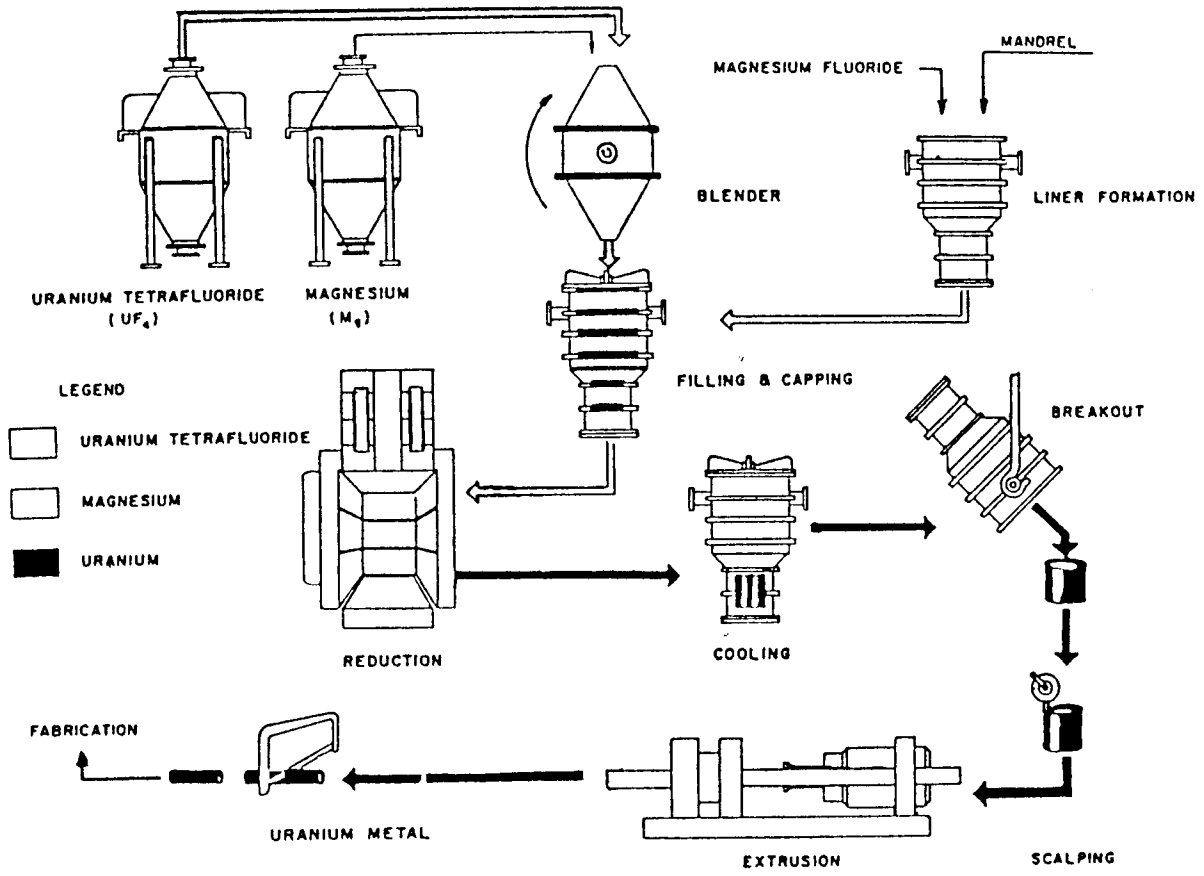

FIGURE 3-4

URANIUM PROCESSING SEQUENCE & CHEMICALS

TABLE 3-2

Chemicals Used for Uranium Processing at the Weldon Spring Uranium Feed Materials Plant

Building	Chemical Name
102	Hexane
102	Nitric Acid
102	Nitrogen
102	Sodium Hydroxide
102	Sulphuric Acid
103 and 403	Sodium Carbonate
103 and 403	Sodium Hydroxide
103 and 403	U_3O_3
103 and 403	UNH^3
103 and 403	UO_3
103 and 403	Uranium Ore Concentrates
104	Lime
105 and 403	Ether
105 and 403	Ethylene Glycol
105 and 403	Hexane
105 and 403	Nitric Acid
105 and 403	Sodium Carbonate
105 and 403	Sodium Hydroxide
105 and 403	Tributyl Phosphate
108	Ferric Nitrate
108	Nitric Acid
109 and 110	Compressed Gas Cylinders
201	Anhydrous Hydrogen
201	Fluoride
201	Ammonia
201	Green Salt
201	Hydrofluoric Acid
201	Hydrogen Gas
201	Nitrogen Gas
201	Orange Oxide
201	Propane
202	Anhydrous Hydrogen
202	Fluoride

TABLE 3-2(cont.)

Chemicals Used for Uranium Processing at the Weldon Spring Uranium Feed Materials Plant

Building	Chemical Name
202	Ammonia
202	Hydrofluoric Acid
301	Caustic Liquid
301	Green Salt
301	Magnesium
301	Uranium Metal
302	Magnesium
302	Graphite Sheets
401	Acid
401	Diesel Fuel
401	Fuel Oil
401	Gasoline
401	Hydrogen Zeolite--Water Softener
401	Phosphate
401	Refrigeration Brine
401	Salt
401	Sodium Zeolite--Water Softener
401	Sulfite
404	Green Salt
404	Helium
404	Hydraulic Oil
404	Hydrogen
404	Uranium Metal
407	Ether
407	Hydrofluoric Acid
407	Laboratory Chemicals
407	Perchloric Acid
408	Gasoline
408	Grease
408	Hydraulic Oil
408	Nitric Acid
410	Perchloric Acid

TABLE 3-2(cont.)

Chemicals Used for Uranium Processing at the Weldon Spring Uranium Feed Materials Plant

Building	Chemical Name
413	Chlorine
413	Chromate Phosphate
413	Sulphuric Acid
417	Acids (misc.)
417	Benzene
417	Corrosive Resistant Coating
417	Epoxy Paint and Catalysts
417	Flammable Materials
417	Gasoline
417	Hot Die Lube
417	Linseed Oil (Boiled)
417	Lubriplate
417	Melcolene
417	Metalube
417	Methylene Glycol
417	Methylisobutyl Ketone
417	Motor Oil
417	Paint
417	Paint Solvents
417	Phenoline Thinner
417	Polyclad
417	Polyurethane Paint
417	Rustbond Primer
417	Tar
428	Propane

Investigation. This site investigation was designed to provide baseline data of areal coverage across the site in areas absent of any chemical soils data.

This initial effort consisted of the collection of 135 samples from 32 locations within the 220 acres of the WSCP/WSRP. Five other boreholes were drilled immediately adjacent to the WSCP, four of which were drilled into the WSOW waste lagoon no. 1, which is located just northeast of Frog Pond, and one borehole was located between the WSCP property and WSOW waste lagoon no. 1. Borehole locations are shown in Figure 3-5.

Phase I soil samples were analyzed for nitroaromatics, metals, nitrate, sulfate, fluoride, chloride and percent moisture.

Analytical results indicated elevated levels of lead, zinc, barium, nitrate and sulfate in WSCP/WSRP soils. Nitroaromatics were not detected on-site. However, percent levels of nitroaromatics were observed in WSOW waste lagoon no. 1.

On-site background metal concentrations were statistically determined during the Phase I soil investigation. Table 3-3 presents the statistical information. This statistical background determination indicated potential contamination consisting of: aluminum, antimony, barium, iron, lead, magnesium, manganese, nickel, vanadium and zinc. This statistical determination was performed to evaluate the

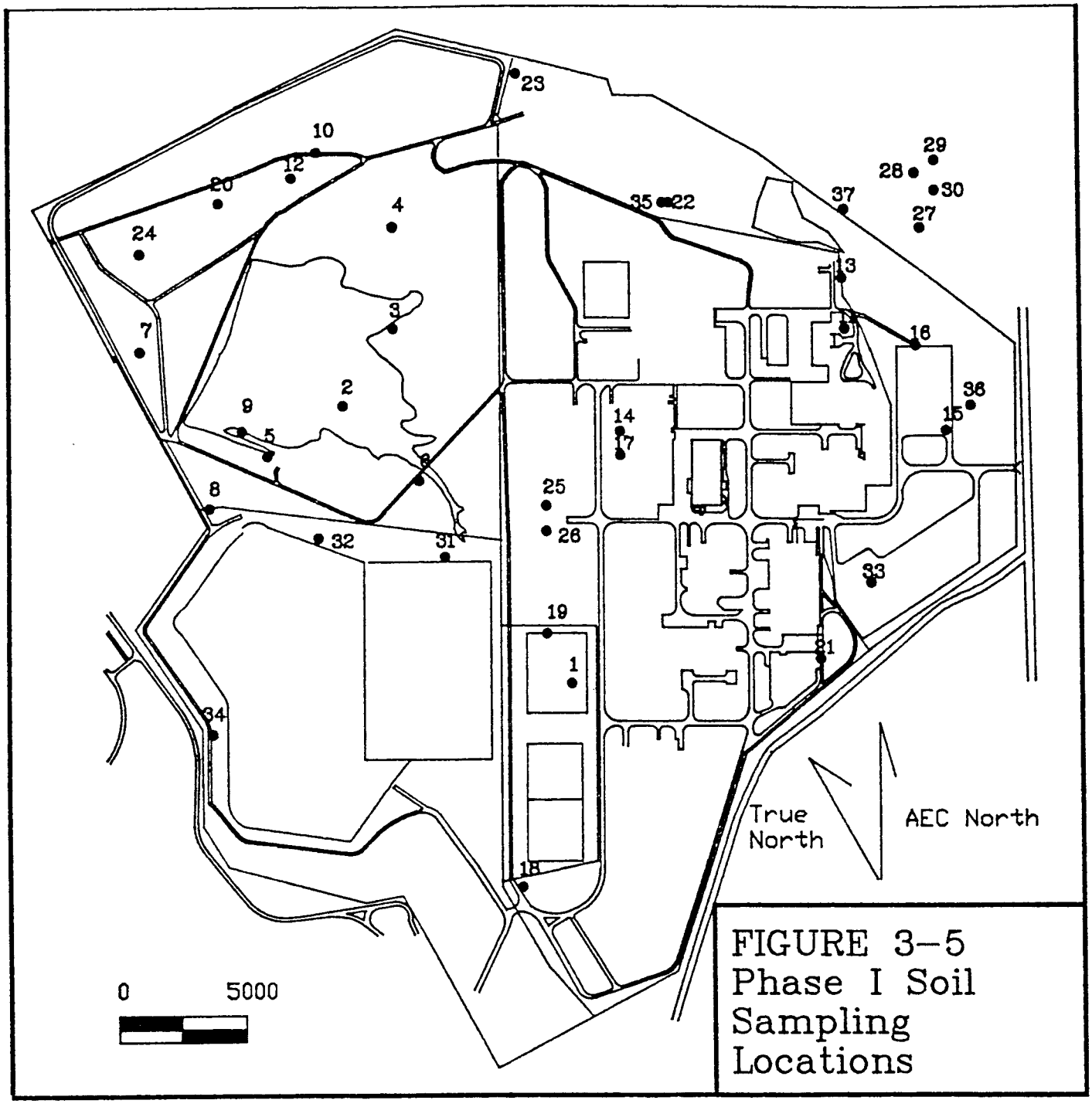

FIGURE 3-5
Phase I Soil Sampling Locations

TABLE 3-3

Statistical Data for Background Metals Concentrations in Soils at the WSCP/WSRP

Compound	Sample Size	Arithmetic Mean mg/Kg	Geometric Mean mg/Kg	Arithmetic Standard Deviation mg/Kg	On-site Background Ranges Low mg/Kg	On-site Background Ranges High mg/Kg
Al	142	12,536	11,350	4,902	1250	27,700
Sb	98	29	25	8	2	40
As	114	6	6	4	2	15
Ba	140	161	145	70	25	390
Be	129	1	1	1	< DL	6
Cd	125	3	3	1	< DL	7
Ca	114	3,495	3,044	1,839	190	9,300
Cr	144	24	23	6	2	42
Co	144	16	14	7	6	40
Cu	143	15	14	6	3	34
Fe	139	18,636	17,914	5,306	8,500	35,400
Pb	127	29	25	16	7	84
Li	92	10	9	3	< DL	17
Mg	133	2,437	2,256	956	417	5,900
Mn	127	495	370	334	49	1,400
Hg	Background less than the detection limit of 0.1 mg/Kg					
Ni	138	19	18	7	7	43
K	145	757	698	311	255	1,701
Se	Background less than the detection limit of 0.5 mg/Kg					
Ag	96	3	2	2	1	13
Na	136	486	437	202	49	982
Tl	Background less than the detection limit of 1.0 mg/Kg					
V	141	35	34	7	6	54
Zn	141	45	39	29	6	220

< DL - Less than detection limit

Source: WSSRAP, 1987

concentration distributions for each metal. Metals with normal distribution may not be contaminants in on-site soils. These on-site background values will be compared with off-site background samples to determine true background conditions as detailed in Section 4.5.2.

3.2 Extent and Magnitude of Contamination

Previous studies have not adequately defined the extent and magnitude of chemical contamination at the Weldon Spring Site. As discussed in the Site History (Section 2.2), the normal operations of the WSOW produced large quantities of "red water" as well as acid waste, bad batches of TNT, and other miscellaneous waste streams. Waste disposal practices during the operation of the WSOW appear to have been driven mainly by expediency. As a result, the potential exists for soil contamination from normal operations, as well as from the leaks and spills that may have occurred during operations.

Existing site sampling locations, when compared with the site history, indicate unsampled areas that could be potential areas of contamination. A statistically developed random sampling program and biased sampling program are required to define the extent and magnitude of contamination.

Elevated nitrate and sulfate levels were observed in locations near potential WSOW source areas. No elevated inorganic anion levels were detected near potential WSUFMP sources.

A more detailed discussion of this effort is presented in "Phase I Chemical Soil Investigation at the WSCP/WSRP" (MK-Ferguson, 1988).

The data presented in this report were collected using acceptable techniques and methods. Chain of custody was maintained according to approved WSSRAP procedures. Sample analyses were performed according to U.S. EPA approved methods or USATHAMA methods (for nitroaromatics). The data presented in this report will be validated according to procedures described in the QAPP and will be used in final data interpretation.

The Phase I data will be used to guide and focus this larger sampling event. Particularly useful is the nitroaromatic data collected from WSOW waste lagoon no. 1. These data demonstrated the nitroaromatic binding to soil particles as concentrations decreased from percent levels to below detection limits in eight feet. This information will be used to focus WSOW biased sampling and random area sampling.

Overall, this baseline effort supplied essential information to guide and focus the Chemical Soil Investigation Sampling Plan.

3.3 Soil Migration Pathways

There are three potential mechanisms for migration of contaminants at the WSCP: groundwater transport, volatilization, and wind or surface water erosion of contaminated soil particles. Groundwater transport is likely to be the most important, especially for the nitroaromatics and inorganics.

Contaminants considered in this section are: inorganics (primarily nitrates and sulfates), metals (principally lead), nitroaromatics, and PCBs. Their migration pathways and mobility are discussed below.

3.3.1 Nitrate

The significant migration pathway for nitrate is movement with groundwater. Nitrate is very mobile in groundwater due to its anionic negative charge and high water solubility (ESE, 1986). It is likely that nitrate will move with the groundwater, without significant soil attenuation (ESE, 1986). Concentrations at the WSCP/WSRP can be lowered mainly by hydrodynamic dispersion.

3.3.2 Sulfate

Like nitrate, the primary significant migration pathway for sulfate is movement with groundwater. Also like nitrate, sulfate is an anion and very mobile (ESE, 1986). Unlike nitrate, sulfate is less subject to biological transformation. Sulfate is susceptible to reduction only at extremely low anaerobic Eh which is unlikely to occur in groundwater beneath the WSCP. Sulfate may also be removed from groundwater by precipitation as a mineral such as gypsum. Sulfate would be expected to be slightly less mobile than nitrate, but is still considered to be a very mobile anionic species. (ESE, 1986)

3.3.3 Lead

Lead is the principal nonradioactive metal contaminating soils at the WSCP/WSRP site. Lead was used extensively in WSOW production facilities because it is resistant to corrosion and sparking. Phase I soil sampling has detected isolated areas of elevated lead concentrations. It is expected that lead contamination will remain in discrete pockets of elevated concentration in the soil. This is due to the usage of lead only in particular areas of production and its hydrogeochemical behavior in the soil.

Lead is strongly adsorbed to soils with a pH above 5. Lead adsorption increases with pH, cation exchange capacity, organic carbon content, and phosphorus levels (ESE, 1985). Movement of lead in the groundwater is unlikely to be the dominant mode of transport, although some lead may be found in groundwater near localized areas of high concentration. The primary migration pathway for lead is expected to be wind or surface water erosion of soil particles containing adsorbed lead. The vegetative cover on the WSOW site should greatly abate this migration pathway by reducing soil erosion.

3.3.4 Nitroaromatics

3.3.4.1 2,4,6 - Trinitrotoluene (TNT)

Migration pathways for TNT are controlled by adsorption (ESE, 1986). However, TNT is not as tightly bound to the soil as lead, so the migration pathways include transport by groundwater as well as direct transport of TNT or TNT-contaminated soil particles.

TNT's reported water solubility is 117-200 mg/l (ESE, 1985). It is unlikely that TNT transport in groundwater will be limited by solubility. Retardation factors (Rd) are a function of the organic carbon content of the soil with higher organic carbon content causing more adsorption resulting in a higher Rd. Horizontal and vertical migration rates in contaminated soil of

as little as one inch per year have been estimated for TNT (ESE, 1985) in clay soils and climatic conditions similar to the WSCP/WSRP.

TNT has a relatively low vapor pressure and a low Henry's Law constant; therefore, volatilization is not expected to be a significant migration pathway.

Biodegradation could be an important mechanism for the attenuation of nitroaromatics and nitrates. Important factors controlling biodegradation rates are: pH, Eh, nutrient availability, and temperature. As a nitroaromatic such as TNT moves through the groundwater regime, it could be transformed microbially and eventually mineralized to ammonia. The ammonia could then be rapidly nitrified to nitrate. Finally, as the groundwater declines in redox potential, nitrate can be reduced to N_2 by denitrification. Unfortunately, data is not available to make a quantitative assessment of the importance of biological degradation processes at the WSCP/WSRP and WSOW.

Photolysis (chemical decomposition due to exposure to light) is a dominant degradation process in surface waters (Spanggord et al, 1980) and is a likely process that may suppress TNT concentrations to undetectable levels in ponds receiving ground water discharge with measureable TNT. Photolytic decomposition products include 1,3,5-TNB.

3.3.4.2 1,3,5 - Trinitrobenzene (TNB)

TNB may be more resistant to degradation than TNT. Sufficient evidence is not available to estimate degradation rates in environmental systems, but the limited data that are available indicate that TNB is resistant to hydrolysis and is neither photolytically nor biochemically degraded as readily as TNT. The environmental behavior of TNB is expected to be very similar to that of TNT. Adsorption to soil particles should be a major factor in controlling TNB migration pathways. Migration pathways will be by groundwater transport and movement of contaminated soil.

The Henry's Law constant for TNB is approximately an order of magnitude greater than for TNT (ESE, 1985). Thus, volatilization could be more of a factor in TNB transport than for TNT.

TNB movement with groundwater is likely to be the most significant migration pathway for TNB at the WSOW.

3.3.4.3 Dinitrotoluenes (DNT)

The DNT isomers (DNTs) are relatively more mobile, volatile and degradable than TNT (ESE, 1985). Retardation factors are estimated as low as 1.2 for DNTs. This implies that DNT isomers would move through the soil with essentially the same velocity

as groundwater. Thus, this is expected to be the primary migration pathway for DNT.

DNT isomers are also quite volatile, with a Henry's Law constant nearly three times that of TNB. Volatilization, especially from surface soils, may be a significant means of DNT migration. Volatilization and degradation by photolysis would be important factors in reducing DNT concentrations in surface soils or water (ESE, 1985).

Photolysis is an important process affecting DNTs in surface waters, with reported half-lives of a few hours to approximately 1 week (Spanggord et al, 1980). Photolytic decomposition and volatilization may account for failure to observe DNTs in surface waters that receive groundwater discharge from the TNT manufacturing area.

3.3.4.4 Dinitrobenzenes (DNB)

DNB isomers should behave very similarly to DNT with respect to volatility and absorption (Spanggord et al, 1980). Transport with groundwater should be the primary migration pathway, with volatilization an important factor in surface soil or water.

3.3.5 Polychlorinated Biphenols (PCB)

PCB migration will be through direct contact with PCB oil and/or through erosion of contaminated soil because PCBs bind tightly to soil particles and are not transported with groundwater (CRC, 1982). PCBs are very stable and do not transform or biodegrade easily in soil (CRC, 1982).

3.3.6 Asbestos

Asbestos fibers are mobile only by wind, surface water, and direct soil mixing. The vegetative cover present at the WSCP/WSRP should control and minimize asbestos migration. The degree and nature of this control is not known and would be extremely difficult to quantify.

3.4 Documentation of Uncontaminated Areas

Knowledge of site history, previous studies, Phase I sampling results, and knowledge of the likely routes of migration for chemical contaminants on-site all indicate potentially contaminated areas. The areas of the site with no implicating factors pointing to chemical contamination must be sampled in a systematic way so they can be shown to be free of contamination. In addition, areas known to be free of contamination, but similar geologically to the contaminated

areas on-site, must be sampled to establish background levels for metals and inorganics to allow a true and valid assessment of on-site contamination.

Sampling locations in these areas have been selected on a random basis. Proper statistical methods have been applied to insure that the number of samples will be adequate to provide a statistically valid coverage of the area and establish the mean and standard deviation of background concentrations of naturally occurring constituents. A detailed description of the statistical approach selected to characterize areas not suspected of being contaminated is presented in Section 4.5.

4.0 SAMPLING PROGRAM

4.1 Sampling Objectives

Soil sampling for chemical characterization will be conducted to meet several objectives. The objectives are to:

1) Determine the extent and magnitude of chemical contamination.

2) Locate potential chemical contamination sources.

3) Document uncontaminated areas.

4) Provide a data base sufficient for consideration of remedial action options.

5) Provide data base sufficient for preparation of risk assessment.

6) Establish background concentrations in native soils.

4.2 Sampling Rationale

The focus of this soils investigation is to quantify the nature and extent of chemical contamination in terms of the specific objectives stated in Section 4.1. Because of the size of the

site and the diversity of activities that have occurred over the last 45 years, two sampling approaches--biased and unbiased sampling--are proposed to provide a comprehensive soil contamination characterization. The biased sampling locations are based on historical documentation and recent site investigation results presented in previous sections. Specific sampling locations were selected based on association with either the WSUFMP operations or the WSOW operations. Areas of known radiological contamination are defined in Section 4.3.1. Specific sampling locations are discussed and identified by site coordinates, along with sampling depths, analytical parameters, and a brief rationale. All soil sampling locations are presented in Plate 3.

Unbiased sampling will be conducted over the entire site in order to provide a statistically valid data base for soils characterization and to document uncontaminated areas. The statistical approach to unbiased sampling is presented in Section 4.5.

4.3 WSUFMP Biased Sampling

Sampling locations discussed in the following sections were selected based on site history, plant operations, and previous data. Soil samples will be collected from 71 locations. Analytical parameters were selected based on contaminant source characteristics and previous data. A total of 191 samples will be collected. The locations, depths, analytical parameters and

rationale are presented in Table 4-5. Collected samples will be analyzed for chemical parameters only and not for radiological constituents since radiological characterization is complete. However, the areas of radiological contamination are of concern for both safety and handling procedures. Section 4.3.1 discusses areas known or suspected to be radiologically contaminated. These areas will be chemically characterized. Section 4.3.2 discusses plant operations in relation to chemical source areas, provides rationale for sample locations, details borehole depths and describes analytical parameters.

4.3.1 Radiological Investigations

RADCON Survey - 1975

A radiological survey was conducted in September 1975, by the U.S. Army Radiation Control team (RADCON), to determine outdoor areas of contamination, identify contaminants and assess the potential radiological hazard to the properties surrounding the site. Natural uranium and its decay products were anticipated to be the major source of contamination. The RADCON team surveyed the perimeter of the site at the fence and 10 meters inside the fence. Measurements were taken on the ground surface at 250-foot intervals.

The survey conducted around the Weldon Spring Chemical Plant buildings indicated that the areas around buildings 428, 429, 437, 439, and 443 were free of detectable contamination. The

areas surrounding the remainder of the buildings were contaminated to varying levels from background to more than 500 times background. Three pieces of uranium metal were found alongside major support buildings. Although the most heavily contaminated areas are characteristically located near major process buildings and the pilot plants, some support buildings were found to be surrounded by significant contamination. For example, visible uranium oxide and uranium fluoride deposits were found alongside the Paint Shop (Bldg. 417). The area in front of the Administration Building (Bldg. 409) was found to be contaminated to approximately eight times the background in portions of the parking lot. Apparently automobile lubricants collected on the parking lot and trapped low-level airborne contaminants during plant operations. All expansion joints between surface materials on-site which contain tar have likewise collected and concentrated contamination.

WSSRAP Survey - 1987

In February, 1985, the DOE established the Weldon Spring Site Remedial Action Program (WSSRAP) to effect remedial action at the site. Because additional radiological information and data were needed to complete the Environmental Impact Statement (EIS), DOE developed a radiological characterization plan for the WSCP/WSRP.

This field work was performed from April through July 1987. The intent of this program was to determine the horizontal and

vertical extent of radioactive contamination within the WSCP/WSRP area that exceeds guidelines for remedial action.

A combination of surface and subsurface radiometric measurements, and surface and subsurface soil samples were collected. Exact sampling and measurement locations were determined by an on-site survey utilizing the AEC coordinate system to positively locate sampling location.

Boreholes were drilled at 317 locations. Samples were collected from each borehole in one-foot increments to a minimum depth of five feet. Boreholes were then logged with a gamma-ray spectrometer. Elevated spectrometer readings triggered subsequent radium and thorium-232 analyses. Selected samples were archived for possible future uranium and/or thorium-230 analysis if the spectrometer log indicated no elevated gamma activities. The following paragraphs briefly discuss the radiological contamination findings at specific locations. Each area is shown in Figure 4-1. Residual soil guidelines are presented in Table 4-1.

A complete description of the radiological characterization can be found in the final report entitled "Radiological Characterization Report of the WSS."

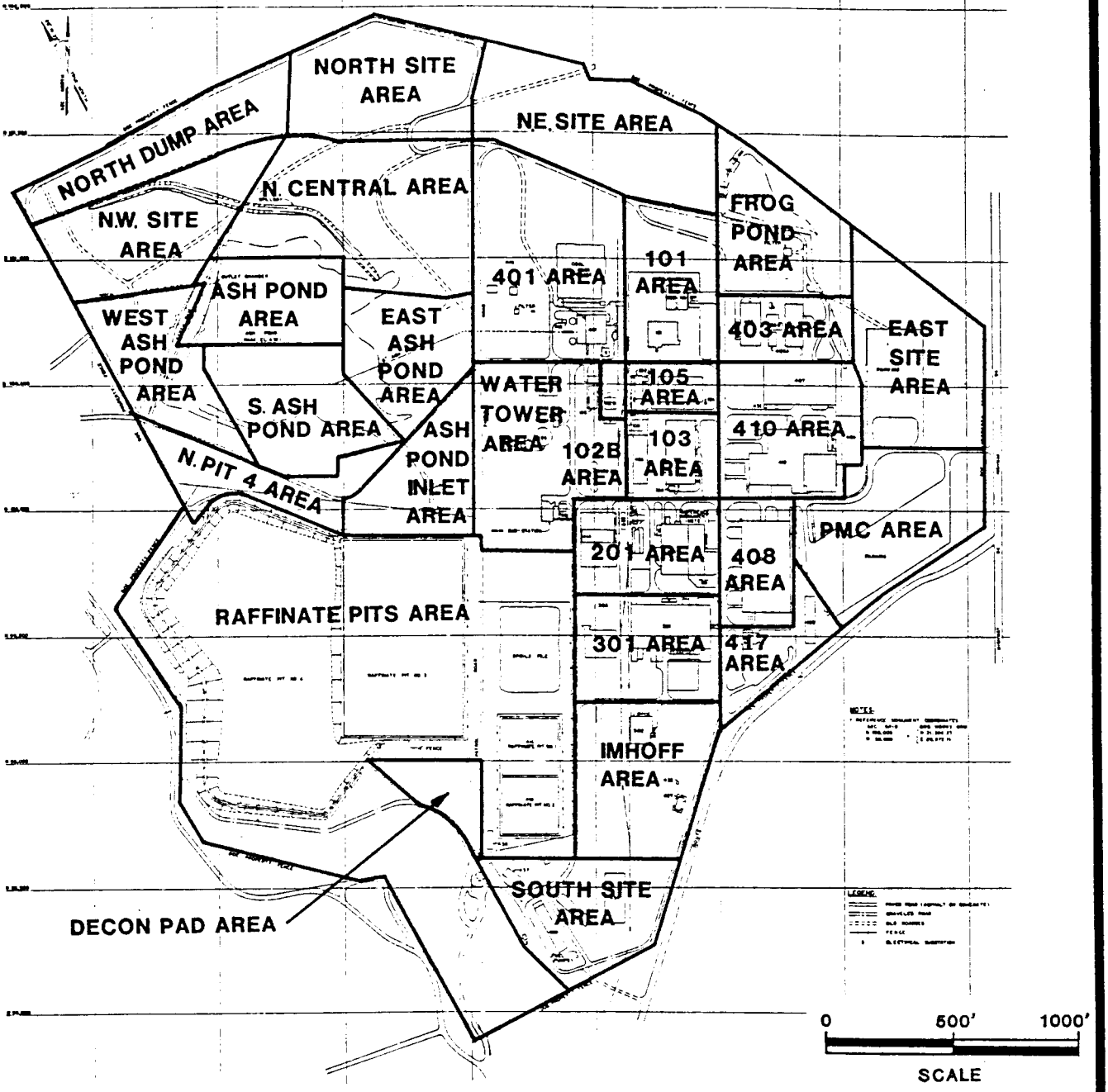

FIGURE 4-1

AREA BREAKDOWN OF WSCP/WSRP FOR RADIOLOGICAL CHARACTERIZATION

TABLE 4-1

RESIDUAL SOIL GUIDELINES FOR RADIONUCLIDES

	Radionuclide	Guideline
*	Uranium, natural	60 pCi/g
	Ra-226 and -228; Thorium-230 and -232	5 pCi/g in upper 15 cm of soil
		15 pCi/g in subsequent 15 cm layers

* Uranium guideline has not been formally established for WSSRAP. This value is currently being used on an interim basis.

pCi/g - picocuries per gram

Source: WSSRAP, 1987

North Dump Area

A borehole drilled near the western boundary of the dump indicates that the contamination extends deeper than five feet. The eastern half of the dump is contaminated to a 36-inch depth. Results indicated Ra-226 contamination slightly below surface soil guidelines in a small region east of the dump area.

North, Northwest, Northeast, and North Central Areas

All in-situ measurements and soil sample results indicate that these areas are below soil guidelines.

Frog Pond Area

In-situ measurements and soil sample results indicate that a large portion of this area is above soil guidelines. The inlet to Frog Pond is contaminated to a depth of 36 inches. A drainage area located NNE of Frog Pond is contaminated to a depth of 12 inches.

The grounds south of Frog Pond contain a mixture of radionuclides exceeding guidelines.

Building 403 Area

Boreholes and surface soil sample results indicate that the grounds surrounding the buildings are contaminated to a depth of

12 inches with the exception of a small area east of building 404 where the contamination extends to 24 inches.

Building 101 Area

Several areas on the concrete dock have elevated gamma radiation readings.

Building 401 Area

A large portion of the grounds in this area are below guidelines. Historical information has indicated feed material spills occurred along the railroad tracks. The contamination within this area is surficial and is predominantly uranium. The area below the coal pile is known to have radionuclides above residual soil guidelines. Drainage from the coal pile area leads into the northeast site area and the outfall from Frog Pond extends across the northern portion of this area.

East Site and PMC Area

All in-situ measurements and soil sample results indicate that these areas are below the residual soil guidelines.

Building 410, 103, and 105 Areas

A borehole drilled in Building 103 area indicates contamination to a depth of 24 inches beneath the building. A borehole drilled in Building 105 showed no contamination above the guidelines. A borehole drilled to the southeast of Building 105 showed considerable contamination. The surface soil in the Building 410 area showed detectable contamination.

102B Area

Boreholes and surface soil samples have indicated contamination in this area above soil guidelines.

Water Tower Area

A major portion of this area is below residual soil guidelines. However, an isolated area around the tank farm and water tower has elevated uranium concentrations.

Ash Pond Inlet Area

This area contains isolated areas of contamination.

East Ash Pond and Ash Pond Areas

No radiological contamination is present in these areas.

South Ash Pond Area

This area is radiologically contaminated to a depth of eight feet.

West Ash Pond Area

The Ash Pond outfall is contaminated at a depth of 60 inches (15 pCi/g U-238) and at 36 inches (60 pCi/g U-238). An area of Th-230 contamination is present at one borehole location.

Building 408 Area

The grounds in this area show contamination to a depth of 12 inches. All sample results for this area are above the residual soil guidelines.

Building 417 Area

Portions of this area are above the residual soil guidelines.

Building 201 and 301 Areas

A borehole drilled in Building 201 is contaminated to a depth of 12 inches. The grounds surrounding the buildings show contamination exceeding guidelines.

Imhoff Tank Area

A large portion of the grounds is below residual contamination guidelines. Isolated areas of contamination exist including one area of Th-230 contamination.

4.3.2 WSUFMP Biased Sampling Approach

This section discusses the use of chemicals associated with the production of uranium trioxide, uranium tetraflouride and uranium metal. Specifically it discusses the site locations where certain chemicals were used, disposed of or spilled during operations and relates the information to the selection of potential contaminant source areas. By combining potential source information with historical soils data, Phase I Water Quality Assessment data, and the containerized chemical inventory conducted in the buildings by PMC personnel in 1987, site-specific soil sampling will be conducted. This sampling will verify the contaminant sources, characterize the extent of these sources, determine the extent of any contaminant migration and provide an assessment of the rate of contaminant migration. All sampling locations, rationale, depths and analytical parameters are presented in Table 4-5 following the discussion of WSCP facilities.

Discussion of the chemical plant is divided into three general areas: Major Building Structures, Yard and Yard Structures, and Surrounding Land Areas.

Major Building Structures. The contents of the buildings are quite variable. Certain buildings have been emptied and partially decontaminated. Most of the buildings contain original process equipment and several have been used to store material removed from other buildings. Major building structures are listed in Table 4-2.

Yard and Yard Structures. These include smaller process buildings and utility structures as well as loose equipment, drums, piping, vehicles, vessels, etc., scattered randomly throughout the yard area. Table 4-3 lists items situated in the yard areas. The major structures consist of small buildings or structures used intimately with the process. However, many of the structures involve utilities which traverse most of the yard. The major fixed yard structures include overhead piping and underground piping. The overhead piping is concentrated near the process buildings and the steam plant, although steam piping connects most buildings in the plant area. Substantial amounts of the insulation used on these overhead pipes contain asbestos and have deteriorated to the point of falling off the pipe to the ground. The underground piping system includes sanitary sewers, process sewers, storm drains, potable and fire water lines, etc. The sanitary system originally fed two septic tanks with filters and an Imhoff tank which discharged effluent by outfall to a

TABLE 4-2

MAJOR BUILDINGS at the WSCP

FEED PREPARATION AND SAMPLING PLANT - BUILDING 101

DIGESTION AND DENITRATION - BUILDING 103

TBP AND ETHER EXTRACTION - BUILDING 105

GREEN SALT PLANT - BUILDING 201

METALS PLANT - BUILDING 301

MAGNESIUM BUILDING - BUILDING 302

STEAM PLANT - BUILDING 401

WET AND DRY CHEMICAL PILOT PLANT - BUILDING 403

METALS PILOT PLANT - BUILDING 404

LABORATORY BUILDING - BUILDING 407

AUXILIARY TO THE PILOT PLANTS - AREA 405

WAREHOUSE - BUILDING 406

MAINTENANCE AND STORES BUILDING - BUILDING 408

ADMINISTRATION BUILDING - BUILDING 409

SCRAP CLASSIFICATION AND EQUIPMENT STORAGE FACILITY - AREA 414

PAINT SHOP - BUILDING 417

STORAGE BUILDINGS - BUILDINGS 433, 434, 435, 436, 437, 438

Source: WSSRAP, 1987

TABLE 4-3

YARD AND YARD STRUCTURES

REFINERY TANK FARM - AREA 102

NITRIC ACID RECOVERY FACILITY - AREA 108

GREEN SALT TANK FARM - AREA 202

PRIMARY ELECTRIC POWER - 412

COOLING TOWER - AREA 413

PROCESS INCINERATOR - AREA 415

ELEVATED WATER TANK - AREA 426

PRIMARY SEWAGE TREATMENT PLANT - AREA 427

PROPANE GAS PLANT - AREA 428

RESERVE WATER FACILITIES - AREA 429

FIRE TRAINING - AREA 439 & 443

RAILROADS

OVERHEAD PIPING SYSTEM

SITE IMPROVEMENTS

WATER DISTRIBUTION

SANITARY SEWER SYSTEM

PROCESS SEWER SYSTEM

OUTFALL SEWER SYSTEM

STORM SEWER SYSTEM

Source: WSSRAP, 1987

drainage easement leading to the Missouri River. The process sewer system also discharges to this easement through the same outfall pipe. Surface drainage that collects on the site is discharged through pipes and open ditches to several outfall ditches leading to off-site areas. Surface water enters the site from small watersheds to the south and northeast.

Surrounding Land Areas. These lie outside the building and yard areas and include: the Frog Pond area to the northeast, the northern boundary area, the Ash Pond area to the northwest, the raffinate pit area to the southwest, and the southern boundary area. Table 4-4 lists the areas comprising the Surrounding Land Areas. Figure 4-2 gives a general delineation of the areas as well as an indication of where surface water moves to and from the site.

The Frog Pond area includes its watershed area and discharge stream exiting the site. This area, specifically the pond and outfall stream, were used by the WSUFMP for stormwater discharge and process wastes from buildings 403 and 404. The area still contains features of the WSOW including a tram line and process wastewater surface conveyance.

TABLE 4-4

SURROUNDING LAND AREA

Frog Pond Area

Northern Boundary Area

Ash Pond Area

Raffinate Pit Area

Southern Boundary Area

Source: WSSRAP, 1988

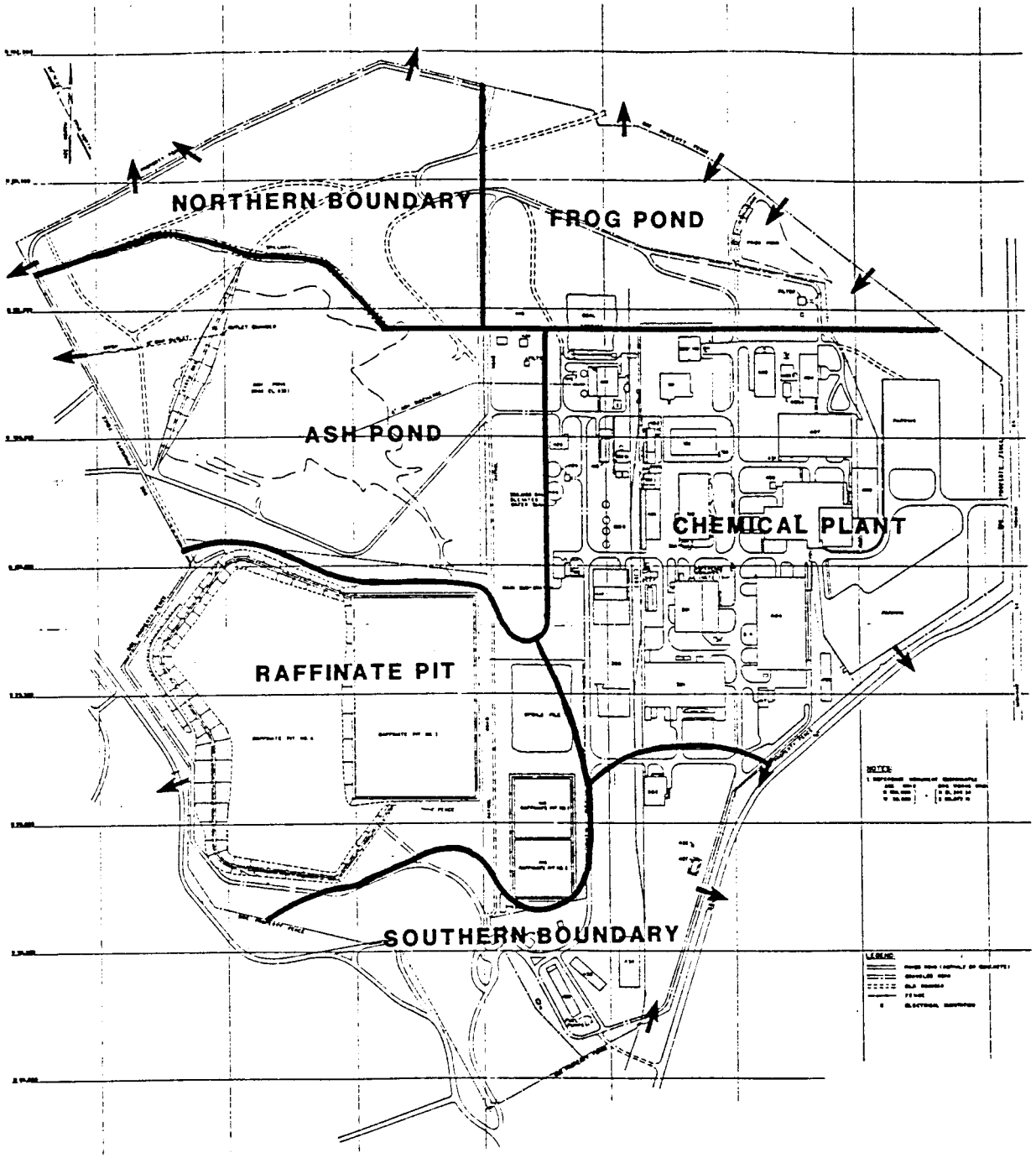

FIGURE 4-2

DELINEATION OF MAJOR AREAS OF THE SITE

The Ash Pond is another major area. Spent ash from the steam plant was slurried to this surface impoundment for settling prior to discharge of the water. The area below the dam contains rubble from the WSOW. Along the south upstream shore of the pond, radiologically contaminated material was dumped.

Areas along the northern boundary, just west of the Frog Pond area, also have been untouched since the WSOW operations except for surface storage of discarded equipment and rubble, (not waste products). Most of this stored material has been removed but remnants still exist. The area was also used by the WSOW as a burn area for TNT waste disposal.

The area south of the raffinate pits was partially modified when the WSUFMP was constructed and has been used for surface dumping of solid waste material. Most material has been removed except for debris close to the remaining buildings. The Imhoff tank for treatment of sanitary sewage and the buildings used during construction are also located in this area but are discussed with yard structures. The eastern part of this area is the watershed for surface drainage southeast to the Missouri River.

The following sections describe WSUFMP process facilities. The need for sampling is discussed along with analytical parameters and sampling locations. Three samples will be collected from each location unless noted. Sample intervals at each location are: 0 to 6 inches, 24 to 30 inches, and 54 to 60 inches, unless otherwise noted. A more detailed description of sample location,

sampling interval, analytical parameters and location selection rationale is presented in Table 4-5, located at the end of this section.

FEED PREPARATION AND SAMPLING PLANT - BUILDING 101, AREA 109, 110

The Feed Preparation and Sampling Plant was designed to process approximately 75 tons per day of the low assay feed material concentrates.

The plant consisted basically of equipment and facilities for drying, grinding, screening, blending and sampling of both wet and dry ore concentrates and process residues. The three major functions performed in the building were to:

- Prepare representative samples of feed material for accountability purposes;
- Eliminate tramp metal, wood and foreign material from feed material; and
- Eliminate ammonia and/or residual organics from feed materials by oxidation and heating.

In addition, a 68,800-square-foot storage pad (Areas 109 and 110) was provided for the storage of incoming drummed feed material. An unloading dock was provided in the storage area.

The storage pad is poured concrete construction with a hardened surface, sloped, and provided with a complete trench drainage system which collects the rain and wash-water drainage from both the pad and Building 101 in a common sump. Sampling will be performed in the wash-water drainage area based on the potential for residual organic contamination. These locations are:

#	Coordinates W	N	Analytical Parameters
1)	50,100	100,730	Metals (MTL), Volatiles (VOA), Semivolatiles (SV) Pesticides, PCB (PP), Total Organic Halides (TOX)
2)	50,100	100,650	MTL, VOA, SV, PP, TOX
3)	50,040	100,700	MTL, VOA, SV, PP, TOX
4)	50,240	100,030	MTL, SV, Inorganics (IO), TOX
5)	50,130	100,960	MTL, SV, IO, TOX
6)	50,120	101,600	MTL, SV, IO, TOX

DIGESTION AND DENITRATION - BUILDING 103

Building 103 is composed of two major sections: the Digestion Section and the Denitration Section. In the Digestion Section, sampled ore concentrates were digested and transferred as slurry to Refinery Building 105 where the solution was purified by solvent extraction. The second section of Refinery Building 105 then received the purified uranium nitrate trioxide. The content and function of the two sections is more fully outlined below.

Digestion Section. The digestion portion of the refinery was designed to dissolve uranium concentrates in nitric acid. The

concentrates were received either in the form of oxides of uranium or in the form of sodium, magnesium and calcium salts of uranium. They were normally free-flowing powders that were transported from the Feed Preparation and Sampling Plant (Building 101) to the refinery in transfer hoppers and were fed directly into the four digesters. The resulting slurry was then transferred and stored in holding tanks from which it was pumped to the extraction plant (Refinery Building 105).

Denitration Section. After purification, the uranyl nitrate solution from the extraction plant (Refinery Building 105) was pumped to the denitration section where it was further concentrated in steam-heated tanks and finally transferred to gas-fired denitration pots.

The resultant dry product, uranium trioxide powder, also known as orange oxide, was pneumatically conveyed from each pot to the penthouse section where it dropped by gravity through a pulverizer, vibrating screen, one-stage sampler, and finally into transfer hoppers for movement to the Green Salt Plant (Bldg. 201). The oxides of nitrogen generated during the denitration cycle were collected and returned to the nitric acid recovery facility.

Sampling will be performed in the vicinity of Building 103 based on the use of nitric acid and metal acids. The sampling locations are:

#	Coordinates W	N	Analytical Parameters
7)	50,220	100,325	MTL, VOA, SV, pH, IO
8)	50,125	100,080	MTL, VOA, SV, pH, IO

TBP AND ETHER EXTRACTION - BUILDING 105

The Refinery Building (Building 105) removed essentially all uranium from the digested slurry received from Building 103 and returned the uranium as purified uranyl nitrate solution to the Denitration Section of Building 103. The process consisted of a two-stage solvent extraction operation in which tributyl phosphate (TBP)-hexane was used as the first stage solvent and diethyl ether as the second stage solvent.

The impurities contained in the digest slurry were concentrated and removed as raffinate from the TBP-hexane extractors in the form of an acid slurry. This slurry was transferred to the raffinate neutralization system prior to disposal in the raffinate pits.

The aqueous re-extract liquor containing the bulk of the uranium present in the feed concentrates was washed with hexane in a spray column to remove entrained TBP. It was then heated to flash off all remaining hexane. The solvent-free re-extract liquor was finally concentrated in a triple effect evaporator

located in the boil-down section and pumped to the Denitration Section of Building 103 as pure uranyl nitrate solution.

Raffinate from the first stage extraction was washed with hexane in a spray-type wash column to remove TBP and then stripped of hexane by boiling off the solvent in a stripping tank. The solvent-free raffinate was pumped to the raffinate neutralization system in the Denitration Section of Building 103 and on to the raffinate pits. All sump liquors in this first-stage extraction section were collected and stripped of TBP and hexane in a similar manner. The solvent-free sump liquor was then pumped to the sump liquor concentration system located in the Digestion Section of Building 103. All TBP and hexane recovered from the extract, raffinate, and sump liquor was adjusted to the proper TBP concentration by boiling off excess hexane in a still. The evaporated hexane was condensed and re-used.

Sampling will be performed in the vicinity of Building 105 based on the use of TBP, hexane, nitric acid, and diethyl ether. Sampling locations are:

#	Coordinates W	N	Analytical Parameters
9)	50,240	100,475	VOA, SV, IO
10)	50,150	100,425	VOA, SV, IO

GREEN SALT PLANT - BUILDING 201

The Green Salt Plant (Building 201) was designed to convert uranium trioxide (UO_3 or orange oxide), the product of Building 103, to uranium tetrafluoride (UF4), known as green salt.

Orange oxide powder was received from the Refinery Building (Building 105) in portable hoppers. The oxide was fed to a reduction reactor where the uranium trioxide (UO_3) was continuously reduced at an elevated temperature to uranium dioxide (UO_2 or brown oxide) with hydrogen gas. The uranium dioxide was then converted to uranium tetrafluoride by contacting it countercurrently at high temperature with hydrogen fluoride (HF) gas in three hydrofluorination reactors operating in series.

Basically, this process contains six reactor banks, each with four horizontal reactors arranged one above the other, a re-run bank similar to the reactor banks, a green salt reverter, and a pilot bank, consisting of three smaller reactor tubes. Uranium trioxide was reduced continuously to uranium dioxide by the countercurrent flow of hydrogen in a tubular reactor.

The hydrogen for the reduction step was made by the catalytic dissociation of anhydrous ammonia in special package units. Hydrofluoric acid for the hydrofluorination step was received from the tank farm (Area 202) as a liquid and was vaporized in steam jacketed tanks. Auxiliary facilities included six dust

collection and four vacuum cleaning systems for handling dusts, a lime scrubbing system for removing the last traces of HF from gases being vented to the atmosphere, two Freon refrigeration systems and a nitrogen producer.

Sampling will be performed in the vicinity of Building 201 based on the use of hydrofluoric acid, a lime scrubbing system, Freon, and asbestos.

The sampling location is:

#	Coordinates W	N	Analytical Parameters
11)	50,225	99,850	MTL, VOA, SV, pH, IO

METALS PLANT - BUILDING 301

The Metals Plant (Building 301) was designed to convert uranium tetrafluoride (UF_4) received from Building 201 to metal. The conversion was accomplished by a batch process, involving a thermite-type reduction of the uranium tetrafluoride with magnesium.

The reduction was carried out in large refractory-lined containers, known as "bombs," which were heated in a furnace for several hours in order to bring the reactants to a temperature at which the reaction, once ignited, occurred spontaneously. After removal from the furnace, the bombs were cooled and disassembled. The metal, which settled to the bottom of the bomb

and solidified, was removed from the slag in a so-called "breakout" operation. The cylindrical metal shape produced in this process was fabricated without recasting and was therefore considered a direct ingot and given the designation of "dingot". The magnesium fluoride slag produced by the reaction was crushed, ground and a portion recycled for use as the refractory liner for the bombs. The chips of metal removed during the machining of the dingot were segregated and collected for reclamation.

Sampling will be performed in the vicinity of Building 301 based on the use of caustics, magnesium, and solvents. Sampling locations are:

#	Coordinates W	N	Analytical Parameters
12)	50,375	99,650	MTL, VOA, SV, pH, IO
13)	50,075	99,400	MTL, VOA, SV, pH, IO
14)	50,225	99,400	MTL, VOA, SV, pH, IO

MAGNESIUM BUILDING - BUILDING 302

The Magnesium Building (Building 302) served as an important auxiliary facility to the Metals Plant (Building 301). It provided facilities (1) for unloading the finely divided magnesium metal chips received either by rail or truck in returnable 22-gallon drums, (2) for pelletizing and storing an inventory of drums in carload lots, and (3) for processing the magnesium through a magnetic separator and repackaging it in weighed lots of 55-gallon drums for use as a single charge in the

metals plant. Because of the hazards involved in storing large quantities of finely divided magnesium, it was necessary to isolate the building from other operating areas. Sampling will be performed in the vicinity of Building 302 based on the use of magnesium and lead.

Sampling location:

#	Coordinates W	N	Analytical Parameters
15)	50,390	99,175	MTL, IO

STEAM PLANT - BUILDING 401

The Steam Plant and its auxiliary facilities furnished the WSUFMP with steam, refrigerated brine, soft water, compressed air, and emergency electric power. The yard structures include coal and ash handling facilities, salt storage, coal storage and ash disposal areas.

The boilers were located outside the building and were supported by individual structural steel frames. The induced draft fans were located to the east of the building and discharged into two ground-supported steel stacks. A stack was used also for a small incinerator installed to the west of the steam plant. Two plant air receivers, a diesel exhaust muffler, an acid storage tank, and a diesel oil storage tank were located outside the building walls. Sampling will be performed in the vicinity of Building

401 based on the use of asbestos, barium chloride, coal, chlorine, hydrofluoric acid, diesel oil, fuel oil, lube oil, gasoline, oxalic acid, phosphate, sulfite and salts.

Sampling locations are:

#	Coordinates W	N	Analytical Parameters
16)	50,575	100,725	MTL, VOA, SV, IO
17)	50,550	100,950	MTL, SV, TOX
18)	50,550	101,070	MTL, SV, TOX
19)	50,550	101,210	MTL, SV, TOX
20)	50,660	100,940	MTL, SV, TOX

WET AND DRY CHEMICAL PILOT PLANT - BUILDING 403

The Wet and Dry Chemical Pilot Plant (Building 403) was designed to house pilot plant equipment for performing operations similar to those carried out in the digestion, extraction, and denitration areas of the operating plant. Sampling performed in the vicinity of Building 403 will be based on the use of nitric acid, magnesium, lime, iron, aluminum, hexane, and TBP. Sampling location is:

#	Coordinates W	N	Analytical Parameters
21)	49,800	100,675	MTL, VOA, SV, IO

METALS PILOT PLANT - BUILDING 404

The Metals Pilot Plant (Building 404) houses the metallurgical pilot plant and includes such facilities as blenders, jolters, breakout equipment, reduction furnaces, vacuum casting equipment and a small ceramics laboratory. The building was designed for maximum flexibility of equipment installation. It is located immediately north of the laboratory (Building 407). Sampling in the vicinity of Building 404 will be based on the use of barium fluoride, lithium chloride, and lithium fluoride. Sampling location is:

#	Coordinates W	N	Analytical Parameters
22)	49,725	100,675	MTL, VOA, SV, IO

WAREHOUSE - BUILDING 406

The Warehouse (Building 406) provides storage space for dry chemicals, recycled and special feed materials, intermediate products and miscellaneous materials. Both railroad car and truck unloading docks are provided. Since most dry chemicals were used in the refinery area, the warehouse is equipped with a ramp so that materials can be moved to other buildings by fork truck. No sampling is proposed in this area due to the presence of large areas of concrete.

SUPPORT FACILITIES

LABORATORY BUILDING - BUILDING 407

Building 407 provided the necessary laboratory facilities for the plant. Approximately two-thirds of the building housed analytical facilities with the remaining third housing development facilities.

Although many chemicals were used in Building 407, there is no historical information indicating routine transport of chemicals from Building 407 to other buildings, nor are there any documented spills in the area. Therefore sampling in the vicinity of Building 407 will not be performed.

MAINTENANCE AND STORES BUILDING - BUILDING 408

The Maintenance and Stores Building (Building 408) provided the on-site maintenance facilities. The building housed maintenance shops, maintenance stores, automotive maintenance, fire trucks and offices for shop and stores supervision. The shops were located side by side along the exterior wall of the building facing the plant. Each had access on the interior side of the building to a "multiple-use" work space which was serviced by a truck aisle running the length of the building. A fire wall divided the building longitudinally into two equal areas. The stores section was on the opposite side of the fire wall from the shops.

Automotive maintenance and repair facilities were located at the south end of the building adjacent to the motor pool. A shipping and receiving dock was provided at the southeast corner of the building which is nearest to the plant entrance. Adjacent to the dock was a decontamination, cleaning and degreasing station. Sampling in the vicinity of Building 408 will be based on the use of many chemicals associated with facility and automotive maintenance. Sampling locations are:

#	Coordinates W	N	Analytical Parameters
23)	49,700	99,550	VOA, SV, PP, IO
24)	49,910	99,830	VOA, SV, PP, IO
25)	49,775	99,975	MTL, VOA, SV, IO, PP

ADMINISTRATION BUILDING - BUILDING 409

The Administration Building (Building 409) was designed and arranged to serve as an administrative and technical headquarters.

Chemical contamination is not expected in the vicinity of building 409 and no sampling will be performed.

SERVICES BUILDING - BUILDING 410

The Services Building (Building 410) housed the following facilities: cafeteria, health department, guard house, gate house and change rooms.

Although Building 410 contained chemicals for first aid and health services, there is no record of routine transport of chemicals in and out of the building nor any record of chemical spills in the vicinity, and sampling will not be performed.

SCRAP CLASSIFICATION AND EQUIPMENT STORAGE FACILITY-AREA 414

The Scrap Classification and Equipment Storage Facility (Area 414) provided for the storage of large pieces of equipment and for the receipt, classification and salvage of usable parts.

The facility consists of a concrete pad and a prefabricated building. The building housed salvage and reclamation operations and provided storage for equipment that could not be stored outdoors. Fenced enclosures are installed for classified scrap. No sampling is planned for this area.

PAINT SHOP - BUILDING 417

The Paint Shop (Building 417) was housed in a separate one-story building divided into two equal sections by a fire wall. One section was used for general storage and the other as work space. Sampling in the vicinity of Building 417 will be based on the routine use of benzene, methylisobutyl ketone, phenoline thinner, various paint solvents, and metals.

Sampling locations are:

#	Coordinates W	N	Analytical Parameters
26)	49,800	99,340	MTL, VOA, SV, IO, TOX
27)	49,870	99,440	VOA, SV, IO
28)	49,830	99,470	MTL, VOA, SV, IO

STORAGE BUILDINGS-BUILDINGS 433, 434, 435, 436, 437 & 438

These buildings fulfilled several functions during the construction of the plant. They were constructed for temporary use as construction warehouses, personnel offices, shops, motor pool including fuel station, garages and general storage. Building 437 is constructed of brick and was previously part of the WSOW. The remaining buildings are Butler-type on concrete slab.

Sampling locations are:

#	Coordinates W	N	Analytical Parameters
29)	50,740	98,250	MTL, VOA, SV, IO
30)	50,710	98,350	MTL, VOA, SV, IO
31)	50,830	98,410	VOA, SV, IO
32)	50,680	98,410	MTL, VOA, SV, IO
33)	50,610	98,370	MTL, VOA, SV, PP, IO
34)	50,570	98,330	MTL, VOA, SV, PP, IO
35)	50,560	98,440	MTL, VOA, SV, PP, IO

36)	50,670	98,610	MTL, VOA, SV, PP, IO, TOX

REFINERY TANK FARM - AREA 102

The Refinery Tank Farm provided facilities for the unloading, storing, and transferring of liquid process materials required in the refinery operation which were supplied or handled in tank-car or tank-truck quantities. Storage tanks were furnished for hexane, ethyl ether, dilute nitric acid, sulfuric acid, and 50 percent caustic soda solution. Other facilities in this area include unloading docks, transfer pumps and drum filling equipment.

Tank Farm 102A handled all of the above materials except nitric acid, which was handled in Tank Farm 102B.

There are no buildings in the area. All equipment was located in open concrete saddle pedestals. Twelve tanks (19,000 to 26,000 gal) were located in the area but have been removed.

Sampling in the vicinity of the tank farm will be based on the use of hexane, nitric acid, sulfuric acid, ethyl ether and sodium hydroxide. Sampling locations are:

#	Coordinates W	N	Analytical Parameters
37)	50,500	100,140	MTL, VOA, SV, PP, IO, pH
38)	50,500	100,240	MTL, VOA, SV, PP, IO, pH
39)	50,440	100,170	MTL, VOA, SV, PP, IO, pH

40)	50,440	100,380	MTL, VOA, SV, PP, IO, pH
41)	50,440	100,450	MTL, VOA, SV, PP, IO, pH
42)	50,310	100,520	MTL, VOA, SV, PP, IO, pH
43)	50,360	100,540	MTL, VOA, SV, PP, IO, pH
44)	50,350	100,480	MTL, VOA, SV, PP, IO, pH
45)	50,340	100,420	MTL, VOA, SV, PP, IO, pH

NITRIC ACID RECOVERY FACILITY - AREA 108

The Nitric Acid Recovery Plant was designed to recover for re-use the bulk of the nitric acid required for digestion. Accordingly, the facility was equipped to:

- o collect and absorb nitrogen oxides from the Digestion and Denitration Building in water or weak nitric acid; and
- o reconcentrate the recovered weak nitric acid.

The recovery plant was essentially an outdoor installation. Housing was provided for compressors and instrument panels. Sampling in the vicinity of Area 108 will be based on the use of nitric and ferric acids. Sampling location is:

#	Coordinates W	N	Analytical Parameters
46)	50,350	100,350	MTL, TOX, pH, IO

GREEN SALT TANK FARM - AREA 202

The Green Salt Tank Farm (Area 202) provided for tank car unloading and storage of anhydrous hydrofluoric acid (AHF) and anhydrous ammonia, both utilized in the Green Salt Plant (Building 201). In addition, storage and tank car loading facilities were installed for the 70 percent hydrofluoric acid (70% HF) recovered in the green salt process.

The five AHF tanks were located within an insulated enclosure. Five additional tanks were not enclosed, but were located within a diked area. Unloading pumps for AHF and a loading pump for 70% HF acid were installed. A compressor house was provided for the ammonia unloading compressor. Sampling in the vicinity of the Green Salt Tank Farm will be based on the use of hydrofluoric acid, anhydrous ammonia and anhydrous hydrogen fluoride. Sampling locations are:

#	Coordinates W	N	Analytical Parameters
46)	50,370	99,830	MTL, TOX, pH, IO
47)	50,370	99,850	MTL, TOX, pH, IO
48)	50,370	99,110	MTL, TOX, pH, IO
49)	50,300	99,950	MTL, TOX, pH, IO
50)	50,350	99,980	MTL, TOX, pH, IO

ELECTRICAL TRANSFORMER AREAS

Substation No. 412, the main electrical substation on site, contains the electrical equipment (switches and transformers) necessary for the transformation of incoming power at 34.5 KV to plant distribution power of 13.8 KV. Numerous smaller electrical transformers are located in the WSCP and samples will be collected based on the use of PCB and PCB contaminated oil. Sampling locations are:

#	Coordinates W	N	Analytical Parameters
51)	50,790	98,300	PCB
52)	49,940	99,740	PCB
53)	50,200	99,640	PCB, IO
54)	50,250	99,920	PCB, IO
55)	50,680	99,990	PCB
56)	50,440	100,340	PCB
57)	50,480	100,640	PCB, IO
58)	49,700	100,360	PCB
59)	49,780	100,800	PCB

COOLING TOWER - AREA 413

The Cooling Tower is constructed of redwood lumber. It was designed to handle 12,000 gpm and to cool the water from 110°F to 90°F at a wet bulb temperature of 78°F.

A reinforced concrete basin with flume was installed, having a capacity of 80,000 gallons--the minimum amount of water storage required for proper operation of the cooling tower.

A steel frame building with corrugated asbestos siding was constructed adjacent to the cooling tower to house the pumping facilities, the chemical treatment and the electrical equipment necessary for the operation. Sampling in the vicinity of Area 413 will be based on the use of chlorine, chromate phosphate, and sulphuric acid. Sampling location is:

#	Coordinates W	N	Analytical Parameters
60)	50,525	100,525	IO

PROCESS INCINERATOR - AREA 415

The Process Incinerator was a small combustion unit for (1) burning trash or wastes from which uranium was to be recovered from the ashes and (2) burning of classified documents. Chemical contamination is not suspected in this area and no sampling will be performed in this area.

ELEVATED WATER TANK - AREA 426

The Elevated Overhead Storage Tank has a capacity of 350,000 gallons and stands 186 feet above the foundation. It is supported by six tubular steel legs set on a concrete foundation

and is equipped with a steam-heated standpipe. The installation provided a positive means of preventing any possible backflow

from the process system to the potable water system. Chemical contamination is not suspected in this area and no sampling will be performed in this area.

PRIMARY SEWAGE TREATMENT PLANT - AREA 427

A Primary Sewage Treatment Plant was installed near the south site boundary. It was sized to handle sewage wastes for approximately 1,300 persons per day. An Imhoff tank design for sludge settling and digestion was used. Sampling will be based on the spectrum of chemicals used on-site. A single grab sample will be collected and analyzed for metals, semivolatiles, PCBs, pesticides, inorganic anions, and TOX.

PROPANE GAS PLANT - AREA 428

A Propane Gas Plant was installed near the west side of the building area to provide fuel gas to the various plants to satisfy process heating requirements. Two 30,000-gallon storage tanks were provided. No chemical contamination is expected in this area, and samples will not be collected.

RESERVE WATER FACILITIES - AREA 429

The Reserve Water Facilities consist of a large ground storage tank and an auxiliary pump house. No contamination is expected and samples will not be collected.

FIRE TRAINING - AREA 439 & 443

During operations of the plant, the fire protection department maintained fire training facilities on the site. The foundations of these facilities are all that remains. Sampling in this area will be based on the presence of drums of unknown chemicals located during the 1987 chemical inventory. Since oil possibly contaminated with PCB's may have been utilized in the fire training area, the samples will be analyzed for PCB's, PCDF's and dioxins in addition to other parameters. Two grab samples will be collected from the fire training area. Sampling locations are:

#	Coordinates W	N	Analytical Parameters
62)	50,910	100,860	Nitroaromatics, MTL, VOA, SV, PP, PCDP's, dioxins, TOX - Grab from pit
63)	50,810	100,770	MTL, SV, PP, PCDF's, dioxins, TOX - Grab from filter

RAILROADS

A railroad system was installed within the plant site for delivering raw materials to and removing product from the plant.

The trackage is connected at the south boundary line to a railroad spur line that previously served the WSOW. The new railroad system within the plant area consists of double tracks that pass through the building area, and terminate at track bumpers located near the north boundary line. Track turnouts are strategically located to facilitate the movement of loaded or empty cars to and from the various buildings. Limestone ballast at a greater than normal depth was utilized on 190 feet of the track adjacent to the Green Salt Tank Farm, Area 202, in order to neutralize acid spills or drips from hydrofluoric acid tank car unloading. Decontamination of box cars was accomplished using a reinforced concrete basin installed under the east track adjacent to the feed storage pad, Areas 109 and 110. A track hopper is erected under the west track adjacent to the coal storage area for unloading coal from hopper cars to use in Building 401. Sampling will be performed in this area based on an uninvestigated tank area south of Areas 109 and 110. Sampling location is:

#	Coordinates W	N	Analytical Parameters
64)	50,360	100,660	MTL, VOA, SV, IO, PP

UNDERGROUND TANKS

Several underground tanks are present in various areas of the WSCP. These tanks were primarily used to store gasoline, fuel

oil, diesel fuel and other hydrocarbons. Sampling will be performed near each underground tank. Sampling locations are:

#	Coordinates W	N	Building	Analytical Parameters
65)	50,390	100,820	401	VOA
66)	50,750	100,770	439	MTL, SV, PP, TOX
67)	49,740	100,970	101	MTL, VOA, PP, TOX
68)	50,590	98,210	436	VOA
69)	49,870	99,590	408	VOA, PP

MISCELLANEOUS

Included in this category are several filters, isolated tanks and other areas suspected of being chemically contaminated. Analytical parameters were selected based on location, known process and/or suspected contaminants. Samples will be collected at 0 to 6 inch, 24 to 30 inch, and 54 to 60 inch intervals unless noted. Sampling locations are:

#	Coordinates W	N	Area	Analytical Parameters
70)	50,510	99,530	303	MTL, VOA, SV, PP
71)	50,460	99,600	303	MTL, VOA
72)	50,520	99,770	419	MTL, VOA, SV, IO, PP
73)	50,980	100,420	428	MTL, VOA, SV, PP
74)	49,880	100,240	410	MTL, VOA, SV, TOX

75)	49,800	100,620	407	MTL, VOA, SV, IO, PP, TOX, Asbestos
76)	49,730	100,040	404	MTL, SV, PP, TOX - Grab from filter
77)	49,890	100,840	403	MTL, SV, PP
78)	51,970	100,520	Ash Pond	Nitroaromatics, MTL, VOA, SV, IO, PP, TOX, pH

OVERHEAD PIPING SYSTEM

Steam, air, brine and fuel gas were carried in pipe-lines supported overhead on steel pipe racks and bridges. Steam was distributed through a network of asbestos-insulated pipes to the various buildings where it was used for process and heating purposes.

In order to accommodate all the various piping systems, a support system was erected which consisted of steel pipe poles and structural steel and pipe bents, along with several structural steel bridges. The supports were installed on concrete foundation piers.

Utility lines included in the overhead piping systems were as follows:

High pressure air
Instrument air
Ethylene glycol, supply and return
Fuel gas
High pressure steam

Piping for the transfer of the following chemicals was also part of the overhead distribution systems:

Concentrated nitric acid

Dilute nitric acid

Sulfuric acid

Lime slurry

Aluminum nitrate

Ferric nitrate

Caustic

Sodium carbonate

Diethyl ether

Hexane

Deionized water

Additional process lines include:

Digested slurry

"NG" liquor (recycled uranyl nitrate solution)

Aqueous uranyl nitrate

Raffinate

Sump liquor slurry

NO_2 fume headers

Since no documented leaks or spills occurred from overhead piping or railroad systems, samples will not be collected from these areas. However, sample locations selected randomly as discussed in Section 4.5 will provide coverage of affected areas.

SANITARY SEWER

A network of underground sewers was installed to collect and carry sanitary effluent from the various buildings to the primary sewage treatment plant, Area 427.

It was necessary due to the topography of the site to install septic tanks and drainage fields for the steam plant (Building 401) and the pilot plants (Building 403 and 404) since gravity flow to the sanitary sewer system was not possible.

The sanitary sewer system is from 4 to 12 feet deep and consists of 4,780 lineal feet of vitrified clay pipe, 6 in. to 10 in. diameter, and 245 lineal feet of 6 in. cast iron soil pipe.

PROCESS SEWER SYSTEM

A network of underground process sewers was installed to handle large quantities of manufacturing wastes containing chemicals and small amounts of low level radioactive materials. No reported leaks or failures of the process sewer system are known. Minor amounts of leakage would be extremely difficult to detect with borehole sampling. A more rational approach is to observe excavation operations, inspect the sewer lines and collect biased samples during excavation operations.

All WSUFMP Biased Sampling Locations are presented in Table 4-5.

TABLE 4-5

Weldon Spring Feed Materials Plant Biased Sampling Locations

POINT #	COORDINATES WEST	COORDINATES NORTH	COORDINATES DESCRIPTION	NUMBER OF SAMPLES	DEPTH OF SAMPLE	SAMPLE TYPE COMP./GRAB	TYPE OF SOIL CHEMICAL ANALYSIS*	RATIONALE
Building 101 Area								
1)	50,100	100,730	Uninvestigated area east of 101	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,M,N	Unknown area
2)	50,100	100,650	Uninvestigated area east of 101	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,M,N	Unknown area
3)	50,040	100,700	Uninvestigated area east of 101	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,M,N	Unknown area
4)	50,240	101,030	Drum storage, north of 109 & 110	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,G,H,L,N	Unknown contents; nitric acid, organics
5)	50,130	100,960	Drum storage, north of 109 & 110	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,G,H,L,N	Unknown contents
6)	50,120	101,600	Drum storage, north of 109 & 110	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,G,H,L,N	Unknown contents
Building 103 Area								
7)	50,220	100,325	Process Lines at 103	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,O	Process lines into-out of building
8)	50,125	100,080	Process lines at 103	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,O	Process lines into-out of building
Building 105 Area								
9)	50,240	100,475	Process Lines at 105	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	F,G,H,L	Process lines into-out of building
10)	50,150	100,425	Process Lines at 105	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	F,G,H,L	Process lines into-out of building
Building 201 Area								
11)	50,225	99,850	Chemical transfer at 201 area	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,O	Chemical transfer point
Building 301 Area								
12)	50,375	99,650	Chemical transfer at 301 area	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,O	Chemical transfer point
13)	50,075	99,400	Chemical transfer at 301 area	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,O	Chemical transfer point
14)	50,225	99,400	Chemical transfer at 301 area	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,O	Chemical transfer point

* See key code for analytical description, page 112.

TABLE 4-5 (cont.)

POINT #	COORDINATES WEST	COORDINATES NORTH	COORDINATES DESCRIPTION	NUMBER OF SAMPLES	DEPTH OF SAMPLE	SAMPLE TYPE COMP./GRAB	TYPE OF SOIL CHEMICAL ANALYSIS	RATIONALE
Building 302 Area								
15)	50,390	99,175	Grassy area north of building 302	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,L	Lead & Magnesium chips released in this area
Building 401 Area								
16)	50,575	100,725	Incineration 401	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L	Stock/incinerator area
Building 401 Area								
17)	50,550	100,950	Coal storage area north of 401	3	0-6", 2-2.5", 4.5-5'	Composite at each interval	D,G,H,N	Uninvestigated area
18)	50,550	101,070	Coal storage area north of 401	3	0-6", 2-2.5", 4.5-5'	Composite at each interval	D,G,H,N	Uninvestigated area
19)	50,550	101,210	Coal storage area north of 401	3	0-6", 2-2.5", 4.5-5'	Composite at each interval	D,G,H,N	Uninvestigated area
20)	50,660	100,940	Coal storage area north of 401	3	0-6", 2-2.5", 4.5-5'	Composite at each interval	D,G,H,N	Uninvestigated area
Building 403 Area								
21)	94,800	100,675	Process line 403	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L	Process line
Building 404 Area								
22)	49,725	100,675	Process line 404	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L	Process line
Building 408 Area								
23)	49,700	99,550	One drum east of 408	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	F,H,L,M	Unknown contents of drums; cyanide, PCBs
24)	49,910	99,830	Drum storage west of 408	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	F,G,H,L,M	Unknown contents; sodium cyanide, PCBs
25)	49,775	99,975	Degreasing station 408	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M	Use of solvents, degreasers, cleaning agents
Building 417 Area								
26)	49,860	99,340	Drum storage area south of 417	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M	Unknown contents of drums; benzene, MBK, phenolene, solvents
27)	49,870	99,440	Drum storage area south of 417	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	F,G,H,L	Unknown contents of drums

TABLE 4-5 (cont.)

POINT #	COORDINATES WEST	COORDINATES NORTH	COORDINATES DESCRIPTION	NUMBER OF SAMPLES	DEPTH OF SAMPLE	SAMPLE TYPE COMP./GRAB	TYPE OF SOIL CHEMICAL ANALYSIS	RATIONALE
Building 417 Area (continued)								
28)	49,830	99,470	Drum storage area south of 417	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L	Unknown contents of drums
Buildings 433, 434, 435, 436, 437, & 438								
29)	50,740	98,250	Drum storage area west of 436	2	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L	Unknown contents of drum
30)	50,710	98,350	Drum storage area, west and adjacent to 436	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L	Unknown contents of drums
31)	50,830	98,410	Drum storage area, west of 436	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	F,G,H,L	Unknown contents of drums
32)	50,680	98,410	Drum storage area, east and adjacent to 436	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,G,H,F,L	Unknown contents of drums
33)	50,610	98,370	Drum storage area west of 435	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M	Unknown contents of drums
34)	50,570	98,330	Drum storage area west of 436	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M	Unknown contents of drums
35)	50,560	98,440	Drum storage area east side of 435	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M	Unknown contents of drums; PCBs, sulfuric, nitric, sodium fluoride
36)	50,670	98,610	Concrete pad east of 437	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M,N	Unknown concrete pad; PCBs, sulfuric, nitric, sodium fluoride
Area 102 A and B								
37)	50,500	100,140	Area 102B tank farm area	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M	Unknown contents of tanks; hexane, sulfuric, ethyl ether, sodium hydroxide
38)	50,500	100,240	Area 102B tank farm area	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M,O	Unknown contents of tanks, hexane, sulfuric, ethyl ether, sodium hydroxide
39)	50,440	100,170	Area 102B tank farm area	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M,O	Unknown contents of tanks, hexane, sulfuric, ethyl ether, sodium hydroxide

TABLE 4-5 (cont.)

POINT #	COORDINATES WEST	NORTH	COORDINATES DESCRIPTION	NUMBER OF SAMPLES	DEPTH OF SAMPLE	SAMPLE TYPE COMP./GRAB	TYPE OF SOIL CHEMICAL ANALYSIS	RATIONALE
Area 102 A and B (continued)								
40)	50,440	100,380	Area 102B tank farm area	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M,O	Unknown contents of tanks, hexane, sulfuric, ethyl ether, sodium hydroxide
41)	50,440	100,450	Area 102B tank farm area	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M,O	Unknown contents of tanks; hexane, sulfuric, ethyl ether, sodium hydroxide
42)	50,310	100,520	Area 102A tank farm area	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M,O	Unknown contents of tanks; hexane, sulfuric, ethyl ether, sodium hydroxide
43)	50,360	100,540	Area 102A tank farm area	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M,O	Unknown contents of tanks; hexane, sulfuric, ethyl ether, sodium hydroxide
44)	50,350	100,480	Area 102A tank farm area	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M,O	Unknown contents of tanks; hexane, sulfuric, ethyl ether, sodium hydroxide
45)	50,340	100,420	Area 102A tank farm area	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M,O	Unknown contents of tanks; hexane, sulfuric, ethyl ether, sodium hydroxide
Area 108								
46)	50,350	100,350	108, west side near railroad tracks	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,L,N,O	Nitric acid area, nitric & ferric acids
Area 202								
47)	50,370	99,830	South end of 202 adjacent to HF tanks	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,L,N,O	Possible metals & acid; hydrofluoric acid, anhydrous ammonia, hydrogen fluoride
48)	50,370	99,850	South end of 202 adjacent to HF tanks	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,L,N,O	Possible metals & acid
49)	50,370	99,110	South end of 202 adjacent to HF tanks	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,L,N,O	Possible metals & acid
50)	50,300	99,950	South end of 202 adjacent to HF tanks	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,L,N,O	Possible metals & acid
51)	50,350	99,980	South end of 202 adjacent to HF tanks	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,L,N,O	Possible metals & acid

TABLE 4-5 (cont.)

POINT #	COORDINATES WEST	COORDINATES NORTH	COORDINATES DESCRIPTION	NUMBER OF SAMPLES	DEPTH OF SAMPLE	SAMPLE TYPE COMP./GRAB	TYPE OF SOIL CHEMICAL ANALYSIS	RATIONALE
Transformers								
52)	50,790	98,300	Transformer substation, west of 436	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	M	Possible PCBs
53)	99,940	99,740	Substation west of 408	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	M	Possible PCBs
54)	50,200	99,640	Substation north of 301	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	L,M	Possible PCBs; caustics, magnesium, asbestos
55)	50,250	99,920	Substation west of 201	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	L,M	Possible PCBs; hydrofluoric acid, lime, Freon, asbestos
56)	50,680	99,990	Substation west of 201	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	M	Possible PCBs
57)	50,440	100,340	Substation west of 108	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	M	Possible PCBs, nitric & ferric acids
58)	50,480	100,640	Substation south of 401	3	0-6", 2-3.5', 4.5-5'	Composite at each interval	L,M	Possible PCBs; barium chloride, chlorine, hydrofluoric, phosphate, sulfate,
59)	49,700	100,360	Substation north of 410	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	M	Possible PCBs
60)	49,780	100,800	Substation north of 405B	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	M	Possible PCBs
Building 413 Area								
61)	50,525	100,525	Chemical transfer area 413	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	L	Chemical transfer point
Area 427								
62)	50,180	98,830	Waste treatment facility Area 427	1	Sludge & sediment from bottom of pond	Grab from bottom of pond	D,G,H,L,M,N	Unknown contents pond
Areas 439 & 443								
63)	50,910	100,860	Fire training pit west of 439	1	Sludge & sediment from bottom of pit	Grab	A,D,F,G,H,M,N	Unknown contents

TABLE 4-5 (cont.)

POINT #	COORDINATES WEST	COORDINATES NORTH	COORDINATES DESCRIPTION	NUMBER OF SAMPLES	DEPTH OF SAMPLE	SAMPLE TYPE COMP./GRAB	TYPE OF SOIL CHEMICAL ANALYSIS	RATIONALE
Areas 439 & 443 (continued)								
64)	50,810	100,770	Filter south of 439	1	Sludge & sediment from bottom of filter	Grab	D,G,H,L,M,N	Unknown contents
Railroad Area								
65)	50,360	100,660	Tank area east of 101 on railroad tracks	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M	Unknown contents
Tanks - Underground								
66)	50,390	100,820	Underground fuel tank, NE of 401	3	2' intervals to 10'	Composite at each interval	F,M	Unknown contents
Tanks - Underground								
67)	50,750	100,770	Underground tank south of 439	5	2' intervals to 10'	Composite at each interval	D,G,H,M,N	Unknown contents
68)	49,740	100,970	Underground treatment tank near 101	3	2' intervals to 10'	Composite at each interval	D,F,M,N	
69)	50,590	98,210	Fuel storage tank south of 436	5	Composite Samples at 2' intervals 40 10' (0-2, 2-4, 4-6, 6-8, 8-10)	Composite at each interval	F	Underground fuel tanks; PCBs, sulfuric acid, nitric acid, sodium fluoride
70)	49,870	99,590	Underground storage tank south of 408	5	Samples at 2' intervals to 10' (0-2, 2-4, 4-6, 6-8, 8-10)	Composite at each interval	F,M	Unknown contents
Miscellaneous								
71)	50,510	99,530	Area south of 303	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,M	Unknown area
72)	50,460	99,600	Area 313 "chips storage" around foundation	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L	Unknown storage area
73)	50,520	99,770	Scrap storage yard south of 419	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M	Unknown storage area
74)	50,980	100,420	Stainless steel tank, TBP outside fence west of 428	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,M	Unknown contents; propane

TABLE 4-5 (cont.)

POINT #	COORDINATES WEST	NORTH	COORDINATES DESCRIPTION	NUMBER OF SAMPLES	DEPTH OF SAMPLE	SAMPLE TYPE COMP./GRAB	TYPE OF SOIL CHEMICAL ANALYSIS	RATIONALE
75)	49,880	100,240	Radiologically contaminated area west of 410	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,G,H,M,N	Unknown area
76)	49,800	100,620	Concrete pad	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,F,G,H,L,M,N,K	Unknown area
77)	49,730	100,040	Filter, north of 404	1	Sludge & sediment from bottom of filter	Grab	D,G,H,M,N	Unknown contents; barium fluoride, lithium chloride, lithium fluoride
78)	51,970	100,520	Landfill (drum disposal area)	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	A,D,F,G,H,L,M,N,O	Unknown disposal area
79)	49,890	100,840	Tank north of 403	3	0-6", 2-2.5', 4.5-5'	Composite at each interval	D,G,H,M	Unknown contents

KEY FOR SOIL CHEMICAL ANALYSES

A = Nitroaromatics group (2,4-DNT; 2,6-DNT; 1,3-DNB; 1,3,5-TNB, and 2,4,6-TNT)

B = Nitrite

C = Sulfate

D = Metals

E = Mercury

F = GC/MS volatile fraction

G = GC/MS acid fraction

H = GC/MS BNA fraction

I = Hexavalent chromium

K = Asbestos

L = Inorganics, SO_4, SO_3, NO_3, NO_2, Fl

M = Pesticides/PCBs

N = TOX

O = Soil pH

P = Select metals - aluminum, antimony, barium, iron, lead, magnesium, manganese.

Note: See WSSRAP, RI/FS, QAPP for method description, detection limits, and holding times

4.4 WSOW Biased Sampling Program

4.4.1 Chemical Sources and Source Areas

The TNT and DNT production process that was carried out by Atlas Powder Company during the operation of the WSOW was similar to that used at other TNT and DNT plants.

TNT plants all use the same basic chemical process, i.e., the treatment of liquid toluene with mixed nitric and sulfuric acids followed by removal of undesired isomers and residual dinitrated toluene by conversion to soluble species. The undesired isomers plus residual dinitrated species were removed from the reaction mixture by treatment with aqueous sodium sulfite solution, called "sellite," which reacted with everything except the desired product. The spent sellite solution, containing the extracted sulfonate derivatives, was known as "red water," and constituted a major inherent waste stream.

Red water is a deep red, almost black, aqueous stream containing an extremely complex mixture of nitroaromatics and various inorganic salts. The organic portion is mostly accounted for by the various sulfonated derivatives of the three undesired TNT isomers.

Other organic constituents include smaller fragments, dissolved a-TNT, and complex, unidentified dye bodies formed from the photolysis of a-TNT by sunlight. The inorganic portion consists

mainly of unreacted sulfite plus nitrite and nitrate formed in the extraction reactions. Red water varies somewhat in composition from plant to plant and from run to run, but a typical composition is:

Water

Na_2SO_3-Na_2SO_4

$NaNO_2$-$NaNO_3$

Sulfonated or sellited nitro compounds

Solids

Ash

Figure 4-3 shows the schematic flow diagram of the batch process which was used by WSOW. Numerous buildings at the WSOW have been identified. Table 4-6 relates building number to process description where known. The nitration reactions are carried out in three consecutive batch units referred to as "Mono," "Bi," and "Tri" Houses. The feed chemicals to the Mono House (T-7) are toluene and waste acid from the Bi House (T-12), fortified with 60% HNO_3.

After reaction, the waste acid was transferred to a storage tank for recovery, and the partially nitrated toluene was pumped to the Bi House where further nitration was effected with waste acid from the Tri House (T-9), fortified with 60% HNO_3. The result was a mixture of all possible dinitrated isomers, "Bi Oil." After settling and separation, the Bi Oil was pumped to the Tri House where the feed acid was a mixture of 98% nitric acid and

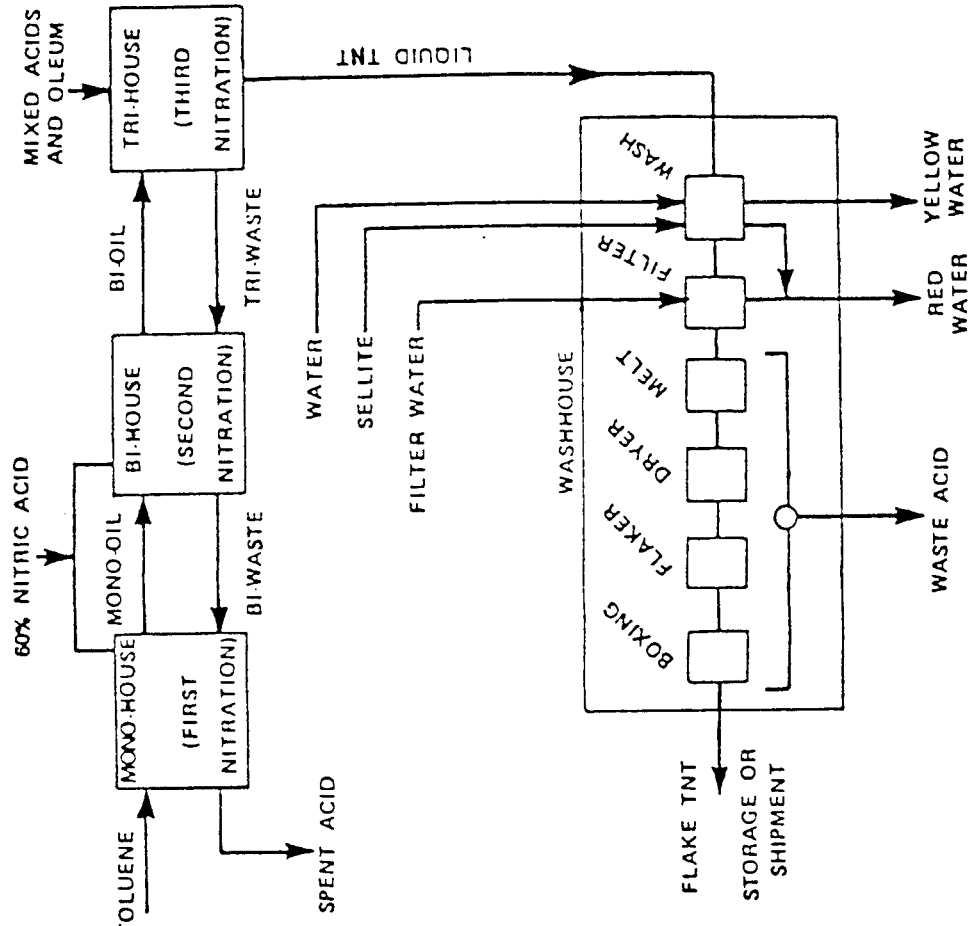

FIGURE 4-3

WSOW SCHEMATIC FLOW DIAGRAM WITH WASTE STREAMS

TABLE 4-6

WELDON SPRING ORDNANCE WORKS PROCESS BUILDING DESIGNATION

T-1	Toluene Storage
T-3	Acid Unloading
T-4	Acid Unloading
T-5	Acid Unloading
T-6	Acid Unloading
T-7	Mono Nitrating Houses
T-8	Acid Recovery Houses
T-9	Trinitrating Houses
T-10	Acid Storage
T-11	Valve House
T-12	Bi-Fortifier Houses
T-13	Wash Houses
T-16	Settling Houses
T-17	Sellite Storage
T-18	Wet Powder Holdovers
T-19	Grainer Houses
T-20	Motor House
T-22	Settling Tanks
T-23	Dry Holdover
T-24	Pack Houses
T-25	Motor House
T-26	Rubbish Sheds
T-32	Settling Tanks
T-33	Transfer House
T-35	Pelleting
T-36	Box Service
T-37	Box Conveyor
T-38	Strapping House

Source: WSSRAP, 1987

oleum. The nitrated product from this third nitration stage operation was crude TNT containing a-TNT (2,4,6-trinitrotoluene), which was the desired product, and unsymmetrical TNT isomers, which were the impurities. The crude TNT was fed to the Wash House (T-13) for purification.

The purification of crude TNT involves crystallization in water, free acid neutralization with soda ash and solutilization and removal of undesirable nitrated products by treatment with a solution of sodium sulfite (sellite). The wastewater from the sellite purification stage was transferred to the red water treatment plant for disposal by evaporation-concentration and concentrate incineration.

The TNT slurry was transferred to a filter tank where it was washed and filtered on a screen leaving layers of TNT crystals. The crystals were reslurried with water and pumped to a melt tank where TNT was melted and most of the water was removed by evaporation. The molten product was run into hot air dryers for the removal of residual water. The water-free product was solidified on a water-cooled flaker drum or stainless steel belt, and the resultant film was removed in the form of small flakes by scraping the drum or belt with a beryllium blade. The flaked TNT was boxed and sent to a packing house for transfer to a storage or loading area.

Four waste streams are shown in Figure 4-3: spent acid, waste acid, red water, and yellow water. The spent acid was not

discharged; the nitric acid was distilled off and reused and the residual sulfuric acid was sold for commercial use. The waste acid (mostly spillage, floor drainage and the like) was neutralized with lime or soda ash and discharged to the chemical sewer for treatment and discharge to wastewater lagoons or surface drainage. The yellow water, essentially a dilute nitrator, and the red water were destroyed as previously described.

Dinitrotoluene (DNT), a closely related explosive, can be made in a TNT plant and was produced at the WSOW. No DNT was produced in production lines 1, 2, 3, and 4. Plate 1 shows the location of the process and waste lines as they existed on what is now the WSCP/WSRP. Of the 18 production lines which existed during the peak production period, only lines 1-4 were located in the vicinity of the WSCP/WSRP.

At the time of the closing of the WSOW, all lines, equipment and facilities were reportedly decontaminated to a known condition.

In addition to equipment and building contamination, all earth known to be contaminated around process buildings, catch tanks, and drainage ditches was removed in 1946. The depth of the soil contamination varied from 4 inches to 3 feet, depending on the nature of the soil.

Since the WSOW facilities have been demolished and much process-specific information was destroyed in 1974, a

building-by-building description of the process is not possible. This biased sampling effort is guided by investigations at the WSTA and at other ordnance works facilities (West Virginia, Alabama Army Ammunition Plant).

4.4.2 WSOW Biased Sampling Approach

The biased sampling program for WSOW sources was developed based on WSOW building locations, WSOW topography, current knowledge of WSOW production and waste management practices, and investigations at other ordnance works. Biased sampling locations were targeted towards TNT production areas representing potential source areas. Sampling depths were established using a cut and fill map (Plate 2) to assure that original WSOW topography was sampled. The cut and fill map was prepared by comparing 1954 topography to 1964 topography and contouring the difference in elevation. Cut areas were topographically higher in the WSOW time frame. Fill areas were lower topographically in WSOW days. The accuracy of this map is plus or minus two feet. Sampling locations in fill areas will be sampled to greater depths than cut areas. Analytical parameters were selected based on chemicals used in TNT production which may be present after forty years.

Sampling locations, depths, analytical parameters, and selection rationale for the WSOW biased soil sampling are presented in Table 4-7. Sample locations are shown in Plate 3.

TABLE 4-7

WSOW Biased Soil Sampling Locations

Borehole Number	Coordinates West	Coordinates North	Borehole Depth	Number of Samples	Chemical Analysis*
Wash House Area of TNT Production Line No. 1					
1	49,370	100,740	12	6	A, L, O, P
2	49,425	100,725	14	7	" "
3	49,410	100,758	14	7	" "
4	49,468	100,712	14	7	" "
5	49,475	100,770	14	7	" "
75	49,450	100,870	14	7	" "
Drainage From TNT Production Line No. 1					
6	49,450	100,450	16	8	A, L, O, P
7	49,583	100,650	20	10	" "
8	49,635	100,850	21	11	" "
9	49,625	101,000	12	6	" "
Final Production Area of TNT Line No. 1					
10	50,040	101,285	6	3	A, L, O, P
11	50,055	101,215	6	3	" "
12	50,100	101,240	6	3	" "
13	50,140	101,255	8	4	" "
TNT Production Line No. 2 Acid Recovery Building Drainage					
14	50,550	101,050	14	7	A, L, O, P
15	50,550	101,000	20	10	" "
16	50,550	100,950	22	11	" "
17	50,500	100,950	22	11	" "
18	50,600	100,950	22	11	" "
TNT Production Line No. 2 T-11 Building Area					
19	50,765	100,685	10	5	A, L, O, P
20	50,785	100,685	10	5	" "
Wash House Area of TNT Production Line No. 2					
21	50,760	100,150	12	6	A, L. O, P
22	50,785	100,120	12	6	" "
23	50,800	100,150	12	6	" "
24	50,900	99,985	10	5	" "
25	50,850	100,100	10	5	" "
26	50,850	100,185	12	6	" "
27	50,900	100,250	10	5	" "
TNT Production Line No. 3 T-11 Building Area					
28	51,285	99,990	8	4	A, L, O, P
29	51,400	100,400	10	5	" "
30	51,400	100,450	10	5	" "

* See key for chemical analyses description, page 112.

TABLE 4-7 (cont.)

WSOW Biased Soil Sampling Locations — Page 2 of 3

Borehole Number	Coordinates West	Coordinates North	Borehole Depth	Number of Samples	Chemical Analysis	
Final Production Area of TNT Line No. 2						
31	51,185	100,845	10	5	A, L, O, P	
32	51,220	100,860	10	5	" "	
33	51,250	100,890	10	5	" "	
34	51,280	100,890	10	5	" "	
35	51,320	100,875	10	5	" "	
36	51,365	100,880	10	5	" "	
37	51,400	100,850	10	5	" "	
38	51,430	100,900	8	4	" "	
Final Settling Tank of TNT Production Line No. 3						
39	52,220	100,750	14	7	A, L, O, P	
40	52,200	100,725	14	7	" "	
Drainage From TNT Lines 2 and 3						
41	52,116	100,760	20	10	A, L, O, P	
42	52,123	100,732	20	10	" "	
43	52,135	100,710	20	10	" "	
Wash House Area of TNT Production Line No. 3						
44	51,815	100,360	8	4	A, L, O, P	
45	51,780	100,315	8	4	" "	
46	51,840	100,280	8	4	" "	
47	51,800	100,265	8	4	" "	
48	51,760	100,243	8	4	" "	
TNT Production Line No.4 T-9 Building Area						
49	51,225	98,775	10	5	A, L, O, P	
50	51,200	98,800	8	4	" "	
51	51,225	98,825	8	4	" "	
TNT Production Line No.4 T-10 Building Area						
52	51,642	98,925	8	4	A, L, O, P	
53	51,334	98,945	10	5	" "	
54	51,322	98,950	8	4	" "	
TNT Production Line No.1 T-24 Building Area						
55	51,200	101,500	8	4	A, L, O, P	
56	51,200	101,450	8	4	" "	
Wastewater Line Excavation						
57	51,565	100,850	10	5		*

TABLE 4-7 (cont.)

WSOW Biased Soil Sampling Locations

Borehole Number	Coordinates West	North	Borehole Depth	Number of Samples	Chemical Analysis
Burning Grounds Area					
58	52,300	101,400	10	5	A, K, L, O, P *
59	52,350	101,400	10	5	" " *
60	52,400	101,400	10	5	" " *
61	52,250	101,400	10	5	" " *
WSOW Rubble Area					
62	52,900	100,400	10	5	A, K, L, O, P *
63	52,775	100,475	10	5	" " *
Cinder Pile					
64	51,400	100,690	0 to 18"	1	A, K, L, O, P
WSOW Dump Area					
65	51,300	100,850	0 to 12"	1	" "
66	51,275	100,845	0 to 12"	1	" "
67	51,250	100,855	0 to 12"	1	" "
68	51,320	100,850	0 to 12"	1	" "
WSOW Foundation					
69	51,550	100,850	0 to 12"	1	" "
WSOW Foundation					
70	51,700	100,850	0 to 12"	1	" "
WSOW Rubble Pile					
71	51,745	100,925	0 to 12"	1	" "
72	51,770	100,920	0 to 12"	1	" "
WSOW Rubble and Foundation					
73	52,400	100,700	0 to 12"	1	" "
74	52,350	100,700	0 to 12"	1	" "

All surface sampling locations are approximate.
Exact locations will be surveyed prior to sampling.

4.4.2.1 Selection and Number of Locations

Soil sampling locations were selected based on WSOW processes, building locations, and topography. For example, areas producing or transporting wastewater have the highest potential for nitroaromatic contamination. Surface drainageways from production areas carried wastewater (USGS, 1944) and should be sampled. Areas of acid usage increase the potential for metals contamination. The areas to be sampled are presented in Table 4-7. The rationale for sampling each area is detailed in the heading above each group of samples and is followed by specific sample locations, borehole depths, number of samples and chemical analyses. Seventy-five boreholes are proposed for the WSOW biased sampling. In addition, 11 surface soil samples will be collected from six areas.

4.4.2.2 Sampling Depths and Intervals

Borehole depths are presented in Table 4-7. Depths were determined by evaluating past and present topography and assuring that each borehole penetrated WSOW topography. Sampling intervals were selected based on the nature of the soils and the suspected contaminants mobility. The primary WSOW contaminants are nitroaromatics and metals, both of which bind to soil particles. Therefore, samples will be collected continuously and composited over two-foot intervals.

4.4.2.3 Analytical Parameters

Analytical parameters for WSOW biased samples include nitroaromatics, select metals, nitrate, nitrite, sulfate, and pH. The exact parameters are listed in Table 4-7. Exact analytical methods are explained in Section 5.0.

4.5 Unbiased Area Sampling

To date, an extremely limited data base has been developed for chemical characterization and contaminant distribution over the 220-acre WSCP/WSRP site. Therefore, in order to meet the sampling objectives to: (1) determine the extent and magnitude of contamination, (2) document uncontaminated areas and (3) provide representative data for risk assessment preparation, it will be necessary to conduct a statistically designed, unbiased sampling effort. The sample design will provide uniform coverage of the site, complementary to the biased sampling programs discussed in Sections 4.3 and 4.4.

The primary objective of the area sampling is to document areas believed to be uncontaminated. The recorded site history indicates probable areas of contamination, and these areas are addressed in the biased sampling program. However, there remains a significant area previously unaddressed as to its status of contamination. While a very large number of samples would be required to document the absence of contamination at specific

locations over the entire site, a statistically designed sampling approach will provide a method for determining areas free of contamination to a known confidence level.

Establishing background metals and inorganic anion concentrations in native soils are also addressed in this section.

4.5.1 Statistical Sampling Approach

The appropriate number of sample locations for achieving data sufficiency and representation is determined using a statistical approach outlined in "Preparation of Soil Sampling Protocol: Techniques and Strategies" (Mason, 1983).

The approach requires the collection of samples on a regular line transect pattern over the investigation area with randomly selected starting locations. The line transect pattern consists of equilateral triangles laid out to form a hexagon. The size of the hexagon and corresponding side lengths of the equilateral triangle are determined using the following formula where L equals the length of a side of a triangle.

$$A = 2.598(L^2)$$

The area is determined by fitting the site into a square area extending 50 feet beyond the site boundary. The total area of the site using this method is 20,250,000 square feet. This area,

when used in the above formula, results in a sample spacing of 558 feet and a hexagonal side length of 279 feet.

Based on a 95% confidence level and 20% acceptable error margin using the following formula:

$$n = (CR)^2 \, t^2/p^2$$

Where: n = number of samples
cr = coefficient of variation
t = two tailed t value
p = allowable margin of error

The total number of sample locations is determined to be 91. Figure 4-4 shows the example locations determined by the Line Transect A system. In order to plot at least 91 sample locations within the site boundary, two hexagonal grids are placed over the site with randomly selected starting locations for orientation. In some cases, the sample points fall in locations currently unaccessible. These sample locations will be moved off the grid in the direction of the shortest distance from the grid node. For example, sample locations which fall in the region of the raffinate pits have been moved out of the pit to the closest accessible area. In this manner, the number of sample locations will remain at 91 in order to achieve a 95% confidence level.

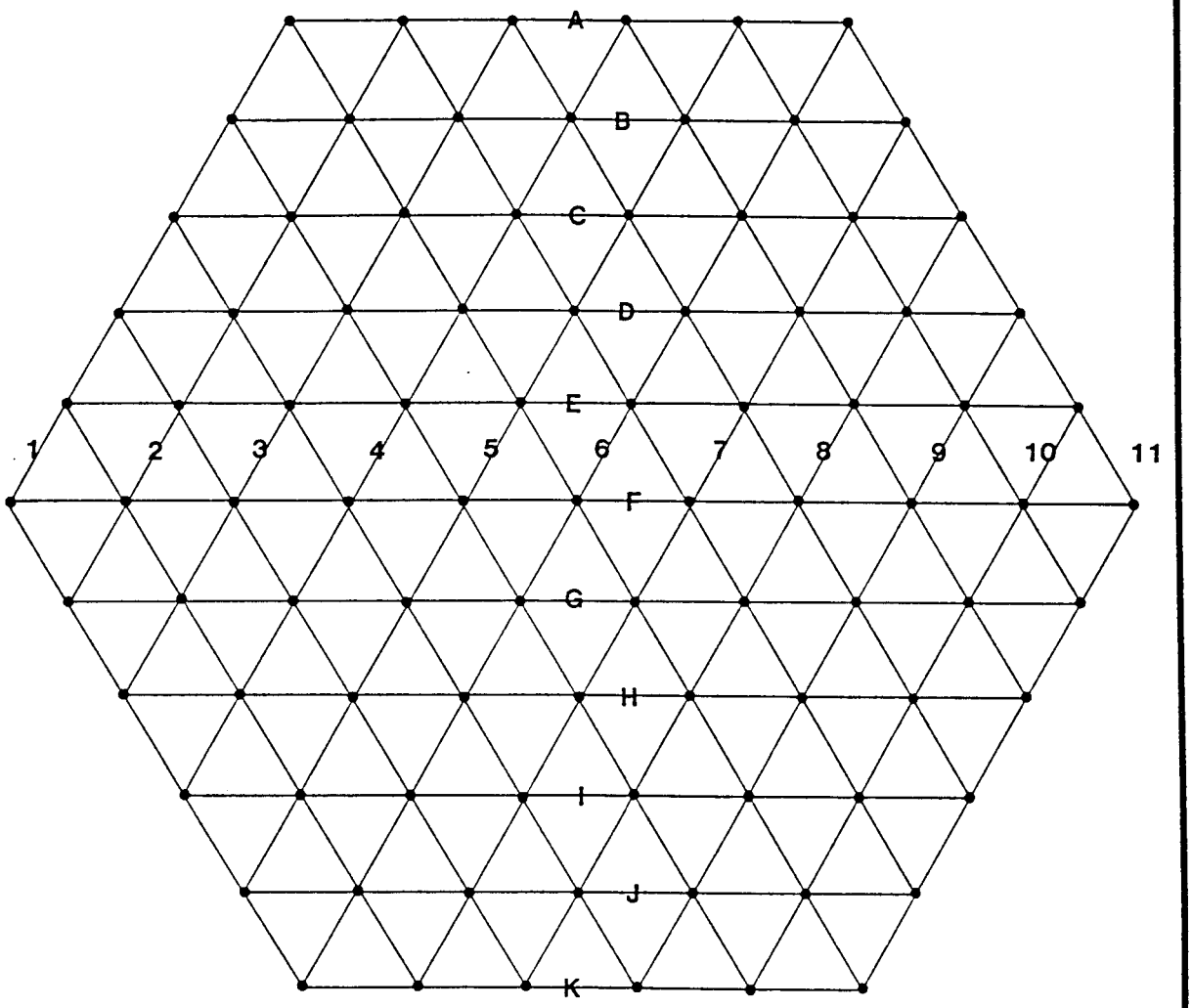

FIGURE 4-4

EXAMPLE LOCATIONS

Figure 4-5 presents an overlay of the two hexagonal grids on the site figure. Figure 4-6 presents the sample locations numbered 1-91.

The overall sampling program, both biased and unbiased, was used to determine the probability of detecting a hotspot of a given size. The formula for determining this probability is:

$p = n A^1/A$

n = # of sample locations

A^1 = Area of target

A = Area of study

p = Probability of detection

The total number of sample locations to be used in contamination assessment is 277. There are 245 samples from this work plan and 32 samples from the Phase I Soil Investigation.

The target was assumed to be elliptical in shape with a semimajor axis of 100 feet and a semiminor axis of 50 feet. This target shape was selected based on a point spill or discharge source with overland dispersion. The target size was selected based on the operational life of the WSOW and WSUFMP. Any spills or discharges are assumed to have occurred with enough frequency to

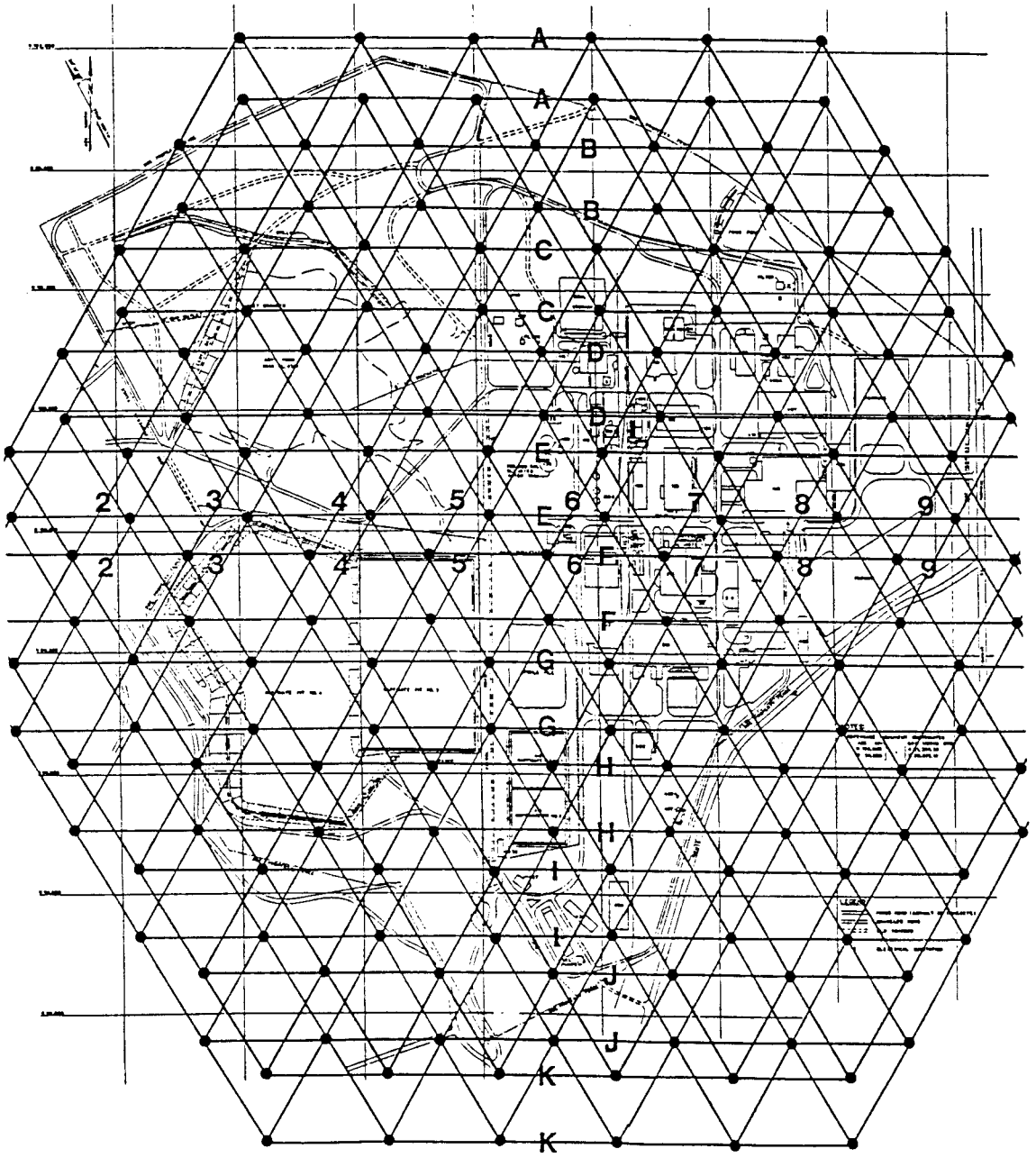

FIGURE 4-5

HEX GRID OVERLAY

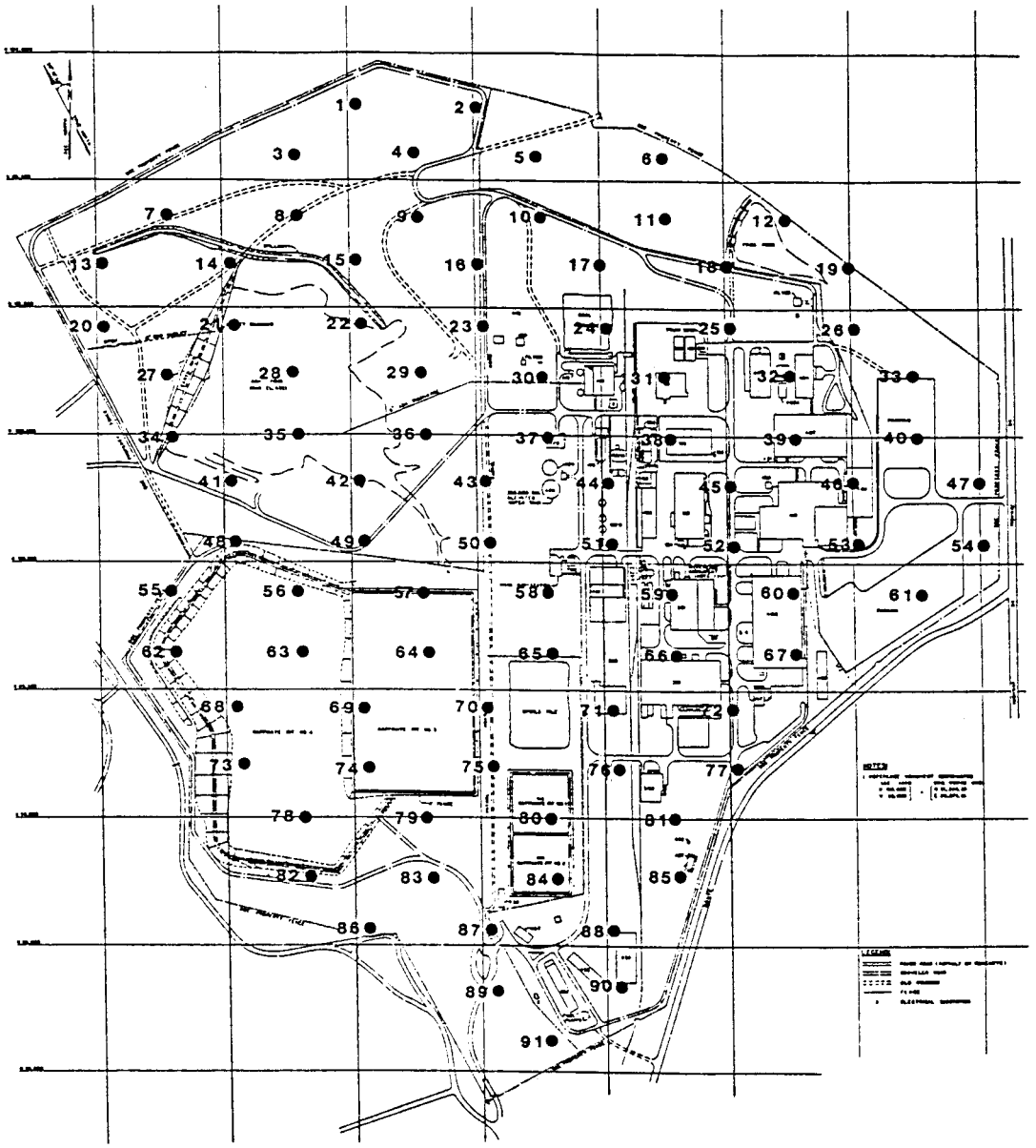

FIGURE 4-6

RANDOM GRID

create an area 200 feet long by 100 feet wide. Using the previously stated equation and assumptions, the probability of detecting elliptical hotspots 200 feet by 100 feet is 45 percent. Changes in target size or shape can affect this probability. However, this target shape and size are realistic, given the known processes and lack of uncontrolled dumping.

4.5.1.1 Sampling Depths and Intervals

Borehole depths were determined by evaluation of the cut and fill topography presented in Plate 2. In order to ensure coverage to the probable extent of vertical migration, borehole depths will be to fifteen feet in cut areas and undisturbed areas. Borehole depths in fill areas will equal the fill depth plus fifteen feet of undisturbed soil. Portions of alternating two-foot intervals will be composited for analyses. For example, the 0-1 interval will be composited with the 2-3, 4-5 and 6-7 foot intervals, and the 8-9 foot interval will be composited with the 10-11, 12-13 and 14-15 foot intervals, resulting in two samples for analysis from 15 feet of sample core. Therefore, a sample will represent 4 one-foot alternating intervals. No more than 4 one-foot intervals will be composited per sample. The composite intervals

were selected to detect large areas of contamination in areas not expected to be contaminated and to keep the number of samples to a manageable number. Detection of contamination under this program may require additional sampling to further define the actual extent. Table 4-8 presents borehole depths, cut and fill depths and sample intervals.

4.5.1.2 Number of Samples

The total number of composite samples is 227. These samples will provide a statistically valid site-wide data base for the contamination assessment.

4.5.1.3 Analytical Parameters

All random samples will be analyzed for a wide range of organic and inorganic constituents in order to provide documentation of previously unsampled areas. The analytical parameters were selected by analyzing and interpreting Phase I soil results (Section 3.1.2) and cut and fill relationships (Plate 2).

The Phase I Soil Investigation established the propensity of nitroaromatics to bind to WSCP/WSRP soil particles as percent

TABLE 4-8

Area Sampling Depth and Intervals

Sample Number	Sample Coordinates West	North	Cut or Fill Depth	Borehole Depth	Number of Samples	Composite Intervals	Soil Chemical Analysis
1	51,500	101,800	0'	15'	2	(0-1, 2-3, 4-5, 6-7) (8-9, 10-11, 12-13, 14-15)	A, B1
2	51,000	101,800	0'	15'	2	" "	A, B1
3	51,750	101,600	0'	15'	2	" "	A, B1
4	51,250	101,600	0'	15'	2	" "	A, B1
5	50,700	101,600	0'	15'	2	" "	A, B1
6	50,200	101,600	2'C	15'	2	" "	A, B1
7	52,300	101,320	6'C	15'	2	" "	A, B1
8	51,750	101,330	0'	15'	2	" "	A, B1
9	51,250	101,300	0'	15'	2	" "	A, B1
10	50,700	101,300	0'	15'	2	" "	A, B1
11	50,250	101,300	2'	15'	2	" "	A, B1
12	49,690	101,250	8'C	15'	2	" "	A, B1
13	52,500	101,150	2'F	17'	3	(0-1, 2-3, 4-5, 6-7) (8-9, 10-11, 12-13, 14-15) (16-17)	A, B2, C1
14	52,000	101,150	2'F	17'	3	" " "	A, B2, C1
15	51,500	101,150	2'F	17'	3	" " "	A, B2, C1
16	51,000	101,150	0'	15'	2	(0-1, 2-3, 4-5, 6-7) (8-9, 10-11, 12-13, 14-15)	A, B1

* Location moved off grid to accessible location

A = 0-1, 2-3, 4-5, 6-7 ANALYZED FOR A, D, F, G, H, L, N, O.

B = 8-9, 10-11, 12-13, 14-15 (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

C = 16-17, 18-19, 20-21, 22-23 DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

D = 24-25, 26-27, 28-29, DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

E = 30-31, 32-33, 34-35, DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

TABLE 4-8

Area Sampling Depth and Intervals

Sample Number	Sample Coordinates West	North	Cut or Fill Depth	Borehole Depth	Number of Samples	Composite Intervals		Soil Chemical Analysis
17	50,500	101,150	10'F	25'	4	+(16-17, 18-19, 20-21, 22-23)	(24-25)	A, B2, C2, D1
18	50,000	101,150	4'C	15'	2	"	"	A, B1
19	49,500	101,150	2'C	15'	2	"	"	A, B1
20	52,500	101,900	6'F	21'	3	"	"	A, B2, C1
21	52,000	100,900	4'F	19'	3	"	"	A, B2, C1
22	51,500	100,900	0'	15'	2	"	"	A, B1
23	51,000	100,900	0'	15'	2	"	"	A, B1
24	50,500	100,900	14'F	29'	4	+(26-27, 28-29)		A, B2, C2, D1
25	50,000	100,900	0'	15'	2	"	"	A, B1
26	49,500	100,900	4'F	19'	3	"	"	A, B2, C1
27	52,250	100,725	6'F	21'	3	"	"	A, B2, C1
28	51,780	100,750	2'F	17'	3	"	"	A, B2, C1
29	51,280	100,750	2'F	17'	3	"	"	A, B2, C1
30	50,750	100,700	2'C	15'	2	"	"	A, B1
31	50,280	100,750	2'F	17'	3	"	"	A, B2, C1

* Location moved off grid to accessible location

A = 0-1, 2-3, 4-5, 6-7 ANALYZED FOR A, D, F, G, H, L, N, O.

B = 8-9, 10-11, 12-13, 14-15 (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

C = 16-17, 18-19, 20-21, 22-23 DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

D = 24-25, 26-27, 28-29, DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

E = 30-31, 32-33, 34-35, DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

TABLE 4-8

Area Sampling Depth and Intervals

Sample Number	Sample Coordinates West	North	Cut or Fill Depth	Borehole Depth	Number of Samples	Composite Intervals		Soil Chemical Analysis
32	49,780	100,730	6'F	21'	3	"	"	A, B2, C1
33	49,310	100,740	4'F	19'	3	"	"	A, B2, C1
34	52,240	100,440	2'F	17'	3	"	"	A, B2, C1
35	51,770	100,430	2'F	17'	3	"	"	A, B2, C1
36	51,230	100,420	0'	15'	2	"	"	A, B1
37	51,730	100,420	2'C	15'	2	"	"	A, B1
38	50,220	100,420	2'C	15'	2	"	"	A, B1
39	49,740	100,420	8'F	23'	3	"	"	A, B2, C1
40	49,270	100,420	4'C	15'	2	"	"	A, B1
41	52,010	100,320	2'F	17'	3	"	"	A, B2, C1
42	51,500	100,340	2'C	15'	2	"	"	A, B1
43	50,970	100,330	2'C	15'	2	"	"	A, B1
44	50,500	100,330	4'C	15'	2	"	"	A, B1
45	50,000	100,330	2'F	17'	3	"	"	A, B2, C1
46	49,520	100,330	4'F	19'	3	"	"	A, B2, C1
47	49,000	100,330	6'C	15'	2	"	"	A, B1

* Location moved off grid to accessible location

A = 0-1, 2-3, 4-5, 6-7 ANALYZED FOR A, D, F, G, H, L, N, O.

B = 8-9, 10-11, 12-13, 14-15 (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

C = 16-17, 18-19, 20-21, 22-23 DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

D = 24-25, 26-27, 28-29, DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

E = 30-31, 32-33, 34-35, DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

TABLE 4-8

Area Sampling Depth and Intervals

Sample Number	Sample West	Coordinates North	Cut or Fill Depth	Borehole Depth	Number of Samples	Composite Intervals	Soil Chemical Analysis
48	51,970	100,080	2'F	17'	3	" "	A, B2, C1
49	51,500	100,020	2'F	17'	3	" "	A, B2, C1
50	51,000	100,020	2'F	17'	3	" "	A, B2, C1
51	50,500	100,020	0'	15'	2	" "	A, B1
52	50,000	100,020	2'F	17'	3	" "	A, B2, C1
53	49,500	100,020	0'	15'	2	" "	A, B1
54	49,000	100,010	6'C	15'	2	" "	A, B1
55	42,240	99,830	0'	15'	2	" "	A, B1
*56	51,700	100,000	0'	15'	2	" "	A, B1
*57	51,250	99,950	20'F	35'	5	+(30-31, 32-33, 34-35)	A, B2, C2, D2, E1
58	50,750	99,850	0'	15'	2	" "	A, B1
59	50,250	99,850	4'C	15'	2	" "	A, B1
60	49,750	99,900	4'C	15'	2	" "	A, B1

* Location moved off grid to accessible location

A = 0-1, 2-3, 4-5, 6-7 ANALYZED FOR A, D, F, G, H, L, N, O.

B = 8-9, 10-11, 12-13, 14-15 (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

C = 16-17, 18-19, 20-21, 22-23 DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

D = 24-25, 26-27, 28-29, DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

E = 30-31, 32-33, 34-35, DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

TABLE 4-8

Area Sampling Depth and Intervals

Sample Number	Sample Coordinates West	North	Cut or Fill Depth	Borehole Depth	Number of Samples	Composite Intervals		Soil Chemical Analysis
61	49,250	99,900	4'C	15'	2	"	"	A, B1
*62	52,350	99,660	0'	15'	2	"	"	A, B1
*63	51,800	100,000	0'	15'	2	"	"	A, B1
*64	51,000	99,650	18'F	33'	5	"	"	A, B2, C2, D2, E1
65	50,710	99,650	2'F	17'	3	"	"	A, B2, C1
66	50,240	99,650	4'C	15'	2	"	"	A, B1
67	49,720	99,650	0'	15'	2	"	"	A, B1
*68	52,200	99,410	0'	15'	2	"	"	A, B1
*69	51,000	99,000	2'F	17'	3	"	"	A, B2, C1
70	51,000	99,430	2'F	17'	3	"	"	A, B2, C1
71	50,510	99,430	4'F	19'	3	"	"	A, B2, C1
72	50,010	99,430	0'	15'	2	"	"	A, B1
*73	52,150	99,150	0'	15'	2	"	"	A, B1
*74	51,450	98,850	2'F	17'	3	"	"	A, B2, C1
75	50,980	99,180	2'F	17'	3	"	"	A, B2, C1
76	50,480	99,180	2'F	17'	3	"	"	A, B2, C1

* Location moved off grid to accessible location

A = 0-1, 2-3, 4-5, 6-7 ANALYZED FOR A, D, F, G, H, L, N, O.

B = 8-9, 10-11, 12-13, 14-15 (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

C = 16-17, 18-19, 20-21, 22-23 DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

D = 24-25, 26-27, 28-29, DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

E = 30-31, 32-33, 34-35, DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

TABLE 4-8

Area Sampling Depth and Intervals

Sample Number	Sample Coordinates West	North	Cut or Fill Depth	Borehole Depth	Number of Samples	Composite Intervals		Soil Chemical Analysis
77	50,000	99,200	2'C	15'	2	"	"	A, B1
*78	52,180	99,000	2'F	17'	3	"	"	A, B2, C1
79	51,350	99,000	2'F	17'	3	"	"	A, B2, C1
*80	50,550	99,000	2'F	17'	3	"	"	A, B2, C1
81	50,250	99,000	0'	15'	2	"	"	A, B1
82	51,720	98,780	2'F	17'	3	"	"	A, B2, C1
83	51,300	98,790	2'F	17'	3	"	"	A, B2, C1
*84	50,550	98,790	2'F	17'	3	"	"	A, B2, C1
85	50,250	98,750	0'	15'	2	"	"	A, B1
86	51,500	98,550	0'	15'	2	"	"	A, B1
87	51,040	98,550	0'	15'	2	"	"	A, B1
88	50,500	98,550	0'	15'	2	"	"	A, B1
89	50,950	98,300	0'	15'	2	"	"	A, B1
90	50,500	98,350	0'	15'	2	"	"	A, B1
91	50,800	98,150	0'	15'	2	"	"	A, B1

* Location moved off grid to accessible location

A = 0-1, 2-3, 4-5, 6-7 ANALYZED FOR A, D, F, G, H, L, N, O.

B = 8-9, 10-11, 12-13, 14-15 (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

C = 16-17, 18-19, 20-21, 22-23 DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

D = 24-25, 26-27, 28-29, DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

E = 30-31, 32-33, 34-35, DEPENDING ON TOTAL DEPTH (-1 IF ANALYZED FOR L, O) (-2 IF ANALYZED FOR A, D, F, G, H, L, N, O)

levels of nitroaromatics in the old waste lagoon decreased below detectable levels in approximately eight feet. This tendency may be viewed as "worst case" since the waste lagoon contained water acting as a driving hydraulic head for several years and still retains water. As a result of this analysis, the lowest composite sample from each random sample location will not be analyzed for nitroaromatics. Undisturbed and cut areas will have one composite sample analyzed for nitroaromatics, while fill areas will have at least two (depending on fill thickness) composite samples analyzed for nitroaromatics. Since the processes and potential contaminants from the WSOW and WSUFMP are known, it is not necessary for all random samples to be analyzed for the complete Hazardous Substances List (HSL). Very limited numbers of volatile and semivolatile organic compounds were used in TNT and uranium production. Any organic contamination outside of production areas should be minor in nature. Therefore, only the upper composite samples at each location will be analyzed for the complete HSL. Locations in cut or undisturbed areas will have one sample analyzed for the complete HSL, while fill areas will have at least two (depending on fill thickness) samples submitted for complete HSL analyses, so that one composite sample for HSL compounds will be representative of the original surface material. The Phase I Water Quality Assessment documented the absence of organic compounds in the groundwater, further indicating the lack of significant vertical migration of organic soil contaminants.

All random samples will be analyzed for WSSRAP indicator parameters which include nitrate, nitrite, sulfate, fluoride, soil pH, and percent moisture. These indicator parameters, coupled with the nitroaromatic and HSL analyses, will allow interpretation of all random sample data.

4.5.2 Background Samples

Background samples will be collected from an uncontaminated area within 5 miles of the site, and will be equal to 20% of the number of random samples. The area selected for background samples need not be upwind since significant wind transport is not expected from WSOW or WSUFMP processes. These samples will be analyzed for selected metals (aluminum, antimony, barium, iron, lead, magnesium, manganese, nickel, vanadium, and zinc) and inorganic anions and will be used to establish an environmental baseline data set for contamination assessment. These background samples will allow a valid assessment of calculated background values for on-site metal concentrations. Due to the widespread use of nitric and sulfuric acid in WSOW production, the potential exists for broad areas to be affected by these chemicals. Therefore, background samples for inorganic anions must be collected off-site in an area unaffected by WSOW or WSUFMP processes. Figure 4-7 shows the location of the background samples in relation to the WSCP. Two samples will be collected from each of 25 boreholes spaced according to the previously defined grid. Samples will be composited in the same manner as random samples. According to the St. Charles County Soil

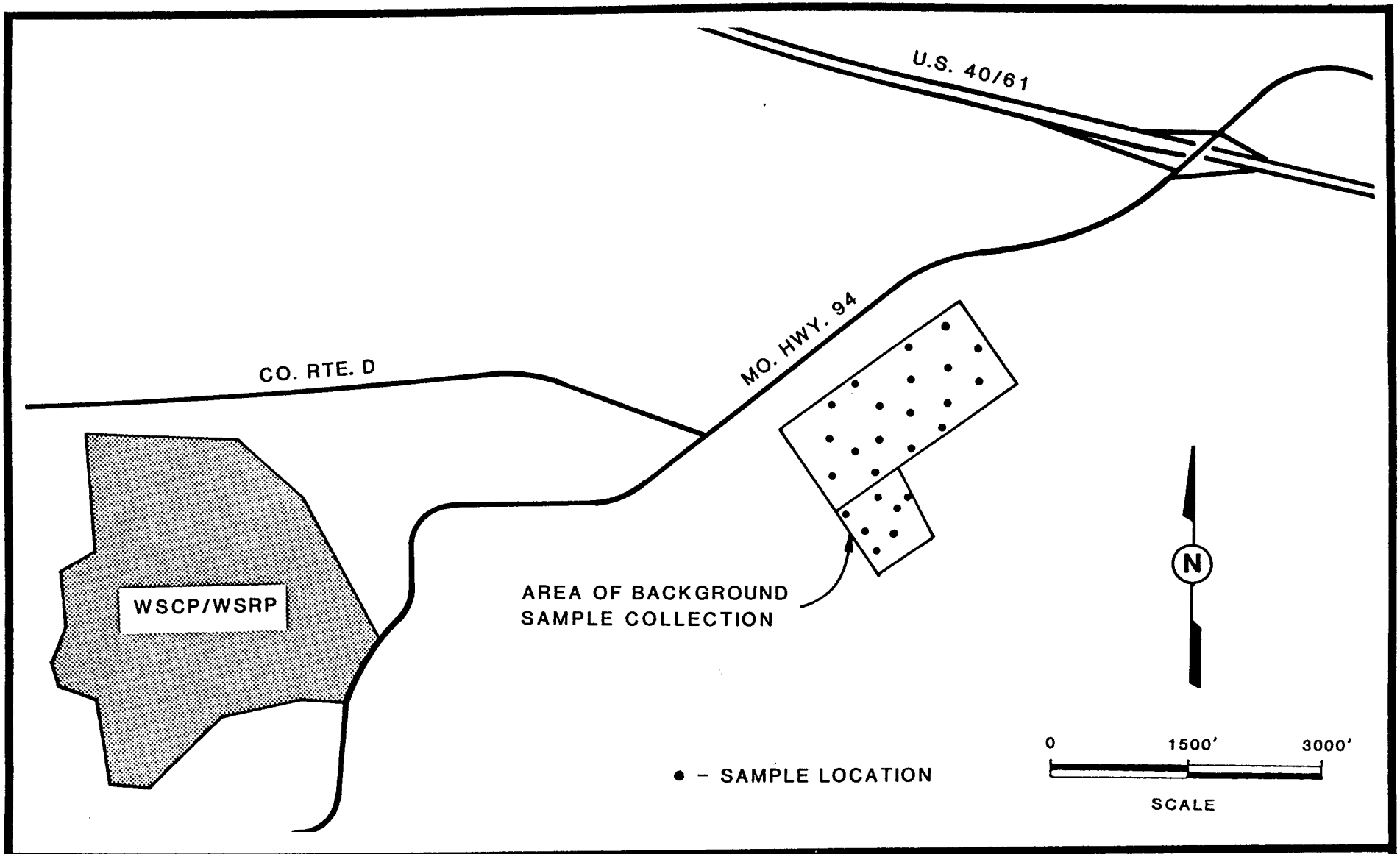

FIGURE 4-7

BACKGROUND SOIL SAMPLE LOCATIONS

Conservation Service Soil Survey, this area exhibits the same soil association (Armster-Mexico-Hatten Assoc.) and vegetative cover native to the WSCP/WSRP area. The area is also located near the Missouri-Mississippi River surface divide and is unaffected by surface drainage from the WSUFMP and WSOW areas.

4.6 Sampling Procedures

4.6.1 Sample Collection

Soil samples will be collected by continuous coring to the desired depth, using hollow stem augers and continuous sampling equipment capable of obtaining a 2 inch diameter by 60 inch long continuous sample. The sampling device will advance with the augers, and is divided longitidinally to facilitate sample removal. This type of sampling equipment has been sucessfully used on WSS soils in previous investigations, and provides sufficient sample for all required analyses and allows thorough geologic logging. Split spoons will be used if samples are not properly retained.

Actual sample collection will be performed using stainless steel spatulas to collect the samples from the desired intervals. Composites will be mixed in a stainless steel pan prior to filling sample containers. Compositing will be performed by mixing visually equal aliquots. All sample collection and compositing will be performed in areas protected from direct

sunlight. All drill cuttings will be collected and stored on-site in the Ash Pond Area.

4.6.2 Radiological Screening of Samples

Continuous monitoring for radiological contamination will be performed during all drilling and sampling activities conducted within areas known or suspected to be radiologically contaminated. A G-M probe will be placed immediately over exposed surface and subsurface samples. Samples which exceed a count rate of 700 cpm will be considered radiologically contaminated and will be handled according to WSSRAP Standard Operating Procedures 2.05.01, Radiation Soil Sampling.

4.6.3 Sample Preservation

Soil samples will be preserved by cooling to $4^{o}C$ as soon as possible after collection and compositing, and will be maintained at $4^{o}C$ during shipment to the laboratory. All samples will be collected in glass jars with polytetrafluorethylene (TFE) lined lids.

Chain-of-custody documentation will be maintained from the time of collection until the samples are delivered to the laboratory according to approved WSSRAP procedures.

4.6.4 Field Equipment Decontamination

The following decontamination efforts will be used to clean sampling equipment and prevent cross-contamination during sample collection and compositing.

All sampling tools will be decontaminated between samples according to the following decontamination procedure:

1. Steam clean
2. Deionized water rinse
3. Toluene Rinse
4. Double Hexane Rinse
5. Air dry

All rinse solvents will be collected and disposed of properly. In addition, where possible, sampling equipment will be stored in plastic containers or precleaned aluminum foil.

Auger flights, drill rigs, drill rods and samplers will be cleaned by steam cleaning on the decontamination pad. This pad allows the whole rig to be cleaned and the wash-water collected for proper management. All augers, samplers and drill rods will be steam cleaned between boreholes. Samplers will be steam cleaned between samples and subjected to the previous described solvent rinse procedure.

All wastewater, waste solvents, and soiled cleaning materials used for decontamination will be collected for proper treatment or disposal.

4.6.5 Borehole Grouting

After completing each borehole and removal of drilling equipment, the boreholes will be completely backfilled with a Bentonite-cement grout which will remain plastic and provide a flexible seal for each boring. This grouting program will maintain the integrity of WSCP/WSRP soils for potential long term disposal. Moisture content of the existing soils will prevent dessication of grout seals. Drill cuttings will be removed from the sampling location and placed in the Ash Pond area. Ultimate disposal must await completion of characterization activities.

5.0 ANALYTICAL PROCEDURES

Appendix B of the WSSRAP Quality Assurance Program Plan (QAPP) outlines all analytical methodologies and detection limits for the analytical parameters addressed in this work plan. A general discussion of the methodologies for organics, inorganics, and nitroaromatics is given in the following sections.

5.1 Organics

Selected soil samples will be analyzed for organic compounds as detailed in "Attachment A, USEPA Contract Laboratory Program Statement of Work for Organic Analysis," October 1986. These analyses include: volatiles, semi-volatiles (including acid and base neutral fractions), pesticides, and PCBs. These analyses will be performed in accordance with the analytical procedures described in the above referenced Scope of Work (SOW). Detection limits are also listed in the above referenced document. Analytical data will be validated as described in the QAPP. Nitroaromatics will be discussed separately.

5.2 Inorganics

Soil samples will be analyzed for several inorganic compounds including metals, nitrate, nitrite, sulfate, chloride, fluoride and pH. Those analyses included in the SOW for inorganic analysis under the USEPA Contract Laboratory Program (CLP) will

be analyzed according to the CLP-required procedures. CLP-required detection limits will also be met. Nitrate, nitrite, sulfate, chloride, and fluoride analyses will be performed according to EPA method 300.0. Soil pH will be determined according to EPA method 9045.

5.3 Nitroaromatics

All nitroaromatic analyses will be performed according to USATHAMA methodology. Analysis will be performed by High Pressure Liquid Chromatography (HPLC). USATHAMA-required standards of precision and accuracy will be met. Approximate detection limits are listed below.

Compound	Approximate Detection Limit
TNT	1 mg/Kg
2,4 -DNT	1 mg/Kg
2,6 -DNT	1 mg/Kg

In the event that high percent-levels of nitroaromatics are detected, soil samples will be submitted for the characteristic of reactivity testing as defined in 40 CFR 261, subpart C to determine explosive stability.

All analytical data will be validated as described in the QAPP.

All primary analyses will be performed by metaTRACE, Inc. of St. Louis, Missouri. Replicate samples will be submitted to JTC Associates of Rockville, Maryland. All sample containers and field blanks will be prepared by the laboratories.

5.4 Sample Containers

Soil samples will be placed in appropriate sample containers. All soil samples, with the exception of volatile organics, will be placed in amber glass jars with TFE-lined caps. Volatile organic samples will be placed in 40-milliliter glass jars with TFE-lined caps.

6.0 QUALITY ASSURANCE

The purpose of the soil sampling quality assurance (QA) procedures is to ensure that the data collected are of known and sufficient quality to assess contamination at the site both qualitatively and quantitatively. Soil sample quality and representativeness will be maintained by the quality assurance measures and samples described in this section. Further description of the overall site characterization quality assurance program is addressed in the QAPP.

QA samples will be collected to assess analytical and sampling variability, to determine the effects of compositing on samples, to demonstrate the effectiveness of decontamination procedures and to assure that samples are not contaminated during shipment to the laboratory. Laboratory data will be validated according to the procedures outlined in the QAPP. Precision, accuracy and representativeness will be determined as outlined in the QAPP.

QA samples will be collected throughout soil investigations at the WSS. Duplicate and replicate samples, field handling blanks and field blanks will be collected to assess sample quality and representativeness during each step of the sampling process. Each QA sample type will be discussed in detail in the following sections.

6.1 Duplicate Samples

Duplicate samples will be collected at the same time, in the same way, and contained, preserved, and transported in the same manner as the original sample. Duplicate samples will be used to verify the reproducibility and precision of the data. All duplicate samples will be submitted as blind duplicates.

All sample locations will require a 1 in 20 duplication for data validation.

6.2 Field Blanks

Field blanks of a known soil composition will be handled in the same manner as the sample and subsequently analyzed to identify possible sources of contamination during collection, preservation, handling and transport. One field blank per sampling team, per day will be prepared in advance of the sampling event. Field blanks will be used to determine analytical accuracy.

6.3 Triplicate Samples

Triplicate samples provide a measure of precision and representativeness of a single sample which tests the homogeneity of the sample. Five percent of all samples will be split into duplicate samples to provide blind duplicates for the analytical laboratory and a third replicate for the referee (JTC) laboratory to determine interlab precision. The use of a referee (JTC) laboratory aids in determining the reliability of the data by detecting bias in the analysis.

6.4 Matrix Spikes, Matrix Spike Duplicates, Spikes and Duplicates

The laboratory is required to perform quality assurance analyses to evaluate analytical method performance. Matrix spikes (MS) and matrix spike duplicates (MSD) are required for organic analyses at a 1 in 20 frequency. Spikes and duplicates are required for all inorganic and nitroaromatic analyses at the same 1 in 20 frequency. These samples will assess laboratory and method performance.

7.0 DATA DOCUMENTATION

This section discusses the documentation procedures to be followed during site sampling and include: log book entry, sample identification, and chain-of-custody procedures.

7.1 Log Books

All field measurements will be recorded in project log books. All data will be recorded directly and legibly in field log books with entries signed and dated. Any entries to be changed will be changed so as to not obscure the original entry. The reason for the change will be stated and the change and explanation will be signed and identified at the time the change is made.

Specific log book entries will be made during soil boring operations.

The log books will be of bound waterproof paper and will be completed using waterproof ink or marker. The book will contain a listing of all personnel at the sampling location and their affiliation, the time of arrival and departure from the site and each sampling location, personnel risiting and/or inspecting and/or auditing the sampling crews, accidents, unusual occurrences or observation, variations from specifications and the contractor's representative authorizing the variations, weather conditions, readings on evironmental monitoring and other

relevant equipment information necessary to allow a re-creation of events. The recorded information will serve as a permanant record of field activities and will serve as a reference resource for evaluating observed data anomalies which may be attributed to weather conditions or field procedures.

In addition to log book entries, specific technical information will be recorded on borehole logging form ENP 7-1. Information to be recorded on the borehole logging form includes:

- Date
- Location number
- Coordinates
- Description of location
- Elevation
- Depth
- Geologic description of soil

Soil descriptions will be done in accordance with the Unified Soil Classification System as described in ASTM D2487-69 (1975), test method for classification of soils for engineering purposes.

The borehole log entries will be made by a geologist with a minimum of a 4 year degree in Geology or Geological Engineering and recent relevant experience in preparing lithologic logs in unconsolidated materials.

7.2 Sample Identification

Field samples will be identified with appropriate sample labels which include: date, time, location number, preservation method, and requested analyses. Sample location numbers will be labeled according to the WSSRAP Standard Operating Procedure (SOP) 4.01.01 (Appendix A - QAPP).

7.3 Chain of Custody

Established Chain-of-Custody (COC) procedures will be followed to document sample possession and to verify that the samples are not tampered with or altered prior to analysis. The WSSRAP COC procedure provides an accurate written record of each sample from the time of collection through analysis and allows the results of the analysis to be used as evidence. COC will be maintained according to WSSRAP SOP Number 4.01.02 (Appendix A - QAPP).

The COC record form (4.01.02) will accompany a sample or group of samples as custody of the sample(s) is transferred from the original custodian to subsequent custodians. Copies of all COC forms will be maintained in project files at the weldon spring site.

7.4 Packaging and Shipping

Samples will be packaged for shipment to the laboratory as specified in WSSRAP SOP 4.01.04 (Appendix A - QAPP).

COC will be maintained throughout shipment to a laboratory or storage. Completed COC forms will be sealed inside transporting containers, a copy of which will be filed in the WSSRAP filing system. Copies of COC forms returned from laboratories will be included in this file. The lab copy will assure that the samples arrived intact.

Laboratories receiving samples will be notified prior to shipping and instructed to notify the shipper in the event that samples are damaged or missing.

All applicable Department of Transportation regulations will be followed during sample shipment.

7.5 Reporting

Completed COC records will be filed in the WSSRAP project filing system and the Environmental Safety and Health (ES&H) files. Copies of the COC forms returned from laboratories will also be filed in the ES&H file. Any problems or variances to the approved COC procedures will be recorded in the file and reported to the Quality Assurance Manager.

8.0 REPORTING REQUIREMENTS

Upon completion of the soil sampling and laboratory analysis program, a comprehensive data review will be performed in preparation of a chemical contaminant preliminary data report. The preliminary data report will present raw data only and will not include a contamination assessment. The data report will compare the data against the field blanks to detect contamination from sampling, compare field sampling replicates, review laboratory quality control, delineate unusable data and attach appropriate qualifiers to usable data. The data report will also explain the limitations of qualified data and summarize detection limits for non-detectable results.

Following the completion of the data report, a contamination assessment report will be prepared in support of the overall site characterization report. Specifically, the report will assess contamination by considering the quantities and types of contaminants at and around the site and transport mechanisms that are allowing or may allow migration of contaminants from the site. The contamination assessment report will include a summary of findings most relevant to the objectives of the site characterization and to the evaluation of remedial action alternatives.

9.0 REFERENCES

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U.S. Army Toxic and Hazardous Materials Agency. April, 1977, Installation Assessment of Weldon Spring Training Area. Aberdeen Proving Ground, MD.

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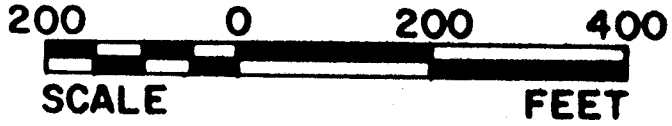

MKE DOCUMENT NO. 5121-C:DW-D-01-0278-A

U. S. DEPARTMENT OF ENERGY
OAK RIDGE, TENNESSEE

DESIGNED	DRAWN
CHECKED	
INSPECTED	
RECOMMENDED	

CHEMICAL PLANT CONSTRUCTION DRAWINGS

PLATE 1

1943 WELDON SPRING ORDNANCE WORKS

APPROVED	DATE	CHIEF ENG./QA MGR.	DATE	PMC ENG'G. MGR.	DATE	DOE PROJ. ENG.	DATE

A E	ENG'G MGR.	QA MK-F	DOE APP.

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON-KNUDSEN COMPANY
WSSRA PROJECT
180 HOWARD ST. SAN FRANCISCO, CA 94105

PROJECT NO. DE-AC05-86OR21548

DRAWING NO. 5121E-CP-501

3-9-87

106
● 0.0

Borehole location, number and depth of contamination (feet)

654
○ 0.0

Surface soil sample location, number and depth of contamination (feet)

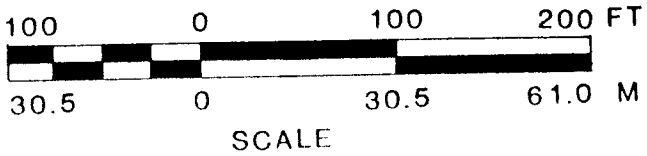

PLATE 2

SITE SOIL ZONES WITH GREATER THAN

15 pCi/g U-238, 5 pCi/g RA-226, 5-pCi/g TH-230

98000

97800

48000

48800

CHEMICAL PLANT ADMINISTRATIVE RECORD FILE

ARFS FILE # C-201-2

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SECTION	SECTION TITLE
200	**REMEDIAL INVESTIGATION (RI)**
201	Sampling and Analysis Plans

DOCUMENT NUMBERS	DOCUMENT TITLE
C-200-201-1.05(r)	WASTE ASSESSMENT RAFFINATE PIT SAMPLING PLAN WELDON SPRING SITE
C-200-201-1.06(r)	GEOPHYSICAL/GEOTECHNICAL INVESTIGATION SAMPLING PLAN WSS

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

CHEMICAL PLANT
201-1.05

ADMIN FILE S.L. - CORRESP.

3589-88-I-DOE-227

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

M-K FERGUSON CO.
RECEIVED
MAY 27 1988
WSSRAP CONTRACT 3589

May 27, 1988

ADDRESSEES

RAFFINATE PIT SAMPLING PLAN

Enclosed is Revision 1 of the "Waste Assessment Raffinate Pit Sampling Plan" for the Weldon Spring Site. This plan has been revised to address comments received from USEPA and the Missouri Department of Natural Resources as indicated in the "Responsiveness Summary," also enclosed.

We trust that this adequately resolves the issues raised during the review of this Plan. We are proceeding with sampling activities as described in the enclosures.

If you have any questions concerning these items, please call.

Sincerely,

R. R. Nelson

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosures

cc w/o enclosures:
R. E. Hlavacek, MK-Ferguson

ADDRESSEES FOR LETTER DATED MAY 27, 1988

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Environmental Review Branch
U. S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
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Mr. David E. Bedan (3 copies)
Division of Environmental Quality
Missouri Department of Natural Resources
Post Office Box 176
Jefferson City, Missouri 65102

DOE/OR/21548-010

United States Department Of Energy

WASTE ASSESSMENT
RAFFINATE PIT SAMPLING PLAN
WELDON SPRING SITE

REV. 1

WELDON SPRING SITE REMEDIAL ACTION PROJECT

WASTE ASSESSMENT

RAFFINATE PIT SAMPLING PLAN

WELDON SPRING SITE

REVISION 1

PREPARED FOR

U.S. DEPARTMENT OF ENERGY

PREPARED BY

MK-FERGUSON COMPANY

WSSRAP

May, 1988

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1.0 INTRODUCTION

The purpose of this sampling plan is to provide a summary of existing data and to define the rationale for collection of the complement of data necessary to fully characterize the wastes contained in the Weldon Spring Raffinate Pits (WSRP). For complete characterization of the WSRP, combined data from radiological, chemical and physical analyses must be evaluated. The existing data base provides limited characterization analyses to address the radiological and chemical parameters. Additional physical, chemical, and radiological testing of the sludge/sediment in the WSRP must be performed. This additional data is needed for sludge/sediment treatability studies which in turn are necessary for the development/evaluation of remediation alternatives, design of the selected alternative, and verification of remedial effectiveness.

This sampling plan will deal primarily with the sampling and analysis of the sludge/sediments in the WSRP. Section 1.2, Previous Studies, includes sufficient chemical characterization data to evaluate remedial alternatives for the water ponded on the raffinate pits.

1.1 BACKGROUND

1.1.1 Site History

In 1956, the Atomic Energy Commission (AEC) acquired about 89 hectares (ha) (220 acres) of the original Weldon Spring Ordnance Works property from the Department of Army (DA) for use as the Weldon Spring Uranium Feed Materials Plant (WSUFMP). The WSUFMP operated between 1957 and 1966 and during that time processed uranium ore concentrates and recycled scrap to produce pure uranium trioxide, uranium tetrafluoride, and uranium metal. An average of 16,000 tons of uranium materials were processed at this plant per year. Thorium ore concentrates were also processed. These processes generated several chemical and radioactive waste streams, including raffinate streams from the refinery operation and the magnesium fluoride slurry streams (washed slag) from the uranium recovery process. These streams were slurried to the pits where the solids settled out and the supernatant liquids drained to the plant process sewer which drained offsite to a natural drainageway and ultimately to the Missouri River. The solids remaining in the pits consist of silica and other insolubles associated with the yellow cake ore feed materials, along with hydroxides and other precipitates formed from the pH neutralization of the raffinates with lime. Washed slag residues from the uranium metal production operation were also discharged to the pits.

After the plant was closed by the AEC, the DA acquired the facility in 1967 to convert it to herbicide production. The project was cancelled prior to becoming operational.

The 21-ha (52-acre) portion of the site that contains the four raffinate pits was transferred back to AEC in 1971. As the successor agency to AEC, DOE has assumed responsibility for maintenance of the entire site including the WSRP area. The location of the WSRP area is shown in Figure 1-1.

Figure 1-2 is a plan view of the four pits. These pits were constructed by excavating down into the existing clay formation and using the removed clay for constructing the dikes.

1.1.2 Physical Description of Pits

Raffinate Pits 1 and 2 were constructed in 1958, adjacent to each other, on nearly level terrain. Each pit covers an area of about 0.5 ha (1.2 acres) and has a depth of about 4 m (13 ft). The dikes of these two pits are approximately 1 m (3 ft) above the surrounding grade. Pits 1 and 2 each contain approximately 13,300 m^3 (17,400 cy) of low-level radioactive residues from past uranium refining and metal production operations. These waste volumes represent 94 percent of the capacity of each of the two pits (NLO, 1977). Table 1-1 presents the surface area, volume, and content of each of the four pits.

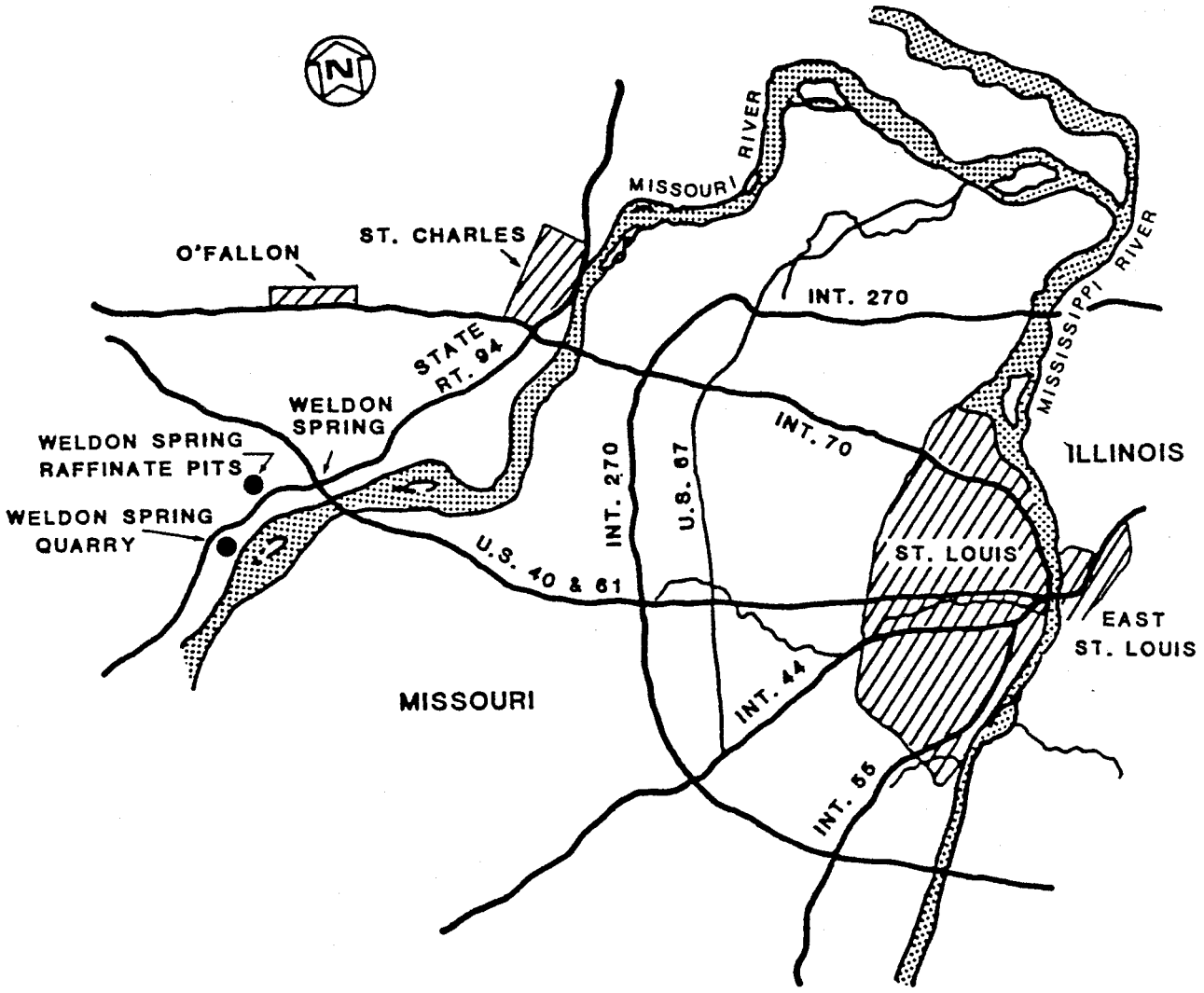

FIGURE 1-1

WSRP AREA MAP

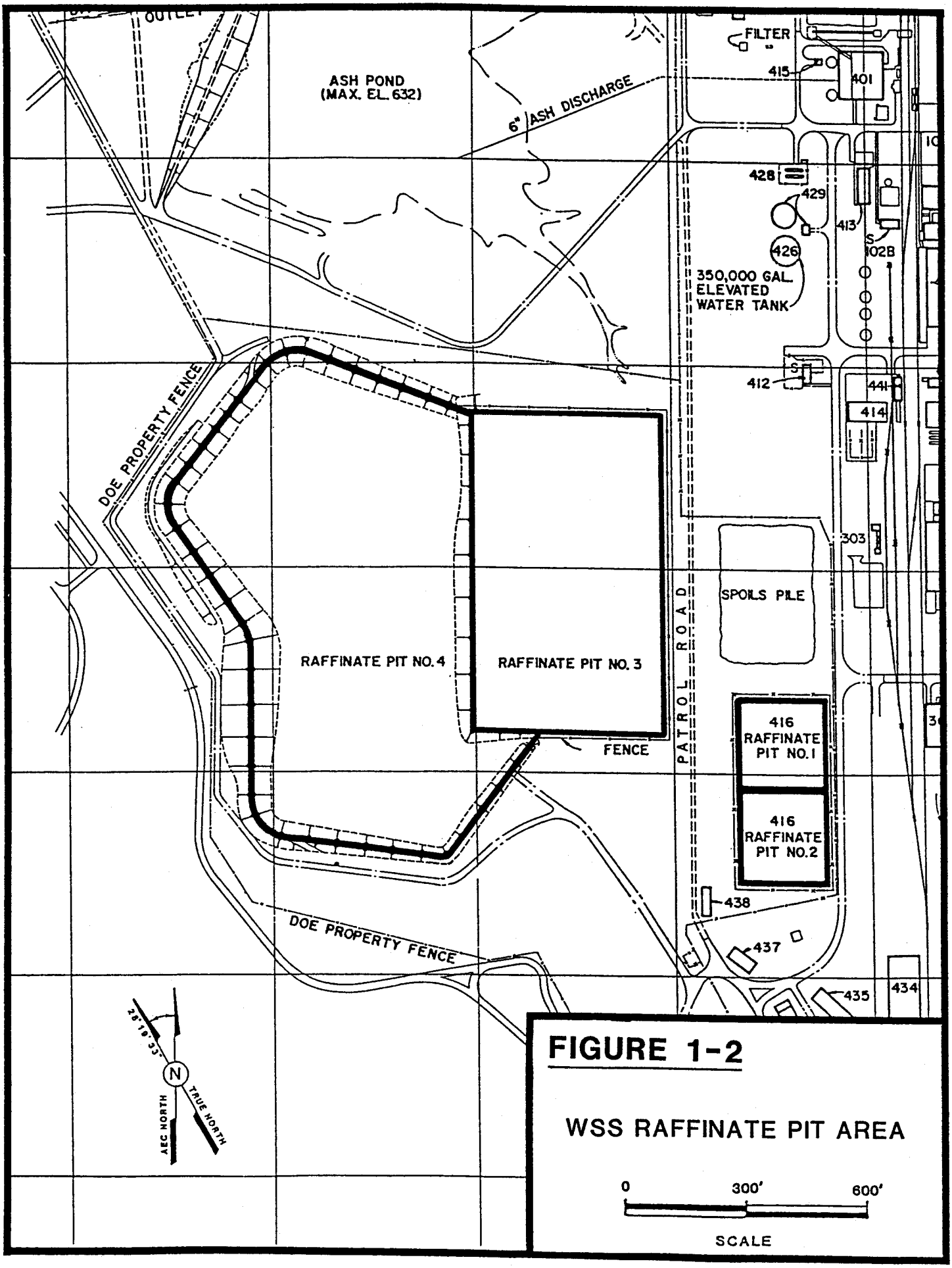
OUTLET
ASH POND
(MAX. EL. 632)
6" ASH DISCHARGE
FILTER
415
401
428
429
413
426
350,000 GAL.
ELEVATED
WATER TANK
S
102B
412
441
414
303
DOE PROPERTY FENCE
SPOILS PILE
PATROL ROAD
RAFFINATE PIT NO. 4
RAFFINATE PIT NO. 3
FENCE
416
RAFFINATE
PIT NO. 1
416
RAFFINATE
PIT NO. 2
438
437
435
434
DOE PROPERTY FENCE
N
AEC NORTH
TRUE NORTH
FIGURE 1-2
WSS RAFFINATE PIT AREA
0
300'
600'
SCALE

TABLE 1-1
Surface Area and Volume of the Weldon Spring Raffinate Pits

Pit	Year Constructed	Surface Area	Total Pit Volume (acres)	Total Waste Volume (cy)	Percent Filled (cy)
1	1958	1.2	18,500	17,400	94
2	1958	1.2	18,500	17,400	94
3	1959	8.4	166,700	129,600	78
4	1964	15.0	444,400	55,600	12
TOTALS		**25.0**	**648,100**	**220,000**	

Note: To convert acres to hectares, multiply by 0.4047.

To convert cubic yards to cubic meters, multiply by 0.7646.

To convert tons to kilograms, multiply by 0.9071.

Ref. BNI, 1984

Pit 3 was constructed in 1959 with a design volume of 127,500 m^3 (166,700 cy), a surface area of approximately 3.4 ha (8.4 acres), and a depth of about 3.5 m (11 ft). The natural terrain slopes downward toward the west boundary so that the dikes around Pits 3 and 4, although approximately at the same elevation as those around Pits 1 and 2 are, in fact, much higher with respect to the original grade. A portion of the dike in the northeast corner of Pit 3 was constructed on existing terrain so that the dike is about 7 m (23 ft) above original grade in that area. Pit 3 contains approximately 99,100 m^3 (129,600 cy) of radioactive residues from past uranium refining and metal production operations and is 78 percent filled (NLO, 1977; Weidner and Boback, 1982).

Pit 4 was constructed in 1964 with a design volume of 339,800 m^3 (444,400 cy) and is approximately 12 percent filled. The east dike of Pit 4 is common to the west dike of Pit 3. The west dike of Pit 4 extends to a maximum of about 11 m (35 ft) above the existing grade. Approximately 42,500 m^3 (55,600 cy) of radioactive materials are stored in Pit 4, and the residue fill is irregular across the pit. Pit 3 is designed to overflow into Pit 4 through a connecting pipe 2 m (7 ft) below the top of the common dike.

The sludge material in the pits is covered with water for most of the year. The amount of water in the pits varies depending on the climatic conditions of a given year. During the hot, dry

summer months, the surface water in Pits 1 and 2 often evaporates, leaving the raffinate sludge with a dry and cracked surface. The level of water in Pits 3 and 4 also varies, but past observation has found some surface water always present.

Maintenance, surveillance, and environmental monitoring have been continually conducted at the WSRP site since the former DOE contractor, Bechtel National, Inc., began operation in 1981. The site is fenced, posted, and patrolled by security guards. The grass is mowed, brush is cleared for access to each pit, and the fences are repaired as necessary.

In 1982, a portion of the dike around Pit 4 was repaired to stabilize a shallow, circular arc slide. The slide occurred because of the steep (38-47%) side slopes of sections of the existing dikes. The side slopes of Pit 4 were constructed at undesirably steep slopes in this section because a perimeter road encroached on the space needed for construction.

1.1.3 Process Waste Description

There are three major waste types present at the WSRP site. These are:

1. Neutralized raffinate liquors generated from uranium refining operations, including washed slag residues

from uranium metal production operations and raffinate solids from the processing of thorium recycle materials;

2. Contaminated water ponded on each raffinate pit; and
3. Contaminated rubble.

Each of these waste types is addressed in greater detail in the following text.

1.1.3.1 Neutralized Raffinate Liquors

Neutralized raffinate liquors were generated as follows: the Weldon Spring Uranium Feed Materials Plant (WSUFMP) received yellow cake ore from various uranium mills across the U.S. The yellow cake feed material was ultimately dissolved in a process stream containing nitric acid solution. This solution contained the dissolved uranium along with all the other impurities found in the yellow cake ore. Once the uranium was stripped from the solution, the resulting waste was mixed with lime to produce what is referred to as neutralized raffinates. These neutralized raffinates were discharged directly to the raffinate pits.

In the final stage of the uranium production process, uranium tetrafluoride was reacted with magnesium producing uranium metal and magnesium fluoride. The magnesium fluoride slag was then redissolved with yellow cake feed material to recover unreacted uranium contained in the slag. The remaining magnesium

fluoride, or washed slag, was deposited in the pits. Neutralized raffinates and washed slag were processed out of Building 103, the digestion and denitration building of the WSUFMP.

The residues contained in Pits 1, 2, and 3 consist of the neutralized raffinates and washed slag residues as descirbed above. Thorium is also present in these pits from the uranium feed material and from uranium decay during storage in the pits.

Pit 4 contains the same types of residues that are present in Pits 1, 2, and 3 plus raffinate solids from processing of thorium-232. It also contains recycle materials and copious quantities of drums and rubble dumped during closure of the Feed Materials Plant.

1.1.3.2 Contaminated Water

Approximately 54 million gallons of water is currently ponded on the raffinate pits. Section 1.2.4 of this sampling plan provides a detailed discussion of the analysis performed on these waters.

1.1.3.3 Contaminated Rubble

The contaminated rubble consists of drums and steel scrap dumped during closure of the WSUFMP and when the Army began conversion of a portion of the plant for herbicide production. The main dumping area is in Pit 4. All of the rubble is presumed to be radiologically contaminated since it originated from the WSUFMP. There is no indication that any of this rubble includes containerized chemical wastes. Visual inspection of the rubble has revealed no drums remaining intact. A number of samples of the sludge material will be taken sufficiently close to the rubble area to verify the presence or absence of chemical contamination.

1.1.4 Raffinate Pit Constituents

Radium is present in the raffinate pits due to the decay of uranium to radium and trace amounts of radium in the yellow cake. In addition, some feed materials at the WSUFMP were high-grade uranium ore which would contribute both thorium-230 and radium-226 to the wastes in the raffinate pits.

The majority of the radium (both 226 and 228) was removed at the uranium mill and disposed of with the mill tailings. As for thorium, a significant amount is retained with the uranium when raw uranium ore is processed into yellow cake. Processes at the

Feed Materials Plant separated thorium-230 from the uranium and sent it to the raffinate pits.

The relative solubilities of uranium, thorium and radium determine the radiological composition of the raffinate pit water. Of the three, thorium is the most insoluble in aqueous solutions, while radium is slightly soluble in water with the evolution of hydrogen. However, uranium is attacked by water and several uranium compounds are stable in solution. Therefore, uranium activities should be greater than radium activities and both uranium and radium activities should be greater than thorium activities.

Numerous tanks, drums and other equipment were disposed of in Pit 4 during the 1967-1969 decontamination effort by the Army. Most of the equipment from Buildings 101, 103, and 105 was dismantled and dumped in Pit 4. The equipment in these buildings would have been contaminated with uranium in a soluble form. Near the end of production at the Feed Materials Plant, uranium was used to purge thorium wastes from all steps of the process. Wastes from this purge were disposed of in Pit 4.

1.2 PREVIOUS STUDIES

Three reports have been prepared regarding various properties of the raffinate pit sludges and sediments. Bechtel National, Inc. (BNI) subcontracted with Eberline Instrument Corporation in 1983

to take samples of the waste in the raffinate pits and analyze them for stable metals and radiochemistry. BNI also subcontracted with Environmental Science and Engineering, Inc. (ESE) in 1983 to sample and analyze the raffinate pit wastes in an effort to select equipment best suited to dewater the raffinate pit sludges. In 1986, BNI obtained samples of the raffinate pit sludges and subcontracted Thermo Analytical/Eberline Laboratory to perform radiological analysis and analysis for EP Toxicity, PCBs, reactivity, ignitability, and pH.

One report has also been prepared for characterization of the raffinate pit surface waters. This report was prepared by the current Project Management Contractor (PMC) in 1987.

1.2.1 Bechtel National, Inc. Study, 1983 (with Eberline)

The samples were collected and analyzed by Eberline Instrument Corporation in 1983. The data reported here are analytical results on a single, blended, mixed, composite sample prepared from multiple-location samples taken from each pit. The stable metals (Table 1-2) were analyzed using the method of atomic absorption analysis.

From the referenced study, results of analyses of the chemical components of the raffinate sludge in each pit are presented in Table 1-2 and the radiological components in Table 1-3.

TABLE 1-2

Analysis of Stable Metals from Previous Studies

Weldon Spring Raffinate Pits Sludge (mg/kg-dry)

Analysis	Pit 1 Composite	Pit 2 Composite	Pit 3 Composite	Pit 4 Composite
Aluminum	4.3	4.1	6.2	4.0
Arsenic	130	170	54	1.0
Boron	60	350	50	30
Barium	23	20	10	22
Beryllium	0.016	0.025	0.015	0.007
Cadmium	9.1	7.3	5.1	2.8
Calcium	980	990	990	980
Cobalt	9.4	14	11	2.1
Chromium	90	60	60	70
Copper	5.5	4.9	5.5	4.4
Iron	210	200	130	210
Lead	110	140	220	1.5
Lithium	4.4	9.2	23.7	10.1
Magnesium	1,800	1,700	1,700	860
Manganese	7.8	7.8	9.4	8.8
Mercury	1.8	0.75	17	2.3
Molybdenum	4,700	2,800	2,500	370
Nickel	30	27	27	22
Phosphate	0.7	0.6	0.8	0.5
Potassium	650	620	220	310
Selenium	0.89	0.5	1.4	0.5
(Total)Silicon	10,000	16,400	13,000	13,800
Silver	2.0	0.39	1.4	0.1
Strontium	84	220	50	40
Titanium	1,000	860	1,150	670
Vanadium	5,000	800	800	300
Zirconium	17,000	14,400	19,000	11,500
Sodium	10,000	5,000	5,000	4,000
Zinc	10	20	10	10
Nitrate	50,000	18,000	22,000	220
Fluoride	23,000	2,500	107,000	64,300
Chloride	670	230	300	50
Sulphate	400	200	370	270
Hydroxide (% $CaCO_3$)	7	10	10	11
pH (pH units)	8.1	8.7	9.4	8.5

Ref. BNI, 1983

TABLE 1-3

Raffinate Pits Radioisotope Contents From Previous Studies

(pCi/g dry)

Radioisotope	Pit 1	Pit 2	Pit 3	Pit 4
Radium-226	430±130	440±130	460±130	11±3
Radium-228	850±85	200±20	100±10	60±10
Thorium-232	100±20	120±20	120±20	120±20
Thorium-230	24000±1000	24000±1000	14000±1000	1600±100
Uranium-238	710±70	470±40	520±50	620±60
Uranium-234	810±80	560±50	570±50	610±60
Uranium-235	40±5	30±4	30±4	30±4

(a) These data do not include lead-210 which would increase total curies, if included. The activity of lead-210 at the WSRP site has not been measured. However, since almost all of the radioactive material brought onto the site was either uranium ore concentrates, uranium scrap, or thorium scrap, only an insignificant amount of lead-210 should be present, and this from radioactive decay of the radium and thorium in the pits. This is due to the long half-lives of radium-226 (1,600 years) and thorium-230 (80,000 years), and the short time (less than 40 years) during which decay has occurred. (Note: only lead-208 (stable) should be present from the thorium-232/thorium-228 chain).

(b) Data presented in this table are based on analysis of sludges obtained from the pits by BNI in May 1983.

Note: The ± values indicate measurement accuracy.

Table 1-2 shows the presence of high concentrations of silicon, zirconium, sodium, nitrates, and fluoride, as well as elevated levels of arsenic, calcium, magnesium, and molybdenum in all four pits.

Table 1-3 presents a preliminary estimate of the radioisotopic content of each of the four raffinate pits at the WSRP site. According to this estimate, the average concentration of radioactive materials in the raffinate sludge is about 3,500 pCi/g. The level of radiation at approximately 0.3 m (1 ft) above the sludge ranges from 0.2 to 1.5 mR/h.

1.2.2 Bechtel National, Inc. Study, 1983 (with Environmental Science & Engineering)

In 1983 Bechtel National, Inc. (BNI) contracted with Environmental Science and Engineering, Inc. (ESE) to sample and test the physical properties of the raffinate pit sludges. Testing was actually performed by Monteagle, Inc., Environmental and Energy Consultants, and Reitz & Jens, Inc.

The initial project intent was to use test results to select the type and size of mechanical dewatering equipment best suited to dewater the raffinate pit sludges. Early test results indicated that the sludges had a considerably higher solids content than expected. For this reason all further tests related to

mechanical dewatering were stopped and replaced with a series of tests useful in developing other treatment options.

Sludges in each of the raffinate pits were sampled by driving a core sampling device into the sludge bed at preselected locations. The sampling was conducted from a polystyrene barge. The sampler was driven with a safety slide hammer and extractor. The sampler itself was constructed of 3-inch PVC tubing with a retaining apparatus and check valve to hold the sample during extraction.

Sludge samples were obtained from eight locations (three each from Pits 3 and 4, one each from Pits 1 and 2). Sample locations are shown in Figure 1-3. A summary of the sampling data is provided in Table 1-4. Samples were obtained from the top, middle and bottom of each core, providing 24 individual sludge samples. Sludge composites were made by homogenizing individual samples from each location within each pit. Preliminary tests were conducted on individual sludge samples; most testing was conducted on the composite samples (Reference ESE, 1983).

Table 1-5 lists percent total solids of each discrete sample. Percent total solids is defined as the weight of the solids in a sample divided by the total weight of the sample times one hundred. The total solids determination is useful in estimating the homogeneity or heterogeneity of the sludge. It can be

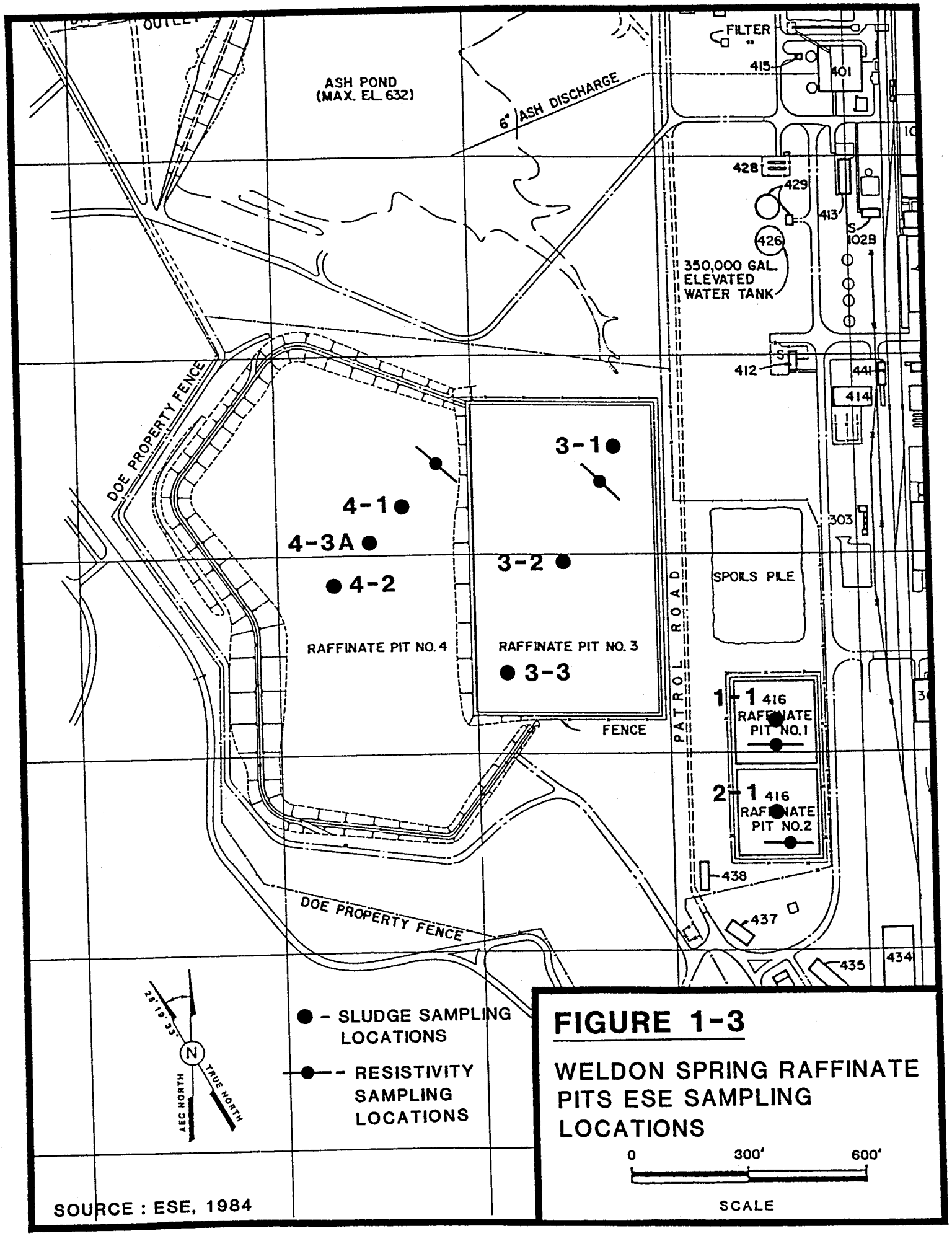

FIGURE 1-3

WELDON SPRING RAFFINATE PITS ESE SAMPLING LOCATIONS

TABLE 1-4

Weldon Spring Raffinate Pit Sampling Data

Sample Location	Time Sampled	Water Level Elevation	Depth to Top of Sludge (feet)	Depth to Bottom of Sludge (feet)	Depth of Sludge (feet)
3-3	1127 5/3/83	659.67	4.5	11.5	7.0
3-2	1140 5/3/83	659.67	4.0	13.0	9.0
3-1	1245 5/3/83	659.67	2.5	19.0	16.5
4-1	0846 5/5/83	647.68	6.0	9.0	3.0
4-2	1026 5/5/83	647.68	11.0	13.0	2.0
4-3a*	1328 5/5/83	647.68	9.5	12.0	2.5
2-1	1710 5/6/83	662.05	4.0	14.0	10.0
1-1	0908 5/6/83	662.01	4.0	15.5	11.5

* Station 4-3 was adjusted due to lack of sludge at original location; 4-3a was located between 4-1 and 4-2.

Source: Monteagle, Inc., 1983; and ESE, 1983.

TABLE 1-5

Total Solids - Discrete Samples

Sample I.D.	% Total Solids (by weight)	Sample I.D.	% Total Solids (by weight)
Pit No. 1:		Pit No. 4:	
P-1 Top	37.8	P-4 1-Top	33.6
P-1 Middle	30.2	P-4 1-Middle	37.1
P-1 Bottom	30.4	P-4 1-Bottom	27.7
Pit No. 2:			
P-2 Top	25.6	P-4 2-Top	27.2
P-2 Middle	24.5	P-4 2-Middle	20.0
P-2 Bottom	32.6	P-4 2-Bottom	18.2
Pit No. 3:			
P-3 1-Top	50.0	P-4 3-Top	38.5
P-3 1-Middle	24.5	P-4 3-Middle	42.3
P-3 1-Bottom	28.3	P-4 3-Bottom	67.9
P-3 2-Top	22.6		
P-3 2-Middle	27.0		
P-3 2-Bottom	25.6		
P-3 3-Top	24.3		
P-3 3-Middle	22.5		
P-3 3-Bottom	25.1		

Ref.: WSRP Sludge Core Samples - BNI 1983 - ESE

interpreted from the solids data in Table 1-5 that the physical density of the sludge appears to be heterogeneous with no discernible trends or patterns. Interpretation of the data, however, is difficult due to the vibratory sampling technique.

Table 1-6 is a summary of physical properties of the composite sludge samples. The liquid and plastic limits are expressed as moisture contents (weight of water divided by the weight of solids for a given sample). Above the liquid limits, the soil-water system is a suspension. Between the liquid limit and the plastic limit the system is said to be in the plastic state. The difference between these two limits is called the plasticity index and is the range over which a soil-water system acts as a plastic material.

The specific gravity of solids is the ratio of the dry density of the solid fraction (weight of solids divided by volume of sample) of a sample to the density of water (62.4 lbs/cf). This parameter can also be an indicator of homogeneity or heterogeneity. Although the specific gravity is shown to vary from pit to pit because the samples from each pit were composited for this particular test, the degree of heterogeneity within each pit is quantitatively indeterminate.

Resistivity is the measure of the resistance of a given material to electric current. This measurement was made in-situ at varying depths in an effort to identify the extent of layering

TABLE 1-6

WSRP Physical Properties of Composite Samples

Property	Pit 1	Pit 2	Pit 3	Pit 4
Moisture Content	262	240	266	295
Liquid Limit	126	140	129	157
Plastic Limit	65	75	66	70
Plasticity Index	61	65	63	87
Specific Gravity of Solids	2.94	2.73	2.68	2.75
Resistivity (ohm-meter)	0 to 16.47	0 to 5.74	0.82 to 9.88	16.47 to 72.51
Response to Vibration*	none	none	none	none
% Finer than #200 Screen	90.8	99.93	89.2	94

* Vibration testing performed with equipment conforming to ASTM D-2049.

Ref. Reitz & Jens, Inc. (BNI, 1983, ESE)

or stratification in each pit. The data exhibited on Table 1-6 shows a wide range of resistivities indicating the presence of stratification with depth.

Tests were conducted to determine whether the sludge solids would separate from the water fraction, or whether the sludge would flow in response to vibration, using ASTM D-2049. During the tests very little change in the material was observed after 15 minutes of vibration. The only visible change was that the top surface of the sample developed a smoother appearance. No change was observed when a furrow was struck across the sample and the sample was vibrated for 5 minutes. These results indicate that the material might possibly be excavated with conventional construction equipment (i.e. front end loaders) without recourse to special handling techniques.

The tests showing the percent finer than the #200 screen size indicate that the sludge consists primarily of very fine-grained particle size. Electron micrography photographs revealed that the particles are highly flocculated with some needle-shaped particles. These tests show that the sludge will not easily be dewatered using conventional mechanical methods.

Table 1-7 presents estimates of the sludge permeability range based on consolidation tests using Terzaghis one-dimensional consolidation theory (Reference Holtz and Kovacs, 1981).

TABLE 1-7

WSRP Permeability Results from Composite Samples of Raffinate Sludge

Pit	Natural w%*	Final w%*	Calculated Permeability Range
1	215.6	146.9	7×10^{-7} to 5×10^{-8} cm/sec.
2	196.4	158.6	5.8×10^{-7} to 1.1×10^{-8} cm/sec.
3	174.1	125.6	7.5×10^{-7} to 7.7×10^{-8} cm/sec.
4	171.6	121.1	9.4×10^{-7} to 1.5×10^{-7} cm/sec.

* water content by weight

Ref. Reitz and Jens, Inc. (ESE, 1983)

Permeability is a measure of the rate at which water flows through soil. The range of permeabilities presented in the table is beyond the limit (1 X 10^{-6}cm/s) of any reliable direct measurement using either a constant-head or falling-head permeameter testing apparatus. These test results can be interpreted as relative and imply that the permeability is less than 1 X 10^{-6} cm/s.

Table 1-8 presents additional test results for the composite samples. The use and interpretation of moisture content, total solids, density, and specific gravity have been discussed. An additional parameter, viscosity, is a measure of fluidity. Information on sludge viscosity is used in the selection and sizing of mechanical equipment which might be used for mixing or pumping the sludge. These data will be reviewed and applied as appropriate in conjunction with additional data which are to be collected by the PMC through the execution of this sampling plan.

1.2.3 Bechtel National, Inc., Study, 1986 (with Thermoanalytic/Eberline Laboratory)

BNI conducted an initial Resource Conservation and Recovery Act (RCRA) characteristic sampling program for the Weldon Spring Site (WSS) Raffinate Pits in 1986. The 28 sampling locations are shown on Figure 1-4. These locations were chosen using a random number generator method. At each location, up to three samples were obtained and sent to the Thermoanalytic/Eberline

TABLE 1-8

Composite Sample Testing Results of Raffinate Sludge

Pit No.	Moisture Content % of Wet Sample by Weight	Moisture* Content by Percentage	Total Solids % by Weight	Density (lbs/cf)	Specific Gravity of Sludge
1	72.4	123	27.6	200	1.189
2	70.6	142	29.4	235	1.217
3	72.7	191	27.3	320	1.204
4	74.7	254	25.3	380	1.182

Pit No.	Viscosity, cps **	Driving Weight, in grams to obtain 600 r.p.m
1	262%	74.35
2	240%	76.10
3	266%	75.29
4	295%	73.92

* Weight of water divided by weight of solids

** Centipoise

Ref. BNI 1983-ESE

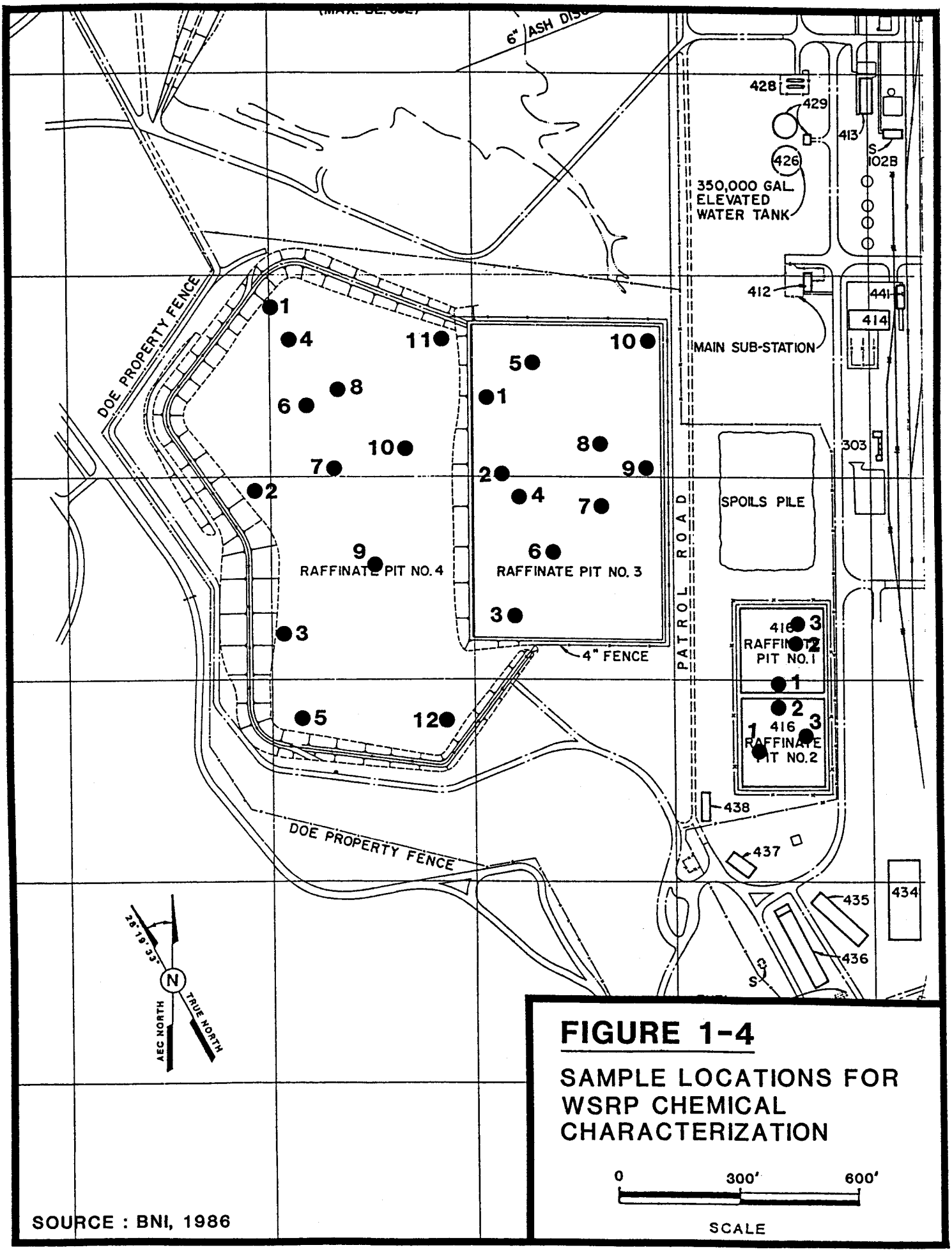

FIGURE 1-4

SAMPLE LOCATIONS FOR WSRP CHEMICAL CHARACTERIZATION

0 300' 600'

SCALE

SOURCE : BNI, 1986

Laboratory in Albuquerque, New Mexico, for radiological analysis. Each sample was analyzed for uranium 234, 235, and 238, thorium 230 and 232, radium 226 and 228, lead 210, and polonium 210. Maximum, minimum and average concentrations are given in Table 1-9.

Eighteen samples were analyzed by Eberline Analytical Laboratories (EAL) for EP toxicity, reactivity, ignitability, PCBs and pH. All analytical results reported were below regulatory limits and EAL concluded that the material did not exhibit any of the four characteristics of RCRA hazardous waste (Reference BNI, 1986).

1.2.4 WSSRAP Project Management Contractor Study, 1987

Surface water samples were collected from the four raffinate pits as a part of the Phase I Water Quality Assessment conducted in April of 1987 by the PMC. Representative samples for each pit were collected from the shore and composited from at least four locations per pit. These samples were collected using a stainless steel bailer which was slowly lowered to a point just above the sediment. These samples were analyzed for the groundwater parameters listed in Table 1-10.

TABLE 1-9
Weldon Spring Raffinate Pits
Sludge Sample Radionuclide Activities

Radionuclide		Concentrations in pCi/q-dry			
		Pit No. 1	Pit No. 2	Pit No. 3	Pit No. 4
U-234	Low	410	310	380	9
	High	2,100	1,700	5,900	2,200
	Avg.	1,057	910	1,588	291.5
U-238	Low	280	280	350	9
	High	1,800	1,700	6,000	2,200
	Avg.	900	884	1,580	291.5
Th-230	Low	70	40	130	1.8
	High	4,400	33,000	270,000	2,900
	Avg.	1,541	26,673	32,896	737
Th-232	Low	1	1	2	.8
	High	46	390	3,100	160
	Avg.	16	108	357	45
Ra-226	Low	930	270	86	.8
	High	3,600	3,600	3,600	190
	Avg.	2,404	1,452	1,211	50
Ra-228	Low	8	100	20	5
	High	200	430	300	870
	Avg.	98	195	189	182
Pb-210	Low	1,100	480	260	5
	High	5,400	4,700	4,400	350
	Avg.	2,600	2,384	1.685	103
Po-210	Low	610	540	130	2
	High	5,400	4,400	4,000	340
	Avg.	2,587	2,119	1,597	70
Locations sampled		3	3	10	12
Total No. samples		7	9	26	13

(BNI 1986 - EAL)

TABLE 1-10

Groundwater - Analytical Parameters

(Dissolved Fraction)

Phase 1 Water Quality Assessment

Uranium - Natural	Fluoride
Radium 226	Hardness
Radium 228	Total Dissolved Solids
Thorium 230	Total Organic Carbon
Thorium 232	CLP Metals; Lithium
Gross Alpha	CLP Organics
Gross Beta	U.S. ATHAMA Nitroaromatics
Nitrate	PCBs
Sulfate	Pesticides
Chloride	

Source: WSSRAP, 1987

The analyses in Table 1-10 (Groundwater - Analytical Parameters) were selected based on known or suspected contaminants (nitroaromatics, radionuclides, etc.) and to provide documentation of presence/absence regarding species not expected to be present in the water (organics, Hazardous Substance List (HSL) compounds, PCBs, pesticides, etc.).

Surface water samples from each pit were analyzed for nitroaromatics. A trace level (0.28 ppb) of 2,4 DNT was detected in Raffinate Pit 2. It is possible that some nitroaromatically contaminated soil from across the area of the former Ordnance Works Facility was used in the construction of this pit. No other nitroaromatics were detected in any of the raffinate pit waters, as expected.

Raffinate pit water samples were also tested for four inorganic anions (nitrate, sulfate, chloride, and fluoride) and three water quality indicator parameters (Total Organic Carbon (TOC), Total Dissolved Solids (TDS) and hardness). The results of these analyses are shown in Table 1-11. A comparison of recent data to historical data for the four inorganic anions is presented in Table 1-12.

Due to the nature of the uranium purification process used at the WSUFMP, high levels of nitrates and sulfates were present in the raffinate slurry as it entered the pits. Due to

TABLE 1-11

Inorganic Anion and Water Quality Data for the Raffinate Pits

Phase 1 Water Quality Assessment

Concentration mg/L Location No.	Date Sampled	Nitrate (as N)	Sulfate	Chloride	Fluoride	Hardness	TDS	TOC	Cyanide	Phenol
SW-3001 Raffinate Pit #1		422	231	1.50	1.90	872	3160	12	0.032	<0.005
SW-3002 Raffinate Pit #2		10.1	493	2.34	1.57	422	818	8	0.025	<0.005
SW-3003 Raffinate Pit #3		947	704	3.37	4.84	2107	6390	6	0.027	<0.005
SW-3004 Raffinate Pit #4		46.6	136	5.69	4.69	252	694	8	0.032	<0.005

Source: WSSRAP, 1987

TABLE 1-12

Concentrations of Inorganic Anions in Raffinate Pit Water

Compound	Concentration (mg/L)					Sludge - 1983
	1987	1984[a]	1983[a]	1979[a]	1967[a]	(mg/Kg dry)
Pit 1						
Nitrate (as N)	442	652	697	-	5625	11250
Sulfate	231	400	100	-	2300	400
Fluoride	1.9	2.5	1.1	-	--	23000
Chloride	1.5	17	15	-	210	670
Pit 2						
Nitrate (as N)	10	204	-	-	8550	4050
Sulfate	493	990	460	-	3300	200
Fluoride	2.3	2.7	1	-	--	2500
Chloride	1.6	5.7	6	-	50	230
Pit 3						
Nitrate (as N)	947	1890	1485	2925	8325	4950
Sulfate	704	640	268	620	2200	370
Fluoride	4.8	8.9	2.7	6	--	107000
Chloride	3.4	25	20	37	90	300
Pit 4						
Nitrate (as N)	47	92	99	126	4725	495
Sulfate	136	150	70	140	2200	270
Fluoride	4.7	7.8	5.8	13	--	64300
Chloride	5.7	7.7	7	10	90	50

[a] Source - DOE, DEIS - 1987.

stratification of the sludges and lack of mixing, significant quantities of the inorganic anions would be expected to be bound in the sludge. Much higher levels existed in past pit water samples and in the raffinate sludge (Table 1-12).

Sulfate concentrations in the pit waters are 231, 493, 704 and 136 mg/L in Pits 1 through 4, respectively. This contamination probably originated as wastes from the yellow cake impurities removed by the solvent extraction process. As with nitrates, much higher amounts of sulfates are contained in the raffinate sludge and interstitial water.

Fluoride levels are slightly elevated in raffinate pit waters. The presence of fluoride in the pits is due to the reintroduction of magnesium fluoride into the digestion phase of the process to recover entrapped uranium. A large portion of the raffinate pit sludge is presumed to consist of magnesium fluoride.

Chloride levels were low for all four pits as would be expected, since chlorides were not used in the uranium process.

Total dissolved solids and hardness varied from pit to pit. The highest value was observed in Pit 3 and the lowest in Pit 4. This is as anticipated since Pit 3 contains the largest volume of wastes and Pit 4 was used for only a short time before production ceased.

Total organic carbon concentrations ranged from 6 to 12 mg/L. These values are as expected since no organic chemicals were used in the processing operation. These levels are probably due to natural organic sources such as algae (which is present in all four pits) or decaying organic matter.

Surface water samples collected from the raffinate pits contained varying amounts of metals. The results for each pit are shown in Table 1-13. All but 4 of the 24 CLP metals analyzed were present in at least one of the pits. All of the metals present in the ponded waters are also present, at higher concentrations, in the raffinate sludge (DOE, DEIS 1987). Due to the pH of the water (8.4 to 9.4) and the low solubility of metals in high pH aqueous solutions, most of the metals are expected to exist as solids in the sludge.

In the digestion stage, the magnesium fluoride slag from the final stage of the process was redissolved with yellow cake feed material to recover unreacted uranium; thus substantial quantities of magnesium, as magnesium fluoride, were deposited in the pits. This explains the elevated magnesium levels.

The remaining metals (Table 1-13) probably originated as impurities in the yellow cake concentrate feed material which were removed during the metallurgical purification process.

TABLE 1-13

CLP Metals Concentrations in the WSRP
(ug/L)

U.S. E.P.A. Primary/Scndry Drinking Water Standard ug/L		Al	Sb	Ar	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
		S	S	50	1000	S	10	S	50	S	1000	300	50	S	S	50	2	S	S	10	50	S	S	S	5000
CRDL - ug/L **		200	60	10	200	5	5	5000	10	50	25	100	5	-	5000	15	0.2	40	5000	5	10	5000	10	50	20
Location No.	Date Sampled																								
SW-3001	4/24/87	405	U	22	71	8	0.5	254000	85	U	45	109	22	U	15400	17	U	11	28400	U	25	388000	U	2090	9
SW-3002	4/24/87	279	102	38	31	7	U	105700	83	U	12	220	U	U	40800	14	U	48	14300	U	10	113000	U	1800	15
SW-3003	4/24/87	517	395	5	86	3	U	260500	194	33	30	433	257	U	196000	33	U	174	78200	U	40	900000	U	535	26
SW-3004	4/24/87	230	U	U	102	U	U	11600	31	U	19	101	358	U	39400	10	U	33	15200	U	8	172000	U	89	19

Source WSSRAP, 1987

S - No Drinking Water Standard

** - Contract-Required Detection Limits, US EPA Contract Laboratory Program

U - Undetected at Contract-Required Detection Limits

Surface water samples from all four raffinate pits were also analyzed for volatile and semi-volatile organics, pesticides, and PCBs. No detectable levels of these compounds were observed in the water ponded on the raffinate pits.

Both Ra-226 and Ra-228 isotopes were present in raffinate pit ponded waters at varying activity levels. The highest level of radium-226 was detected in Pit 1 (61 pCi/L). Pit 4 contained the lowest radium-226 activity at 3.4 pCi/L. Radium-228 was observed in Pits 2, 3, and 4 at activities of 6, 32, and 13 pCi/L, respectively.

Thorium-230 was detected only in Pits 2 and 3 at levels of 13 and 16 pCi/L, respectively. Less than 5 pCi/L of thorium-230 was observed in Pit 4. Thorium-230 and thorium-232 activities could not be determined in Pit 1 due to interference. Based on thorium levels in the sludge in Pits 1 and 2, water in Pit 1 is expected to contain approximately 13 pCi/L thorium-230.

Based on the above analysis of surface water samples from the raffinate pits, no further analysis is deemed necessary at this time to characterize the waters ponded on the pits.

1.3 DATA NEEDS/SAMPLING PLAN OBJECTIVES

Radiological and chemical characterization thus far has provided an indication of the types of radiochemicals and chemicals

present in the raffinate pit sludges. From a radiologic standpoint, further testing is necessary to define the radioactive source term present in the raffinate sludge. Further chemical characterization is necessary to identify substances allegedly dumped during operation of the chemical plant and subsequent clean-up activities.

Physical characterization is complete enough to conclude that the sludges exist in a highly heterogeneous state and that the solids content is sufficiently high to preclude the effective use of mechanical dewatering techniques. Further testing is necessary, however, in connection with treatability studies. These studies will explore other stabilization technologies in an effort to achieve the regulatory goals of volume and toxicity reduction. The studies that will require additional sludge testing are: 1) stabilization studies including chemical methods, vitrification, pozzuolanic materials, dewatering techniques, and reprocessing the recoverable radioactive materials; and 2) liner compatibility studies. Section 3 of this sampling plan details all the proposed testing.

2.0 SAMPLING

2.1 SAMPLING RATIONALE

2.1.1 Radiological

The purpose of the radiological characterization of the raffinate pit sludges is to accurately determine the concentrations of radionuclides in the sludges. The importance of accurately determining these concentrations is two-fold. First, the radium-226 source term must be estimated to design an effective radon-222 barrier as part of an engineered cover. The second reason is to help assess the feasibility of recovering constituents (e.g. radionuclides or metals) from the sludges.

The radon barrier of a disposal cell is modeled in relation to a 1000-year design life (40 CFR 192). Significant concentrations of Ra-226 exist in the sludge today and, in 1000 years, 35 percent of the Th-230 will transform into Ra-226. Sixty-five percent of the original Ra-226 will also still be present. It is important, then, to estimate as accurately as possible the concentrations of these two radionuclides in the raffinate pit sludges in order to maximize the accuracy of subsequent radon barrier thickness calculations.

In 1984, the raffinate pit sludges were sampled by Bechtel National, Inc., (BNI). This is the most recent, most

comprehensive sampling effort of the sludges performed to date. This effort showed that there is great pit-to-pit variability for all radiologic species.

The BNI data was used to determine the number of samples per pit necessary to characterize the average radionuclide concentrations of each pit at a given level of statistical confidence. The accuracy determined to be adequate for this characterization was 90 percent confidence intervals about the mean with a relative error of the mean of 30 percent. The BNI data for Th-230 and Ra-226 was tabulated and the averages and standard deviations calculated. Only Th-230 was evaluated further because this radionuclide controls (for the 1000-year design-life of the disposal cell) the Ra-226 source term. Additionally, the statistical variability of the Ra-226 concentration was less than the statistical variability of the Th-230 concentration. The statistical variability of the uranium species concentrations is also less than the Th-230 concentration variability.

The derived sample requirements were then scaled volumetrically relative to Pit 3. Considering that Pit 3 contains nearly one-half the total sludge volume, the number of samples needed for the other pits could be scaled relative to Pit 3 without significant increases in error but with significant cost savings. This caused the number of samples to be reduced for Pits 1 and 2 and slightly increased for Pit 4. Then

approximately 85 percent of the sludge will be characterized with at least the desired level of accuracy.

It should be noted that the sludge is being characterized volumetrically and without regard to any vertical or horizontal stratification characteristics. It is not feasible to develop layer averages since there is no way to estimate how the sludge will be excavated and its subsequent disposal. The placement of the samples required to complete the sludge characterization will be made with regard to the previous sampling so as to provide uniform coverage of sludge area and depth.

2.1.2 Chemical

The purpose of the chemical characterization of the sludge/sediment material within the pits is to define the degree of contamination and to help quantify the magnitude of the effort that will be required to ultimately dispose of the wastes. The variability of contaminant types within the sludges will determine the disposal alternatives to be evaluated. Knowledge of these contaminants is required to develop the rationale behind liner engineering and compatibility testing.

The chemical characteristics of the raffinate sludge materials can be predicted to a limited extent from the history of the processes performed during the plant's operation, and from knowledge of the process sewers which drained to the pit.

However, because of alleged indiscriminate dumping of other chemicals into the pits, a scan for Hazardous Substance List (HSL) compounds will be conducted on samples acquired across each of the pits. This will determine the actual concentration of suspected wastes, as well as verify the presence or absence of other chemicals which may have been deposited in the pits.

The sludges will be analyzed for chemical products and by-products of process chemicals used on site, as well as their degradation products. These compounds include: metals, nitroaromatics and inorganic anions such as chloride, fluoride, nitrates, and sulfates. It is expected that no organic chemical contamination from volatile or semi-volatile fractions are present in the sludge; however, scans for likely compounds within these groups will be performed to confirm their absence. The sampling for the chemical parameters will be accomplished with the sampling efforts for radiologic characteristics. A list of the individual compounds and elements within each group is included as Attachment B.

Since these data will be applied primarily toward evaluation of disposal alternatives, a 90 percent confidence limit and one standard deviation about the mean were chosen as adequate for devising the sampling strategy.

The approach utilizes the formula

$$n=(cv)^2(t)^2/(p)^2$$

where n = the number of samples

cv = the coefficient of variation in percent

t = the student's t value for 90% confidence and 30 degrees of freedom

p = the acceptable error in percent

In the absence of usable data to determine actual variations in concentrations across the pits some assumptions must be made for the values of cv and p. Assumptions which were made for the raffinate sludge sampling were that the Coefficient of Variation equals 65% and the acceptable error will be chosen at 20%. The t-value for 90% confidence level and 30 degrees of freedom was obtained from the student's t table as 1.66. Calculating the minimum necessary number of samples (n) from these numbers:

$$n = (65)^2(1.66)^2/(20)^2$$

$$n = 29.10$$

Rounding up, n = 30

Approximately 30 samples would deliver a 90% confidence level with two standard deviations about the mean.

Since each of the pits contains, in effect, a different statistical population, a coverage of 30 samples per pit will be necessary to achieve the desired confidence. Consideration was given to combining the sampling efforts for Pits 1 and 2, since the pits are immediately adjacent to one another and the wastes were deposited in both pits in a relatively short span of time. However, review of existing data has shown some large variations in the concentrations of radiologic characters between the two pits. Therefore, these pits will be treated as separate statistical populations, with at least 30 samples taken in each of the four pits. Figure 2-1 exhibits the sample location layout.

A complete column of sample will be collected at each location to assess the degree of stratification of the waste materials. Of greatest concern with respect to high degrees of variation are the semi-volatile organic compounds and their impacts on liner compatibility. To date, no data have been collected on the semi-volatile fraction from the raffinate pit sludges. A breakdown of the numbers of samples and analyses to be performed, by pit, is given in Tables 3-2 through 3-6 (in Section 3.1).

Other parameters being investigated include CLP metals (plus lithium, molybdenum and zirconium), volatile organics, nitroaromatics, PCBs/pesticides, and inorganic anions (including chloride, fluoride, nitrate and sulfate). Previous studies have investigated, to a very limited extent, the sludge's content of

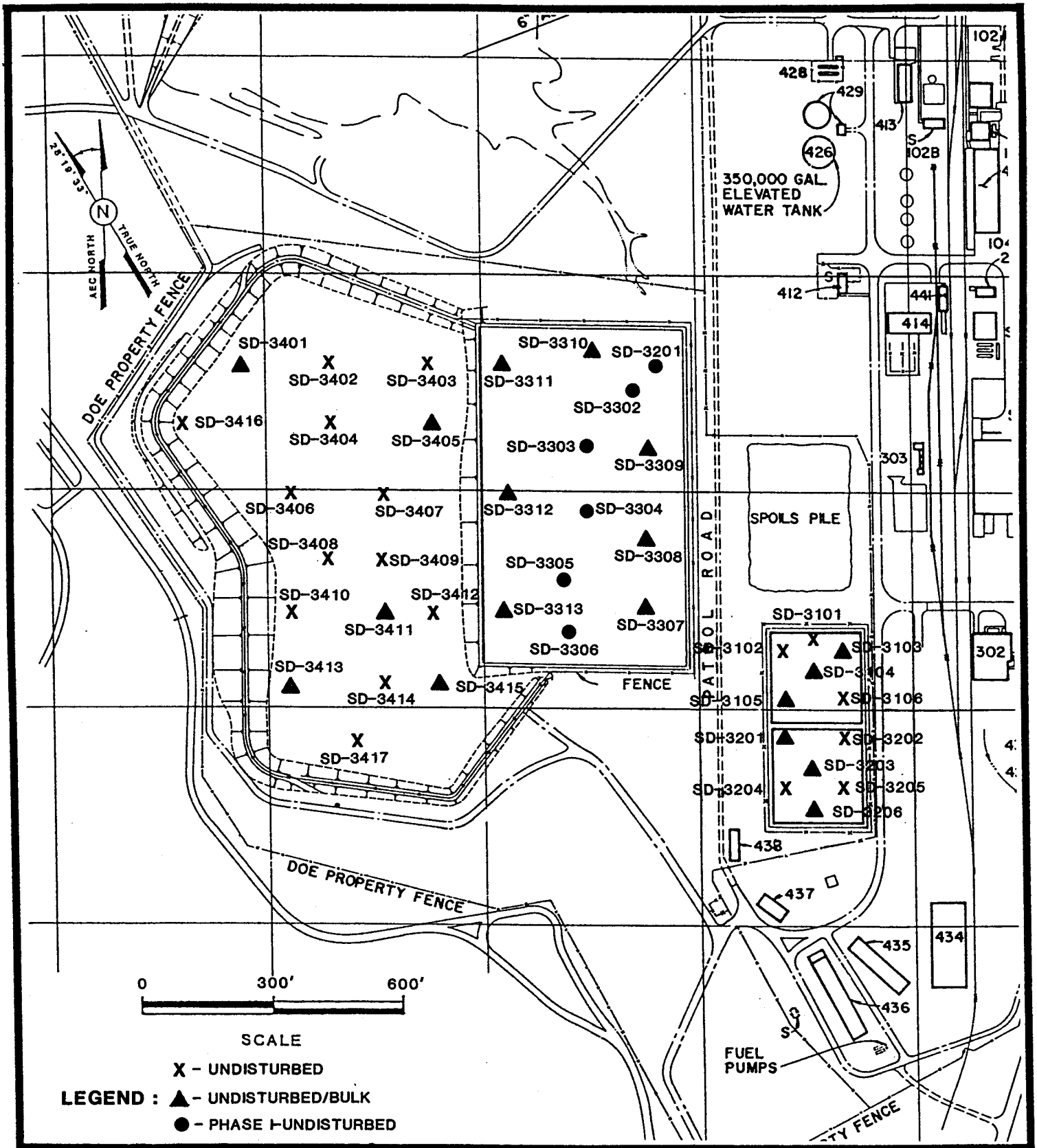

FIGURE 2-1

SAMPLING LOCATIONS FOR THE WSS RAFFINATE PITS CHARACTERIZATION

metals (minus lithium, molybdenum and zirconium), PCBs/pesticides, as well as the presence of nitroaromatics and inorganic anions in the supernatant waters. These studies revealed occasional areas across the pits where concentrations of metals (As, Ba, Cd, Pb, Hg, Ag) slightly exceeded detection limits (as determined through EP Toxicity tests). No evidence of PCB/pesticide contamination was found in the sludge. In the supernatant water of the raffinate pits, nitroaromatics were detected only in Pit 2. The inorganic anions were detected in waters from all four of the pits at varying concentrations.

Thirty samples will be collected from each pit, although the number of analyses for some parameters will be scaled down from thirty. Table 3-6 (Section 3.1) provides a breakdown of the analytical parameters in the investigation and the number of samples per pit for each parameter.

In an attempt to reduce the costs of the raffinate sludge characterization effort, yet maintain data reliability and statistical utility, factors such as pit size and previous data were considered when determining data quantity needs for volatile organics. Because of the relatively small size of Pits 1 and 2 (200 feet per side), the volatile nature of the compounds, and the age of the wastes in the pits (20-plus years) it is likely that variations in concentrations will be smaller than those for metals or semi-volatiles, if volatiles are present at all.

The number of analyses for PCBs/pesticides has been scaled back since some analyses previously performed on the sludges for these compounds indicated no presence above detection limits. Also, the number of analyses for nitroaromatics has been slightly decreased based on historical information and preliminary sampling of the supernatant waters which showed no evidence of these compounds in Pits 1, 3, and 4, and 0.28 ppb of 2,4 DNT in Pit 2. Should significant variability be encountered with the Phase 1 samples from Pit 3, then the analyses will be expanded.

Sampling, by a PMC subcontractor, will be accomplished in a single phase for Pits 1, 2, and 4 and in two phases for Pit 3. Pit 3 sampling will be expanded due to its considerably greater volume of sludge material.

Sampling will commence at Pit 3 with the collection of composite samples from six locations along a curved line (see Figure 2-1) from the southwest corner of the pit and moving towards the northeast corner (the corner from which the raffinate wastes were discharged). These samples will be submitted immediately for analysis, from which data will be used as a rough measure of the variability of concentrations across Pit 3. While awaiting analytical results (approximately 7 to 10 days) from Pit 3 samples, the sampling barge will be transferred to the other pits and complete sampling will be conducted at Pits 1, 2, and 4. The sample layout presented for Pit 3 in Figure 2-1 was devised assuming some reasonably limited analytical variation across the

pit area. If instead the pit shows a coefficient of variation near 100 percent or greater, alternative strategies may be considered prior to the Phase II sampling in Pit 3. Upon review and evaluation of Pit 3 Phase I data (concurrent with completion of sampling Pits 1, 2 and 4), a decision will be made on correct sample location layout, and the sampling equipment will be returned to Pit 3 to execute the appropriate sampling strategy.

2.1.3 Physical

The purpose of the physical characterization is to determine the degree of heterogeneity of the sludge both horizontally and vertically within each pit. In addition, selected physical parameters are indicative of the feasibility of various methods of stabilization. Since previous studies indicate a random distribution of physical parameters, sample locations are based on an even areal distribution across each pit. Samples at intervals of two feet will be taken continuously through the sludge.

The range of variation of physical parameters within each pit may have significant influence on in-situ stabilization techniques. A five-gallon grab sample from each discrete sample interval will be utilized in treatability studies.

Compositing of discrete samples for stabilization testing will be performed off-site and will be based on the parameters determined

in the physical characterization testing. Also, the stabilization technique under consideration will affect the extent of compositing. Composited samples from each pit will be used for vitrification, dewatering and reprocessing treatability studies. Compositing samples for in-situ stabilization techniques will be based on the effective depth range of the in-situ technique. Any remaining portion of sample will be stored for use in future bench scale studies, if required. If further testing is not necessary, the samples will be returned to the raffinate pits.

2.2 SAMPLING PROCEDURES

Characterization of the sludge material from the raffinate pits is necessary in order to define and evaluate the disposal alternatives. Representative samples of the sludge will be collected and evaluated for chemical, radiological, and physical parameters and the data used to support technical decisions and, if necessary, to demonstrate regulatory compliance.

The sample collection effort will be performed by a PMC subcontractor selected through a competitive bidding process. The precise sampling methodology will be determined by the subcontractor with approval of the DOE.

2.2.1 Description of the Sludge Material

Previous studies on the physical properties of the sludge indicate that the materials are very fine grained (nearly 95% passing the No. 200 sieve). The water content ranges from 70 to 75 percent with some stratification of solids apparent. The material has been described as having the consistency of pudding. Preliminary data indicates that wet bulk densities range from 73.9 lb/cf to 76.1 lb/cf. Depth estimates of the sludge range from an average of four feet in Pit 4 to approximately sixteen feet in Pit 3. The sludge is underlain by a stiff saturated clay.

2.2.2 Sample Location Access

The samples will be collected using a barge-mounted drilling rig. The barge rig will be maneuvered to specific sample locations through the use of ropes or cables. Samples will be located by line-of-sight cross-reference between survey grid stakes on each bank of the pits.

The individual samples will be acquired by driving an outer casing into the sludge in order to isolate a column of material. Drilling and sampling will take place within the casing.

2.2.3 Sample Collection

2.2.3.1 Method of Collection

Samples will be collected from the barge-mounted drilling rig as described above. It is anticipated that the material will be of such a consistency as to require casing of the entire column and sampling through the casing. Undisturbed samples will be collected with a piston sampler, consisting of an outer tube and a coaxial piston that creates a suction pressure within the tube. This method has been used successfully to retrieve high moisture content, fine-grained sludge material (see Reference 9). Bulk samples will be obtained by cleaning out an 8-10 inch casing. Different procedures will be attempted in order to optimize recovery, including augering, bailing or fabricating a large diameter piston sampler.

2.2.3.2 Quantity/Containers/Preservation

Analysis of sludge materials will require that some minimum quantities be properly packaged to maintain sample integrity. Table 2-1 details the container types and volumes to be used and the parameters to be tested on aliquots from each container. Finally, the table also lists the method by which the samples will be preserved.

Table 2-1
Sample Containers for Radiological and Chemical Analysis

Parameters	Containers	Preservatives
Volatile Organics	2-40ml vials	Refrigeration
Organics--Semi-Volatile, Pesticides, PCBs, Nitroaromatics	2-250ml wide-mouth amber glass jars	Refrigeration
Inorganics--Metals, Radiologic, Ionic Species	2-250ml wide-mouth amber glass jars	Refrigeration

2.2.3.3. Decontamination of Sampling Equipment

Equipment that could possibly influence the chemical or radiologic character (either concentration or substance) of the samples through direct or indirect contact will be decontaminated between uses, as necessary. Each discrete undisturbed sample will be collected with a sampler that has been decontaminated with pressure steam followed by a triple rinse with distilled water. Other sampling equipment that will potentially contact the sample material (casing, augers etc.) will be decontaminated with pressure steam between sampling locations. The flotation device and drilling rig will be decontaminated with pressure steam following sampling in each pit.

The decontamination procedures will consist of pressure steam cleaning (and abrasive brushing, if necessary) followed by a triple rinse with distilled water, where indicated. This method has been shown to be effective during previous investigations at the WSS. The effectiveness of the decontamination will be verified by the following methods: 1) visual inspection of the sampling components; 2) radiologic scan through the use of an alpha probe or GM probe (as appropriate); and 3) occasional collection of rinsate samples from the down-hole sampler.

2.2.4 Sample Container Labeling

All samples will be assigned specific numbers consistent with the WSSRAP Standard Operating Procedure's (SOP's) Environmental Numbering System for sediment. Information included on the labels will be site name and address, sample number, percent recovered, sampling personnel, date, time and comments. Following completion of each label with the specific sample data, the labels will be taped to protect the information and ensure that it remains legible.

3.0 SAMPLE ANALYSIS

All sample analysis will be performed according to industry standard testing protocols. The criteria to be met for each type of analysis are detailed in the following sections. Specific testing criteria are listed in Table 3-1 according to the parameters of interest in this study. Tables 3-2, 3-3, 3-4 and 3-5 show the number of analyses anticipated from the sampling effort in each pit. Table 3-6 provides a summary of sampling parameters and tests. These numbers are based on the sludge depths reported in Table 1-4 (Reference ESE, 1983).

3.1 RADIOLOGICAL

3.1.1 Uranium

In general the raffinate pit samples will be analyzed for total uranium with results reported as ppm-U. The analytical method used will follow EPA 600/4-80-032 "Prescribed Procedures for Measurement of Radiation in Drinking Water" August 1986. A small portion (2-10%) of the samples will be analyzed for isotopic uranium; U-234, U-235, U-238. The results will be reported as activity per unit volume and will be used to indicate the isotopic distribution of uranium in the sampled media. The

TABLE 3-1

Sample Analysis Criteria

Parameter	Standard Method of Analysis
Radiologic:	
Uranium and Thorium	EPA 520/5-84-006, Procedure 00-07
Radium	EPA 600/4-80-032
Chemical:	
Volatile Organics	CLP SOW #WA-87-J002
Semi-Volatile Organics	CLP SOW #WA-87-J002
PCBs	CLP SOW #WA-87-J002
Pesticides	CLP SOW #WA-87-J002
Metals (plus Li, Mo and Zi)	CLP SOW #WA-87-K026
Nitroaromatics	EPA Method 609 and USATHAMA Methodology
Inorganic Anions	EPA Method 300.0
Physical:	
Sludge Moisture Content	ASTM D2216
Sludge and Solid Specific Gravity	SMEWW Method 213E and ASTM D854
Sludge Capillary Moisture	ASTM D3152
Sludge Particle Size Analysis	ASTM D422
Sludge Viscosity and Gel Strength	See Note 1
Sludge Surface Charge	Zeta Meter
Atterberg Limits	ASTM 4318
Sludge Centrifuge Moisture Yield	ASTM D425
Sludge Consolidation	ASTM D2435
Sludge Phase Separation	See Note 2

Note 1: Viscosity and Gel Strength

Viscosity shall be measured according to ASTM D4016. To measure gel strength, the viscometer is turned off and the grout or sludge allowed to stand for ten (10) minutes. The viscometer is then turned on at a low rate of shear (5 s^{-1} for a Fann viscometer) and the gel strength is read directly as the maximum deflection on the scale.

Note 2: Phase Separation

Phase separation, a measurement of drainable water, is determined by a settling test in a 250-ml graduate cylinder. A sludge sample (200 ml) is poured into the graduate and allowed to stand. Phase separation is calculated as the volume of clear, drainable surface water divided by the total initial volume X 100.

TABLE 3-2
Pit 1
Sampling Parameters

DEPTH LOCATION	0 - 2 ft.	2 - 4 ft.	4 - 6 ft.	6 - 8 ft.	8 - 10 ft.
1 - 1	V N S I P M	V N S I P M R	V N S I P M R	V N S I P M R	V N S I P M R
1 - 2	V N S I P M	V N S I P M R	V N S I M	V N S I M	V N S I P M R
1 - 3	V N S I P M	V N S I P M R	V N S I M	V N S I M	V N S I M
1 - 4	V N S I M	V N S I M	V N S I M	V N S I M	V N S I M
1 - 5	S I M	S I M	S I M	S I M	S I M
1 - 6	S I M	S I M	S I M	S I M	S I M

V = VOLATILES
S = SEMI-VOLATILES
P = PCB'S/PESTICIDES
M = METALS
N = NITROAROMATICS
I = INORGANIC ANIONS
R = RADIOLOGICAL

TABLE 3-3
Pit 2
Sampling Parameters

DEPTH LOCATION	0 - 2 ft.	2 - 4 ft.	4 - 6 ft.	6 - 8 ft.	8 - 10 ft.
2 - 1	V N S I P M	V N S I P M R	V N S I P M R	V N S I P M	V N S I P M
2 - 2	V N S I P M	V N S I P M	V N S I M	V N S I M R	V N S I P M
2 - 3	V N S I P M	V N S I P M	V N S I M	V N S I M	V N S I M R
2 - 4	V N S I M	V N S I M	V N S I M	V N S I M	V N S I M
2- 5	S I M	S I M	S I M	S I M	S I M
2- 6	S I M	S I M	S I M	S I M	S I M

V = VOLATILES
S = SEMI-VOLATILES
P = PCB'S/PESTICIDES
M = METALS
N = NITROAROMATICS
I = INORGANIC ANIONS
R = RADIOLOGICAL

TABLE 3-4

Pit 3

Sampling Parameters

Depth Location	0 - 2 ft.	2 - 4 ft.	4 - 6 ft.	6 - 8 ft.	8 - 10 ft.	10 - 12 ft.	12 - 14 ft.	UPPER COMP.	MIDDLE COMP.	LOWER COMP.
*3-1	V R	R	V R	R	V R	R	V R	N S I P M	N S I P M	N S I P M
*3-2	V R	R	R	V R	R	R		N S I P M		N S I P M
*3-3	V R	R	R	V R	R			N S I P M	N S I P M	N S I P M
*3-4	V R	R	R	V R	R		V R	N S I P M		N S I P M
*3-5	V R	R	R	V R	R			N S I P M		N S I P M
*3-6	V R	R	R	V R	R			N S I P M		N S I P M
'3-7	R	R	R	R	R					
'3-8	R	R	R	R	R					
'3-9	R	R	R	R	R					
'3-10	R	R								
'3-11										
'3-12										
'3-13										

* = Phase 1 Locations

' = Phase 2 Chemical Parameters to be determined based on Phase 1 analytical data

V = VOLATILES

S = SEMI-VOLATILES

P = PCB'S/PESTICIDES

M = METALS

N = NITROAROMATICS

I = INORGANIC ANIONS

R = RADIOLOGICAL

TABLE 3-5
Pit 4
Sludge Sampling Parameters

DEPTH LOCATION	0 - 2 ft.	2 - 4 ft.	4 - 6 ft.	6 - 8 ft.	8 - 10 ft.
4 - 1	R S M I V P N	R S M I V P N	R S M I V P N	R S M I V P N	V P N S M I
4 - 2	R S M I V P N	R S M I V P N	R S M I V P N	R S M I V P N	V P N S M I
4 - 3	R S M I V P N	R S M I V P N	R S M I V P N	R S M I V P N	V S M I
4 - 4	R S M I V P N	R S M I V P N	R S M I V P N	R S M I V P N	V S M I
4 - 5	R S M I V	R S M I V P N	R S M I V	R S M I V	V
4 - 6	R S M I	R S M I P N	R S M I	R S M I	
4 - 7	R	R S M I	R	R M	
4 - 8	R	R S M I	R		
4 - 9	R	R			
4 - 10	R	R			
4 - 11	R	R			
4 - 12	R	R			
4 - 13	R	R			
4 - 14	R	R			
4 - 15	R	R			
4 - 16	R	R			
4 - 17	R	R			

V = VOLATILES
S = SEMI-VOLATILES
P = PCB'S/PESTICIDES
M = METALS
N = NITROAROMATICS
I = INORGANIC ANIONS
R = RADIOLOGICAL

TABLE 3-6
Sampling Summary

	Pit 1	Pit 2	Pit 3	Pit 4	Total
# Locations	6	6	13	17	42
# Samples	30	30	51	54	165
Particle Size	2	2	7	4	15
Moisture Content	6	6	21	10	43
Specific Gravity	6	6	21	10	43
Phase Separation	6	6	21	10	43
Viscosity	6	6	21	10	43
Atterberg Limits	6	6	21	10	43
5-gal. composite	18	15	49	10	92
Volatiles	20	20	15	25	80
Semi-Volatiles	30	30	14	30	104
PCBs/Pesticides	10	10	14	20	54
Metals	30	30	14	30	104
Nitroaromatics	20	20	14	20	74
Inorganic Anions	30	30	14	30	104
Radiological	7	4	50	49	110
De-con Rinsates	2	2	3	3	10
Field Blanks	2	2	5	4	13
Field Duplicates	2	2	3	3	10

analytical method used for the isotopic uranium analyses will follow EPA 520/5-84-006 "Eastern Environmental Radiation Facility Radiochemistry Procedures Manual" August 1984.

The results of these analyses will be used to estimate the uranium source term for the sampled media. The source term will then be used in various pathway analysis calculations, in risk assessments for total uranium, and in the final-disposal-cell design.

3.1.2 Thorium

The raffinate pit samples will be analyzed for isotopic thorium; Th-232, Th-230, and Th-228. The results will be reported as activity per unit volume and will be used to indicate the isotopic distribution of thorium in the sampled media. The analytical method used will follow EPA 520/5-84-006 "Eastern Environmental Radiation Facility Radiochemistry Procedures Manual" August 1984.

The results of these analyses will be used to estimate the thorium source term for the sampled media. The source term will then be used in various pathway analysis calculations for thorium (mainly Th-230), in the final-disposal-cell design, and in estimating thoron (radon-220) flux from the final disposal cell.

3.1.3 Radium

The raffinate pit samples will be analyzed for radium-226 and radium-228. The results will be reported as activity per unit volume. The analytical method used will follow EPA 600/4-80-032 "Prescribed Procedures for Measurement of Radiation in Drinking Water" August 1986.

The results of these analyses will be used to estimate the radium-226 and radium-228 source terms independently. The source terms will then be used in various pathway analysis calculations for radium, in the final-disposal-cell design, and in estimating radon (radon-222) flux from the final disposal cell.

3.2 CHEMICAL

3.2.1 HSL Compounds

Analyses for those volatile organics, semi-volatile organics, PCBs/pesticides and metals contained within the Hazardous Substance List (see Table 3-1) will be performed following the CLP methodologies. A detailed list of these analyses are presented in Appendix B of the WSSRAP Quality Assurance Program Plan.

3.2.2 Nitroaromatics

Analyses for nitroaromatics including 2,4 DNT, nitrobenzene and isophorone will be performed through EPA Method 609. 2,4,6 TNT will be quantified through performance of the United State Army Toxic and Hazardous Materials Agency (USATHAMA) methodology for that compound by a USATHAMA registered laboratory.

3.3 PHYSICAL

The number of physical tests required to adequately characterize the sludge waste is currently estimated as shown on Table 3-6. These numbers represent the minimum number of tests to be performed. Specific parameter testing may be expanded based on data variability. Samples representative of the top and bottom of each bulk sampling location in Pits 1, 2 and 4 and samples representative of the top, middle and bottom of bulk sampling locations in Pit 3 will be tested for moisture content, specific gravity, phase separation, viscosity and Atterberg limits. Particle size distributions will be performed on samples from multiple locations within each pit as shown on Table 3-6. The remaining physical testing parameters will be determined using a single composite sample.

Physical sample analysis will be required to evaluate the feasibility of the selected stabilization technologies. The indicative parameters for chemical stabilization and dewatering

methods other than mechanical are presented in Table 3-7. These parameters will be used in the feasibility evaluations. Vitrification tests will be accomplished by providing a composite sample to Pacific Northwest Laboratories where they will vitrify the material and analyze the off-gasses. This analysis will provide input for the evaluation of the feasibility and, if necessary, the design of the off-gas treatment system. These special studies are discussed in detail in the special study on sludge stabilization.

3.4 LABORATORY FUNCTIONS AND RESPONSIBILITIES

The analytical laboratory will be required to furnish standard operating procedures, equipment calibration and maintenance procedures, and personnel qualifications required to perform all analytical procedures. The laboratory will also report, for each method, the detection limit, sensitivity, interferences or bias, and analysis time. The laboratory must follow prescribed QA/QC protocol as mandated by the CLP/USATHAMA methodologies or internal QA plans. Written documentation of the results of that QA/QC testing prescribed in the laboratory QA/QC plan and described in the QAPP must be furnished. Any variance from those procedures will be reported and noted for data qualification.

TABLE 3-7

Indicative Parameters for Treatability Studies

Parameter	Stabilization Method
Sludge Moisture Content	Chemical stabilization; in-situ stabilization techniques
Sludge Specific Gravity	Chemical stabilization
Sludge Capillary Moisture	Dewatering
Sludge Particle Size Analysis	Confirm % passing #200 sieve
Sludge Viscosity	Handling techniques (pumpability and mixing)
Sludge Solids Specific Gravity	Chemical stabilization
Sludge Phase Separation	Chemical stabilization
Sludge Solids Surface Charge	Dewatering
Centrifuge Moisture Yield	Dewatering - decant water will be analyzed as worst case for liner compatibility study
Consolidation	Dewatering
Atterberg Limits	Handleability

4.0 QUALITY ASSURANCE MEASURES

All aspects of the site characterization, field investigations and data collection will conform to and adopt the required practices of the WSSRAP Quality Assurance Project Plan (QAPP). The QAPP presents the policies, organizations, objectives, functional activities and specific quality assurance (QA) and quality control (QC) activities designed to achieve the data quality goals of WSSRAP. Detailed below are the specific practices to be employed as quality assurance measures during characterization of the wastes in the raffinate pits.

The general QA objectives for analytical data are that data of known and acceptable quality be provided. To provide a check of the quality of the laboratory analytical data, a number of blank, duplicate, and spiked samples will be submitted to the analytical laboratory as per standard protocol for the CLP. Blank samples will be analyzed to check for container contamination and the adequacy of the field decontamination procedures. Duplicate samples provide a check for sampling and analytical error. Spiked samples will be analyzed for recovery determination. The frequency of submittal is detailed in the following sections.

4.1 FIELD BLANKS

One sample per each twenty samples collected will be acquired as field blanks by filling a sample container with distilled, deionized water, exposed to the sampling environment to detect accidental or incidental contamination.

4.2 DECONTAMINATION (RINSATE) BLANKS

One rinsate blank sample will be prepared per every twenty sludge samples collected. Following decontamination, the sample will be prepared by rinsing the sampling apparatus with distilled water and collecting the rinsate to check for residual contamination on the sampling tools.

4.3 BLIND FIELD DUPLICATES

One sample per every twenty samples collected for chemical/radiological analysis will be split and both samples analyzed by the same laboratory to determine data reproducibility. These samples will be labelled with different sample numbers to disguise their relationship.

5.0 DATA DOCUMENTATION

5.1 SAMPLE TRANSFER/CHAIN-OF-CUSTODY RECORDS

All raffinate pit samples leaving the Weldon Spring Site shall be in Department of Transportation regulated and approved containers. All sludge samples shall be handled and shipped according to Standard Operating Procedure (SOP) ENP-11.

5.2 FIELD REPORTS

The construction engineer responsible for monitoring field activities will, as outlined in Standard Operating Procedure numbers ENP-12 and ENP-18 (see Attachment A), fill out a field activity report and make appropriate entries into the field daily diary. Appropriate entries include date, time, sample number, location sketch, physical description, analyses requested, recovery and any problems encountered in obtaining the sample. Logs of stratification breaks, color, texture, etc. will also be recorded for the undisturbed samples.

5.3 PHOTOGRAPHS

Following extrusion from the sampling tool, all sludge samples shall be photographed. A legible sample identification card will be in each frame to identify the sample in the picture.

6.0 REPORTING REQUIREMENTS

Appropriate data obtained from this sampling plan will be reported in the Remedial Investigation Report. Original data forms and reports will be placed in the site document control files.

7.0 REFERENCES

1. Bechtel National, Inc., 1984, Engineering Evaluation of Alternatives for the Disposition of the Weldon Spring Raffinate Pits Site, Appendix A, US DOE Oak Ridge Operations Office, Contract No. DE-AC05-81OR20722, Bechtel Job No. 14501, US DOE

   Characteristics of waste in the WSRP-1983 sampling and analysis by Eberline Instrument Corporation. Chemical and radiological data by pit. No description of sampling method. No validation information.

2. Bechtel National, Inc., 1986, Results of Additional Testing of the Raffinate Pits at WSS, FUSRAP Project DOE Contract No. DE-AC05-81OR20722, Bechtel Job No. 14501, US DOE

   Radiological testing and initial RCRA screening. 26 sample locations, top, middle, and bottom samples at each location. Sample method not described. No validation information.

3. Environmental Science and Engineering, Inc., et. al., Oct. 1983, Material Test Report, Sludge Sampling and Testing Services, Weldon Spring Storage Site, Missouri, Subcontract No. 14501-AA-SC-46.

   Physical characterization of raffinate pit sludge. Eight sample locations, top, middle, and bottom samples for each location. No validation information.

4. Holtz, Robert D., and Kovacs, William D., 1981. An Introduction to Geotechnical Engineering. Prentice-Hall, Inc., Englewood Cliffs, NJ

   Industry standard civil engineering reference text.

5. Mason, Benjamin J., Mar. 1983, Preparation of Soil Sampling Protocol: Techniques and Strategies. EPA-600/4-83-020 Environment Research Center, University of Nevada, Las Vegas, Cooperative Agreement No. CR 808529-01-2.

   Provided back-up documentation and rationale for implementing specific statistical considerations to the raffinate pit sampling strategy.

6. Meier, Jim, and Ferguson, Rick, Report of Telephone Conversation, Jan. 4, 1988, Telephone conversation between Jim Meier of PMC and Rick Ferguson of the Corps of Engineers concerning sludge sampling.

7. Michels, D. E., 1977, "Sample size effect on geometric average concentrations for log-normally distributed contaminants", Environmental Science and Technology, v. 11, no. 3, p. 300-302.

Indicates how increasing sample size leads to diminishing gains in accuracy with regard to characterization of a contaminated area in the environment.

8. Nyhan, J. W.; Schofield, T. G.; White, G. C.; and Trujillo, G.; 1981, Sampling soils for 137Cs using various field sampling volumes, Los Alamos National Laboratory, LA-8951-MS, 12 p.

Indicates how increasing sample size leads to diminishing gains in accuracy with regard to characterization of a contaminated area in the environment.

9. Project Management Contractor, MK-Ferguson Company, 1987, WSSRAP Water Quality Phase I Assessment Report, Section 5.3 Surface Water-WSRP, DOE/OR/21548-003

Chemical characterization of surface water ponded on raffinate pits. QA and QC information available.

10. U.S. Department of Energy, 1987, Draft Environmental Impact Statement Remedial Action at the Weldon Spring Site. DOE/EIS-0117D. Washington, D.C.. February 1987.

11. U.S. Environmental Protection Agency, July 1985, Contract Laboratory Program, Statement of Work, Inorganic Analysis, EPA SOW No. 785.

12. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Nov. 1986, Test Methods for Evaluating Solid Wastes Vol. II - Field Manual Physical/Chemical Methods. EPA Doc. No. SW-846 Third Edition.

Comprehensive explanation of sampling strategy design.

ATTACHMENT A

MK-FERGUSON COMPANY

Weldon Spring Site Remedial Action Project
Prime Contract No. DE-AC05-86OR21548

ENP-11	Rev. No. 0
Issue Date	
Page 1 of 1	

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

SET I.D. _____

APPROVAL SHEET FOR

PROCEDURES FOR HANDLING AND
SHIPPING OF GEOTECHNICAL SAMPLES

	Signature	Date
PROJECT MANAGER	D Hammond	2/8/88
ENGINEERING MANAGER	D K Lewis	2/8/88
CONSTRUCTION/OPERATION MANAGER	L J Stewart	2/8/88
E. S. & H. MANAGER	Boyd A Wilson	2/8/88
QUALITY ASSURANCE MANAGER	J. J. Hairston	2/8/88

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

1.0 OBJECTIVE

1.1 To provide instruction to the Field Technical Representative (FTR) for packaging, marking, and shipping soil and rock samples collected in the field.

2.0 APPLICABILITY

2.1 This procedure outlines the minimum requirements for handling and shipping soil and rock samples collected in the process of site characterization. Figures 1 through 3 show completed examples of the required forms.

- Soil Sample Inventory
- Soil Sample Inventory Summary
- Diffusion Coefficient/Radon Emanation Sample Inventory

Figures 4 through 7 show the proper labeling procedures for the appropriate samples collected.

2.2 Soil samples from field sampling programs consist of large and small bulk samples, Standard Penetration Test (SPT) samples, Shelby Tube samples and large diameter (2 or 3 inch) ring or tube samples.

2.3 In conjunction with this Engineering Procedure and when shipping any soil or rock sample thought to possess low levels of radioactivity, ES&H Procedure 2.03.10 "Packaging and Shipping Radioactive Materials" is applicable and must be strictly followed.

3.0 EQUIPMENT

- 5-gallon plastic buckets with lids
- Large plastic bags - 3 mil thick
- Small plastic bags - 2 mil thick
- Shelby tube shipping boxes
- Twist ties

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

4.0 PROCEDURE

4.1 Sample ID

A sample identification number will be assigned to each discrete sample to ensure that data collected retains uniqueness from other data collected when ambiguity is possible. The final number assignment for all samples will be made in accordance with the Environmental Numbering System, ES&H Procedure number 4.01.01, where practical.

4.2 Large Bulk Samples

Large bulk samples shall be placed into a 5-gallon bucket which has been lined with a large plastic bag. A twist tie shall be used to securely fasten the top of the plastic bag. The top of the plastic bag shall have a complete sticky-back sample tag placed on it. The lid shall be securely fastened onto the top of the bucket. Complete sticky-back sample tags shall be placed on the top and on the side of the plastic bucket and covered with clear tape.

4.3 Small Bulk and Standard Penetration (SPT) Samples

Small bulk and SPT samples shall be placed inside small sample bags and shall be double-bagged. A complete sticky-back sample tag shall be placed on the outside of the inner bag prior to insertion into second bag. A twist tie shall be used to securely fasten the top of each plastic bag.

If several small bulk samples or SPT samples are collected from one or more test pit or borehole locations, they should be placed into a 5-gallon bucket with Soil Sample Inventory forms placed inside the bucket showing what location ID and sample ID's are contained within this 5-gallon bucket. The outside of the bucket should then be labelled on the lid and side or on a blank sticky label, with an indelible pen. Requisite label information shall be the site name and sample ID of the samples contained therein. In any case, a complete sticky-back label should be placed on the side of the bucket and covered with clear tape.

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

4.4 Large Diameter Ring Samples

Ring samples shall have the top and bottom capped with a plastic cap. The drilling subcontractor shall provide the rings as well as plastic caps. Caps shall be sealed to the ring or tube with plastic tape.

Labeling ring samples shall consist of placing a completed stick-back sample label on the side of the ring. Once this has been done the ring shall be placed inside a single, small plastic bag and securely fastened with a twist tie.

If several ring samples are collected from one or more borehole locations, they shall be placed into a 5-gallon bucket with Soil Sample Inventory forms placed inside the bucket that shows what sample ID's are contained within this 5-gallon bucket. The outside of the bucket should then be labelled on the lid and side, with an indelible pen, as to the site name and ID's of the samples contained therein.

In no instance shall the ring samples be allowed to freeze during handling and shipping operations.

4.5 Shelby Tube Samples

Shelby tube samples, once recovered, shall have the top and bottom of the tube sealed with paraffin. If insufficient space remains at the bottom of the tube for sealing, trim away 3/4-inch of soil and seal the tube. Once the wax has hardened, a plastic cap shall be placed over both ends. Seal the caps to the Shelby tube with strapping tape. The drilling subcontractor shall provide the Shelby tubes, paraffin, plastic caps, and the means to melt the paraffin.

Labeling of Shelby tube samples shall include placing a completed stick-back sample label on the side and near the top of the Shelby tube, and one sticky-back sample label on the plastic cap covering the top of the tube. The Shelby tube shall then be placed inside an adequately constructed shipping crate in preparation for shipment.

In no instance shall Shelby tube samples be allowed to freeze or be placed in any position different from the orientation in the bore hole. Vibration and movement of Shelby tubes should be minimized.

4.6 Post-collection/Pre-shipping Instruction

Prior to shipping soil samples, and preferably as they are collected, the Soil Sample Inventory Summary form shall be complete with the appropriate sample ID, sample type (large or small disturbed bulk sample, SPT, ring, Shelby tube or drill cuttings), material type (Unified Soil Classification, ASTM D2487 and D2488), depth sample taken from, if sample was taken from a borehole or test pit, where the sample was shipped and any comments. It is the Field Technical Representative's responsibility to retain a copy of the Soil Sample Inventory Summary form.

Additionally, the Diffusion Coefficient/Radon Emanation Sample Inventory Log must also be complete and returned to the Radiation Protection Manager or his designee within approximately 5 days.

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

FIGURE 1

SOIL SAMPLE INVENTORY

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

SOIL SAMPLE INVENTORY

DATE: 01-31-88 FIELD REP.: John Smith

SAMPLE I.D.	DEPTH INT.	SAMPLE I.D.	DEPTH INT.
SD 3001	0-2'		
SD 3001	2'-4'		
SD 3001	4'-6'		
SD 3001	6'-8'		
SD 3001	8'-10'		
SD 3001	10'-10.5'		
9SD 3999	0-5'		
SD 3999	5'-10'		
SC-107351-58320	2.0'-2.5'		
SD-3508	0-2'		

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

FIGURE 2

SOIL SAMPLE INVENTORY SUMMARY

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

SOIL SAMPLE INVENTORY SUMMARY

SITE WSSRAP DATE: 4-10-87

FIELD REP.: John Smith

	SAMPLE ID	SAMPLE TYPE	MATERIAL TYPE	SAMPLE DEPTH	BOREHOLE/ TEST PIT	SHIPPED TO	COMMENTS
	SD-3001	LD	Sludge	0-2'	TP	ORNL	1-Sgal, TypeA
	SD-3001	LD	Sludge	2'-4'	TP	ORNL	1-Sgal, TypeA
	SD-3001	LD	Sludge	4'-6'	TP	ORNL	1-Sgal, TypeA
	SD-3001	LD	Sludge	6'-8'	TP	ORNL	1-Sgal, TypeA
	SD-3001	LD	Sludge	8'-10'	TP	ORNL	1-Sgal, TypeA
	SD-3001	LD	Sludge	10'-11.5'	TP	ORNL	1-Sgal, TypeA
	SD-3999	T	ML	0-2'	BH	Chen	& Associates
	SD-3999	T	ML	2-4	BH	Chen	& Associates
	SD-3999	T	ML	4-6	BH	Chen	& Associates

SAMPLE TYPE: LD-LARGE DISTURBED, SD-SMALL DISTURBED, SPT-STANDARD PENETRATION TEST, R-RING, T-SHELBY TUBE, C-DRILL CUTTINGS

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

FIGURE 3

DIFFUSION COEFFICIENT/RADON EMANATION SAMPLE INVENTORY LOG

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

DIFFUSION COEFFICIENT/RADON EMANATION SAMPLE INVENTORY LOG

SITE WSSRAP DATE SHIPPED: 4-10-87

FIELD REP: John Smith SHIPPED VIA: Trailways Bus Page 1 of 1

Sample (DIFFUSION COEFFICIENTS)

Sample ID.	DEPTH	MATERIAL TYPE	BORROW	COMMENTS:
1. SO-3001	2'-4'	Silty Clay	X	1-5gal
2. SO-3025	6'-8'	Sand-contaminated		1-5gal
3. SO-3840	5'-9'	Clay-contaminated		1-5gal
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

SAMPLE (RADON EMANATION)

Sample ID.	DEPTH	MATERIAL TYPE
1. SD-3099	2'-4'	Sludge
2. SD-3699	N/A	Stab. Sludge
3. SO-3047	10'-12'	contaminated clay
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		

SHIP SAMPLES TO:
Rogers & Associates Engineering
515 E-4500 S. Suite C-100
Salt Lake City, Utah 84107
(801) 263-1600

ADDITIONAL COMMENTS:

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

FIGURE 4

LABELING LARGE BULK SAMPLES

ATTACH TO TOP OF PLASTIC LINER INSIDE 5 GALLON SHIPPING CONTAINER.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: SD-3999
Depth Interval:
Beginning Depth: 0 Ending Depth: 2 ft.
Comments: Sludge Sample
Collected By: J. Smith
Date: Jan. 18, 1988

ATTACH TO TOP OF LID ATOP 5 GALLON SHIPPING CONTAINER.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: SD-3999
Depth Interval:
Beginning Depth: 0 Ending Depth: 2 ft
Comments: Sludge Sample
Collected By: D. Smith
Date: JAN. 18, 1988

ATTACH TO SIDE OF 5 GALLON SHIPPING CONTAINER NEAR THE TOP.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: SD-3999
Depth Interval:
Beginning Depth: 0 Ending Depth: 2 ft.
Comments: Sludge Sample
Collected By: D. Smith
Date: JAN. 18, 1988

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

FIGURE 5

LABELING SMALL BULK SAMPLES AND STANDARD PENETRATION TEST (SPT) SAMPLES

SAMPLE IS DOUBLE BAGGED. ATTACH ON THE OUTSIDE OF THE INNER BAG.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: SO-3001
Depth Interval:
Beginning Depth: 2.0' Ending Depth: 4.0'
Comments: Soil Sample
Collected By: J. Smith
Date: JAN. 31, 1988

IN SHIPPING NUMEROUS SPT OR SMALL BULK SAMPLES FROM THE SAME BOREHOLE OR TEST PIT, PLACE THEM IN A 5 GALLON SHIPPING CONTAINER AND LABEL AS SHOWN BELOW.

ATTACH TO TOP OF LID ATOP 5 GALLON SHIPPING CONTAINER.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: SO-3001
Depth Interval:
Beginning Depth: N/A Ending Depth: N/A
Comments: SPT Sample
Collected By: J. Smith
Date: JAN. 31, 1988

ATTACH TO SIDE OF 5 GALLON SHIPPING CONTAINER NEAR THE TOP.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: SO-3001
Depth Interval:
Beginning Depth: N/A Ending Depth: N/A
Comments: Small Bag Samples
SO-3001, 3005, 3007
Collected By: John Smith
Date: JAN. 31, 1988

IF SAMPLES ARE FROM NUMEROUS TEST PITS OR BOREHOLES, LIST SEPARATE LOCATION IDS IN COMMENTS COLUMN.

PLACE INSIDE SHIPPING CONTAINER A SOIL SAMPLE INVENTORY (BOREHOLE INFORMATION) OR SOIL SAMPLE INVENTORY SUMMARY (TEST PIT AND/OR BOREHOLE INFORMATION) FORMS LISTING ALL SAMPLES CONTAINED WITHIN.

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

FIGURE 6

LABELING LARGE DIAMETER RING SAMPLES

ATTACH ON THE SIDE OF THE BRASS RING.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: SO:3508
Depth Interval:
Beginning Depth: 0.0 Ending Depth: 2.0
Comments: Ring Sample
Collected By: D. Smith
Date: Jan. 25, 1988

PLACE SEVERAL RING SAMPLES IN 5 GALLON SHIPPING CONTAINER AND LABEL OUTSIDE OF CONTAINER AS DIRECTED IN FIGURE 5 "LABELING SMALL BULK SAMPLES AND STANDARD PENETRAION TEST (SPT) SAMPLES".

PLACE INSIDE SHIPPING CONTAINER A SOIL SAMPLE INVENTORY SUMMARY FORM LISTING ALL SAMPLES CONTAINED WITHIN.

FIGURE 7

LABELING SHELBY TUBE SAMPLES

ATTACH ON THE OUTSIDE OF THE SHELBY TUBE, NEAR THE TOP.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: 50-10735/-58320
Depth Interval:
Beginning Depth: 2.0 Ending Depth: 2.5
Comments: Shelby Tube
Collected By: J. Smith
Date: Jan. 9, 1988

ATTACH ON THE TOP OF THE PLASTIC CAP WHICH COVERS THE TOP OF THE SHELBY TUBE.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: 50-10735/-58320
Depth Interval:
Beginning Depth: 2.0 Ending Depth: 2.5
Comments: Shelby Tube
Collected By: J. Smith
Date: Jan. 9, 1988

PLACE INSIDE SHIPPING CRATE A SOIL SAMPLE INVENTORY SUMMARY FORM LISTING ALL SAMPLES CONTAINED WITHIN.

MK-FERGUSON COMPANY

Weldon Spring Site Remedial Action Project

Prime Contract No. DE-AC05-86OR21548

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PROCEDURE TITLE: COMPLETING THE DAILY FIELD ACTIVITY REPORT

SET I.B. _____

APPROVAL SHEET FOR

COMPLETING THE DAILY FIELD

ACTIVITY REPORT

	Signature	Date
PROJECT MANAGER	J. Hammond	2/5/88
ENGINEERING MANAGER	D R Lewis	2/8/88
CONSTRUCTION/OPERATIONS MGR.	C. J. Stewart	2/5/88
E. S. & H. MANAGER	Roger A Miles	2/8/88
QUALITY ASSURANCE MANAGER	J. J. Hairston	2/8/88

PROCEDURE TITLE: COMPLETING THE DAILY FIELD ACTIVITY REPORT

1.0 OBJECTIVE

1.1 This Standard Operating Procedure describes the procedures to be followed in completing the Daily Field Activity Report (DFAR). The need for completing a DFAR for a subcontract shall be determined by the Technical Representative (TR) and shall be requested either in the technical specifications or as instructions to the Field Technical Representative (FTR). The DFAR permits tracking of all billable items and serves as a basis of payment at the completion of the subcontract. Proper completion is vital to the successful execution of the contract. Adherence to the provisions of this procedure will ensure proper completion of the DFAR.

1.2 Figure 1 shows an example of a completed DFAR. Variations in the specification line items prevents using common line items on the form. A blank form is shown as Figure 2. As an alternative a specific DFAR may be developed for specific subcontracts. This DFAR form should be included in the Technical Specifications for the subcontract. Alternative DFAR forms should have line items with identifiable units and quantities and spaces for signatures or initials of Contractor's and Subcontractor's representatives.

1.3 Each DFAR shall be prepared with the item number description. The item and unit of payment shall be recorded as it appears in the Subcontract Pricing Schedule. A sample DFAR should be inserted in the Request For Proposal so that the bidder is fully aware of its existence. The items listed on the DFAR should be prepared by the FTR in cooperation with the Subcontract Administrator (SA). The FTR shall daily record the total material and/or labor quantities on the appropriate line. Then the FTR and the Subcontractor's Representative shall initial the indicated space for the day's activities.

PROCEDURE TITLE: COMPLETING THE DAILY FIELD ACTIVITY REPORT

2.0 PROCEDURE

2.1 Preparation of the Daily Field Activity Report.

2.1.1 In the blanks provided, enter the site name, Subcontract number, the full name of the FTR, and the week. The week should be shown as Monday's date to Sunday's date. Write in each date to correspond to the day of the week.

2.1.2 Enter the appropriate billable work items for which records must be kept. Lump sum items such as Mob/Demob are not necessary. If additional space is needed, use a second sheet clearly labeling these as sheets 1 of 2 and 2 of 2. A breakdown of items not in the pricing schedule should go into the FTR's Diary, not on the DFAR.

2.2 Daily entries for labor and/or material quantities.

2.2.1 Enter the totals of work done for each day in each category. The FTR shall total the items and ensure that units of measurement are in agreement with the pricing schedule. Some costs can be in "hours" or by "volume" or by "each". For example, casing installation may be in units of hours or by lineal feet. Tensiometer installations are by "each". The same type of work, under different conditions may be priced differently and thus require separate entries. For example, drilling an 8-inch borehole may or may not be at the same cost per foot, or per hour, as a 6-inch borehole. Be aware that certain single labor entries could be a group of tasks rather than a single task; for example, well installation and development includes labor for casing installation, gravel pack, bentonite seal, grouting, and well development.

2.2.2 Enter the unit quantity for materials used each day. Verify that units agree with the pricing schedule. Refer to the item number to ensure that materials are not lumped in with labor costs for these tasks.

2.2.3 Discuss the entries with the Subcontractor's representative and have that person initial the column for each day's entry. No other entries shall be made after the column is initialed. Show a dash in each unused item. Details are given on the example, Figure 1. The FTR shall indicate on the DFAR if the Subcontractor's representative refuses to initial the day's entry.

2.2.4 Changes made on the DFAR entries shall be initialed by both the FTR and the Subcontractor.

2.3 After completing each sheet, the FTR should total all items. This total provides the FTR with a weekly progress summary that can be reported to the SA.

2.4 The DFAR is the basis of payment for each subcontract line item. The Subcontractor shall receive a copy of this document to prepare the billing. This will reinforce the instructions of the Subcontract on structuring the invoice so that it is consistent with the subcontract, i.e., on a daily basis for each line item and not on a hole by hole basis.

PROCEDURE TITLE: COMPLETING THE DAILY FIELD ACTIVITY REPORT

FIGURE 1

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

DAILY FIELD ACTIVITY REPORT

SITE NAME WSSRAP CONTRACT NO. 3589-SC-WP999 WEEK OF: 1/1/88 to 1/10/88

FTR: John Smith SUBCONTRACTOR: ABC Drilling

BILLABLE WORK	ITEM NO.	DATE UNITS	1-4 MON	1-5 TUES	1-6 WED	1-7 THUR	1-8 FRI	1-9 SAT	1-10 SUN	WEEKLY SUMMARY
Rock Coring	2.1	Lf	0	120	0	0	0	0		120
Drilling	2.3	Lf	0	0	0	9.5	20 Diverted	150		265
Stand by	3.1	Hr	0	0	1.5	1.5	0 Diverted	1.5		4.5
Devel. & Instal. (Well)	3.2	Hr	0	0	3	2	5	0		10
PVC Screen	4.2	Lf	0	0	20	0	10	0		30
Daily Per Diem	6.0	per day	1	1	1	1	1	1		6
									No Work	
FTR INITIALS:			DS	DS	DS	DS	DS	DS	DS	
SUBCONTRACTOR INITIALS:			ABC	ABC	ABC	ABC	ABC	ABC	ABC	

PROCEDURE TITLE: COMPLETING THE DAILY FIELD ACTIVITY REPORT

FIGURE 2

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

DAILY FIELD ACTIVITY REPORT

SITE NAME _____ CONTRACT NO. _____ WEEK OF: _____

FTR: _____ SUBCONTRACTOR: _____

BILLABLE WORK	ITEM NO.	DATE / UNITS	MON	TUES	WED	THUR	FRI	SAT	SUN	WEEKLY SUMMARY
FTR INITIALS:										
SUBCONTRACTOR INITIALS:										

MK-FERGUSON COMPANY

Weldon Spring Site Remedial Action Project
Prime Contract No. DE-AC05-86OR21548

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PROCEDURE TITLE: FIELD DAILY DIARY

APPROVAL SHEET FOR

FIELD DAILY DIARY

	Signature	Date
PROJECT MANAGER		2/8/88
ENGINEERING MANAGER		2/8/88
CONSTRUCTION/OPERATIONS MGR.		2/8/88
E. S. & H. MANAGER		2/8/88
QUALITY ASSURANCE MANAGER		2/8/88

PROCEDURE TITLE: FIELD DAILY DIARY

1.0 OBJECTIVE

1.1 This procedure provides guidelines for the minimum entries made by the Field Technical Representative (FTR) in the Bound Daily Diary while at a work site.

1.2 This procedure assigns responsibility and accountability to the FTR to maintain a bound daily diary. The diary shall contain the minimum entries described below and any other entries that the FTR's professional judgement dictates to completely document the conditions and events that affect the assignment.

1.3 This diary is assumed to be the only record of activity which can protect the Project Management Contractor (PMC) in case of litigation or dispute by the Subcontractor. Incidents and conditions are readily forgotten and those personnel who could provide any facts about the activities may have left the project.

2.0 PROCEDURE

2.1 At the start-up of each field assignment, the FTR should record (as a minimum) the following information in the diary:

- The diary shall be a permanently bound waterproof notebook. All entries should be made in waterproof ink or a pencil of at least 3-H hardness.
- A description of all significant equipment on the work site;
- The names and position of each crew member;
- A full inventory of all materials brought to the work site and a comparison with contractual quantities required;
- Any reference literature or special equipment provided by the PMC.

2.2 The FTR shall record the following information on a daily basis:

- Copies of "Daily Field Activity Report" or FTR diary provided to the Subcontractor.
- Active and inactive crews and equipment;
- Start and stop times of activities including arrivals and departures of individuals from the job site;
- Weather or surface conditions which may effect the activities (wind, rain, mud, heavy brush, etc);
- All conversations with and instructions given to the Subcontractor;
- All agreements or disagreements recorded on "Daily Field Activity Reports" affecting pay items or procedures;
- The names and purpose of any visitor entering the work area;
- A periodic summary of work accomplished (number of holes, footage, casing used, samples collected, etc.);
- Any additional material ordered or purchased for the project;
- Any information about conditions or procedures which appear to be unsafe and corrective actions taken.

2.3 At completion of the project, the following data shall be recorded:

- A complete inventory of all unused materials remaining plus any waste to be disposed of;
- Any work left undone (e.g., site restoration);
- A description of cleanup procedures;

- The final cumulative totals of materials used and work accomplished.

ATTACHMENT B

ATTACHMENT B

(REF: US EPA CONTRACT LABORATORY PROGRAM STATEMENT OF WORK, 1984)

EXHIBIT C

Hazardous Substance List (HSL) and
Contract Required Detection Limits (CRDL)**

Volatiles	CAS Number	Detection Limits* Low Water[a] ug/L	Low Soil/Sediment[b] ug/Kg
1. Chloromethane	74-87-3	10	10
2. Bromomethane	74-83-9	10	10
3. Vinyl Chloride	75-01-4	10	10
4. Chloroethane	75-00-3	10	10
5. Methylene Chloride	75-09-2	5	5
6. Acetone	67-64-1	10	10
7. Carbon Disulfide	75-15-0	5	5
8. 1,1-Dichloroethene	75-35-4	5	5
9. 1,1-Dichloroethane	75-35-3	5	5
10. trans-1,2-Dichloroethene	156-60-5	5	5
11. Chloroform	67-66-3	5	5
12. 1,2-Dichloroethane	107-06-2	5	5
13. 2-Butanone	78-93-3	10	10
14. 1,1,1-Trichloroethane	71-55-6	5	5
15. Carbon Tetrachloride	56-23-5	5	5
16. Vinyl Acetate	108-05-4	10	10
17. Bromodichloromethane	75-27-4	5	5
18. 1,1,2,2-Tetrachloroethane	79-34-5	5	5
19. 1,2-Dichloropropane	78-87-5	5	5
20. trans-1,3-Dichloropropene	10061-02-6	5	5
21. Trichloroethene	79-01-6	5	5
22. Dibromochloromethane	124-48-1	5	5
23. 1,1,2-Trichloroethane	79-00-5	5	5
24. Benzene	71-43-2	5	5
25. cis-1,3-Dichloropropene	10061-01-5	5	5

(continued)

Volatiles	CAS Number	Detection Limits* Low Water[a] ug/L	Low Soil/Sediment[b] ug/Kg
26. 2-Chloroethyl Vinyl Ether	110-75-8	10	10
27. Bromoform	75-25-2	5	5
28. 2-Hexanone	591-78-6	10	10
29. 4-Methyl-2-pentanone	108-10-1	10	10
30. Tetrachloroethene	127-18-4	5	5
31. Toluene	108-88-3	5	5
32. Chlorobenzene	108-90-7	5	5
33. Ethyl Benzene	100-41-4	5	5
34. Styrene	100-42-5	5	5
35. Total Xylenes		5	5

[a]Medium Water Contract Required Detection Limits (CRDL) for Volatile HSL Compounds are 100 times the individual Low Water CRDL.

[b]Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Volatile HSL Compounds are 100 times the individual Low Soil/Sediment CRDL.

Semi-Volatiles	CAS Number	Detection Limits* Low Water[c] ug/L	Low Soil/Sediment[d] ug/Kg
36. Phenol	108-95-2	10	330
37. bis(2-Chloroethyl) ether	111-44-4	10	330
38. 2-Chlorophenol	95-57-8	10	330
39. 1,3-Dichlorobenzene	541-73-1	10	330
40. 1,4-Dichlorobenzene	106-46-7	10	330
41. Benzyl Alcohol	100-51-6	10	330
42. 1,2-Dichlorobenzene	95-50-1	10	330
43. 2-Methylphenol	95-48-7	10	330
44. bis(2-Chloroisopropyl) ether	39638-32-9	10	330
45. 4-Methylphenol	106-44-5	10	330
46. N-Nitroso-Dipropylamine	621-64-7	10	330
47. Hexachloroethane	67-72-1	10	330
48. Nitrobenzene	98-95-3	10	330
49. Isophorone	78-59-1	10	330
50. 2-Nitrophenol	88-75-5	10	330
51. 2,4-Dimethylphenol	105-67-9	10	330
52. Benzoic Acid	65-85-0	50	1600
53. bis(2-Chloroethoxy) methane	111-91-1	10	330
54 2,4-Dichlorophenol	120-83-2	10	330
55. 1,2,4-Trichlorobenzene	120-82-1	10	330
56. Naphthalene	91-20-3	10	330
57. 4-Chloroaniline	106-47-8	10	330
58. Hexachlorobutadiene	87-68-3	10	330
59. 4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
60. 2-Methylnaphthalene	91-57-6	10	330
61. Hexachlorocyclopentadiene	77-47-4	10	330
62. 2,4,6-Trichlorophenol	88-06-2	10	330
63. 2,4,5-Trichlorophenol	95-95-4	50	1600

(continued)

Semi-Volatiles	CAS Number	Detection Limits* Low Water[c] ug/L	Low Soil/Sediment[d] ug/Kg
64. 2-Chloronaphthalene	91-58-7	10	330
65. 2-Nitroaniline	88-74-4	50	1600
66. Dimethyl Phthalate	131-11-3	10	330
67. Acenaphthylene	208-96-8	10	330
68. 3-Nitroaniline	99-09-2	50	1600
69. Acenaphthene	83-32-9	10	330
70. 2,4-Dinitrophenol	51-28-5	50	1600
71. 4-Nitrophenol	100-02-7	50	1600
72. Dibenzofuran	132-64-9	10	330
73. 2,4-Dinitrotoluene	121-14-2	10	330
74. 2,6-Dinitrotoluene	606-20-2	10	330
75. Diethylphthalate	84-66-2	10	330
76. 4-Chlorophenyl Phenyl ether	7005-72-3	10	330
77. Fluorene	86-73-7	10	330
78. 4-Nitroaniline	100-01-6	50	1600
79. 4,6-Dinitro-2-methylphenol	534-52-1	50	1600
80. N-nitrosodiphenylamine	86-30-6	10	330
81. 4-Bromophenyl Phenyl ether	101-55-3	10	330
82. Hexachlorobenzene	118-74-1	10	330
83. Pentachlorophenol	87-86-5	50	1600
84. Phenanthrene	85-01-8	10	330
85. Anthracene	120-12-7	10	330
86. Di-n-butylphthalate	84-74-2	10	330
87. Fluoranthene	206-44-0	10	330
88. Pyrene	129-00-0	10	330
89. Butyl Benzyl Phthalate	85-68-7	10	330
90. 3,3'-Dichlorobenzidine	91-94-1	20	660
91. Benzo(a)anthracene	56-55-3	10	330
92. bis(2-ethylhexyl)phthalate	117-81-7	10	330
93. Chrysene	218-01-9	10	330
94. Di-n-octyl Phthalate	117-84-0	10	330
95. Benzo(b)fluoranthene	205-99-2	10	330
96. Benzo(k)fluoranthene	207-08-9	10	330
97. Benzo(a)pyrene	50-32-8	10	330

(continued)

Semi-Volatiles	CAS Number	Detection Limits* Low Water[c] ug/L	Low Soil/Sediment[d] ug/Kg
98. Indeno(1,2,3-cd)pyrene	193-39-5	10	330
99. Dibenz(a,h)anthracene	53-70-3	10	330
100. Benzo(g,h,i)perylene	191-24-2	10	330

[c]Medium Water Contract Required Detection Limits (CRDL) for Semi-Volatile HSL Compounds are 100 times the individual Low Water CRDL.

[d]Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Semi-Volatile HSL Compounds are 60 times the individual Low Soil/Sediment CRDL.

Pesticides	CAS Number	Detection Limits* Low Water[e] ug/L	Low Soil/Sediment[f] ug/Kg
101. alpha-BHC	319-84-6	0.05	8.0
102. beta-BHC	319-85-7	0.05	8.0
103. delta-BHC	319-86-8	0.05	8.0
104. gamma-BHC (Lindane)	58-89-9	0.05	8.0
105. Heptachlor	76-44-8	0.05	8.0
106. Aldrin	309-00-2	0.05	8.0
107. Heptachlor Epoxide	1024-57-3	0.05	8.0
108. Endosulfan I	959-98-8	0.05	8.0
109. Dieldrin	60-57-1	0.10	16.0
110. 4,4'-DDE	72-55-9	0.10	16.0
111. Endrin	72-20-8	0.10	16.0
112. Endosulfan II	33213-65-9	0.10	16.0
113. 4,4'-DDD	72-54-8	0.10	16.0
114. Endosulfan Sulfate	1031-07-8	0.10	16.0
115. 4,4'-DDT	50-29-3	0.10	16.0
116. Endrin Ketone	53494-70-5	0.10	16.0
117. Methoxychlor	72-43-5	0.5	80.0
118. Chlordane	57-74-9	0.5	80.0
119. Toxaphene	8001-35-2	1.0	160.0
120. AROCLOR-1016	12674-11-2	0.5	80.0
121. AROCLOR-1221	11104-28-2	0.5	80.0
122. AROCLOR-1232	11141-16-5	0.5	80.0
123. AROCLOR-1242	53469-21-9	0.5	80.0
124. AROCLOR-1248	12672-29-6	0.5	80.0
125. AROCLOR-1254	11097-69-1	1.0	160.0
126. AROCLOR-1260	11096-82-5	1.0	160.0

[e]Medium Water Contract Required Detection Limits (CRDL) for Pesticide HSL Compounds are 100 times the individual Low Water CRDL.

[f]Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Pesticide HSL compounds are 15 times the individual Low Soil/Sediment CRDL.

*Detection limits listed for soil/sediment are based on wet weight. The detection limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, as required by the contract, will be higher.

** Specific detection limits are highly matrix dependent. The detection limits listed herein are provided for guidance and may not always be achievable.

Table 1. Elements Determined by Inductively Coupled Plasma Emission or Atomic Absorption Spectroscopy

Element	Contract Required Detection Level[1,2] (ug/L)
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20

Table 2. Cyanide Determination

Element	Contract Required Detection Level[1], [2] (ug/L)
Cyanide	10

1: Any analytical method specified in SOW Exhibit D may be utilized as long as the documented instrument or method detection limits meet the Contract Required Detection Level (CRDL) requirements. Higher detection levels may only be used in the following circumstance:

If the sample concentration exceeds two times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not equal the contract required detection level. This is illustrated in the example below:

For lead:
Method in use = ICP
Instrument Detection Limit (IDL) = 40
Sample concentration = 85
Contract Required Detection Level (CRDL) = 5

The value of 85 may be reported even though instrument detection limit is greater than required detection level. The instrument or method detection limit must be documented as described in Exhibit E.

2: These CRDL are the instrument detection limits obtained in pure water that must be met using the procedure in Exhibit E. The detection limits for samples may be considerably higher depending on the sample matrix.

ATTACHMENT C

SET I.D. _____

Weldon Spring Site Remedial Action Project (WSSRAP)
ENVIRONMENTAL SAFETY AND HEALTH PROCEDURE MANUAL SOP No.: 2.03.10
Rev.: 1
2.03.10 PACKAGING & SHIPPING PROCEDURES FOR RADIOACTIVE MATERILAS Date: 05-13-88
Page: 1 of 9

APPROVED: ES&H MGR. _____ QUALITY MGR. _____

OBJECTIVE:

To provide guidance for packaging, marking, labeling, and shipping radioactive materials so as to ensure compliance with U.S. Department of Transportation (DOT) regulations.

APPLICABILITY:

During the course of remedial action at the WSS, radioactive materials will be shipped off-site for laboratory analysis. This procedure applies to the shipment off-site of any material of which the combined activity of all radionuclides in the material exceeds 2000 picocuries per gram (pCi/g). Failure to comply with this procedure could result in liabilities and fines levied against the shipper.

REFERENCE:

Code of Federal Regulations, Title 49, Parts 100-178 (Revision June, 1986)

EQUIPMENT AND MATERIALS:

1. Type A sample container(s) (5-gallon steel bucket, lid, and gasket, enclosure ring, locking nut and bolt).

2. Plastic liners with closures.

3. "Radioactive material" markings and labels:

   - Appropriate Radioactive White-1 or Radioactive Yellow-11 label as determined by this procedure.

   - Stencil(s) of "USA DOT 7-A Type A Radioactive Material LSA n.o.s. UN2912"; for liquid samples "This end up".

- o Calibrated G-M Probe (located with ES&H radiological equipment)
- o Exposure rate meter

PROCEDURE:

A. Method for estimating the total activity of all radionuclides in a 5-gallon steel container.

1. This section of the procedure describes a quick and conservative means of determining whether the material of concern must be classified as radioactive material. If the material is suspected to contain Th-230 then part A.1, A.2. and B.1 of this procedure does not apply.

   a. After the material has been placed in the container and before the lid has been fastened on, place the G-M Probe very near the surface of the material and obtain a one-minute count. (Note: Here, "container" refers to the primary vessel holding the material.)

   b. Fill out Part 1 of Form 2.03.10.01

   c. If the count rate of the G-M probe reads less than 700 counts per minute the material is assumed to contain less than 2000 pCi/g total activity. (The basis of this assumption is a calculation on file with the Radiation Protection Manager (RPM).) Continue with Part B of this procedure. | 1

2. If the activity of the material is known from previous characterization studies or sample analysis this information may be used instead of method A.1 above with the RPM's approval. (49 CFR 172.402) | 1

   a. Fill out Part 1 of Form 2.03.10.01, "Comments" section only, explaining where this data may be found.

B. Materials (excluding instruments, equipment, and articles) shipped off-site will conform to one of the two following classifications (see also Section A of this procedure):

1. Should the total activity of all radionuclides be less than 2000 picocuries per gram (pCi/g)(based on either A.1 or A.2 above), the material is then classified as non-radioactive and is therefore exempt from any shipping requirements concerning radioactivity. (49 CFR 173.403) | 1

NOTE: Frequently WSSRAP samples will contain more than one radionuclide. The 2000 pCi/g limit applies to the sum of the activities of all of the radionuclides present in the material being shipped.

Radioactive materials or materials that could potentially contain radioactivity cannot be shipped off-site without signed approval (Form 2.03.10.01) from the RPM or his designee. | 1

2. Should the total activity of all radionuclides be greater than 2000 pCi/g (based on A.1 or A.2 above), the material may be shipped either as limited quantity or as low specific activity (LSA). Materials from the WSS determined to be radioactive material will be shipped as "Radioactive material LSA n.o.s." for reasons of conservatism and ease of repetitive application of this shipping procedure. | 1

a. Place a plastic liner in a Type A container (5-gallon steel bucket) and fill the container with material as appropriate.

b. Pull the ends of the liner together and seal it closed.

c. Place lid and gasket on container. Install the lock-ring around the edge of the lid. Secure the lock-ring with a bolt and nut such that the accidental removal of the lid and content spillage is prevented. (Approximately 40 foot pounds).

d. Wipe any loose material from the outside of the container. Ensure that any removable contamination is less than 22 dpm/cm^2 (see WSSRAP Procedure No. 2.03.08). Include Form 2.03.03.01 with Form 2.03.10.01. Fill out only the smear survey section of Form 2.03.03.01. (49 CFR 173.443)

e. Measure the gamma levels at four locations on the surface of the 5-gallon steel bucket. Record these values on Form 2.03.10.01.

f. Determine the maximum radiation level in millirem per hour at one meter (3.3 feet) from the external surface of the container. Round up to the first decimal place. This is the transportation index to be applied to this container. Record this value on Form 2.03.10.01. (49 CFR 173.403)

g. Items e) and f) above and Table 1 will be used to determine the appropriate category of label to be applied to the container. The label to be applied shall be the highest category required for any of the two determining conditions for the package. (49 CFR 172.403)

Table 1: Category of label to be applied to radioactive materials containers.

TRANSPORT INDEX (TI)	RADIATION LEVEL AT PACKAGE SURFACE (RL)	LABEL CATEGORY
N/A	RL $\leq$0.5 mrem/hr	White-1
TI <1.0	0.5mrem/hr <RL <50 mrem/hr	Yellow-11
1.0 <TI	50 mrem/hr <R	Yellow-111

The following applicable items of information must be entered in the blank spaces on the "radioactive" label by legible printing using a durable weather resistant means of marking:

i. "Contents". The name of the radionuclides. For mixtures of radionuclides, the most restrictive radionuclides on the basis of radiotoxicity must be listed as space on the label allows.

ii. "Activity". Units shall be expressed in appropriate curie units.

iii. "Transportation index" as applicable.

A label must be placed on two opposite sides of the container.

h. The outside of each container must be marked as follows (in letters of at least one-half inch): (49 CFR 172.301, 172.310, 178.350)

USA DOT - 7A Type A
Radioactive material, LSA, n.o.s. UN2912

Liquid samples must be labeled "This end up".

The ES&H RPM has a stencil for this purpose.

Any internal packages or containers must be packed with closures upwards. (49 CFR 172.312)

i. Attach a label listing the shipper's name, address, and telephone number to each container. (49 CFR 172.306)

1

j. Another shipping consideration for material shipped as "Radioactive material LSA n.o.s." is the average concentration of the contents. Table 2 lists the average concentration limits for the radionuclides of concern at the WSS.

Table 2 Average concentration limits for Type A containers shipping material as radioactive LSA.

NUCLIDE	CONCENTRATION LIMIT (uCi/g)
U-238	unlimited
U-nat	unlimited
Th-nat	unlimited
Th-232	unlimited
Th-230	0.1
Ra-224	5
Ra-226	0.1
Ra-228	0.1
Pb-210	5
Ac-228	0.1

This will ensure that the material meets the definition of low-specific activity and meets the requirements of activity limits for Type A packages. (49 CFR 173.403, 173.431)

Record the average concentration of each radionuclide in the comments section of Part 2 of Form 2.03.10.01 or on an attached sheet (note attached page in comments section). This implies that the sample must be radiologically characterized by the WSSRAP radiological laboratory or WSSRAP RPM before shipment. (See Section A.2) | 1

3. The RPM or his designee will authorize a container to be shipped only after a completed Part 1 of Form 2.03.10.01 has been filled out by the originator. If the RPM or designee determines that the container can be shipped as non-radioactive material, no further effort is required by the originator and the container may be shipped. | 1

   If the RPM or designee determines that the container must be shipped as radioactive material then the originator must complete Part 2 of Form 2.03.10.01 and comply with Section B.2 of this procedure. Additionally, the originator must complete the carrier's shipping papers as follows: | 1

   a. All description(s) must be printed in English and shall not contain any code or abbreviation except to specify the type of package and weight or volume. (49 CFR 172.201)

   b. The container(s) must be described on the shipping papers exactly as follows (descriptions in parentheses require determination by shipper) (49 CFR 172.203):

      "Radioactive Material, LSA, n.o.s. UN2912, (weight or volume) (limiting radionuclide(s) present), (form e.g. soil, liquid, gas, solid...) (total activity), (label category) (Transportation index)".

   c. Included on the shipping paper must be the shippers' certification worded exactly as follows in either (i) or (ii) (49 CFR 172.204):

      i. "This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation".

NOTE: The words "herein-named" may be substituted for the words "above-named".

ii. "I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respect in proper condition for transport by (*) according to applicable international and national governmental regulations."

d. No radioactive material from the WSS shall be transported by passenger aircraft. (49 CFR 172.204)

e. When a hazardous material and a material not subject to the requirements of 49 CFR Parts 170-178 are described on the same shipping paper the hazardous material shipping entries: 1

i Must be entered first, or
ii Must be entered or highlighted in a color that clearly contrasts with any description on the shipping paper of a non-hazardous material,
iii Must be identified by the entry of an "X" placed before the proper shipping name in a column captioned "HM".

4. Complete WSSRAP Chain of Custody requirements per ES&H SOP 4.01.02

* Additional language indicating the modes of transportation to be used may be inserted at this point. All modes of transportation may be indicated provided that any mode not applicable to a specific shipment is deleted.

FORM 2.03.10.01

PACKAGING & SHIPPING RADIOACTIVE MATERIALS

PACKAGING & SHIPPING RADIOACTIVE MATERIALS

FORM 2.03.10.01

SHIPPING DATE: 09-02-87 ORIGIN: WSSRAP DESTINATION: Columbia Mo

CARRIER: Riedel

ORIGINATOR: S. Smith / WSSRAP

RPM APPROVAL: John Doe

PART 1

CONTAINER I.D.	INSTRUMENT READING (cpm)	RADIOACTIVE MAT'L[a] (YES/NO)	INSTRUMENT MODEL/SN

COMMENTS: Radionuclide concentration known from previous analysis.

PART 2

CONTAINER I.D.	SURFACE GAMMA LEVELS (mrem/hr)	HIGHEST 1-METER GAMMA LEVEL (mrem/hr)	TRANSPORTATION LABEL INDEX CATEGORY	WT (lbs)
(1)	<0.5, all four sides	0.02 (bkg)	TI(N/A) White 1	5.5
(2)	<0.5, all four sides	0.02 (bkg)	TI(N/A) White 1	5.5

COMMENTS: See radionuclide concentrations on back

a) If the count rate is greater than 700 cpm the material is to be considered radioactive material. Further on site analysis is required.

CHEMICAL PLANT
201-1.06

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

3589-88-I-DOE-322

M-K FERGUSON CO.
RECEIVED
JUL 27 1988
WSSRAP CONTRACT 3589

July 26, 1988

ADDRESSEES

GEOPHYSICAL/GEOTECHNICAL INVESTIGATION SAMPLING PLAN

Enclosed is a final copy(s) of the Geophysical/Geotechnical Investigation Sampling Plan for the Weldon Spring Chemical Plant. This investigation will gather the additional data necessary to derive required geotechnical design parameters and evaluate the suitability of the site for constructing a long term storage facility.

The final copy includes a responsiveness summary for USEPA & MDNR review comments.

Sincerely,

R.R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

ADDRESSEES FOR LETTER DATED JULY 26, 1988

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cc w/enclosure:
Document Control
Repositories

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

April 11, 1988

ADDRESSEES

Enclosed are five copies of the Geophysical/Geotechnical Investigations Sampling Plan for your review. Your review and comments should be completed by May 5, 1988.

If you have any questions, please feel free to call.

Sincerely,

R. R. Nelson

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosures (5 copies)

ADDRESSEES FOR LETTER DATED APRIL 11, 1988

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Missouri Department of
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII
726 MINNESOTA AVENUE
KANSAS CITY, KANSAS 66101

Cys: Rod
Steve
Ken
Doc Control
Dean

MAY 12 1988

Mr. Rodney R. Nelson
U.S. Department of Energy
Weldon Spring Site Remedial
Action Project
Route 2, Highway 94, South
St. Charles, Missouri 63303

Dear Mr. Nelson:

We have completed our review of the "Geophysical/Geotechnical Investigation Sampling Plan." Our general comments on earlier partial work plan submittals are adequately addressed in this submittal. Specifically, sections describing the sufficiency and validity of the available field and laboratory data have been incorporated, and additional testing is shown to be justified. Also, technical approaches for the proposed investigations appear to be sound. However, a general review of the document points out the following:

The work plan does not attempt to link this study with related studies necessary prior to design of the containment structure, such as sampling and testing to determine the suitability of proposed borrow soils. Presumably, the forthcomming RI/FS work plan will accomplish this.

The work plan presents the geophysical studies in a very positive manner with regard to their application to the problem of defining bedrock fracture zones, cavities, and channels. While these techniques are applicable and should provide useful information, the reliability of the techniques may be overstated. It is important for all parties to understand that these procedures may fail to detect the identified bedrock features even though proper equipment and procedures are used.

The work plan consists of three principal parts: 1. An introduction and review of the site history and previous studies; 2. A proposed scope of work; and 3. Appendices specifying the work to be performed by the subcontractor. The Appendices (specifications) are difficult to follow due to the various addendums and modifications. However, as stated in previous review comments on the partial submittals, the specifications do not appear to be consistent with the scope of work outlined in

JU261C
5-16-88

the body of the work plan. This problem should be reconciled prior to soliciting bids.

Thank you for the opportunity to comment on this work plan. Our specific comments are contained in the enclosure to this letter. We are expecting comments on this work plan from the Missouri Department of Natural Resources within the next few days, and they will be forwarded to you at that time. Please call if you have any questions.

Sincerely yours,

Katie Biggs

B. Katherine Biggs
Chief, Environmental Review Branch

Enclosure

cc:Dave Bedan, MDNR (w/encl)

SPECIFIC COMMENTS

The following comments relate to specific sections of the Geophysical/Geotechnical Investigation Sampling Plan. The comments are presented according to the section and page within the text.

1. Section 1.4.2, p. 49, Seismicity of the area should also be investigated and considered in this assessment.

2. Section 1.4.3, p. 52, If present in significant thickness, engineering properties of the residuum may be important to design and should probably be defined to the extent possible.

3. Section 1.4.3, p. 57, Appropriate Number of Samples and Tests - Several assumptions are involved in making the indicated statistical analysis. It does not appear that five tests for each engineering parameter per geologic unit are adequate to allow for vertical and horizontal variations, weathering profiles, etc.

It is suggested that moisture content, dry unit weight (if possible) and field strength tests (pocket penetrometer and/or vane shear) be run on all samples, and sufficient classification tests (Atterberg limits and gradation) be run on representative samples to facilitate the horizontal and vertical characterization of the soil profile. These data, when analyzed, will allow the selection of representative soil samples from each geologic unit for use in strength, permeability, and consolidation tests.

4. Section 2.1.2, p. 67, The sequencing of events is not clear. Will geophysical surveys be performed and interpreted before the drilling program begins or the other way around? In any case, engineering and geologic personnel should also have input in determining the depth and location of boreholes.

5. Section 2.1.2, p. 67, The geophysical logging program for the two deep holes needs to be discussed in more detail, including the type of down hole surveys to be run.

6. Section 2.1.2, p. 69, The procedure should state the criteria for taking more than one undisturbed sample every five feet, i.e., every five feet or at more frequent intervals if changes in soil type occur.

7. Section 2.1.4, p. 71, The supervising geologist should estimate the shear strength of all cohesive soil samples at the time the sample is retrieved, using a pocket penetrometer and/or vane shear device.

8. Section 2.2.3, p. 74, The geophysical methods selected include seismic, electrical resistivity and electromagnetic conductivity. The plan should include a detailed survey grid for each method, supported with documentation explaining the survey grid and the expected results, i.e., depth of investigation, resolution with depth, etc. As previously pointed out, the plan must identify what surveys will be performed and how.

9. Section 3.1.2, p. 79, As indicated in comment no. 2, we believe the residuum should also be tested if present in sufficient thickness.

10. Section 3.1.2, p. 79, Samples for engineering properties tests (strength, consolidation, and permeability) should be selected subsequent to completion and evaluation of moisture content, dry unit weight, classification (Atterberg limits and gradation) and undrained strength tests (field and laboratory) to assure that the samples are representative of the geologic unit.

11. Section 3.1.2, Table 3-1, Moisture contents should be determined on all samples to provide a continuous profile at each boring location. Dry unit weight should be determined on all undisturbed and on other samples if possible. The number of uu triaxial shear tests should be increased to assist in the characterization of lateral and vertical variations in strength and compressibility. Table 1-7 indicates a need for more cu triaxial shear strength tests than shown.

12. Section 3.1.2, p. 84, In-situ field permeability tests may provide useful design information.

13. Section 4.3, p. 91, Geophysical Surveys - This section indicates that approved written procedures and work instructions will be issued prior to commencement of the work. We would appreciate the opportunity to review these prior to their implementation.

1260

JOHN ASHCROFT
Governor

FREDERICK A. BRUNNER
Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL QUALITY
P.O. Box 176
Jefferson City, MO 65102

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation,
and Historic Preservation

cys: Rod
Steve
Ken
Doc Control
Dear

May 13, 1988

Ms. B. Katherine Biggs, Chief
Environmental Review Branch
U.S. EPA, Region VII
726 Minnesota Ave.
Kansas City, KS 66101

Dear Ms. Katie Biggs:

DNR COMMENTS ON DRAFT GEOPHYSICAL/GEOTECHNICAL INVESTIGATION SAMPLING PLAN - WELDON SPRING SITE (APRIL 1988)

The Missouri Department of Natural Resources (MDNR) has reviewed the draft "Geophysical/Geotechnical Investigation Sampling Plan" prepared by the U.S. Department of Energy for the Weldon Spring Site. The plan is generally well thought out, accurate and informative. Our comments follow:

Most of the geophysics related to cavity detection is aimed at detecting cavities in bedrock. The downhole camera work that has been done to date, as well as other drillhole data, suggest that voids likely to be encountered in the bedrock will have no significant impact on the structural integrity of the facility.

Voids in the overburden are a greater concern because of 1) reduced strength of overburden in comparison to bedrock, and 2) potential size and increase in size with normal subsurface weathering, stoping, moisture changes, etc. The overwhelming majority of sinkhole collapses in Missouri are not caused by catastrophic failure of cavernous bedrock. They are caused by slumping of soil materials into openings in the overburden usually developed in the interval of the weathered bedrock-overburden contact zone. The soil that falls into the bedrock openings in the interval of overburden-bedrock contact zone is carried away be seasonal surges of water flow through these openings. The soil void stopes upward to the surface.

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5-16-88

The chance of a surface collapse by upward stoping at the Weldon Spring facility is not significant. The low permeability cohesive soils that overlie the residual soils and bedrock are not prone to such collapse conditions. The near-surface soils inhibit infiltration of water which reduces water velocity in the residuum and shallow bedrock. Nevertheless, the geophysical efforts should concentrate on detecting cavities in overburden, especially in the overburden-weathered bedrock zone as these are the ones which could potentially affect the structural integrity of the facility.

Another serious concern is that the plan apparently does not include determining geotechnical characteristics of residual soils which are present under the majority of the site. This material could certainly affect the design of the facility. In fact, voids in overburden (if present) would most likely be found in the residual soils. Residual soils with low dry unit weights (below 90 to 95 pounds per cubic foot) would be those with the highest collapse potential and leakage potential. Residual soils are separate and distinct from the bedrock itself. The two units should not be lumped together as they are on Page 52 of this document.

A related error appears in Appendix A where dry unit weights of basal till are listed to range from 104.8 pcf to 86.5 pcf. Possibly, the lower number represents either a typographical error or analysis of a residuum sample.

MDNR appreciates the opportunity to comment on this sampling plan. If you have any questions on these comments please call me at (314) 751-4533 or Mr. William Duley of the Division of Geology and Land Survey at (314) 364-1752.

Sincerely,

DIVISION OF ENVIRONMENTAL QUALITY

David E. Bedan
Weldon Spring Work Group Coordinator

DEB/cjj

cc: Mr. Ron Kucera, Deputy Director, DNR
Mr. William C. Ford, Director, DEQ
Mr. Jim Williams, Division of Geology & Land Survey
Mr. William Duley, Division of Geology & Land Survey
Mr. Nick Di Pasquale, Director, WMP
Mr. Dan Wall, U.S. EPA, Region VII
Mr. Rod Nelson, U.S. DOE, WSSRAP
Mr. Dan Bauer, U.S. Geological Survey

DOE/OR/21548-014

United States Department Of Energy

GEOPHYSICAL/GEOTECHNICAL INVESTIGATION SAMPLING PLAN

REV. 1

WELDON SPRING SITE REMEDIAL ACTION PROJECT

GEOPHYSICAL/GEOTECHNICAL INVESTIGATION SAMPLING PLAN

U.S. DEPARTMENT OF ENERGY

WSSRAP

JULY, 1988

REV. 1

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I	Environmental Chain of Custody Form
J	Work Plan-Geophysical Investigation Specification 3589-SC-WP028 Weldon Spring Site

SECTION 1

INTRODUCTION

1.0 INTRODUCTION

1.1 Purpose and Scope of Plan

This sampling plan presents a rationale and procedures for further geotechnical and geophysical investigations of the Weldon Spring Site (WSS). The proposed investigation will gather the additional data necessary to derive required geotechnical design parameters and evaluate suitability of the WSS for constructing a long-term waste disposal facility.

This document reviews data from the previous geotechnical and geophysical investigations for adequacy and sufficiency. The plan then describes additional geotechnical and geophysical investigations required to fully characterize the proposed disposal facility site.

The proposed investigation categories are:

- Surface geophysical surveys
- Geotechnical drilling and sampling
- Geotechnical laboratory testing

The surface geophysical surveys will integrate various techniques to characterize soil and bedrock units. Geotechnical drilling and sampling will provide information to correlate geophysical measurements with known subsurface conditions. The disturbed and

undisturbed samples collected during geotechnical drilling will be tested for a broad range of engineering parameters. These data will be used for engineering design of the disposal facility and to demonstrate suitability of the site.

1.2 Relevant Site History

The Weldon Spring Site is located about 30 miles west of St. Louis and 14 miles southwest of St. Charles, Missouri. From 1941 to 1944 the Department of the Army operated the Weldon Spring Ordnance Works for the production of trinitrotoluene (TNT) and dinitrotoluene (DNT).

In 1956, the Atomic Energy Commission acquired approximately 205 acres of the original Weldon Spring Ordnance Works for use as a uranium feed materials plant. During plant operation (until 1966), four pits were excavated for storage of raffinate sludge from the plant.

In 1984, Bechtel National, Inc. (BNI) performed a detailed geological investigation for a long-term residual radioactive materials storage area (BNI, 1984). This investigation found that the raffinate pit area was suitable for long-term storage.

In 1986, BNI performed a hydrogeological investigation to provide information for siting a disposal facility on the 217-acre site of the former uranium feed materials plant (BNI, 1987), which

appeared to be acceptable for the long-term storage of low-level radioactive and hazardous wastes. Favorable site features included:

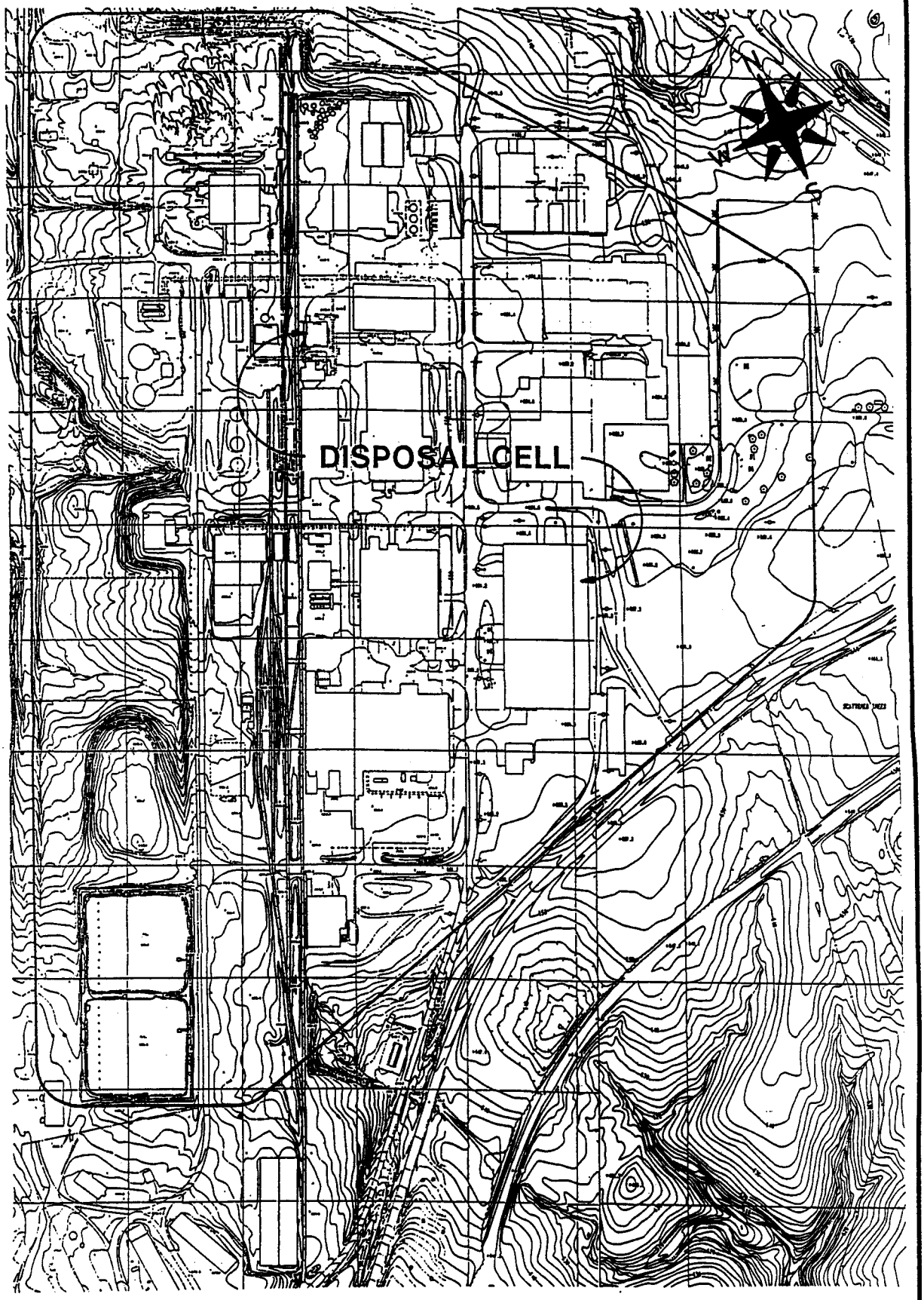
- Thick overburden
- Strong, cohesive soils
- No well developed surface drainage
- Good sorbtive soil characteristics for radionuclides
- Native soils that are stable for engineered slopes
- Proximity to wastes
- Situated on surface drainage divide

Seventy-five acres (Figure 1-1) have been selected for more detailed investigation as a disposal facility site. This area has been selected based largely on the thickness and quality of overburden soils. The 75-acre area is the subject of this plan.

1.3 Evaluation of Previous Studies

1.3.1 Background

Several investigations and geotechnical testing programs have been performed at the site. These studies included drilling, trenching, geotechnical laboratory testing, and surface geophysical surveys. These investigations were designed for purposes other than locating a disposal facility within the



REFERENCE : SURDEX CORP., 1987

FIGURE 1-1

AREA TO BE EVALUATED FOR PROPOSED DISPOSAL CELL

75-acre area and, therefore, lack sufficient detail to characterize the proposed disposal facility site.

During previous investigations, over 75 borings were drilled in the chemical plant and raffinate pit areas. These borings include test borings for construction of buildings and borings for installation of monitoring wells. In addition to borings, 21 trenches were excavated into the undisturbed soils of the raffinate pits and chemical plant areas. Soil samples were obtained and some geotechnical laboratory testing was performed. Seismic refraction, electrical resistivity, electromagnetic, and magnetometer surveys were also performed. The following sections describe these previous studies, the quality of data generated, and applicability to the current study.

1.3.2 Geotechnical Investigations

The completed geotechnical sampling studies are discussed individually. Reports evaluated include:

- U.S. Army Corps of Engineers (1955)
- Henry M. Reitz (1964)
- Bechtel National, Inc. (1984)
- Bechtel National, Inc. (1987)

1.3.2.1 U.S. Army Corps of Engineers (1955)

Investigation Purpose

Subsurface explorations were initiated by the St. Louis District, U.S. Army Corps of Engineers (COE), at Weldon Spring, Missouri under the direction of the United States Atomic Energy Commission in November 1954. The field investigation took place during November and December 1954. The final report was completed in February 1955. The purpose of the investigation was to gather geotechnical data for general foundation design work.

Drilling and Sampling Scope

A total of eight boreholes were advanced into limestone bedrock using "standard truck-mounted rotary drilling equipment." However, no depths were recorded on the boring logs, so no depth information is available. Four- or eight-inch augers were used to advance the boreholes to bedrock. It is not known whether hollow-stem or solid augers were used. Fractured rock was penetrated with a 4.75-inch roller bit.

Undisturbed soil samples were taken at two boreholes by driving 4.75-inch thin-walled Shelby tubes. At one borehole, disturbed samples were taken using a Standard Penetration Test (SPT) with a

split-spoon sampler. Rock cores were obtained with NX diamond bits.

Sampling Adequacy

Standard drilling and sampling methods were used by the COE during this investigation. Augering is an acceptable means for advancing a borehole in shallow clays. Shelby tubes and split-spoons are standard equipment for taking undisturbed and disturbed samples respectively.

No information is available on the drilling or sampling procedures. Augering is a simple operation unless it is affected by adverse soil conditions such as flowing sands or caving. Since boring logs generally indicated clays and silts, the drilling method and procedures are assumed to be appropriate.

Since no information on sample recovery or sample characteristics is given in the boring logs, other sampling validity estimates must be used. Based on laboratory test results, some disturbance in the Shelby tube samples is apparent. There is no way to determine whether the disturbance resulted from sampling, sample handling, or testing procedures. Therefore, no conclusions can be drawn regarding sampling validity.

The COE boring logs were valid for the investigation though they are inadequate in content. Individual soil descriptions, sample

recovery rates, intermediate and total borehole depths, and groundwater data are not reported. This incomplete record prevents a direct comparison of the COE data with subsequent site investigations.

Sampling Sufficiency

Eight boreholes were sufficient for the scope and extent of the COE foundation investigation. Each borehole was appropriately advanced to bedrock. Continuous Shelby tube sampling was done in two boreholes, and split-spoon sampling was done in one borehole.

Scope of Lab Testing

The following geotechnical laboratory tests were run on the COE samples:

LABORATORY TEST	NO. OF TESTS
Moisture content	83 (a)
Atterberg limits	15
Proctor compaction	1 (b)
Consolidation	2
Unconfined compression (undisturbed)	11
Unconfined compression (remolded)	5
Direct shear	
(CU) (consolidated-undrained)	1
(CD) (consolidated-drained)	2
(UU) (unconsolidated-undrained)	2

(a) Includes moisture tests apparently made on auger cuttings

(b) Assumed to be Standard Proctor

Data Validity

The laboratory soil tests were valid for their purpose. These results must be considered invalid for disposal cell siting, however, since results cannot be correlated with sufficient confidence to specific soil types. The Proctor compaction is the only test considered valid.

1.3.2.2 Henry M. Reitz (1964)

Investigation Purpose

In 1963, Henry M. Reitz Consulting Engineers performed investigations to determine geotechnical characteristics of soils underlying the proposed new raffinate pit. The final report for this investigation was completed in January 1964.

Drilling and Sampling Scope

A total of 12 boreholes were advanced using "mechanical" and "hand" augering equipment. Five mechanical auger borings extended to rock with borehole depths ranging from approximately 19 to 33 feet. Seven hand auger borings, with depths ranging from approximately 5 to 20 feet, were terminated within the soil overburden. No information is provided in the report on whether

hollow-stem or solid augers were used. No information on sampling procedures is given.

Undisturbed soil samples were taken at three boreholes at a depth of approximately 10 feet. Disturbed samples were also taken at one of these boreholes.

Sampling Adequacy

The drilling and sampling methods were valid for the raffinate pit sludge. Their validity to disposal cell siting cannot be determined however, since no information was provided on sampling methods, sample recovery or soil characteristics.

The Reitz boring logs appear to be reasonable for their purpose, but are inadequate for current disposal cell siting needs. Sample recovery rates, depths to soil changes, and groundwater data are not reported. Also, based on limited correlation with Atterberg limits testing, it appears that some soil descriptions on the boring logs may not correspond to the Unified Soil Classification System (USCS). However, the logs do provide some useful overburden depth information.

Sampling Sufficiency

Twelve boreholes were generally adequate for the limited scope and extent of this raffinate pit investigation. The extent of

sampling is not sufficient for present needs. From laboratory test data, it appears that only three undisturbed samples were retrieved. The method by which these samples were taken is not known. In addition, it cannot be determined if sufficient disturbed samples were retrieved, since no information can be found regarding this aspect of the sampling program.

Scope of Lab Testing

The following geotechnical laboratory tests were conducted on collected samples:

LABORATORY TEST	NO. OF TESTS
Moisture content	70
Atterberg limits	2
Compaction	2 (a)
Permeability	3
Vane shear strength (peak)	29 (b)
Vane shear strength (continuous)	27 (b)
Triaxial shear strength (UU-remolded)	5

(a) ASTM-D698 (Standard Proctor)

(b) Vane type, method and test procedure unknown

Data Validity

As with the 1955 Corps of Engineers investigation, test results cannot be correlated to specific soil type due to inadequate depth information reported on the boring logs. Therefore, test results must be considered invalid for disposal cell siting except for the Atterberg limit and compaction tests.

1.3.2.3 Bechtel National, Inc. (1984)

Investigation Purpose

Bechtel National, Inc. (BNI) conducted a geologic site characterization study of the raffinate pits area between December 1982 and November 1984 to:

- Define the site stratigraphy
- Describe the lithology and general conditions of each geologic unit
- Determine the existence of groundwater and how it relates to the geology

Field work was performed between December 1982 and April 1983. Laboratory soil sample testing was completed by McClelland Engineers in July 1983 and the final report was issued by BNI in November 1984.

Drilling and Sampling Scope

A total of 26 holes, with depths ranging from approximately 15 to 150 feet (average depth of about 30 feet), and 15 test pits, with depths ranging from approximately 15 to 27 feet (average depth of about 22 feet), were advanced into the overburden in the raffinate pits area. Eight-inch hollow-stem augers and NX core

drilling equipment were used for the holes. A backhoe with a 3-cubic-yard bucket was used for excavating test pits.

Undisturbed Shelby tube soil samples were taken from four boreholes on the dikes that contain raffinate pits nos. 3 and 4. All other borehole soil samples were taken using split-spoon samplers. No samples were obtained from any of the test pits.

Sampling Adequacy

The drilling and sampling methods used were appropriate for the BNI site investigation. Hollow-stem augering and NX core drilling are preferred methods of drilling on a contaminated site. Shelby tubes were used to acquire undisturbed samples. The procedures used for drilling and sampling are well documented in the investigation report.

The Bechtel boring and trenching logs appear to be generally complete and adequately documented. However, descriptions of the soil in the boring logs lack detail. A "generic" soil description is used for each soil type; the identical description is repeated in all borehole logs whenever a certain soil type is encountered. Thus, localized differences were not noted giving the impression that each of the soil types is uniform throughout the area investigated. Specific and distinct descriptions are given for each soil type in the test pit logs.

Sampling Sufficiency

Borehole depths are insufficient for present needs. Only eight of the 26 boreholes extended to competent bedrock. This is inadequate to define bedrock contours or to determine overburden thickness in the area of the site to be investigated. More boreholes located at greater distances from the raffinate pits are needed to help define overall geologic structure.

The extent of sampling is not sufficient for the present requirement. Four boreholes were sampled using Shelby tubes. All of these borings were located on raffinate pit dikes. Additional Shelby tube samples are needed from boreholes situated entirely within the natural soils. Disturbed sample coverage was sufficient for the BNI investigation. Current requirements include undisturbed sample testing in addition to disturbed sample testing.

Scope of Lab Testing

The following geotechnical laboratory tests were conducted on samples collected for this investigation:

LABORATORY TEST	NO. OF TESTS
Moisture content	75 (a)
Dry unit weight	59 (a)
Specific gravity	20
Atterberg limits	22
Gradation	22
Triaxial shear strength	
(CD multistage)	8
(CD multi-specimen)	3
(CU multistage)	5
(CU multi-specimen)	4
Permeability	5 (b)

(a) Includes data from triaxial shear strength tests

(b) Results from consolidation phase of triaxial shear strength tests

Data Validity

The documentation of soil samples, soil types, and laboratory testing is adequate for purposes of design. The test results are valid for disposal cell siting unless otherwise stated.

Dry unit weight, specific gravity, moisture content, Atterberg limits, and gradation tests are basic soil identification tests that are relatively simple to perform. These test values are valid and useful.

Triaxial shear strength tests were performed on laboratory consolidated soil samples under both drained and undrained conditions. Consolidated-drained tests (CD) and consolidated-undrained tests (CU) with pore-pressure measurements were conducted using both one-specimen multistage test procedures

procedures and three-specimen multi-specimen test procedures. CD tests provided data on effective (long-term or drained) soil shearing strengths, and CU tests with pore-pressure measurements provided data on both effective and total (short-term or undrained) soil shearing strengths.

Only six of the 20 triaxial strength test results reflect natural in-situ soils, while the remaining 14 tests were carried out on remolded dike fill materials. Of the six tests run on the natural soils, four triaxial test results applied to the Ferrelview Clay (three CD multistage tests and one CU multi-specimen test) and two triaxial test results applied to the Clay Till (one CD multistage test and one CD multi-specimen test).

Only two of the six applicable triaxial test results appear accurate. Both of these tests were carried out on Ferrelview Clay soils. For the remaining four tests, effective strength friction angles are reported to vary from 0 to 10 degrees, which is not typical for soils tested under drained loading conditions. The two "acceptable" triaxial test results report more reasonable effective strength friction angles of approximately 30 degrees.

There are a number of reasons why most of the strength test results may be inaccurate and, therefore, inadequate for purposes of design. These reasons are detailed below based on the laboratory test data presented by McClelland Engineers (1983).

- There appears to be a lack of consistent failure criteria for the first and second stages of multistage triaxial strength tests. Typically, the maximum deviator stress, principal stress ratio, or some predetermined maximum strain value is chosen to define sample failure (Bowles, 1982; Lambe and Whitman, 1969; Terzaghi and Peck, 1967; U.S. Dept. of the Navy, 1982; Wroth, 1984). However, it is not readily apparent what failure criteria have been chosen for these tests. As a result, it is possible that during the first stages of the test, the samples may have failed and been sheared to such an extent that a failure plane could have developed and remained despite subsequent consolidation during the next stage. This would weaken the specimen, and test results would significantly underestimate effective friction angles and overestimate cohesion for a drained test.

- Many samples were not sufficiently back-saturated before testing took place. Approximately one-half of the soil samples were back-saturated to a pore-pressure "B" parameter of less than 0.90, and some samples were back-saturated only to B = 0.65. The parameter B expresses the ratio of the change in pore-pressure to the change in total stress, and can be thought of as the portion of the total stress which is being carried by the pore water (Lambe and Whitman, 1969; U.S. Dept.

of the Navy, 1982). For testing clayey soils, "B" parameters should be as close to 1.0 as possible in order to fully saturate the sample (Lambe and Whitman, 1969; Mitchell, 1976).

- Some samples were reported to lengthen slightly after initial consolidation was completed. This tends to discredit either the validity of the data reporting or the manner in which the samples were consolidated. Regardless of the source of this error, the test results for these samples are not valid.

- The length to diameter ratio (L/D) for some samples appears to be too low when compared to accepted triaxial test procedures. Generally, L/D for triaxial shear strength specimens should fall between 2.2 and 2.7; however, L/D values as low as 1.7 were reported for some samples in this study. The effect of this procedural error again causes some doubt on the usefulness of these test results.

Consolidation data from the triaxial strength tests were recorded in the form of time curves. However, no void ratio or vertical strain versus log-pressure curves were presented, so no direct determination of compression characteristics and preconsolidation pressures is possible. There may be some means of determining desired consolidation characteristics from the basic test data,

but the means are not readily apparent from existing laboratory data. The consolidation data cannot be considered useful for design purposes because of the triaxial strength test data concerns and, in particular, the reported sample lengthening after laboratory consolidation.

Some qualitative consolidation information can be obtained from the triaxial strength test data. Stress paths from the two "reasonable" triaxial test results show dilative behavior and induced negative pore-pressures, which suggest that the Ferrelview Clay may be overconsolidated (Bowles, 1982; Lambe and Whitman, 1969; Mitchell, 1976). This should be verified through additional consolidation testing as part of this program.

Permeability data resulting from the consolidation phase of triaxial strength testing appear to be inconsistent. Therefore, values associated with these tests are suspect, and the permeability data are not considered useful for design purposes.

1.3.2.4 Bechtel National, Inc. (1987)

Investigation Purpose

Bechtel National, Inc. (BNI) performed a hydrogeological

characterization study to:

- Provide a groundwater monitoring system to determine if contaminants from the site have degraded groundwater quality
- Evaluate the site geology and hydrogeology for utilization of the site as a waste disposal facility

Field work was conducted between January 1986 and August 1986. The final report was completed by BNI in July 1987.

Drilling and Sampling Scope

A total of 35 boreholes with depths ranging from 54 to 94 feet and five test pits with a consistent depth of about 15 feet were located around the chemical plant area and north of the raffinate pits. Six-inch OD hollow-stem augers and both NQ and NXB wireline core drilling equipment were used. A backhoe was used to excavate the test pits.

Generally, boreholes were sampled at 5-foot intervals with split-spoon samplers. One or two undisturbed samples per borehole were obtained from 24 of the borings. Undisturbed sampling was accomplished using 3-inch OD Shelby tubes. Samples were not obtained from the test pits.

Sampling Adequacy

The drilling and sampling methods were appropriate for this hydrogeological study. Hollow-stem augering and NQ or NXB core drilling are preferred drilling methods in contaminated soils and rock. Casing was not installed in boreholes to seal possible contamination pathways prior to rock coring. Shelby tubes were used for reliable geotechnical testing.

The boring and test pit logs appear valid, generally complete, and adequately documented. Specific and distinct descriptions are given for each soil type within each borehole documenting localized variations in soil characteristics.

Sampling Sufficiency

For the scope of this hydrogeological study, the extent of the borehole and trenching plan was sufficient since this study incorporated data from boreholes previously drilled by BNI in 1984. Each borehole extended into reasonably competent limestone bedrock.

The extent of sampling is not sufficient for present design needs. Only one or two Shelby tube samples were taken in each borehole. Undisturbed sampling was not done in about one-third of the borings. Undisturbed sampling apparently was not a priority for this study, as indicated by the minimal number of

laboratory tests requiring undisturbed samples. Disturbed samples were obtained at approximately 5-foot intervals.

Scope of Lab Testing

The following geotechnical laboratory tests were run on samples collected for this investigation:

Laboratory Test	No. of Tests
Moisture content	25
Dry unit weight	33
Specific gravity	32
Atterberg limits	30
Gradation	40
Centrifuge moisture equivalent	20
Cation exchange capacity	5
Distribution ratio	5

Data Validity

Documentation of soil samples, soil types, and laboratory testing were adequate. It is assumed that the tests were properly performed and that the results are valid unless otherwise stated.

Dry unit weight, specific gravity, moisture content, Atterberg limits and gradation test results are basic soil identification tests that are relatively simple to perform. These test values are valid and useful.

Results from the centrifuge moisture equivalent tests appear to be reasonable, although there is a fairly wide variation in test

Results from the centrifuge moisture equivalent tests appear to be reasonable, although there is a fairly wide variation in test values. As expected, the Ferrelview Clay shows the highest test value, while the Basal Till exhibits the lowest. This is consistent with the types of materials involved. The fine-grained Ferrelview Clay should retain more moisture than either the sandy Clay Till or the gravelly Basal Till.

Both cation exchange capacity and distribution ratio measure chemical characteristics of the soil and pore water interactions. The test results appear to be reasonable although there is a wide variation in values. An insufficient number of test results is available for each soil type. Therefore, the test results are inadequate for design purposes.

1.3.3 Geophysical Surveying

Three geophysical investigations were carried out at the Weldon Spring Site (WSS) between 1982 and 1987 by Weston Geophysical Corporation (WGC) and Detection Sciences, Inc. (DSI) under contract to Bechtel National, Inc. (WGC, 1983; WGC, 1984; DSI, 1986). The studies utilized a total of five different geophysical techniques. Table 1-1 lists the geophysical techniques used, survey dates, and the survey subcontractors.

T A B L E 1-1

GEOPHYSICAL SURVEYS PERFORMED AT WSS

SURVEY METHOD	DATE	COMPANY
Seismic Refraction	Feb/March 1986	Detection Sciences, Inc.
Electromagnetic	February 1986	"
Seismic Refraction	March/April 1984	Weston Geophysical Corp.
Electrical Resistivity	March/April 1984	"
Seismic Refraction	December 1982	"
Electrical Resistivity	December 1982	"
Self Potential	December 1982	"
Magnetometer	December 1982	"

1.3.3.1 Scope and Purpose of Surveys

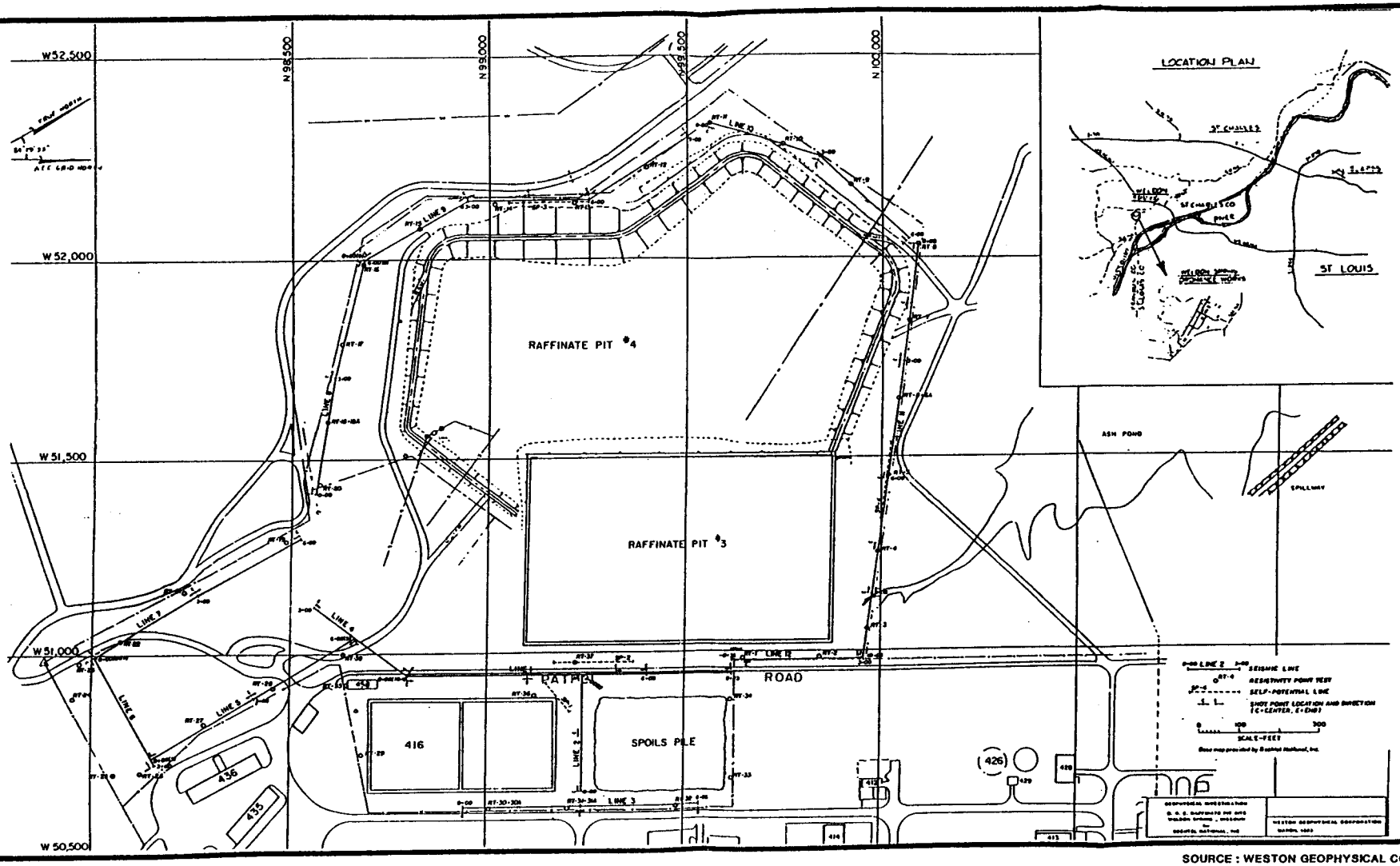
Each of the three investigations utilized multiple geophysical techniques. The combination of several survey methods and subsequent correlation of results can be used to corroborate and enhance the findings of a single method and provide more detailed information on the subsurface. However, in some instances, a particular survey was employed to investigate a specific parameter. Table 1-2 lists the general purpose of each geophysical survey method performed at WSS.

Most of the geophysical surveys performed by Weston Geophysical Corp. in 1982-84 were carried out in the vicinity of the raffinate pits area (Figure 1-2 and 1-3). Magnetometry and some electrical resistivity surveys were performed at five tentative monitoring well locations denoted as A through E on Figure 1-4. The seismic refraction and electromagnetic studies performed by Detection Sciences, Inc. were performed in the area north of Raffinate Pit 4 and east of raffinate pits 1 and 2 as shown on Figures 1-5 and 1-6. Results of these studies and their applicability to the current investigation are discussed in the following sections.

T A B L E 1-2

PURPOSE OF GEOPHYSICAL STUDIES AT WSS

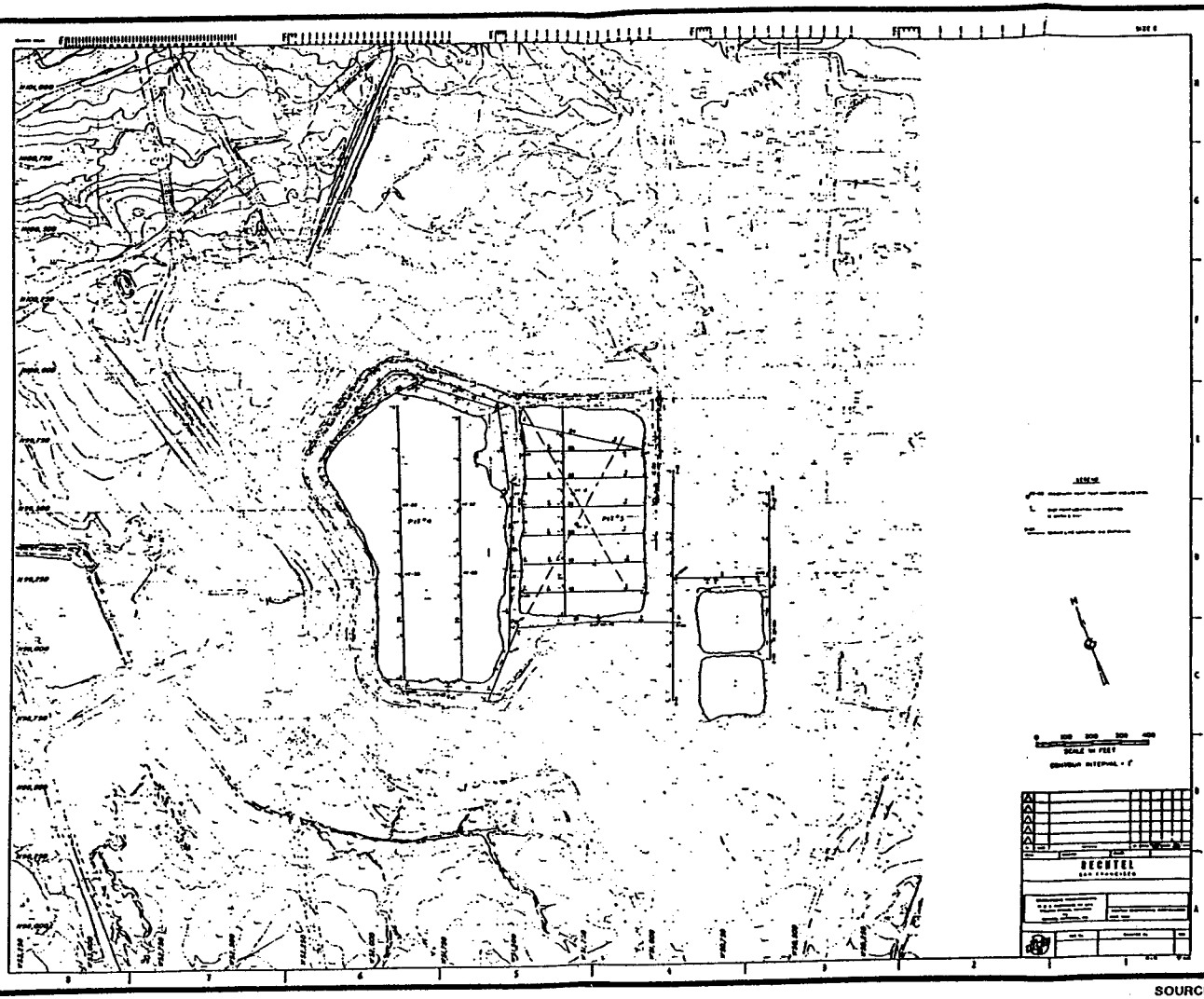
METHOD	PURPOSE
Seismic Refraction	Provide subsurface information regarding the overburden thickness and depth to rock, seismic velocities, and characteristics of bedrock.
Electromagnetic	Identify contaminant plumes in the groundwater and provide a basis for selecting monitoring well locations.
Electrical Resistivity	Provide information on subsurface layering and depths including depth to groundwater.
Self Potential	Detect background potentials from fluid streaming, bioelectric activity or variations in the electrolytic concentration in water.
Magnetometry	Detect buried metal objects (e.g. abandoned process lines) in the overburden at proposed monitoring well locations.



SOURCE : WESTON GEOPHYSICAL CORP., 1983

FIGURE 1-2

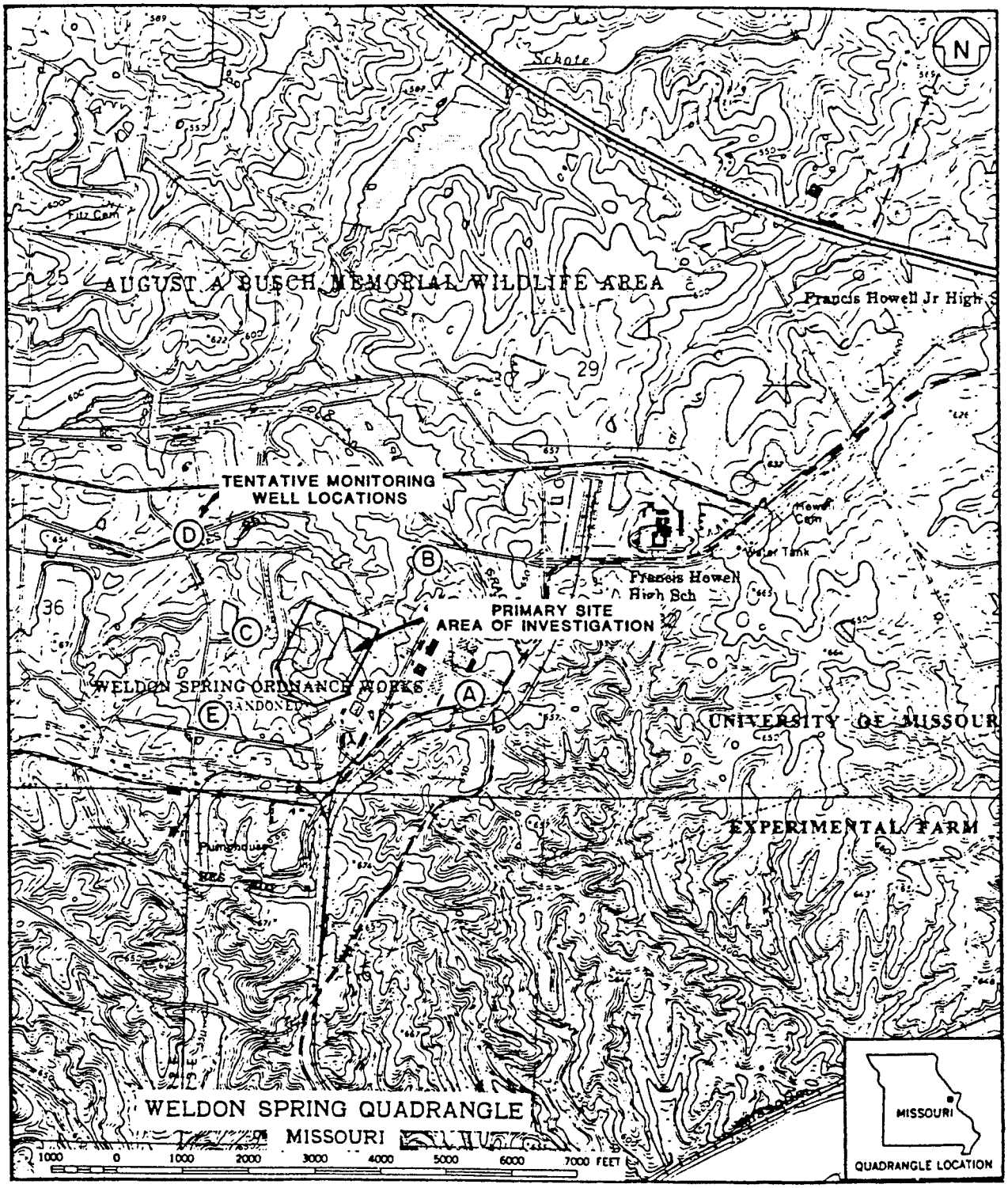
GEOPHYSICAL SURVEY PLAN - WESTON GEOPHYSICAL CORP.



SOURCE : WESTON GEOPHYSICAL CORP., 1984

FIGURE 1-3

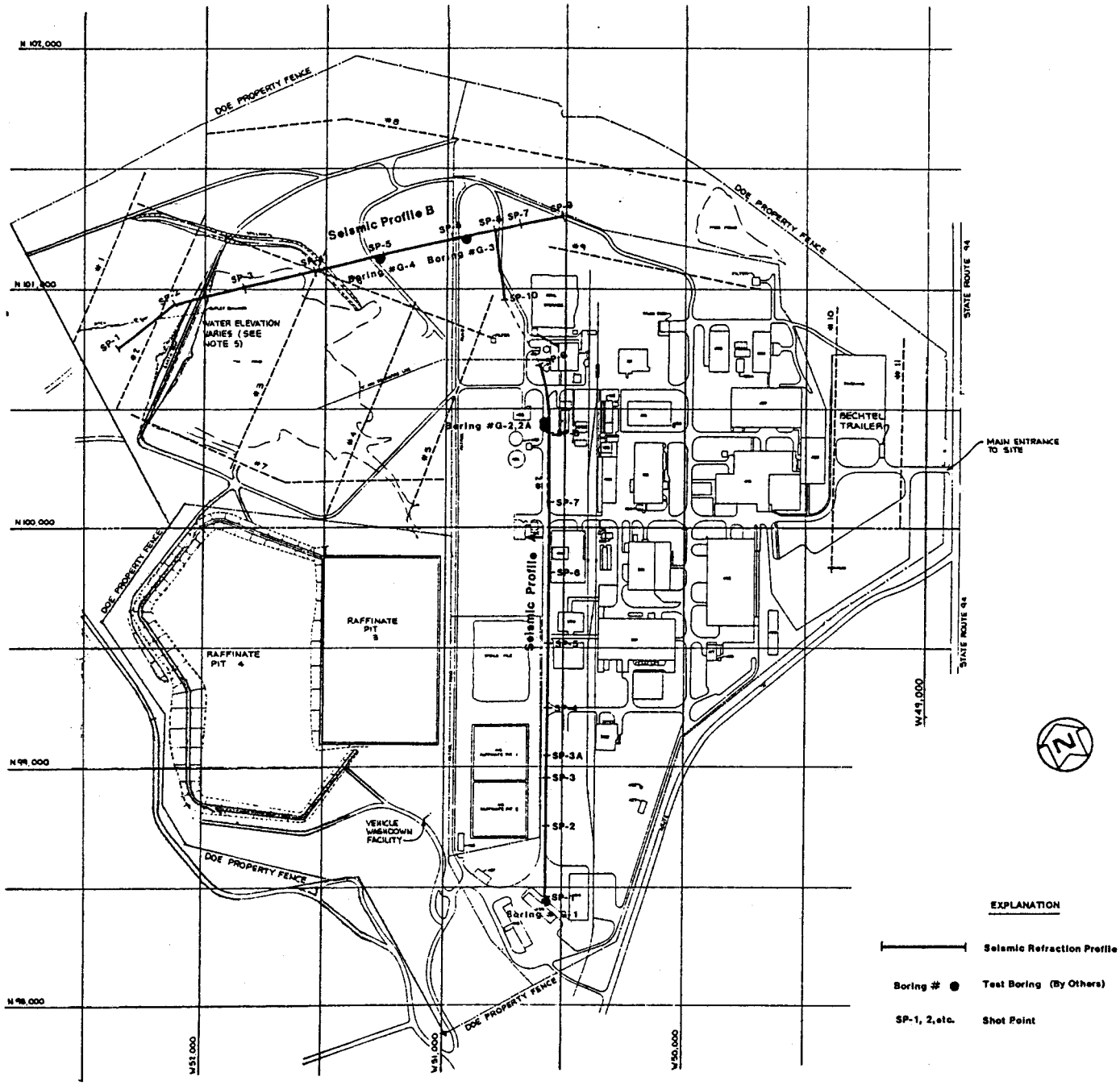
GEOPHYSICAL SURVEY PLAN – WESTON GEOPHYSICAL CORP.



REFERENCE : USGS QUADRANGLE, WELDON SPRING, MO

FIGURE 1-4

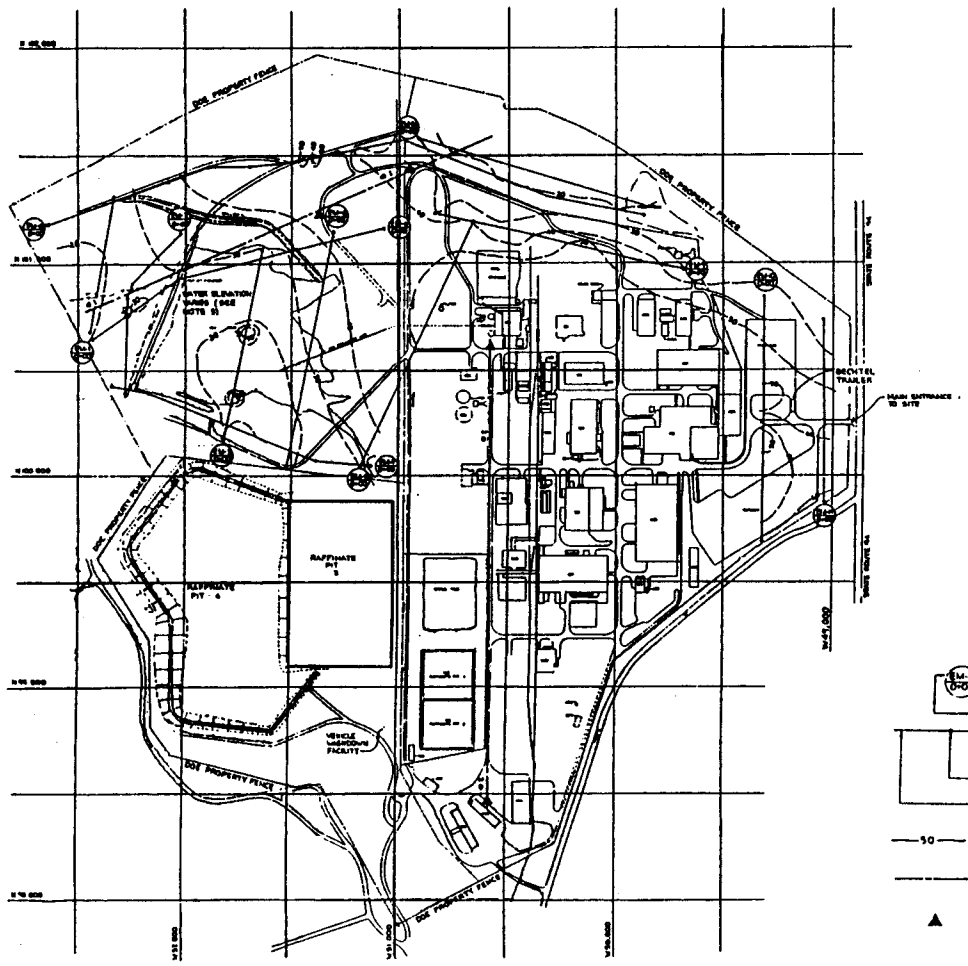
MAGNETOMETER AND ELECTRICAL RESISTIVITY SURVEY LOCATIONS-WESTON GEOPHYSICAL CORP.

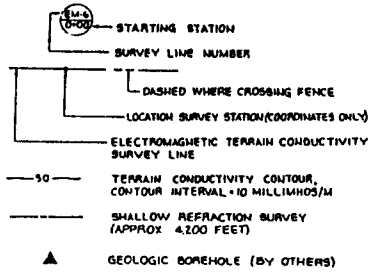


SOURCE : DETECTION SCIENCES, INC., 1986

FIGURE 1-5

GEOPHYSICAL SURVEY PLAN - DETECTION SCIENCES, INC.





GENERAL NOTES

1. GEOPHYSICAL SURVEYS SHALL BE PER SPECIFICATION 201-23-C-01.
2. LOCATIONS SHOWN FOR GEOPHYSICAL SURVEYS ARE APPROXIMATE. EXACT LOCATIONS WILL BE DETERMINED IN THE FIELD BY BECHTEL.
3. THE GREATEST DEPTH OF OVERBURDEN IS APPROXIMATELY (C5) FEET.
4. GEOPHYSICAL SURVEYS SHALL BE DISCONTINUED AT FENCE LINES AND RESUMED AT OPPOSITE SIDE OF FENCE. FENCE SHALL NOT BE DISTURBED
5. GEOPHYSICAL SURVEYS WILL NOT BE REQUIRED IN AREAS OF STANDING WATER
6. EM SURVEY WAS PERFORMED WITH A GEONICS EM 34-3 INSTRUMENT.
7. EM SURVEY WAS PERFORMED USING HORIZONTAL COPLANAR DIPOLE CONFIGURATION WITH A 20 METER INTERCOIL SPACING.
8. FOR AS-BUILT INFORMATION ON THE SHALLOW SEISMIC REFRACTION SURVEY, SEE THE SUBCONTRACTOR'S REPORT.

SOURCE : DETECTION SCIENCES, INC., 1986

FIGURE 1-6

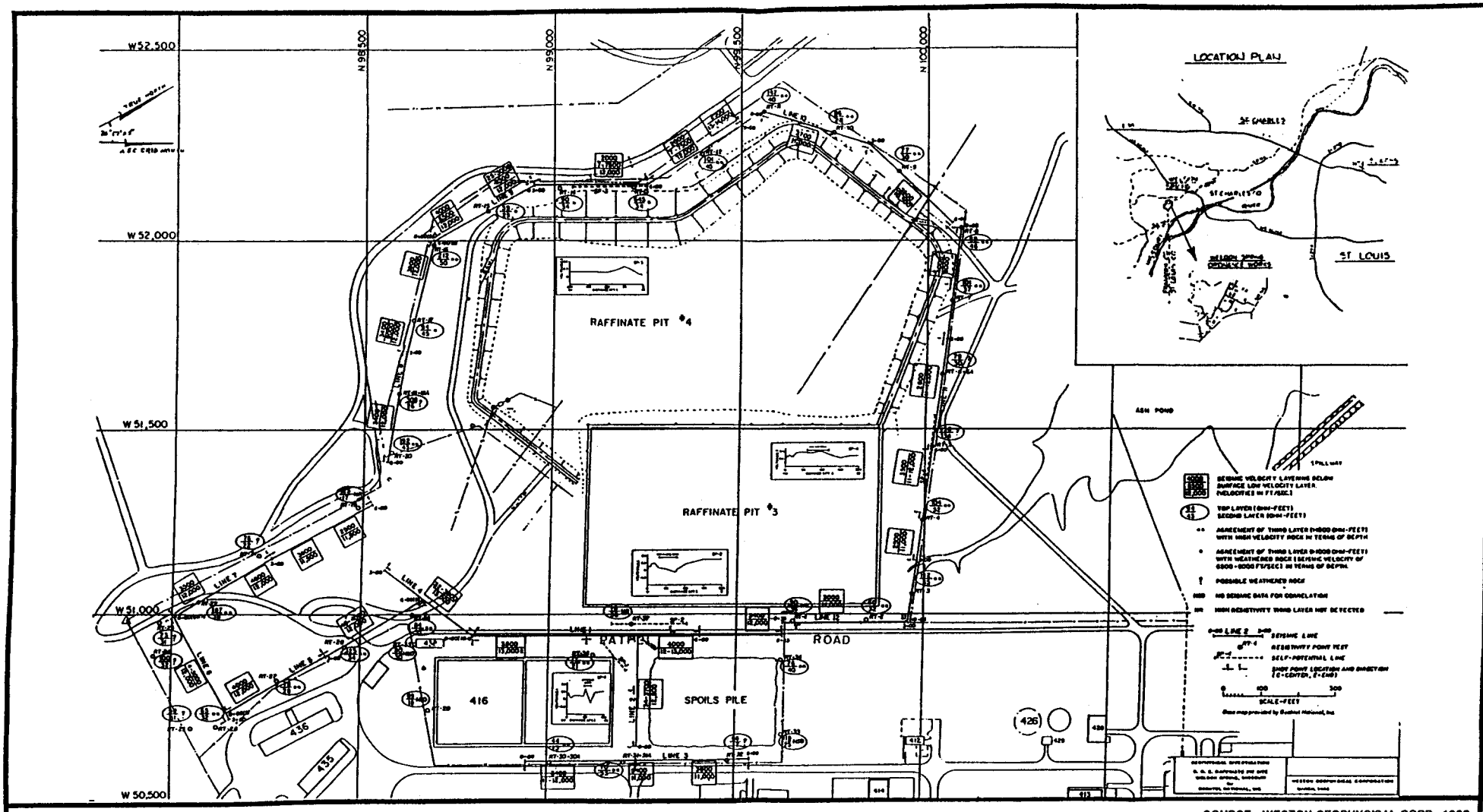
TERRAIN CONDUCTIVITY CONTOUR MAP SHOWING AREAL LIMITS OF THE SURVEY

1.3.3.2 Data Validity

Weston Geophysical Corp., 1982

The seismic refraction, electrical resistivity, and self potential survey results are summarized on Figure 1-7. The study area is characterized by a near-surface low velocity layer (1,200 to 1,800 ft/sec), underlain by a more consolidated layer (2,000 to 5,400 ft/sec), which in turn is underlain by bedrock (11,000 to 13,000 ft/sec). The depth to bedrock varies between 30 and 60 feet (DSI, 1986). Survey lines closest to the proposed disposal cell area were compared with drillhole information to test the accuracy of the surveys. Survey results from lines 1, 2, 3, 10, 11, and 12 are shown on Figures 1-8 and 1-9. Data from drillholes B19A, B17, B21, and G15, located in the vicinity of these lines and penetrating bedrock, correlate well with the seismic survey results.

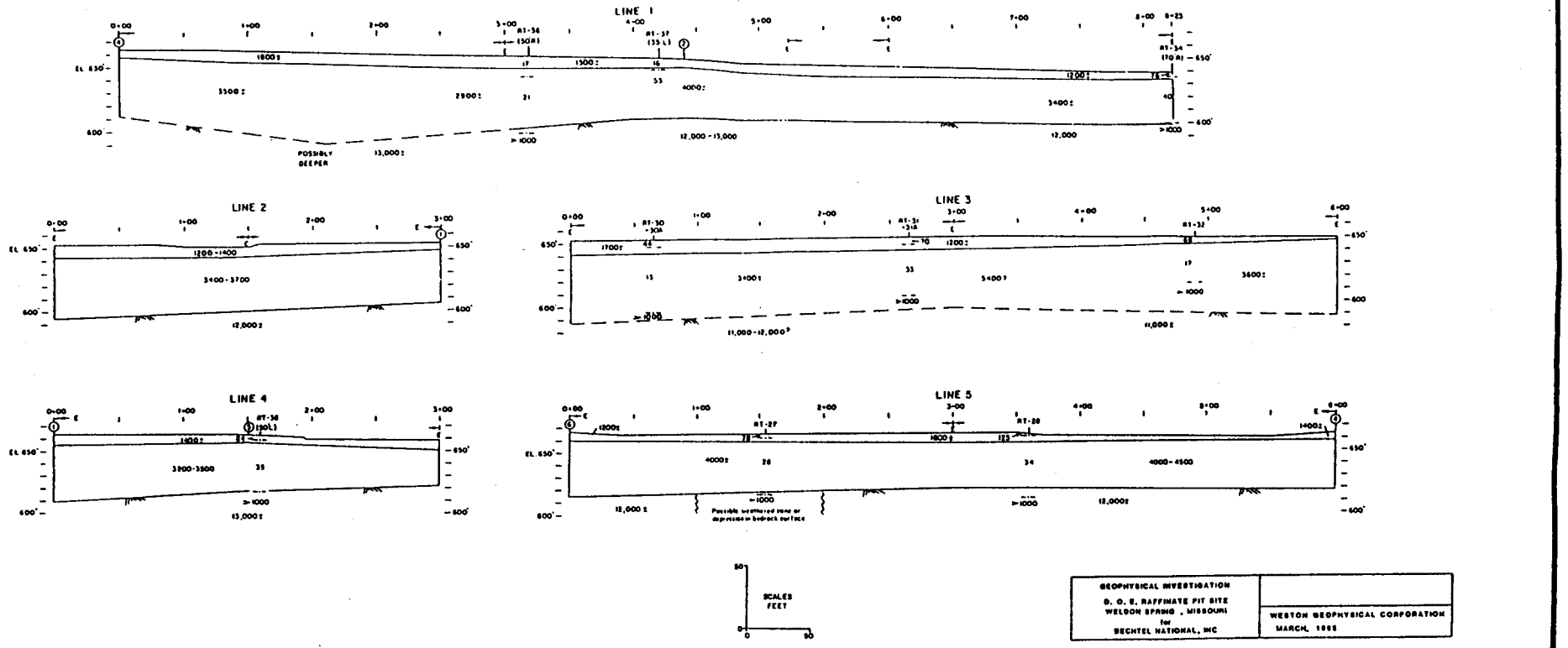
One discrepancy is that the weathered bedrock surface was characterized as overburden because of its relatively low velocity. The bedrock depths determined by seismic refraction apparently delineate the less fractured, more competent limestone and not the actual top of bedrock. From an engineering standpoint, this competent rock boundary is probably more significant than the top of weathered rock. This fractured bedrock layer has an average thickness of 10 feet in



SOURCE : WESTON GEOPHYSICAL CORP., 1983

FIGURE 1-7

SUMMARY OF GEOPHYSICAL DATA

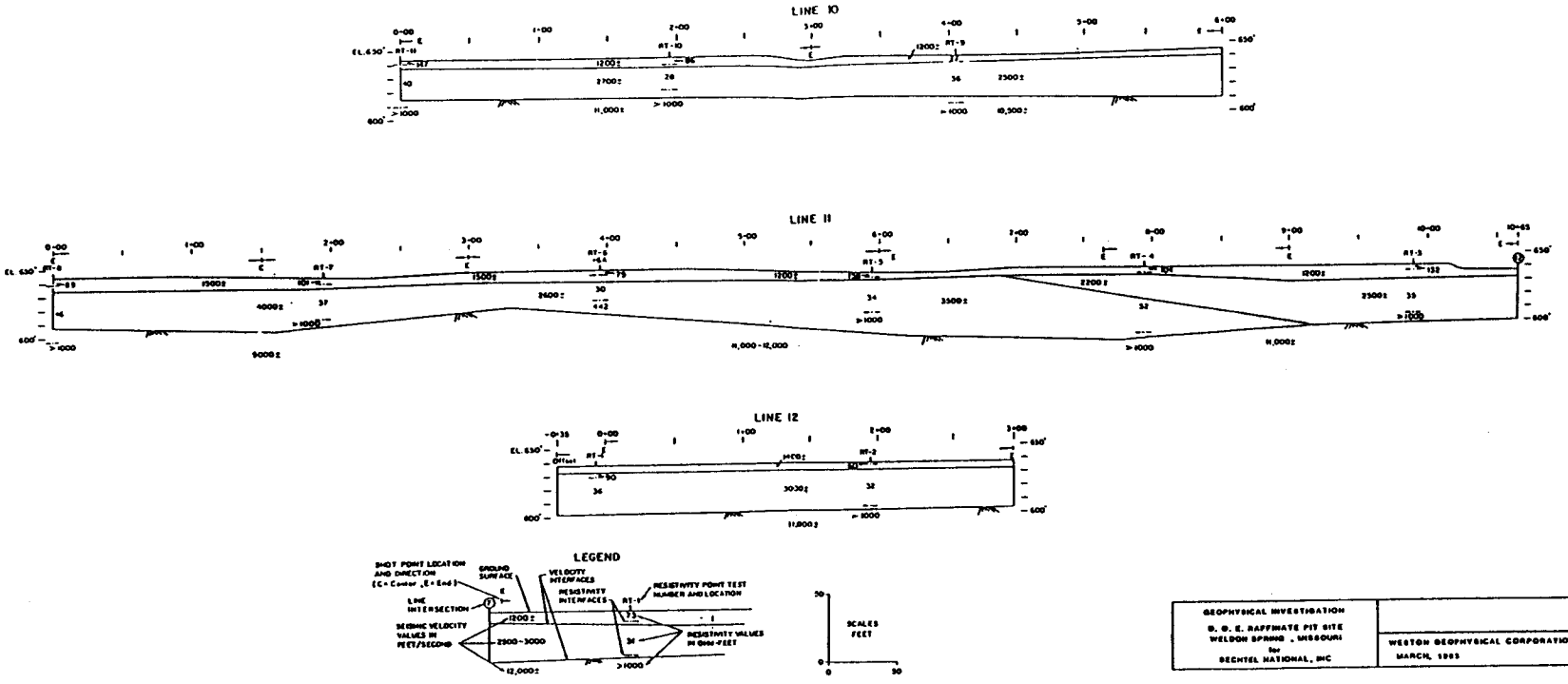


NOTE : SEE FIGURE 1-9 FOR EXPLANATION .

SOURCE : WESTON GEOPHYSICAL CORP., 1983

FIGURE 1-8

SEISMIC PROFILES LINES 1, 2, 3, 4 & 5



SOURCE : WESTON GEOPHYSICAL CORP., 1983

FIGURE 1-9

SEISMIC PROFILES LINES 10, 11 & 12

most drillholes, but is 19 feet thick in hole G15 as indicated by low rock quality designation (RQD) values. A second discrepancy between borehole and geophysical information results from the similar seismic velocities of various overburden layers. This causes layers with similar velocities (densities) to be grouped into a single unit.

The electrical resistivity values indicate a three-layer subsurface condition which correlates well with seismic refraction data. Results range from 60 to 150 ohm-feet for the uppermost layer, 30 to 50 ohm-feet for the thick intermediate layer, and over 1,000 ohm-feet for bedrock. These values appear to be consistent with expected resistivity. Correlation of the seismic refraction results with electrical resistivity surveys is shown on Figures 1-8 and 1-9. Results obtained by these methods appear consistent. Although original field data was not included in the reports, the data appears to be accurate and the results valid.

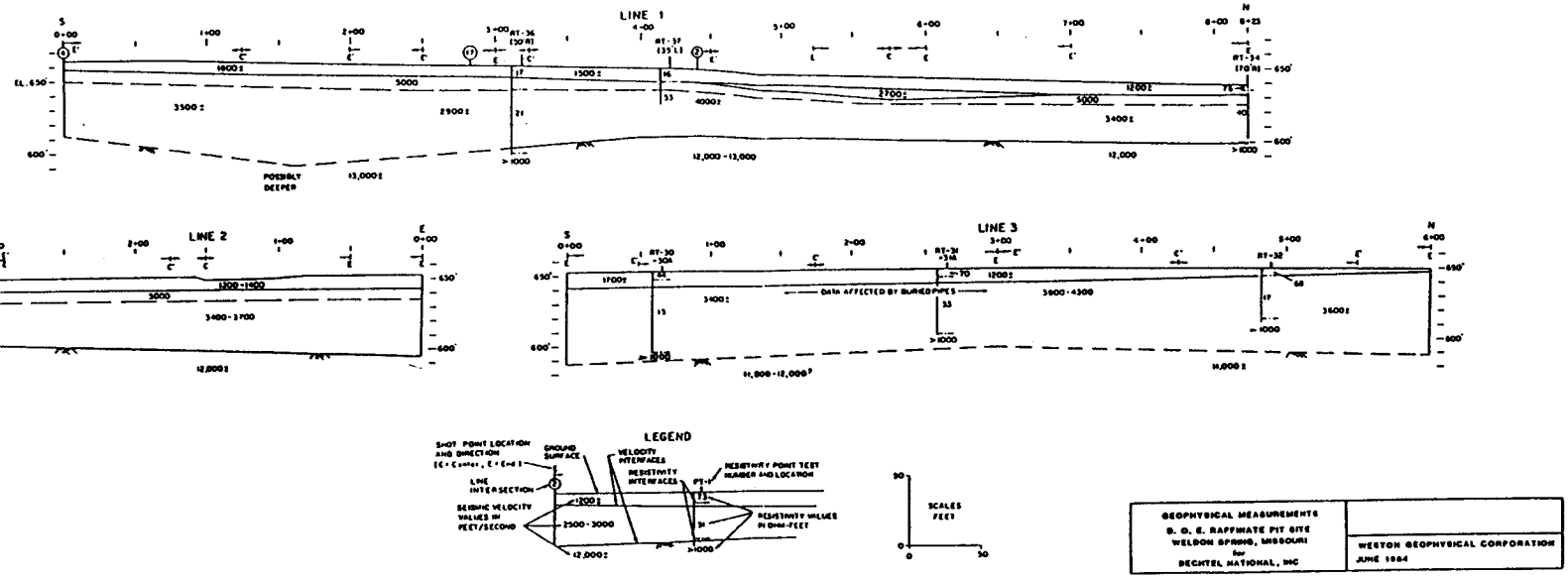
The self potential data appear to be accurate. The results are plotted on Figure 1-7. Only lines SP-1 and SP-2 reveal anomalies indicated by potential reversals. These negative anomalies were identified as a characteristic of fluid streaming, a condition that is typical of permeable materials. However, the soils in the area consist of impermeable clays, clayey silts, and silty clays as demonstrated by the boring logs and supported by low

resistivity values. Therefore, the correlation of the SP anomalies with existing groundwater conditions is questionable. Magnetometric and electrical resistivity survey data appear accurate and results seem to have valid and reasonable interpretations.

Weston Geophysical Corp., 1983-1984

Seismic refraction surveys conducted in and around raffinate pits 3 and 4 revealed a rather complicated overburden structure (Figure 1-10). Seismic velocities under the ponds suggest the presence of four layers. This may be explained by an increase in moisture content. The seismic velocity of the overburden increases with moisture content to approximately 5,000 ft/sec when saturated. Lower velocity materials may be present beneath the ponds, but were not detected due to higher velocity, saturated surface material. The seismic refraction interpretation is based on the assumption that seismic velocity increases with depth.

A comparison of interpreted seismic data with borehole logs indicated that the bedrock depth determined from the seismic survey is not the top of rock but the depth to competent, less-fractured rock. The bedrock surface was characterized as overburden because of its relatively low velocity due to its weathered and fractured condition.



SOURCE : WESTON GEOPHYSICAL CORP., 1984

FIGURE 1-10

SEISMIC PROFILES OF RAFFINATE PIT NO. 3, LINES 1,2 & 3

Electrical resistivity results generally correlate well with the seismic refraction interpretation. In some instances, the depth to top of bedrock was less than the seismic results as shown on Figure 1-10. The geophysical results from the investigations in the raffinate pit area have characterized the subsurface as shown on Table 1-3.

Detection Sciences, Inc., 1986

Seismic refraction survey results (Figures 1-5 and 1-11) indicate four layers in the subsurface. These are described in Table 1-4. Borehole logs, however, indicate eight or more layers in the subsurface. This can be explained by the similarity in seismic velocities of various overburden layers resulting in layers with similar velocities (densities) grouped into a single unit. A further complication in interpretation results from groundwater within unconsolidated soils which increases the apparent velocity of the material and may mask the presence of underlying lower velocity material.

Results from the DSI investigation appear to be reasonable and consistent with the borehole logs. The seismic results also generally agree with previous investigations performed near the raffinate pits.

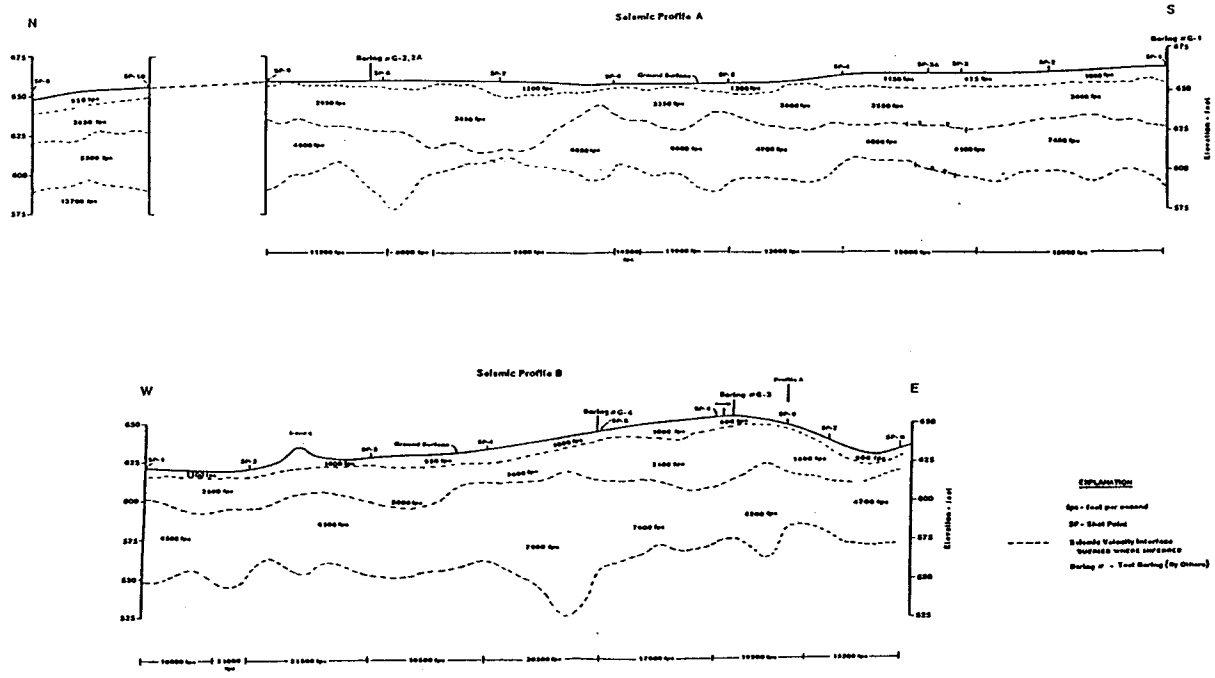
The electromagnetic (EM) surveys (Figure 1-6) were affected by buried metallic debris, pipes, and power lines. Most of the

T A B L E 1-3

CORRELATION OF SEISMIC, RESISTIVITY, AND GEOLOGICAL RESULTS, RAFFINATE PIT AREA

SEISMIC VELOCITY (ft/sec)	RESISTIVITY (ohm-ft)	MATERIAL
1,200	80 to 130	Silty clay
2,400 to 3,800	30 to 50	Unsaturated clays and clay tills
7,000 to 9,000	Greater than 1,000	Basal tills, cherty clays, and weathered bedrock
10,000 to 13,000	Greater than 1,000	Bedrock

Source: Weston Geophysical Corp., 1983



SOURCE : DETECTION SCIENCES, INC., 1986

FIGURE 1-11

SEISMIC PROFILES A AND B (PLATE 2)

T A B L E 1-4

SEISMIC REFRACTION RESULTS

Layer	Velocity ft/sec	Material
1	950-1,200	Topsoil, loess (up to 15 feet thick)
2	1,800-5,000	Overburden, weathered bedrock
3	4,000-7,650	Weathered bedrock
4	8,000-25,500	Competent bedrock

Source: Detection Sciences, Inc., 1986

observed terrain conductivities were interpreted based on the known geology and hydrology of the area. In the Ash Pond area, results indicated southwest to northeast groundwater flow. North of the chemical plant, a high conductivity (50 mmhos/m) may indicate degraded groundwater quality. East of the chemical plant, the high conductivities were interpreted as a possible expression of a solution feature. These interpretations cannot be verified at present due to the lack of drillhole information.

1.3.3.3 Validity of Methods

The geophysical methods used in the investigations were acceptable techniques and fulfilled the program objectives. Magnetometry was used only to detect magnetic anomalies at proposed monitoring well locations. The method was appropriate and the results suggested changes in proposed well locations at some sites. The accompanying electrical resistivity surveys provided additional support in characterizing the subsurface materials.

Seismic refraction surveys were most useful for determining depth to competent bedrock. Accuracy increased considerably once drillhole logs were correlated with seismic profiles. Seismic survey limitations were recognized and subsequent interpretations were more accurate.

Electrical resistivity surveys support the results of the refraction studies by providing independent data that could be correlated with the seismic studies. Interpretations were similar and usually did not differ by more than 5%, except in some instances where interpretations varied by 15% to 20%. The Wenner electrode configuration was used. It is a common and acceptable technique. Computer programs such as INVERSE were used to interpret the data and model the subsurface. This method is more accurate than manual matching of resistivity curves.

Electromagnetic traverses generally provided valid data. The presence of cultural features (power lines, subsurface pipes, and metallic structures) precluded surveys from being carried out near the chemical plant site.

The self potential technique is basically used to investigate shallow contaminant plumes. It provides qualitative information on the extent and degree of contamination. The negative anomalies detected in some areas at WSS could be interpreted as either fluid streaming or variations in the water chemistry of overburden material.

1.3.3.4 Data Sufficiency

The data obtained from previous geophysical investigations at WSS were applicable for interpretations of the subsurface in and around the raffinate pits. The data obtained were sufficient for

the scope of the BNI investigations. The coverage extended only slightly into the proposed disposal facility area. Based on the existing data, subsurface interpretations in the disposal facility area must be extrapolated from the raffinate pit area and correlated to borehole logs. Insufficient coverage in the disposal facility area needs to be augmented by additional geophysical studies.

1.3.4 Summary

Previous site investigations have been thoroughly reviewed and evaluated to determine applicability of the results for present disposal facility design requirements. Table 1-5 summarizes the findings of sections 1.3.2 and 1.3.3 regarding adequacy and sufficiency of data and investigative methods. In general, there is a lack of coherence among the studies because they were conducted for different objectives. None of the previous investigations are considered to be directly applicable and sufficient for current needs. Much of the data is useful but incomplete. As described in the previous sections, much more detail is required to obtain the engineering parameters necessary for the engineering design. The additional data requirements are discussed in Section 1.4.

TABLE 1-5

APPLICABILITY OF PREVIOUS SITE INVESTIGATIONS TO PERMANENT DISPOSAL FACILITY DESIGN

	Corps of Engineers	Henry M. Reitz	BNI (1984)	BNI (1987)	Geophysical Surveys
Purpose	General Foundation Design	Raffinate Pit Design	Geohydrologic Characterization of Raffinate Pits Area	Site G.W. Monitoring and Geohydrologic Characterization	Raffinate Pits Investigation
Location	SP/DF	RP	RP	DF	RP & AP
No. Borings	8	12	26	35	N/A
Sampling Adequacy	o	--	o	*	o
Sampling Sufficiency	--	--	o	o	*
Data Validity	o	--	o	o	*

+ = Directly applicable and sufficient.
* = Generally applicable, some deficiencies.
o = Somewhat applicable, important deficiencies.
-- = Poor, many deficiencies.

AP = Ash Pond area
RP = Raffinate Pits area
DF = Disposal Facility area
SP = Steam Plant area

1.4 Justification for Further Investigations

1.4.1 Rationale

This sampling plan proposes further site investigations necessary to demonstrate suitability of the site as a satisfactory disposal facility. Data analyses and interpretation will yield engineering characteristics of soil and bedrock affecting disposal facility performance. The following sections provide a rationale for the proposed investigations including:

- Siting decisions concerning the disposal facility
- Sufficiency and validity of the proposed data gathering
- Data requirements to establish disposal facility design criteria
- Objectives of the specific data collection methods
- Methods of data analysis and possible need for additional studies

1.4.2 Disposal Facility Siting

Siting a waste disposal facility requires a foundation that will remain stable for the facility design life. Surface stability processes such as erosion and settlement can be observed and measured. Subsurface conditions that may affect stability can be observed directly only by trenching or drilling. Remote sensing

by geophysical methods gives an indirect indication of subsurface conditions that usually require corroboration by drillholes.

The proposed investigation must demonstrate that the selected site is currently stable and has a high probability of remaining stable for at least 1,000 years. The results from the investigation described in this plan together with knowledge of the site geology will aid in assessing whether these criteria can be met.

1.4.3 Data Sufficiency/Validity

To characterize a disposal facility site, data must be collected. This data must be representative and accurate and the results must be reproducible. The following sections describe the methods that will be followed to obtain sufficient and valid data.

1.4.3.1 Geotechnical Drilling

To adequately characterize an area such as the proposed disposal facility locale, preliminary boreholes should be placed approximately 200 to 500 feet apart, with additional borings used to investigate critical locations or anomalous conditions (Bowles, 1982; U.S. Dept. of the Navy, 1982). All borings should be drilled into competent bedrock, so that sufficient overburden thickness and bedrock elevation data can be collected (U.S. EPA,

1987). The location of some of the boreholes should coincide with proposed geophysical survey line locations so that the boring results can confirm the geophysical data. Such a baseline of corroborated data can then be used to more accurately interpret the geophysical results over the entire site. The proposed drilling program is discussed in Section 2.1.

Because the site may be contaminated, wash type borings which could spread contaminants from upper to lower soils, or to bedrock, are inappropriate (U.S. EPA, 1975; U.S. EPA, 1987). Percussion drilling is not appropriate since water is required within the borehole to slurry the cuttings for removal and since it is not recommended for undisturbed sampling (U.S. Dept. of the Navy, 1982). Auger boring is the preferred method of soil drilling and particularly hollow-stem augers which serve as a casing to keep the borehole open during drilling. Since water is not required to flush the soil cuttings to the surface in auger drilling, the potential for downhole contamination is minimized.

1.4.3.2 Geotechnical Lab Testing

The sampling plan objectives relative to the geotechnical laboratory testing program are to determine the quality of the reported data and verify that it is acceptable for its intended end use. The EPA (U.S. EPA, 1976; U.S. EPA, 1982) indicates that the data quality considered to be acceptable must be defined as quantitatively as possible. Because of the inherent variability

of soils and rocks and the requirement for a quantitative acceptability standard, a statistical sampling and testing plan has been developed to address the adequacy and representativeness of the sampling and testing effort.

The overall approach of the statistical sampling and testing plan is:

1. Determine the number and types of geotechnical samples and the associated geotechnical parameters that will be considered in the disposal facility design.

2. Identify the end use of each engineering parameter.

3. Determine and summarize the valid data from existing geotechnical testing.

4. Compute sample means, standard deviation, and coefficients of variation.

5. Compute the number of samples and tests required for a desirable confidence level and a predefined confidence interval for each parameter and material type.

6. Determine the adequacy and representativeness of the collected data.

The approach presented by EPA (1976, 1982) and Barth and Mason will be used to calculate the number of required samples and tests. A confidence level of 90% will be used. If the existing number of valid data points is less than that for meeting the minimum criterion in Step 5, additional sampling and testing will be performed to meet the requirements.

Material Types and Engineering Parameters

The foundation materials of interest in the disposal facility design consist of:

Ferrelview Clay
Clay Till
Basal Till

Material of interest will also include the residuum (weathered rock/residual soil) if sufficient thickness is encountered. Other overburden material, with the exception of loess, is not expected to be present but will be tested if encountered. Loess will be excavated and spoiled when encountered. Bedrock is not included in the above list since its quantitative engineering properties are not required for design.

The bedrock will be described and classified during drilling. Rock data that might affect disposal facility design (e.g. RQD and percent of core recovery) will be presented in the drill

logs. Also, the geophysical exploration will provide information on the integrity of the bedrock foundation and possibly the presence of solution features and fractures. Laboratory tests of bedrock cores are therefore not planned as part of the characterization program.

Data From Previous Studies

The previous studies on geotechnical sampling and testing are documented in the following reports:

- U.S. Army Corps of Engineers Report (1955)
- Henry M. Reitz (1964)
- Bechtel National, Inc. (1984) (laboratory test by McClelland Engineers)
- Bechtel National, Inc. (1987)

The reports contain laboratory test data for the foundation materials in the Weldon Spring chemical plant and raffinate pits sites.

Table 1-6 summarizes the quantity and types of valid geotechnical test data contained in these reports for the three major soil types in the disposal facility area including Ferrelview Clay, Clay Till, and Basal Till. The table shows that most of the previous tests were performed on samples of Ferrelview Clay and Clay Till. There is a lack of comparable data for the Basal Till, and insufficient analyses for strength, consolidation, and

TABLE 1-6

SUMMARY OF VALID GEOTECHNICAL TEST DATA

FROM PREVIOUS STUDIES

Ferrelview Clay
No. of Tests

Tests	COE	HMR	BNI (1984)	BNI (1987)	TOTAL
Dry unit weight	-	-	12	7	19
Moisture content	-	-	15	7	22
Specific gravity	-	-	4	11	15
Atterberg limits	-	-	5	8	13
Capillary moisture	-	-	-	-	-
Gradation	-	-	5	10	15
Triaxial shear strength (CD)	-	-	1	-	1
Triaxial shear strength (CU)	-	-	1	-	1
Permeability	-	-	-	-	-
Consolidation	-	-	-	-	-
Compaction	1	2	-	-	3

TABLE 1-6 (continued)

Clay Till
No. of Tests

Tests	COE	HMR	BNI (1984)	BNI (1987)	TOTAL
Dry unit weight	-	-	5	14	19
Moisture content	-	-	7	15	22
Specific gravity	-	-	2	17	19
Atterberg limits	-	-	2	16	18
Capillary moisture	-	-	-	-	-
Gradation	-	-	2	18	20
Triaxial shear strength	-	-	-	-	-
Permeability	-	-	-	-	-
Consolidation	-	-	-	-	-
Compaction	-	-	-	-	-

Table 1-6 (continued)

Basal Till
No. of Tests

Tests	COE	HMR	BNI (1984)	BNI (1987)	TOTAL
Dry unit weight	-	-	-	5	5
Moisture content	-	-	-	3	3
Specific gravity	-	-	-	1	1
Atterberg limits	-	-	-	5	5
Capillary moisture	-	-	-	-	-
Gradation	-	-	-	6	6
Triaxial shear strength	-	-	-	-	-
Permeability	-	-	-	-	-
Consolidation	-	-	-	-	-
Compaction	-	-	-	-	-

permeability parameters for all soil and rock materials. Each valid test identified in Table 1-6 is documented in Appendix A. Documentation includes laboratory test, soil type, boring number, sample number, and test results.

Appropriate Number of Samples and Tests

As discussed previously, the appropriate number of samples and tests for achieving data sufficiency and representativeness can be determined using a statistical approach. Assuming that an engineering parameter is normally distributed, the number of samples and tests required to maintain a confidence level for that parameter to lie within a certain confidence interval can be computed. Using this approach, five tests are required for each engineering parameter of each soil type. However, as described in the following paragraph the number of tests performed will generally exceed the minimum required number calculated statistically. Standard engineering practices and professional judgement will be applied in selecting samples for testing.

Data Sufficiency

The sufficiency of the existing geotechnical test data can be evaluated based on the number of tests required as determined above. The difference between the number of existing valid test results (determined as described in Section 1.3.2) and the required number of results (5) is the number of tests that should

required number of results (5) is the number of tests that should be carried out in the testing program shown in Table 1-7. The quantities presented in Table 1-7 are the minimum that should be performed. Most physical and index property tests are relatively quick and inexpensive. These tests should be performed both for additional quality assurance checks and for obtaining basic data required for strength, compressibility, consolidation, and permeability. The index properties are frequently used in empirical correlations for estimating strengths, compression indices, preconsolidation pressures, and permeability. These estimates can provide another check on the reliability of the values of these parameters obtained by direct testing methods.

1.4.3.3 Geophysical Surveys

The objectives of the previous investigations were different from those contemplated for the disposal facility area. Previous studies were performed primarily to determine the depth to bedrock and the characteristics of the overburden. The proposed survey is designed to both define the thickness and characteristics of the overburden and determine limestone bedrock parameters. The degree of fracturing in the bedrock and the presence of voids or other solution features that may affect the disposal facility foundation are of particular interest.

TABLE 1-7

Minimum Number of Laboratory Tests
Required on Foundation Materials

Tests	No. of Tests Required		
	Ferrelview Clay	Clay Till	Basal Till
Dry unit weight	0	0	0
Moisture content	0	0	2
Specific gravity	0	0	4
Atterberg limits	0	0	0
Capillary moisture	5	5	5
Gradation	0	0	0
Triaxial shear strength (undrained-consolidated)	4	5	5
Triaxial shear strength (undrained-unconsolidated)	4	5	5
Permeability	5	5	5
Consolidation	5	5	5
Compaction	2	5	0[a]

(a) Basal Till soils are not expected to require compaction

The previous geophysical surveys were located primarily outside the present area of interest. Although geophysical data acquired in the raffinate pits are valuable in understanding the general site characteristics, current program objectives require specific information on the subsurface within the boundaries of the proposed disposal facility.

Only two seismic refraction lines from previous investigations are located within the proposed disposal facility area (Figures 1-5 and 1-11). The north-south line passing east of raffinate pits 1 and 2 is relevant because it extends along the western boundary of the disposal facility. Seismic data obtained along this line will be useful in characterizing the subsurface. The east-west seismic profile extends only 500 feet into the disposal facility area and consequently only the eastern 500 feet of the profile is relevant.

Three EM survey lines by Detection Sciences, Inc. (1987) are located within the study area. The resulting terrain conductivity contour map (Figure 1-6) covers only the northern and eastern portion of the disposal cell. These data will be useful once additional EM surveys are performed within the central area of the proposed disposal cell.

The geophysical testing program proposed for the disposal cell area is discussed in Section 2.2. Methods of investigation include various geophysical techniques, correlation with

previously acquired data, and ground-truth information provided by boreholes.

The existence of borehole logs and additional drilling will assist in the geophysical interpretation. Boreholes corroborate geophysical results and provide non-interpretive, ground-truth information used to derive more accurate interpretations.

1.4.4 Data Requirements

To site a disposal facility, an area must be screened to show that certain engineering requirements are met. These requirements are that the foundation of the disposal facility:

- Has sufficient strength to withstand horizontal and vertical forces induced by the disposal facility
- Maintains integrity for the design life of the disposal facility

To meet these criteria, soil samples must be collected and tested. Standard engineering models are then developed using the collected data. The model results will demonstrate whether or not the selected site is stable under design loads.

1.4.5 Data Collection Methods

The geotechnical and geophysical testing will use standard methods. The sampling and testing procedures are defined in the following sections.

1.4.5.1 Geotechnical Drilling and Sampling

Geotechnical samples can be either disturbed or undisturbed. Completely undisturbed soil samples are impossible to obtain, and the quality of an undisturbed sample is related to how much disturbance the sample was subjected to during sampling procedures. Disturbed samples are collected with samplers which significantly alter the structure of the in-situ soil during sampling procedures.

Disturbed samples are generally obtained using some type of split-spoon sampler. Because these samplers are usually hammer driven, vibration affects the soil within the sampler. Also, the driving shoe at the tip of the sampler has a relatively large volume displacement which disturbs the soil as it enters the sampler (U.S. EPA, 1987; U.S. Dept. of the Navy, 1982). For these reasons, disturbed sampling techniques cannot be used in obtaining soil samples for permeability, consolidation, or shear strength testing as these tests require samples with a minimum of disturbance.

Disturbed soil samples can be used for physical property and index testing such as gradation, compaction, or Atterberg limits. In addition, the standard penetration test (SPT) has been correlated with geotechnical properties such as relative density and undrained shear strength (Bowles, 1982; Lambe and Whitman, 1969; Mitchell, 1976; Terzaghi and Peck, 1967). Therefore, disturbed sampling is most useful when SPT equipment and procedures are used.

Undisturbed borehole samples are retrieved using thin-wall seamless brass or steel tubing pushed into the soil under hydraulic or pneumatic pressure. Some disturbance occurs along the outside of the sample due to friction with the inside wall of the tube; however, this disturbed area is usually trimmed off prior to laboratory testing.

In general, as the diameter of the tube increases, the quality of the soil samples increases since wall friction tends to disturb the same amount of soil regardless of the tube diameter. However, sampling costs escalate rapidly as larger tubes are used so that a compromise must be reached between sampling and testing requirements. An additional constraint is that the sampler must fit within the hollow inner stem of the augers. Three inch diameter tube samples are most common and provide adequate samples for strength, permeability, and consolidation testing of nominally undisturbed soils.

Boring logs are required to provide a record of the soil and rock types encountered during drilling. Logs also show where samples were taken within the borehole and provide sample identification and sampling method documentation.

1.4.5.2 Geotechnical Lab Testing

The following standards will be used when performing geotechnical laboratory tests:

- American Society of Testing and Materials
- Army Corps of Engineers

Specific standard methods which apply to individual laboratory tests are given in Table 3.1.

1.4.5.3 Geophysical Surveys

Various geophysical methods may be applied to meet current objectives. Data is generally obtained using signals from electronic sensors recorded in the field on a data logger and later transferred to a computer for storage and processing. Although a variety of techniques are used to obtain data by any individual method, the basic geophysical principles are followed. These techniques vary among companies involved in geophysical studies and are too numerous and complex to describe. In electrical resistivity (ER) surveys, for example,

the electrode configuration may be Wenner, Schlumberger, modified Schlumberger, monopole, dipole-dipole, or modifications of these with the first two configurations the most commonly used. Seismic refraction and reflection lines may vary in length of spread, overlap, geophone separation, energy applied, location of shot points, and minor modifications of arrays.

There are also variations in techniques applicable to electromagnetic (EM), induced polorization (IP), and self potential (SP) surveys. Microgravity and magnetometry surveys are less complex with the separation between stations and type of instrument being the basic variations. The applicability and objective of each geophysical method proposed at WSS is further discussed in Section 2.2.

SECTION 2

PROPOSED SCOPE OF WORK

2.0 PROPOSED SCOPE OF WORK

The proposed geotechnical and geophysical work tasks are necessary to demonstrate that radioactive and hazardous wastes can be safely encapsulated at the Weldon Spring Site. The combined geotechnical and geophysical studies will characterize the soil and bedrock horizons beneath the proposed disposal facility site and provide engineering parameters for design.

The "Contractor" referred to in the following sections is the Project Management Contractor responsible for overseeing the work tasks. The "Subcontractor" is the party actually performing the specific task.

2.1 Geotechnical Drilling

2.1.1 Purpose and Scope

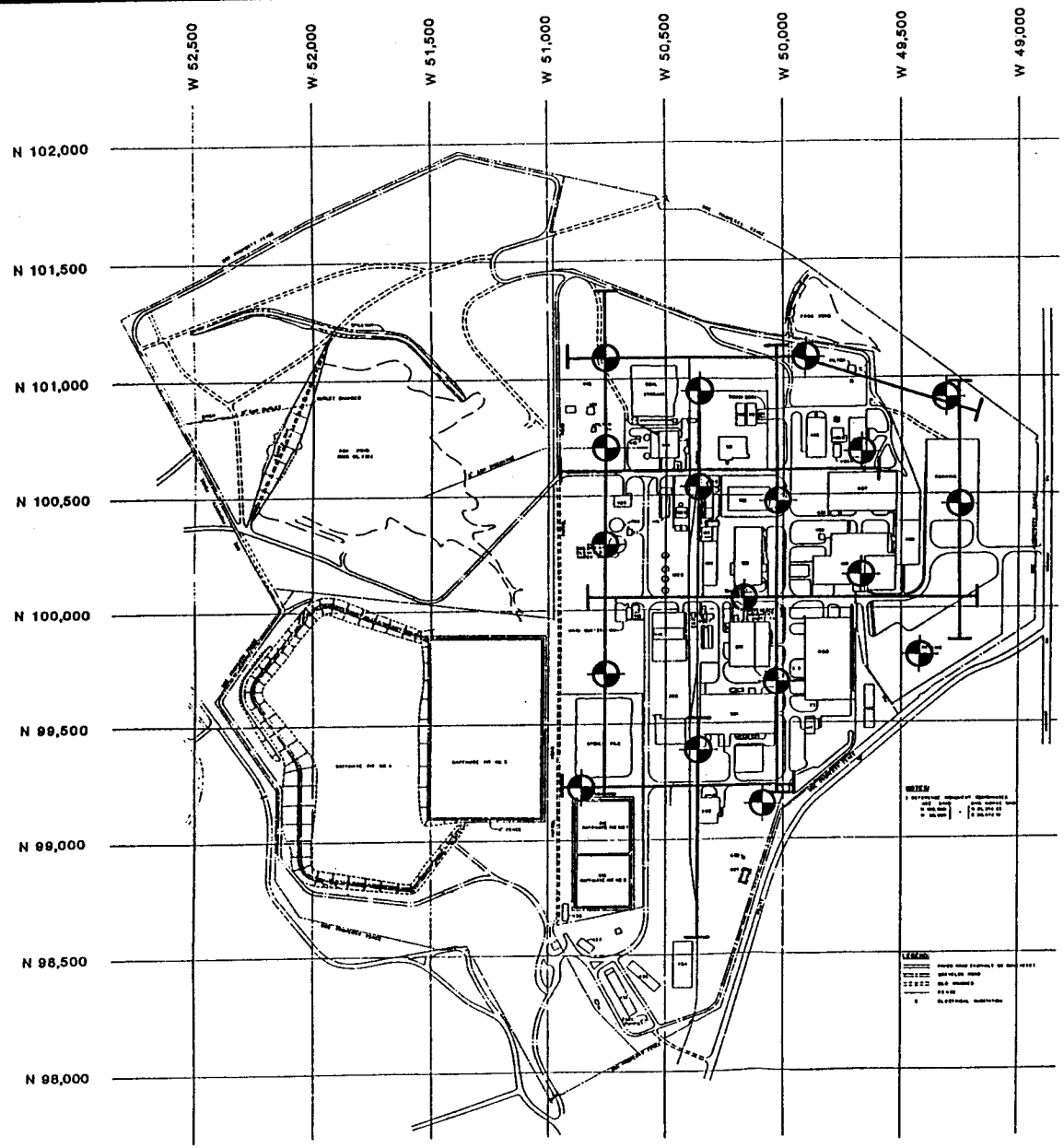
The drilling program will be used to obtain samples required for design of the disposal facility and to obtain direct visual information on soil and rock parameters and thickness of overburden. Twelve boreholes will be drilled beneath geophysical survey lines and six additional boreholes will be placed within the disposal facility area to provide additional soil and bedrock data away from the geophysical survey lines.

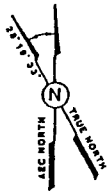
Drill holes provide noninterpretive, ground-truth information on soil and bedrock conditions. The 18 boreholes will be used to correlate geophysical measurements to subsurface conditions. Laboratory tests of samples will be performed to obtain geotechnical design data (Section 3.1.2). Additional borings into the bedrock may later be required if geophysical data reveals solution features.

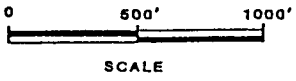
2.1.2 Drilling Locations

Approximate borehole locations are shown on Figure 2-1 on a tentative geophysical survey grid that encompasses the proposed disposal facility area. Most of the borings will be located within the chemical plant area and thus may require coring through or breaking concrete foundations to reach overburden soils.

Boreholes will generally be 50 to 70 feet deep. A minimum of two boreholes will be drilled to approximately 200 feet below the ground surface. These deep holes will be geophysically logged. All boreholes will penetrate at least 20 feet into competent bedrock. The depth and location of all boreholes will be determined by the Contractor's technical representatives including geophysicist, geologist, and engineer.







– APPROXIMATE LOCATION OF PROPOSED BORINGS

– APPROXIMATE LOCATION OF PROPOSED GEOPHYSICAL LINES

FIGURE 2-1 PLAN MAP

TENTATIVE BORING LOCATIONS AND GEOPHYSICAL LINES

Samples in the overburden will be collected at 2 1/2 foot intervals or continuously as determined by the field geologist. After a hole is advanced five feet below the ground surface, at least one undisturbed sample will be taken every five feet or at every change of material type until refusal.

Disturbed split-spoon samples will be collected between undisturbed samples. Rock samples will be obtained by coring below auger or sampler refusal.

2.1.3 Drilling Equipment and Methods

Standard drilling equipment will be used. The equipment will be capable of undisturbed and disturbed sampling above and below the groundwater table. Drilling equipment will be sufficient for coring and recovering rock core to a depth of 300 feet. The drilling Subcontractor will advance an 8-inch or 10-inch OD hollow-stem auger to refusal depth, and a 3-inch OD NQ wireline core barrel below auger refusal.

Undisturbed soil samples will be collected with new and previously cleaned 30-inch or 36-inch Shelby tubes (3-inch OD) pushed with smooth hydraulic or pneumatic pressure to the full usable length. Usable length is defined as 24 inches for a 30-inch long tube and 30 inches for a 36-inch long tube. The

Contractor may redefine usable length if sample recovery is inadequate or sample disturbance is too great.

The loaded Shelby tube shall be detached from the sampler head and then capped and wax-sealed upon removal from the borehole. After capping and sealing, Shelby tubes will be stored vertically in an environment protected from temperature extremes. Sampling techniques and equipment shall be in accordance with ASTM D1587 (Shelby Tube Sampling).

Disturbed soil samples will be recovered from clean and uncontaminated split-spoon samplers. Split-spoon soil samples will be sealed in airtight 8-ounce (or larger) glass jars and stored in a protected environment. Techniques and equipment used for split-spoon sampling shall be in accordance with ASTM D1586 (Standard Penetration Test).

Rock cores will be obtained using clean and uncontaminated 3-inch OD NQ wireline core barrels. Recovered cores will be placed in standard core boxes. Boxes will be labelled, and stored in a protected dry location to prevent mishandling and damage to the rock samples. Rock coring shall employ techniques and equipment as called for in ASTM D2113-83.

Coring shall be performed through the hollow stem of the auger. If this method proves to be unsatisfactory for any reason, a 6-inch diameter casing (schedule 40 PVC pipe) will be installed

to the depth of auger refusal and grouted in place before coring operations begin. The PVC casing will have flush threaded joints. No adhesives or solvents shall be used to cement the pipe lengths together. The borehole will be reamed to a diameter of at least 10 inches prior to casing installation to create sufficient annular space for grouting the casing into the borehole. A cement-bentonite grout mix will be used and will completely fill the annular space between the outside of the conductor casing and the natural soils of the open borehole. Grout will be tremmied from the bottom of the hole. The grout mix and the curing time will follow the Manual of Water Well Construction Practices (U.S. EPA, 1975). The casing will prevent potential leakage and cross-contamination between overburden soils and the limestone bedrock. All boreholes will be plugged after sampling has been completed and in accordance with established WSSRAP procedures.

2.1.4 Drilling and Sampling Procedures

Drilling and sampling will be performed in accordance with accepted procedures as discussed in the U.S. EPA RCRA Technical Enforcement Guidance Document (U.S. EPA, 1986). Standard operating procedures (SOPs) have been developed for WSSRAP based on EPA guidance. A supervising geologist will be present to document all drilling and sampling activities. The geologist will perform pocket penetrometer or vane shear testing on all cohesive soil samples immediately after the sample is retrieved.

Results will be recorded on the core logs. Samples will be handled, tested, and shipped in accordance with approved WSS procedures for potentially contaminated materials.

2.1.5 Decontamination

All sampling equipment, augers, drill rods, drill bits, and other equipment which has been in contact with the site soils or rock shall be decontaminated by high pressure hot water or steam before each borehole is drilled. The entire drilling rig will be decontaminated upon arrival on-site and upon completion of drilling activities. Interior portions of equipment such as pumps and hoses which are not accessible for cleaning with a pressure or steam cleaner shall be thoroughly cleaned and flushed with potable water. Decontamination will be performed at the established site decontamination pad. Split-spoon samplers shall be washed with a dispersant (such as Calgon or tri-sodium phosphate) and water, rinsed with potable water, rinsed with de-ionized water, and reassembled prior to further sampling. Solid waste from the drilling program shall be placed in barrels. The contents of each barrel will be identified. The barrels will be stored in a secure area on site.

2.2 Geophysical Surveys

2.2.1 Purpose

The primary emphasis of the geophysical program will be to try to determine if solution features are present in the bedrock below the proposed disposal facility area. These features could adversely affect the integrity of a disposal facility. The geophysical survey will also attempt to obtain other parameters that might impact the design or integrity of the disposal facility. Characteristics to be detected and delineated include, but are not limited to:

- Bedrock channel, cavity, joint, and fracture distribution
- Overburden types, thicknesses, extents, and characteristics
- Depth to top of bedrock
- Bedrock layer condition and extent
- Depth to top of saturated overburden
- Perched water tables
- Overburden and bedrock velocities and densities

2.2.2 Survey Layout

The proposed disposal facility site is located on 75 acres and includes portions of the chemical plant and raffinate pit area. Numerous buildings, concrete paving, buried pipes and other hindrances must be considered when planning the layout of geophysical survey lines. The proposed area will be crossed by north-south and east-west survey lines varying in length from 500 to 2500 feet. Approximate geophysical survey line locations are shown on Figure 2-1. These locations are only tentative and precise locations will have to be determined based on careful consideration of the many obstructions and sources of interference on the site. The location of the lines will be determined by the Subcontractor in consultation with the Contractor's geophysicist. Required depth of investigation is approximately 200 feet below top of bedrock. Both long and short survey lines will be used to investigate deep and shallow conditions/layers respectively.

Elevation and position of survey lines and stations will generally be located to an accuracy of 0.1 feet. Higher precision may be required for some surveys. Precise elevations and required positions will be determined by a licensed surveyor.

2.2.3 Geophysical Methods

The following geophysical methods are potentially applicable in this study:

- Seismic refraction
- Seismic reflection
- DC electrical resistivity (ER)
- Electromagnetic induction (EM)
- Induced polarization (IP)
- Self potential (SP)
- Microgravity
- Magnetometry

Seismics, ER, and EM are the primary methods for the current program. The accuracy of geophysical interpretations will be increased by combining and correlating data from more than one method. The primary methods will be employed for data acquisition; secondary methods may be used to support the data obtained. A description of how these methods and results address the program objectives follows.

Seismic refraction surveys yield overburden and bedrock seismic velocities. Velocities are then used to identify the top and general condition of bedrock, thickness and general consistency of overburden materials, and location of the water table in

overburden. When correlated with other geophysical methods, seismic refraction surveys could identify possible anomalous areas where solution features may be present.

Seismic reflection surveys also yield data on soil and bedrock seismic velocities. This information shows variations within the bedrock horizons. Deep penetration to 200 feet below top of bedrock may be possible through high resolution survey techniques, but shallow and irregular bedrock surfaces may disperse the reflected waves. This method may therefore be used as a secondary technique to complement the refraction surveys.

DC electrical resistivity (ER) surveys detect resistivity contrasts in subsurface materials. ER can identify overburden and bedrock layers, lateral variations in composition, and hidden lower density layers not detected by seismic methods. ER may also detect the overburden/bedrock contact and large subsurface fracture zones, cavities, or channels. This technique complements seismic methods and correlates with the electromagnetic induction data to derive more accurate interpretations or locations of fractured or cavernous areas. Both lateral profiling and vertical sounding surveys are applicable to the present investigation.

Electromagnetic induction (EM) survey data will be integrated with the ER surveys to locate anomalous areas that may contain fractures, voids, or cavities. Various exploration depths up to

250 feet may be investigated with this technique using vertical soundings as well as lateral profiling. The combination of EM and ER survey data with borehole information results in a better understanding of specific subsurface features.

Induced polarization (IP) surveys detect polarization phenomena caused by water-borne ions in clays that fill voids primarily in the overburden and above the water table. If the polarizations can be differentiated, they may identify anomalous subsurface features such as cavities. The IP survey is a secondary method that provides additional information to corroborate EM and ER data.

Self potential (SP) surveys measure the natural electric potentials in the subsurface caused by electrochemical activity such as a contaminant plume interaction with groundwater. This method can detect "streaming potentials" caused by fluid movement through fractures, joints, or cavities in the shallow subsurface.

Microgravity surveys detect density contrasts in the subsurface such as large solution features within the bedrock. With appropriate computer modeling programs, the density contrasts are identified and interpreted. To compensate for the inadequate depth control, other geophysical results and drilling are used to enhance microgravity.

Magnetic surveys are not applicable to current program objectives at WSS. Their only use would be to identify magnetic anomalies caused by buried pipes, structures or other metallic debris (cultural interference) which would impact other survey measurements.

2.2.4 Survey Techniques

The geophysical methods described in the previous section employ a variety of techniques to obtain data. Although the general principle of each method is described in the literature, the data may be obtained and processed by a variety of procedures. Differing methodologies may all be valid. Subcontractors rely on a particular combination of techniques, corresponding reduction procedures, computer programs and experience. The selection of techniques is left to the Subcontractor's discretion subject to review and concurrence by the Contractor's technical staff. Selected techniques must use proven methodologies and geophysical principles and be responsive to the primary objective of locating solution features.

SECTION 3

ANALYTICAL REQUIREMENTS

3.0 ANALYTICAL REQUIREMENTS

3.1 Geotechnical Laboratory Testing

3.1.1 Site Soils

Geotechnical laboratory testing is necessary to provide valid and sufficient data for each soil type within the Weldon Spring Site. Section 1.4.3.2 describes the statistical evaluation used to determine the minimum number of valid test results necessary to achieve data sufficiency.

Site soils relevant to design of the disposal facility are generally divided into three types. In order of increasing depth below ground surface they are:

- Ferrelview Clay
- Clay Till
- Basal Till

In addition, the residuum (weathered rock/residual soil) will be included for testing if sufficient thickness is encountered and if good quality representative samples can be obtained.

3.1.2 Laboratory Tests

The proposed laboratory testing program will be combined with results determined to be valid from the previous investigations to provide complete geotechnical design data. Assigning specific soil samples to each laboratory test will take place after the boring logs have been thoroughly reviewed and analyzed.

Testing will be performed in different phases so that representative samples can be selected for the more sophisticated tests such as shear strength and permeability. Geotechnical laboratory tests suggested for the proposed drilling and sampling program described in Section 2.1 are shown in Table 3-1 and are followed by a brief test description. For some of the detailed tests required for data adequacy such as triaxial shear strength, additional basic tests such as moisture content are recommended as a check on data consistency and reliability.

Moisture content, a physical soil property, is the ratio of the weight of the free water within the soil voids to the weight of the soil solids expressed as a percentage. The results of this test are used to help define soil horizons and to determine volume-weight relationships of the in-situ soils (U.S. EPA, 1983; U.S. Dept. of the Navy, 1982). When used with the Atterberg limits, moisture content can indicate whether a soil is preconsolidated. One moisture content test will be run on each

Table 3-1

SUGGESTED MINIMUM
NUMBER OF GEOTECHNICAL
LABORATORY TESTS

LABORATORY TEST	FERRELVIEW CLAY	CLAY TILL	BASAL TILL
Moisture Content (ASTM D2216)	18	18	18
Dry Unit Weight	18	18	1
Specific Gravity (ASTM D854)	3	3	5
Capillary Moisture (ASTM D3152 & ASTM D2325)	5	5	5
Gradation (ASTM D422)	5	5	5
Atterberg Limits (ASTM D4318)	12	12	12
Triaxial Shear Strength: Consolidated Undrained (CU), pore-pressure measurements, 3-point test (EM-1110-2-1906)	$_3$(a)	$_3$(a)	$_3$(a)
Unconsolidated Undrained UU (EM-1110-2-1906)	5	5	5
Falling Head Permeability (EM-1110-2-1906)	5	5	5
Consolidation (ASTM D2435)	5	5	5
Compaction (ASTM D698)	2	5	0

(a) Each "test" consists of one (1) specimen subjected to three (3) CU test cycles, with increasing confining (consolidation) pressures, in order to obtain three (3) data points for each "test" performed.

of the triaxial shear strength (CU and UU), permeability, and consolidation test soil samples.

Dry unit weight is another physical property of the soil, and measures the weight of the soil solids within a given volume. This test must be run on undisturbed samples, and helps to define soil horizons and determine volume-weight relationships of the soils (U.S. EPA, 1983; U.S. Dept. of the Navy, 1982). As with moisture content, one dry unit weight test will be performed on each of the triaxial shear strength (CU and UU), permeability, and consolidation soil samples.

Specific gravity measures the ratio between the unit weight of soil solids and the unit weight of water. The primary uses of the soil specific gravity are in determining volume-weight relationships and in helping to classify soils and soil types (U.S. EPA, 1983; U.S. Dept. of the Navy, 1982). Because of existing test data, only three tests will be performed on Ferrelview Clay and Clay Till samples. Five tests will be run on the Basal Till.

Capillary moisture measures the moisture content of a soil subjected to an external suction pressure. Typically, suction values ranging from -0.1 bars to -15 bars are used. Capillary moisture values are used to determine long-term moisture contents for radon attenuation studies and also for correlating unsaturated hydraulic conductivities with soil saturation

(Mitchell, 1976). Five capillary moisture tests will be run on each soil type.

Gradation tests are used to measure the relative percentages of gravel, sand, silt, and clay-size portions of a soil. Test results are used to help classify soils and to aid in defining soil horizons. Five additional gradation tests are specified for each soil type in this investigation.

Atterberg limits, in the form of plastic and liquid limits, are used to classify and characterize fine-grained soils. The plastic limit is defined as the moisture content at which a soil just begins to exhibit plastic behavior, and the liquid limit is defined as the moisture content at which a soil first begins to flow. These limits are highly correlated with shear strength, consolidation, and shrink/swell characteristics of fine-grained soils (Bowles, 1982; Lambe and Whitman, 1969; Mitchell, 1976; Terzaghi and Peck, 1967; U.S. EPA, 1975; Wroth, 1984). Three Atterberg limit tests will be performed for each of the following: triaxial shear strength (CU and UU), permeability, and consolidation for a total of twelve Atterberg limit tests per soil type.

Triaxial shear strength tests determine soil shearing strength under varying drainage and loading conditions. Consolidated-undrained (CU) tests with pore-pressure measurements provide both effective and total strength parameters for a

laboratory consolidated soil sample. Unconsolidated-undrained (UU) tests measure the undrained shear strength of soil samples which have not undergone laboratory consolidation. In general, effective strength applies to long-term or drained loading conditions, while total strength approximates actual soil strength during short-term or undrained loading conditions (Lambe and Whitman, 1969; Wroth, 1984). The undrained shear strength represents a more accurate soil strength during short-term undrained loading conditions. Three 3-point CU tests with pore-pressure measurements and five UU tests will be performed on each soil type.

Falling head permeability tests measure the flow rate of water through a given soil sample under a decreasing hydraulic gradient. Test results are given in terms of coefficients of permeability which are then used to classify the relative soil permeability. Five falling head tests will be run on undisturbed samples of each soil type. Field permeability tests may be performed if the soil encountered is below the groundwater table.

One-dimensional consolidation tests analyze time-dependent settlement behavior of fine-grained soils. Total settlement, secondary settlement, and time rates of settlement are calculated from test results. In addition, maximum past pressures and overconsolidation rates can be determined (Bowles, 1982; Lambe and Whitman, 1969; Terzaghi and Peck, 1967; Wroth, 1984). Test data from these consolidation tests will be correlated with

undrained shear strength (Wroth, 1984). Five consolidation tests will be run on each soil type.

Compaction tests determine the maximum dry density and optimum water content for a soil compacted at a specified energy level. These tests are used to determine the required compactive effort and methods of compaction. Two additional compaction tests will supplement existing data for the Ferrelview Clay. Five tests will be run on the Clay Till. The Basal Till will not be compacted during construction and thus will not be tested.

3.2 Geophysical Surveys

3.2.1 Data Reduction Methods

Data reduction translates the raw data into useful results and consists of a sequential process consisting of data retrieval, input, calculation, and output. Computer programs enhance and simplify geophysical data reduction by eliminating tedious and lengthy calculations of manual data processing. Preliminary data reduction will be done as field measurements are collected. Survey techniques can be modified and instruments can be adjusted to optimize data acquisition methods and data reliability.

Because of variable subsurface characteristics including numerous subsurface layers, irregular bedrock surface, saturated soils, perched water tables, and the water table in the bedrock,

computer data reduction procedures at WSS may require modification by manual data reduction methods. Some manual data reduction may also be required to verify computer results. Reduction processes are described in numerous geophysical publications (Breiner, 1973; Keller and Frischnecht, 1960; Telford, 1976). References and computer codes will be documented by the Subcontractor once the specific geophysical techniques are clearly identified. Independent verification of reduction methods by multiple checks, cross checks (with other results), and spot checks, especially of lengthy calculations, will be performed.

3.2.2 Data Analysis

Results of the data reduction process are used to derive subsurface interpretations. This process includes:

- Correlating data with parameters documented in the literature
- Correlating data with ground-truth information from boreholes
- Correlating data with a stored reference data base included in the computer codes
- Independent analysis of results and interpretations
- Verifying compatibility of results by correlating data obtained from different geophysical methods

The objective of the analyses is subsurface characterization. This is generally shown by means of pseudo-sections along the geophysical survey lines depicting the subsurface configuration, location of water tables, anomalous zones, and values of the soil and rock properties (e.g. resistivity or seismic velocity). Preliminary interpretations are drawn from the original data. Subsequent modifications or additions are based on further detailed correlations, additional ground-truth information, or refinements to computer models. The survey results will be presented as tables, cross-sections, and contour maps.

3.2.3 Models

Geophysical models of the WSS would be generally confined to microgravity surveys, if performed. The other survey methods yield results that directly portray the subsurface pseudo-sections. Microgravity survey models compare observed anomalies with conceptual density variations in the subsurface.

SECTION 4

QUALITY ASSURANCE

4.0 QUALITY ASSURANCE

Geotechnical drilling and sampling, geotechnical lab analysis, and geophysical surveys will be designed, performed and reviewed in accordance with the following quality assurance (QA) procedures. The QA plan includes all applicable WSSRAP procedures established in the Weldon Spring Quality Assurance Program Plan (QAPP) in accordance with EPA guidelines. The following QA requirements provide assurance that methods and techniques used to collect, analyze, and report data shall produce scientifically sound results consistent with the program objectives. Work will be carried out in accordance with WSSRAP Engineering Procedures (ENPs) and Standard Operating Procedures (SOPs). Forms required for the Geophysical/Geotechnical programs include:

- Chain of custody forms (Appendix I)
- Sample seals and tags
- Field data sheets

The required QA elements are generally described in the QAPP and in the relevant SOPs and ENPs. Task-specific aspects of the elements directly applicable to the Geophysical/Geotechnical Sampling Plan are presented in this document.

4.1 Geotechnical Drilling and Sampling

Quality assurance during drilling and sampling operations will consist of surveillance and audits of the drilling Subcontractor. Drilling and sampling procedures will be inspected. Samples will be stored in containers that will prevent sample contamination or cross-contamination.

All drilling and sampling activities shall be continuously inspected by qualified, experienced personnel. A PMC geologist or soils engineer with experience in geotechnical drilling, sampling, rock coring, and core recovery procedures will log each borehole.

4.2 Geotechnical Lab Analysis

All soil samples and rock cores will be labeled immediately after removal from the sampler. Labeling will correspond with identification provided on the borehole logs for each sample taken. All soil samples and rock cores will be stored in an environment safe from mishandling or temperature extremes.

Sample disturbance will be minimized during transport to the testing facility. Correlating sample identification to assigned laboratory tests will be verified at the laboratory upon receipt of the sample. Thorough sample tracking and documentation will be initiated and maintained throughout the testing program.

Laboratory test results will be cross-checked and approved by different personnel before being sent from the laboratory. Adherence to proper ASTM and COE standards will be verified by the Contractor prior to the start of laboratory testing.

4.3 Geophysical Surveys

Quality assurance during geophysical testing will consist of:

- Written procedures and work instructions defining the methods and sequence for performing the tests

- Approved written procedures and work instructions issued to the appropriate personnel prior to the commencement of the work and used during the performance of the tests

- Test performance by qualified personnel

- The presence of at least two persons (Subcontractor and Contractor technical representatives) for all geophysical work

- Mutual on-site verification by the Subcontractor and Contractor representatives of data acquisition, data storage, documentation of inconsistencies, problem

resolution, and adherence to all Contractor and DOE guidelines and QA/QC procedures

- Recording test results by the personnel performing the tests

- Photographing field procedures and survey locations

- Auditing all elements of the geophysical investigation and taking corrective action as required

SECTION 5

DATA DOCUMENTATION

Appendix D

Specification WP028, Geotechnical Investigation

5.0 DATA DOCUMENTATION

All field activities performed by WSSRAP staff and subcontractors will be thoroughly documented by a combination of chronological field notes encompassing all field activities, photographs of field activities, and data forms for specific sampling activities and field measurements. During the course of the geotechnical and geophysical sampling and testing, a qualified field geologist, geophysicist, or engineer will record daily activities in a permanently bound, waterproof, and paginated notebook. Entries in this notebook shall include:

- Date
- Weather conditions
- All on-site personnel involved
- Chronological record of the day's activities (a description of the activity and the time will be included)
- Any measurements or other information not recorded on designated field forms

5.1 Geotechnical Samples

5.1.1 Sample Transfer/Chain-of-Custody Records

The presence of contaminated soils requires careful handling of samples and detailed documentation. Since the extent of

subsurface contamination has not been completely delineated, all samples taken within the boundary of WSS will be considered as potentially contaminated and treated accordingly. The principal component of the quality control procedures lies in the accuracy of documentation and chain-of-custody records. Procedural requirements are:

- Strict adherence to the proposed sampling techniques as described in ASTM procedure
- Prepared labels showing project, hole location, sample identification number, date, and type of sampler
- Standardized field tracking report forms to establish sample custody in the field
- Documentation of preservation methods, if required

5.1.2 Test Records

Appropriate forms for reporting raw data and test results will be used. These forms will address all pertinent factors. In addition to the standard information required, these forms will also include the continuation of chain-of-custody by showing the hole and sample number, sample type, date, and name of the sampler. The form will also include a section where the reviewer will initial and date the form after the data and/or results have been checked. All tables and headings will be clearly identified and the appropriate units will be shown.

5.1.3 Borehole Logs

Borehole logs will be kept on-site and updated as drilling progresses. Information contained in these logs will provide an accurate characterization of the soil/rock encountered, drilling conditions, well completion (if appropriate), and any other related data pertinent to understanding borehole conditions. These logs will be prepared by a qualified geologist and reviewed for accuracy by the Contractor. The following data will be included on each borehole log (additional information may be required):

- Hole identification
- Hole location (coordinates and elevation)
- Drilling method(s) and equipment
- Drilling contractor, driller, and logger's names
- Date of drilling commencement and completion
- Total borehole depth
- Depth to water table and bedrock
- Hole diameter
- Casing diameters and quantities
- Type of casing and method of installation
- Grouted interval
- Accurate advance penetration control
- Lithologic description of materials and soil classification
- Sample numbers, depth of sample, and sample interval

- Length of sample recovered
- Description of sampling method; number of blows for Standard Penetration Tests (SPTs)
- Drilling rate and any unusual drilling problems, especially any drop of drill rods or rapid penetration
- Description of completion operations

For core logs, the appropriate information listed above will be recorded in addition to the following:

- Core length
- Coring rate
- Fluid gain or loss
- Core logs
- Percentage of recovery
- Discontinuities
- Rock quality designation
- Rock classification and lithology

5.1.4 Photographs

Photographs will be taken of soil samples prior to placement in storage containers. Opened split-spoon samples will be photographed using an adequate scale and label depicting the sampled interval, hole number, date and soil type. Rock samples may be photographed in the core boxes and must depict similar information as the soil samples. Additional photographs of

important sections of samples or drilling processes may be taken if these are relevant to the accurate documentation of the drilling/logging operation. Upon completion of the investigations, the photographs will be labeled and compiled to provide clear documentation.

5.1.5 Calculations

All calculations required for the geotechnical sampling program will follow standard quality control procedures of verification by independent checking. The reviewer will place his/her initials and date on each calculation page after appropriate verification of calculations, assumptions, data, and results. Any corrections or additions will be written without erasing or eliminating previous figures and initialed by the reviewer.

5.2 Geophysical Surveys

5.2.1 Test Records

Data record labeling shall show date, time, survey type, methodology, equipment operator, length and number of the survey lines, coordinates, instrument settings, orientation, spacings (if required), and any other inferred or required information that impacts data acquisition.

5.2.2 Equipment Calibration

All geophysical equipment will be calibrated to the manufacturer's specifications prior to commencement of any field activities and again after testing is completed. For systems with internal calibration, calibration will be performed daily prior to the start of work. Accurate documentation of all calibration will be maintained. All specifications for calibration shall be traceable to nationally recognized standards. Should no nationally recognized standards exist, the basis for calibration shall be documented.

5.2.3 Assumption Documentation

Geophysical data acquisition, reduction and interpretation generally follow standard physical and mathematical principles documented in the literature (Breiner, 1973; Keller and Frischnecht, 1966; Telford, 1976). However, certain assumptions are usually required for the data reduction process. For example, in seismic refraction investigations assumptions are required for the number of subsurface layers present and the homogeneity of the individual layers. Similar assumptions may apply to the other geophysical methods.

There also may be basic assumptions inherent in the data reduction methods themselves. For example, seismic refraction interpretation assumes that seismic velocity increases with

depth. The interpretation of other geophysical parameters may also be based on similar types of assumptions. The validity of these assumptions can be verified by correlating interpretations obtained from the various geophysical methods as well as utilizing ground-truth information from boreholes. The data reduction and analysis procedures (Section 5.2.4 and 5.2.5) will document assumptions made in the interpretation process.

5.2.4 Computer Runs

Various computer programs will be used during the data reduction procedure. The number of computer runs will be determined once the quality and quantity of data is evaluated. Computer programs will be verified and documented prior to reducing the data.

5.2.5 Data Reduction and Analysis

Proper documentation (labeling and filing) of data will be maintained throughout the reduction process. This involves clear identification of field data and final product as well as all assumptions made in the data reduction and analysis process.

All independent checks will be documented. Inconsistencies in both raw data and final results will be documented. These include inconsistencies noted in correlations of data with previous results, correlations of data among the various

geophysical methods, correlations with borehole information, and apparent inconsistencies in the data itself.

5.3 Daily Logs

The events of the day shall be maintained in a daily log by the subcontractors. These logs will include, but not be limited to, the activities performed, locations where the activity was performed, the time, the weather conditions, problems encountered and actions taken to solve them, personnel working on-site, and equipment used. These logs will become part of the permanent project record.

SECTION 6

REFERENCES

6.0 REFERENCES

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Appendix A

Summary of Valid Data From Previous Investigations

ENGINEERS
AND
CONSTRUCTORS

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

WELDON SPRING REMEDIAL ACTION PROJECT
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PHONE: (314) 441-8086

PROC-87-SM-318

August 14, 1987

ATTENTION: All Prospective Proposers

ADDENDUM NO. 01

TO

REQUEST FOR PROPOSAL NO. RFP-3589-WP028

GEOPHYSICAL INVESTIGATION

This Addendum No. 01 is issued in accordance with the Request For Proposal documents. Exact copies of this addendum have been sent to all subcontractors on the "Prospective Proposer's List".

The following modifications and/or clarifications are hereby incorporated into RFP-3589-WP028:

I. Delete in its entirety Specifications WP028, dated June 10, 1987. In its place incorporate Specifications WP028, dated August 7, 1987. The revised Specification WP028, dated August 7, 1987 reflects minor changes to Specification WP028, dated June 10, 1987. Revised sections of the Specification indicated by a vertical line in the right margin.

II. Delete in its entirety Technical Instructions to Proposers 3589-SC-WP028 dated July 7, 1987. In its place incorporate Technical Instructions to Proposers 3589-SC-WP028, dated August 7, 1987.

III. Attachment No. 1, enclosed herewith, provides additional information on the hydrogeological characteristics of the Weldon Spring Chemical Plant.

CORPS OF ENGINEERS (1955)

Laboratory Test	Soil Type	Borehole No.	Sample No.	Test Results
Compaction	Ferrelview Clay	DH-8	composite	max.=110.0 pcf Wopt=16.2%

HENRY M. REITZ (1964)

Laboratory Test	Soil Type	Borehole No.	Sample No.	Test Results
Atterberg Limits	Ferrelview Clay	TH-2	N/A (5'-6')	LL=50, PI=32
		TH-2	N/A (8.5'-9.5')	LL-59, PI=41
Compaction	Ferrelview Clay	TH-2	N/A (5'-6')	max=105.2 pcf, Wopt=17.5%
		TH-2	N/A (8.5'-9.5')	max=101.4 pcf, Wopt=18.5%

BECHTEL NATIONAL, INC. (1984)

Laboratory Test	Soil Type	Borehole No.	Sample No.	Test Results
Moisture Content	Ferrelview Clay	B-12	12	19.8%
		B-12	12	22.6
		B-13	5	21.2
		B-13	6	28.5
		B-13	7	22.8
		B-13	7	26.2
		B-13	8	23.9
		B-13	8	19.7
		B-13	8	24.0
		B-13	10	23.2
		B-13	11	24.1
		B-13	11	24.2
		B-15	9	27.4
		B-15	9	21.5
		B-15	10	21.6
	Clay Till	B-12	13	19.5%
		B-12	13	20.0
		B-12	13	21.8
		B-12	14	17.1
		B-12	14	18.7
		B-12	15	14.6
Dry Unit Weight	Ferrelview Clay	B-12	12	102.1 pcf
		B-12	12	101.1
		B-13	5	103.6
		B-13	6	91.9
		B-13	7	100.2
		B-13	7	98.3
		B-13	8	106.2
		B-13	8	99.9
		B-13	10	100.2
		B-13	11	100.4
		B-15	9	104.5
		B-15	10	96.0
	Clay Till	B-12	13	104.8 pcf
		B-12	13	103.7
		B-12	14	109.9
		B-12	14	100.6
		B-12	15	118.2

BECHTEL NATIONAL, INC. (1984)

(continued)

Laboratory Test	Soil Type	Borehole No.	Sample No.	Test Results
Specific Gravity	Ferrelview Clay	B-12	11	2.72
		B-13	8	2.81
		B-13	11	2.69
		B-15	9	2.71
	Clay Till	B-12	13	2.72
		B-12	15	2.75
Gradation	Ferrelview Clay	B-12	11	N/A
		B-13	5	N/A
		B-13	8	N/A
		B-13	11	N/A
		B-15	9	N/A
	Clay Till	B-12	13	N/A
		B-12	15	N/A
Atterberg Limits	Ferrelview Clay	B-12	11	LL=32, PI=13
		B-13	5	LL=42, PI=16
		B-13	8	LL=38, PI=22
		B-13	11	LL=66, PI=45
		B-15	9	LL=52, PI=29
	Clay Till	B-12	13	LL=56, PI=35
		B-12	15	LL=41, PI=24
Triaxial Shear Strength	Ferrelview Clay	B-15	9	C'=500 psf, $\phi=29^{o}$
Triaxial Shear Strength (CU)	Ferrelview Clay	B-15	7 & 8	C'=300 psf, $\phi=30^{o}$ (C+ϕ not plotted)

BECHTEL NATIONAL, INC. (1987)

Laboratory Test	Soil Type	Borehole No.	Sample No.	Test Results
Moisture Content	Ferrelview Clay	G-8	3	24.5%
		G-9	2	24.6
		GMW-3	ST-1	24.7
		GMW-7	ST-1	24.6
		GMW-12	ST-1	25.7
		GMW-13	ST-1	23.8
		GMW-15	ST-1	24.9
	Clay Till	G-5	ST-1	22.9%
		G-6	3	18.0
		G-8	6	16.9
		G-9	5	18.7
		G-19	2	16.9
		G-20	2	23.5
		G-21	ST-1	14.2
		GMW-4	ST-1	19.7
		GMW-5	ST-1	18.7
		GMW-6	ST-1	18.6
		GMW-8	ST-1	15.7
		GMW-10	ST-1	17.2
		GMW-11	ST-1	23.3
		GMW-14	ST-1	23.3
		GMW-18	ST-1	21.7
	Basal Till	GMW-1	ST-1	23.0%
		GMW-2	ST-1	23.1
		GMW-9	ST-1	16.5
Dry Unit Weight	Ferrelview Clay	G-8	3	115.1 pcf
		G-9	2	103.5
		GMW-3	ST-1	101.7
		GMW-7	ST-1	108.0
		GMW-13	ST-1	109.9
		GMW-15	ST-1	98.8
		GMW-17/G-10	SS-2	107.9
	Clay Till	G-5	ST-1	105.4 pcf
		G-6	3	110.6
		G-8	6	103.9
		G-9	5	107.3
		G-19	2	107.9
		G-20	2	96.7
		GMW-4	ST-1	102.9
		GMW-5	ST-1	113.4
		GMW-6	ST-1	104.7
		GMW-8	ST-1	100.3

BECHTEL NATIONAL, INC. (1987)
(continued)

Laboratory Test	Soil Type	Borehole No.	Sample No.	Test Results
Dry Unit Weight (continued)	Clay Till	GMW-10	ST-1	104.6
		GMW-11	ST-1	105.5
		GMW-14	ST-1	98.2
		GMW-18	ST-1	105.2
	Basal Till	G-15	7	104.8 pcf
		G-21	SS-5	99.4
		GMW-1	ST-1	86.5
		GMW-7	SS-9	103.6
		GMW-9	ST-1	104.8
Specific Gravity	Ferrelview Clay	G-8	3	2.53
		G-9	2	2.63
		G-14	1	2.45
		G-16	1	2.62
		GMW-3	SS-2	2.56
		GMW-3	ST-1	2.62
		GMW-7	ST-1	2.64
		GMW-12	ST-1	2.59
		GMW-13	ST-1	2.66
		GMW-15	ST-1	2.67
		GMW-18	SS-2	2.67
	Clay Till	G-5	ST-1	2.43
		G-6	1	2.67
		G-6	3	2.65
		G-8	6	2.61
		G-9	5	2.60
		G-19	2	2.68
		G-20	2	2.67
		G-21	ST-1	2.64
		GMW-4	ST-1	2.46
		GMW-5	ST-1	2.62
		GMW-6	ST-1	2.66
		GMW-11	ST-1	2.55
		GMW-13	SS-4	2.68
		GMW-14	ST-1	2.68
		GMW-15	SS-6	2.68
		GMW-17/G-10	SS-4	2.62
		GMW-18	ST-1	2.55
	Basal Till	GMW-1	ST-1	2.45

BECHTEL NATIONAL, INC. (1987)
(continued)

Laboratory Test	Soil Type	Borehole No.	Sample No.	Test Results
Gradation	Ferrelview Clay	G-8	1	N/A
		G-8	3	N/A
		G-9	2	N/A
		GMW-3	SS-2	N/A
		GMW-3	ST-1	N/A
		GMW-7	ST-1	N/A
		GMW-12	ST-1	N/A
		GMW-13	ST-1	N/A
		GMW-15	ST-1	N/A
		GMW-18	SS-1	N/A
	Clay Till	G-5	ST-1	N/A
		G-5	SS-3	N/A
		G-6	3	N/A
		G-8	6	N/A
		G-9	5	N/A
		G-19	2	N/A
		G-20	2	N/A
		G-21	ST-1	N/A
		GMW-4	ST-1	N/A
		GMW-4	SS-4	N/A
		GMW-5	ST-1	N/A
		GMW-6	ST-1	N/A
		GMW-7	SS-6	N/A
		GMW-8	ST-1	N/A
		GMW-10	ST-1	N/A
		GMW-11	ST-1	N/A
		GMW-14	ST-1	N/A
		GMW-18	ST-1	N/A
	Basal Till	G-15	7	N/A
		G-21	SS-5	N/A
		GMW-1	ST-1	N/A
		GMW-2	ST-1	N/A
		GMW-7	SS-9	N/A
		GMW-9	ST-1	N/A

BECHTEL NATIONAL, INC. (1987)
(continued)

Laboratory Test	Soil Type	Borehole No.	Sample No.	Test Results
Atterberg Limits	Ferrelview Clay	G-8	3	LL=49, PI=33
		G-9	2	LL=40, PI=23
		G-21	SS-2	LL=63, PI=43
		GMW-3	SS-2	LL=55, PI=41
		GMW-7	ST-1	LL=55, PI=37
		GMW-12	ST-1	LL=50, PI=32
		GMW-13	ST-1	LL=45, PI=28
		GMW-15	ST-1	LL=61, PI=44
	Clay Till	G-5	ST-1	LL=53, PI=36
		G-6	3	LL=46, PI=29
		G-8	6	LL=47, PI=31
		G-9	5	LL=50, PI=34
		G-19	2	LL=41, PI=27
		G-20	2	LL=62, PI=43
		G-21	ST-1	LL=42, PI=29
		GMW-3	SS-4	LL=81, PI=56
		GMW-4	ST-1	LL=48, PI=33
		GMW-5	ST-1	LL=44, PI=29
		GMW-6	ST-1	LL=42, PI=28
		GMW-8	ST-1	LL=44, PI=28
		GMW-10	ST-1	LL=39, PI=23
		GMW-11	ST-1	LL-58, PI=44
		GMW-14	ST-1	LL=53, PI=39
		GMW-18	ST-1	LL=44, PI=39
	Basal Till	G-21	SS-5	LL=35, PI=19
		GMW-1	ST-1	LL=66, PI=43
		GMW-2	ST-1	LL=35, PI=16
		GMW-5	SS-5	LL=31, PI=14
		GMW-9	ST-1	LL=41, PI=26

Appendix B

Specifications WP024-01 and WP024-02, Geotechnical Drilling and Sampling Characterization

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

SPECIFICATIONS WP024-01

SUBCONTRACT NO. 3589-SC-WP024

GEOTECHNICAL DRILLING AND SAMPLING CHARACTERIZATION

MK-FERGUSON COMPANY

WELDON SPRING REMEDIAL ACTION PROJECT

ST. CHARLES, MISSOURI

06/10/87

SPECIFICATION 3589-SC-WP024
SECTION NO. 01
WELDON SPRING SITE

GEOTECHNICAL DRILLING
AND
SAMPLING CHARACTERIZATION PROJECT

1.0 SCOPE AND OBJECTIVES

The purpose of the work is to determine the geotechnical characteristics of the soils by drilling and standard soils sampling.

This project is conducted by MK-Ferguson company (MK-F), to collect soils data at Weldon Spring Site Remedial Action Project.

2.0 LOCATION

The site is in St. Charles County, Missouri approximately 30 miles west of St. Louis, Missouri, as shown on Figures 1 and 2.

3.0 PROJECT SUPERVISION

All technical activities shall be under the supervision of the MK-Ferguson Co. (MK-F) Construction Engineer (CE). No work shall commence without the Contractor's approval.

4.0 DRILLING AND SAMPLING

4.1 General

Drilling for this subcontract is subject to the specification clauses contained in Section No. 02 of this Subcontract.

4.2 Site Conditions

4.2.1 Surface

The surface conditions on the site and in the area immediately west of the building area is relatively flat and vegetated with grasses. These areas are readily accessible by existing, improved dirt roads and paved roads and thus access problems should be minimal in the area. However, there may be areas of soft soils which will require working pads (see Section No. 02, Paragraph 6.0). Every effort will be made by MK-F to avoid drilling in locations with poor access.

4.2.2 Subsurface

Based on the best available information for the project area, the natural soils consist of 30 to 50 feet of silts and clays which overlie limestone bedrock.

4.3 Hole Location and Depths

This project is exploratory in nature. Test pit and boring locations may be anywhere within the area shown in Figure 2 of Section 02., other than areas covered by structures or paving. A total of ten (10) borings shall be drilled to an approximate depth of 50 feet (50') but shall not penetrate competent bedrock.

4.4 Sampling

Borings shall be advanced with conventional geotechnical exploratory equipment as outlined in Section No. 02. Soil sampling shall be continuous as outlined in Section No. 02.

The Sampling intervals in the overburden will be at two and one half feet (2-1/2') on center and then every five feet (5') on center past a depth of forty feet (40'). Sampling shall consist of Standard Penetration Tests (SPT), and at the discretion of the Contractor, Shelby tube or Ring Lined Split Barrel samples will be substituted for SPT sampling at certain sample intervals.

4.5 Test Pits

The Subcontractor shall supply a track or tractor mounted backhoe with a two foot (2') wide bucket capable of excavating to depths of twelve feet (12'). During the excavation of the test pits, the subcontractor shall segregate the top one foot (1') of topsoil from other excavated soils while minimizing the area of disturbance. The Subcontractor shall carefully replace excavated soils following completion of sampling in the test pits and replace the topsoil as the topmost layer of the backfill.

4.6 Soils Logging and Supervision

Soils logging, sampling, and drilling monitoring will be performed by the Contractor.

4.7 Health Physics

The Contractor shall provide industrial hygiene and/or health physics support, as appropriate, during all field operations in areas of radiological and/or chemical contamination.

The Subcontractor shall comply with all applicable Federal, State, and local health and safety regulations and requirements, including, but not limited to, those established pursuant to the Occupational Safety and Health Act (OSHA) and the WSSRA Project Safety and Health Plan.

4.8 Quality Assurance

The Contractor shall direct all fieldwork. Periodic Quality Assurance Surveillance will be performed by the Contractor to verify compliance with specification requirements.

4.9 Permits

The Subcontractor shall abide by the requirements contained in any required permits, letters of authorization, and environmental laws which are applicable to the data collection project. Copies of the applicable documents shall be transmitted to the Subcontractor by the Contractor prior to the start of fieldwork.

4.10 Site Restoration

The Subcontractor shall reclaim areas disturbed by drilling and test pitting activities performed under this subcontract.

4.10.1 All disturbed areas shall be recontoured to approximate original contours.

4.10.2 The Subcontractor shall purchase an appropriate seed mixture, spread this seed mixture over the disturbed areas, and lightly rake the seed into the surface.

SPECIFICATION 3589-SC-WP024

SECTION NO. 02

SCOPE OF WORK

WELDON SPRING SITE
GEOTECHNICAL DRILLING SPECIFICATIONS

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GEOTECHNICAL DRILLING SPECIFICATIONS

1.0 DRILL RIG EQUIPMENT AND CAPABILITIES

A drilling rig used for soil sampling shall be capable of drilling in clayey or granular soil, above or below the water table. It shall be able to conduct standard penetration tests (SPT) and push Shelby tubes. A hollow stem auger rig equipped for rotary/mud drilling satisfies the requirements of this Specification. Any change in the proposed drilling rig capabilities or other equipment must be approved in writing by the Contractor.

The Subcontractor must supply the three inch (3") outside diameter (O.D.), two and one half inch (2-1/2") inside diameter (I.D.), and twenty-four inch (24") long tube, ring lined split barrel samplers. This sampler shall be designed to accepting a 2.5" O.D. by 6" long brass tube having a 0.042 wall thickness.

2.0 SOIL SAMPLING STANDARDS, METHODS AND MATERIALS

2.1 Standards

The subcontractor's equipment must be capable of performing soil sampling using all sampling techniques and equipment in accordance with the latest American Society for Testing and Materials (ASTM) Standard. Copies of these standards are available from MK-F upon request. These include:

- ASTM D1586 - Standard Penetration Test (SPT).
- ASTM D1587 - Shelby tube sampling.
- ASTM D3550 - Ring-lined barrel sampling.

2.2 Methods

2.2.1 Standard Penetration Tests (SPT)

These tests shall be performed according to the ASTM D1586 method. The recovered SPT samples shall be sealed in airtight "olive sized" (8 ounce or larger) plastic jars, immediately on removal from the drill hole.

2.2.2 Shelby Tube Samples

Samples shall be obtained by pushing a new three (3") inch O.D. x thirty-six (36") inch long Shelby tube beneath the lead hollow-stem auger, into undisturbed ground, to its usable length or to a point of refusal. A constant smooth hydraulic pressure shall be applied as necessary to penetrate the material being sampled. Upon removal from the hole, the loaded Shelby tube shall be removed from sampler head and sealed with wax and end caps or as directed by the Contractor.

2.2.3 Ring Lined Split Barrel Samples

Samplers shall be pushed in the manner similar to that used in Shelby tube sampling, where possible. Immediately upon removal from the hole, the split barrel samplers shall be capped and taped. All brass tubes for each sample shall be retained in this manner.

2.3 Sample Handling

The Subcontractor shall place all contained samples (Shelby Tubes), neatly and carefully, in the immediate vicinity of the drill site, as directed by the Contractor. The Contractor will be responsible for labeling and shipping all samples. The Subcontractor shall assist the Contractor in handling and opening split spoons and hand samples to the Contractor for packaging and labeling.

2.4 Materials

2.4.1 Subcontractor Furnished Material

The following items will be provided by the Subcontractor for the Weldon Spring Site drilling and sampling program.

Item	Quantity	Description
1	160	Plastic jars for SPT samples, 8 ounces or larger, olive size.
2	25	Shelby tubes, three inch (3") outside diameter (O.D.) by thirty-six inches (36") long, with wax and end caps.
3	140	Brass tubes (liner), two and one half (2 1/2") inches O.D. by six (6") inches long, 0.042" wall thickness, with caps, tape and storage boxes.
4	230'	PVC, two inch (2") Schedule 40, flush-jointed, threaded, slotted 0.010" screen.
5	50'	PVC, two inch (2"), Schedule 40, flush-jointed, threaded riser
6	6	PVC slip caps
7	6	PVC Bottom plugs for piezometers
8	1000 lbs.	Bentonite pellets, 1/4" to 1/2" diameter, minimum 90% montmorillonite.
9	6	Filter pack, clean coarse silica sand. (20 to 40 mesh)

3.0 DRILLING FLUIDS AND ADDITIVES

All drilling fluids and additives must be approved by the Contractor prior to their use. Where the potential exists for drilling fluids and/or additives to contaminate existing surface or ground water, such fluids/additives shall be contained at each drill site and disposed of as directed by the Contractor.

4.0 INSTALLATION OF PIEZOMETERS

The Subcontractor shall, upon reaching bedrock, install a two inch (2") diameter piezometer according to the following specifications.

The hole shall be backfilled with bentonite pellets - 1/4 to 1/2 inch diameter having a minimum purity of 90% montmorillonite as specified by the American Colloid Company or equivalent from the top of competent bedrock to five feet (5') above the bottom of the glacial till. These pellets shall be placed through the augers in five foot (5') lifts (maximum) and hydrated with Contractor approved water.

After the final lift of bentonite pellets has hydrated, the Subcontractor shall install a 2 inch (2") inside diameter piezometer. This piezometer shall be constructed of 2 inch (2") Schedule 40 PVC, flush-threaded, factory slotted (0.010") screen and riser. The screen shall extend from the top of the bentonite plug to within five feet (5') of the surface. All screen and riser shall be placed through the augers. After the screen and riser are in place, the Subcontractor shall install a sand pack as the augers are removed. This sand pack shall extend from the bottom of the screen to one foot (1') above the top of the screen. The filter pack shall consist of a clean coarse silica sand (WB-40 or equivalent). After the filter pack is in place, the remainder of the annular space shall be sealed using the previously specified bentonite pellets. The riser pipe shall extend between 2 and 3 feet above the grade and be covered with a PVC slip cap.

5.0 WORKING PADS

It is anticipated that the surface soils may be soft in certain areas. In these areas, working pads shall be supplied and constructed by the Subcontractor from portable loading mats. The dimensions of the pads shall be limited to those required to support the drill rig and provide working space in order to limit displacement of soft soils.

6.0 FIELD DOCUMENTATION

The CE shall maintain a "Daily Field Activity Report" (a sample copy is attached to Section 02 as Figure 3) detailing billable drilling work. The Subcontractor is required to initial this report on a daily basis and note any differences that cannot be resolved. Any differences shall be documented for future reviews and resolution between the Subcontract Administrator and Subcontractor.

7.0 DECONTAMINATION EQUIPMENT AND PROCEDURES

Augers and downhole tools shall be thoroughly washed/cleaned before moving to a new hole or demobilizing from the site by the Subcontractor. These augers and tools will then be inspected by MK-F personnel before being returned to service or demobilization by the Subcontractor. MK-F shall be responsible for furnishing all potable water and cleaning equipment to decontaminate drilling equipment. Any necessary decontamination work shall be performed at the stipulated standby time (hourly rate).

8.0 PERMITS

The Subcontractor shall abide by the requirements contained in any required permits, letters of authorization, and environmental laws which are applicable to the data collection project.

9.0 LEGAL ACCESS

The Contractor will be responsible for and provide legal access Agreements and permits (if applicable) for the drilling locations. It will be the Subcontractor's responsibility to comply with the terms of the access agreements and permits which the Contractor will provide to the Subcontractor prior to commencement of work.

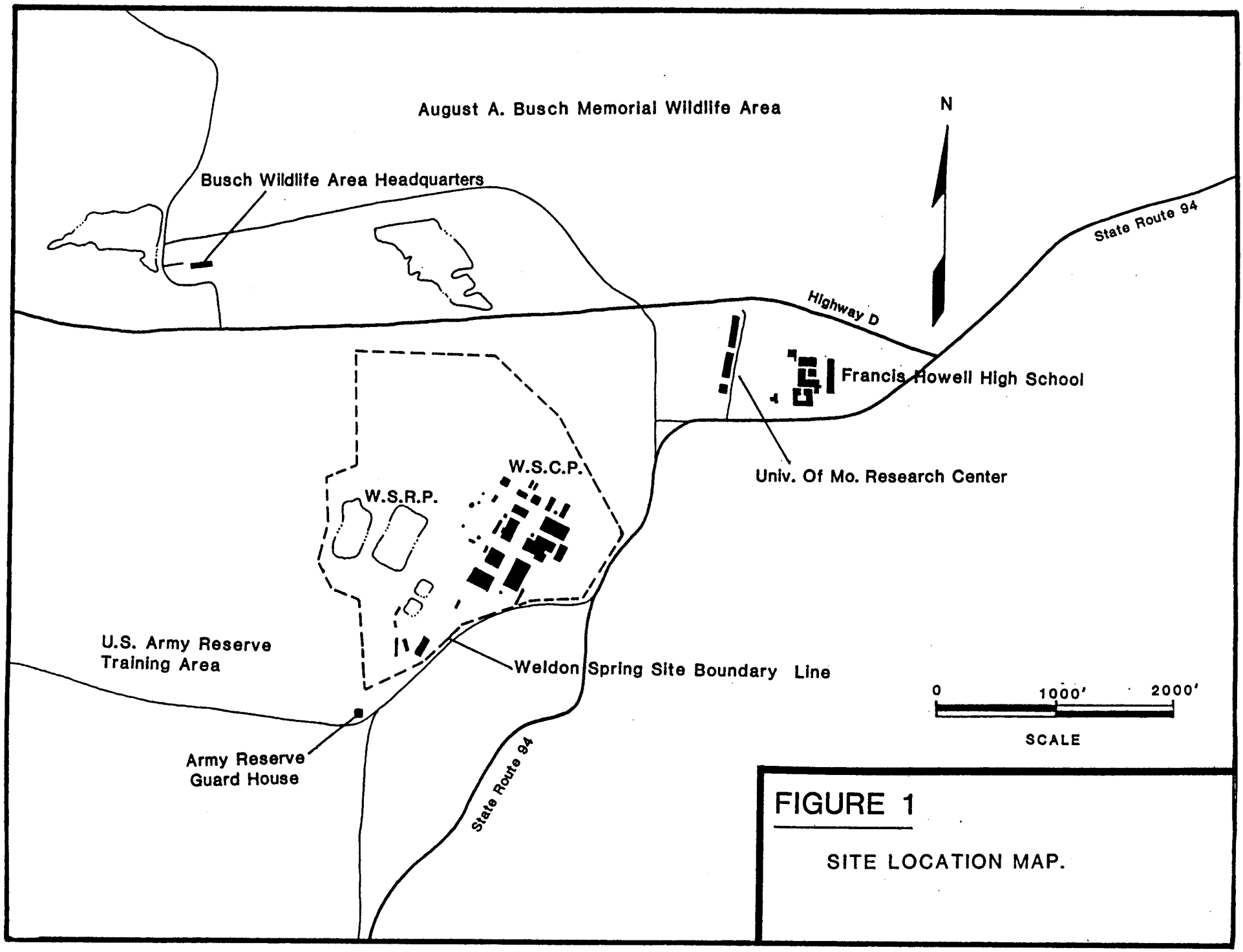

FIGURE 1

SITE LOCATION MAP.

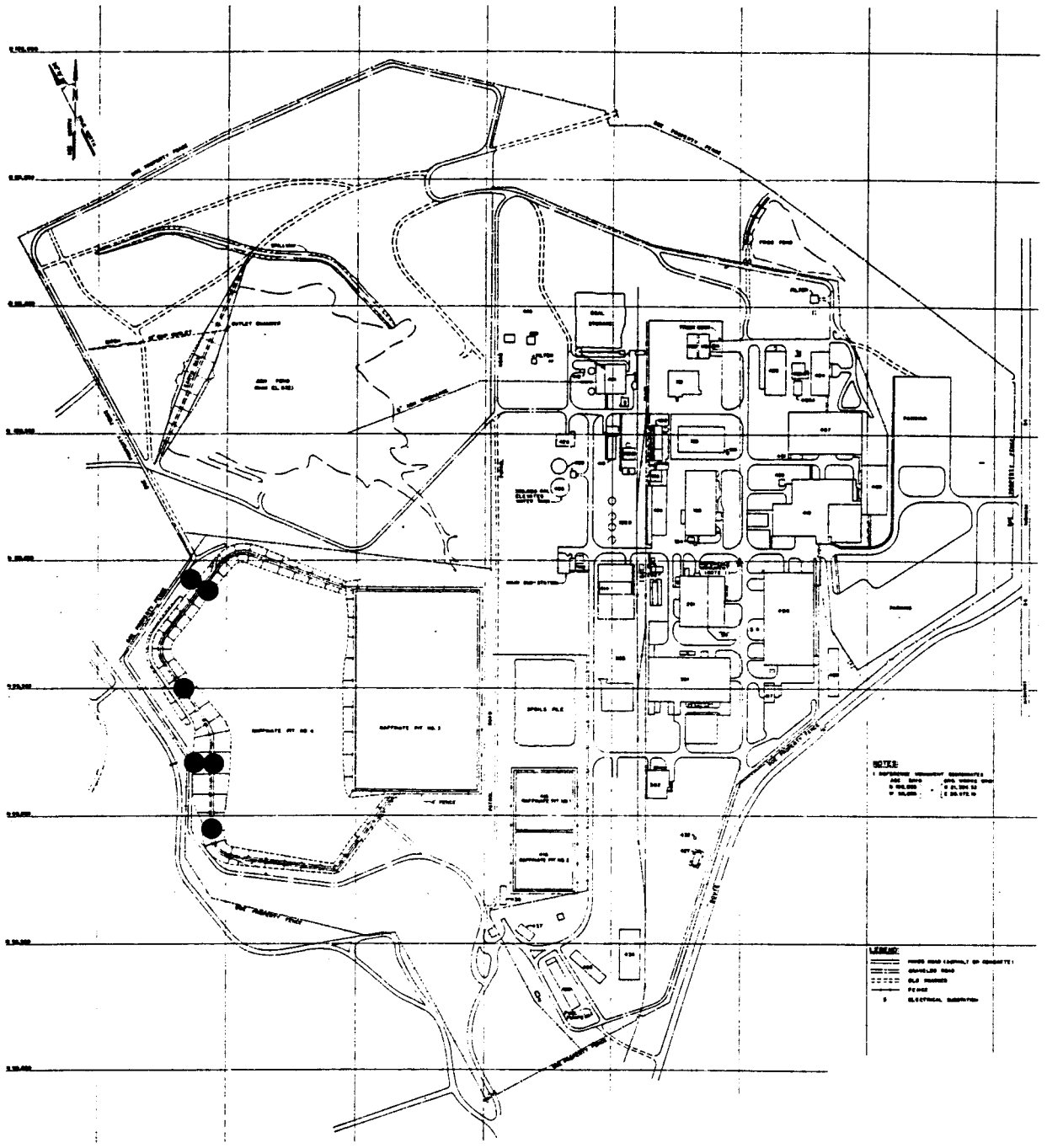

Figure 2

Geotechnical Sample Locations

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

DAILY FIELD ACTIVITY REPORT

SITE NAME : _____ CONTRACT NO. : _____ WEEK OF : _____

F.T.R. : _____ SUBCONTRACTOR : _____

BILLABLE WORK	ITEM NO.	DATE / UNITS	MON.	TUES.	WED.	THUR.	FRI.	SAT.	SUN.	WEEKLY SUMMARY
F.T.R. INITIALS :										
SUBCONTRACTOR INITIALS :										

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

SPECIFICATIONS WP024-02

SUBCONTRACT NO. 3589-SC-WP024

GEOTECHNICAL DRILLING AND SAMPLING OF PIT 4 DIKE

MK-FERGUSON COMPANY

WELDON SPRING REMEDIAL ACTION PROJECT

ST. CHARLES, MISSOURI

06/10/87

SPECIFICATION 3589-SC-WP024-02
SECTION NO. 01
WELDON SPRING SITE

GEOTECHNICAL DRILLING AND SAMPLING OF PIT 4 DIKE

1.0 SCOPE AND OBJECTIVES

The purpose of the work is to determine the geotechnical characteristics of the soils by drilling and standard soils sampling. Piezometer installation will provide a means to monitor the phreatic surface through the dike.

This project is conducted for MK-Ferguson Company (MK-F), to collect soils data at Weldon Spring Site Remedial Action Project.

2.0 LOCATION

The site is in St. Charles County, Missouri approximately 30 miles west of St. Louis, Missouri, as shown on Figures 1 and 2.

3.0 PROJECT SUPERVISION

All technical activities shall be under the supervision of the MK-Ferguson Co. (MK-F) Construction Engineer (CE). No work shall commence without the Contractor's approval.

4.0 DRILLING AND SAMPLING

4.1 General

Drilling for this subcontract is subject to the specification clauses contained in Section No. 02 of this Subcontract.

4.2 Site Conditions

4.2.1 Surface

The surface conditions on and at the toe of the dike of pit 4 varies from gravel packed to vegetated with grasses. The crest of the dike ranges in width from eight (8) to twenty feet (20'). The outer slope of the embankment is 2:1. The inner slope is fenced and the pit contains radiologically contaminated water. The area is readily accessible by improved dirt roads and paved roads and thus access problems should be minimal.

However, there may be areas of soft soils which will require working pads (see Section No. 02, Paragraph 6.0). Every effort will be made by MK-F to avoid drilling in locations with poor access.

4.2.2 Subsurface

Based on the best available information for the project area, the natural soils consist of 25 to 30 feet of silts and clays which overlie limestone bedrock. The dike rises approximately 25' above the surrounding terrain.

4.3 Hole Location and Depths

This project is exploratory in nature. Boring locations are shown in Figure 2 of Section 02. A total of six (6) borings shall be drilled; two (2) at the toe and four (4) on the crest of the dike, to an approximate depth of 30 to 60 feet but shall not penetrate competent bedrock.

4.4 Sampling

Borings shall be advanced with conventional geotechnical exploratory equipment as outlined in Section No. 02. Soil sampling shall be continuous as outlined in Section No. 02.

The Sampling intervals in the dike will be continuous and through the foundation soils at five feet (5') on center. Sampling shall consist of Standard Penetration Tests (SPT), and at the discretion of the Contractor, Shelby tube or Ring Lined Split Barrel samples will be substituted for SPT sampling at certain sample intervals.

4.5 Soils Logging and Supervision

Soils logging, sampling, and drilling monitoring be performed by the CE.

4.6 Health Physics

The Contractor shall provide industrial hygiene and/or health physics support, as appropriate, during all field operations in areas of radiological and/or chemical contamination.

The Subcontractor shall comply with all applicable Federal, State, and local health and safety regulations and requirements, including, but not limited to, those established pursuant to the Occupational Safety and Health Act (OSHA) and the WSSRA Project Safety and Health Plan.

4.7 Quality Assurance

The CE shall direct all fieldwork. Periodic Quality Assurance Surveillance will be performed by the Contractor to verify compliance with specification requirements.

4.8 Permits

The Subcontractor shall abide by the requirements contained in any required permits, letters of authorization, and environmental laws which are applicable to the data collection project. Copies of the applicable documents shall be transmitted to the Subcontractor by the Contractor prior to the start of fieldwork.

4.9 Site Restoration

The Subcontractor shall reclaim areas disturbed by drilling activities performed under this subcontract. All disturbed areas shall be recontoured to approximate original contours. Seeding is specified as follows.

4.9.1 All disturbed areas shall be recontoured to approximate original contours.

4.9.2 The Subcontractor shall purchase and apply an appropriate seed mixture, and rake into disturbed areas.

SPECIFICATION 3589-SC-WP024

SECTION NO. 02

SCOPE OF WORK

WELDON SPRING SITE
GEOTECHNICAL DRILLING SPECIFICATIONS

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SPECIFICATION 3589-SC-WP024
SECTION NO. 2

GEOTECHNICAL DRILLING SPECIFICATIONS

1.0 DRILL RIG EQUIPMENT AND CAPABILITIES

A drilling rig used for soil sampling shall be capable of drilling in clayey or granular soil, above or below the water table. It shall be able to conduct standard penetration tests (SPT) and push Shelby tubes. A hollow stem auger rig equipped for rotary/mud drilling satisfies the requirements of this Specification. Any change in the proposed drilling rig capabilities or other equipment must be approved in writing by the Contractor.

The Subcontractor must supply the three inch (3") outside diameter (O.D.), two and one half inch (2-1/2") inside diameter (I.D.), and twenty-four inch (24") long tube, ring lined split barrel samplers. This sampler shall be designed to accepting a 2.5" O.D. by 6" long brass tube having a 0.042 wall thickness.

2.0 SOIL SAMPLING STANDARDS, METHODS AND MATERIALS

2.1 Standards

The subcontractor's equipment must be capable of performing soil sampling using all sampling techniques and equipment in accordance with the latest American Society for Testing and Materials (ASTM) Standard. Copies of these standards are available from MK-F upon request. These include:

- ASTM D1586 - Standard Penetration Test (SPT).
- ASTM D1587 - Shelby tube sampling.
- ASTM D3550 - Ring-lined barrel sampling.

2.2 Methods

2.2.1 Standard Penetration Tests (SPT)

These tests shall be performed according to the ASTM D1586 method. The recovered SPT samples shall be sealed in airtight "olive sized" (8 ounce or larger) plastic jars, immediately on removal from the drill hole.

2.2.2 Shelby Tube Samples

Samples shall be obtained by pushing a new three (3") inch O.D. x thirty-six (36") inch long Shelby tube beneath the lead hollow-stem auger, into undisturbed ground, to its usable length or to a point of refusal. A constant smooth hydraulic pressure shall be applied as necessary to penetrate the material being sampled. Upon removal from the hole, the loaded Shelby tube shall be removed from sampler head and sealed with wax and end caps or as directed by the Contractor.

2.2.3 Ring Lined Split Barrel Samples

Samplers shall be pushed in the manner similar to that used in Shelby tube sampling, where possible. Immediately upon removal from the hole, the split barrel samplers shall be capped and taped. All brass tubes for each sample shall be retained in this manner.

2.3 Sample Handling

The Subcontractor shall place all contained samples (Shelby Tubes), neatly and carefully, in the immediate vicinity of the drill site, as directed by the Contractor. The Contractor will be responsible for labeling and shipping all samples. The Subcontractor shall assist the Contractor in handling and opening split spoons and hand samples to the Contractor for packaging and labeling.

2.4 Materials

2.4.1 Subcontractor Furnished Material

The following items will be provided by the Subcontractor for the Weldon Spring Site drilling and sampling program.

Item	Quantity	Description
1	160	Plastic jars for SPT samples, 8 ounces or larger, olive size.
2	25	Shelby tubes, three inch (3") outside diameter (O.D.) by thirty-six inches (36") long, with wax and end caps.
3	140	Brass tubes (liner), two and one half (2 1/2") inches O.D. by six (6") inches long, 0.042" wall thickness, with caps, tape and storage boxes.
4	230′	PVC, two inch (2") Schedule 40, flush-jointed, threaded, slotted 0.010" screen.
5	50′	PVC, two inch (2"), Schedule 40, flush-jointed, threaded riser
6	6	PVC slip caps
7	6	PVC Bottom plugs for piezometers
8	1000 lbs.	Bentonite pellets, 1/4" to 1/2" diameter, minimum 90% montmorillonite.
9	6	Filter pack, clean coarse silica sand. (20 to 40 mesh)

3.0 DRILLING FLUIDS AND ADDITIVES

All drilling fluids and additives must be approved by the Contractor prior to their use. Where the potential exists for drilling fluids and/or additives to contaminate existing surface or ground water, such fluids/additives shall be contained at each drill site and disposed of as directed by the Contractor.

4.0 INSTALLATION OF PIEZOMETERS

The Subcontractor shall, upon reaching bedrock, install a two inch (2") diameter piezometer according to the following specifications.

The hole shall be backfilled with bentonite pellets - 1/4 to 1/2 inch diameter having a minimum purity of 90% montmorillonite as specified by the American Colloid Company or equivalent from the top of competent bedrock to five feet (5') above the bottom of the glacial till. These pellets shall be placed through the augers in five foot (5') lifts (maximum) and hydrated with Contractor approved water.

After the final lift of bentonite pellets has hydrated, the Subcontractor shall install a 2 inch (2") inside diameter piezometer. This piezometer shall be constructed of 2 inch (2") Schedule 40 PVC, flush-threaded, factory slotted (0.010") screen and riser. The screen shall extend from the top of the bentonite plug to within five feet (5') of the surface. All screen and riser shall be placed through the augers. After the screen and riser are in place, the Subcontractor shall install a sand pack as the augers are removed. This sand pack shall extend from the bottom of the screen to one foot (1') above the top of the screen. The filter pack shall consist of a clean coarse silica sand (WB-40 or equivalent). After the filter pack is in place, the remainder of the annular space shall be sealed using the previously specified bentonite pellets. The riser pipe shall extend between 2 and 3 feet above the grade and be covered with a PVC slip cap.

5.0 WORKING PADS

It is anticipated that the surface soils may be soft in certain areas. In these areas, working pads shall be supplied and constructed by the Subcontractor from portable loading mats. The dimensions of the pads shall be limited to those required to support the drill rig and provide working space in order to limit displacement of soft soils.

6.0 FIELD DOCUMENTATION

The CE shall maintain a "Daily Field Activity Report" (a sample copy is attached to Section 02 as Figure 3) detailing billable drilling work. The Subcontractor is required to initial this report on a daily basis and note any differences that cannot be resolved. Any differences shall be documented for future reviews and resolution between the Subcontract Administrator and Subcontractor.

7.0 DECONTAMINATION EQUIPMENT AND PROCEDURES

Augers and downhole tools shall be thoroughly washed/cleaned before moving to a new hole or demobilizing from the site by the Subcontractor. These augers and tools will then be inspected by MK-F personnel before being returned to service or demobilization by the Subcontractor. MK-F shall be responsible for furnishing all potable water and cleaning equipment to decontaminate drilling equipment. Any necessary decontamination work shall be performed at the stipulated standby time (hourly rate).

8.0 PERMITS

The Subcontractor shall abide by the requirements contained in any required permits, letters of authorization, and environmental laws which are applicable to the data collection project.

9.0 LEGAL ACCESS

The Contractor will be responsible for and provide legal access Agreements and permits (if applicable) for the drilling locations. It will be the Subcontractor's responsibility to comply with the terms of the access agreements and permits which the Contractor will provide to the Subcontractor prior to commencement of work.

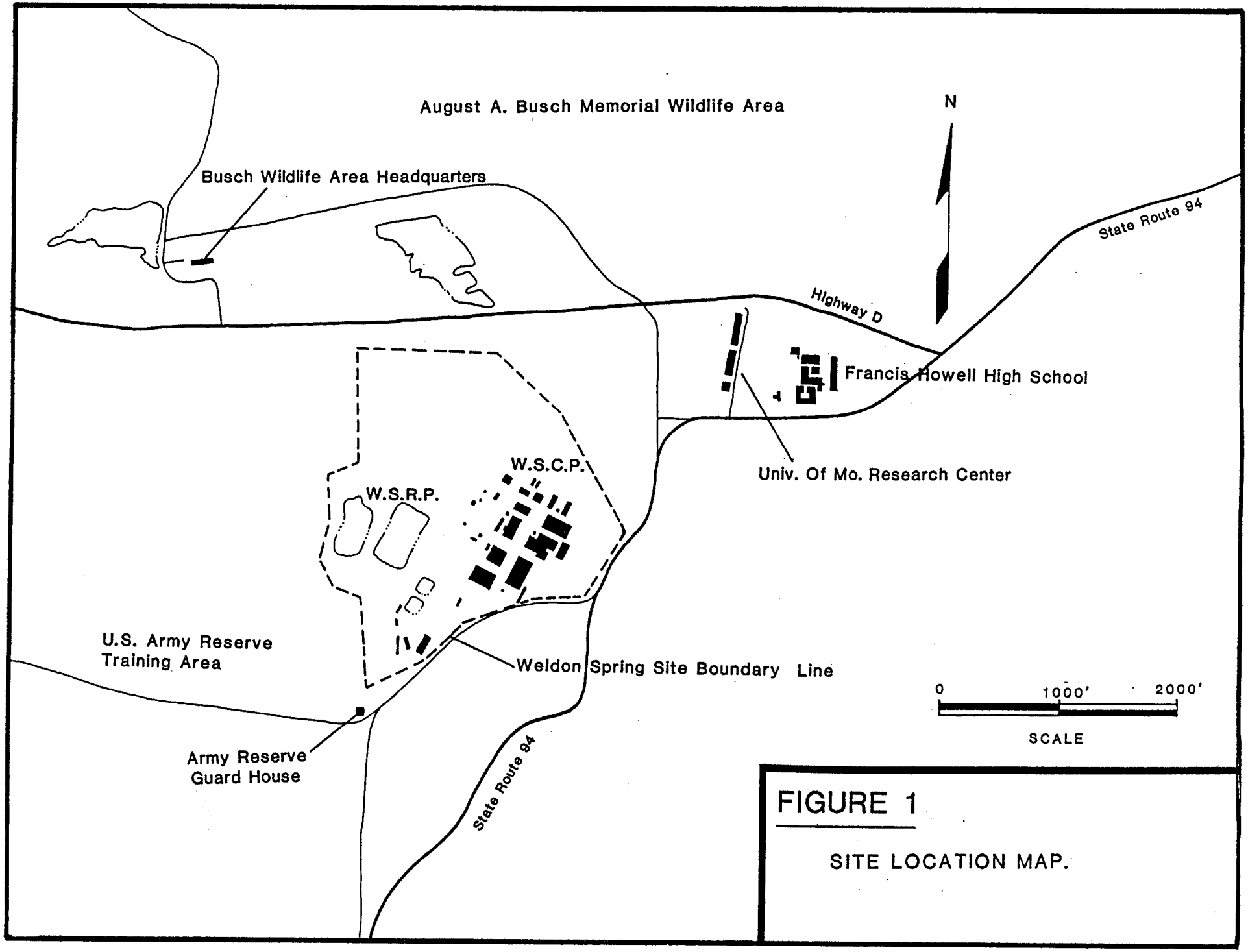


FIGURE 1

SITE LOCATION MAP.

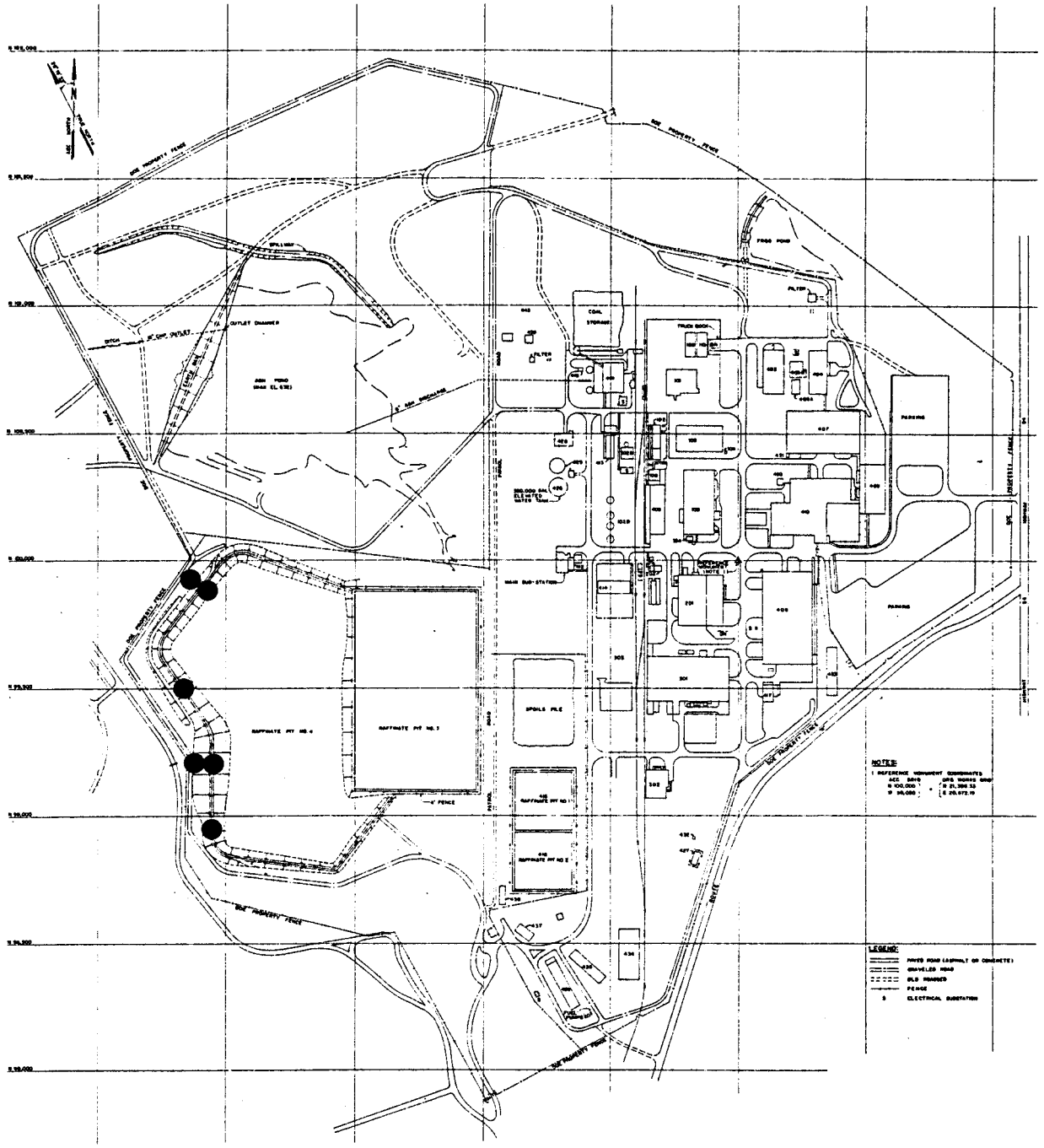


Figure 2

Geotechnical Sample Locations

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

DAILY FIELD ACTIVITY REPORT

SITE NAME : _____ CONTRACT NO. : _____ WEEK OF : _____

F.T.R. : _____ SUBCONTRACTOR : _____

BILLABLE WORK	ITEM NO.	DATE / UNITS	MON.	TUES.	WED.	THUR.	FRI.	SAT.	SUN.	WEEKLY SUMMARY
F.T.R. INITIALS :										
SUBCONTRACTOR INITIALS :										

Appendix C

Addendum No. 01 to WP024

ENGINEERS
AND
CONSTRUCTORS

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

WELDON SPRING REMEDIAL ACTION PROJECT
ROUTE 2, HIGHWAY 94 SOUTH
ST. CHARLES, MISSOURI 63303
PHONE: (314) 441-8086

PROC-87-SM-298

July 17, 1987

ATTENTION: All Prospective Proposers

ADDENDUM NO. 01

TO

REQUEST FOR PROPOSAL NO. RFP-3589-WP024

GEOTECHNICAL DRILLING AND SAMPLING CHARACTERIZATION

This Addendum No. 01 is issued in accordance with the Request For Proposal documents. Exact copies of this addendum have been sent to all subcontractors on the "Prospective Proposer's List".

The following modifications and/or clarifications are hereby incorporated into RFP-3589-WP024:

I. Add to Specification WP024-01 Section 4.5 Test Pits:

No individuals are to be in any of the test pits, therefore, no shoring is required.

II. Revision to Specifiction WP024-01 Section 2.2 Methods:

Did read:
3.2.1 Standard Penetration Tests (SPT)

Shall now read:
2.2.1 Standard Penetration Test (SPT)

III. Clarification to Specification WP024-01. Section 2.2.1 does state the required method. Tests shall be performed according to the ASTM D1586 method.

IV. Clarification to Specification WP024-01.
Section 2.2.2 does state the required method.

Samples shall be obtained by pushing a new three (3") inch O.D. x thirty-six (36") inch long Shelby tube beneath the lead hollow-stem auger, into undisturbed ground, to its usable length or to a point of refusal.

V. Revision to Specification WP024-01 Section 4.3 Hole Location and Depths.

4.3 Did read:
This project is exploratory in nature. Test pit and boring locations may be anywhere within the area shown in Figure 2 of Section 02, other than areas covered by structures or paving. A total of ten (10) borings shall be drilled to an approximate depth of 50 feet (50') but shall not penetrate competent bedrock.

4.3 Shall now read:
This project is exploratory in nature. Test pit and boring locations may be anywhere within the area shown in Figure 2 of Section 02, other than areas covered by structures. Approximately six inches (6") of concrete covers only one (1) of the boring locations. A total of ten (1) borings shall be drilled to an approximate depth of 50 feet (50') but shall not penetrate competent bedrock.

The due date and hour for proposals under this Request for Proposal remains scheduled for Wednesday, July 29, 1987 at 3:00 p.m. local time. Proposals may be hand-delivered to the cognizant Subcontract Administrator, S. A. Mager, during the 15-minute time period immediately prior to this deadline, or mailed to reach MK-F prior to bid due date/time.

You are reminded that each addenda to this RFP must be acknowledged on the first sheet of the proposal sheet of the

proposal form by inserting the NUMBER (i.e. 01) in the space provided.

Sincerely,

S. A. Mager

S. A. Mager
Subcontract Administrator

SAM/kh

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

SPECIFICATIONS WP028

SUBCONTRACT NO. 3589-SC-WP028

GEOPHYSICAL INVESTIGATION

MK-FERGUSON COMPANY

WELDON SPRING REMEDIAL ACTION PROJECT

ST. CHARLES, MISSOURI

AUGUST 7, 1987

SPECIFICATION 3589-SC-WP028

WELDON SPRING SITE

GEOPHYSICAL INVESTIGATION

1.0 OBJECTIVE & SCOPE

1.1 OBJECTIVE

The objective of the geophysical investigation is to provide a geological model of the subsurface below the proposed area for the disposal cell. The geological model shall address, in adequate detail for design, the characteristics of the overburden and the bedrock, with particular attention to the configuration of the bedrock surface, and the distribution, orientation, dimensions, and condition of cavities, channelways, and fracture systems within the bedrock.

1.2 SCOPE

The geophysical investigation shall consist of acquisition survey(s), data processing, interpretation, modelling and reporting to provide the Contractor with continuous subsurface information across the disposal cell area.

The investigation shall be limited in geographical extent to an area of about 44 acres: 30 acres within the perimeter of the proposed disposal cell area, plus 14 acres within a 100-foot-wide area surrounding the perimeter (see Exhibit 2). The depth of investigation shall be not less than 200 feet below the top of bedrock.

1.3 The Subcontractor shall submit a report fulfilling the requirements of this Specification. A draft version of the report shall be submitted for review and comment by the Contractor prior to issuance of the final report.

2.0 PROJECT SUPERVISION

2.1 The geophysical surveys shall be designed and conducted by the Subcontractor in close coordination with the Contractor to ensure that the data needs will be fulfilled.

3.0 SITE CONDITIONS

3.1 As shown on Exhibit 2, improved dirt roads and paved roads form an east-west, north-south grid across the area of investigation. However, there may be areas of soft soils which may require working pads should the Subcontractor wish to occupy them with geophysical equipment, instruments, or vehicles.

3.2 Numerous buildings, as well as raffinate pits, coal storage and spoils piles, and other features shown on Exhibit 2, exist on the site, and may influence the physical layout, equipment and types of surveys for a geophysical investigation. The Subcontractor shall be aware of the potential for utilities within or immediately adjacent to the area to be investigated. Power lines, overhead and underground metallic pipelines, and metallic structures are all present.

3.3 Topographically, the area of investigation is one of relatively flat terrain with surface elevations generally between about 640 and 665 feet above sea level. Exhibit 3 shows the topography across the site area.

3.4 The best information available to the Contractor at this time shows that in general, unconsolidated overburden overlies bedrock across the area of investigation. Generally, the overburden, with an average thickness of about 30 feet, consists of topsoil, modified loess, clay (Ferrelview Formation), clay till, basal till, and cherty clay in descending order from the ground surface. The continuity of each of these overburden units across the entire area is suspect.

3.5 Bedrock is comprised of the cherty limestone of the Burlington/Keokuk Formation. The upper surface of the bedrock unit is highly irregular and has been referred to as being "pinnacled." This irregularity, and the variability of the rock mass within its upper 40 feet, has been attributed to dissolution and other weathering phenomena. Underlying the weathered zone of the bedrock, the limestone is competent, fine-to coarse-grained locally fractured and contains solution features.

3.6 The best information available at this time shows a subsurface structure of four layers. The velocity, thickness or depth, and geologic interpretation of each layer are summarized below:

3.6.1 Layer 1 - 950 to 1200 feet per second (fps); up to 15 feet thick; topsoil and possibly other loose overburden such as the modified loess unit.

3.6.2 Layer 2 - 1800 to 5000 fps, averaging about 3000 fps, but with anomalously high and low velocities detected; 10 to 43 feet thick;

predominantly overburden, but may include weathered bedrock.

3.6.3 Layer 3 - 4000 to 7650 fps, averaging 6000 fps; depth to top of layer ranges between 15 and 45 feet; predominantly weathered bedrock, but may include compacted and/or saturated overburden.

3.6.4 Layer 4 - 8000 to 25,500 fps, averaging 17,000 fps; depth to top of layer is 43 to 110 feet, averaging 70 to 75 feet; harder, more competent, and less weathered bedrock.

4.0 PERSONNEL

4.1 The geophysical investigation shall be performed by personnel qualified on the basis of education, experience, and training. The professional geophysicists, other degreed professionals, as well as non-degreed technicians that perform the field and central office tasks shall have actual and verifiable experience in geophysical surveying, data processing, interpretation and modelling procedures proposed by the Subcontractor. The Subcontractor shall, prior to starting work, satisfy the Contractor that the Subcontractor's personnel are the same as those proposed. The Subcontractor shall notify and receive approval from the Contractor for any personnel changes.

5.0 PERFORMANCE DOCUMENTATION

5.1 The documentation of the results of the geophysical investigation shall demonstrate satisfactory completion of the investigation and form the basis for the Subcontractor's interpretations, judgements, and decisions. The documentation shall be complete,

including as appropriate, the following minimum requirements:

- o Field data forms, logs, and notebooks
- o Land survey data
- o Final computer output
- o Verification of assumptions
- o Photographs
- o Peer review reports
- o Calculations
- o Results and interpretation of the geophysical investigation

All such documentation generated by the Subcontractor shall become a part of the project records.

5.2 The Subcontractor shall provide access at any time to all of the project documentation (field notes, calculations, etc.) necessary to produce the final report.

6.0 EQUIPMENT REQUIREMENTS

6.1 The geophysical survey techniques and equipment proposed by the Subcontractor for the site investigation shall be selected on the basis of the following factors:

- o Site conditions

- o Type of information required
- o Extent of information required
- o Results of previous geological and geophysical investigations
- o Suitability of geophysical survey techniques and equipment for fulfilling the data needs and satisfying the stated objective
- o Speed, economy and accuracy with which the investigation can be performed and completed.

6.2 Geophysical survey techniques and equipment employed in the site investigation shall be limited to surface methods to ensure that the following data be provided with a high degree of confidence:

- o Total thickness of overburden
- o Lateral and vertical extent/dimensions of each overburden layer
- o Material types, characteristics and variation of each overburden layer, including velocities/densities
- o Depth to bedrock
- o Distribution, orientation and dimensions of solution channels and other anomalous features or irregularities in the bedrock surface

- Distribution, orientation, dimensions and depth below bedrock surface of solution cavities, channelways and their interconnections

- Distribution, dimensions and orientation of joints, solution-widened joints and of other fracture systems

- Lateral and vertical extent of bedrock layers, including weathered zone

- Material types, characteristics and variation of bedrock layers, including velocities/densities

- Nature of cavity, channel or joint infilling material (air, water, clay, other geologic material, or combination)

- Location of top of saturated overburden/perched water tables

- Location of water table within the bedrock

6.3 The Subcontractor's proposed techniques, equipment and instrumentation shall ensure that the time at the job-site and the central office is minimized.

6.4 The Subcontractor shall provide all of the personnel, geophysical equipment and instrumentation, and any ancillary equipment necessary to perform and complete the geophysical investigation.

7.0 CALIBRATION OF EQUIPMENT

7.1 The Subcontractor shall assure that the geophysical survey equipment used to obtain field measurements during the site investigation is calibrated and maintained in accordance with documented procedures at prescribed intervals and/or prior to use. The Subcontractor shall calibrate equipment to National Bureau of Standards (NBS) criteria. If NBS standards have not been established, the Subcontractor shall calibrate equipment to the appropriate manufacturer's standard.

7.2 The Subcontractor shall furnish the Contractor with a signed and dated copy of the documented calibration procedures at the time of award and thereafter. The procedures shall be based on the type of equipment, effect of error on the quantities measured, stability characteristics of the equipment, required precision and accuracy, or other conditions affecting measurement control. Procedure content should include, as appropriate:

- Identification of equipment.
- Documented or reference calibration methods.
- Acceptance limits.
- Frequency of calibration.
- Tagging of the equipment to indicate calibration status.

- o Identification and traceability of calibration standards.

- o Segregation and identification of equipment failing calibration to prevent inadvertent usage.

- o Required documentation.

7.3 The Subcontractor shall furnish the Contractor with records prepared and maintained for each piece of equipment subject to calibration to indicate that the Subcontractor's established calibration procedures and schedules have been followed. The records should contain a history of calibration, acceptance/failure, and repair. Each file should include, as appropriate:

- o Name and identification number of the equipment.

- o Calibration frequency.

- o Names of individual(s) performing the calibration.

- o Acceptance limits.

- o Most recent calibration data and results of equipment evaluation.

- o Identification of calibration standard and/or test equipment used.

- o Certificates or statements of calibration provided by manufacturers or external organizations.

- o Schedule of due dates for recalibration.

7.4 The geophysical survey equipment and instrumentation used by the Subcontractor during the site investigation shall be uniquely identified by the manufacturer's serial number or an assigned identification number. Whenever possible, the assigned number shall be indicated by a label or tag attached to the equipment. Calibration status shall be indicated by a label or tag attached to the equipment and showing date of last calibration and due date of recalibration.

7.5 Should the latter be impractical, records traceable to the equipment shall be readily retrievable for reference with the recalibration due date clearly indicated.

8.0 PERFORMANCE

8.1 The Subcontractor shall, at a minimum, design the geophysical investigation to ensure that all personnel and equipment are on-site at the proper time, conduct the field data acquisition and preliminary processing for quality control, process all data acquired during the field surveys, interpret the data, model the results, and prepare and submit the data and final reports of the investigation to the Contractor.

8.2 The Subcontractor, at a minimum, shall design the surveys to provide continuous subsurface coverage across the area of investigation and ensure that the data needs will be fulfilled. During the conduct of the surveys, the Subcontractor shall verbally keep the Contractor informed of the status of the data acquisition process and the outlook for successful and timely completion of the work. The final report shall include a geological model representative of the

subsurface at the proposed disposal cell site, with appropriate descriptive and explanatory narrative, as well as appropriate graphical data and interpretation representations.

9.0 SITE CLEANUP AND RESTORATION

9.1 The Subcontractor shall be responsible for site cleanup and restoration required as a result of the geophysical surveys. This shall include:

1. Removing any survey stakes and flagging.

2. Repairing fences or damaged structures.

3. Retrieving detonator leads, backfilling shot holes and inspecting area for remaining explosives, if explosive charges are used for seismic sources.

10.0 DATA PROCESSING

10.1 Processed data shall be legible and in a form suitable for reproduction, filing and retrieval. Calculations shall include assumptions, methods of computation, parameters and physical units so that a qualified individual can review and understand the processing and verify the results. Data processing shall be identified by project name and number, activity or survey type and location, originator and data collected, and reviewer and date reviewed.

10.2 Assumptions shall be documented; assumptions which cannot be verified shall be identified. The methods used for reducing and processing the field data shall be identified. Associated computer output shall be identified by run number or other unique means.

10.3 The results and conclusions of processing large quantities of data shall be summarized. The results and conclusion can be presented in, or form the bases for drawings, graphs and tables.

11.0 DECONTAMINATION

11.1 If the Subcontractor is directed by the Contractor to decontaminate any equipment, he shall be reimbursed at the standby hourly rate.

Appendix E

Addenda Nos. 01 and 02 to WP028

IV. Incorporate the drawings identified on the enclosed Index of Drawings. Drawings are sent as a separate package.

V. Delete in its entirety the Pricing Proposal for RFP WP028. In its place incorporate 3589-SC-WP028 Pricing Proposal Rev. 1.

The due date and hour for proposals under this Request for Proposal remains scheduled for Friday, September 4, 1987 at 3:30 p.m. local time. Proposals may be hand-delivered to the cognizant Subcontract Administrator, Mr. S. A. Mager, during the 15-minute time period immediately prior to this deadline, or mailed to reach MK-F prior to bid due date/time.

You are reminded that each addenda to this RFP must be acknowledged on the first sheet of the proposal sheet of the proposal form by inserting the NUMBER (i.e. 01) in the space provided.

Sincerely,

S. A. Mager

S. A. Mager
Subcontract Administrator

SAM/kh
Enclosure

ENGINEERS
AND
CONSTRUCTORS

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

WELDON SPRING REMEDIAL ACTION PROJECT
ROUTE 2, HIGHWAY 94 SOUTH
ST. CHARLES, MISSOURI 63303
PHONE: (314) 441-8086

PROC-87-SM-336

August 28, 1987

ATTENTION: All Prospective Proposers

ADDENDUM NO. 02

TO

REQUEST FOR PROPOSAL NO. RFP-3589-WP028

GEOPHYSICAL INVESTIGATION

This Addendum No. 02 is issued in accordance with the Request For Proposal documents. Exact copies of this addendum have been sent to all subcontractors on the "Prospective Proposer's List".

The following modifications and/or clarifications are hereby incorporated into RFP-3589-WP028:

I. SPECIFICATION

Delete in its entirety Section 1.2 SCOPE from Specification WP028 dated: August 7, 1987. In its place incorporate the enclosed revised Section 1.2 SCOPE.

II. DRAWINGS

Delete in its entirety Exhibit 3 "Disposal Cell." In its place incorporate the enclosed revised Exhibit 3 Rev. 1.

The due date and hour for proposals under this Request for Proposal is now scheduled for September 18, 1987 at 3:30 p.m. local time. Proposals may be hand-delivered to the cognizant Subcontract Administrator, Mr. S. A. Mager, during the 15-minute time period immediately prior to this deadline, or mailed to reach MK-F prior to bid due date/time.

You are reminded that each addenda to this RFP must be acknowledged on the first sheet of the proposal sheet of the proposal form by inserting the NUMBER (i.e. 02) in the space provided.

Sincerely,

S. A. Mager

S. A. Mager
Subcontract Administrator

SAM/kh
Enclosures

SPECIFICATION 3589-SC-WP028

1.2 SCOPE

The geophysical investigation shall consist of acquisition survey(s), data processing, interpretation, modelling and reporting to provide the Contractor will continuous subsurface information across the disposal cell area.

The investigation shall be limited in geographical extent to an area of about 75 acres (see Exhibit 3). The depth of investigation shall be not less than 200 feet below the top of bedrock.

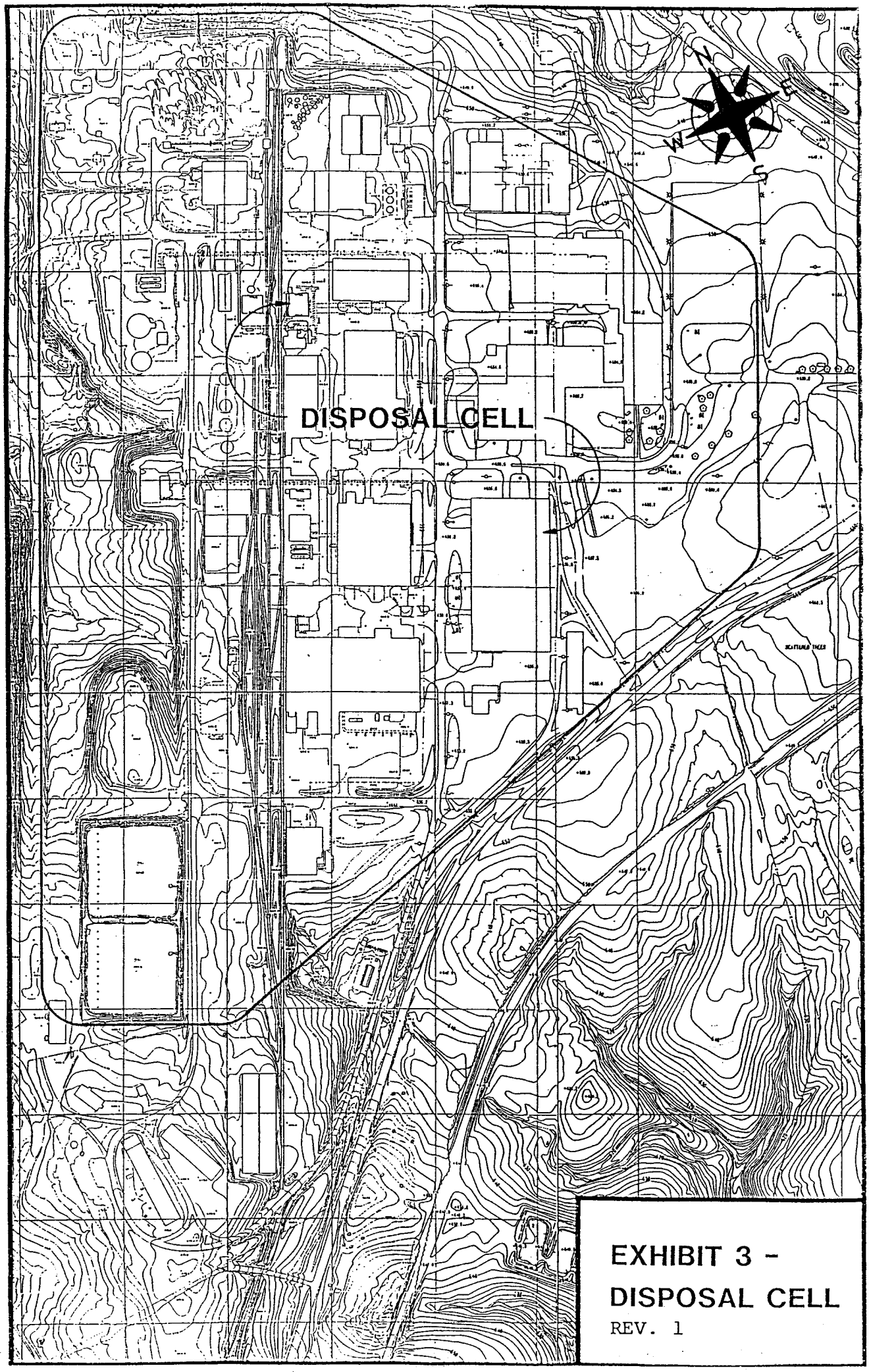


EXHIBIT 3 - DISPOSAL CELL

REV. 1

Appendix F

Specification WP029, Geotechnical Laboratory Testing

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

SPECIFICATIONS WP029

SUBCONTRACT NO. 3589-SC-WP029

GEOTECHNICAL LABORATORY TESTING

MK-FERGUSON COMPANY

WELDON SPRING REMEDIAL ACTION PROJECT

ST. CHARLES, MISSOURI

Dated: 07-09-87

SPECIFICATION 3589-SC-WP029

SECTION A

DATED 07/09/87

SCOPE OF WORK

GEOTECHNICAL LABORATORY TESTING

1.0 Scope and Objectives

The Subcontractor shall provide the services and supplies required for geotechnical laboratory testing of radiologically and chemically contaminated and uncontaminated soils, rock, sludges, and stabilized sludge in support of MK-F's prime Contract to the U.S. Department of Energy under the Weldon Spring Site Remedial Action Project (WSSRAP).

The objective of this Subcontract is to provide a detailed geotechnical evaluation of the soils at a potential disposal site and the Raffinate pit sludges. Sludge stabilization testing is intended to provide a range of mix designs that will meet workability, absorption, and strength criteria. Mix design will be phased work, closely coordinated and directed by a designated Contractor representative.

The following outlines the proposed scope of services that will be required to obtain geotechnical information of the proposed materials.

2.0 Soil, Rock, and Sludge Sample Containers and Labeling

Sample collection and delivery will be the responsibility of the Contractor. Soil samples will be contained in large and small plastic bags, jars, Shelby tubes, and 2 to 3 inch diameter tube (ring) samples. Bulk samples will be contained in 5 gallon buckets with lids. The samples will be independently labeled by the Contractor for adequate identification as to site, location, sample number, depth, etc. All undisturbed samples (Shelby tubes) as indicated by the Contractor shall be stored in the vertical position.

3.0 On-Site Laboratory Requirements

The Subcontractor may choose to provide a mobile laboratory, to be parked at a designated location on the Weldon Spring Site for approximately four (4) months. The Subcontractor shall direct all wash water and any other water resulting from laboratory operations to the existing sump located at the mobile laboratory site and operate the existing pump in that sump to ensure that the sump does not overflow. An on-site laboratory used by the Subcontractor shall be equipped in accordance with the applicable health and safety regulations.

4.0 Laboratory Testing

Laboratory testing, (as defined below), of retained soil, rock, sludge, and stabilized sludge samples will be required. All testing shall be performed in conformance with the latest edition of the appropriate ASTM Standard or other specified standard. Tests required, but for which no standard exists, will require the Subcontractor to present, in writing, proposed test procedures. These methods will then be approved, disapproved, or approved with modification to the satisfaction of the Contractor and the Subcontractor prior to performing any testing. Tests which may be necessary include, but are not limited to, the following:

Sieve analysis without hydrometer (ASTM ~~C136~~ D422)
Sieve analysis with hydrometer (ASTM D422)
Atterberg limits (ASTM D4318)
Moisture content (ASTM D2216)
Moisture density (ASTM D698)
Capillary moisture relationships (ASTM D3152 and ASTM D2325)
Specific gravity (ASTM D854)
Triaxial permeability (Army Corps of Engineers EM 1110-2-1906)
Three point sets Triaxial (R) (Army Corps of Engineers EM1110-2-1906)
Three point sets Triaxial (Q) (Army Corps of Engineers EM-1110-2-1906)
One-dimensional consolidation (ASTM D2435)
Crumb tests (ASTM Proceedings STP623)
Pinhole (ASTM ~~D422~~ STP 623)
Remolding of samples per test sample
Leaching tests (EP Toxicity)
Partially saturated hydraulic conductivity
Aggregate specific gravity and absorption (ASTM-C127)
Aggregate soundness (ASTM C88-course aggregate only) (Sodium)

Los Angeles abrasion (ASTM C535)

Rock crushing in preparation of samples per bulk samples

Petrographic analysis of rock samples (ASTM C295)

Resistance of rock material to freezing and thawing (ASTM C666 Procedure A)

5.0. Testing Procedures

The following are some specific requirements relating to the testing to be done under the terms of this Subcontract.

1) Compacting Samples of Cohesive Soil and Stabilized Sludge

Samples of compacted soil shall be prepared in a split mold having inside dimensions equal to the dimensions of the desired sample. The soil shall be compacted into the mold in 6 equal layers using a pressing or kneading action of a tamper having a contact area with the soil of less than one-sixth the area of the mold. The surface of the layer shall be thoroughly scarified before placing the next layer. Under no circumstances shall standard impact types of compaction be acceptable.

The sample shall be prepared according to the ASTM D-698 test procedure using an appropriate amount of water to produce the desired water content.

The desired density shall be produced by either kneading or tamping each layer until the accumulated weight of the soil placed in the mold is compacted to a known volume or by adjusting the number of tamps per layer and the force per tamp. For the latter method of

control, special constant force tampers are necessary. After each sample has been compacted to finished dimensions and removed from the mold, the appropriate laboratory test may be performed. Input parameters such as moisture content at compaction, etc., will be provided by the Contractor.

Preparation of compacted granular soils shall be performed as outlined in the U.S. Army Corps of Engineers' "Laboratory Soil Testing," publication EM 1110-2-1906.

2) Consolidation Testing

Consolidation tests must include time-rate of settlement plots of all load increments. These plots will be both log-time or square root of time plots, whichever best defines the end of primary consolidation. An on-site laboratory, if used, shall be equipped with a minimum of three (3) consolidation machines.

3) Triaxial Testing

Triaxial testing of select undisturbed or compacted samples shall include one or more of the following: permeability test, unconsolidated undrained tests (Q), and consolidated undrained tests with pore pressure measurements (R). All testing shall be conducted according to procedures outlined in EM 1110-2-1960. A "B" parameter of 0.97 or higher is required on all test samples prior to shearing, unless otherwise indicated. Input parameters such as confining pressures, etc., will be provided by the Contractor. Photographs showing an external view(s) and a cross section view of each sample, at failure, shall be included in the test data.

4) Capillary Moisture Relationships

Capillary Moisture relationships shall be determined for a specific soil sample using a combination of ASTM D3152 and ASTM D2325 test methods to produce a series of moisture contents at tension values ranging from minus 0.1 to 15 bars. The increments used shall be 0.1, 0.3, 0.5, 1.0, 2.0, 4.0, 7.0, 10.0 and 15.0 bars.

Partially saturated hydraulic conductivity tests shall use pressure chamber apparatus and/or suction apparatus as described by Klute and Dirksen.[1] Equipment must be capable of maintaining pressure heads of -7000 cm of water.

Procedures used to determine the main wetting and drying curves of individual samples shall be similar to those used by Klute and Heermann.[2]

5) Partially Saturated Hydraulic Conductivity Tests

Partially saturated hydraulic conductivity tests shall use pressure chamber apparatus and/or suction apparatus as described by Klute and Dirksen.[1] Equipment must be capable of maintaining pressure heads of -7000 cms of water.

Procedures used to determine the main wetting and drying curves of individual samples shall be similar to those used by Klute and Heermann.[2]

[1]Klute, A., and C. Dirksen, "Methods of Soil Analysis, Part I. Physical and Mineralogical Methods, Chapter 29," 1985 Second Edition.

[2]Klute, A., and D.F. Heermann, "Water Movement in Uranium Mill Tailings Profiles", 1978, Fort Collins, Colorado.

6) Leaching Tests

Leachability test procedures will be conducted in accordance with EP Toxicity Test Procedures as described in 40 CFR Part 261 Appendix II. The leachate produced from the first extraction of a series of extractions shall be retained for use as leachant in the subsequent samples. The Contractor will provide the sequencing of samples to be tested.

The Subcontractor shall perform water quality analysis on the leachate produced from the last sample in a series. Analysis will be for uranium and the metals listed in the EP Toxicity Procedures only.

7) Sludge and Stabilized Sludge Testing

A research by design sludge stabilization program is being developed by the Contractor. The Subcontractor will be responsible for mixing (remolding) and testing the stabilized sludge samples. Tests will consist of in-situ moisture content and density for sludge samples and density, moisture content, and unconfined compression for stabilized sludge samples. EP Toxicity tests will be performed on select stabilized sludge samples.

A Contractors Representative will be present during sample preparation and testing to direct and observe the work. The Contractor will provide all dry materials necessary for mix designs. Dry materials will likely be cement, fly ash, and/or other pozzolans.

6.0. Project Schedule

A specific Delivery Order (DO) (Attachment 14) will be given to the Subcontractor with each batch of samples to be tested. All analyses for each phase must be completed no later than four (4) weeks after receipt of the samples unless otherwise specified in the DO as issued. For selected specific gravity, moisture density, gradation, and Atterberg Limits tests a two (2) week completion will be required. Stabilized sludge tests will be performed in coordination with a designated Contractor Representative.

7.0. Quality Assurance

All laboratory testing shall be performed by experienced and qualified personnel in conformance with the applicable ASTM or other required test procedures as indicated in the Laboratory Testing Section. Any deviation from these procedures or any analytical procedures that are not available from ASTM or Army Corps of Engineers shall be submitted in writing to the Contractor for review and approval of required changes of any such procedure, prior to performing the test. These deviations shall be carefully documented and included on the typed laboratory report to be submitted with the effected test results. The laboratory, including equipment, shall be available to the Contractor's Representative prior to and during the testing for inspection.

The laboratory must have a Contractor's approved Quality Assurance (QA) Program in affect to assure that the data transmitted is correct and that the laboratory tests are run according to the required standard. The Subcontractor shall provide a designated person as the primary contact person should any questions arise as to the reliability of transmitted data.

8.0. Subcontract Performance

All testing is subject to review and acceptance by the Contractor. Acceptance or non-acceptance of a deliverable, will be made by the Contractor within 14 days after receipt of test data. Tests improperly or inadequately performed, will be retested at no cost to the Contractor.

All testing must be performed by the Subcontractor. No tests are to be further subcontracted without prior approval by the Contractor. If tests are to be run at a subcontractor owned off-site laboratory, the laboratory used must be specified on Attachments to Section C. Shipment of samples will be paid by the Contractor only to the Subcontractors off-site lab nearest to Weldon Spring, Missouri.

Any discrepancies in data must be identified and explained on the "Comments" section of the forms attached under Section C of this specification; as to the unusual nature or reason for apparent invalid test results.

9.0. Deliverable Quality Assurance

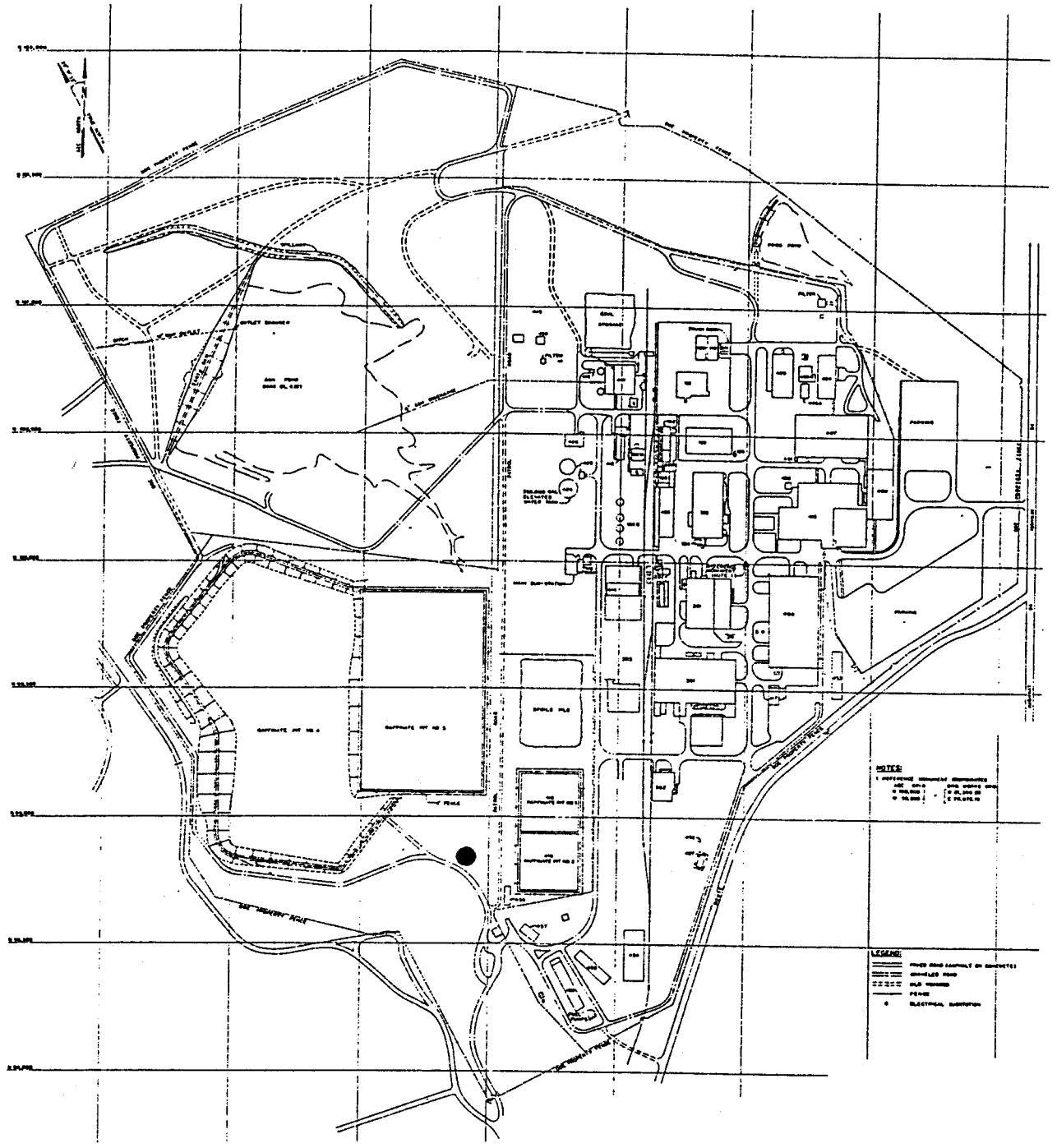
Results of all analyses shall be submitted on the specified reporting forms (Section C) and accompanied by legible copies of all associated laboratory work sheets. Reporting forms shall be typewritten with all lines on the form being completed. The letter designation "N/A" for not applicable or "N/K" for not known will be used in all blank spaces. If some steps or procedures were not performed as specified by delivery order requirements, the reasons must be stated on the appropriate reporting form or submitted as an attachment thereto. All laboratory worksheets shall provide objective evidence that the data has been checked by appropriate personnel other than those performing the tests.

10.0 Sample Storage and Shipment

The Subcontractor must return WSSRAP samples to the Weldon Spring Site. The Subcontractor must certify in writing that the samples being returned are only those received from WSSRAP and are not samples from other sources. Samples must be returned with their original containers, labeled and packaged in accordance with all applicable DOT regulations.

11.0 Health and Safety Requirements

Some of the samples received will be radiologically contaminated. The Contractor will provide personnel to screen and mark contaminated samples. These samples shall be handled in accordance with Special Conditions 10 and 11 of this Subcontract. The Subcontractor shall submit, two (2) weeks after award, a detailed description of the measures to be taken to conform with the applicable health and safety requirements.



● – Mobile Lab And Sump Location

Figure 1

Site Map

SPECIFICATION 3589-SC-WP029

SECTION B
DATED 07/09/87

DELIVERY REQUIREMENTS

GEOTECHNICAL LABORATORY TESTING

The Subcontractor shall provide the testing and analysis as set forth in the individual Delivery Orders (DO) (work plans) and deliver the following items on or before the date indicated therein.

Deliverables	No. of Copies	Contract Delivery Date
1a. Soil laboratory results for selected specific gravity, moisture-density (proctor), gradation, and Atterberg Limits tests reported in accordance with Attachment 1, Attachment 2, Attachment 3, and Attachment 13 of Section C.	2	Two weeks after Work/Plan Delivery Order & samples are received by the Subcontractor
b. Soil laboratory results for the balance of tests not identified in 1a above, reported in accordance with Attachments 2 through 13 of Section C.	2	Four weeks after Work test Plan/Delivery Order and samples are received by the Subcontractor
c. Description of health and safety measures.	1	Two weeks after award

Two copies of the results are required. One copy shall consist of the original data containing both laboratory worksheets, handwritten and edited results using copies of the Attachment 1 through 13 above depending upon the test performed. Also describe condition of samples prior to testing, evidence of disturbance, damage to containers, and any other pertinent information regarding the samples.

SPECIFICATION 3589-SC-WP029

SECTION C
DATED 07/09/87

REPORTING REQUIREMENTS

Summary of Attachments

FORM NUMBER	ATTACHMENT NUMBER	TITLE
MKF-AL-ENG-1 (4/87)	1	Physical Property Test Results
MKF-AL-ENG-2 (4/87)	2	Mechanical Sieve Test Results
MKF-AL-ENG-3 (4/87)	3	Hydrometer Analysis Test Results
MKF-AL-ENG-4 (4/87)	4	Soil Erosion Properties Test Results
MKF-AL-ENG-5 (4/87)	5	Rocky Material Property Results
MKF-AL-ENG-6 (4/87)	6	In-situ Moisture and Density Determinations
MKF-AL-ENG-7 (4/87)	7	Permeability Test Results
MKF-AL-ENG-8 (4/87)	8	Capillary-Moisture Relationship
MKF-AL-ENG-9 (4/87)	9	Moisture-Density Results
MKF-AL-ENG-10 (4/87)	10	Consolidation Test Results
MKF-AL-ENG-11 (4/87)	11	Unconsolidated-Undrained Triaxial "Q" Test
MKF-AL-ENG-12 (4/87)	12	Unconsolidated-Undrained Triaxial "R" Test with Pore Pressure Measurement
MKF-AL-C-1 (4/87)	13	Deliverable Transmittal/Review*
	14	Delivery Order Form

* Note: Instruction for completing Attachment No. 13, Form MKF-AL-C-1 are as follows:

Check appropriate box: If all analyses required by the Delivery Order are being transmitted, check "Total"; if the delivery is partial, check "Partial" and insert date. The balance will be sent to MK-F.

Add any description, comment, etc., in section provided under "Title/Description of Documents."

Sign and date form under section "Approved By:".

ATTENTION: Should the Subcontractor be required to reanalyze/resubmit analyses, the box "Revision" must be checked and the revision designator assigned to Attachment 1 entered in the blank provided next to the box.

Appendix G

Proposed Modification to Specification WP029

PROPOSED MODIFICATION TO SPECIFICATION WP029

Section II, Health and Safety Requirements, will be modified. Presently, the section states that some samples will be radiologically contaminated. Since this specification was prepared , chemical contaminants have been detected on the Weldon Spring Site. This information will be included in the modified section. The Subcontractor will still be required to submit a health and safety plan to protect workers from contaminated samples.

PROMOD/TXTMYRNA

Appendix H

Specification WP091, Geotechnical Coring and Sampling

SPECIFICATIONS WP091

GEOTECHNICAL CORING AND SAMPLING

MK-FERGUSON COMPANY

WELDON SPRING REMEDIAL ACTION PROJECT

ST. CHARLES, MISSOURI

3/1/88

SPECIFICATION WP091

WELDON SPRING SITE
GEOTECHNICAL CORING
AND
SAMPLING

1.0 SCOPE AND OBJECTIVES

The purpose of the work is to procure bedrock core samples.

This project is conducted by MK-Ferguson Company (MK-F), to collect geotechnical data at Weldon Spring Site Remedial Action Project.

2.0 LOCATION

The site is in St. Charles County, Missouri approximately 30 miles west of St. Louis, Missouri.

3.0 PROJECT SUPERVISION

All technical activities shall be under the supervision of the MK-Ferguson Company construction engineer (CE). No work shall commence without the Contractor's approval.

4.0 DRILLING AND SAMPLING

4.1 General

Drilling for this subcontract shall be performed in accordance with "Standard Practice Diamond Core Drilling For Site Investigation" (ASTM D2113-83) except as noted in this specification.

4.2 Surface

The surface conditions on the Site and in the area immediately west of the building area is relatively flat and vegetated with grasses. These areas are readily accessible by existing, improved dirt roads and paved roads and thus access problems should be minimal in the area. However, there may be areas of soft soils which will require working pads. Every effort will be made by MK-F to avoid drilling in locations with poor access.

4.3 Boring Location and Depths

Bedrock coring shall be an extension of borings made under the authority of Specification WP024-01. Coring through the uppermost twenty (20) feet of competent bedrock shall be performed in sixteen (16) of the original borings. Coring through the uppermost two hundred (200) feet of competent bedrock shall be performed in two (2) of the original borings. The selection of borings to advance the two hundred (200) foot corings shall be at the discretion of the Construction Engineer.

4.6 Coring Rods and Bits

The Subcontractor shall use NQ wireline rods and NQ wireline bits for this coring program.

4.5 Soils Logging and Supervision

The Subcontractor shall not be responsible for preparing the boring log as described in Section 7 of ASTM D2113-83 (Boring Log). Bore logging and drilling monitoring will be performed by the Contractor.

4.6 Cross-Contamination Prevention Measures

The Subcontractor shall at all times prevent the contamination or cross-contamination of all borings. Prevention measures include appropriate drilling procedures and decontamination of drilling equipment. A designated representative of the Contractor will observe decontamination activities to assure that no contamination or cross-contamination occurs. Potential contaminants include, but are not limited to oil, greases, hydraulic fluids, fuels, and contaminated soils.

To reduce the potential of contamination occurring, the drilling rig, tools, drilling stem, and all other pertinent equipment shall upon entering the site, be steam cleaned or hot high pressure washed under the direct supervision of the Contractor. All decontamination shall be performed at the decontamination facility located near the south end of the site. The Contractor shall supply a hot high pressure washer.

Cleaning of the entire rig and tools shall be accomplished on a one-time basis before work begins. Decontamination of the entire rig will not be required again, unless the equipment becomes contaminated. If the rig or any other equipment becomes contaminated due to equipment breakdown or the Subcontractor's negligence, decontamination shall be at the Subcontractors' expense. Drill bits, drilling rod, other downhole tools, and hand tools shall be decontaminated between boreholes. Only potable water from the Contractor's source shall be used to supply the hot high pressure washer.

Interior portions of equipment, such as pumps and hoses, which are not accessible for cleaning with a pressure washer shall be thoroughly cleaned and flushed with potable water from the Contractor's source. Oils, greases, or pipe dope shall not be used on pipe threads or drilling rods. Non-hydrocarbon based lubricants, such as silicon or teflon are acceptable.

Drilling equipment used in known or suspected contaminated areas shall be handled with special precautions to prevent the introduction of any contaminants into the well or boring. No hand tools, drill bits, drill stem, or any other equipment other than that in use in the borehole shall be allowed to contact the ground surface at any time. New, clean plastic sheeting shall be required for the temporary storage of such items. If any equipment or supplies come into contact with the ground, or are otherwise contaminated, they shall be thoroughly cleaned by hot high pressure washing.

Cross-contamination shall be minimized by thoroughly cleaning all external and internal surfaces of all drilling equipment, tools, drill bits, drilling stem, mud tubs, pumps, hoses, and all other appurtenant equipment after each hole is completed and before moving to the next drilling location. Cleaning shall be accomplished by completely removing all soil from the equipment and thorough hot high pressure washing.

During drilling operations, the Subcontractor shall prevent soils and liquids other than approved drilling fluids from entering the borehole. Steel surface casing of the appropriate diameter and at least five feet (5') in length shall be used when liquids are present on the surface at a drilling location. The surface casing shall be thoroughly decontaminated by hot high pressure washing prior to use at another drilling location.

4.7 Drilling Fluids

Uncontaminated, potable water shall be used as a drilling fluid for rock coring. The water source shall be provided by the Contractor. The Subcontractor shall be responsible for providing hoses, tanks, and other equipment and transporting water to drilling locations. All tanks, hoses, and other water-handling equipment shall be decontaminated by hot high pressure washing prior to commencing work. Hoses, valves, and other fittings shall be cleaned between drilling locations.

No other drilling fluid or additives other than water shall be used. Absolutely no toxic and/or contaminating substances shall be added to the drilling fluids, nor be permitted to enter boring as a result of the Subcontractor's operations.

4.8 Sampling During Coring

The Subcontractor shall attempt to attain a core run with a minimum of five feet and maximum of 10 feet in length. The Subcontractor will supply pre-manufactured and treated cardboard core boxes capable of holding at least 10 feet of rock core. The cores will be delivered to the Contractor for logging and storage. The Subcontractor will be required to use a 10 foot long core barrel and use his workman-like "best" techniques to obtain full runs.

Competent core will be stored in the cardboard core boxes. Unconsolidated, very friable, or clayey sections of core will be placed in clear, plastic-sheeting core tubing or bags, sealed, and stored along with the competent core in the core boxes. Some sections of core chosen by the Contractor may also be sealed in the core tubing for subsequent chemical analysis. The Subcontractor will assist the Contractor in collecting, sealing, and storing samples.

4.9 Lost Equipment, Lost Boreholes, and Borehole Abandonment

A hole shall be termed "lost" if the Contractor determines that the condition of the hole will prevent its successful completion, or if for any reason it is impractical to continue operations. The term "abandonment" shall mean abandonment to suit the convenience of the Contractor.

A hole which is determined to be lost shall be grouted from its total depth to land surface using a high solids bentonite clay grout. The grout mix shall consist of 50 pounds of grout solids mixed with not more than 23 gallons of water. If the Contractor determines that a hole has been lost for reasons within the control of the Subcontractor, or because of negligence, incompetence, or malpractice on the part of the Subcontractor or Subcontractor's personnel, or because of the use of defective or unsuitable equipment, the Subcontractor shall not be paid for any drilling, demobilization, or other services performed in the lost hole. The Subcontractor will not be paid for equipment lost in the hole. This includes boreholes lost in the event drill bits, drill rod, or other downhole tools are lost in the borehole and cannot be recovered by the Subcontractor's efforts.

In addition, the Subcontractor shall be required to grout the hole from its bottom to land surface, and then move over and drill a new hole in the proper manner to replace the abandoned one. The Subcontractor shall be notified in writing of the decision.

4.10 Standby Time

Standby time shall be defined as time during which the Subcontractor has been instructed by the Contractor to cease working pending further instructions.

Decontamination time shall be defined as time spent decontaminating drilling equipment, well screens, and casing as specified in Section 3.3 and is not considered standby time.

Time spent for clean-up and restoration of drilling locations or for other routine housekeeping or equipment maintenance is not considered standby time.

All standby time shall be recorded on the Daily Field Activity Report discussed below.

4.11 Field Documentation

The Contractor will maintain a "Daily Field Activity Report" (a sample copy is attached as Figure 1) detailing Subcontractor activities. The subcontractor is required to initial this report on a daily basis and note any differences that cannot be resolved. Any differences shall be documented for future reviews and resolution between the Contractor and Subcontractor. This is the only form that will serve to document quantities of work.

A designated Contractor representative will be assigned to each drilling rig to document the activities. The Contractor representative will assure that work is performed in accordance with specifications.

5.0 Health Physics

The Contractor shall provide industrial hygiene and/or health physics support, as appropriate, during all field operations in areas of radiological and/or chemical contamination.

The Subcontractor shall comply with all applicable Federal, State, and local health and safety regulations and requirements, including, but not limited to, those established pursuant to the Occupational Safety and Health Act (OSHA) and the WSSRAP Construction Safety and Health Management Program.

6.0 Quality Assurance

The Contractor shall direct all fieldwork. Periodic Quality Assurance surveillance will be performed by the Contractor to verify compliance with specification requirements.

Appendix I

Environmental Chain of Custody Form

WELDON SPRING SITE REMEDIAL ACTION PROJECT (WSSRAP)
Route 2, Highway 94, St. Charles, Missouri 63303
Phone (314) 441-8086 Telex (314) 447-0805

ENVIRONMENTAL SAMPLE CHAIN OF CUSTODY FORM

WSSRAP Contact:_____ WSSRAP File No.:_____

Phone Extension:_____ Date Sampled:_____

Laboratory Receiving Samples:_____

Sample Number	No. of Containers	Description	Parameters	Turnaround Time Required

Samplers' Signatures:_____

Relinquished By:	Received By:	Date	Time	Reason for Transfer

Appendix J

Work Plan Investigation
Geophysical Specification 3589-SC-WP028
Weldon Spring Site

WORK PLAN
GEOPHYSICAL INVESTIGATION
SPECIFICATION 3589-SC-WP028
WELDON SPRING SITE

Prepared for:

MK-FERGUSON COMPANY
St. Charles, Missouri

Prepared by:

GEOTECHNOLOGY SERVICES, INC.
St. Louis, Missouri

May 24, 1988

20961

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES

May 24, 1988 20961

MK-Ferguson Company
Weldon Spring Remedial Action Project
Route 2, Highway 94 South
St. Charles, Missouri 63303

Attention: Mr. S. A. Mager
Subcontract Administrator

Reference: Work Plan
Geophysical Investigation
Specification 3589-SC-WP028

Gentlemen:

Enclosed are three (3) copies of "Work Plan, Geophysical Investigation, Specification 3589-SC-WP028, Weldon Spring Site" for your review and approval. We understand that a meeting has been scheduled for May 31, 1988 at your office to discuss the details of this work plan prior to commencing the field operations.

We look forward to working with MK-Ferguson personnel on this project. If you have any questions regarding the contents of this work plan, please do not hesitate to contact me.

Sincerely,

GEOTECHNOLOGY SERVICES, INC.

Sal M. Gazioglu

Sal M. Gazioglu, P.E.
Principal
Manager - Environmental Services

SMG/sjw

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1.0 INTRODUCTION

Geotechnology Services, Inc. has been retained by MK-Ferguson Company to perform a geophysical investigation at the proposed disposal cell at the Weldon Spring Site. The geophysical investigation consists of an integrated program of multiple geophysical data acquisition surveys, data processing, interpretation and modelling to develop subsurface information across the disposal cell area.

The Scope of work is outlined in Specification 3489-SC-WP028, dated July 7, 1987 and amended on August 7, 1987, and August 28, 1987 included as Appendix A. As a minimum, surface seismic refraction, DC resistivity, EM induction conductivity, and self potential (SP) surveys are required by the specifications. The area of investigation includes approximately 75 acres, with the depth of investigation ranging up to 200 feet below the top of bedrock.

This work plan provides the details of a geophysical investigation proposed by Geotechnology, consistent with our proposal dated September 15, 1987. Briefly, the work plan includes a discussion of the project requirements, purpose, geophysical systems, application of integrated systems and clarification of specification requirements; detailed discussion of our technical plan, including instrumentation, field procedures and calibration requirements; project schedule; and project team.

2.0 PROJECT REQUIREMENTS

2.1 Purpose of Project

The purpose of this geophysical investigation is to provide a geological model of the subsurface conditions below the proposed disposal cell at the Weldon Spring Site.

2.2 Geophysical Systems

Surface geophysical survey systems will be employed to investigate the specific subsurface, overburden, bedrock and groundwater conditions stated in Specification 3589-SC-WP028, for the Weldon Spring Site. These systems will include:

- Gradient magnetometry
- Engineering seismic refraction
- High resolution shallow seismic reflection
- Vertical D.C. electrical resistivity (VES)
- Spontaneous potential (SP)
- Shallow Electromagnetic induction (EM)
- Deeper Electromagnetic induction (EM)
- Very Low Frequency EM (VLF/EM) (Optional)

2.3 Application of Integrated Systems

All the geophysical data acquired during this project, as well as the previously supplied geotechnical information, will be subject to cross-reference and correlation in order to develop a subsurface model. Based on previous investigations (Bechtel, 1987), it is apparent that any geophysical investigation without external correlation could be misleading for this site. Subsurface data collected by means of borings is usually the prime ground truthing cross-reference data utilized to correlate geophysical interpretations. In order to offset this

possibility, all data from an area or zone that yields contradictory results will be thoroughly reviewed before including such data into the final interpreted subsurface model.

2.4 Clarification of Specification

Employment of an integrated geophysical investigation to determine an appropriate subsurface model requires that several requirements of Specification 3489-SC-WP028 be clarified, including:

- Utilizing the geophysical results for "design" (1.1 Objective, line 4, page 1) should require that the interpreted model be confirmed to an acceptable probability level by ground truthing. Such final ground truthing is often acquired long after the acquisition of geophysical data which itself it usually utilized to target the ground truthing program. Therefore, before any parameters for "design purpose" are based upon these geophysical results, the interpreted geophysical model should be subject to revisions (feedback) incorporating all such ground truthing data.

- Although the overall target depth of investigation of the integrated survey is 200 feet below the top of bedrock, some of the proposed geophysical techniques are used to penetrate specific depth horizons or zones.

- The term "continuous subsurface information" usually refers to continuity of information of a 2-dimensional profile presentation based upon data acquired at some meaningful grid or data point spacing. The Weldon Spring site contains several surface and buried obstacles, buildings, utilities, etc., which will inhibit or prevent the overall acquisition of such data. For 3-dimensional coverage, it may be necessary to acquire scattered point data that would enhance a 3-dimensional model but would be disjointed and not continuous information if presented on a 2-dimensional profile without extrapolation between data points.

- An integrated geophysical survey conducted for design purposes which is limited to surface methods only is required to provide with a high degree of confidence (pages 6 & 7, section 6.2) such information as: material types of overburden and rock and their densities; the nature of joints and solution features in overburden and rock, the nature of the infilling material, and water levels. Such identifications may require correlation with core data, geophysical logging, and single-hole and

cross-hole compressional and shear wave velocity data. Material types are more accurately described by directly observed geological data. Without subsurface geophysical data, the accuracy of the classifications of material types is reduced to an inference of the character of the material present based on the survey data, particularly in the case of a difficult data site. Therefore, the surface geophysical data should not be utilized for "design" without correlation with other information.

3.0 TECHNICAL APPROACH

3.1 Location of Geophysical Surveys

Specified geophysical techniques will be performed to acquire data in the vicinity of the 8 traverses shown in Plate 1. The traverses are tentatively designated as Lines 1 through 8, and together are comprised of approximately 12,000 lineal feet. The locations of the lines were selected based on the following factors:

- providing sufficient areal coverage;
- utilizing existing subsurface data;
- avoiding surface cover which prohibits or significantly hinders geophysical data acquisition such as buildings, paved roads and parking areas, railroad tracks, shallow underground utilities and raffinate pits;
- aligning electrical and magnetic "noise" such as underground utilities, overhead pipes, railroad tracks, and metal fences, such that they be perpendicular to the survey line or-in a possibly usable but less satisfactory alignment-parallel to the survey line;
- accommodating tentative boring locations and geophysical lines suggested by MK-Ferguson, provided the locations satisfy the above requirements.

Information used to locate survey lines are based solely upon site plans provided by MK-Ferguson Company. Positions of the survey lines may be subject to modifications after the site is physically reviewed. The lines will be surveyed in the field with respect to control points provided by MK-Ferguson by staking at 100-foot intervals.

3.2 Geophysical Data Acquisition

The following data acquisition plan assumes that each technique produces acceptable results. In some areas, particular methods may not provide adequate information due to geologic or manmade conditions that are not conducive to that

particular technique. In these instances we may request to adjust the work plan such that a non-informative technique be replaced with additional data acquisition using a technique currently in the work plan.

The geophysical data acquisition will be performed in three phases as follows:

- Phase I - EM induction and gradient magnetometry
- Phase II - Seismic refraction and reflection
- Phase III - SP and DC resistivity

For continuity, the data analysis and interpretation methods are presented within the data acquisition program. Detailed data interpretation and consolidation will take place after all the data have been acquired, however, some preliminary interpretation may be necessary in order to proceed from one method to another. Due to the shortened daily working hours, it may be necessary for the phases to be lengthened or to overlap in time. Additionally, Phase II and Phase III may be interchanged depending upon the quality of data collected in Phase I.

3.3 Phase I Geophysical Survey

3.3.1 Scope of Work

A combination of electromagnetic (EM) and magnetic survey techniques will be used to provide data from which an interpreted layer-conductivity model may be derived. Electrical "noise" due to power lines, overhead and underground pipes, and metallic structures does exist at the site. The effects of electrical noise may be identified and possibly minimized by integrating specific electromagnetic and magnetic procedures. Even though the locations of many utilities, metallic fences and structures are known, several fast-track surveying methods are proposed to evaluate the presence of shallow buried (and surface) conductors from deeper geologic conductors.

3.3.2 Instrumentation

The following instruments, or their equivalent, will be obtained by Geotechnology for use in Phase I:

- SHALLOW EM INDUCTION
  - Geonics EM31-DL terrain conductivity meter
  - Data logger
- DEEP EM INDUCTION
  - Geonics EM34-3XL/DL or EM34-3 terrain conductivity system
  - Data logger
- MAGNETICS
  - EDA OMNI PLUS Magnetic Gradiometer (self-contained data logger)
- VLF/EM (optional)
  - ABEM VLF/EM WADI (self-contained data logger)

Most of the data acquired in Phase I will be downloaded from a data logger (external or internal) onto storage disks via a Zenith 181 portable lap-top computer. A Geonics IBM PC forward modeling program will be used for layered conductivity analysis.

3.3.3 Field Procedures

Initially, a base station area will be surveyed with the EM31, EM34, and magnetic gradiometer for calibration purposes. The area should be free of electrical "noise" from near surface conductors, have relatively constant conductivity (lower than 30 mmhos/meter), and preferably be accessible from outside the control area. A single base station will be selected within this area for calibrating all three instruments. The instruments will be operated at the base station before and after each survey.

The Geonics EM34-3 or EM34-3XL/DL system will be used first at a constant coil spacing and constant dipole attitude in order to quickly generalize the site conductivities and identify areas exhibiting possible noise due to near-surface conductors. The EM34 system is capable of measuring conductivities at coil spacings of 10, 20 and 40 meters for both horizontal and vertical dipoles providing information from depths ranging from approximately 7.5 to 60 meters.

Once areas prone to conductive interference are generally located, shallow EM induction and magnetic methods may be used to assist in delineating the noisy areas. Thus, the shallow methods may be employed predominately in areas where they are most needed.

A Geonics EM31-DL with data logger will be used primarily to depict the non-magnetic conductors, and an EDA OMNI PLUS magnetic gradiometer with self-contained data logger would be used to depict magnetic targets. Both of these systems may be pulsed at short intervals for continuous recording which can be conducted at a slow walking pace. The data stored in the data loggers may be downloaded onto a portable Zenith 181 lap-top computer. These two methods will be run concurrently.

Deep EM induction data will be acquired in areas least susceptible to electric noise due to near-surface conductors, as determined from the previously acquired data. The EM34-3XL/DL or EM34-3 will be used and conductivities for 3 different coil spacings and 2 different dipole attitudes (a total of six readings) recorded at each station. The coverage is anticipated to require 40 stations. A data logger may be used and downloaded onto the Zenith 181. The data would be used later for modeling vertical changes in conductivity.

A VLF/EM (Very Low Frequency EM) system (optional) may be used in addition to the above techniques. This system will be used to locate and delineate the vertical orientations of conductive zones in the overburden and bedrock, as well as to evaluate the relative overburden thickness. VLF/EM relates to the magnetic component of the electromagnetic field (radio waves) generated by long distance very low frequency radio transmitters. Radio waves are distorted by variations in ground conductivity and the perturbations can be measured accordingly.

The proposed VLF system is the ABEM VLF/EM WADI. The ABEM WADI is an automatic, digital system that can be operated by one man at a walking pace. WADI data is stored in the unit, is automatically interpreted and displayed directly on a built-in LCD. The recorded data up to several thousand data points (plotted curves, station values and coordinates, interpreted conductor dips and depths) can be directly downloaded to a standard serial printer.

If the VLF/EM system proves to be very informative, its survey locations would be extended to fill-in and tie-in the seismic refraction and reflection and other geophysical data.

3.4 Phase II Geophysical Survey

3.4.1 Scope of Work

Seismic refraction and reflection data will be acquired in order to detect velocity contrasts present within the overburden, at the surface of the limestone bedrock, and at depths of at least 200 feet beneath the bedrock surface. The refraction and reflection data are intended to complement each other, therefore, a total of 12,000 lineal feet along survey

lines 1 through 8 are proposed for each seismic method. Seismic data acquisition should begin immediately after the completion of Phase I.

3.4.2 Instrumentation

Geotechnology plans to obtain the following equipment or their equivalent for the seismic method used in Phase II:

- SEISMIC REFRACTION AND REFLECTION
  - Geometrics ES 1225, 12-channel engineering seismograph
  - Seismic cable, 440 feet (maximum geophone spread length) with 12 geophone takeouts
  - Mark 8 Hz vertical geophones (refraction)
  - Mark 100 Hz vertical geophones (reflection)
  - BETSY downhole electric firing capsules with 8-gauge cartridges (50 to 500 grains of Pyrodex each)
  - Geometrics HVB-1 electric blaster
  - Hammer, strike plate, and trigger switch

Information recorded on the ES 1225 will be transferred to storage disks via a Zenith 181 portable lap-top computer. The Interpex program GREMIX, based on the generalized reciprocal method, will be used to interpret the refraction data. The Geometrics GEOFLEX high-resolution shallow-seismic reflection program will be used to process and interpret the reflection data.

3.4.3 Field Procedures

Initially, refraction data will be acquired along the survey lines located in the southeast portion of the study area. Based on existing subsurface data, the limestone bedrock of this area is apparently shallower than elsewhere on the site occurring at depths ranging from less than 20 feet to 35 feet. Initially, the geophone spacing will be about 20 feet (possibly greater in the central portion of the spread) in order to identify thin

overburden layers, diminish hidden layer possibilities, and help to better-define pinnacles. This information, particularly that pertaining to the surface of the bedrock, if detectable, may be helpful throughout the remainder of the subject area. Approximately five shots will be taken for each geophone spread: one at each end of the spread; one near the center of the spread; and a shot off each end of the spread at up to a spread length distance.

In order to avoid interference between charges and geophones, all shots will be taken approximately 2 to 3 feet perpendicularly away from the line that is coincident with the geophone spread. The 8-gauge cartridge charges will be placed in 1.5 to 3 foot deep holes, backfilled and tamped to prevent venting. The charge size may vary from 50 grains to 500 grains of Pyrodex, depending on the source offset, source coupling and subsurface conditions. Water and/or a mat cover may be applied to each shot hole in order to promote source coupling and control airborn dust and debris. Each cartridge requires 50 volts for ignition to take place. The Geometrics HVB-1 blaster produces a 200-volt signal, therefore, two cartridges may be connected in parallel if a larger charge is required, specifically for off-end shots. Open shot holes will be filled and all cap wires will be gathered.

The presence of asphalt pavement along a survey line may require the removal of small portions of the asphalt and underlying base course, if present, at the locations of shot holes and geophones.

The field data recorded on the ES 1225 seismograph will be transferred to a Zenith 181 computer and stored on disk. First breaks will be picked and time-distance graphs will be plotted and analyzed to check for data accuracy and to establish layers and layer velocities. All seismic data will be hand-reduced by phantoming, parallelism, and end-time analysis before applying

computer modeling techniques. The computer analysis may require several cycles of manual changes and correlation with external data before the computer program can be used to refine the model and produce a final interpretation.

Soil identification by examination of shot hole material and surface trawling material would be used to help evaluate the overburden horizon on which the seismic spread lies. If possible, each spread would be laid out over the same surface material for continuity so that the interpretive techniques used would deal with more narrow velocity values and not average of a wide span of values. Horizontal changes in layering sequences would be interpreted by split-spread analysis rather than averaging velocities across the spread.

To complement the seismic refraction data and to extend the depth of seismic data acquisition to at least 300 feet, a high-resolution seismic reflection survey is proposed. Water table horizons and variations within bedrock may be detected by reflection, though it is probable that the overburden layering, and possibly the top of bedrock, may be too shallow to resolve adequately. It is possible to reach penetration to 300 feet by seismic refraction, however, a spread length of at least 1000 feet would be required, as well as the use of large quantities of explosives.

The shallow high-resolution seismic reflection method proposed is referred to as "common offset" and is based on test shooting off the end of a geophone spread to establish an optimum distance between the source and the receiver. Once established, this distance remains a fixed parameter up to the next test spread.

Reflected and refracted events are digitally recorded on the ES 1225 seismograph which contains high-pass reflection filters. A short cable with geophone spacings of 10 to 20 feet is utilized with high-frequency 100 Hz reflection geophones. A sledge hammer source may be used in place of the 8-gauge cartridges provided that sufficient energy is produced to give information from at least 200 feet beneath the surface of the limestone bedrock.

The field data is transferred to a storage disk via a Zenith 181 computer. The common offset records are then reviewed on the monitor for picking first break "static" data. The static-corrected common offset records are sequentially printed out and then inspected for character of the seismic signals and presence of weak and strong reflectors. Different processing and filtering techniques are applied to the data to enhance definition of the stratigraphic horizons. The processed data is stored and the final seismic pseudo-sections are produced. Velocity analyses are then conducted and the selected velocities utilized to calculate depth intervals.

3.5 Phase III Geophysical Survey

3.5.1 Scope of Work

Self-potential (SP) data and vertical electrical soundings (VES) D.C. resistivity will be acquired in Phase III geophysical surveys.

The SP would be useful in analyzing telluric current flow between the alkaline groundwater fluids and any oxides above the water table. Current flow through conductors or disseminated conductors (contaminants) and channeling through porous zones such as fractures and solution channels, may generate a Streaming Potential.

A standard 4-electrode (Schlumberger or Wenner) VES D.C. resistivity would be used to detect different overburden and bedrock layers based upon their electrical characteristics. The locations of the soundings will be selected depending on the need to resolve the seismic problems of hidden layers, velocity inversions, and velocity overlaps. Additionally, areas containing large amounts of electrical interference due to surface conductors, as noted by the EM induction and magnetic data, will be avoided.

3.5.2 Instrumentation

Geotechnology plans to obtain the following equipment or their equivalent for the SP and D.C. resistivity methods:

- SP AND D.C. RESISTIVITY
  - ABEM Terrameter 300B with current and potential electrodes
  - ABEM Terrameter Booster 2000 (optional D.C. resistivity only)
  - Cables and reels
  - Gossen Geohm - 3 Earth Resistivity meta (optional - D.C. resistivity only)

The forward and reverse modeling program RESIX, by Interpex, will be used for layered resistivity analyses of the VES data.

3.5.3 Field Procedures

The SP method will require only 2 potential electrodes, cable and the receiver within the Terrameter 300B. One electrode, designated as the base electrode, will be placed at the beginning of a survey line; the other electrode will be placed at successively greater distances along the survey line away from the base electrode and the natural potential between the electrodes will be measured at every separation.

VES is conducted by measuring the voltage that is generated between the two potential electrodes when the transmitter induces current into the ground through the two current electrodes. To define 300 feet of penetration requires an electrode spacing to at least 1,000 feet. It is anticipated that the Terrameter 300B will provide sufficient current out to the desired spacings. However, the Terrameter Booster 2000 will be used if more voltage is necessary due to highly resistive near-surface conditions.

The shallow portion of the VES configuration is proposed to supplement the seismic refraction data. Five-foot linear electrode spacing will be used for the upper 50 feet and the normal logarithmic electrode spacings used for the deeper penetration. The linear data will be manually analyzed and the logarithmic data will be computer analyzed for multi-layering (up to 10 layers) and inverse modeling.

3.6 Instrument Calibration and Data References

All instruments will be calibrated to the manufacturers specifications traceable to the National Bureau of Standards (NBS). All data except for VES, SP, and deeper EM data, will be digitally recorded and entered into data loggers, or directly into computers or printed out in hard copy. Additionally, data summary sheets will be maintained for all geophysical techniques and will be referenced to time, date, site, traverse line, station number or coordinate, instrument operator, methodology, and with pertinent remarks and logs. Elevation control and positioning will be referenced to the supplied topographic map. All data, data sheets, notebooks, calculations, publications, photographs, time sheets, work schedules, instrument logs, work logs, computer plots and derivations, pertinent documentation and project records generated for this project will be filed as project material.

4.0 PROJECT SCHEDULE

The schedule shown in Plate 2 gives the order and duration of field work required for each geophysical method. Without contingency and barring delays due to mobilization/demobilization, weather, instrument downtime, holidays, etc., the field work should be completed in 38 working days. Additional time has been allotted for preliminary interpretation during the data acquisition portion. Approximately 4.5 weeks will be required to process and interpret the data after the field work is complete. Though some computer programs provide selection of velocity horizons as an option, because of the complexity of this site, this approach is likely to be unreliable. As a result most of the initial data reduction must be done manually, which accounts for the additional time required to process the data. The final report should be available 6.5 weeks after the completion of field work. Preliminary information will be available during the progress of data processing and interpretation.

5.0 PROJECT TEAM

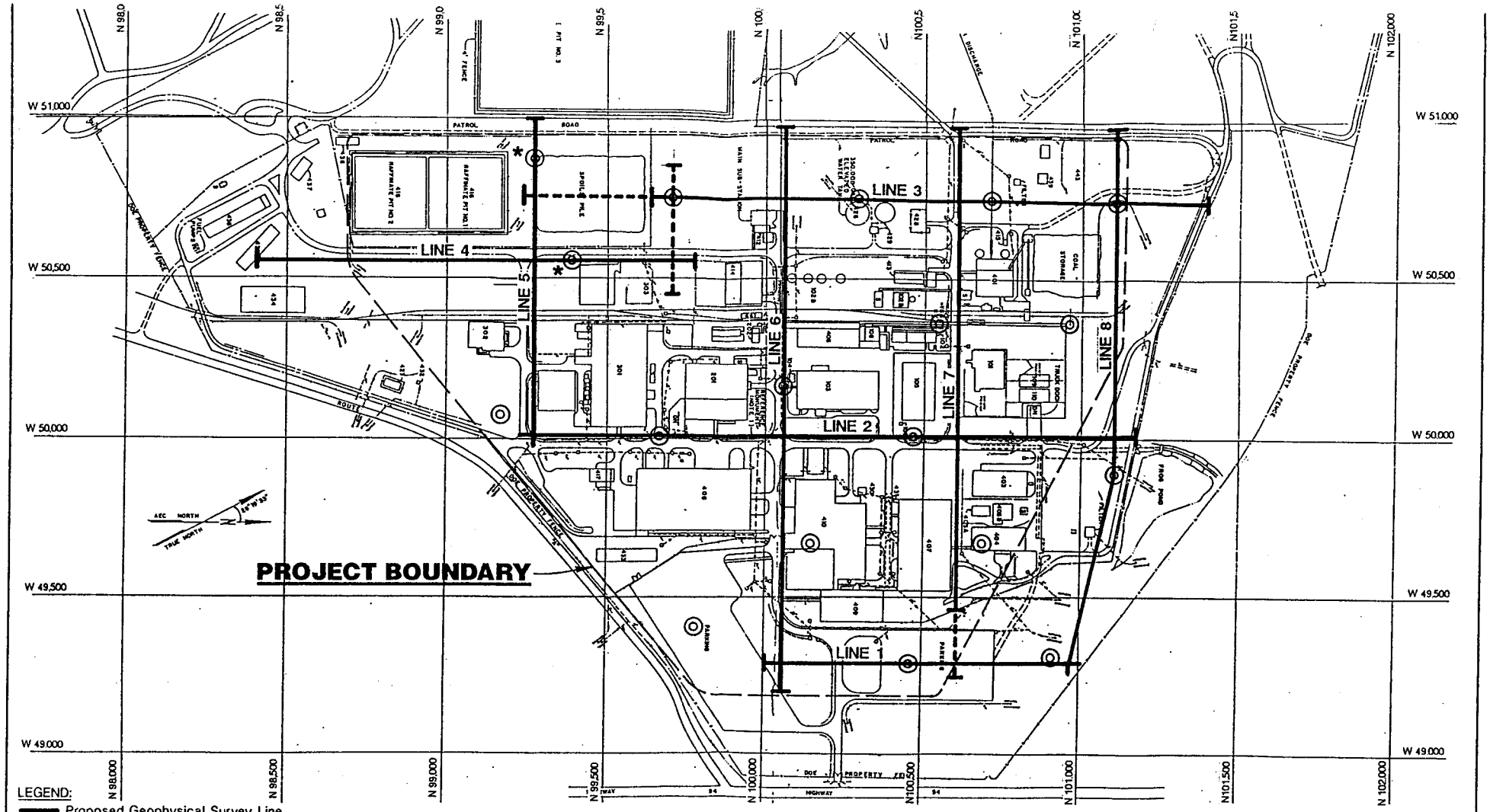
The Project Team is organized as shown on Plate 3 and consists of the following individuals:

Project Manager - Sal M. Gazioglu, P.E.

Principal Geophysicist - Marvin Ehrlich, R.Gp., P.E.

On-site Superintendent - Lawrence C. Rosen, M.S.

Field Technicians - Douglas W. Lambert, M.S.
David Cisiewski
Alan K. Renner



LEGEND:

- Proposed Geophysical Survey Line
- Possible Extension of Geophysical Line
- Proposed Boring Location
- * Boring location has been adjusted to overlie survey line.

NOTE:
Plan adapted from undated Morrison-Knudsen Engineers, Inc. drawings titled "Storm Sewer and Drainage Ditches"

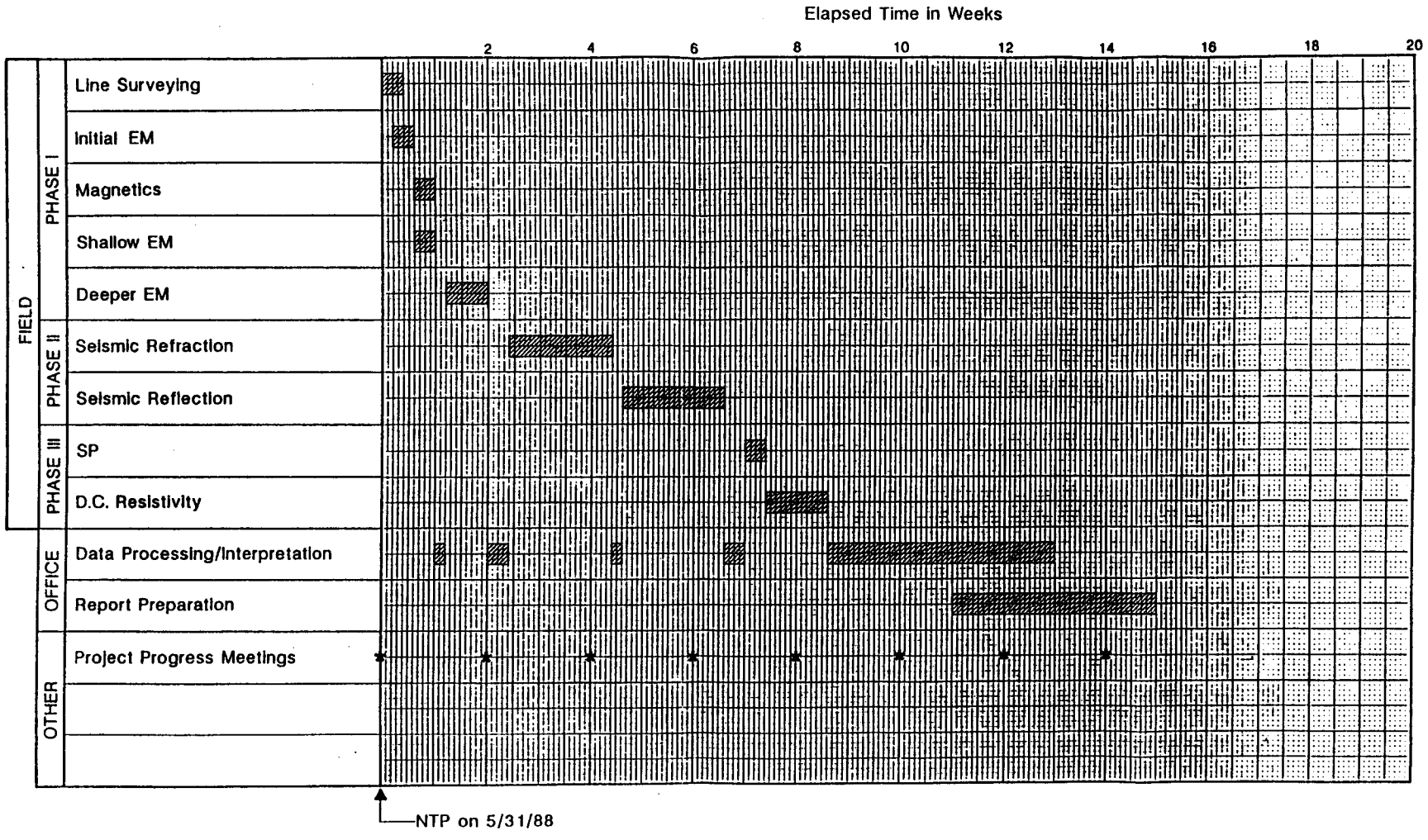
Geophysical Investigation
Weldon Spring Chemical Plant

PLAN OF SITE AND PROPOSED GEOPHYSICAL SURVEY LINES

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS, MISSOURI

PLATE 1

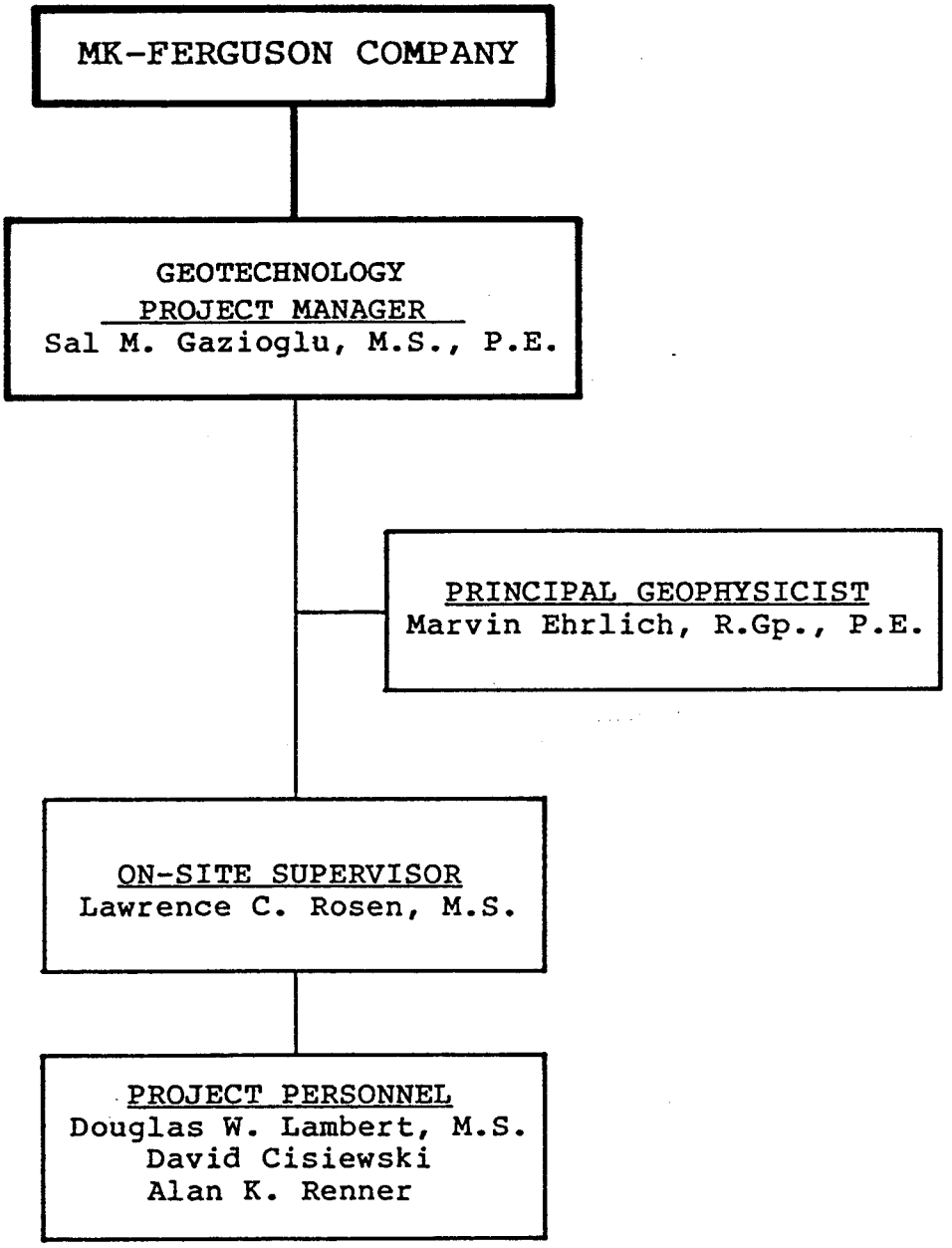
20961.02



Geophysical Investigation
Weldon Spring Chemical Plant
PROPOSED PROGRESS SCHEDULE

GEOTECHNOLOGY

PLATE 2



Geophysical Investigation
Weldon Spring Chemical Plant

PROJECT ORGANIZATION CHART

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS, MISSOURI

PLATE 3

CHEMICAL PLANT ADMINISTRATIVE RECORD FILE

ARFS FILE # C-201-3

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SECTION	SECTION TITLE
200	REMEDIAL INVESTIGATION (RI)
201	Sampling and Analysis Plans

DOCUMENT NUMBERS	DOCUMENT TITLE
C-200-201-1.07	WORKPLAN FOR THE RI/FS-EIS FOR THE WSSRAP
C-200-201-1.08	HYDROGEOLOGICAL INVESTIGATION SAMPLING PLAN
C-200-201-1.9	PLAN FOR MONITORING RADIONUCLIDE EMISSION OTHER THAN RADON AT WELDON SPRING SITE CRITICAL RECEPTORS
C-200-201-1.10	ENVIRONMENTAL DATA ADMINISTRATION PLAN

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

CHEMICAL PLANT
201-1.07

3589-88-I-DOE-225

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

M-K FERGUSON CO.
RECEIVED
MAY 25 1988
WSSRAP CONTRACT 3589

May 25, 1988

ADDRESSEES

RI/FS-EIS WORK PLAN

Enclosed, we are pleased to provide the RI/FS-EIS Work Plan for your review and comment. This document summarizes existing information about the site; provides an overall picture of the environmental compliance requirements for this project; and includes other pertinent information.

The work plan also serves as the implementation plan as required under NEPA (Ref. Appendix A).

We would appreciate your input by June 21, 1988, at which time we will agree on timing for a public meeting.

Sincerely,

R. R. Nelson

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure

cc w/o enclosure:
G. P. Turi, NE-23, DOE/HQ
R. E. Hlavacek, MK-Ferguson

ADDRESSEES FOR LETTER DATED MAY 25, 1988

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DOE/OR/21548-033

Work Plan for the Remedial Investigation/Feasibility Study-Environmental Impact Statement for the Weldon Spring Site, Weldon Spring, Missouri

August 1988

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

DOE/OR/21548-033

Work Plan for the Remedial Investigation/Feasibility Study-Environmental Impact Statement for the Weldon Spring Site, Weldon Spring, Missouri

August 1988

prepared by

J.M. Peterson, M.M. MacDonell, L.A. Haroun, F.K. Nowadly,* W.C. Knight,* and G.F. Vajda†

Energy and Environmental Systems Division, Argonne National Laboratory

prepared for

U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, under Contract W-31-109-Eng-38

**Affiliated with Jacobs Engineering Group, Inc., Weldon Spring, Missouri.*

†*Affiliated with Dames and Moore, Park Ridge, Illinois.*

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NOTATION

The following is a list of the acronyms, initialisms, and abbreviations (including units of measure) used in this document.

ACRONYMS, ABBREVIATIONS, AND INITIALISMS

AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
ARAR	applicable or relevant and appropriate requirement
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
DNR	Department of Natural Resources
DNT	dinitrotoluene
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy-Headquarters
DOE-OR	U.S. Department of Energy-Oak Ridge Operations
DOE-RL	U.S. Department of Energy-Richland Operations
DOE-WSS	U.S. Department of Energy-Weldon Spring Site Project Office
EA	environmental assessment
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERA	expedited response action
FFA	Federal Facility Agreement
FONSI	finding of no significant impact
FS	feasibility study
ICRP	International Commission on Radiological Protection
IRA	interim response action
MKT	Missouri-Kansas-Texas (Railroad)
MSL	mean sea level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NLO	National Lead Company of Ohio
NPL	National Priorities List
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
QAPP	quality assurance project plan
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROD	record of decision
SARA	Superfund Amendments and Reauthorization Act
SCCAHW	St. Charles Countians Against Hazardous Waste

SFMP	Surplus Facilities Management Program
SLAPS	St. Louis Airport Site
TCL	Target Compound List
TNT	trinitrotoluene

UNITS OF MEASURE

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
cfs	cubic feet per second
Ci	curie(s)
cm	centimeter(s)
cm^3	cubic centimeter(s)
ft	foot (feet)
ft^2	square foot (feet)
gal	gallon(s)
g	gram(s)
gpm	gallon(s) per minute
h	hour(s)
ha	hectare(s)
in.	inch(es)
km	kilometer(s)
km^2	square kilometer(s)
L	liter(s)
µg	microgram(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
mg	milligram(s)
mi	mile(s)
mi^2	square mile(s)
mph	mile(s) per hour
pCi	picocurie(s)
ppb	part(s) per billion
ppm	part(s) per million
rem	Roentgen equivalent man
s	second(s)
t	metric ton(s)

1 INTRODUCTION

1.1 SUMMARY AND BRIEF HISTORY OF THE WELDON SPRING SITE REMEDIAL ACTION PROJECT

The Weldon Spring Site Remedial Action Project is being conducted as a Major System Acquisition under the Surplus Facilities Management Program (SFMP) of the U.S. Department of Energy (DOE). The major goals of the SFMP are to eliminate potential hazards to the public and the environment that are associated with contamination at SFMP sites and to make surplus real property available for other uses to the extent possible.

The Weldon Spring site is located near Weldon Spring, Missouri, about 48 km (30 mi) west of St. Louis (Figure 1). It is surrounded by large tracts of land owned by the federal government and the state of Missouri. The site consists of four raffinate pits, an inactive chemical plant, and a contaminated quarry. The raffinate pits and chemical plant are on adjoining land about 3.2 km (2 mi) southwest of the junction of Missouri (State) Route 94 and U.S. Route 40/61, with access from Route 94. The quarry is located in a comparatively remote area about 6.4 km (4 mi) south-southwest of the raffinate pits and chemical plant area; the quarry can also be accessed from Route 94. These areas are fenced and closed to the public.

From 1941 to 1944, the U.S. Department of the Army operated the Weldon Spring Ordnance Works, constructed on the land that is now the Weldon Spring site, for production of trinitrotoluene (TNT) and dinitrotoluene (DNT). The Army used the quarry for disposal of rubble contaminated with TNT. In the mid 1950s, 83 ha (205 acres) of the ordnance works property was transferred to the U.S. Atomic Energy Commission (AEC); this is now the raffinate pits and chemical plant area. An additional 6 ha (15 acres) was later transferred to the AEC for expansion of waste storage capacity. From 1957 to 1966, the AEC operated a uranium-processing facility at the Weldon Spring uranium feed materials plant, which subsequently became the Weldon Spring chemical plant. Ore concentrates and some scrap metal were processed at the plant, and products that included uranium metal were then shipped to other sites. Thorium-containing materials were processed on an intermittent basis. Radioactive raffinates from the processing were placed in four on-site pits. Other radioactive wastes were disposed of in the quarry.

After closure by the AEC, the chemical plant was reacquired by the Army in 1967. The Army partially decontaminated several buildings, dismantled some of the equipment, and began converting the facilities to produce herbicides. In 1969, prior to becoming operational, the herbicide project was canceled. In 1971, the Army returned the 21-ha (51-acre) portion of the site containing the raffinate pits to the AEC. As successor to the AEC, DOE assumed responsibility for the raffinate pits. In 1984, the Army repaired several of the buildings at the chemical plant; decontaminated some of the floors, walls, and ceilings; and isolated some contaminated equipment.

Several areas in the vicinity of the raffinate pits and chemical plant area and the quarry, but outside of current fenced boundaries, are radioactively and chemically

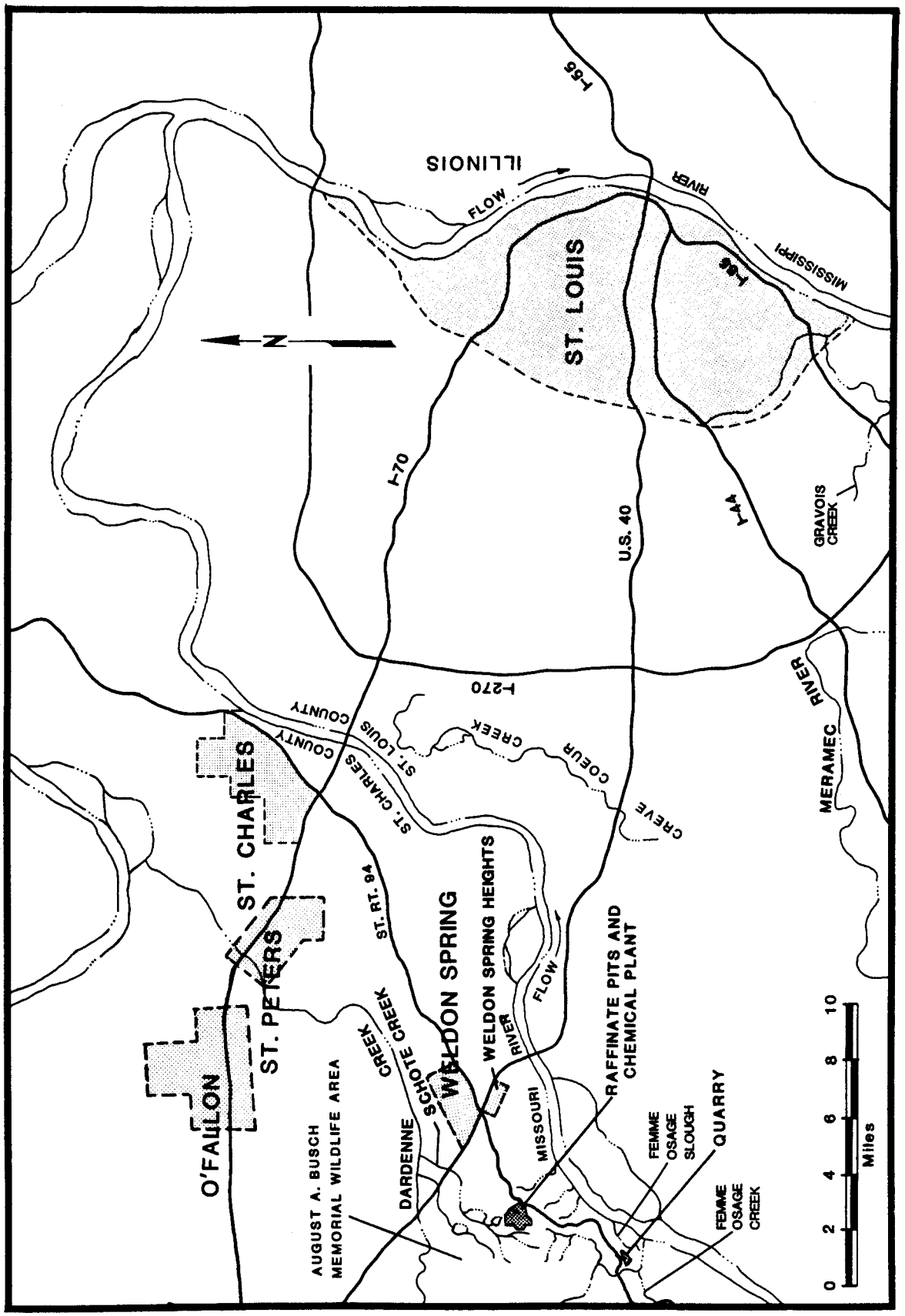


FIGURE 1 Area and Vicinity Map of the Weldon Spring Site, Weldon Spring, Missouri

contaminated as a result of activities previously carried out at the Weldon Spring site. These contaminated areas are termed vicinity properties. The DOE is responsible for the contaminated vicinity properties associated with previous uranium-processing activities conducted at the site. This contamination consists of radioactive constituents (i.e., uranium, thorium, and radium) and any chemicals associated with the processing of these materials. The DOE is also responsible for any chemical contamination that is mixed with radioactive contamination. The U.S. Department of the Army is responsible for contamination on vicinity properties resulting from previous ordnance production activities. The DOE is continuing to work with the Army in identifying off-site areas contaminated as a result of Army activities. To minimize disturbance of the environment, DOE will coordinate the cleanup of vicinity properties with the Army.

In May 1985, DOE designated the control and decontamination of the Weldon Spring site as a Major Project (this project has since been designated as a Major System Acquisition). In October 1985, custody of the chemical plant was transferred to DOE. A project management contractor for the Weldon Spring Site Remedial Action Project was selected in February 1986, and a DOE project office was established on the site in July 1986. The project management contractor, MK-Ferguson Company, assumed control of the Weldon Spring site on October 1, 1986.

On October 15, 1985, the U.S. Environmental Protection Agency (EPA) proposed to include the quarry on the National Priorities List (NPL). This listing occurred on July 30, 1987. On June 24, 1988, EPA proposed to expand this designation to include the raffinate pits and chemical plant area.

1.2 OVERVIEW OF THE ENVIRONMENTAL COMPLIANCE PROCESS

In February 1987, DOE issued a draft environmental impact statement (EIS) to assess the environmental impacts of alternatives for long-term management of contaminated materials associated with remedial action at the Weldon Spring site (U.S. Dept. Energy 1987a). The draft EIS was prepared in accordance with the National Environmental Policy Act (NEPA), as implemented by regulations promulgated by the Council on Environmental Quality (CEQ) and DOE's implementing guidelines. A Notice of Intent to prepare this draft EIS was issued March 2, 1984, in the *Federal Register*, and a public scoping process was conducted. The draft EIS was prepared taking into account the comments received during the scoping process.

The response actions, i.e., removal actions and remedial actions, to be carried out by DOE at the Weldon Spring site are subject to EPA oversight under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). For this project, the oversight function is being carried out by EPA Region VII. Because preparation of the draft EIS was already in progress when EPA's role in the project was identified, DOE and EPA entered into a Federal Facility Agreement (FFA) in August 1986 whereby the respective responsibilities of these two agencies were defined. By this agreement, DOE intended to meet EPA's remedial investigation/feasibility study (RI/FS) requirements under CERCLA with the EIS and supporting documentation.

Since publication of the draft EIS in February 1987, the Phase I water quality assessment (U.S. Dept. Energy 1987c) has provided significant new information relevant to environmental concerns at the Weldon Spring site. In response to this new information (i.e., high concentrations of nitrates and sulfates and significant quantities of nitroaromatics in the groundwater at the site), DOE announced in June 1987 its intent to issue for public comment a revised draft EIS on remedial action at the Weldon Spring site. Since that time, EPA Region VII has formally requested that DOE prepare an RI/FS for this project, pursuant to the requirements of CERCLA. The DOE and EPA have agreed that the appropriate environmental review required by an RI/FS and an EIS can be more expeditiously accomplished by incorporating those elements required by an EIS into the format of an RI/FS (herein referred to as an RI/FS-EIS). The purpose of this work plan is to describe the integrated process by which DOE intends to implement the Weldon Spring Site Remedial Action Project.

This document consists of three parts. The first part is an RI/FS-EIS work plan (essentially an RI/FS work plan prepared in accordance with EPA guidance), which (1) is typically prepared prior to detailed site characterization activities, (2) summarizes existing information regarding the site, and (3) serves to integrate the site characterization and analysis of alternatives phases of the remedial action process. The second part of this document (Appendix A) augments the information given in the body of the RI/FS-EIS work plan and contains information necessary to ensure compliance with DOE procedures for preparation of an EIS. This appendix was prepared in accordance with DOE guidance for an EIS implementation plan. The third part of the document (Appendix B) consists of responses to the major issues raised during public review of the draft EIS.

For purposes of investigation and evaluation relevant to the Weldon Spring Site Remedial Action Project, the Weldon Spring site has been divided into two separate areas: (1) the raffinate pits and chemical plant area and (2) the quarry. These two areas are considered to be one site for purposes of NEPA and CERCLA compliance. However, because the areas are geographically separate and have very distinct physical characteristics, it is reasonable to treat them separately for purposes of environmental analysis. The seven environmental compliance components associated with these two areas are shown in Figure 2. The relationship of these environmental compliance components to the RI/FS-EIS are shown in Figure 3.

Several distinct response actions may be needed at each of these two areas. The three major actions currently envisioned for the raffinate pits and chemical plant area are (1) management of the contaminated surface structures, raffinate pit wastes, surface water, and soils; (2) assessment of the need to restore contaminated groundwater; and (3) cleanup of contaminated vicinity properties. These three actions will be addressed in the RI/FS-EIS and supported by a single response decision. This decision will also include disposition of the bulk wastes currently in the quarry (Figure 3). It is possible that the groundwater restoration issue will be ready for a decision at a different time than the waste disposal issue. If this is the case, DOE may handle groundwater restoration as a separate operable unit to satisfy the requirements of NEPA and CERCLA for this decision.

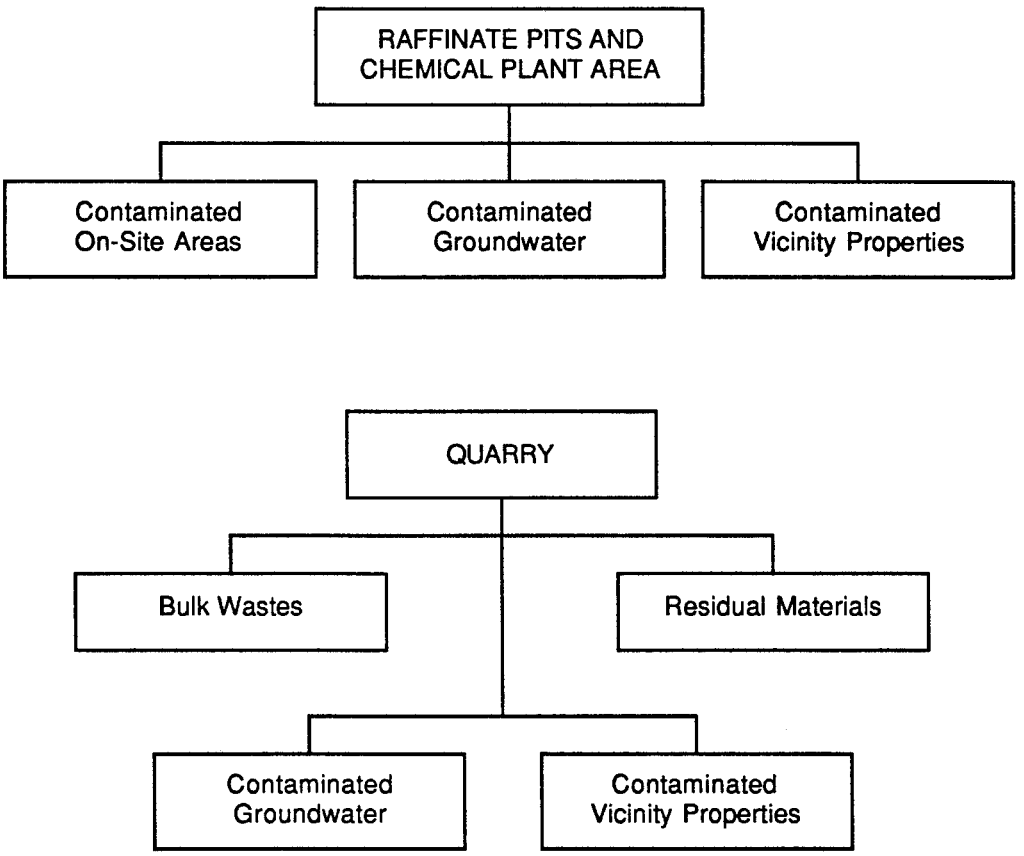


FIGURE 2 Environmental Compliance Components for the Weldon Spring Site Remedial Action Project

Four distinct response actions may be required at the quarry: bulk waste removal, removal of any residual materials following bulk waste removal, groundwater restoration, and cleanup of contaminated vicinity properties. The DOE is proposing to address bulk waste removal as a separate operable unit and will prepare a separate RI/FS and environmental assessment (EA) to support this decision (see additional discussion in Section 3.11 of this work plan). The need to remove any residual materials following bulk waste removal and the need to restore groundwater at the quarry cannot be determined until the bulk wastes have been removed and the remaining conditions evaluated. The DOE will address this issue following bulk waste removal and will involve EPA Region VII and the state of Missouri in its determination. Although removal of residual materials and groundwater restoration are shown as two separate compliance components (or operable units) in Figures 2 and 3, these may be addressed as one operable unit pending the results of environmental investigations at the quarry following bulk waste removal.

Of the vicinity properties for which it is responsible, DOE is planning to clean up those that pose an unacceptable risk to public health and the environment. Management

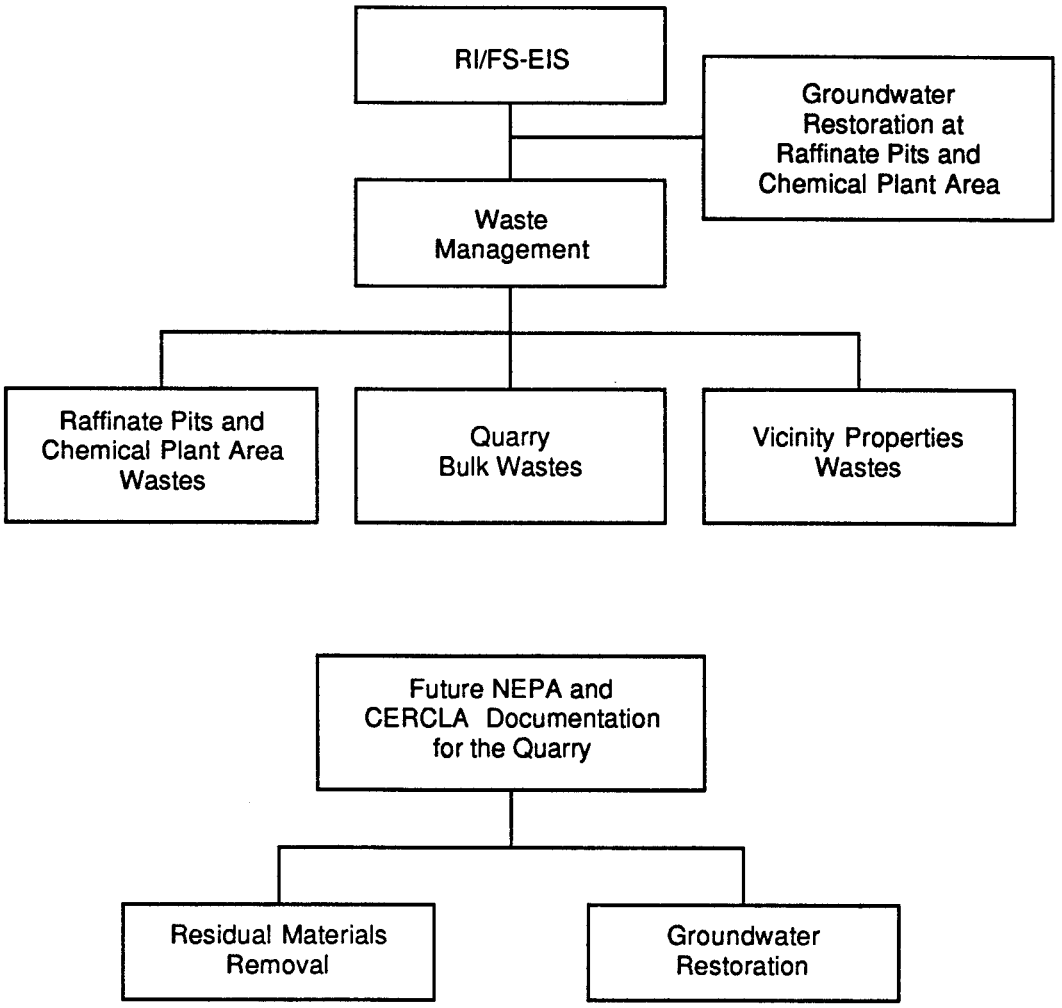


FIGURE 3 Environmental Compliance Documentation for the Weldon Spring Site Remedial Action Project

of the resulting contaminated materials will be included in the record of decision (ROD) for disposition of the raffinate pits and chemical plant area (including the bulk quarry wastes). Appropriate NEPA and CERCLA compliance documentation will be prepared prior to cleanup of the vicinity properties. Those vicinity properties cleaned up prior to the ROD will be addressed per the modified engineering evaluation/cost analysis (EE/CA) process discussed in Section 3.10.1. The cleanup of any remaining vicinity properties at the raffinate pits and chemical plant area will be included in the RI/FS-EIS. A thorough study of the need for additional cleanup of vicinity properties in the quarry area will be part of the NEPA and CERCLA processes for the residual materials and groundwater restoration operable units at the quarry.

1.3 SUMMARY OF PROPOSED APPROACH

The DOE proposes to implement a multifaceted approach at the Weldon Spring site, consisting of the following elements:

- A thorough site characterization program will be completed prior to issuance of the RI/FS-EIS for public review. The results of this characterization program will be documented in an RI report that will provide the level of environmental information required to support decisions under both NEPA and CERCLA.

- Concurrent with site characterization, a baseline risk assessment will be prepared to determine the potential threats to public health and the environment in the absence of any remedial action at the site. The results of this assessment will be included as the near-term impacts for the no-action alternative in the FS-EIS.

- The RI/FS-EIS will be prepared to analyze various alternatives for conducting remedial action at the Weldon Spring site consistent with the requirements of NEPA and CERCLA.

- Prior to issuance of the ROD for this project, various interim response actions (IRAs) will be performed to mitigate actual or potential uncontrolled releases of radioactively or chemically hazardous substances to the environment. The scope of the IRAs will be limited to those actions that can be performed under CERCLA and within the constraints of CEQ regulations for NEPA (i.e., actions will be limited to those that do not have adverse environmental impacts or limit the choice of reasonable alternatives for the ultimate disposition of the site).

- Also prior to issuance of this ROD, DOE is planning to remove the bulk wastes from the quarry and transport them to the raffinate pits and chemical plant area for temporary storage; this will be accomplished as a separate operable unit. This action will be documented in an RI/FS and EA and will be conducted within the same constraints of CEQ regulations for NEPA as the IRAs.

Several actions will occur prior to the ROD for waste disposal. The quarry bulk wastes are proposed to be removed and placed in temporary storage at the raffinate pits and chemical plant area. In addition, various IRAs will be performed, including decontamination of certain vicinity properties, as well as other actions that will alter the environmental conditions at the raffinate pits and chemical plant area. The baseline risk assessment will be prepared using current site conditions. If appropriate, this assessment will be updated at the time the RI/FS-EIS is issued to accurately reflect site conditions at that time.

This multifaceted approach has several advantages:

- Because the RI/FS-EIS will be in a format providing the level of detail required by both NEPA and CERCLA, separate documentation for NEPA and CERCLA will not be required. The DOE, in cooperation with EPA Region VII and the state of Missouri, will ensure that all NEPA and CERCLA requirements are contained within the RI/FS-EIS.

- This approach is intended to result in a single ROD by both DOE and EPA.

- This approach provides for the appropriate degree of public participation required under NEPA and CERCLA.

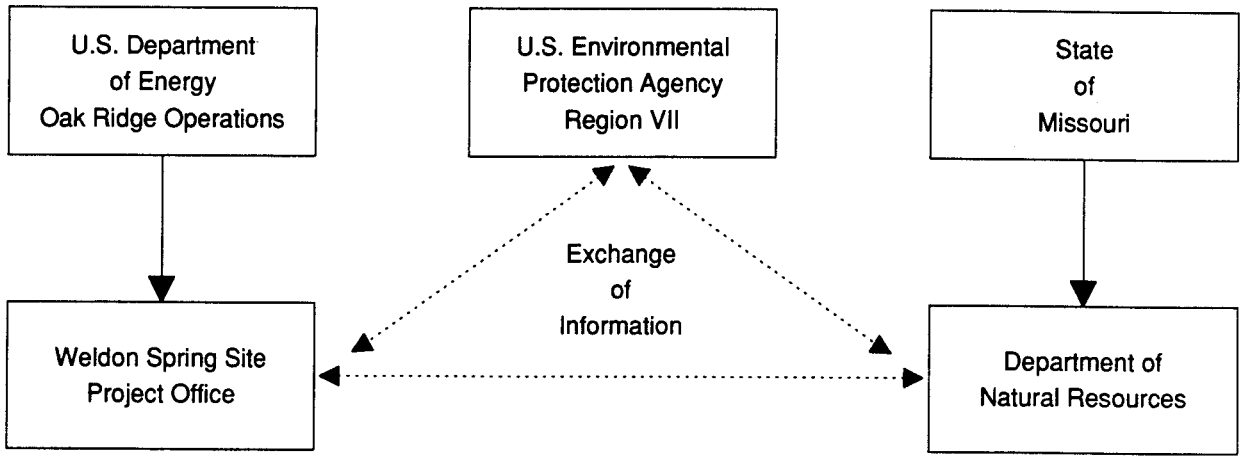
- Limited actions can be initiated via the IRAs to ensure the health and safety of on-site personnel and to minimize or preclude off-site releases of contamination.

- Removal of the bulk wastes from the quarry will reduce the risk to public health and the environment by eliminating the primary source of contamination in this area and reducing the potential for migration.

This approach will allow DOE to meet the requirements of NEPA and CERCLA and to initiate response action activities expeditiously.

The FFA signed in August 1986 provides for an exchange of information and expertise between EPA Region VII and DOE, and it establishes a basis for delisting the Weldon Spring site from the NPL upon completion of the Weldon Spring Site Remedial Action Project. This agreement, which was signed prior to the promulgation of SARA in October 1986, may need to be revised to incorporate new requirements mandated by SARA. The need for such revisions is being discussed with EPA. The DOE will also consult with the state of Missouri on this project. The DOE will interface directly with the Missouri Department of Natural Resources (DNR), the agency designated by the state of Missouri to coordinate state involvement. The relationship between DOE, EPA, and the Missouri DNR and the major responsibilities of each are shown in Figure 4. Through its community relations plan, DOE will also exchange information with the St. Charles County Commission, federal and state legislators from Missouri, local citizens, and public interest groups.

Two additional agencies that are directly involved in this project are the U.S. Geological Survey (USGS) and the University of Missouri. These agencies are funded by DOE and perform specific geological and hydrological studies based on their expertise and experience in these areas.



U.S. Department of Energy	U.S. Environmental Protection Agency	Missouri Department of Natural Resources
Perform environmental analyses and prepare NEPA and CERCLA documentation in accordance with existing requirements and guidance.	Ensure compliance with NEPA and CERCLA requirements.	Ensure compliance with state environmental review requirements. Coordinate review and response of other appropriate state agencies.
Prepare engineering and characterization plans and reports.	Review engineering and characterization plans and reports.	Review engineering and characterization plans and reports.
Monitor the environment before, during, and after response action activities to ensure a safe environment for the nearby population.	Ensure a safe environment for the workers and nearby population.	Ensure a safe environment for the workers and nearby population. Conduct independent environmental monitoring, as appropriate.
Perform response action activities.	Oversee response action activities.	Oversee response action activities. Perform special studies, as appropriate.

FIGURE 4 Relationship between the U.S. Department of Energy, U.S. Environmental Protection Agency Region VII, and State of Missouri for the Weldon Spring Site Remedial Action Project

This work plan presents a description of the Weldon Spring site, its history, and the existing environmental setting. In addition, the document includes an initial evaluation of site contamination, environmental transport mechanisms, and potentially exposed individuals. It also presents the procedures that will be followed to obtain data that, with evaluation, will allow the RI/FS-EIS process to be completed and documented. As a component of the overall program of project management, quality assurance, and quality control, this work plan also includes a description of the organization, project controls, and task schedules that will be employed to fulfill the requirements of the proposed studies.

2 SITE BACKGROUND AND SETTING

2.1 SITE DESCRIPTION

The 21-ha (51-acre) raffinate pits area at the Weldon Spring site contains four surface impoundments (raffinate pits) covering approximately 11 ha (26 acres). These pits were constructed by excavating the existing clay formation and using the removed clay to construct the dikes. The raffinate pits contain the residues from uranium and thorium processing operations previously conducted at the chemical plant (U.S. Dept. Energy 1987a). These residues are generally covered with water during the entire year. Ash Pond and Frog Pond are two additional surface water bodies in the chemical plant area. The 67-ha (166-acre) chemical plant consists of 13 major buildings and approximately 30 support structures, as shown in Figure 5 (U.S. Dept. Energy 1987c).

The quarry is located in limestone and covers about 3.6 ha (9 acres). The deepest part is filled with water covering about 0.2 ha (0.5 acres) and is the only surface water body within this controlled area. The layout of the quarry is shown in Figure 6. The quarry was used for disposal of a variety of wastes at different times during the Weldon Spring site's operational period. A major source of potable groundwater in this area is the county well field located about 1.6 km (1 mi) southeast of the quarry in the Missouri River alluvium (U.S. Dept. Energy 1987a). The nearest well is located about 0.8 km (0.5 mi) from the quarry.

The Weldon Spring site is located within the St. Louis metropolitan area in St. Charles County. The St. Louis metropolitan area has a population in excess of 2.5 million. The communities of Weldon Spring and Weldon Spring Heights are located approximately 3.2 km (2 mi) from the chemical plant and raffinate pits area and have a combined population of about 800. The Francis Howell High School is located about 1 km (0.6 mi) east of the raffinate pits and chemical plant area on State Route 94. An estimated 2,300 persons are on campus daily during the school year (U.S. Dept. Energy 1987a). The largest city in St. Charles County is the city of St. Charles, which is located about 24 km (15 mi) northeast of the raffinate pits and chemical plant area and has a population of about 40,000. St. Charles County has been experiencing a rapid population growth in the last few decades. The 1980 population of 144,000 represented a 55% increase over the 1970 population.

2.2 SITE HISTORY

In 1941, the U.S. Department of the Army acquired about 7,000 ha (17,000 acres) of land in St. Charles County, Missouri. The Weldon Spring Ordnance Works was constructed on this land and was operated for the Army as a TNT and DNT explosives production facility from November 1941 through January 1944 by Atlas Powder Company. The ordnance works was closed and declared surplus to Army needs in April 1946. By 1949, all but about 810 ha (2,000 acres) had been transferred to the state of Missouri (August A. Busch Memorial Wildlife Area) and the University of Missouri (agricultural research land). A large portion of the land transferred to the University of Missouri is now included in the Weldon Spring Wildlife Area. Except for several small parcels

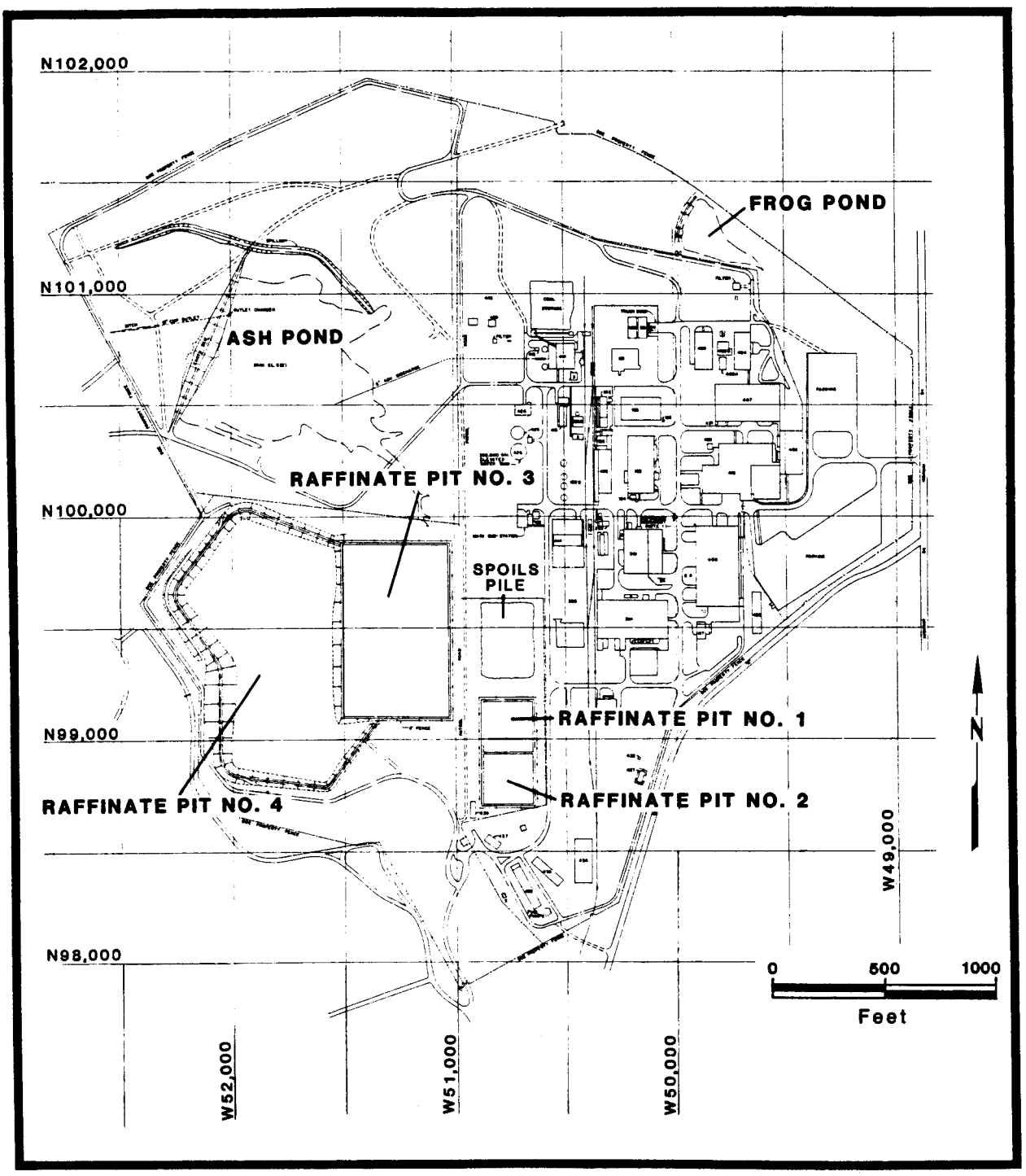


FIGURE 5 Layout of the Weldon Spring Raffinate Pits and Chemical Plant Area

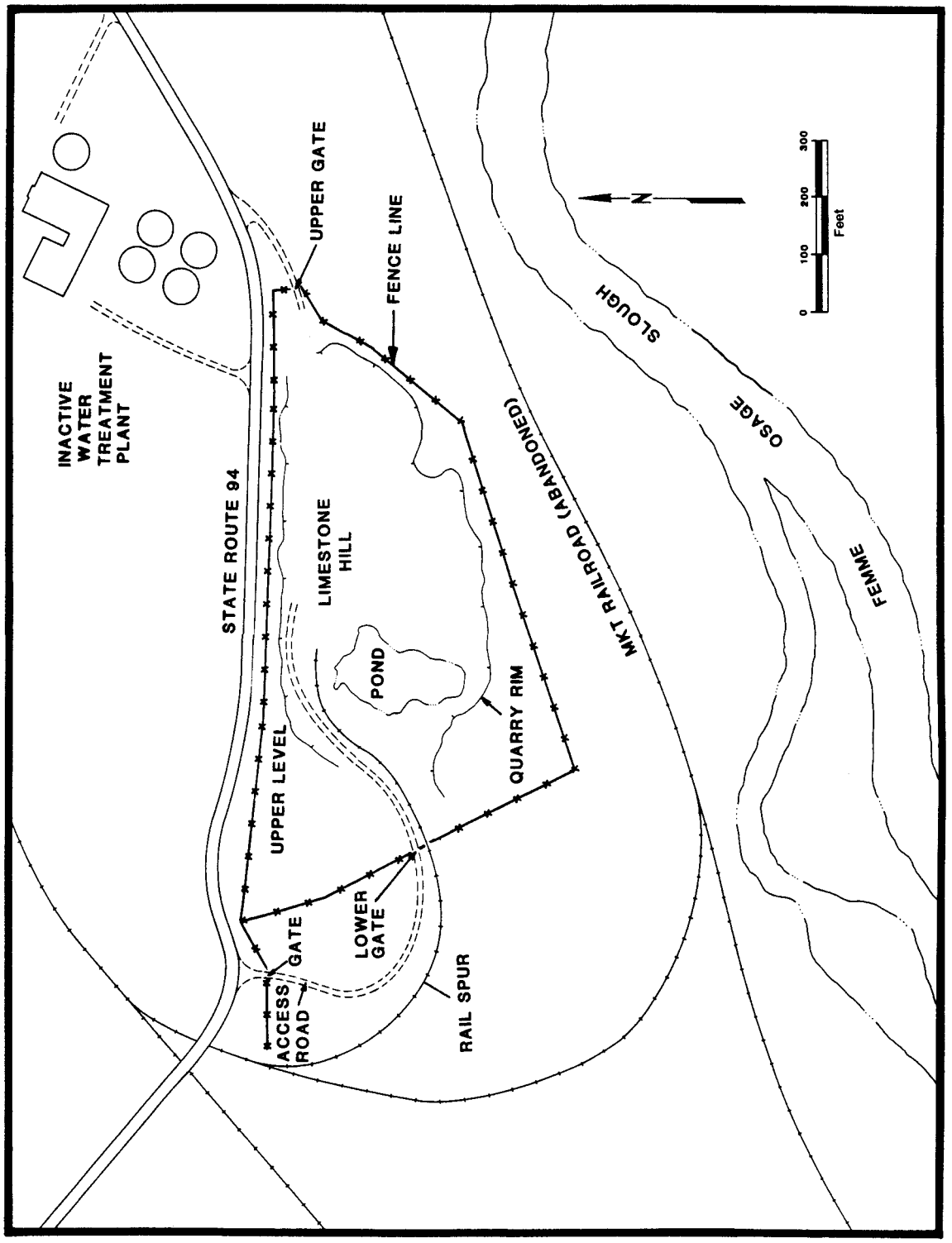


FIGURE 6 Layout of the Weldon Spring Quarry

transferred to St. Charles County, the remaining property became the current Weldon Spring site and the adjacent U.S. Army Reserve and National Guard Training Area.

Through a memorandum of understanding between the Secretary of the Army and the General Manager for the AEC in May 1955, 83 ha (205 acres) of the former ordnance works was transferred to the AEC for construction and operation of the Weldon Spring Uranium Feed Materials Plant. Considerable explosives decontamination was performed prior to construction of the plant. The feed materials plant processed uranium and thorium ore concentrates from 1957 to 1966, with the Uranium Division of Mallinckrodt Chemical Works acting as the AEC operating contractor.

During plant operations, uranium ore concentrates and recycled scrap were processed to produce uranium trioxide, uranium tetrafluoride, and uranium metal; an average of 14,000 t (16,000 tons) of uranium materials was processed per year. In addition, a limited amount of thorium ore concentrates was processed at the plant. These processes generated several chemical and radioactive waste streams, including raffinates from the refinery operation and magnesium fluoride slurry (washed slag) from the uranium recovery process. These streams were slurried to the raffinate pits where the solids settled out and the supernatant liquids were decanted to the plant process sewer; this sewer drained off-site to the Missouri River. The solids remaining in the pits consist of silica and other insoluble metals and oxides associated with the uranium ore feed materials, hydroxides and other precipitates formed from lime neutralization of the raffinates, and washed slag residues from uranium metal production.

The AEC closed the feed materials plant in December 1966; however, in August 1967, the plant was selected as the site for an herbicide production facility. The AEC granted a license to the Army for the radioactive source material that was present as contamination throughout the site. On December 31, 1967, the feed materials plant was transferred to the Kansas City District of the U.S. Army Corps of Engineers for the design and construction of the herbicide facility. Excluded from the transfer were custody and control of the source and special nuclear material stored in the four raffinate pits. Because the AEC did not elect to remove the source and special nuclear material, the 21 ha (51 acres) on which the raffinate pits are located was transferred back to the AEC in December 1971.

Decontamination and dismantling operations at the feed materials plant, now referred to as the chemical plant, were initiated for the Army in January 1968 by Thompson-Stearns-Roger Corporation to allow for construction of the herbicide facility. However, the extensive decontamination effort and associated costs required to meet radiological contamination limits imposed on the facility, combined with a reduction in the military's requirements for herbicides, resulted in cancellation of the project on February 4, 1969. The cancellation occurred before any processing activities were initiated. The Army retained responsibility for the land and facilities at the chemical plant.

The National Lead Company of Ohio (NLO) was contracted by the AEC to perform environmental monitoring and maintenance of the raffinate pits and quarry. Bechtel National, Inc. -- under contract to DOE -- assumed management responsibility for the raffinate pits and quarry from NLO in October 1981. In November 1984, DOE

was directed by the Office of Management and Budget to assume custody and accountability for the chemical plant from the Army. This transfer occurred on October 1, 1985. The site is currently under control of DOE and its project management contractor, MK-Ferguson Company.

2.3 ENVIRONMENTAL SETTING

2.3.1 Physical Setting

The Weldon Spring site is located in two distinct physiographic regions. The raffinate pits and chemical plant area is situated at the southern edge of the dissected till plains of the Central Lowlands Physiographic Province. The quarry is located about 6.4 km (4 mi) south-southwest of the raffinate pits and chemical plant area on the northern flank of the Salem Plateau of the Ozark Plateaus Physiographic Province. Parts of the raffinate pits and chemical plant area are covered with buildings and ponds, and the remainder is covered with vegetation (predominately grasses, shrubs, and small trees), gravel, or paved surfaces. The August A. Busch Memorial Wildlife Area is located to the north, the Weldon Spring Wildlife Area to the south and east, and the U.S. Army Reserve and National Guard Training Area to the west of the raffinate pits and chemical plant area. At the quarry, which is surrounded by the Weldon Spring Wildlife Area, vegetation consists largely of grasses, shrubs, and small trees. The deepest portion of the quarry is filled with water.

The Missouri River is located approximately 2.4 km (1.5 mi) southeast of the raffinate pits and chemical plant area and 1.6 km (1 mi) east of the quarry. At its closest point to the Weldon Spring site, the Mississippi River lies about 23 km (14 mi) north of the raffinate pits and chemical plant area and about 29 km (18 mi) north of the quarry. Surface hydrological features in the vicinity of the Weldon Spring site are shown in Figure 7.

2.3.2 Topography and Site Drainage

The Weldon Spring site is located in the southwest portion of St. Charles County. The county, roughly triangular in shape, is bounded by the Mississippi River on the north and east and the Missouri River on the south. Approximately half of the county land is floodplain and half is uplands characterized by gently rolling topography. The southwest uplands, which contain the site, are dissected by small stream valleys.

The raffinate pits and chemical plant area straddles the watershed divide that separates the Mississippi and Missouri river valleys. Gently rolling topography characterizes areas to the north and west whereas the terrain to the south and east is heavily wooded, rugged, and ravined (Figure 8). Elevations range from approximately 190 m (610 ft) mean sea level (MSL) near the northern edge of the raffinate pits and chemical plant area to approximately 200 m (670 ft) MSL near the southern edge.

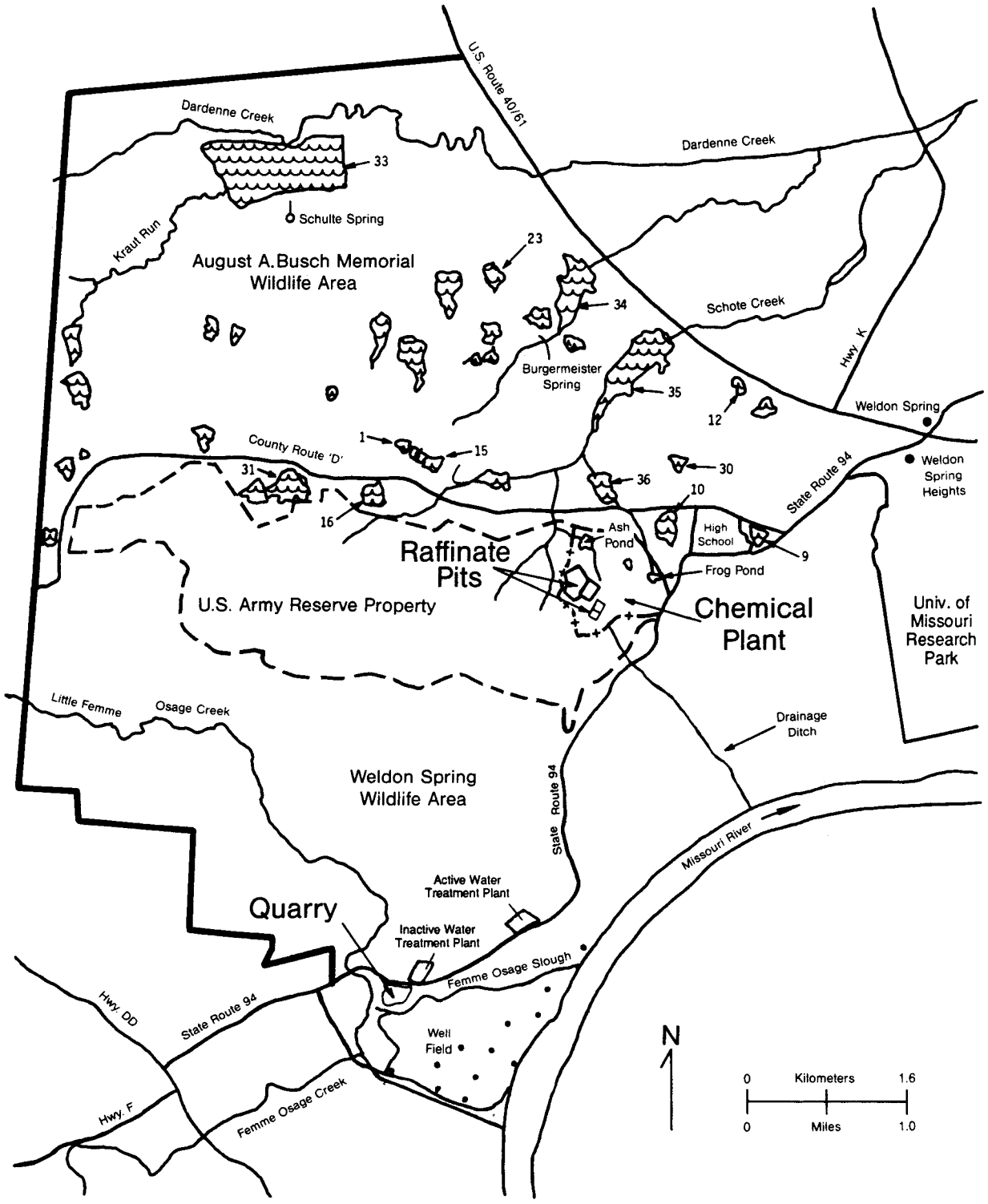


FIGURE 7 Surface Hydrological Features in the Vicinity of the Weldon Spring Site (the numbers refer to lakes in the Busch Wildlife Area) (Source: Modified from U.S. Department of Energy 1987a)

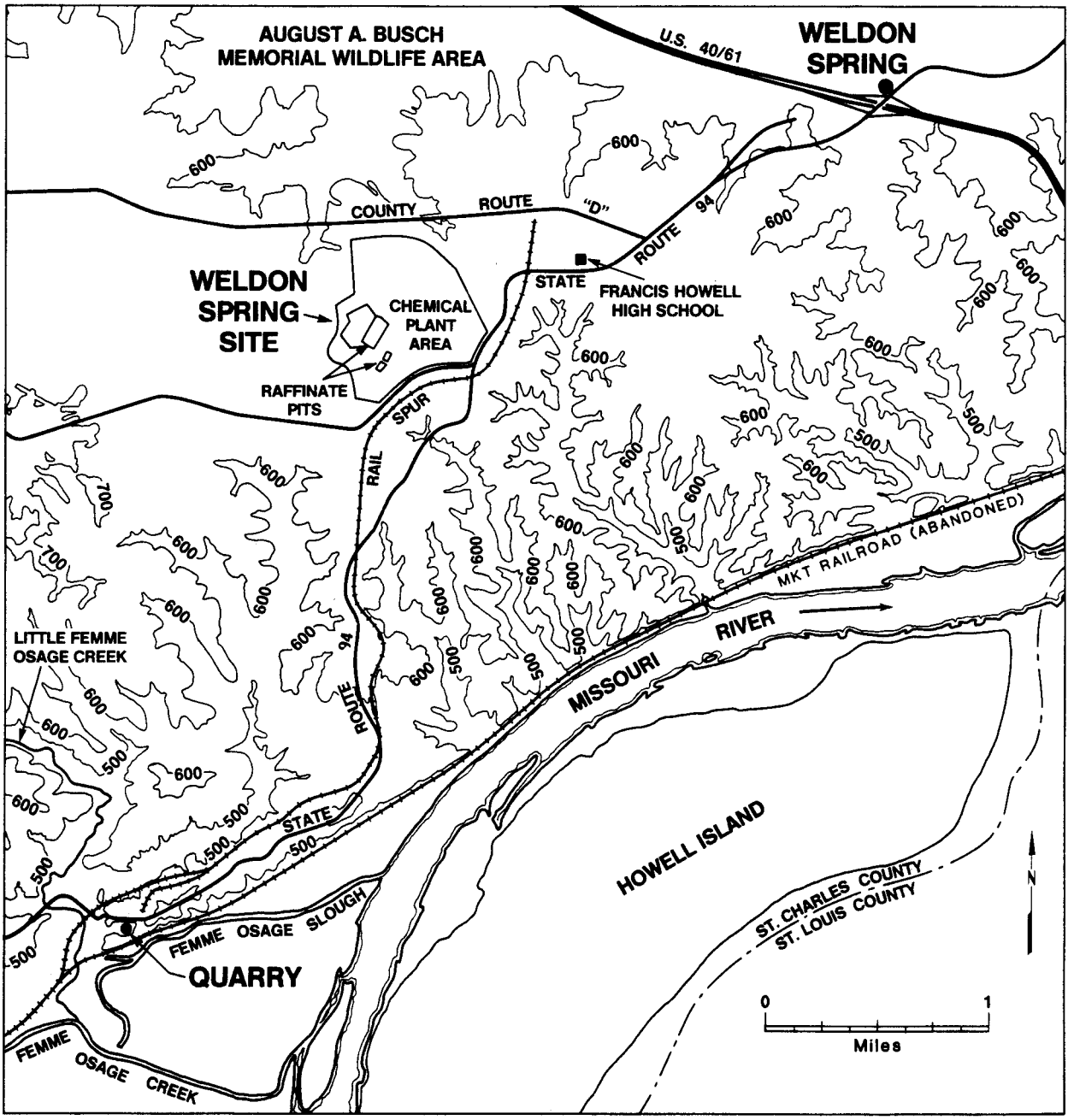


FIGURE 8 Topographic Map of the Weldon Spring Area (Elevations in Feet above MSL) (Source: Modified from U.S. Department of Energy 1987a)

Drainage and the migration of contaminants are influenced by pits, buildings, drainage ditches, and other man-made features -- as well as by ponds and other surface features, including remnants of a channel through the Ash Pond area. Surface hydrological features near the raffinate pits and chemical plant area are shown in Figure 9.

Most surface drainage from the raffinate pits area discharges either via intermittent streams in the Army Reserve training area to the west or into Ash Pond on the chemical plant area. Discharges from the intermittent streams and Ash Pond combine near County Route "D" and flow northward into Schote Creek; from there they enter Dardenne Creek, which discharges into the Mississippi River. An additional surface drainage system reaching the Mississippi River exits the chemical plant area from Frog Pond. Frog Pond drains stormwater events from most of the chemical plant area (via the stormwater sewer). Surface water flow from the northeastern edge of the chemical plant also drains to Frog Pond.

Drainage from the southern portion of the chemical plant area flows southeast to the Missouri River. As flows occur, a portion enters the subsurface; this flow reemerges farther downstream in springs or the stream channel. The drainage originates from two sources. The first is the sanitary sewer system for the chemical plant. Although this system was taken out of service in 1986, it does receive some flow from the stormwater runoff system. The sanitary system drain pipe merges with the chemical plant process sewer, which is also unused. The second source of southeast drainage flow is the overland flow from the southern portion of the chemical plant area during precipitation events.

The limestone quarry is southwest of the raffinate pits and chemical plant area and borders the Missouri River alluvial floodplain. The surrounding topography, except the floodplain area to the south, is rugged and heavily wooded and is characterized by deep ravines. The quarry floor and rim are at an elevation of about 140 and 170 m (450 and 550 ft) MSL, respectively.

Drainage in the quarry area occurs primarily through the subsurface, with limited surface drainage on the southern rim. The quarry drainage flows to the Missouri River, 1.6 km (1 mi) to the east, through Femme Osage Creek and Little Femme Osage Creek. About 210 m (700 ft) south of the quarry is a 2.4-km (1.5-mi) section of the original Femme Osage Creek that was dammed at both ends by the University of Missouri between 1960 and 1963. This section is now called the Femme Osage Slough. The water level of the slough is affected by the levels of the Missouri River and the groundwater, and the average water level is about 140 m (450 ft) MSL (U.S. Dept. Energy 1988a). The St. Charles County well field is located between the Femme Osage Slough and the Missouri River. The location of production wells in the well field is shown in Figure 10.

2.3.3 Geology

The following general description of the geology of the raffinate pits and chemical plant area highlights the major geologic characteristics of the area. More detail is provided in a recently completed hydrogeological characterization report for the chemical plant (Bechtel Natl. 1987).

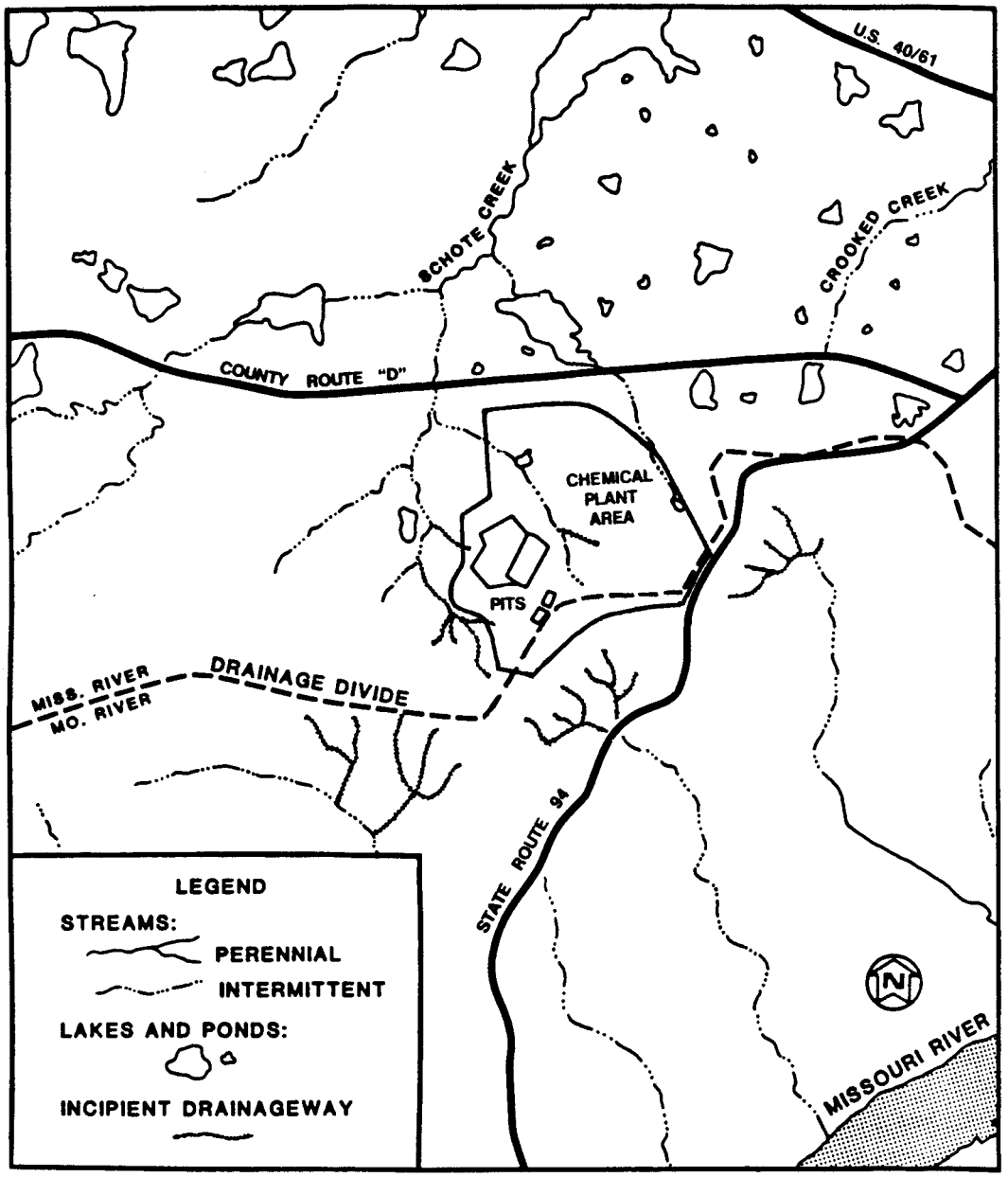


FIGURE 9 Surface Hydrological Features in the Vicinity of the Raffinate Pits and Chemical Plant Area (Source: Modified from U.S. Department of Energy 1987a)

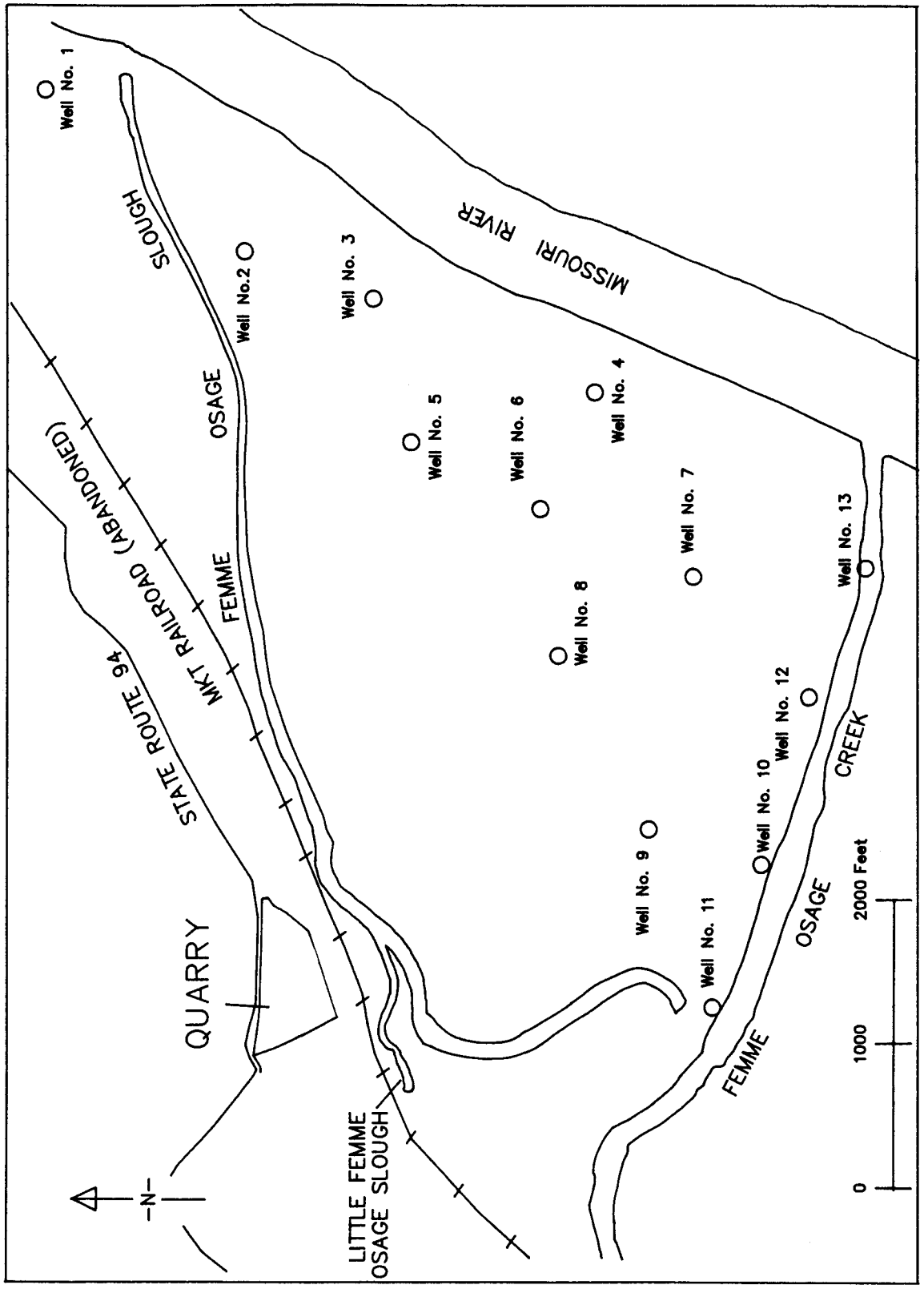


FIGURE 10 Surface Hydrological Features in the Vicinity of the Quarry and Location of Production Wells in the St. Charles County Well Field

The raffinate pits and chemical plant area is underlain by Quaternary age unconsolidated sediments and Paleozoic age bedrock formations. The unconsolidated materials in this area can be categorized into six units (see Table 1). The predominant soil type belongs to the Harvest-Urban land complex group and has a low permeability. More than 20 m (64 ft) of alluvial deposits overlie the bedrock in the Missouri River valley. Underlying the unconsolidated deposits is a thick sequence of limestones and sandstone bedrock formations of Paleozoic age. The uppermost limestone bedrock formation is fractured and contains many karst features, such as solution-enlarged cavities and voids that developed along bedding planes and northeast-trending joints. Other karst features that occur in St. Charles County include springs, losing streams, caves, and sinkholes (U.S. Dept. Energy 1987a).

TABLE 1 Unconsolidated Overburden Units in the Raffinate Pits and Chemical Plant Area

Unit	Characteristics	Thickness (m)
Topsoil	Sandy clay, blackish-brown, organic-rich.	0.15-1.5
Modified loess	Clayey silt, mottled gray-dark yellowish-orange, becomes dense and plastic with depth, manganese stained (the loess is modified in the sense that it contains higher than average clay content for loess).	0.3-4.6
Clay (Ferrelview Formation)	Clay, mottled gray-dark yellowish-orange, plastic, dense, manganese stained, contains weathered iron nodules.	0-4.6
Clay till	Clay, yellowish-brown, plastic, dense, manganese stained, blocky fractures, contains sand- to pebble-sized quartz, granitic rock, and chert dispersed throughout the clay matrix.	0.3-11.3
Basal till	Sandy, clayey silt, yellowish-brown, abundant in broken chert nodules, loosely bound by matrix.	0.3-2.4
Cherty clay	Multicolored brown, red, orange, and yellow, very dense, clay matrix with tightly bound abundant granular- to cobble-sized chert.	0-4.6

Source: U.S. Department of Energy (1987a).

The uppermost stratum at the quarry is Kimmswick limestone, and the quarry floor is Decorah shale. Limestone bedrock exposed on the quarry walls and on the steep bluffs along the Missouri River is predominantly Ordovician limestone, shale, dolomite, and sandstone.

A generalized stratigraphic column of geologic formations that are typically encountered in the vicinity of the Weldon Spring site is presented in Table 2. Also included are data on water-yielding capabilities of the different formations or formation groups. Primarily as a result of Paleozoic structural activity, the bedrock formations of the region have been formed into arches, basins, and other structures. The Weldon Spring site is located on the gently dipping east flank of the northwest-trending House Springs-Eureka anticline.

2.3.4 Hydrology

The Mississippi River is north and the Missouri River south of the Weldon Spring site. All runoff from land surfaces in the area eventually reaches the Mississippi or Missouri River. The combined flow of these two rivers at St. Louis averages about 5,100 m^3/s (180,000 cfs) (U.S. Dept. Energy 1987a).

Most of the raffinate pits and chemical plant area is located on the Mississippi River (northern) side of the drainage divide in the headwater of Schote Creek (Figure 9). Surface runoff from this area flows into nearby intermittent streams, Ash Pond, or Frog Pond on the chemical plant area (Figure 7). Surface discharges from the streams and Ash Pond combine near County Route "D" and flow northward to Lake 35 in the Busch Wildlife Area just southwest of U.S. Route 40/61; surface discharges from Frog Pond flow into Lake 36 in the Busch Wildlife Area (Figure 7). Schote Creek enters Dardenne Creek about 6 km (3.7 mi) northeast of the raffinate pits and chemical plant area and has a drainage area of about 13 km^2 (5 mi^2). Water in Dardenne Creek eventually reaches the Mississippi River near Seeburger, Missouri, about 32 km (20 mi) northwest of St. Louis (U.S. Dept. Energy 1987a).

Rainwater and snowmelt runoff and percolation enter various drains at the chemical plant area. The drains collect the water into the chemical plant process sewer, which exits on the southern slope of the drainage divide. Effluent from this exit flows to the Missouri River through a drainage ditch (Figure 7).

Preliminary estimates of flood peak discharges have been prepared by the U.S. Army Corps of Engineers, St. Louis District, for Schote Creek at several reaches and for different recurrence intervals. At the raffinate pits and chemical plant area, the 100-year and 500-year flood peak discharges at the main stem of Schote Creek are expected to be about 60 and 76 m^3/s (2,100 and 2,700 cfs). The 500-year flood elevation near the raffinate pits and chemical plant area would be about 160 m (530 ft) MSL. Thus, the area would not be affected by either a 100-year or a 500-year flood occurring in the main stem of Schote Creek (U.S. Dept. Energy 1987a).

TABLE 2 Generalized Stratigraphic Column in the Vicinity of the Weldon Spring Site

System	Series	Stratigraphic Units	Depth from Ground Level to Top of Formation (ft)	Thickness (ft)	Typical Thickness[a] (ft)	Physical Characteristics	Remarks
Quaternary	Holocene	Alluvium	0	0-65	10-30	Gravelly, silty loam over occasionally gravelly, silty clay loam.	Deposits underlie tributaries to the Missouri and Mississippi rivers.
				65-120	100-110	Silty loam, clay, and sand over sand and gravelly sand.	Deposits underlying the Missouri and Mississippi river floodplains generally yield large quantities of water to wells (600-2,600 gal/min).
	Pleistocene	Loess and glacial drift	0	0-150	5-30 30-60	Silty clay, silty loam, clay, or loam over residuum and bedrock, or both.	Yields little water to wells (<5 gal/min).
Pennsylvanian		Undifferentiated	0-120	0-75	b	Partly silty red shale with purplish-red to light gray clay.	Limited occurrence. Yields small quantities of water to wells (<1-10 gal/min).
Mississippian	Meramecian	St. Louis Limestone	0-120	0-105	70-75	Limestone: white to light gray, lithographic to finely crystalline, medium- to thick-bedded. Contains some shale.	Individually, the rock units yield small to moderate quantities of water to wells (5-50 gal/min). Collectively, these units yield sufficient water to supply most domestic and stock needs.
		Salem Limestone	0-225	0-140	90-130	Limestone: light gray to white, fine to coarsely crystalline, cross-bedded. Some siltstone and shale in lower part.	
		Warsaw Formation	0-345	0-95	70-90	Calcareous shales and interbedded shaly limestone, grades downward to shaly dolomitic limestone.	
	Osagean	Keokuk and Burlington Limestone	0-405	0-220	160-200	Limestone: white to bluish-gray, medium to coarsely crystalline, thick-bedded. Cherty.	
		Fern Glen Limestone	0-500	0-85	50-70	Limestone: yellowish-brown, fine-grained, medium- to thick-bedded. Contains appreciable chert.	
	Kinderhookian	Chouteau Limestone	0-580	0-105	50-70	Dolomitic limestone: gray to yellowish-brown, fine-grained, thin- to medium-bedded.	

TABLE 2 (Cont'd)

System	Series	Stratigraphic Units	Depth from Ground Level to Top of Formation (ft)	Thickness (ft)	Typical Thickness[a] (ft)	Physical Characteristics	Remarks
Devonian	Upper	Bushberg Sandstone	0-625	0-20	5-15	Quartz sandstone, reddish-brown, fine- to medium-grained, friable.	Yields small to moderate quantities of water to wells (5-50 gal/min).
		Lower part of Sulphur Spring Group, undifferentiated	0-625	0-60	35-40	Calcareous siltstone, and sandstone with oolitic limestone with some dark, hard, carbonaceous shale.	Group also includes Glen Park and Grassy Creek formations.
Ordovician	Cincinnatian	Maquoketa Shale	0-650	0-75	30-50	Calcareous or dolomitic shale, typically thinly laminated, silty, with shaly limestone lenses.	Yields small quantities of water to wells.
	Champlanian	Kimmswick Limestone	0-710	0-140	90-100	Limestone: white to light gray, coarsely crystalline, medium- to thick-bedded. Cherty near base.	Yields small to moderate quantities of water to wells (10-50 gal/min).
		Decorah Formation	0-810	0-35	30	Interbedded green and yellow shale, with thin beds of limestone.	
		Plattin Limestone	0-840	0-195	100-125	Limestone: light to dark gray, finely crystalline. Thin-bedded, weathers with pitted surface.	
		Joachim Dolomite	0-950	0-135	90-110	Dolomite: yellowish-brown, silty, thin- to thick-bedded. Grades into siltstone; shales common.	
		St. Peter Sandstone	0-1070	0-250	120-150	Quartz sandstone: yellowish white to white, fine- to medium-grained, massive-bedded.	Yields moderate quantities of water to wells (10-40 gal/min).
		Everton Formation	0-850	0-65	0	Sandy dolomite.	Everton Formation discontinuous.
	Canadian	Powell Dolomite	0-950	0-65	50-60	Dolomite: medium to finely crystalline, often sandy, occasionally cherty or shaly.	Generally yields small quantities of water to wells (<10 gal/min).
		Cotter Dolomite	0-1250	75-275	200-250	Dolomite: light gray to light brown, medium to finely crystalline. Cherty.	Argillaceous, interbedded with green shale.

TABLE 2 (Cont'd)

System	Series	Stratigraphic Units	Depth from Ground Level to Top of Formation (ft)	Thickness (ft)	Typical Thickness[a] (ft)	Physical Characteristics	Remarks
Ordovician (Cont'd)	Canadian (Cont'd)	Jefferson City Dolomite	100-1500	145-225	160-180	Dolomite: light brown to brown, medium to finely crystalline.	
		Roubldoux Formation	350-1700	150-170	150-170	Dolomitic sandstone.	Yields moderate to large quantities of water to wells (10-300 gal/min).
		Gasconade Dolomite	500-1850	250	250	Cherty Dolomite-Gunter Member is arenaceous dolomite.	Gunter Member is about 30 ft thick.
Cambrian	Upper	Eminence Dolomite	750-2100	190	200	Dolomite: medium- to massive-bedded, light gray, medium- to coarse-grained.	Yields moderate to large quantities of water to wells (10-500 gal/min).
		Potosl Dolomite	950-2250	100	100	Dolomite: massive, thick-bedded, medium- to fine-grained. Abundant quartz druse.	Fresh water only in southwest part of St. Charles County; saline water elsewhere in county.
		Derby Dolomite and Doe Run Dolomite	1050-2350	140	150	Dolomite: thin- to medium-bedded, alternating with thin-bedded siltstone and shale.	Hydrologic characteristics unknown in St. Charles County; occurs as a confining bed elsewhere in the state.
		Davis Formation	1200-2500	170	170	Contains shale, siltstone, fine-grained sandstone, dolomite, and limestone conglomerate.	
		Bonneterre Dolomite	1350-2650	430	400	Dolomite: typically light gray, medium- to fine-grained, medium-bedded.	Yields unknown in St. Charles County; however, water is probably saline.
		Lamotte Sandstone	1800-3100	460	450	Predominantly quartzose sandstone.	
Precambrian					2200-3500		Igneous rock. Yields no water.

[a]Typical thickness refers to thickness of formation normally encountered while drilling.

[b]Insufficient data for estimate.

Source: Data from Kleeschulte and Emmett (1986).

The quarry is located on the Missouri River (southern) side of the drainage divide (Figures 7 and 9). Surface streams in the vicinity of the quarry area include Femme Osage Creek, Little Femme Osage Creek, an unnamed tributary to Little Femme Osage Creek, and Femme Osage Slough (Figure 7). The Missouri River bottom at the quarry (river mile 49 from the confluence with the Mississippi River) is at an elevation of about 129 m (422 ft) MSL. Although the floodplain area below the quarry is partially behind a levee, the area floods occasionally to a depth of about 1 m (3-4 ft) and takes 1 to 2 months to dry; it is drained by a 41-cm (16-in.) diameter pipe through the levee (U.S. Dept. Energy 1987a).

A large volume of surface water currently exists in the raffinate pits, in ponds on the chemical plant area, and in the quarry. Although the amount of water in these impoundments varies significantly according to season, the raffinate pits generally contain about 216,000 m^3 (57,000,000 gal) and the quarry pond about 11,000 m^3 (3,000,000 gal). Two major ponds on the chemical plant area are Ash Pond and Frog Pond. Although the volume of water in Frog Pond varies throughout the year, it typically is 2,000 m^3 (500,000 gal). Ash Pond contains water intermittently, depending on seasonal precipitation events.

2.3.5 Buildings, Structures, and Other Facilities

Numerous buildings and structures associated with former ordnance works activities have been demolished or removed from the chemical plant area. The remaining buildings, facilities, and structures were used to support the chemical plant operations. Additional demolition and decontamination activities were conducted after cessation of operations. There are currently 13 major buildings, approximately 30 support structures, and other miscellaneous facilities and equipment in the chemical plant area -- including sewage treatment facilities, power lines, transformers, construction vehicles, and several office trailers. The major buildings, structures, and other facilities are listed in Table 3.

2.3.6 Local Land Use

Urban areas occupy about 6% and nonurban areas about 90% of St. Charles County (based on 1983 information). The remaining area is dedicated to transportation and water uses. It has been estimated that approximately 4% of the county's nonurban land will be converted to urban uses during 1980 to 2000 (U.S. Dept. Energy 1987a). The two closest communities to the site are Weldon Spring and Weldon Spring Heights, which are located about 3.2 km (2 mi) northeast of the raffinate pits and chemical plant area (Figure 7). The combined population of these two communities is approximately 800.

Development in the county has been dynamic in the past, and strong residential and commercial/industrial demands are anticipated to continue. The cities of St. Charles, St. Peters, O'Fallon, Lake St. Louis, and Wentzville are located along I-70 where major development has occurred. The area south of I-70 from St. Charles City to Wentzville and bounded by U.S. 40/61 to the west and the recently abandoned Missouri-Kansas-Texas (MKT) Railroad to the south is locally referred to as the "Golden

TABLE 3 Major Buildings, Structures, and Facilities at the Chemical Plant

Building or Area	Name/Function
101	Sampling plant
102	Refinery tank farm
103	Digestion and denitration
104	Lime storage
105	Ether extraction
106	Refinery sewer sampler
108	Nitric acid plant
109	West drum storage
110	East drum storage
201	Green salt building
202 (A&B)	Green salt tank farm
301	Metals building; concrete pad storage area and drum packaging stations on south side of building
302	Magnesium building
303	Foundation (only remaining structure)
401	Steam plant; coal conveyor and coal yard north of Building 401; smokestacks west of Building 401
403	Chemical pilot plant and filter and substation north of Buildings 403 and 404
404	Metal pilot plant
405 (A&B)	Pilot plant maintenance building
406	Warehouse
407	Laboratory
408	Maintenance and stores
409	Administration building
410	Services building
412	Electrical substation
413	Cooling tower and pump house
414	Salvage building
415	Process incinerator
417	Paint shop
426	Water tower
427	Primary sewage treatment plant
428	Fuel gas plant
429	Reserve water facilities
430	Ambulance garage
431	Laboratory sewer sampler
432	Main sewer sampler
433-436	Storage buildings
437	Records retention building
438	Storage building
439	Fire training building
441	Cylinder storage
443	Fire training storage building

Triangle." This area is considered likely to experience the most growth in the coming decades. The Golden Triangle includes the cities of St. Charles, St. Peters, O'Fallon, Lake St. Louis, Wentzville, Weldon Spring, Cottleville, Harvester, Dardenne, and All Saints Village. In addition to development within the Golden Triangle, there is substantial development potential in other areas of the county.

The August A. Busch Memorial Wildlife Area is located to the north and the Weldon Spring Wildlife Area to the south and east of the raffinate pits and chemical plant area. Both of these wildlife areas are park-like tracts administered by the Missouri Department of Conservation and are dedicated to various kinds of recreational uses.

The University of Missouri operates the St. Charles County Extension Center and owns 300 ha (740 acres) of land to the east of the raffinate pits and chemical plant area. This land is currently used for pasture, but about 100 ha (250 acres) is being developed as a high-technology research park, which will remain under ownership of the University of Missouri. The purpose of the research park is to help stimulate the development of high-technology industries in the St. Louis area. A state of Missouri highway maintenance facility and Francis Howell High School are also located east of the raffinate pits and chemical plant area along State Route 94.

The St. Charles County water treatment plant is located on State Route 94 about 1.6 km (1 mi) northeast of the quarry. The design capacity of this treatment plant is 61,000 m^3/day (16 mgd), and it is currently processing about 76,000 m^3/day (20 mgd) from the county well field. Five workers operate three shifts over a 7-day period at the treatment plant, with three operators during the first shift and one operator during each of two subsequent shifts. During the summer months, two additional workers are hired to perform various jobs at both the water treatment plant and the nearby county well field. Subcontract personnel are utilized at the treatment plant on an as-needed basis.

The U.S. Army Reserve and National Guard Training Area is located immediately west of the raffinate pits and chemical plant area. No permanent personnel are currently assigned to the training area, although one individual may be assigned on an intermittent basis to perform such duties as answering the telephone and checking the grounds. Regular weekend training occurs at reduced levels compared to normal training operations at other facilities because certain activities (e.g., digging foxholes) are not permitted.

2.3.7 Ecology

The Weldon Spring site is located within the Bluestem Prairie, Oak-Hickory Forest Mosaic (northern) subsection of the Prairie Parkland province. The Oak-Hickory Forest (northern) subsection also occurs within the Weldon Spring area. Much of the land surrounding the Weldon Spring site is state-owned wildlife areas containing secondary growth forest (August A. Busch Memorial Wildlife Area, Weldon Spring Wildlife Area, and Howell Island Wildlife Area). Nonforested areas occur over much of St. Charles County and are largely used for crop production and pastures or are old-field habitat.

Habitat types within the vicinity of the Weldon Spring site include open fields and pastures, forests (upland, slope, and bottomland), and cultivated fields. Slope forests are similarly dominated by oak and hickory but also include sugar maple, American elm, and black walnut among the predominant species. Bottomland forests occur within the Missouri River floodplain and along stream and lake banks. Typical tree species can include willow, eastern cottonwood, silver maple, American elm, boxelder, red mulberry, pecan, oak (pin and bur), hackberry, and persimmon. Old-field habitat includes species such as Indian mallow, crabgrass, ragweed, aster, Canada thistle, mustard, fleabane, and goldenrod. Cultivated fields contain harvestable crops whereas pastures contain herbaceous plants for grazing. The raffinate pits and chemical plant area is essentially old-field habitat; however, mowing maintains much of the area in a pasture-like condition. The quarry consists of slope and bottomland forests, and eastern cottonwood is the predominant species.

Based on habitat preferences and ranges of Missouri mammals, over 30 species could be common to abundant in the area. These would include eastern cottontail rabbit, opossum, raccoon, white-tailed deer, and several species of mouse, vole, shrew, squirrel, bat, and fox. Several mammal species -- most notably the woodchuck, eastern mole, and plains pocket gopher -- dig burrows into habitat similar to that occurring at the raffinate pits and chemical plant area.

In the Busch Wildlife Area immediately north of the raffinate pits and chemical plant area, almost 300 species of birds have been observed. About one-third of these nest in the area whereas a smaller number are common to abundant throughout at least three seasons of the year. About 10 waterfowl species are common to abundant during the spring and fall migration, and a few species such as Canada goose, mallard, and wood duck nest and/or overwinter in the area. The ponds in the raffinate pits and chemical plant area and the quarry provide habitat suitable for waterfowl.

St. Charles County is within the range of more than 50 reptile and amphibian species. Some of these species occur at the Weldon Spring site due to the variety of terrestrial and aquatic habitats that are present.

Aquatic habitats in the vicinity of the Weldon Spring site include intermittent and permanent streams that drain the site, various-sized ponds and lakes, and the Mississippi and Missouri rivers that ultimately receive drainage from St. Charles County. The Busch Wildlife Area contains 32 lakes and ponds that support a warmwater fishery. Common species include carp, black bullhead, bluntnose minnow, fathead minnow, bluegill, black crappie, white crappie, gizzard shad, largemouth bass, and channel catfish (the channel catfish is regularly stocked). Lakes 34, 35, and 36 of the Busch Wildlife Area receive drainage from the raffinate pits and chemical plant area.

Based on habitats and distributions of Missouri fishes, the fish species that would most likely be abundant in streams in the site vicinity include carp, creek chub, redfin shiner, bigmouth shiner, fathead minnow, white sucker, green sunfish, orangespotted sunfish, johnny darter, and fantail darter. The major species in the Missouri and Mississippi rivers include gar, gizzard shad, carp, river carpsucker, buffalo, channel catfish, freshwater drum, white bass, sturgeon, paddlefish, blue catfish, and blue sucker. Largemouth bass, bluegill, and crappie are also abundant in backwaters and oxbows.

Three endangered species could be present in the Weldon Spring vicinity: bald eagle (*Haliaeetus leucocephalus*), fat pocketbook pearly mussel (*Potamilus capax*), and Higgins' eye pearly mussel (*Lampsilis higginsi*). No designated critical habitat currently exists in the project area. Although the specialized habitat requirements and/or preferences of these species are not generally met by the Weldon Spring site, it is possible that the more mobile species (such as the bald eagle) could intermittently occupy the site (U.S. Dept. Energy 1987a). The mussel species would not be found in any of the aquatic areas that may be designated for response action (e.g., ponds, lakes, ditches, and drainageways) because their habitat is limited to larger rivers.

2.3.8 Regional Climate

The climate in the Weldon Spring area is continental, with moderately cold winters and warm summers. Alternating warm/cold, wet/dry air masses converge and pass eastward through the area, almost daily. The variability of the climate is demonstrated by the record low and high temperatures for the state, i.e., -40°C (-40°F) and 48°C (118°F), recorded in 1905 and 1936, respectively. The monthly average temperature is 13°C (56°F), with the average daily minimum being 7°C (45°F) and the average daily maximum being 19°C (66°F).

Normal annual precipitation in the area is approximately 94 cm (37 in.), and the heaviest rainfalls occur in the spring and early summer. Summer rains frequently occur as thunderstorms, occasionally with hail and high winds. Locally, rainfalls can be very heavy; as much as 25 cm (10 in.) has been recorded in 24 hours. The three winter months are the driest, with an average precipitation totaling about 15 cm (6 in.); the three spring months are typically the wettest, with an average total near 30 cm (12 in.) (U.S. Dept. Energy 1987a).

Wind speeds and directions recorded at the Weldon Spring site during 1985 are illustrated in Figure 11. Prevailing winds in the vicinity of the Weldon Spring site are from the south during the summer and fall. Wind speeds during these months average 13.9 km/h (8.7 mph). Winds during the winter months are from the northwest and west-northwest, averaging 17.6 km/h (11 mph) (U.S. Dept. Energy 1987b). Tornadoes occur in the St. Louis area once or twice per year, most often in April and May.

2.4 RECENT ENVIRONMENTAL MONITORING AND SITE CHARACTERIZATION STUDIES

An environmental monitoring program is in place at the Weldon Spring site in accordance with DOE requirements. This program will continue for the duration of the project. During 1981 to 1985, DOE conducted environmental monitoring programs to identify changes (if any) in the radioactive contaminant levels in and around the raffinate pits and quarry. At that time, the raffinate pits and quarry were under caretaker status of the DOE, and the chemical plant was controlled by the Army. Following its assumption of responsibility for the chemical plant in 1985, DOE revised the overall environmental monitoring program to provide a more comprehensive determination of the levels of radioactive and chemical contamination in and around the chemical plant,

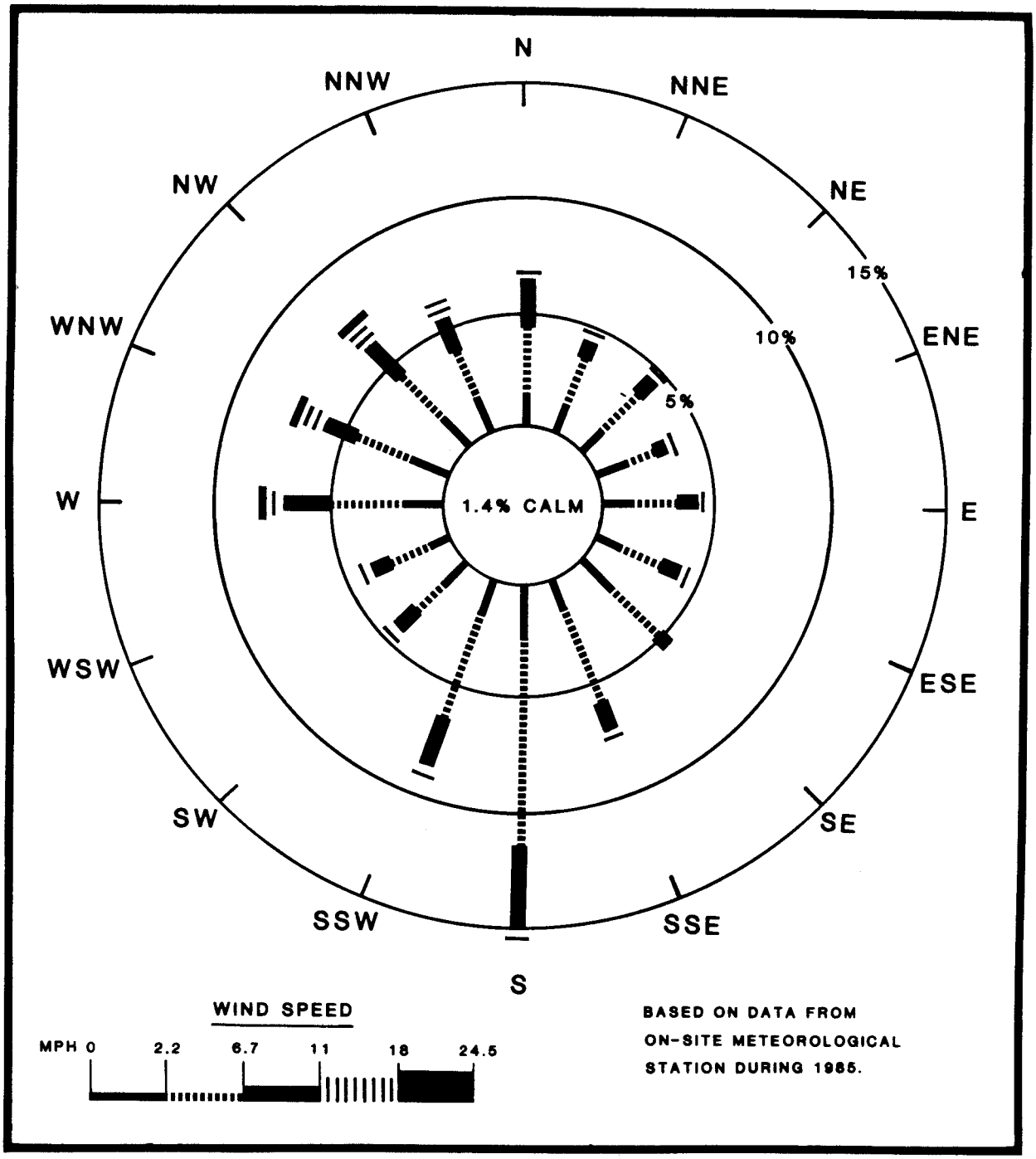


FIGURE 11 Annual Wind Rose for the Weldon Spring Site in 1985 (Source: Bechtel National 1986)

raffinate pits, and quarry. Six monitoring wells were installed in the quarry area, and 19 new wells were installed in and around the chemical plant where no monitoring wells had previously existed. These well installations were completed in late 1986. In addition, fugitive dust samplers were installed around the perimeter of the Weldon Spring site and at nearby locations (U.S. Dept. Energy 1987b).

In 1984, a radiological characterization of the quarry was completed. During this characterization effort, selected samples were analyzed for a variety of chemical species. These data became available in late 1985 and early 1986. The results led to a second, more comprehensive characterization of the quarry materials that emphasized chemical determinations. The results of the second study became available in March 1987. A sampling effort was also performed in 1986 to chemically characterize the sludge material in the raffinate pits (U.S. Dept. Energy 1987b).

Agencies other than DOE were also involved in sampling activities at the Weldon Spring site during 1986. Both the U.S. Geological Survey and the Missouri DNR collected samples from the quarry and the raffinate pits (U.S. Dept. Energy 1987b).

In 1987, DOE initiated the Phase I water quality assessment (U.S. Dept. Energy 1987c) to evaluate baseline water quality at the Weldon Spring site. Information gathered during this sampling program has been used to guide subsequent characterization activities. The Phase I program consisted of sampling 50 existing and new monitoring wells and 23 surface water locations. Groundwater samples were analyzed for nitroaromatics, select inorganic anions, various water quality indicators, radionuclides, and the complete Target Compound List (TCL) (U.S. Environ. Prot. Agency 1986a). Surface water samples were analyzed for radionuclides, select inorganic anions, various water quality indicators, and TCL metals at selected locations. Results from this monitoring program indicated the presence of high concentrations of nitrates and sulfates and significant quantities of nitroaromatics, particularly 2,6-DNT, in the groundwater at the Weldon Spring site (U.S. Dept. Energy 1987c).

An extensive field program was conducted by DOE from April to July 1987 to characterize the horizontal and vertical extent of radioactive contamination in the raffinate pits and chemical plant area (Marutzky, Colby, and Cahn 1988). This field program included exposure-rate measurements taken at the ground surface and at 1 m (3 ft) above the surface to delineate areas of elevated exposure rates. At locations exhibiting elevated exposure rates, in-situ measurements of uranium, radium, and thorium-232 were taken. If in-situ measurements showed elevated concentrations, soil samples were collected and analyzed for these elements. Randomly selected soil samples were also collected and analyzed.

Section 2.5 of this work plan summarizes the nature and extent of radioactive and chemical contamination at the Weldon Spring site, based upon currently available information. Section 4 of the work plan summarizes the rationale for developing the various field sampling and analysis plans that will be used to obtain the data needed to support detailed environmental analyses.

2.5 SUMMARY OF RECENT SITE CONTAMINATION DATA

The nature and extent of contamination at the Weldon Spring site will be further defined during the site characterization (RI) phase of this project. The following discussion is a brief summary of the known and suspected nature and extent of contamination at the raffinate pits and chemical plant area and the quarry, based upon studies that have been conducted since 1984. The individual sampling plans being developed (see Section 4.2) are designed to complete the characterization data base resulting from these studies. The discussion is generally organized by site area (i.e., raffinate pits and chemical plant area, quarry, and vicinity properties).

2.5.1 General

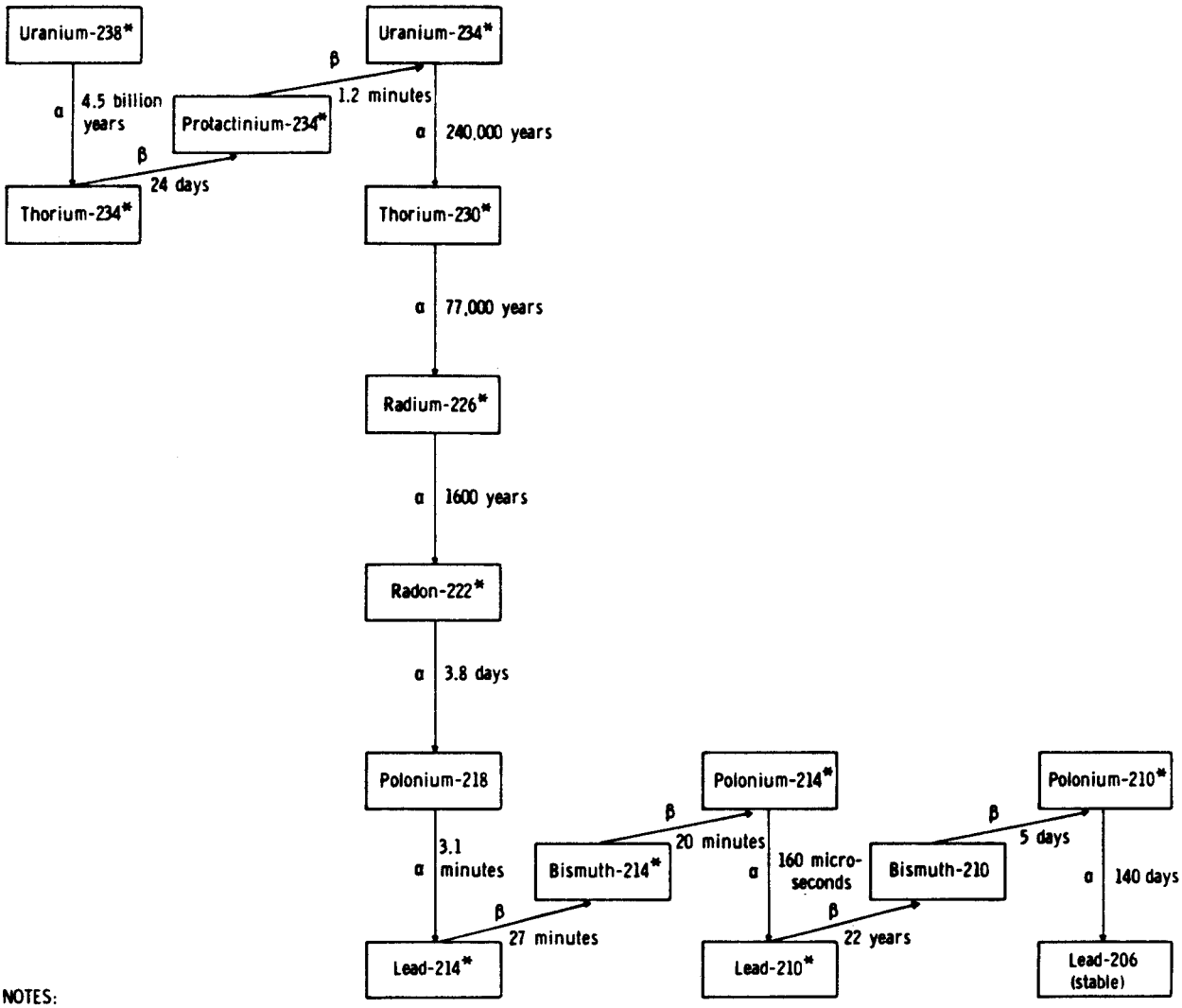
Radioactive and nonradioactive (i.e., chemical) contamination has been detected at the Weldon Spring site. In addition, some nearby vicinity properties are also contaminated with radioactive and chemical contaminants originating from the raffinate pits and chemical plant area and/or the quarry.

Uranium and thorium ore concentrates and some scrap metal were processed at the chemical plant during its operational period. An estimated 600,000 m^3 (780,000 yd^3) of radioactively contaminated materials resulted from these past operations, and these materials are currently located at the Weldon Spring site. Sludges in the raffinate pits and quarry, which comprise about one-third of the total volume of contaminated materials, contain most of the radioactive contaminants. About two-thirds of the total volume of contaminated materials consists of soil and rubble. These materials are contaminated with naturally occurring radionuclides of the uranium-238 and thorium-232 decay series (Figures 12 and 13). The estimated concentrations and inventories of the major radionuclides at the raffinate pits, chemical plant, and quarry are listed in Table 4.

Nonradioactive chemicals -- such as nitroaromatics, heavy metals, strong acid salts, and some other organics -- are present at the site due to TNT production and/or uranium-processing activities. In addition, contaminants such as polychlorinated biphenyls (PCBs) and asbestos are present because of previous uses of equipment and buildings at the site.

2.5.2 Raffinate Pits and Chemical Plant Area

Raffinate pits 1, 2, and 3 contain raffinate sludge and slag resulting from the refining of uranium ore concentrates and the recycling of scrap metal carried out at the chemical plant. Pit 4 contains similar slag and sludge as well as wastes from the processing of thorium-containing materials and drums and rubble from the partial decontamination of the chemical plant. The physical characteristics of these wastes and the volume of wastes in each pit are given in Table 5. It is estimated that the pits contain a total of about 170,000 m^3 (220,000 yd^3) of wastes.



NOTES:

Only the dominant decay mode is shown.
The times shown are half-lives.
The symbols α and β indicate alpha and beta decay.
An asterisk indicates that the isotope is also a gamma emitter.

FIGURE 12 Uranium-238 Radioactive Decay Series

The wastes in the pits are generally stratified and heterogeneous. The amount of surface water covering the wastes varies during the year. In summer, all surface water may evaporate from pits 1 and 2, but surface water is always present in pits 3 and 4. Pits 1 and 2 have not been dry since 1982. Pit 3 is designed to overflow into pit 4 through a pipe in the dike wall common to both pits. Pit 3 contains the largest volume of wastes.

Thorium-230 is the predominant radionuclide in the pit wastes. The average concentration of thorium-230 in the raffinate sludge is estimated to be 3,500 pCi/g (wet

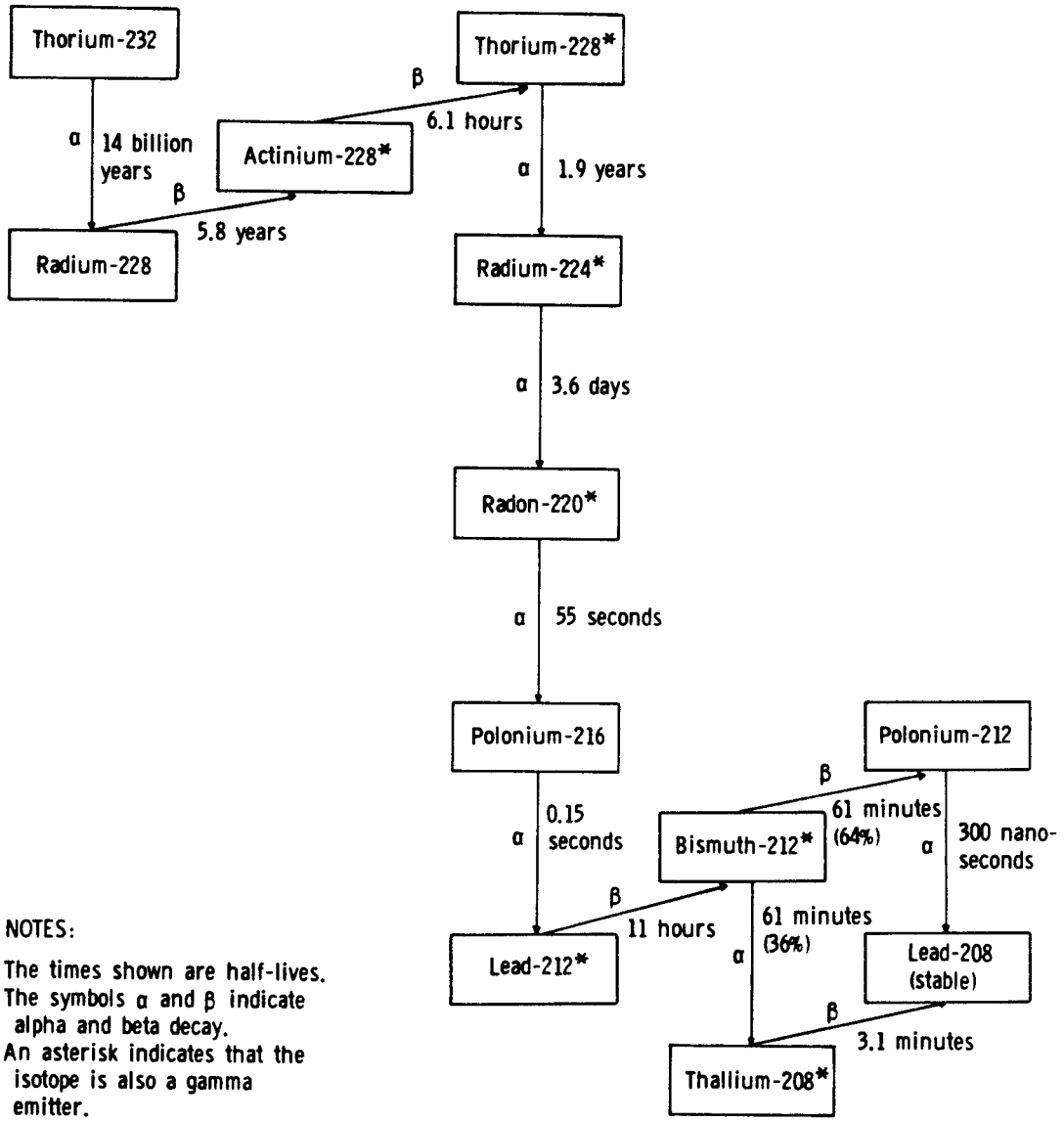


FIGURE 13 Thorium-232 Radioactive Decay Series

wt.), and the total inventory is estimated to be 700 Ci. For radium-226, the average concentration and total inventory in the wet sludge are 97 pCi/g and 20 Ci, respectively. Because of ingrowth of radium-226 from the radioactive decay of thorium-230 (which has a half-life of 77,000 years), the concentration of radium-226 in the raffinate sludge (averaged over the four pits) will increase to a peak concentration of 3,200 pCi/g (wet wt.) in about 9,000 years. After this, the radium-226 concentration will decrease at the same rate as the parent thorium-230.

The raffinate sludge has high concentrations of several metals, including iron, lead, magnesium, and molybdenum. The principal anions are nitrate, sulfate, and fluoride. In 1984, a composite sample of raffinate sludge was analyzed for 82 organic priority pollutants (19 pesticides, 7 PCBs, and 56 acid and base/neutral compounds) and

TABLE 4 Summary of Radioactive Concentrations and Inventories of the Weldon Spring Wastes

Species	Average Concentrations (pCi/g) and Inventories (Ci)[a]					
	Raffinate Pits[b]		Quarry		Chemical Plant	
	pCi/g	Ci	pCi/g	Ci	pCi/g	Ci
Uranium-238[c]	150	30	170	30	20	7
Thorium-232	32	6	16	3	3	1
Thorium-230	3,500	700	540	90	6	3
Radium-226	97	20	63	10	3	1

[a]Inventory values for all wastes and average concentrations for the chemical plant wastes are estimated to one significant figure.

[b]Concentrations are given in terms of the wet sludge.

[c]The amounts of uranium-238, uranium-235, and uranium-234 are assumed to be present in their natural activity ratio, 238:235:234 = 1:0.046:1.

Source: U.S. Department of Energy (1987a).

TABLE 5 Summary of the Physical Characteristics of Sludge in the Raffinate Pits

Pit Number	Construction Date	Pit Volume (m^3)	Percent Filled	Surface Water Volume (m^3)	Waste Volume (m^3)	Weight Percent Solids	Wet Bulk Density (g/cm^3)	Solids Weight (t)
1	1958	14,100	94.0	2,000	13,300	27.6	1.191	4,370
2	1958	14,100	94.0	2,000	13,300	29.4	1.219	4,770
3	1959	127,500	77.8	19,000	99,200	27.3	1.206	32,660
4	1964	339,800	12.5	57,000	42,500	25.3	1.184	12,730

Source: Modified from U.S. Department of Energy (1987a).

13 organic nonpriority pollutants. All concentrations were reported as being below detection limits, which varied from 0.1 to 1 ppm for the different individual compounds (U.S. Dept. Energy 1987a).

Water in the pits exists in two phases: free water above the sludge and water in intimate contact and bound to the raffinate material making a sludge or gel. The water in intimate contact with the raffinate material would be expected to have higher concentrations of dissolved solids than free water standing over the sludge.

Surface water sampling locations and groundwater monitoring well locations for the raffinate pits and chemical plant area are shown in Figures 14 and 15, respectively. The radiological results of the Phase I water quality assessment are presented in Table 6 (groundwater at the raffinate pits and chemical plant area), Table 7 (surface water in the raffinate pits), and Table 8 (surface water near the raffinate pits and chemical plant area). According to these results, elevated concentrations of uranium are present in surface water in the four raffinate pits and at off-site sampling locations.

The radioactive contamination on the chemical plant area occurred during the plant's operational period. From June 1957 to December 1966, the feed materials plant was used to process uranium concentrates in the form of sodium diuranate containing 70% uranium. Small amounts of materials containing depleted and slightly enriched uranium were also processed, and thorium concentrates were processed in 1965 and 1966. Uranium is the main radioactive contaminant at the chemical plant area. Estimated concentrations of uranium-238 range from 3.9 to 50,000 pCi/g, with a total estimated inventory of 7 Ci (U.S. Dept. Energy 1987a). Estimated concentrations and inventories of radium-226, thorium-230, and thorium-232 are much lower (see Table 4).

The presence of gamma-emitting radionuclides at the raffinate pits and chemical plant area results in elevated exposure rates. The areas having exposure rates above background levels are shown in Figure 16.

The primary nitroaromatic compounds associated with the Weldon Spring site are 2,4-DNT, 2,6-DNT, and TNT. Decomposition products of these compounds are also present in small quantities. Nitroaromatics have been detected in the soil, surface water, and groundwater at the Weldon Spring site. Figure 17 shows the groundwater monitoring wells in which detectable levels of nitroaromatics have been measured at the raffinate pits and chemical plant area. Traces of nitroaromatics have also been detected in the surface waters of Frog Pond, Ash Pond, and raffinate pit 2 (U.S. Dept. Energy 1987c). Potential nitroaromatic source areas at the raffinate pits and chemical plant area are shown in Figure 18.

Metal contamination is prevalent at the raffinate pits and chemical plant area. High concentrations of lead, iron, magnesium, and molybdenum have been reported in the raffinate pit sludge (U.S. Dept. Energy 1987a). In general, metal concentrations have been at or below normal background levels in recent analyses of groundwater and surface water samples. However, elevated levels of chromium, lithium, magnesium, nickel, and vanadium have been detected in samples of groundwater from monitoring wells 3007 and 3008 (see Figure 15).

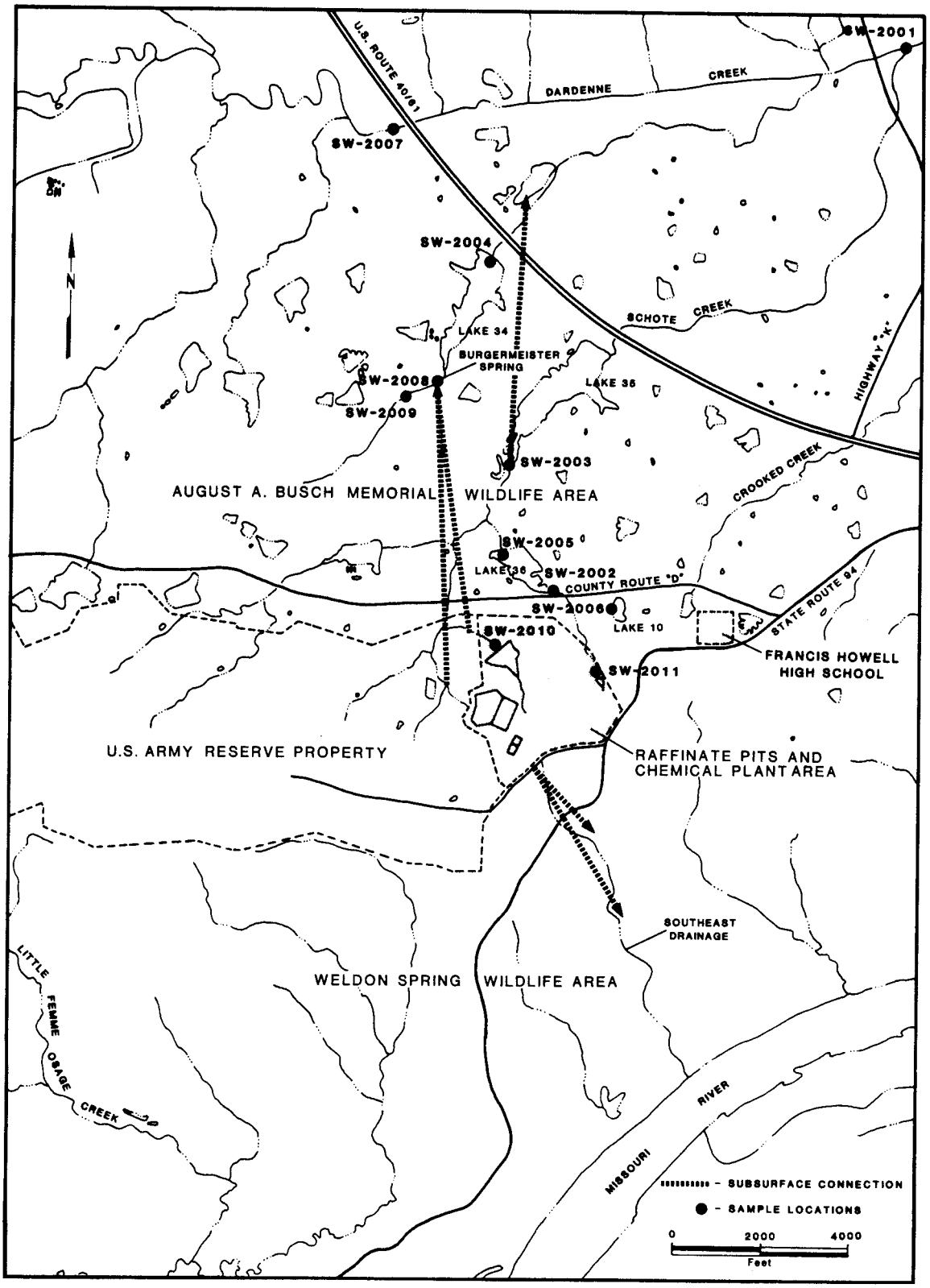


FIGURE 14 Surface Water Sampling Locations near the Raffinate Pits and Chemical Plant Area

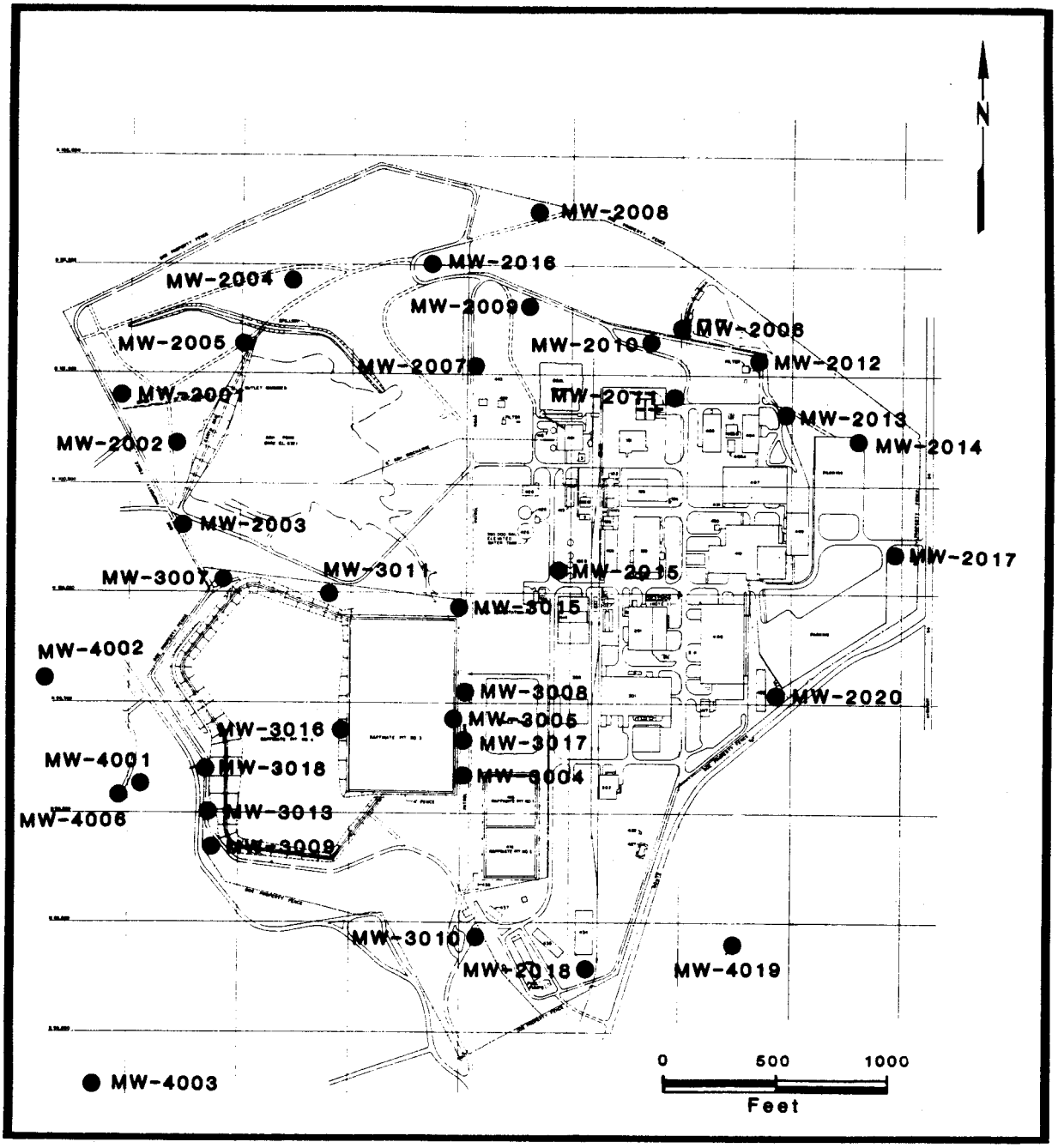


FIGURE 15 Monitoring Wells at the Raffinate Pits and Chemical Plant Area (Source: U.S. Department of Energy 1987c)

TABLE 6 Radiological Data from Groundwater Sampling at the Raffinate Pits and Chemical Plant Area

Sampling Location[a]	Date Sampled	Concentration ± Error[b] (pCi/L)						
		Gross Alpha	Gross Beta	Natural Uranium[c]	Radium -226	Radium -228	Thorium -230	Thorium -232
GW-2001	3/3/87	5.1 ± 3.9	8.7 ± 5.0	<2	<1	<3	<5	<5
GW-2002	3/4/87	I	I	5.3 ± 2	<1	<3	<4	<4
GW-2003	3/4/87	I	I	2.7 ± 1.3	<1	<4	<3	<3
GW-2003-D	3/4/87	I	I	<2	<1	<2	<2	<2
GW-2004	3/3/87	<5	<8	<2	<1	<2	<4	<4
GW-2005	3/5/87	I	2.2 ± 1.2	<1	<3	<2	<2	
GW-2006	3/2/87	<5	11 ± 5	1.9 ± 1.2	<1	<3	<3	<3
GW-2007	3/2/87	7.8 ± 4.3	<7	7.7 ± 6.5	<1	<4	<1	<1
GW-2008	3/4/87	<5	<8	2.7 ± 1.0	<1	<4	<3	<3
GW-2009	3/3/87	<5	<8	2.7 ± 1.3	<1	<5	<2	<2
GW-2010	3/3/87	6.4 ± 4.4	<8	<2	<1	<2	<4	<4
GW-2011	3/3/87	8.0 ± 4.2	10 ± 5.0	<2	<1	<4	<2	<2
GW-2012	3/3/87	<5	<8	<2	<1	<2	2.4 ± 0.6	<1
GW-2013	3/2/87	<6	<8	2.6 ± 1.3	<1	<6	<3	<3
GW-2014	3/2/87	5.6 ± 4.3	22 ± 6	3.9 ± 1.4	<1	<5	<1	<1
GW-2015	3/6/87	<5	<8	8.4 ± 1.8	<1	<4	<5	<5
GW-2015-D	3/6/87	<5	<8	4.6 ± 1.3	<1	<3	<3	<3
GW-2016	3/4/87	<5	<7	<2	<1	<2	<3	<3
GW-2017	3/2/87	<6	8.3 ± 5.4	3.7 ± 1.4	<1	<3	<2	<2
GW-2018	3/5/87	<5	<8	2.0 ± 1.0	<1	<7	<3	<3
GW-2020	3/6/87	<5	<8	4.1 ± 1.2	<1	<5	<2	<2
GW-3007	3/4/87	I	I	6.7 ± 1.4	<1	<3	<2	<2
GW-3008	3/10/87	I	80 ± 50	7.5 ± 1.5	<1	<3	I	I
GW-3009	3/5/87	<5	17 ± 6	14 ± 2	<1	I	<3	<3
GW-3010	3/5/87	<5	<8	2.4 ± 1.2	<1	<2	<3	<3
GW-3010-D	3/5/87	<5	<5	<8	2.1 ± 1.3	<1	<4	<3

TABLE 6 (Cont'd)

Sampling Location[a]	Date Sampled	Concentration ± Error[b] (pCi/L) Gross Alpha	Gross Beta	Natural Uranium[c]	Radium -226	Radium -228	Thorium -230	Thorium -232
GW-3013	3/5/87	I	I	7.4 ± 1.7	<1	<2	<9	<9
GW-4001	3/5/87	<5	<8	<2	<1	<3	<3	<3
GW-4002	3/6/87	<5	<7	<2	<1	<4	<4	<4
GW-4003	3/6/87	<5	<7	<2	<1	I	<3	<3
GW-4006	3/5/87	<5	<7	<2	<1	<4	<3	<3
GW-4019	3/6/87	<5	<7	5.2 ± 1.3	<1	<3	<3	<3

[a]D refers to duplicate sample analysis.

[b]I = interference.

[c]Natural uranium is the sum of all uranium isotopes assumed to be present in their natural activity ratio.

Source: Data from U.S. Department of Energy (1987c).

TABLE 7 Radiological Data from Water Sampling in the Four Raffinate Pits

Sampling Location	Pit No.	Date Sampled	Concentration ± Error[a] (pCi/L) Gross Alpha	Gross Beta	Natural Uranium[b]	Radium -226	Radium -228	Thorium -230	Thorium -232
SW-3001	1	4/24/87	200 ± 30	190 ± 70	45 ± 4	61 ± 7	<3	I[c]	I
SW-3002	2	4/24/87	180 ± 30	210 ± 30	300 ± 30	28 ± 8	6 ± 2.7	13 ± 2	<6
SW-3003	3	4/24/87	150 ± 50	290 ± 60	130 ± 20	42 ± 10	32 ± 4	16 ± 2	<6
SW-3004	4	4/24/87	980 ± 100	1200 ± 300	2400 ± 300	3.4 ± 0.4	13 ± 6	<5	<5

[a]I = interference.

[b]Natural uranium is the sum of all uranium isotopes assumed to be present in their natural activity ratio.

[c]Thorium levels in the sludges of pits 1 and 2 indicate that the water in pit 1 may contain about 13 pCi/L of thorium-230.

Source: Data from U.S. Department of Energy (1987c).

TABLE 8 Radiological Data from Surface Water Sampling near the Raffinate Pits and Chemical Plant Area

Sampling Location	Date Sampled	Concentration ± Error[a] (pCi/L) Gross Alpha	Gross Beta	Natural Uranium[b]	Radium -226	Radium -228	Thorium -230	Thorium -232
SW-2001	3/11/87	<3	<7	2.8 ± 1.0	<1	<5	<7	<7
SW-2002	3/10/87	50 ± 9	35 ± 7	100 ± 10	<1	<8	<2	<2
SW-2003	3/11/87	20 ± 4	14 ± 8	21.08	<1	<1	<1	<1
SW-2004	3/11/87	33 ± 5	17 ± 3	33.32	<1	<1	<1	<1
SW-2005	3/11/87	54 ± 8	23 ± 3	53.72	<1	<1	<1	<1
SW-2006	3/12/87	0 ± 1	4 ± 2	2.72	<1	<1	<1	<1
SW-2007	3/11/87	<3	<7	<1	<1	<4	I	I
SW-2008	3/10/87	97 ± 11	54 ± 7	160 ± 20	<1	<5	8.0 ± 0.6	<2
SW-2010	3/12/87	2100 ± 300	1400 ± 200	2700 ± 300	<1	<4	<2	<2
SW-2011	3/12/87	I	I	2400 ± 30	<1	<3	<2	<2

[a]I = interference.

[b]Natural uranium is the sum of all uranium isotopes assumed to be present in their natural activity ratio.

Source: Data from U.S. Department of Energy (1987c).

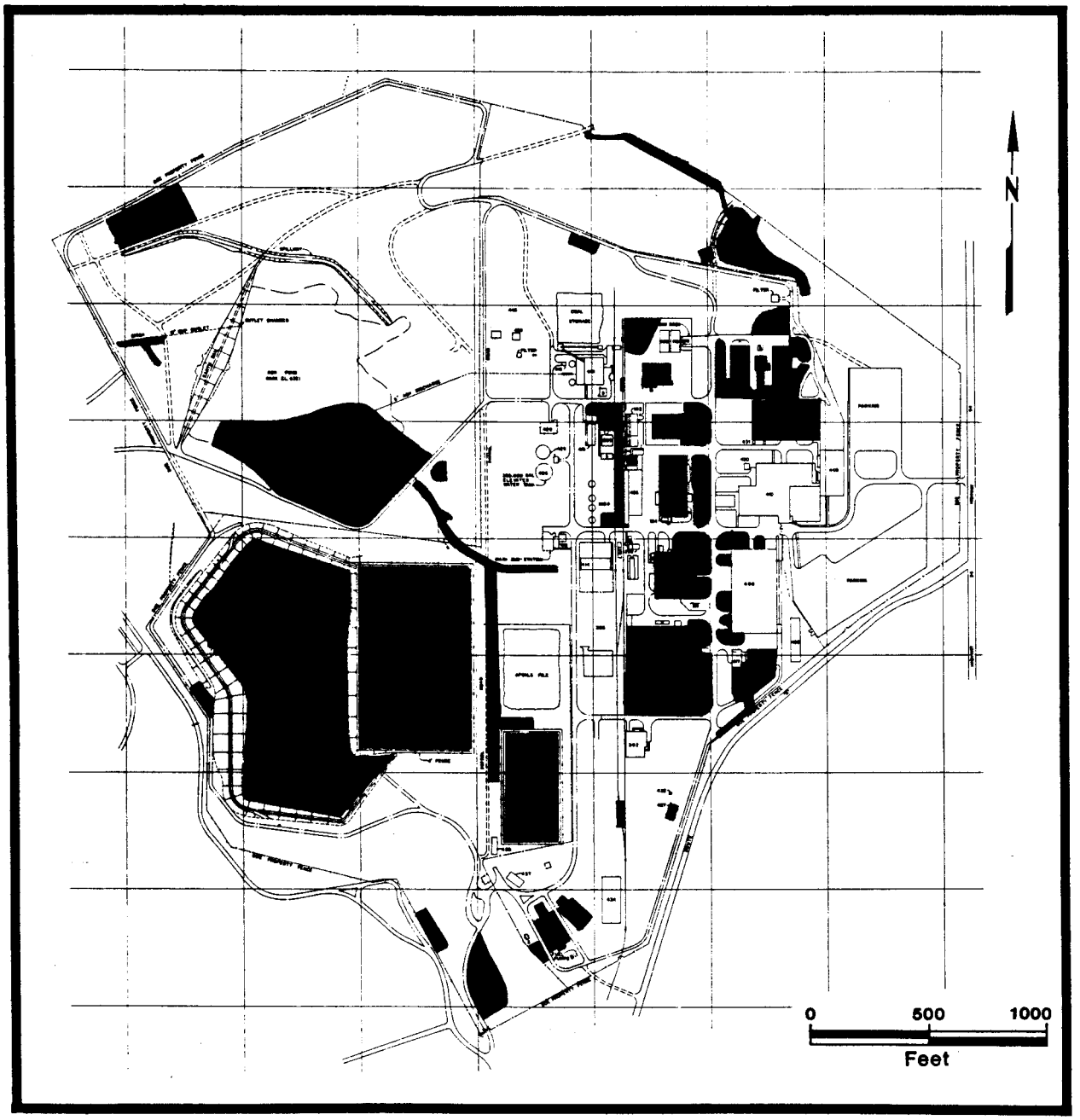


FIGURE 16 Areas in the Raffinate Pits and Chemical Plant Area that Have Exposure Rates above Background

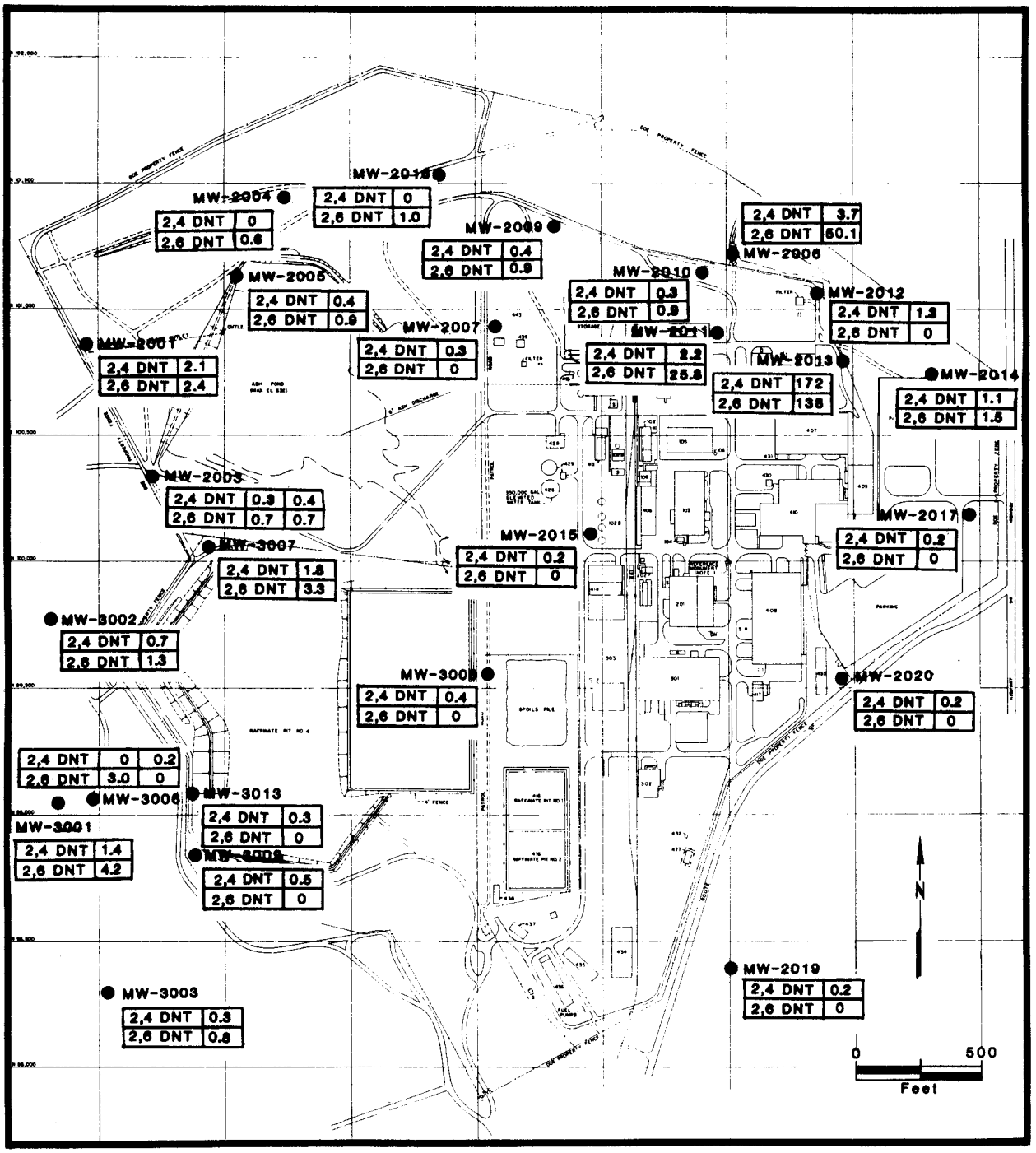


FIGURE 17 Monitoring Wells at the Raffinate Pits and Chemical Plant Area in Which Detectable Levels (μg/L) of Nitroaromatics Have Been Measured (Source: U.S. Department of Energy 1987c)

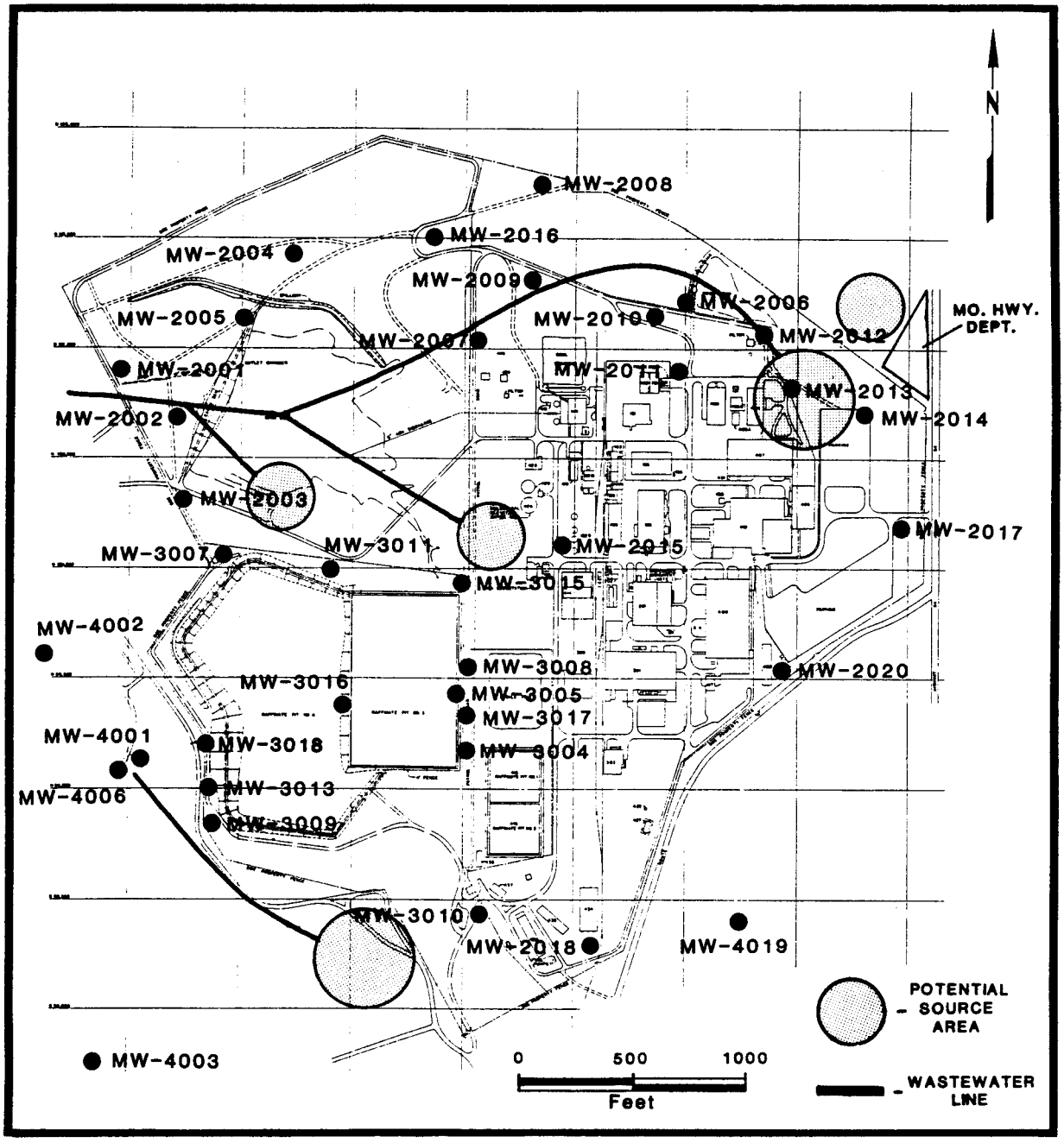


FIGURE 18 Potential Nitroaromatic Source Areas at the Raffinate Pits and Chemical Plant Area (Source: U.S. Department of Energy 1987c)

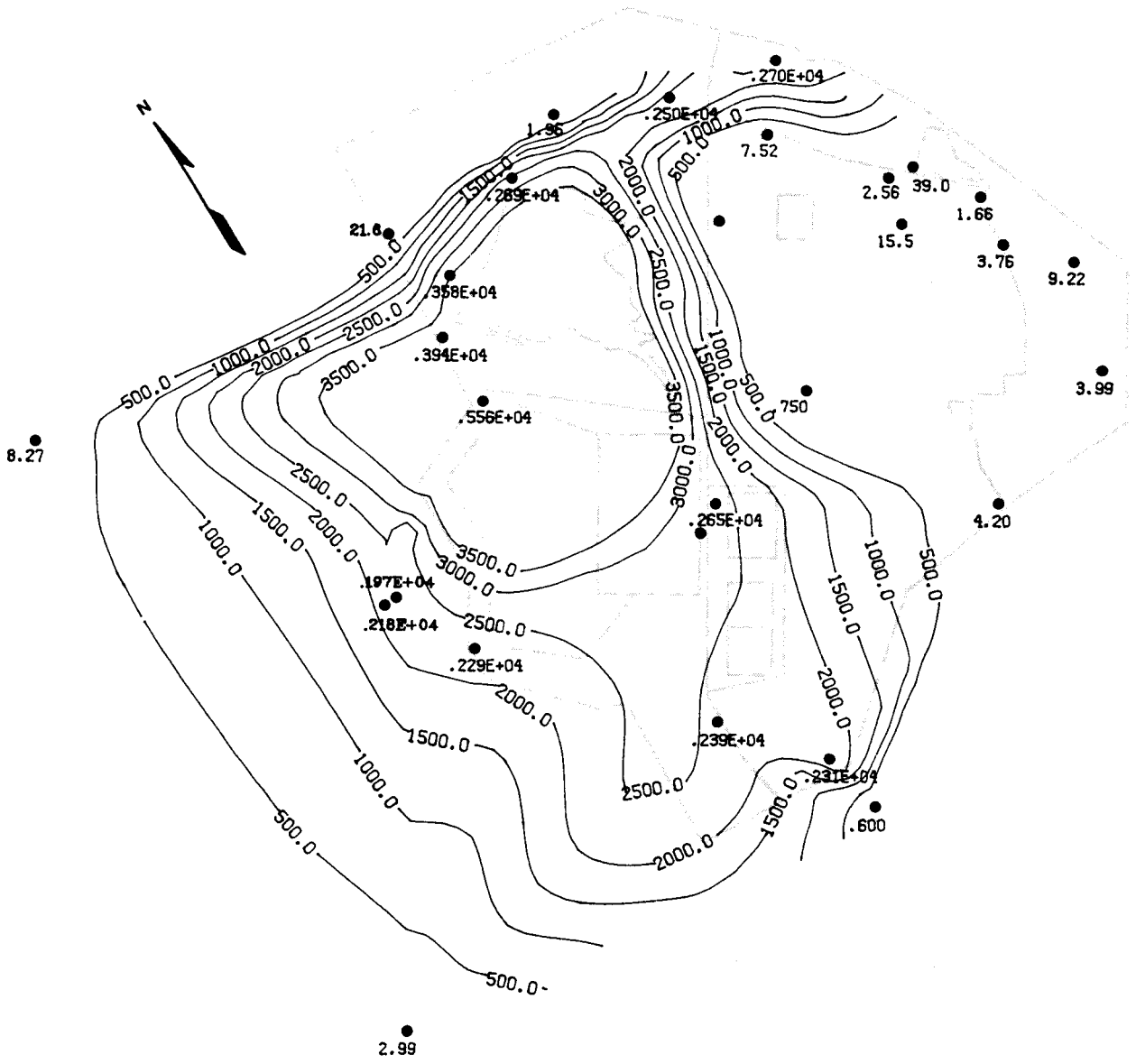


FIGURE 19 Nitrate Isopleth (mg/L as nitrate) in Groundwater at the Raffinate Pits and Chemical Plant Area (Source: Modified from U.S. Department of Energy 1987c)

Inorganic contaminants are present in the soil, groundwater, surface water, buildings, and wastes at the Weldon Spring site. Nitric acid and hydrofluoric acid were used extensively at the chemical plant. High levels of nitrates, sulfates, and fluorides are present in the raffinate pit sludge; high levels of nitrates and sulfates are present in the groundwater beneath the raffinate pits and chemical plant area (see Figures 19 and 20 for nitrate and sulfate isopleths). Inorganic anion and water quality data obtained in March and April 1987 from surface water (including raffinate pits water) and groundwater sampling are presented in Tables 9, 10, and 11.

Tributyl phosphate in hexane and other organics were used in uranium processing at the chemical plant. Two stainless steel tanks currently at the plant are partially filled

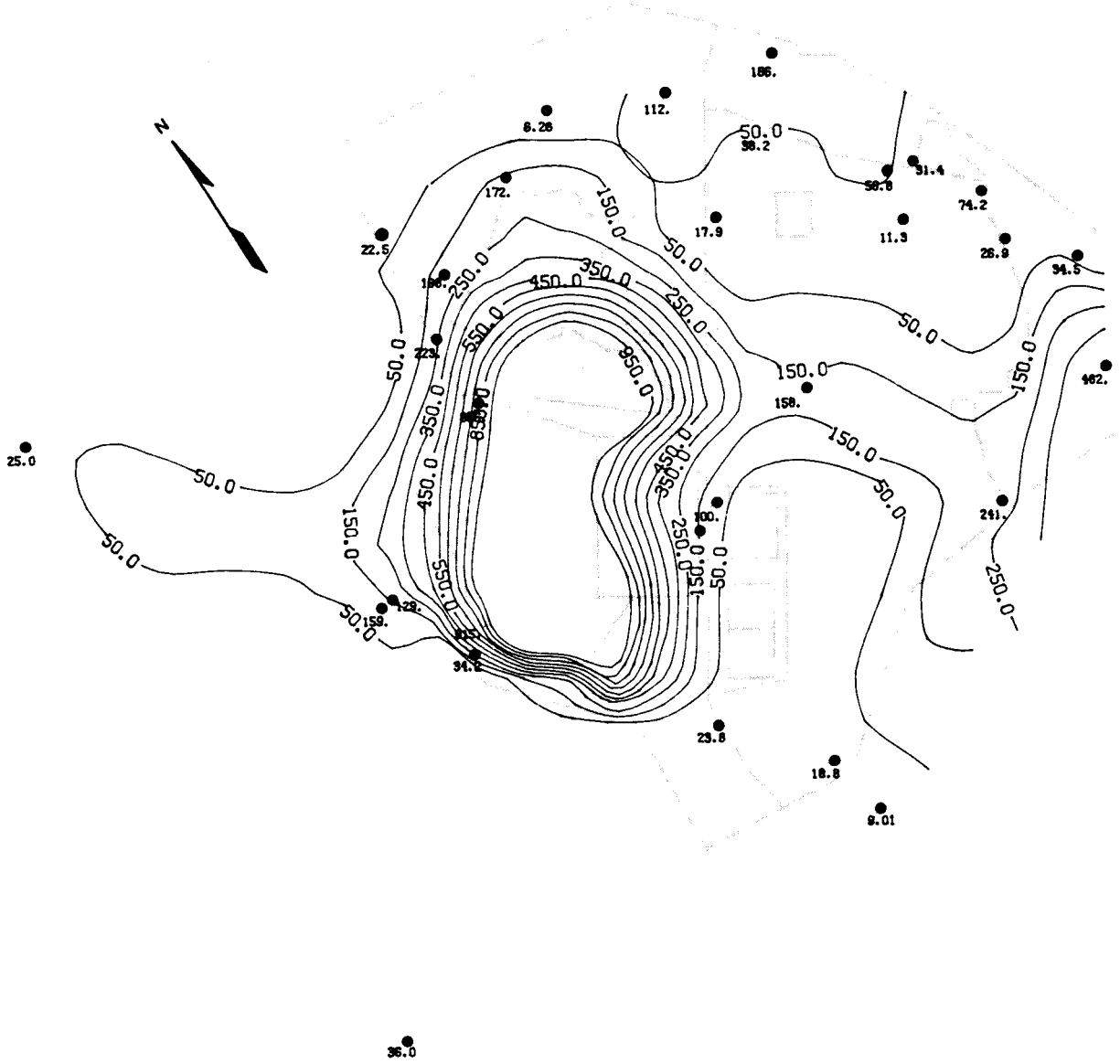


FIGURE 20 Sulfate Isopleth (mg/L) in Groundwater at the Raffinate Pits and Chemical Plant Area (Source: Modified from U.S. Department of Energy 1987c)

with solutions of tributyl phosphate/kerosene oil (a total volume of 30 m^3 [8,000 gal]), and these solutions have elevated concentrations of uranium. Samples from these tanks are currently being evaluated to assess potential reprocessing and disposal alternatives. Other tanks on-site appear empty but were previously used to store hydrofluoric acid, nitric acid, sulfuric acid, caustic soda solutions, propane, and hexane. All process tanks are located above ground; however, several underground tanks were previously used to store petroleum products.

At the chemical plant, 15 transformers contained PCB fluids in the range of 30-40% by volume. In addition, several electrical components -- including transformers, capacitors and switches -- contained PCB-contaminated fluids at PCB concentrations of

TABLE 9 Inorganic Anion and Water Quality Data from Surface Water Sampling at the Raffinate Pits and Chemical Plant Area

Sampling Location	Date Sampled	Concentration[a] (mg/L) Nitrate (as N)	Sulfate	Chloride	Fluoride	Hardness	Total Dissolved Solids	Total Organic Carbon
SW-2001	3/11/87	562	130	8.45	1.12	192	334	4.86
SW-2002	3/10/87	0.2	72.1	198	<0.25	160	526	4.23
SW-2003	3/11/87	0.3	18.8	16.5	<0.25	NM	NM	NM
SW-2004	3/11/87	2.0	25.2	17.2	<0.25	NM	NM	NM
SW-2005	3/11/87	<0.1	23.4	17.1	<0.25	NM	NM	NM
SW-2006	3/12/87	<0.1	11.3	6.67	<0.25	NM	NM	NM
SW-2007	3/11/87	538	119	6.95	0.56	171	306	3.53
SW-2008	3/10/87	12.6	55.9	13.2	<0.25	199	292	2.78
SW-2010	3/12/87	10.9	66.3	5.63	0.42	226	288	1.42
SW-2011	3/12/87	0.2	71.6	817	1.47	226	2302	1.45
EPA standard[b]		10	250	250	2	c	500	c

[a]NM = not measured.

[b]Primary/secondary drinking water standard.

[c]No drinking water standard has been promulgated for these parameters.

Source: Data from U.S. Department of Energy (1987c).

TABLE 10 Inorganic Anion and Water Quality Data from Sampling of the Raffinate Pits Water

Sampling Location	Pit No.	Date Sampled	Concentration (mg/L) Nitrate (as N)	Sulfate	Chloride	Fluoride	Hardness	Total Dissolved Solids	Total Organic Carbon	Cyanide	Phenol
SW-3001	1	4/24/87	422	231	1.50	1.90	872	3160	12	0.032	<0.005
SW-3002	2	4/24/87	10.1	493	2.34	1.57	422	818	8	0.025	<0.005
SW-3003	3	4/24/87	947	704	3.37	4.84	2107	6390	6	0.027	<0.005
SW-3004	4	4/24/87	46.6	136	5.69	4.69	252	694	8	0.032	<0.005
EPA standard[a]			10	250	250	2	b	500	b	b	0.001[c]

[a]Primary/secondary drinking water standard.

[b]No drinking water standard has been promulgated for these parameters.

[c]Missouri drinking water standard.

Source: Data from U.S. Department of Energy (1987c).

TABLE 11 Inorganic Anion Data from Groundwater Sampling at the Raffinate Pits and Chemical Plant Area

Sampling Location[a]	Date Sampled	Concentration[b] (mg/L) Nitrate (as N)	Sulfate	Chloride	Fluoride	Hardness	Total Dissolved Solids	Total Organic Carbon	Cyanide	Phenol
GW-2001	3/3/87	4.8	22.5	5.12	<0.25	307	362	<1	U	U
GW-2002	3/4/87	806	198	23.2	14.9	664	1360	1	U	U
GW-2003	3/4/87	886	223	33.2	14.7	985	2724	16	U	U
GW-2003-D	3/4/87	945	232	32.8	14.6	1331	2520	<1	U	U
GW-2004	3/3/87	0.4	6.26	1.14	<0.25	305	374	63	U	U
GW-2005	3/5/87	605	172	4.43	1.01	419	1562	2.12	U	U
GW-2006	3/2/87	8.8	31.4	87.1	<0.25	411	570	7	U	0.016
GW-2007	3/2/87	<0.1	17.9	1.34	<0.25	312	320	<1	U	U
GW-2008	3/4/87	608	166	64.2	17.0	375	622	1	U	0.013
GW-2009	3/3/87	1.7	38.2	8.04	<0.25	448	596	2	U	U
GW-2010	3/3/87	0.6	56.8	32.2	<0.25	374	590	2	U	U
GW-2011	3/3/87	3.5	11.3	4.44	<0.25	279	314	1	U	U
GW-2012	3/3/87	0.4	74.2	32.2	<0.25	352	546	57	U	U
GW-2013	3/2/87	0.9	26.9	8.62	0.40	415	688	6	U	U
GW-2014	3/2/87	2.2	34.5	2.83	0.28	460	570	3	U	U
GW-2015	3/6/87	0.2	158	2.46	<0.25	502	570	3.26	U	0.011
GW-2015-D	3/6/87	<0.1	158	2.12	0.25	514	568	2.96	U	U
GW-2016	3/4/87	562	112	18.1	15.3	328	656	2	U	U
GW-2017	3/2/87	0.9	462	10.8	0.62	735	1000	1	U	U
GW-2018	3/5/87	519	18.8	2.45	0.54	352	642	0.98	U	U
GW-2020	3/6/87	0.9	241	38.4	<0.25	434	680	8.21	U	U
GW-3007	3/4/87	1251	866	52.2	12.4	2594	5260	10	U	U
GW-3008	3/10/87	597	100	31.7	1.51	3482	6028	2.06	U	0.014
GW-3009	3/5/87	515	34.2	1.64	0.58	478	728	2.20	U	0.020
GW-3010	3/5/87	296	23.8	2.21	0.38	322	500	1.85	U	U
GW-3010-D	3/5/87	537	23.0	2.34	0.55	333	506	1.55	U	U
GW-3013	3/5/87	468	915	2.30	1.09	997	1436	3.51	U	U

TABLE 11 (Cont'd)

Sampling Location[a]	Date Sampled	Concentration[b] (mg/L) Nitrate (as N)	Sulfate	Chloride	Fluoride	Hardness	Total Dissolved Solids	Total Organic Carbon	Cyanide	Phenol
GW-4001	3/5/87	491	159	1.48	0.55	367	652	14.1	0.018	0.011
GW-4002	3/6/87	1.9	25.0	2.16	<0.25	219	232	24.8	U	U
GW-4003	3/6/87	0.7	36.0	7.40	<0.25	294	308	8.78	U	U
GW-4006	3/5/87	444	129	0.78	0.44	226	402	17.7	U	0.011
GW-4019	3/6/87	0.1	9.01	0.91	<0.25	280	278	3.77	U	0.026
EPA standard[c]		10	250	250	2	d	500	d	d	0.001[e]

[a]D refers to duplicate sample analysis.

[b]U means undetected at the contract-required detection limits.

[c]Primary/secondary drinking water standard.

[d]No drinking water standard has been promulgated for these parameters.

[e]Missouri drinking water standard.

Source: Data from U.S. Department of Energy (1987c).

less than 500 ppm (see Figure 21 and Table 12). These fluids and electric equipment have recently been removed from the site (see Section 3.10.2.1). Also, PCB contamination has been found in storage areas, on concrete pads and some building floors, and in localized areas of soil. No PCBs have been detected in groundwater or surface water samples.

Asbestos is present in many areas of the chemical plant, including overhead pipelines inside and outside of buildings, and cement-asbestos siding and internal insulation of some buildings. Asbestos pipeline insulation is typically secured to pipelines with an outer cover of nonasbestos material; this cover has deteriorated in many areas, particularly on outside lines that are exposed to the elements, and asbestos has fallen to the ground or floor. Some pipes have been dismantled and stored in spoil piles, and asbestos remnants are visible in many areas. Asbestos contamination is likely to be present at the following locations:

- Chemical plant buildings and associated indoor and outdoor pipes,
- Pipes adjacent to raffinate pits 1 and 3,
- Soils and sediments, including those from Ash Pond, Frog Pond, and areas northwest and south of Ash Pond,
- Other on-site surface impoundments, including the raffinate pits,
- Soils in localized areas traversed by outdoor pipes, and
- Spoils piles.

Known locations of asbestos at outdoor locations of the chemical plant are shown in Figure 22.

2.5.3 Quarry

The quarry was used for the disposal of chemically and radioactively contaminated materials intermittently from the early 1940s to 1968. The chemically contaminated materials are largely TNT-contaminated rubble and soil. The radioactive materials are those associated with uranium- and thorium-processing activities previously carried out at the chemical plant and at other sites in the St. Louis area. Some of these wastes may be classified as *mixed wastes*, i.e., radioactive wastes that also meet the criteria for classification as hazardous wastes under the Resource Conservation and Recovery Act (RCRA).

The concentrations of radioactive species in boreholes drilled into the quarry wastes vary greatly, as a function of both depth within a borehole and borehole location. It has been estimated that there are 73,000 m^3 (95,000 yd^3) of contaminated wastes in the quarry (U.S. Dept. Energy 1987a). Compared with the raffinate sludge, the concentration and inventory of thorium-230 are lower in the quarry wastes, but the uranium-238 concentration and inventory are similar (Table 4). In addition to uranium,

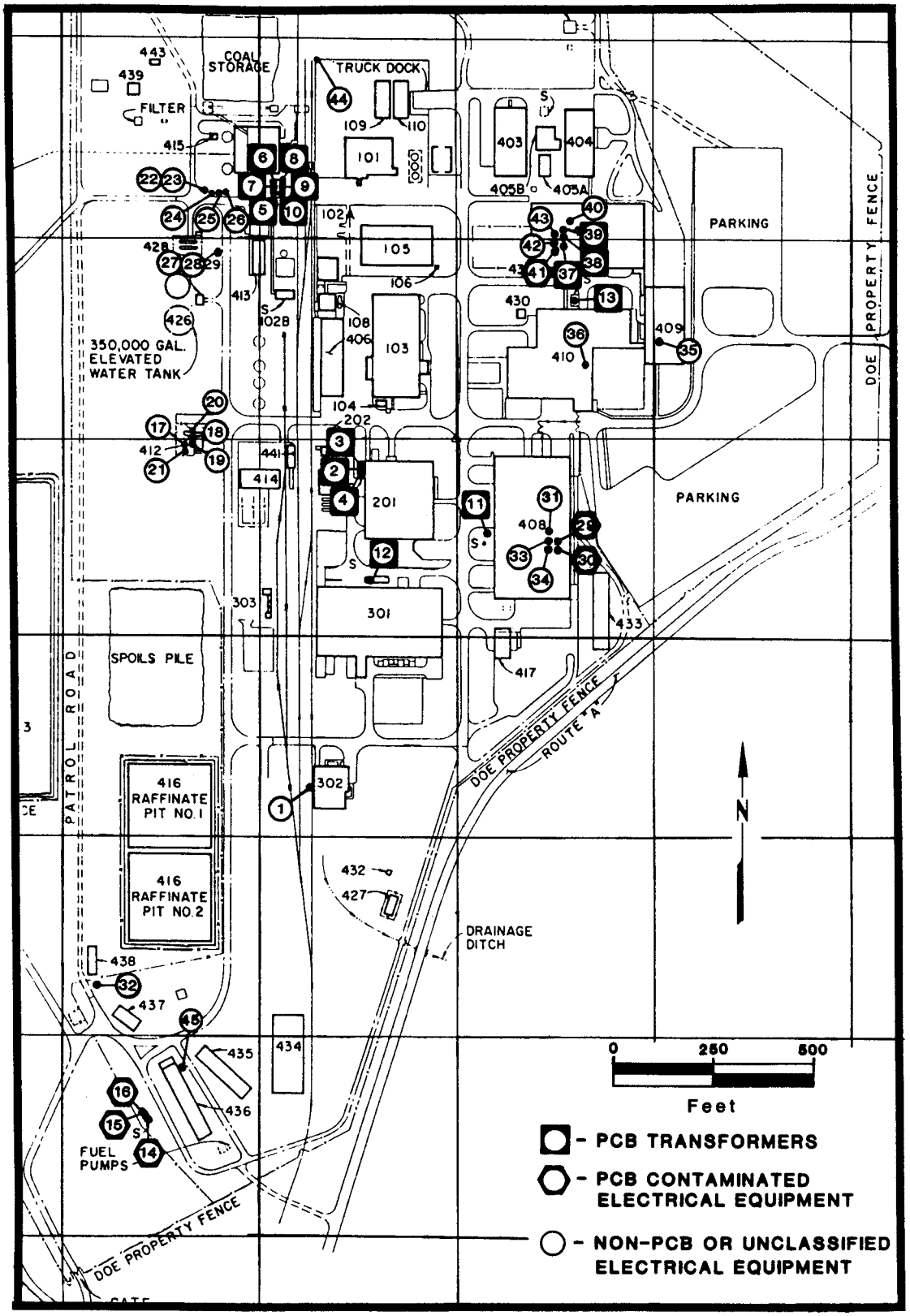


FIGURE 21 PCB-Contaminated Transformers, Capacitors, and Switches at the Chemical Plant

TABLE 12 PCB Contents of Transformers at the Weldon Spring Site

No.[a]	PCB Concentration[b] (ppm)	Capacity (gal)	Location	40 CFR Part 761 Classification
1	NA	-	Pad mounted	No PCBs
2	340,000	423	Pad mounted	PCB transformer
3	410,000	430	Pad mounted	PCB transformer
4	390,000	423	Pad mounted	PCB transformer
5	370,000	475	Pad mounted	PCB transformer
6	360,000	430	Pad mounted	PCB transformer
7	380,000	430	Pad mounted	PCB transformer
8	380,000	475	Pad mounted	PCB transformer
9	370,000	475	Pad mounted	PCB transformer
10	370,000	475	Pad mounted	PCB transformer
11	380,000	430	Pad mounted	PCB transformer
12	350,000	430	Pad mounted	PCB transformer
13	370,000	475	Pad mounted	PCB transformer
14	142	48	Pad mounted	PCB-contaminated electrical equipment
15	211	48	Pad mounted	PCB-contaminated electrical equipment
16	290	48	Pad mounted	PCB-contaminated electrical equipment
17	<0.5	330	Pad mounted	No PCBs
18	<0.5	2160	Pad mounted	No PCBs
19	<0.5	2160	Pad mounted	No PCBs
20	25	2450	Pad mounted	No PCBs
21	<0.5	45	Pad mounted	No PCBs
22	NS	≈15	Pole mounted	Not classified
23	NS	≈15	Pole mounted	Not classified
24	3.5	98	Pole mounted	No PCBs
25	1.0	71	Pole mounted	No PCBs
26	1.0	17	Pole mounted	No PCBs
27	1.5	≈75	Pole mounted	No PCBs
28	5.5	≈15	Pole mounted	No PCBs
29	223	≈50	Pole mounted	PCB-contaminated electrical equipment
30	208	≈50	Pole mounted	PCB-contaminated electrical equipment
31	2.5	≈75	Pole mounted	No PCBs
32	NS	≈50	Pole mounted	Not classified
33	NA	-	Pole mounted	No PCBs
34	NA	-	Pole mounted	No PCBs
35	NA	-	Pole mounted	No PCBs
36	NA	-	Pole mounted	No PCBs

TABLE 12 (Cont'd)

No.[a]	PCB Concentration[b] (ppm)	Capacity (gal)	Location	40 CFR Part 761 Classification
37	380,000	≈200	Roof mounted	PCB transformer
38	400,000	≈250	Roof mounted	PCB transformer
39	420,000	≈350	Roof mounted	PCB transformer
40	NA	-	Roof mounted	No PCBs
41	68	≈90	Wall mounted	PCB-contaminated electrical equipment
42	3.5	≈90	Wall mounted	No PCBs
43	2.5	≈90	Wall mounted	No PCBs
44	NA	-	Pole mounted	No PCBs
45	NS	≈15	On ground	Not classified

[a]Number refers to sampling location (see Figure 21).

[b]NA = not applicable, transformer is air-cooled and contains no dielectric fluids; NS = not sampled.

elevated concentrations of several metals -- including arsenic, copper, lead, and nickel -- have been detected. The presence of gamma-emitting radionuclides in the quarry results in elevated exposure rates. Areas at the quarry having exposure rates above background levels are shown in Figure 23.

Organic volatile and semivolatile compounds, nitroaromatic compounds, PCBs, and pesticides were detected in samples of soils, sludges, and sediments collected from 17 borings. Volatile organics detected in one or more boreholes included methylene chloride, xylene, and ethyl benzene at concentrations ranging from 1 to 50 ppm. (Volatile compounds were probably introduced into field samples during collection or analysis, based on their presence in test and sample blanks.) Semivolatile organic compounds detected in one or more boreholes included the polycyclic aromatic hydrocarbons (PAHs) phenanthrene, fluoranthene, and benzo(b)fluoranthene at maximum concentrations of 150, 190, and 110 ppm, respectively. The maximum value detected for subsurface nitroaromatic compounds was 1,600 ppm for TNT, and the maximum value for PCBs was 120 ppm for Aroclor 1254 (Kaye and Davis 1987). Surficial discoloration of soils in the eastern portion of the quarry (Figure 24) indicates the presence of nitroaromatic compounds that were subsequently determined to be at levels of 1 to 2%.

Groundwater monitoring locations near the quarry are shown in Figure 25. Results obtained during the Phase I water quality assessment and from routine environmental monitoring are presented in Table 13 (radiological parameters), Table 14 (nitroaromatics), Table 15 (metals), and Table 16 (inorganic anion species and water

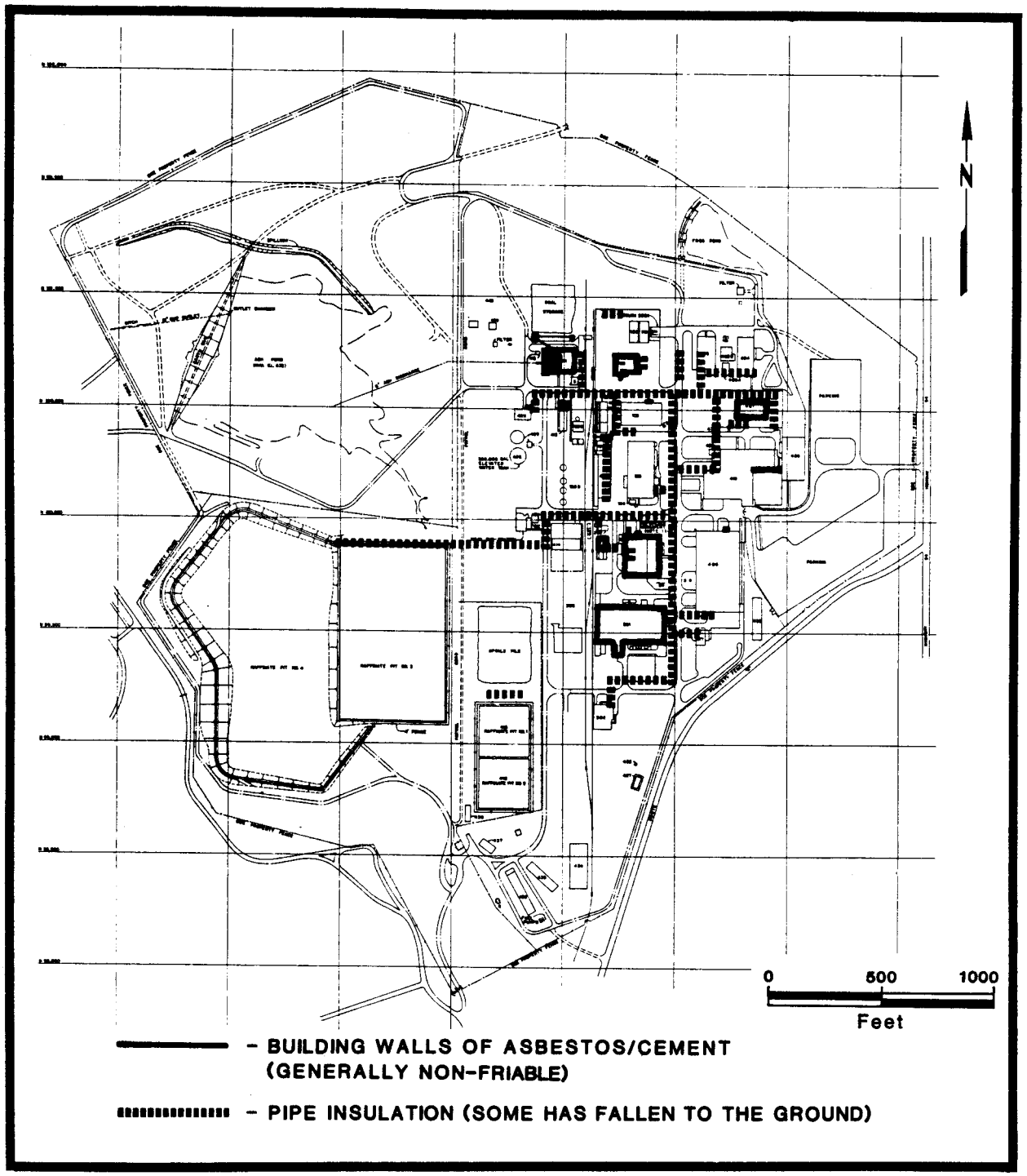


FIGURE 22 Known Locations of Asbestos at Outdoor Locations at the Raffinate Pits and Chemical Plant Area

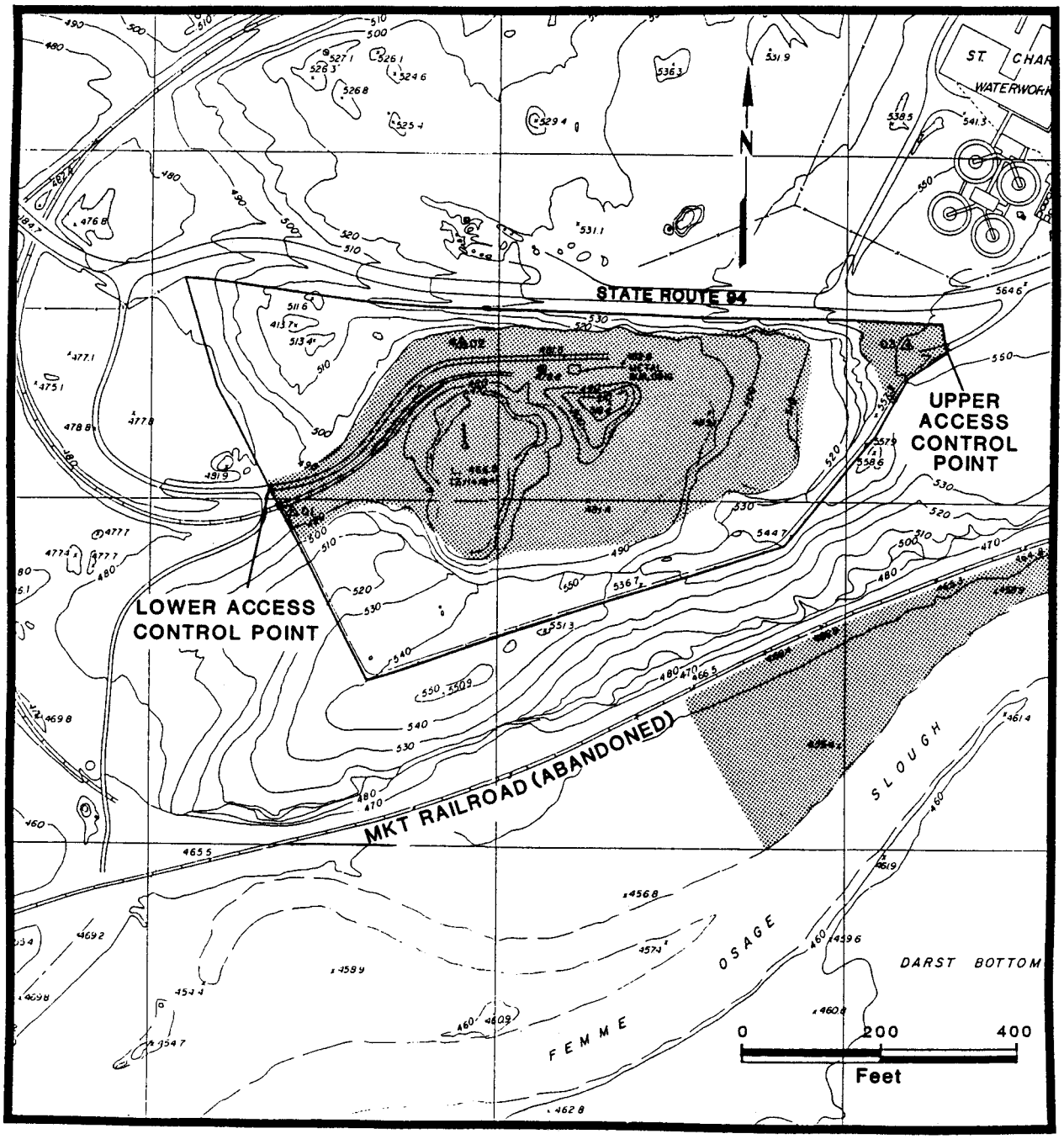


FIGURE 23 Areas at the Quarry that Have Exposure Rates above Background

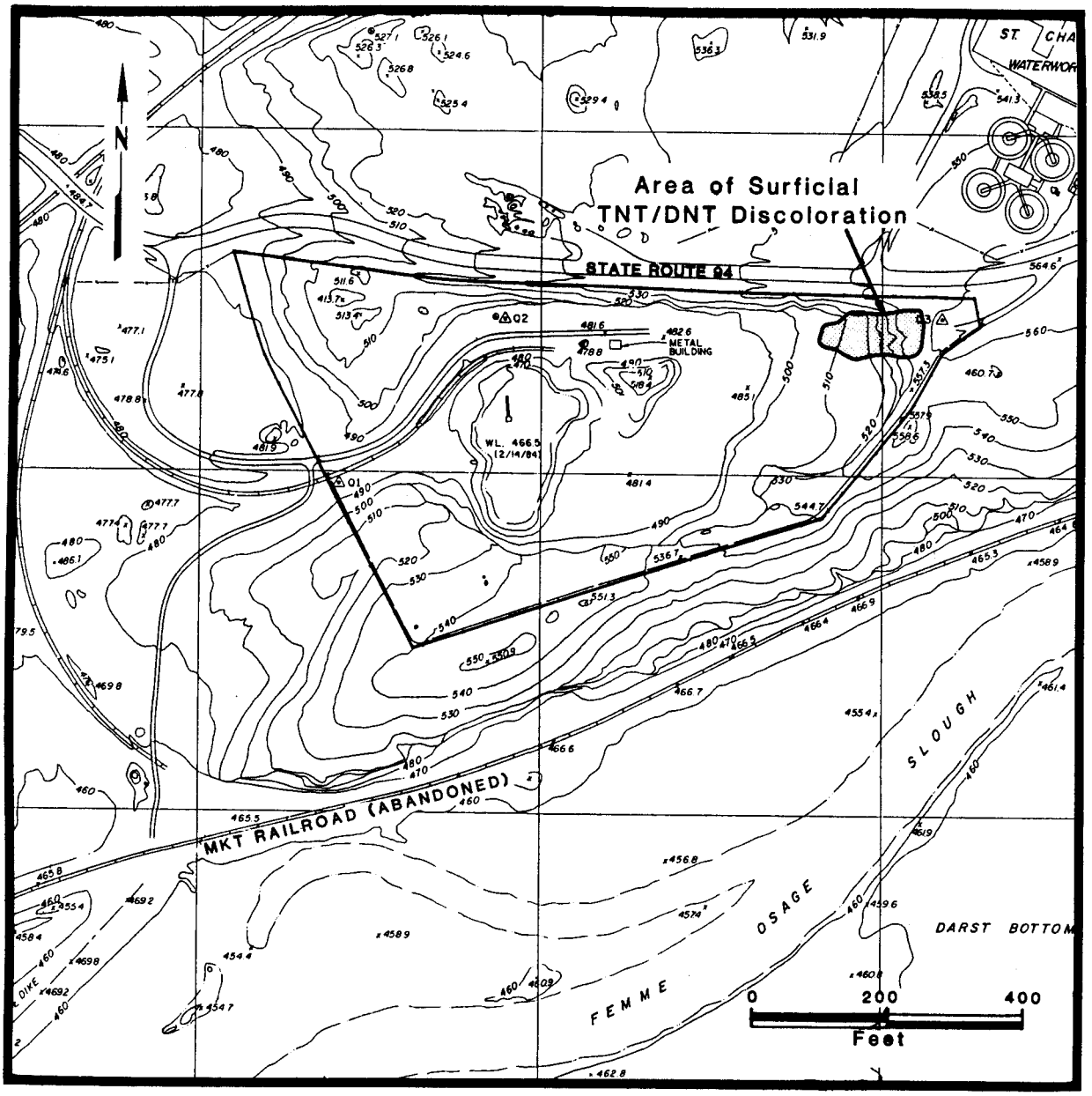


FIGURE 24 Area of Surficial TNT/DNT Discoloration at the Weldon Spring Quarry

quality parameters). The results indicate the presence of nitroaromatic compounds in wells completed in Decorah limestone and in certain alluvial wells north of the Femme Osage Slough. Three volatile organic compounds -- ethyl benzene, toluene, and xylene -- were detected in two alluvial wells (MW-1008 and MW-1009) at concentrations ranging from 8 to 20 ppb. These are the same volatile organic compounds detected in the quarry waste materials. Although subsequent quarterly sampling of these and other alluvial wells failed to detect these compounds, sampling and analysis for volatile organic compounds will continue. Semivolatile organic compounds, PCBs, and pesticides have not been detected in any of the quarry monitoring wells. The metal concentrations in both

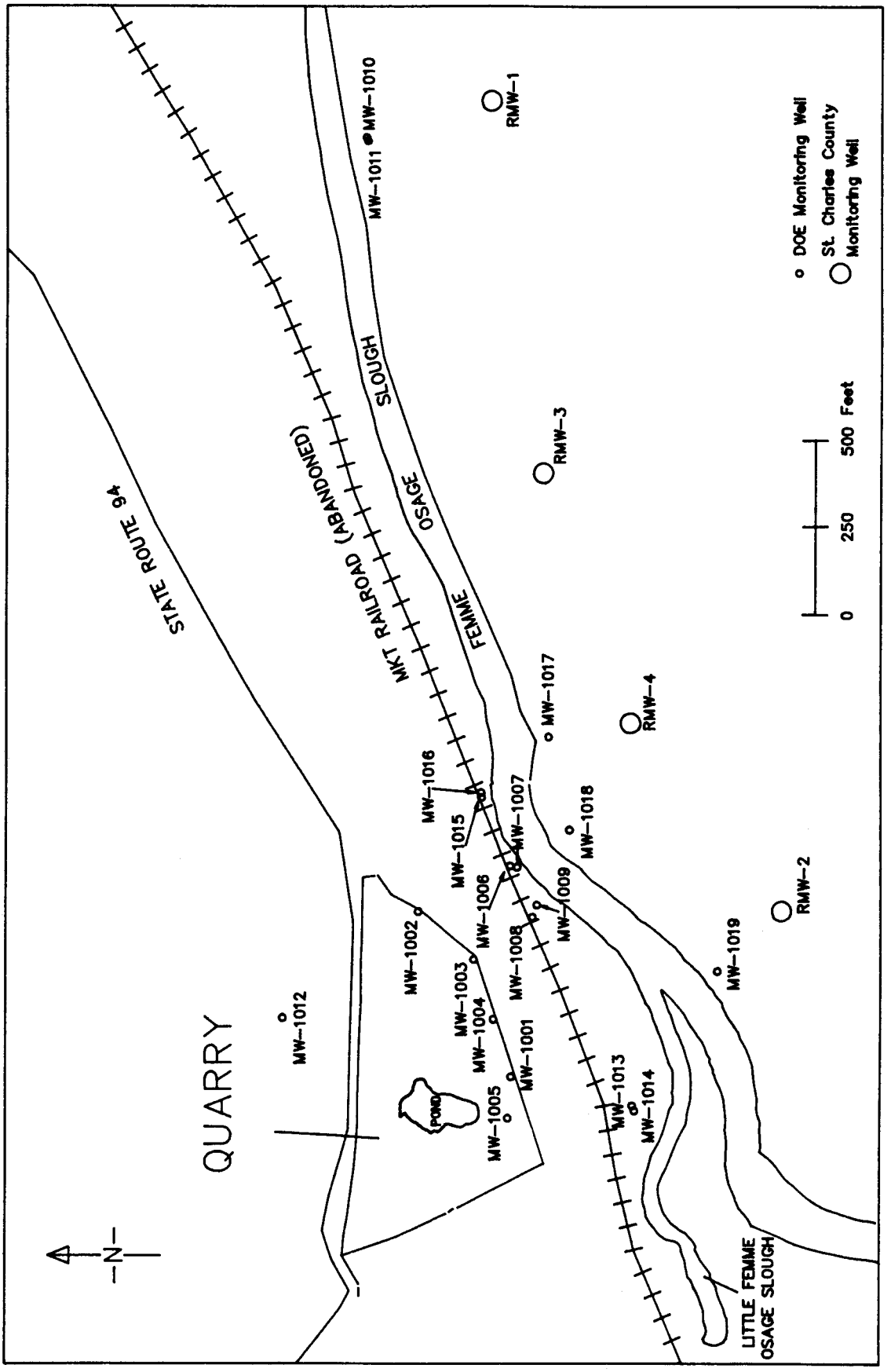


FIGURE 25 Groundwater Monitoring Locations near the Quarry

TABLE 13 Radiological Data from Groundwater Sampling at the Quarry

Sampling Location[a]	Date Sampled	Concentration ± Error (pCi/L) Gross Alpha	Gross Beta	Natural Uranium[b]	Radium -226	Radium -228	Thorium -230	Thorium -232
GW-1002	3/12/87	<4	<8	3.8 ± 1.1	<1	<3	<2	<2
GW-1004	3/11/87	2600 ± 300	2500 ± 300	3900 ± 400	<1	32 ± 6	<1	<1
GW-1005	3/11/87	460 ± 50	490 ± 50	420 ± 50	<1	<2	<1	<1
GW-1006	3/13/87	640 ± 50	850 ± 90	1300 ± 200	1.0 ± 0.1	<5	<2	<2
GW-1007	3/13/87	78 ± 9	120 ± 20	360 ± 40	1.8 ± 0.2	<3	<2	<2
GW-1008	3/13/87	500 ± 50	280 ± 30	770 ± 80	3.7 ± 0.1	<4	<2	<2
GW-1009	3/13/87	<8	<15	12 ± 2.0	<1	<3	<1	<1
GW-1010	3/10/87	<3	<8	<1	<1	<2	<2	<2
GW-1011	3/10/87	<3	<8	<1	<1	<2	<2	<2
GW-1012	3/2/87	<9	28 ± 9	2.9 ± 1.0	<1	<10	12 ± 1	<4
GW-1013	9/28/87	300 ± 30	290 ± 30	1200 ± 200	<1	<8	<1	<1
GW-1014	9/28/87	650 ± 70	490 ± 50	1200 ± 200	<1	<5	<1	<1
GW-1015	9/24/87	310 ± 40	180 ± 20	470 ± 50	<1	<1	<1	<1
GW-1015-D	9/24/87	320 ± 40	170 ± 20	470 ± 50	<1	3.5 ± 1.2	<1	<1
GW-1016	9/24/87	26 ± 6	<6	32 ± 4	<1	<1	<1	<1
GW-1017	9/22/87	<5	<8	1.2 ± 0.6	<1	<4	<1	<1
GW-1018	9/23/87	<3	<7	<1	<1	<1	<1	<1
GW-1019	9/23/87	<3	<6	<1	<1	<1	<1	<1

[a]D refers to duplicate sample analysis.

[b]Natural uranium is the sum of all uranium isotopes assumed to be present in their natural activity ratio.

TABLE 14 Nitroaromatics Data from Groundwater Sampling at the Quarry

Sampling Location	Date Sampled	Concentration (µg/L) 2,4,6-TNT	2,4-DNT	2,6-DNT	Nitro-benzene	1,3,5-Trinitro-benzene	1,3-Dinitro-benzene
GW-1001	10/2/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4
GW-1002	10/1/87	<0.5	<0.2	<0.6	2.2	0.48	<0.4
GW-1004	10/2/87	<0.5	0.33	<0.6	<0.6	0.16	<0.4
GW-1005	10/1/87	<0.5	0.61	<0.6	1.7	0.52	<0.4
GW-1006	9/28/87	7.6	<0.2	1.0	8.5	1.5	<0.4
GW-1007	9/29/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4
GW-1008	9/29/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4
GW-1009	9/22/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4
GW-1010	9/22/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4
GW-1011	9/22/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4
GW-1012	9/30/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4
GW-1013	9/28/87	<0.5	0.56	<0.6	0.95	0.23	<0.4
GW-1014	9/28/87	<0.5	0.33	<0.6	1.6	0.25	<0.4
GW-1015	9/24/87	28.9	<0.2	<0.6	44.0	8.3	<0.4
GW-1016	9/24/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4
GW-1017	9/22/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4
GW-1018	9/23/87	<0.5	0.33	<0.6	<0.6	<0.03	<0.4
GW-1019	9/23/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4

TABLE 15 Metals Data from Groundwater Sampling at the Quarry

Sampling Location	Date Sampled	Concentration[a] (µg/L)											
		Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb
GW-1002	3/12/87	132	U	U	150	U	U	120,000	38	U	7	40	U
GW-1004	3/11/87	370	97	U	95	U	U	103,900	76	U	20	220	U
GW-1005	3/11/87	132	U	U	74	U	U	103,900	47	U	10	23	U
GW-1006	3/13/87	260	77	U	103	U	U	224,400	75	U	20	24	U
GW-1007	3/13/87	203	82	U	512	U	U	208,200	67	U	14	5,130	U
GW-1008	3/13/87	224	79	U	191	U	U	177,700	66	U	14	296	U
GW-1009	3/13/87	186	78	U	328	U	U	198,100	70	U	15	4,570	U
GW-1010	3/10/87	U	U	27	533	U	U	57,200	28	U	9	883	U
GW-1011	3/10/87	U	U	U	170	U	U	69,000	32	U	9	2,250	U
GW-1012	3/2/87	219	86	10	171	U	U	145,600	54	U	18	80	U
GW-1013	9/28/87	121	44	U	159	1	U	126,000	49	10	15	1,860	U
GW-1014	9/28/87	132	47	U	158	1	U	130,000	49	10	15	2,360	U
GW-1015	9/24/87	103	40	U	92	1	U	137,000	45	7	17	118	U
GW-1016	9/24/87	122	-	U	138	U	U	139,000	45	7	15	104	U
GW-1017	9/22/87	110	46	32	962	1	11	139,000	46	18	15	20,190	U
GW-1018	9/23/87	100	60	32	890	1	12	137,000	47	18	14	26,400	U
GW-1019	9/23/87	149	41	48	852	1	U	100,000	33	12	12	9,600	U
EPA standard[b]		c	c	50	1,000	c	10	c	50	c	1,000	300	50
RDL[b]		200	60	10	200	5	5	5,000	10	50	25	100	5

TABLE 15 (Cont'd)

Sampling Location	Date Sampled	Concentration[a] (µg/L)											
		Li	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
GW-1002	3/12/87	U	20,800	620	U	36	6,350	U	U	27,600	U	U	12
GW-1004	3/11/87	U	46,700	840	U	52	8,660	U	23	27,700	U	28	29
GW-1005	3/11/87	U	24,200	64	U	37	7,680	U	U	25,800	U	U	7
GW-1006	3/13/87	U	33,150	3,690	U	39	3,400	U	26	79,370	U	33	30
GW-1007	3/13/87	U	34,100	7,170	U	38	3,290	U	19	67,740	U	30	12
GW-1008	3/13/87	U	32,600	6,180	U	41	3,640	U	19	39,000	U	29	23
GW-1009	3/13/87	U	34,600	4,330	U	39	2,850	U	18	50,800	U	31	17
GW-1010	3/10/87	U	12,800	5,915	U	U	3,310	U	U	15,500	U	U	21
GW-1011	3/10/87	U	15,800	4,240	U	U	2,060	U	U	21,700	U	U	38
GW-1012	3/2/87	U	41,000	380	U	43	8,340	U	22	187,600	U	25	21
GW-1013	9/28/87	U	31,000	633	U	20	3,990	U	U	19,900	U	35	8
GW-1014	9/28/87	U	30,500	786	U	21	4,760	U	U	21,400	U	36	21
GW-1015	9/24/87	U	30,700	39	U	14	2,370	U	U	26,200	U	34	37
GW-1016	9/24/87	U	27,400	206	0.2	26	1,030	U	U	17,900	U	33	16
GW-1017	9/22/87	U	38,500	690	U	24	5,800	U	U	23,900	U	35	U
GW-1018	9/23/87	U	40,400	1,230	U	25	6,550	U	U	24,900	U	36	34
GW-1019	9/23/87	U	31,000	503	U	10	4,490	U	U	11,400	U	27	7
EPA standard[b]		c	c	50	2	c	c	10	50	c	c	c	5,000
RDL[b]		-	5,000	15	0.2	40	5,000	5	10	5,000	10	50	20

[a]U means undetected at the contract-required detection limit; a hyphen indicates that data are not available.

[b]EPA standard = EPA primary/secondary drinking water standard; RDL = contract laboratory program required detection limit.

[c]No drinking water standard has been promulgated for these parameters.

TABLE 16 Inorganic Anion and Water Quality Data from Groundwater Sampling at the Quarry

Sampling Location[a]	Date Sampled	Concentration[b] (mg/L) Nitrate (as N)	Sulfate	Chloride	Fluoride	Hardness	Total Dissolved Solids	Total Organic Carbon	Cyanide	Phenol
GW-1002	3/12/87	0.4	62.7	9.06	<0.25	313	404	3	U	U
GW-1004	3/11/87	537	329	7.0	0.97	530	872	3.48	U	U
GW-1005	3/11/87	579	379	125	0.62	372	600	11.2	U	U
GW-1006	3/13/87	2.2	377	50.9	<0.25	777	1,108	6.28	0.014	U
GW-1007	3/13/87	3.2	132	71.0	<0.25	784	968	8.63	0.013	U
GW-1008	3/13/87	<0.1	238	24.3	<0.25	784	816	6.06	U	U
GW-1009	3/13/87	<0.1	160	28.5	<0.25	740	870	5.01	U	U
GW-1010	3/10/87	<0.25	4.40	7.91	<0.25	215	278	4.17	U	U
GW-1011	3/10/87	<0.25	20	9.64	<0.25	267	318	4.00	U	U
GW-1012	3/2/87	0.8	479	11.4	0.76	528	1,156	13	U	U
GW-1013	9/28/87	<0.1	112	24.5	0.9	444	1,002	3.8	0.008	<0.005
GW-1014	9/28/87	25.2	106	21.5	1.0	524	720	2.3	0.012	<0.005
GW-1015	9/24/87	1.3	160	31.4	1.0	568	727	2.55	<0.005	<0.005
GW-1015-D	9/24/87	1.5	156	30.6	1.0	556	599	6.58	<0.005	<0.005
GW-1016	9/24/87	<0.1	154	14.6	0.9	544	670	2.63	<0.005	<0.005
GW-1017	9/22/87	<0.1	1.3	24.4	1.0	630	715	15	<0.005	<0.005
GW-1018	9/23/87	<0.1	51.4	33.4	0.9	614	701	6	<0.005	<0.005
GW-1019	9/23/87	<0.1	1.05	8.5	0.8	440	483	12	<0.005	<0.005
EPA standard[c]		10	250	250	2	d	500	d	d	0.001[e]

[a]D refers to duplicate sample analysis.

[b]U means undetected at the contract-required detection limits.

[c]Primary/secondary drinking water standard.

[d]No drinking water standard has been promulgated for these parameters.

[e]Missouri drinking water standard.

limestone and alluvial groundwater appear consistent with background levels for the respective aquifers.

Surface water monitoring locations are shown in Figure 26, and the measured radiological parameters are presented in Table 17. The main contaminant in the quarry pond (SW-1008) is uranium, which was recently measured at an average concentration of 2,100 pCi/L. Analysis of water samples from wells in the limestone bluff and in the alluvium between the quarry and the slough indicate that uranium has migrated from the quarry (Kleeschulte and Emmet 1987).

Contaminant migration from the quarry into the alluvium and Femme Osage Slough was investigated in 1987 using uranium as an indicator (Marutzky, Colby, and Cahn 1988). Samples were collected in 0.3-m (1-ft) increments along two geologic cross sections, as shown in Figure 27. The results of the analysis are shown in Figure 28. Because the water table in the area is 0.6 to 1.5 m (2 to 5 ft) below the ground surface, most of the soil samples collected were saturated. Thus, the uranium results reflect both soil and groundwater contributions. Based on typical dissolved groundwater concentrations of uranium in the quarry, ranging from 1,000 to 8,000 pCi/L, the overall groundwater contribution of dissolved uranium ranges from 5 to 20% of the alluvial uranium concentrations present. Because no samples were collected directly beneath the slough, little can be inferred about the presence of uranium in this area; however, samples collected from boreholes immediately south of the slough identified no elevated levels of uranium. Therefore, the isopleths for cross section A-A' in Figure 28 have been dashed to indicate that the uranium distribution in close proximity to the slough is only estimated.

Radiological surveys along the southern quarry wall and adjacent to the right-of-way of the recently abandoned MKT railroad failed to locate any surface contamination that could contribute to the contamination located between the slough and quarry via surface runoff. Rather, the uranium contamination present in the slough area appears to have resulted from transport via groundwater migration. Groundwater migration has deposited uranium along preferential flow pathways. Groundwater elevations fluctuate in response to changing river stages. During higher stages, the groundwater elevation has been observed at the ground surface; as the water table falls, uranium appears to remain in the upper alluvial soils.

The uranium contamination appears to be restricted to an area between the quarry and Femme Osage Slough. The slough may act as a hydrogeologic boundary for groundwater migration north of the slough. Groundwater north of the slough probably discharges into Femme Osage Slough. Seepage into the slough becomes subject to natural dilutional effects.

2.5.4 Vicinity Properties

The vicinity properties are areas near the raffinate pits and chemical plant area and the quarry -- but outside of the current fenced boundaries -- that are contaminated as a result of previous activities conducted at the site. Contamination in the vicinity properties is located mainly along ditches, drainageways, roads, and railroads; some

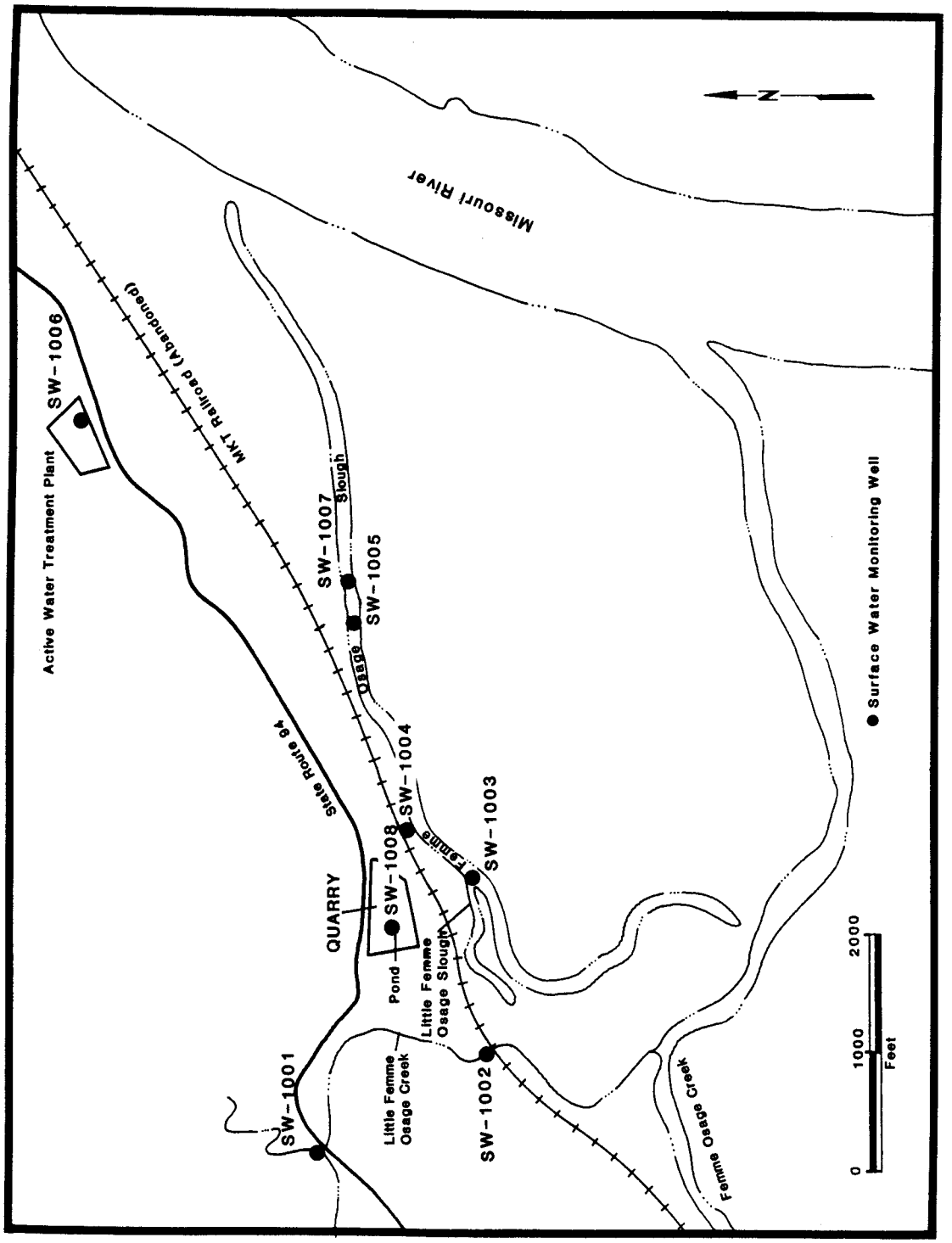


FIGURE 26 Surface Water Sampling Locations near the Quarry (Source: U.S. Department of Energy 1987c)

TABLE 17 Radiological Data from Surface Water Sampling at the Quarry

Sampling Location	Date Sampled	Concentration ± Error[a] (pCi/L) Gross Alpha	Gross Beta	Natural Uranium[b]	Radium -226	Radium -228	Thorium -230	Thorium -232
SW-1001	3/12/87	<4	<8	3.7 ± 1.1	<1	I	<2	<2
SW-1002	3/12/87	<4	<8	<1	<1	<2	<3	<3
SW-1003	3/23/87	26 ± 5	26 ± 4	45 ± 7	<1	<2	<4	<4
SW-1004	3/13/87	26 ± 5	56 ± 7	47 ± 7	<1	<3	<2	<2
SW-1005	3/10/87	19 ± 5	19 ± 5	39 ± 4	<1	<4	<2	<2
SW-1006	3/9/87	<5	<8	<1	<1	<5	<2	<2
SW-1007	3/11/87	<3	<6	25 ± 3	<1	<10	<2	<2
SW-1008	3/11/87	1100 ± 200	1200 ± 200	2100 ± 200	3.9 ± 0.4	<3	<2	<2

[a]I = interference.

[b]Natural uranium is the sum of all uranium isotopes assumed to be present in their natural activity ratio.

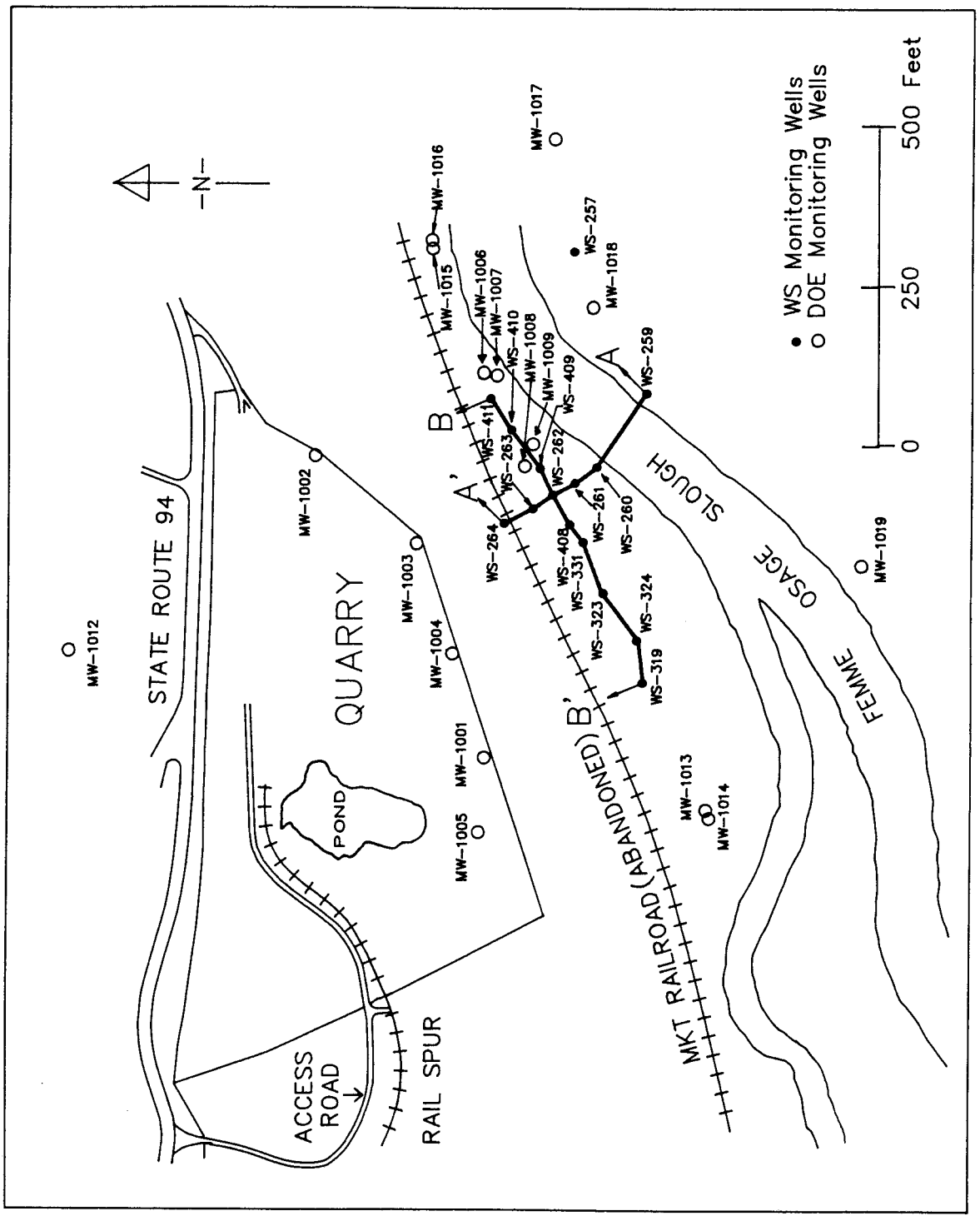
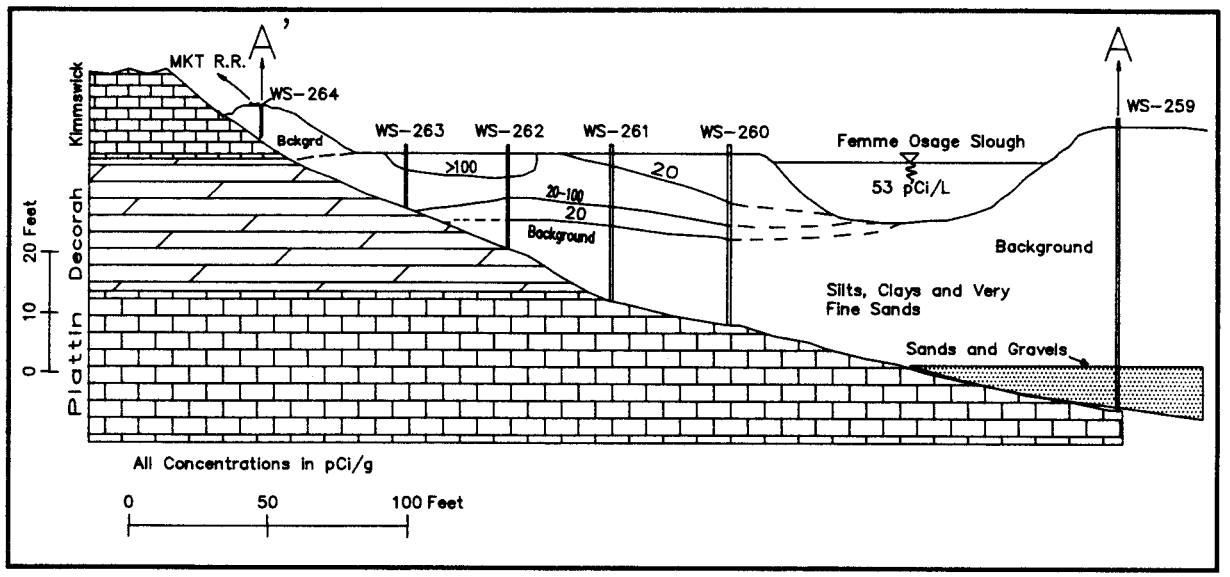


FIGURE 27 Locations Sampled in the Alluvium near the Quarry to Assess Contaminant Migration (Source: Modified from U.S. Department of Energy 1988a)



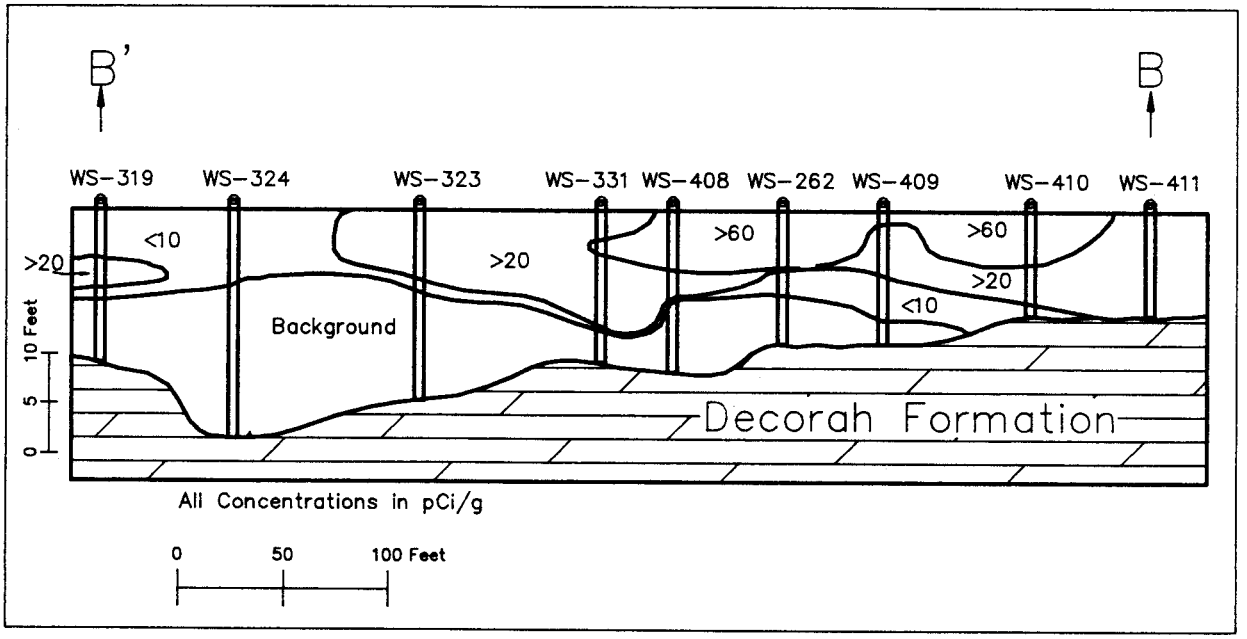


FIGURE 28 Uranium Concentrations (pCi/g) in the Alluvium near the Quarry, Cross Sections A-A' and B-B' (Source: Modified from U.S. Department of Energy 1988a)

nearby ponds and lakes are also contaminated. The contaminated off-site areas that need response action will be identified as a result of the ongoing characterization activities and assessment of potential risks to public health and the environment.

Seventeen contaminated land areas were identified in the vicinity of the Weldon Spring site during a radiological survey performed in 1986 by Oak Ridge Associated Universities at the request of DOE (Boerner 1986; Deming 1986). Seven contaminated areas are located on the U.S. Army Reserve property and ten are located on property owned by the Missouri Department of Conservation. The locations of these contaminated land areas are shown in Figure 29. (Vicinity property A7 was cleaned up in early 1988 [see Section 3.10.2.4].) In addition, some water bodies in the vicinity of the site are contaminated (e.g., Lakes 34, 35, and 36 in the Busch Wildlife Area). The contaminated areas can be grouped into two categories: (1) areas that became contaminated as a result of surface water or groundwater discharges from the raffinate pits and chemical plant area or the quarry and (2) areas that became contaminated by disposal of contaminated materials off-site or by spills from railcars carrying radioactive materials to or from the chemical plant or quarry. The characterization activities for vicinity properties are limited to those in the second category until the discharge of contaminated water from the Weldon Spring site can be stopped.

The potential for adverse human health impacts from exposure to contaminated materials on the 13 nondrainageway areas is extremely low, primarily due to the fact that these properties are uninhabited and access to them is difficult. The four contaminated areas associated with drainage of surface water from the chemical plant area are the southeast drainage (A4/B7), the Ash Pond drainage (A6), and the raffinate pits drainage (A5). The Ash Pond and raffinate pits drainageways discharge into Lakes 34 and 35 in the Busch Wildlife Area. Average annual natural uranium concentrations measured in these waters in 1987 were 25 and 15 pCi/L, respectively. However, these lakes are not used as drinking water sources and, therefore, no significant human exposure is believed to occur via this pathway. The potential doses to visitors to the area from ingesting lake water, eating fish caught in these lakes, or using the lakes for recreational purposes will be evaluated in the RI/FS-EIS.

Response actions on vicinity properties could impact several areas that are located within the Missouri River floodplain, e.g., the lower portion of the southeast drainage (B7) and a small area of land located between the quarry and Femme Osage Slough (B9). Wetlands may also exist on various vicinity properties. A floodplain/wetlands assessment will be prepared and included as a part of the RI/FS-EIS process. This assessment will describe the proposed response actions, discuss the effects of the proposed actions on the floodplain and wetlands, and discuss alternatives -- including mitigative measures. The assessment will be prepared in accordance with the requirements of Executive Order 11988 (Floodplain Management) and Executive Order 11990 (Protection of Wetlands). It is DOE's policy to avoid adverse impacts on wetlands and floodplains to the extent possible and to minimize any unavoidable adverse impacts (10 CFR Part 1022).

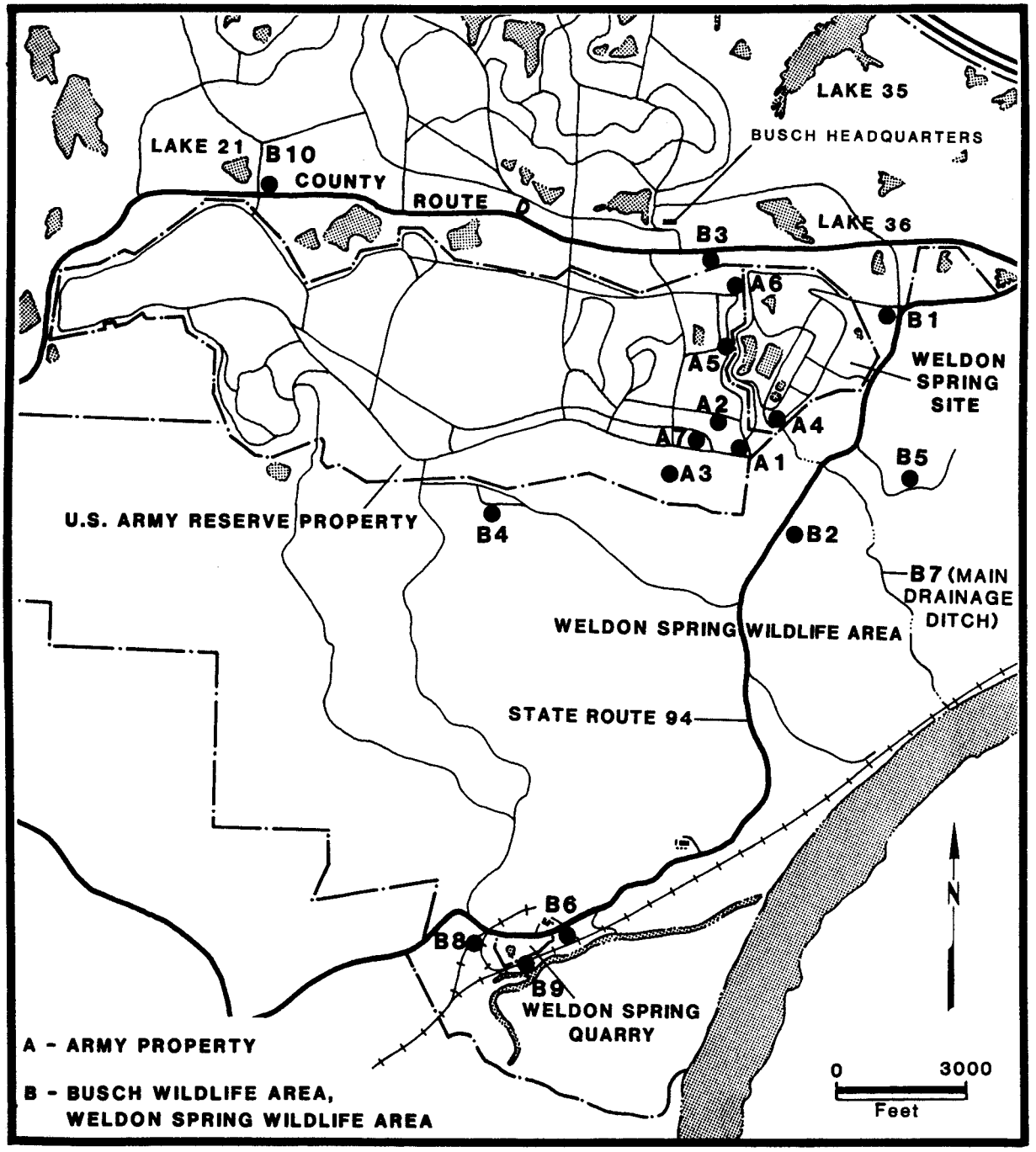


FIGURE 29 Location of Contaminated Vicinity Properties in the Area of the Weldon Spring Site (Source: Modified from U.S. Department of Energy 1988a)

3 INITIAL EVALUATION

3.1 PRELIMINARY IDENTIFICATION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Remedial actions at the Weldon Spring site will be undertaken in accordance with all applicable or relevant and appropriate requirements (ARARs). The identification of ARARs is an iterative process. As the remedial action planning process moves from data gathering in the RI phase to selection of a remedial action alternative in the FS-EIS phase, the list of ARARs will be finalized to those required for implementation of the selected alternative.

Any regulation, standard, requirement, criterion, or limitation under any federal or state environmental law may be either *applicable* or *relevant and appropriate* to a remedial action, but not both. A regulation, standard, requirement, criterion, or limitation is *applicable* if it legally applies to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance. A regulation, standard, requirement, criterion, or limitation is *relevant and appropriate* if it addresses problems or situations sufficiently similar to those encountered at the site such that its use is well suited to the particular site. A requirement that is determined to be relevant and appropriate must be complied with to the same extent as an applicable requirement. However, a determination of relevance and appropriateness may be applied only to portions of a requirement, whereas applicability can be determined only for the requirement as a whole. Only those state laws that are more stringent than federal laws may become ARARs.

The ARARs may be classified into three general categories:

- Contaminant-specific -- related to the level of contamination allowed for a specific pollutant in various environmental media (i.e., soil, water, and air),

- Location-specific -- related to the presence of a special geographical (e.g., floodplain or wetland) or archeological area at or near the site, and

- Action-specific -- related to a method of remedial action identified as an alternative for the site (e.g., disposal requirements or incineration standards).

The ARARs are identified on a project-specific basis -- i.e., site-specific contamination, proposed remedial action alternatives, and site characteristics influence the selection of ARARs. The selection of ARARs will be addressed at various stages in the RI/FS-EIS process as additional information becomes available:

- RI/FS-EIS work plan -- potential ARARs identified (contaminant- and location-specific).

- Completion of RI phase -- ARARs used to identify cleanup goals (contaminant- and location-specific).

- Development of alternatives -- alternatives evaluated with respect to ARARs (action-, contaminant- and location-specific).

For an alternative to be selected, it must meet the associated ARARs -- unless waiver conditions identified in SARA, Section 121(d)(4), are met.

Potential ARARs for the Weldon Spring Site Remedial Action Project are listed in Table 18. Additional federal and state requirements may also be ARARs, depending upon the alternatives identified during the RI/FS-EIS process or as a result of changes in federal or state laws. A complete list of ARARs identified for the various remedial action alternatives will be provided in the FS-EIS.

3.2 CONCEPTUAL EXPOSURE MODEL

The conceptual exposure model consists of the release mechanisms, potential receptors, and potential risks associated with the radioactive and chemical contaminants at the Weldon Spring site. This conceptual model is not intended to be an all-inclusive description of the various components associated with the evaluation of risks at the site. Rather, it is intended to indicate the nature of the evaluation that will be performed in the RI/FS-EIS. The various pathways of exposure cannot be fully determined before site characterization is complete. The conceptual exposure model presented here will be revised, as needed, to reflect the findings of the site characterization program.

3.2.1 Release Mechanisms

The migration of radionuclides and chemicals is related to the physical and chemical characteristics of the contaminants, the chemistry of the local environment, and the nature of the groundwater and surface water movement. A contaminated area can affect the quality of soil, groundwater, surface water, and air. Possible release mechanisms are:

- Dissolution, runoff, leaks, or spills that contaminate surface water;

- Contact of sediments/soils with the contaminated surface water;

- Leaching of contaminated surface and/or subsurface materials to the groundwater;

- Internal gas generation (e.g., radon) and emission to the atmosphere;

TABLE 18 Laws and Orders Potentially Applicable or Relevant and Appropriate to the Weldon Spring Site Remedial Action Project

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Federal Laws

Archeological and Historic Preservation Act of 1974
Archeological Resources Protection Act of 1979
Atomic Energy Act of 1954, as amended
Clean Air Act of 1963, as amended
Clean Water Act, as amended (also referred to as Federal Water Pollution Control Act of 1972, as amended)
Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended
Department of Energy Organization Act of 1977
Endangered Species Act of 1973, as amended
Fish and Wildlife Coordination Act of 1934, as amended
Hazardous Materials Transportation Act of 1974, as amended
National Environmental Policy Act of 1969, as amended
National Historic Preservation Act of 1966, as amended
Noise Control Act of 1972
Noise Pollution and Abatement Act of 1970
Occupational Safety and Health Act of 1970
Safe Drinking Water Act of 1974
Soil and Water Resources Conservation Act of 1977
Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, as amended by the Hazardous and Solid Waste Amendments of 1984
Superfund Amendments and Reauthorization Act of 1986
Toxic Substances Control Act of 1976
Uranium Mill Tailings Radiation Control Act of 1978

Executive Orders

Executive Order 11490, Assigning Emergency Preparedness Functions to Federal Departments and Agencies
Executive Order 11514, Protection and Enhancement of Environmental Quality
Executive Order 11738, Providing for Administration of the Clean Air Act and the Federal Water Pollution Control Act with Respect to Federal Contracts, Grants, or Loans
Executive Order 11807, Occupational Safety and Health Programs for Federal Employees
Executive Order 11988, Floodplain Management
Executive Order 11990, Protection of Wetlands
Executive Order 11991, Relating to the Protection and Enhancement of Environmental Quality

TABLE 18 (Cont'd)

Executive Orders (Cont'd)

Executive Order 12088, Federal Compliance with Pollution Control Standards
Executive Order 12146, Management of Federal Legal Resources
Executive Order 12580, Superfund Implementation

Department of Energy Orders

Order 1540.1 Materials Transportation and Traffic Management
Order 4240.1H Designation of Major System Acquisition and Major Projects
Order 4320.1A Site Development and Facility Utilization Planning
Order 4700.1 Project Management System
Order 5440.1C Implementation of the National Environmental Policy Act
Order 5480.1B Environment, Safety, and Health Program for Department of Energy Operations -- Note: Chapter XI of Order 5480.1B has been amended (see Vaughan [1985] and subsequent updates of Derived Concentration Guides)
Order 5480.4 Environmental Protection, Safety, and Health Protection Standards
Order 5480.14 Comprehensive Environmental Response, Compensation, and Liability Act Program
Order 5481.1B Safety Analysis Review System
Order 5482.1B Environmental Protection, Safety, and Health Protection Appraisal Program
Order 5483.1A Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities
Order 5484.1 Environmental Protection, Safety, and Health Protection Information Reporting Requirements
Order 5000.3 Unusual Occurrence Reporting System
Order 5500.2 Emergency Planning, Preparedness, and Response for Operations
Order 5700.6B Quality Assurance
Order 5820.2 Radioactive Waste Management

Missouri State Environmental Laws

Missouri Clean Water Act
Missouri Clean Air Act
Missouri Hazardous Waste Management Law
Missouri Solid Waste Management Law
Missouri Land Reclamation Act
Governor's Executive Order 82-19 on Flood Plain Management
Missouri 401 Water Quality Certification

- Release of resuspended solids to the atmosphere; and
- Fugitive dust emissions from traffic, wind, and construction activities.

The RI/FS-EIS will address these release mechanisms and any others that are determined to be significant as a result of site characterization activities.

After a release has occurred, it is necessary to analyze the fate of the contaminants in the environment so that the exposure of all potential receptors can be determined. Exposure can be direct or indirect. Direct exposure can result from contact with contaminants due to work or recreational activities. Indirect exposure involves the transport of the contaminants through various media to the potentially affected receptors. The primary contaminant transport media are the atmosphere, surface water, and groundwater. The environmental fate of contaminants in these media are affected by the following factors:

- Atmospheric dispersion,
- Atmospheric transfer to surface water,
- Atmospheric deposition on soil,
- Surface water dilution,
- Groundwater transfer to surface water,
- Surface water transfer to groundwater,
- Groundwater dilution,
- Water transfer to soil, and
- Soil transfer to water.

3.2.2 Population Exposure

The assessment of population exposure consists of (1) developing scenarios of human activities that give rise to exposure, (2) assessing the transport of contaminants from the source through environmental media to potential receptors, and (3) assessing the biological uptake of these contaminants by all potential receptors. This assessment will evaluate the following means of exposure:

- Inhalation of contaminants,
- Ingestion of contaminated surface water and groundwater,

- Direct contact with contaminated soil and water,
- Ingestion of food grown in contaminated soil,
- Ingestion of contaminated meat and milk, and
- Ingestion of contaminated soil.

The assessment will include both radioactive and chemical contaminants.

3.2.3 Potential Risks

The evaluation of potential risks involves a determination of the likelihood that a given pathway of exposure will result in a deleterious health impact. The exposure pathways listed in Section 3.2.2 will be quantitatively evaluated for selected scenarios of human activity.

Exposure from the inhalation pathway will likely be quite minor for existing conditions at the Weldon Spring site. Most of the contamination at the Weldon Spring site is either below ground, below surface water, or covered with vegetation. The relationships of the receptor to the source and to the concentration of the source will be major factors in the level of exposure. The potential for inhalation of airborne particulates will increase if contaminated materials are disturbed, such as will likely occur during response action activities (e.g., demolition of buildings or excavation of contaminated soils).

Exposure through ingestion of contaminated surface water and/or groundwater is the most likely source of exposure. Elevated concentrations of uranium have been detected in the surface water runoff leaving portions of the site, and persons drinking this water could incur measurable radiation doses. On-site monitoring has also detected elevated levels of radionuclides and chemicals in the groundwater, and exposure by ingestion of this contaminated groundwater is also possible. The potential use of surface water and/or groundwater as a source of drinking water will be evaluated.

Direct contact with contaminated materials is a hazard only in areas where contamination is immediately accessible (e.g., in soil and water). Exposure by direct contact with soil is possible because radiation exposure levels in excess of background levels have been recorded at the site. Direct contact with contaminated water is also possible from such activities as swimming and fishing. Such contact could result in potential health hazards because some water bodies in the vicinity of the Weldon Spring site are currently contaminated (e.g., Lakes 34, 35, and 36 in the Busch Wildlife Area).

Exposure through ingestion of food could occur if individuals in the area grow a significant fraction of plant foods for their own consumption or if they collect and eat contaminated wild foods (e.g., mushrooms, berries, and nuts) from the surrounding wildlife areas. Exposure could also occur if there are livestock (e.g., cows) that graze in areas of contaminated soil. Contamination in the soil can be taken up by plants, and consumption of such plants by humans or animals can result in radioactive and chemical

contaminants entering the human food chain. The potential exposure from consumption of food grown in contaminated soil or from consumption of meat and milk derived from livestock feeding in contaminated areas is expected to be minimal because the contaminants have not migrated significantly from the site. Similarly, consumption of fish that live in contaminated lakes in the Busch Wildlife Area and consumption of game animals that feed on plants grown in contaminated soil are also expected to be minimal sources of human exposure.

Ingestion of contaminated soil can occur intentionally (e.g., by a small child) or inadvertently (e.g., by consuming vegetables grown in contaminated soil). There is some potential for this exposure pathway because radioactive and chemical contaminants have been detected in soil at and in the vicinity of the site.

3.3 CONTAMINANTS OF CONCERN

3.3.1 Radioactive Contaminants

Uranium and thorium ore concentrates and some scrap metal were processed at the chemical plant during its operational period. These were the only radioactive materials processed at the plant. Various waste materials associated with uranium and thorium processing at the chemical plant and at other facilities were disposed of in the quarry. Thus, the radioactive contaminants of concern for the Weldon Spring site are those associated with the uranium-238 and thorium-232 decay series (see Figures 12 and 13).

In nature, the radionuclides in a decay series are in a state of secular equilibrium in which the activities of all radionuclides are equal. However, the processing of uranium and thorium ores alters this natural state, and deviation from secular equilibrium is expected. The rate at which secular equilibrium is reestablished depends on the half-lives of the decay products. Because of their relatively short half-lives and the length of time since closure of the chemical plant (about 20 years), all radioactive decay products in the thorium-232 decay series can be assumed to be in secular equilibrium with thorium-232.

By contrast, the activities of the radionuclides in the uranium-238 decay series will change with time at a rate that depends on their original activities and half-lives and on the activities of their parent radionuclides (ingrowth effect). For example, the amount of radium-226 and its decay products in the raffinate pit sludge is estimated to increase 30 fold (from an average concentration of 97 pCi/g to 3,200 pCi/g in about 9,000 years) as a result of a gradual reestablishment of secular equilibrium (U.S. Dept. Energy 1987a). The activities of the various radionuclides in the uranium-238 decay series can be determined from the activities of uranium-238, thorium-230, and radium-226; the activities of the radionuclides from uranium-238 through uranium-234 can be assumed to be equal to that of uranium-238 (because the activities of uranium-238 and uranium-234 are equal in nature and thorium-234 and protactinium-234 have short half-lives), and the activities of the radionuclides from radium-226 through polonium-210

can be assumed to be equal to that of radium-226. The latter assumption will overestimate the short-term concentration of lead-210, bismuth-210, and polonium-210 due to the relatively long half-life of lead-210 (22 years) in comparison to the length of time since these materials were processed (approximately 20 to 30 years). This will result in an overestimate of the short-term hazard from radium-226 and its decay products.

The radioactive contaminants of concern are, therefore, uranium-238, thorium-232, thorium-230 and radium-226. The activities of all other radionuclides at the Weldon Spring site can be determined from these four species.

3.3.2 Chemical Contaminants

The following assessment of chemicals found at the Weldon Spring site is based on results of the Phase I water quality assessment (U.S. Dept. Energy 1987c), Phase I chemical soil investigation (U.S. Dept. Energy 1988b), chemical characterization of the quarry (Kaye and Davis 1987), and earlier studies summarized in the draft EIS (U.S. Dept. Energy 1987a). Investigations to date have been carried out to provide baseline information on water quality and soil contamination and to begin characterization of the wastes; however, further studies are planned to fully characterize the extent of chemical contamination.

3.3.2.1 Organic Contaminants

Nitroaromatics. Results of the Phase I water quality assessment indicate that high concentrations of nitroaromatics (mainly 2,4-DNT, 2,6-DNT, and TNT) are present in the groundwater under the northeast corner of the chemical plant and that generally low-level contamination is present throughout the raffinate pits and chemical plant area (potential source areas of nitroaromatics are shown in Figure 18). Nitroaromatics are also present in the groundwater at the quarry and in alluvial wells north of Femme Osage Slough. Surficial discoloration of soils in the eastern portion of the quarry (see Figure 24) indicates the presence of nitroaromatic compounds that were subsequently determined to be at levels of 1 to 2%. These compounds have also been detected in the surface water, sludges, sediments, and wastes at the quarry.

Volatile and Semivolatile Compounds. Volatile and semivolatile organic compounds have not been detected in the groundwater at the raffinate pits and chemical plant area. Volatile compounds detected in soil and sediment samples from the quarry are believed to be due to contamination introduced during field collection or laboratory extraction. Although three volatile organic compounds (ethylbenzene, toluene, and xylene) were detected in two alluvial wells during the Phase I water quality assessment, subsequent quarterly sampling of these and other wells failed to detect these compounds. The PAHs detected at the quarry were in borings clustered in an area adjacent to the pond.

PCBs and Pesticides. The PCB contamination is present in fluids associated with electrical equipment at the raffinate pits and chemical plant area, which have recently been removed (see Section 3.10.2.1), and in surface structures and localized areas of soil at both the raffinate pits and chemical plant area and the quarry. No PCBs or pesticides have been detected in groundwater or surface water.

3.3.2.2 Inorganic Contaminants

Inorganic Ions. Nitrate, sulfate, and fluoride concentrations have been measured in groundwater from several wells at the raffinate pits and chemical plant area at above drinking water standards (10 [as N], 250, and 2 mg/L, respectively). Elevated nitrate levels were also detected in Ash Pond and Burgermeister Spring. Soil samples collected during the Phase I soil investigation had elevated nitrates and sulfates at numerous locations, most commonly in surficial samples; some slightly elevated fluoride levels were also present. High concentrations of nitrate and fluoride were detected in the raffinate pit solids, and elevated levels of nitrate and sulfate were detected in groundwater at the quarry. Elevated levels of sulfate have also been detected in the quarry pond and in alluvial wells north of Femme Osage Slough (see Table 16 and Figure 27).

Metals. Concentrations of metals have been below background levels in most groundwater samples from the raffinate pits and chemical plant area; however, two wells had elevated levels of chromium, lithium, magnesium, nickel, and vanadium. Results of the Phase I soil investigation indicate that the soils at the raffinate pits and chemical plant area may be contaminated with low levels of metals; isolated areas also had elevated concentrations of barium, lead, and zinc. Additional investigations are required to determine actual background levels and to assess the extent of contamination. High concentrations of several metals -- including iron, lead, magnesium, and molybdenum -- are present in the raffinate pit solids. Elevated levels of iron, manganese, and arsenic have been detected in the quarry pond, but metals were not above background levels in groundwater samples from the quarry area.

Asbestos. Although asbestos is present in many areas of the chemical plant, selected surface soil samples did not have elevated levels. Asbestos levels at perimeter locations of the raffinate pits and chemical plant area were the same as background levels, and those detected in the quarry pond were below the recommended guidelines of the U.S. Environmental Protection Agency (1985).

3.4 POTENTIAL HEALTH EFFECTS

3.4.1 Radioactive Contaminants

The cause-and-effect relationships between radiation exposure and adverse health effects are quite complex, but these relationships have been more extensively

studied than have the cause-and-effect relationships for other environmental contaminants. Physiological effects to an individual are clinically detectable only from radiation exposure resulting in a dose greater than about 10 rem (to the whole body) for a few persons and about 25 rem for nearly all persons over a short period of time (hours). Doses about 10 to 20 times higher, also received over a relatively short period of time (hours to a few days), can be expected to result in some fatalities.

Lower levels of exposures also constitute a health risk, but a direct cause-and-effect relationship between a known exposure to radiation and any given health effect is difficult to define because of the many other possible reasons why a particular effect is observed in a specific individual. For this reason, such effects -- including an increased incidence of cancer in the exposed population and genetic changes in future generations after exposure of a prospective parent -- must be assessed on a statistical basis. Occurrences of cancer in the exposed population may begin to develop only after a lapse of 2 to 20 years from the time of exposure (latent period) and may then continue over a period of about 30 years (plateau period). However, in the case of exposure of fetuses (in utero), occurrences of cancer may begin to develop at birth (no latent period) and end at age 10 (i.e., the plateau period is 10 years). The occurrence of cancer itself does not necessarily result in fatality.

Most authorities agree that a reasonable -- and probably conservative -- estimate of the randomly occurring number of health effects from low levels of radiation exposure to a large number of people is within the range of about 10 to 500 potential cancer deaths per million person-rem. The radiological impacts for the Weldon Spring Site Remedial Action Project will be calculated as 50-year committed effective dose equivalents based on the methodology recommended by the International Commission on Radiological Protection (ICRP). The ICRP gives a risk estimator of 1.65×10^{-4} per person-rem for the induction of fatal cancers and serious genetic effects in the first two generations following radiation exposure (Int. Comm. Radiat. Prot. 1977). This risk estimator will be used to estimate potential health effects from radiation exposure to site-originated radioactive contaminants.

3.4.2 Chemical Contaminants

For most of the chemicals identified at the Weldon Spring site, there appears to be little potential for significant human exposure under current site conditions. An assessment of potential risks to public health from current site conditions will be carried out in the baseline risk assessment. A brief summary of the major toxic effects of selected chemical contaminants is given in Sections 3.4.2.1 and 3.4.2.2.

3.4.2.1 Organic Contaminants

Nitroaromatics. The nitroaromatics 2,4-DNT and 2,6-DNT are classified by the EPA as Group B2 (i.e., probably carcinogenic to humans) and Group C (i.e., possibly carcinogenic to humans) carcinogens. Laboratory studies have shown that TNT can induce cancer in experimental animals (Furedi et al. 1984). Nitroaromatics can induce

methemoglobinemia, a reduction in the oxygen-carrying capacity of the blood, especially in infants. Other effects include toxicity to the liver, kidney, and nervous system. Nitroaromatics can be absorbed following exposure by inhalation, ingestion, or dermal contact, although the extent of absorption depends on the specific compound.

PAHs. The PAHs are classified by the EPA as Group B2 and Group C human carcinogens, depending on the specific compound (U.S. Environ. Prot. Agency 1986b). In experimental animals, PAHs have been shown to induce tumors both at the site of application and systemically. They can also cause skin disorders, immunosuppression, and liver and kidney damage. The limited data available regarding oral absorption of PAHs indicate that some compounds are readily absorbed. Inhaled compounds can be readily absorbed. Dermal absorption can also occur, but the rate and extent are dependent on the specific compound and its concentration.

PCBs. The PCBs have been shown to induce cancer of the liver in experimental animals and are classified as Group B2 human carcinogens (U.S. Environ. Prot. Agency 1986b). In experimental animals, chronic exposure to PCBs has induced such effects as severe weight loss, liver damage, toxicity to the immune system, adverse reproductive effects, and malformations in offspring. In humans exposed to these compounds, the skin and liver are the primary sites affected, but the gastrointestinal and neuromuscular systems can also be affected. The only significant adverse health effects that have been observed in PCB-exposed workers are occasional skin irritations, usually acne-like lesions and rashes, and liver damage. Following oral exposure, gastrointestinal absorption of most isomers is greater than 90%; limited data indicate that PCBs can also be absorbed following exposure by inhalation or dermal contact.

3.4.2.2 Inorganic Contaminants

Inorganic Anions. The health hazards that are associated with nitrate result primarily from the bacterial conversion of ingested nitrate to nitrite. Nitrites alone can induce methemoglobinemia, and they can also react with other compounds, such as amines, to form N-nitroso compounds. Although most N-nitroso compounds are carcinogenic in experimental animals, the contribution of nitrate to a potential carcinogenic hazard for humans and the magnitude of the associated risk is unclear. Low levels of fluorides in drinking water are generally considered to have a beneficial effect on the rate and occurrence of dental caries. Ingestion of higher levels of fluorides can induce dental and skeletal fluoroses whereas inhalation of flourides can irritate the respiratory system.

Metals. Uranium is the most widespread of the metal contaminants at the Weldon Spring site. The two main hazards associated with exposure to uranium compounds are (1) kidney damage caused by the chemical toxicity of soluble ingested uranium compounds and (2) injury caused by the ionizing radiation resulting from radioactive

decay of ingested or inhaled uranium isotopes. The main effect depends on a number of factors, including the solubility of the compound, the route of exposure, and the relative composition of the isotopes. In addition to the adverse effects on the kidney, the chemical toxicity of uranium can also affect the cardiovascular, endocrine, hematopoietic, and immunological systems. The extent of metal contamination at the Weldon Spring site has not yet been well characterized. Of the other metals present at elevated levels, certain compounds of arsenic, chromium, lead, and nickel are carcinogenic and may induce teratogenic and other adverse reproductive effects. Metals that may be present at levels of potential significance will be identified during the baseline risk assessment.

Asbestos. Inhalation of asbestos can induce cancer of the lung and mesothelium (lining of the chest and abdomen). Exposure by inhalation may also cause asbestosis -- a progressive, irreversible lung disease. Ingestion of high concentrations of asbestos may result in damage to the gastrointestinal tract.

3.5 ENVIRONMENTAL FATE

The release, transport, and fate of contaminants in the environment depends on both the properties of the contaminant and the environmental medium in which it occurs. The primary transport media are air, surface water, and groundwater, although transport by air is of minor importance at the Weldon Spring site. The baseline risk assessment will include a comprehensive evaluation of the environmental fate of the contaminants identified at the Weldon Spring site and the potential exposure resulting from these contaminants. A brief summary of the potential transport pathways and fate of selected contaminants is given in Sections 3.5.1 and 3.5.2.

3.5.1 Organic Contaminants

3.5.1.1 Nitroaromatics

Experimental and field data suggest that nitroaromatics are not strongly adsorbed to soil or sediment and may therefore migrate to groundwater. Their residence time in soil depends on the pH and the oxygen and organic carbon content of the soil. Biotransformation can occur in the soil, and both photolysis and biotransformation may be significant fate processes in the aquatic environment (Rickert 1985).

3.5.1.2 PAHs

The PAHs are fairly persistent in the environment. They adsorb strongly to soil and sediment, particularly those with a high organic content. Atmospheric transport generally occurs by adsorption to airborne particulate matter, although PAHs with low molecular weights are typically volatile. Airborne PAHs can be returned to the aquatic

and terrestrial ecosystems by atmospheric fallout and precipitation. They can also reach groundwater and surface waters by leaching from contaminated soil. The PAHs are relatively insoluble in water, but the fraction that is dissolved may undergo rapid, direct photolysis. Although PAHs can be rapidly bioaccumulated, they are also rapidly metabolized and eliminated from most organisms (Clements Assoc. 1985).

3.5.1.3 PCBs

The PCBs are very persistent in the environment. They are relatively inert and have low vapor pressures and low water solubilities. Despite their low vapor pressures, they have high activity coefficients in water, which results in a higher rate of volatilization than would otherwise be expected. The PCBs adsorb strongly to organic soil and sediment. Adsorption to organic material in soil or sediment is considered to be the primary fate of the more heavily chlorinated PCBs. Once bound, the PCBs may persist for years, with slow desorption to the surrounding media. Bioaccumulation and biomagnification of PCBs are common, and some biodegradation can also occur.

3.5.2 Inorganic Contaminants

3.5.2.1 Inorganic Anions

Inorganic anions such as fluoride, nitrate, and sulfate are highly water soluble and therefore very mobile in the environment. This mobility can result in significant leaching from soil and diffusion in soil and water. The extent of migration to groundwater depends primarily on the type of soil affected.

3.5.2.2 Metals

Metal compounds can undergo a wide range of transformation processes, forming complexes with inorganic species or organic ligands that are present in the environment. These processes, collectively referred to as speciation, can occur in all environmental media. The speciation of a metal in a given environment affects it bioavailability, solubility, volatility, and sorptive properties. In addition to speciation, the fate of metals is affected by the properties of the environmental media; for example, the mobility of a metal compound in soil depends on the cation-exchange capacity of the soil whereas its solubility in water depends on the presence of other chemical species and on the pH.

3.5.2.3 Asbestos

Asbestos is quite stable in the environment and may be transported by water or wind dispersion. It is not prone to significant degradation in the aquatic environment. In surface waters, it remains in suspension until it physically degrades or settles by chemical coagulation into the sediment layer (Clements Assoc. 1985).

3.6 MIGRATION PATHWAYS AND POTENTIAL RECEPTORS

The extent of contaminant migration into the nearby environment is dependent, in part, upon the physical and chemical characteristics of the specific contaminants. Certain species that are relatively immobile will migrate little; other, more mobile species will migrate to a greater extent. The three general pathways by which contaminants may migrate are air transport, surface water transport, and subsurface water transport.

In general, air transport is not a significant pathway for contaminant migration at the Weldon Spring site because there is currently no processing of materials at the site. Most of the radioactive and chemical contaminants on the site are in water, in areas covered by water, or in soil, and many of the soil-contaminated areas are overgrown with vegetation. The remaining contaminants are in buildings or process equipment. Air monitoring operations by DOE have sampled for asbestos, organic vapors, and airborne radioactive particles and gases. Measurements of external gamma exposure rates have also been performed as a part of the monitoring program. Except for the quarry, measurements of both on-site (outdoor locations at the raffinate pits and chemical plant area) and off-site values of these constituents have generally been at background levels. Elevated levels of radon gas and elevated external gamma exposure rates have been measured at the quarry. However, because these levels decrease rapidly with distance, background levels are generally reached within a relatively short distance (i.e., within about 0.4 km [0.25 mi]).

The transport of contaminants via the surface water pathway is likely an important mechanism for contaminant migration from the site. Surface water runoff from the raffinate pits and chemical plant area can mobilize contaminants. Migration of these contaminants will generally follow the slope of the land surface to lower elevations. Because of the generally gentle slopes at the raffinate pits and chemical plant area, movement of contaminants for appreciable distances over unpaved surfaces or areas without defined channels is unlikely. Although transport over appreciable distances via surface channels is possible, no natural or artificial surface channels currently traverse the site except for a channel remnant that crosses through the Ash Pond area. However, there are a number of relatively short drainage channels, with and without pipe segments, that could result in the spread of contaminants from their source. Other surface drainage features that may affect contaminant migration include the Ash Pond spillway, the Ash Pond discharge line, the drainage channels to the southeast drainage easement, and the drainage channels from Frog Pond.

Potential subsurface migration pathways include (1) buried sewer and process pipelines, particularly those that have deteriorated; (2) natural subsurface features that tend to impede the downward movement of water and therefore result in lateral spreading, such as low-permeability layers or zones; (3) permeable pathways that are relatively isolated but continuous laterally or vertically, such as solution channels, caverns, or joint-sets; and (4) permeable media of a relatively continuous nature, such as permeable limestone with a combination of fractures, joints, and solution-enlarged features. All of these subsurface pathways may exist at the raffinate pits and chemical plant area to some degree.

Potential receptors of the radioactive and chemical contaminants migrating from the Weldon Spring site include:

- Students and staff of the Francis Howell High School, located east of the raffinate pits and chemical plant area on State Route 94; an estimated 2,300 persons are on campus daily during the school year (U.S. Dept. Energy 1987a).

- Visitors and staff at the St. Charles County Extension Center, located to the east of the raffinate pits and chemical plant area on State Route 94.

- Personnel at the state of Missouri highway maintenance facility, located to the east of the raffinate pits and chemical plant area.

- Personnel at the U.S. Army Reserve and National Guard Training Area, located to the west of the raffinate pits and chemical plant area.

- Other persons who live near the site, drink water from local surface water and groundwater supplies, consume locally grown plant or animal food products, and/or consume fish and game animals that inhabit the surrounding area.

- Visitors and staff at the August A. Busch Memorial Wildlife Area, the Weldon Spring Wildlife Area, and the Howell Island Wildlife Area; attendance at the Busch Wildlife Area alone has averaged 710,000 persons per year over the last 10 years (U.S. Dept. Energy 1987a).

- Trespassers who gain entry to the site in spite of existing access restrictions.

- Persons who fish or swim in nearby surface waters.

- Terrestrial and aquatic organisms.

3.7 DATA GAPS

Although much is currently known about the nature of the contaminants and their environmental fate and transport at the Weldon Spring site, several data gaps exist that must be filled before a final remedy can be selected for disposition of the contaminated materials. The field sampling plans summarized in Section 4.2 have been prepared to obtain the data necessary to fill these gaps so that, when the RI phase is completed, sufficient data will exist to allow for detailed assessment of remedial action alternatives in the FS-EIS. A summary of the current data gaps and the data collection activities being performed to obtain the necessary data is presented in Sections 3.7.1 through 3.7.3.

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- Other persons who live near the site, drink water from local surface water and groundwater supplies, consume locally grown plant or animal food products, and/or consume fish and game animals that inhabit the surrounding area.

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- Trespassers who gain entry to the site in spite of existing access restrictions.

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3.7.1 Extent and Magnitude of Contamination

The extent and magnitude of the radiological contaminants in the soils at the raffinate pits and chemical plant area are understood, based on the history of site activities and the recently completed sampling program (Marutzky, Colby, and Cahn 1988). However, a detailed characterization of chemical contaminants in these soils is not currently available. Therefore, the soil investigation sampling plan for chemical contaminants (Section 4.2.1) will be implemented to provide a complete inventory of chemical contaminants in the soils within this area.

Although the contaminants in the raffinate pits are reasonably well defined, the waste assessment sampling plan for the raffinate pits (Section 4.2.3) will be implemented to provide a complete inventory of these contaminants. Similarly, the waste assessment sampling plan for the process buildings (Section 4.2.3) will provide a detailed inventory of contaminants in the process buildings of the chemical plant.

Results of the recent water quality assessment program have identified the chemical and radiological species present in surface water and groundwater at the Weldon Spring site (U.S. Dept. Energy 1987c). The lake and stream sediment characterization plan (Section 4.2.5) is being implemented to provide information on the nature and extent of contamination of sediments in off-site lakes and streams that have received surface and subsurface discharges from the raffinate pits and chemical plant area.

It is essentially impossible to fully characterize the quarry bulk wastes in situ because of the nature of these wastes, i.e., a heterogeneous conglomerate of steel, rubble, process equipment, and drummed and uncontained process residues intermixed in a soil matrix. It is proposed that these bulk wastes be removed from the quarry in order to minimize the potential for contaminant migration (see Section 3.11). A detailed characterization of the bulk wastes will be performed following their removal from the quarry; hence, this data gap will be filled as a part of the quarry bulk waste removal action. The nature and extent of contamination in the quarry fracture joints and cracks, and the need for groundwater restoration in this area, will be evaluated following bulk waste removal.

3.7.2 Environmental Transport Pathways

The surface pathways of environmental transport at the raffinate pits and chemical plant area (e.g., air and surface water runoff) have been identified and are currently being monitored. Although many subsurface pathways have also been identified and all known springs and seeps have been inventoried and sampled, it is possible that other, unidentified pathways exist. Implementation of the hydrogeological investigation sampling plan (Section 4.2.2) will characterize the hydrogeological conditions at the raffinate pits and chemical plant area. Data from this sampling effort will also assist in determining the need to perform groundwater restoration in this area. A biouptake study (Section 4.2.5) is currently being implemented to assess the extent to which contaminants originating from the Weldon Spring site have been incorporated into local wildlife.

3.7.3 Waste Disposition

Additional data are needed regarding the amenability of various waste materials to treatment and the suitability of the site to isolate the wastes from the public and the environment (i.e., if on-site disposal were selected as a result of the RI/FS-EIS process). The different waste forms associated with the Weldon Spring project will be studied to evaluate the feasibility of various methods of treatment and volume reduction (see Section 3.9). The results of these studies will be incorporated in the RI/FS-EIS to support the screening and evaluation of potential technologies and alternatives. The geophysical/geotechnical investigation sampling plan (Section 4.2.4) will be used to evaluate the suitability of the raffinate pits and chemical plant area for waste disposal.

3.8 RESPONSE OBJECTIVES AND CONCEPTUAL REMEDIAL ACTION ALTERNATIVES

3.8.1 Response Objectives

The objective of response action at the Weldon Spring site -- consisting of the raffinate pits and chemical plant area and the quarry -- is to decontaminate or stabilize radioactively and chemically contaminated materials to protect human health and the environment and bring the site into compliance with ARARs. The selected alternative will implement permanent solutions to the extent practicable. Vicinity properties contaminated in excess of acceptable criteria will be decontaminated and the resultant wastes will be disposed of along with wastes from the raffinate pits and chemical plant area and the quarry. Consistent with the goals of DOE's SFMP, real property will be released for unrestricted use to the extent practicable.

3.8.2 Technology Identification

Section 121 of SARA identifies a strong statutory preference for remedies that are highly reliable and provide long-term protection. In addition to the principal requirements that a selected remedy be protective of human health and the environment and be cost-effective, other selection criteria include the following:

- Preferred remedial actions are those in which the principal element is treatment to permanently or significantly reduce the volume, toxicity, or mobility of hazardous substances, pollutants, and contaminants.

- Where practical treatment technologies are available, off-site transport and disposal without treatment is the least favored alternative.

- Permanent solutions and alternative treatment technologies or resource recovery technologies should be assessed and used to the maximum extent practicable.

The following discussion provides a general overview of the technologies that could be used to protect public health and the environment, based on the current understanding of the Weldon Spring wastes and on the potential for population exposure; during implementation of the RI/FS-EIS process, additional technologies may be identified and evaluated. The discussion is divided into two general categories as prescribed in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP): source control response actions and migration control response actions.

3.8.2.1 Source Control Response Actions

Source control response actions are aimed at protecting public health and the environment by altering the nature of the source (i.e., the radioactively and chemically hazardous constituents in the waste) to reduce the toxicity, mobility, and/or volume of its constituents, thereby limiting the potential for exposure to contaminants via the pathways described in Section 3.6. Potential source control response actions include access restrictions, removal, reprocessing/treatment, temporary storage, and disposal.

Access Restrictions. Access restrictions involve the use of physical barriers (e.g., fences) and/or institutional controls (e.g., deed restrictions and condemnation of property) to reduce the potential for public exposure to contaminated materials. These restrictions, in and of themselves, are not typically effective in terms of protecting public health and the environment. Therefore, access restrictions are usually implemented in conjunction with other source control response actions.

Removal. Removal of contaminated materials may involve decontamination, demolition, and/or excavation. Decontamination of structural surfaces can be accomplished using various methods of washing and/or abrading. Demolition consists of decontaminating and/or dismantling contaminated structures and disposing of the resultant rubble in a designated area. Excavation involves removing contaminated soil and hauling it to a designated area for disposal. Both the demolition and excavation technologies are reliable, can easily be implemented with common construction equipment, and can be extremely effective means of removing contaminated materials. Removal of contaminated liquids, e.g., surface water or groundwater, by mechanical means such as pumping is more difficult to implement but is technically feasible. Removed materials can then be treated and/or disposed of.

Reprocessing/Treatment. Reprocessing/treatment includes a wide range of treatment technologies. Although a number of these technologies can be implemented for contaminated liquids, sludges, and soils, they are not typically suitable for the decontamination of structural surfaces. (This decontamination would be carried out as described above, under source control actions.) In addition, only a limited number of

technologies are effective where radioactive contamination is present. Treatment technologies for radioactive wastes can be divided into two general categories:

- Those that remove radioactive constituents from the waste matrix, and
- Those that change the form of the waste, thereby reducing its toxicity, mobility, and/or volume.

Hazardous waste treatment can be accomplished by chemical, physical, and/or biological technologies.

Chemical treatment technologies are used to alter the nature of the hazardous chemical constituents and can affect waste toxicity, mobility, and/or volume. When radioactive contaminants are also present, a chemical extraction or leaching process can be used to remove the radioactive components from the waste matrix to reduce the volume and/or mobility of contaminants. The liquid leachate can then be reprocessed to recover the radioactive components. Chemical treatment of liquid wastes can involve precipitation, coagulation, adsorption, ion-exchange, or oxidation/reduction techniques.

Physical treatment technologies are used to alter the structure of the waste constituents to facilitate stabilization and management. Physical treatment can reduce toxicity, mobility, and/or volume of contaminated liquids, sludges, or soils. Contaminated liquids at the site could be treated by sedimentation, granular media filtration, microscreening, or vapor recompression/distillation. Contaminated sludges (e.g., in the raffinate pits) could be treated by dewatering technologies such as centrifugation, pressure or vacuum filtration, horizontal belt filtration, screening, drying beds, or gravity thickening. Three classes of physical treatment technologies that could be considered for contaminated soils and dewatered sludges are vitrification, stabilization, and separation.

In the vitrification process, contaminated soil and sludge are immobilized by passing an electrical current through the material, creating temperatures high enough to melt the soil. When power to the system is turned off, the molten volume cools, and a block of glass-like material resembling natural obsidian is produced. This mobility-reducing technology is developmental and has not yet been used on a large-scale project. Stabilization would involve the addition of chemical and cementitious materials to contaminated soil and sludge to produce a solid monolith. This technique would reduce waste mobility. Several separation techniques have been identified for reducing the volume of contaminated material by separating the radioactive constituents from the soil matrix. These techniques are also developmental and include sand sifting, paramagnetic separation, soil sorting, and selective mineral separation.

Biological treatment technologies can be used to alter the nature of a waste and to remove contaminants from a waste matrix. Biological processes are typically employed in conventional wastewater treatment systems and can affect waste toxicity, mobility, and/or volume. Biological treatment processes include activated sludge treatment, trickling filters, and surface impoundments.

Temporary Storage. Temporary storage is the isolation of contaminated material in a manner designed to protect public health and the environment until a permanent disposal option becomes available. Temporary storage can involve the placement of contaminated material on an engineered pad and covering the material with a synthetic membrane, clay cap, or other protective layer. Temporary storage can also be achieved by placing the contaminated material in an existing engineered structure or in a structure newly constructed for containment purposes.

Disposal. Disposal involves the placement of contaminated material in a confined environment for permanent disposition. This can be an extremely effective means of reducing waste mobility and the associated potential for population exposure. Disposal of the large volume of low-specific-activity wastes resulting from implementation of the Weldon Spring Site Remedial Action Project can potentially be on-site, off-site (land-based), or in the ocean.

On-site disposal would entail disposing of the Weldon Spring wastes in a facility designed in accordance with all ARARs. This appears to be a technically feasible source control response action. Off-site (land-based) disposal is also technically feasible; however, a disposal facility would have to be sited and constructed because none currently exists. Ocean disposal could be considered a viable alternative for disposal of some of the Weldon Spring wastes because the degree of radioactivity associated with these wastes is essentially the same as that naturally present on the ocean floor. The suitability of the disposal site (i.e., the ocean floor) would be based on such factors as levels and volumes of radioactive and chemical contamination, water depth, and ocean currents. However, the ocean disposal option has not been approved by the EPA, and it is anticipated that several years of study and a fundamental change in terms of public acceptance would be required prior to its implementation.

3.8.2.2 Migration Control Response Actions

Migration control response actions are designed to mitigate exposure of the population to contaminants that are transported via any of the pathways described in Section 3.6. An additional objective of migration control measures is to limit activities that could disturb and result in the migration of contaminated materials present at the Weldon Spring site. Potential migration control response actions include access restrictions and containment/treatment.

Access Restrictions. Access restrictions involve the use of physical barriers (e.g., fences) and/or the implementation of institutional controls (e.g., deed restrictions and condemnation of property). These methods could be used to reduce contaminant migration by human or animal activities and to limit exposure to off-site areas where contamination has already migrated. Access restrictions are not effective in reducing the impact of environmental factors (e.g., wind and precipitation) on contaminant migration. In general, access restrictions would not serve as a reliable means of protecting public health and the environment in the absence of other supporting response actions.

Containment/Treatment. Containment/treatment involves the use of media-specific technologies for migration control. The purpose of containment, which can involve containment of contaminated material within an engineered structure or in situ, is to reduce contaminant migration and, therefore, the potential exposure of the population. Containment technologies, in and of themselves, do not typically reduce waste toxicity or volume.

Media-specific containment technologies for migration control include:

- Air -- pipe and trench vents, with containment of vented air;
- Soil -- excavation/containment, liners, isolation (e.g., in situ), and stabilization via vegetation;
- Surface water -- dikes, terraces, channels, downpipes, grading, and surface seals (with containment of runoff); and
- Groundwater -- slurry/cutoff walls, grout curtains, subsurface drains/other leachate containment systems, and groundwater pumping.

When used in conjunction with containment technologies, treatment technologies for migration control may reduce waste volume as well as toxicity and mobility. Media-specific treatment technologies for migration control include:

- Air -- filtration of vented air;
- Soil -- excavation/dewatering and encapsulation (e.g., vitrification, stabilization);
- Surface water -- runoff collection (e.g., with dikes or channels) in conjunction with physical/chemical/biological treatment systems; and
- Groundwater -- groundwater pumping/leachate collection in conjunction with physical/chemical/biological treatment systems.

3.8.2.3 Summary of Potential Response Action Technologies

The potential response action technologies described in Sections 3.8.2.1 and 3.8.2.2 are summarized in Table 19 for source control and Table 20 for migration control. Additional technologies that may be appropriate for the proposed action will be identified and evaluated during the FS-EIS process.

TABLE 19 Summary of Response Action Technologies: Source Control

Response Action	Source Control Technology	Type of Contamination	Comments
Access restrictions	Physical barriers	Soils, sludges, structures, surface water, groundwater	Temporarily limits exposure to radioactive and chemical contaminants.
	Institutional controls		
	Deed restrictions	Soils, sludges, structures, surface water, groundwater	Temporarily limits exposure to radioactive and chemical contaminants.
	Condemnation	Property	Temporarily limits exposure to radioactive and chemical contaminants.
Removal	Excavation	Soils, bulk wastes	Reduces exposure to radioactive and chemical contaminants; allows unrestricted use of area. Requires storage or disposal facility and access restrictions during excavation.
	Decontamination	Structural surfaces	Reduces exposure to radioactive and chemical contaminants; allows unrestricted use of area. Requires storage or disposal facility and access restrictions during decontamination.
	Demolition	Structures	Reduces exposure to radioactive and chemical contaminants; allows unrestricted use of area. Requires storage or disposal facility and access restrictions during demolition.

TABLE 19 (Cont'd)

Response Action	Source Control Technology	Type of Contamination	Comments
Removal (Cont'd)	Pumping	Surface water, groundwater	Reduces exposure to radioactive and chemical contaminants; allows subsequent treatment. Requires containment/treatment facility and access restrictions during treatment.
Reprocessing/ treatment	Chemical treatment		
	Leaching/extraction	Soils, bulk wastes, sludges	Reduces exposure to radioactive and chemical contaminants; may reduce toxicity, mobility, or volume of waste constituents; allows unrestricted use of treated area. May require bench-scale testing; requires treatment facility and access restrictions during treatment.
	Precipitation, coagulation, adsorption, ion exchange, lime softening, etc.	Surface water, groundwater	May reduce waste toxicity, mobility, or volume; allows unrestricted use of treated area. May require bench-scale testing; requires treatment facility and access restrictions during treatment.
	Physical treatment		
	Sedimentation, filtration, vapor recompression/distillation, etc.	Surface water, groundwater	May reduce waste toxicity, mobility, or volume. May require bench-scale testing; requires treatment facility and access restrictions during treatment.
	Dewatering	Sludges	May reduce waste mobility or volume; allows unrestricted use of treated area. Requires treatment facility and access restrictions during treatment.

TABLE 19 (Cont'd)

Response Action	Source Control Technology	Type of Contamination	Comments
Reprocessing/ treatment (cont'd)	Physical treatment (cont'd)		
	Vitrification	Soils, sludges	Reduces waste mobility and possibly toxicity. Requires further testing and development; limits future land use; requires access restrictions during treatment.
	Stabilization	Soils, sludges	May reduce waste mobility. Limits future land use; requires treatment facility and access restrictions during treatment.
	Sand sifting	Soils, bulk wastes	Reduces waste volume. Suitability of process for alluvial materials is unknown. Requires further testing and development; requires access restrictions during treatment.
	Paramagnetic separation, soil sorting, selective mineral separation	Soils, bulk wastes, dewatered sludges	Reduces waste volume; may allow unrestricted unrestricted use of treated area. Requires further testing and development; requires access restrictions during treatment.
	Biological treatment		
	Activated sludge, trickling filters, surface impoundments, etc.	Surface water, groundwater,	May reduce waste toxicity, mobility, or volume. Requires treatment facility and/or area; may require bench-scale testing and access restrictions during treatment.

TABLE 19 (Cont'd)

Response Action	Source Control Technology	Type of Contamination	Comments
Temporary storage	On-site	Soils, sludges, bulk wastes, liquids	Reduces waste mobility and exposure to radioactive and chemical contaminants while a more permanent remedy is being developed. Limits future land use; requires storage facility (outdoor area or engineered structure) and access restrictions during storage.
	Off-site	Soils, sludges, bulk wastes, liquids	An off-site temporary storage facility would probably not be available for several years.
Disposal	Land-based facility		
	On-site	Soils, sludges, bulk wastes, liquids	Reduces waste mobility and exposure to radioactive and chemical contaminants. Limits future land use; requires specific siting and construction of disposal facility and access restrictions during the long term.
	Off-site	Soils, sludges, bulk wastes, liquids	Reduces waste mobility and exposure to radioactive and chemical contaminants; allows unrestricted use of decontaminated area. Requires siting and construction of a disposal facility and access restrictions at the facility for the long term. (Disposal site not currently available.)
	Ocean disposal	Soils, sludges, bulk wastes, liquids	Not currently available and may not be available within a reasonable time. Transportation to the ocean port would be expensive.

TABLE 20 Summary of Response Action Technologies: Migration Control

Response Action	Migration Control Technology	Type of Contamination	Comments
Access restrictions	Physical barriers	Soils, sludges, bulk wastes, surface water, groundwater	Temporarily limits exposure to migrated contaminants. Limits land use.
	Institutional controls: Deed restrictions	Soils, sludges, bulk wastes, surface water, groundwater	Temporarily limits exposure to migrated contaminants. Limits land use.
	Condemnation	Property	Temporarily limits exposure to migrated contaminants. Limits land use.
Containment/ treatment	Engineered system or in situ	Soils, sludges, bulk wastes, surface water, groundwater	Reduces waste mobility and, in conjunction with treatment, may also reduce waste toxicity or volume. Requires containment/treatment system(s); may require access restrictions during containment/treatment period.

3.8.3 Remedial Action Alternatives

Remedial action alternatives will be developed and assessed according to the following five categories, as recommended by the current NCP:

1. No action,

2. Alternatives for treatment or disposal at an off-site facility, as appropriate,

3. Alternatives that attain applicable or relevant and appropriate federal public health and environmental requirements,

4. Alternatives that exceed applicable or relevant and appropriate federal public health and environmental requirements, and

5. Alternatives that do not attain applicable or relevant and appropriate public health and environmental requirements but will reduce the likelihood of present or future threat from the hazardous substances and that will provide significant protection to public health and welfare and the environment. This must include an alternative that closely approaches the level of protection provided by the applicable or relevant and appropriate requirements.

Section 105 of SARA requires the President (who subsequently delegated this responsibility to the EPA) to propose amendments to the NCP by April 17, 1988. The EPA is currently drafting revisions to the NCP in response to this requirement. The revised NCP has not yet been issued in final form. Nonetheless, the identification of categories for remedial action alternatives that are recommended by the EPA in its proposed revisions will also be considered in the current evaluation, in the interest of addressing those requirements that may be promulgated before the proposed remedial actions are complete. These categories are:

- No action;

- Containment (migration control) or institutional controls -- involving little or no treatment, but protective of human health and the environment by causing a reduction in waste mobility and related exposure risks; and

- Treatment (source control) with disposal of the remaining wastes either on-site or off-site -- ranging from (a) treatment as the principal element of the alternative, to reduce the principal threat(s) posed by a site (i.e., may not involve the highest degree of treatment or treatment of all wastes) to (b) treatment that will minimize the need for long-term management of the wastes (including monitoring).

On the basis of the technologies identified to date (see Section 3.8.2), a limited number of general remedial action alternatives have been identified:

- No action,
- On-site disposal,
- Off-site disposal,
- On-site treatment with on-site disposal,
- On-site treatment with off-site disposal, and
- Off-site treatment with off-site disposal.

These alternatives address the radioactively and chemically contaminated materials -- including structures, equipment, soils, sludges, and water -- present at the Weldon Spring site and its vicinity properties. They represent a wide range of remedial actions, from no action to treatment and disposal. The following descriptions of the general remedial action alternatives include a variety of engineering options that could be implemented, either singly or in various combinations.

3.8.3.1 No Action

The no-action alternative provides a baseline for comparison to other alternatives. If this option were selected, there would be no reduction in the toxicity, mobility, or volume of the contaminated materials. The potential for human exposure to radioactive and chemical contaminants would probably continue for the short term at the levels presented in the baseline risk assessment. However, as off-site migration continued, long-term exposure would likely increase -- in terms of both levels of exposure and size of the potentially affected population. These exposures could become quite large if changes in land use near the Weldon Spring site were to occur. Redevelopment of the site could also result in the uncontrolled release of contaminated materials.

3.8.3.2 On-site Disposal

On-site disposal would reduce waste mobility. Implementation of this alternative would involve a determination of site suitability and the construction of an on-site disposal facility. After closure of the facility, monitoring and maintenance activities would be performed as needed. These activities would include periodic inspection of the cover, environmental monitoring, and security precautions. Permanent access restrictions and other institutional controls would be required to protect public health. A buffer zone would be created between the disposal facility and surrounding areas.

3.8.3.3 Off-site Disposal

Off-site disposal would reduce waste mobility. Implementation of this alternative would involve the siting and construction of an off-site disposal facility for the Weldon Spring wastes. Once an off-site disposal facility became available, the removal, transport, and disposal of the wastes from the Weldon Spring site could be implemented. Other considerations applicable to on-site disposal (see Section 3.8.3.2) would also apply to off-site disposal.

3.8.3.4 On-site Treatment with On-site Disposal

On-site treatment with on-site disposal would reduce the mobility and could reduce the toxicity and/or volume of the contaminated materials. This alternative would involve many of the same issues related to the on-site disposal alternative (see Section 3.8.3.2). In addition, treatment systems for the various forms of contaminated materials would have to be constructed and operated on-site, and access restrictions would be required during treatment operations. If this alternative were selected, contaminated surface water, groundwater, soils, and sludges would be treated and subsequently disposed of -- with all activities occurring on-site.

3.8.3.5 On-site Treatment with Off-site Disposal

On-site treatment with off-site disposal would reduce the mobility and could reduce the toxicity and/or volume of the contaminated materials. This alternative would involve the same issues related to on-site treatment that are addressed for the previous alternative (Section 3.8.3.4) and the same issues related to off-site disposal that are addressed for the off-site disposal alternative (Section 3.8.3.3).

3.8.3.6 Off-site Treatment with Off-site Disposal

Off-site treatment with off-site disposal would reduce the mobility and could reduce the toxicity and/or volume of the contaminated materials. This alternative would involve the same issues related to the off-site disposal alternative (see Section 3.8.3.3) and the identification of an off-site location for the construction and operation of the treatment facilities.

3.9 FEASIBILITY TESTING

The DOE will perform various studies to support the RI/FS-EIS process. The results of these studies will be used to screen the various technologies and define the alternatives to be assessed in the FS-EIS. The studies listed here are those currently planned. Additional studies may be performed in the future as part of the post-screening investigations that bridge Phases II and III of the FS-EIS process (see Figure 32 for a definition of the various phases of the RI/FS process).

3.9.1 Volume Reduction

The applicability of various volume-reduction techniques for solid waste will be examined relative to the wastes expected to be produced during implementation of the Weldon Spring Site Remedial Action Project. This study will include contaminated soils and sludges, metallic wastes such as equipment and siding, and other building components.

3.9.2 Sludge Stabilization

The feasibility of stabilizing the sludge in the raffinate pits with chemical and cementitious materials to reduce waste mobility will be assessed. Earlier studies conducted by Oak Ridge National Laboratory have demonstrated the technical feasibility of stabilization. Although these tests used a fairly wide range of mixtures with varying results, there is no assurance that the samples used were representative of the raffinate pit sludge at the Weldon Spring site. Additional tests will be performed to better define the quantity and quality of the additives to be used, the mixing techniques to be employed, and the chemical (e.g., leachability) and geotechnical (e.g., strength) characteristics of the resultant mixture using samples that better represent the raffinate pit sludge.

3.9.3 Waste Vitrification

The feasibility of vitrifying the raffinate pit sludge, and possibly the materials in the quarry, will be evaluated. Battelle Pacific Northwest Laboratories (PNL) has recently been testing the feasibility of treating hazardous waste by vitrification. If costs are not prohibitive, vitrification could prove to be an applicable technique for management of the raffinate pit sludge. Based on preliminary data, vitrification appears to be a feasible technology that could result in significant volume reduction. Vitrification could also dramatically reduce the leachability of hazardous substances in the sludge and decrease the rate of radon emissions, thereby reducing waste mobility and toxicity. Preliminary discussions with PNL indicate that vitrification of the raffinate pit sludge might require the addition of some siliceous material (if the current level is insufficient). If so, wastes from the quarry could be a candidate source for the additive. Thus, some of the quarry wastes might also be considered for vitrification.

3.9.4 Waste Reprocessing

The feasibility of reprocessing the raffinate pit sludge will be evaluated relative to recovering resources and reducing the toxicity, mobility, and volume of the sludge. In addition to small quantities of uranium, thorium, and radium, the sludge contains other elements -- including a significant quantity of magnesium fluoride. A preliminary review of the data indicates that removal of all of the uranium, thorium, and radium would not significantly reduce the waste volume; in fact, reprocessing is expected to involve the addition of significant quantities of reprocessing reagents to the sludge, which would increase the final waste volume. Even if the magnesium fluoride were recovered from

the sludge, it is possible that its level of radioactive contamination would render it commercially unusable. Therefore, it appears that the waste-reprocessing method used to reduce the sludge volume would have to reduce the contamination to a level at which the sludge would no longer be considered radioactively contaminated. The same processes considered for the raffinate pit sludge will also be examined for applicability to contaminated soils and sediments.

3.9.5 Lake Silt Removal

Preliminary data indicate that silt in Lakes 34, 35, and 36 in the Busch Wildlife Area is contaminated and may require response action; additional sampling will be performed to evaluate the need for such action. Although these lakes are currently filled with water, existing data indicate that only the silt is contaminated to an extent that might require remediation. If tests confirm the need for cleanup of these lakes, various methods will be evaluated for removing and treating the contaminated silt.

3.9.6 Liner Compatibility

Flexible membrane liners may be used in the construction of any required leachate collection system and/or leak detection system in the disposal facility. Such liners could be adversely affected by the wastes or leachates produced by the wastes placed in the disposal facility. In addition, underlying clays could be detrimentally affected by leachates produced during construction of the disposal facility, during operation of the leachate collection system, and especially after cessation of leachate collection. The compatibility of these potential leachates with flexible membrane liners and engineered sublayers will be evaluated.

3.9.7 Thermal Waste Destruction

The toxicity, mobility, and volume of some of the chemical wastes present at the raffinate pits and chemical plant area and the quarry could be reduced by thermal destruction. The thermal properties and off-gas treatment requirements for the various wastes will be studied. Thermal waste destruction would probably require the use of a mobile incinerator and thus would be applicable to either on-site or off-site treatment.

3.9.8 Land Treatment

The toxicity, mobility, and volume of certain liquid wastes might be reduced by applying the liquids to the ground and allowing natural processes to break down the contaminants. The soil, meteorological, and vegetative conditions at and in the vicinity of the Weldon Spring site will be assessed for compatibility with land treatment. Although the mix of constituents present in contaminated site waters probably precludes use of this method, land treatment could be appropriate when used in conjunction with other treatment methods.

3.9.9 Waste Drying/Dewatering

The volume and mobility of contaminated sludges and sediments could be reduced by drying or dewatering. Methods of drying/dewatering will be evaluated relative to specific site wastes. This technology could be used to support on-site or off-site disposal and would reduce transportation costs for off-site disposal.

3.9.10 In-Situ Leaching

The toxicity, mobility, and volume of certain contaminated soils and sludges could be reduced by in-situ leaching. In this process, a solution is pumped into or sprinkled onto a contaminated zone and allowed to dissolve the desired contaminant. The contaminant-bearing solution is then removed and treated. The appropriateness of this method for various waste types will be evaluated.

3.9.11 Groundwater Treatment

Contaminants associated with the Weldon Spring site have been identified in various samples taken from on-site and near-site monitoring wells. With the exception of nitroaromatics, these contaminants have also been identified in surface waters at the raffinate pits. If, as a result of the RI/FS-EIS process, DOE determines that groundwater at the raffinate pits and chemical plant area must be remediated, a groundwater restoration program will be implemented. Current knowledge of the local aquifer and types of contaminants suggest that groundwater pumping and treatment could be a feasible response. However, other response alternatives will also be evaluated prior to the selection of a final remedy.

3.10 EVALUATION OF POTENTIAL INTERIM RESPONSE ACTIONS

The DOE is proposing to perform various expedited response actions (ERAs) -- synonymous for this project with the term interim response actions (IRAs) -- prior to issuance of the ROD, in order to mitigate actual or potential uncontrolled releases of radioactively or chemically hazardous substances to the environment and to minimize potential health and safety risks to on-site personnel and local human and biotic populations. The scope of the IRAs will be limited to those actions that can be performed within the guidelines for removal actions of CERCLA and the NCP, and remain within the constraints of CEQ regulations for NEPA (i.e., actions will be limited to those that do not have adverse environmental impacts or limit the choice of reasonable alternatives for the ultimate disposition of the site).

Under the July 1982 version of the NCP, removal actions were divided into two categories: (1) immediate, for emergencies, and (2) planned, for near emergencies. The February 1986 revisions of the NCP expanded the definition of removal to combine three previously separate activities -- immediate removals, planned removals, and initial remedial measures -- into one general activity category of removals. The use of ERAs (i.e., IRAs) was designed to address those situations that were previously performed as

initial remedial measures. The primary purpose of conducting a removal action is to expedite response activities at those sites where cleanup solutions are straightforward. In addition, the NCP revisions extended removal authority to permit actions to be taken in response to a threat (rather than to an immediate and significant threat). Thus, removal actions can now be implemented on a non-time-critical basis, i.e., when the action does not need to be initiated within hours or days (classic emergency removal) or within six months (time-critical removal) after the preliminary assessment of a site. By definition, the IRAs proposed for the Weldon Spring site are of a non-time-critical nature.

The EPA lists the following major factors for implementing an ERA (i.e., IRA):

- The action must meet criteria for removal actions as stated in the NCP,
- The action must be implemented within the statutory limits of 1 year and $2 million, for Superfund-financed actions only (waivers of these limits are possible), and
- The action must be consistent with and contribute to the performance of the long-term remedial action for the site.

The IRAs at the Weldon Spring site will be conducted in accordance with relevant guidelines primarily to:

- Reduce the potential for off-site migration of contaminated groundwater and surface water,
- Reduce the potential for extended soil contamination,
- Reduce the potential for air contamination, and
- Protect the health and welfare of on-site personnel and nearby individuals and the environment.

A secondary objective of the IRAs will be to facilitate adequate site characterization.

3.10.1 EE/CA Documentation Process

The decision-making process DOE will follow to document the evaluation of IRA alternatives is shown in Table 21 and Figure 30. The major document prepared to analyze alternatives for implementing the various IRAs is the engineering evaluation/cost analysis (EE/CA) report. A flow chart of the EE/CA process is shown in Figure 31. The decision-making process is intended to be flexible to the specific needs of the various IRAs; not all components of the process will be needed for all IRAs. Specific documentation will be prepared for each IRA to ensure that the environmental review

TABLE 21 Summary of the NEPA and CERCLA Decision-Making Processes for IRAs

Step	Action
I	Notification (DOE Action)
II	Characterization Data (DOE Preparation -- EPA and State Review/Comment)[a]
	Evaluation of Existing Data
	Collection of New Data (As Necessary)
III	Engineering Evaluation/Cost Analysis Report (DOE Preparation -- EPA, State, and Public Review/Comment)[b]
	Site Characterization
	Site Description
	Site Background
	Analytical Data
	Site Conditions That Justify a Removal Action
	Removal Action Objectives
	Statutory Limits
	Scope and Purpose
	Schedule
	Compliance with ARARs (Contaminant- and Location-Specific)
	Removal Action Alternatives
	Screening of Removal Action Alternatives
	Public Health and Environmental Effectiveness
	Timeliness
	Technical Feasibility
	Institutional Considerations
	Analysis of Removal Action Alternatives
	Action-Specific ARARs
	Technical Feasibility
	Cost/Benefit Analysis
	Institutional Considerations
	Environmental Impacts
	Summary
	Comparative Analysis of Removal Action Alternatives
	Technical Feasibility
	Cost
	Institutional Considerations
	Environmental Impacts
	Recommended Removal Action Alternative
IV	NEPA Documentation (DOE Preparation -- EPA and State Review/Comment)
	Memorandum-to-File[c] or Finding of No Significant Impact (FONSI) (As Appropriate)

TABLE 21 (Cont'd)

Step	Action
V	CERCLA Documentation (EPA and State Preparation -- DOE Review/Comment)
	Action Memorandum
VI	Implementation (DOE Performance -- EPA and State Oversight)
	Planning and Design of Removal Action
	Issuance of Notice to Proceed
	Initiation of Work
	Description of Oversight and Monitoring
	Completion of Work
	Inspections
	Acceptance of Completed Work
	Work Completion Report

[a]EPA refers to EPA Region VII and state refers to the state of Missouri.

[b]The scope of this analysis may be expanded for certain IRAs to include the level of environmental analysis required in an EA under NEPA.

[c]A memorandum-to-file is a unique DOE mechanism that was established when DOE's NEPA guidelines (U.S. Dept. Energy 1987d) were first issued in 1980. It was developed to avoid the need to prepare EAs for a large number of DOE actions that, because of limited agency experience, had not yet been added to the list of categorical exclusions.

requirements of both NEPA and CERCLA are satisfied. The DOE will consult with EPA Region VII and the state of Missouri in this regard.

3.10.2 Proposed IRAs

The IRAs proposed for the Weldon Spring Site Remedial Action Project are described in this section. The objectives of these IRAs are to (1) expedite cleanup of the site, (2) reduce threats of releases of chemical and radioactive contaminants into the nearby environment, (3) minimize for on-site personnel and local populations the health and safety risks that are associated with site conditions, and (4) contribute to the long-term, overall remedial action for the site (e.g., by reducing on-site waste volume and facilitating waste disposal activities). Additional IRAs may be proposed as the project proceeds. The selection of those actions will continue to involve coordination with EPA Region VII and the state of Missouri and will follow the guidelines described in Section 3.10 and the general process shown in Table 21.

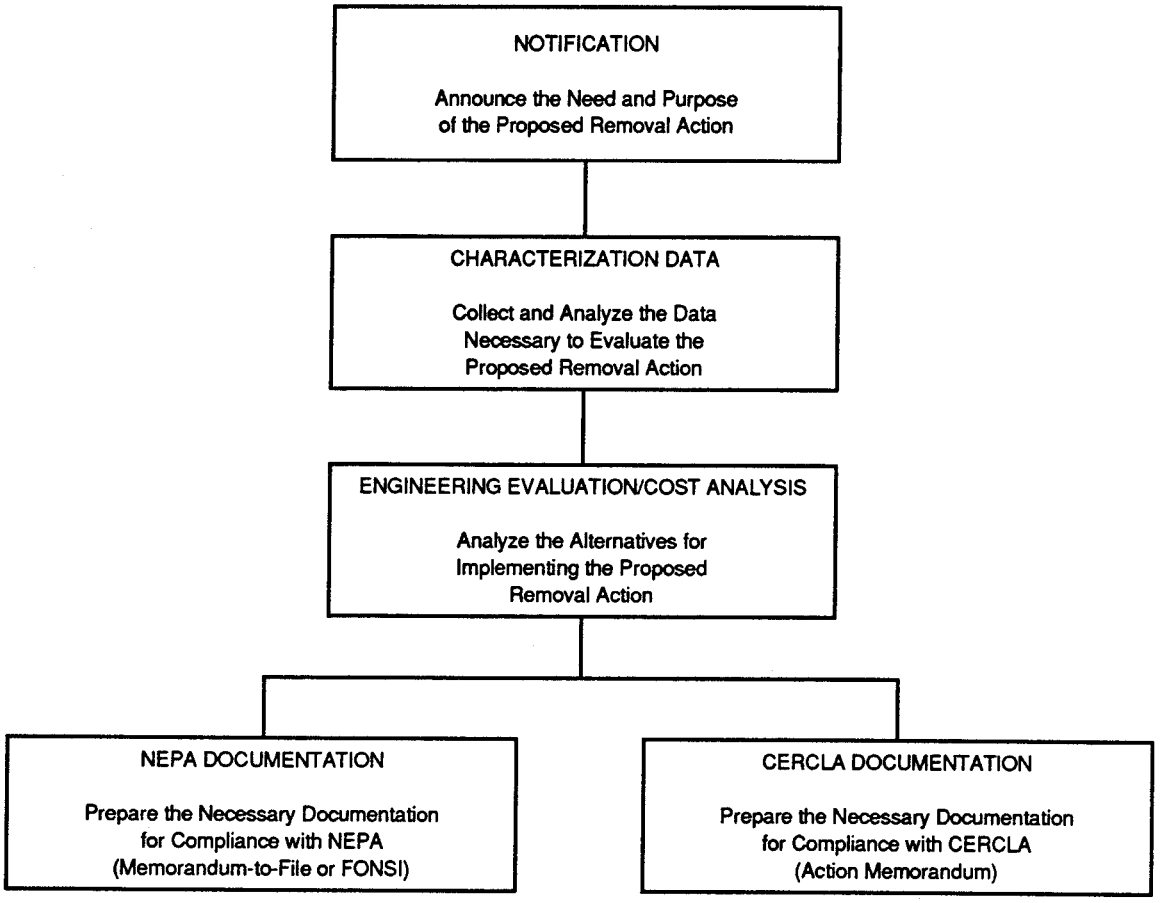


FIGURE 30 Decision-Making Process for Evaluation of IRA Alternatives

3.10.2.1 Removal of PCB Transformers

Fifteen on-site transformers and several additional electrical components on-site held an estimated 25,000 L (6,500 gal) of PCB-containing fluids. Approximately 49,000 L (13,000 gal) of PCB fluids and flushing solutions were removed and transported to an off-site licensed incineration facility; the flushed units were then transported off-site to a licensed disposal facility. Eleven non-PCB transformers were removed as well. Removal of these radioactively clean, out-of-service transformers from the site was carried out in compliance with existing regulations and will prevent leakage of the PCBs during subsequent response action activities at the raffinate pits and chemical plant area. Thus, this action has reduced the volume of on-site materials requiring disposal and has decreased the potential health threats to workers during subsequent on-site activities that would have been associated with PCB contamination.

Status: EPA and state concurrence received in November 1987.
Removal action completed in August 1988.

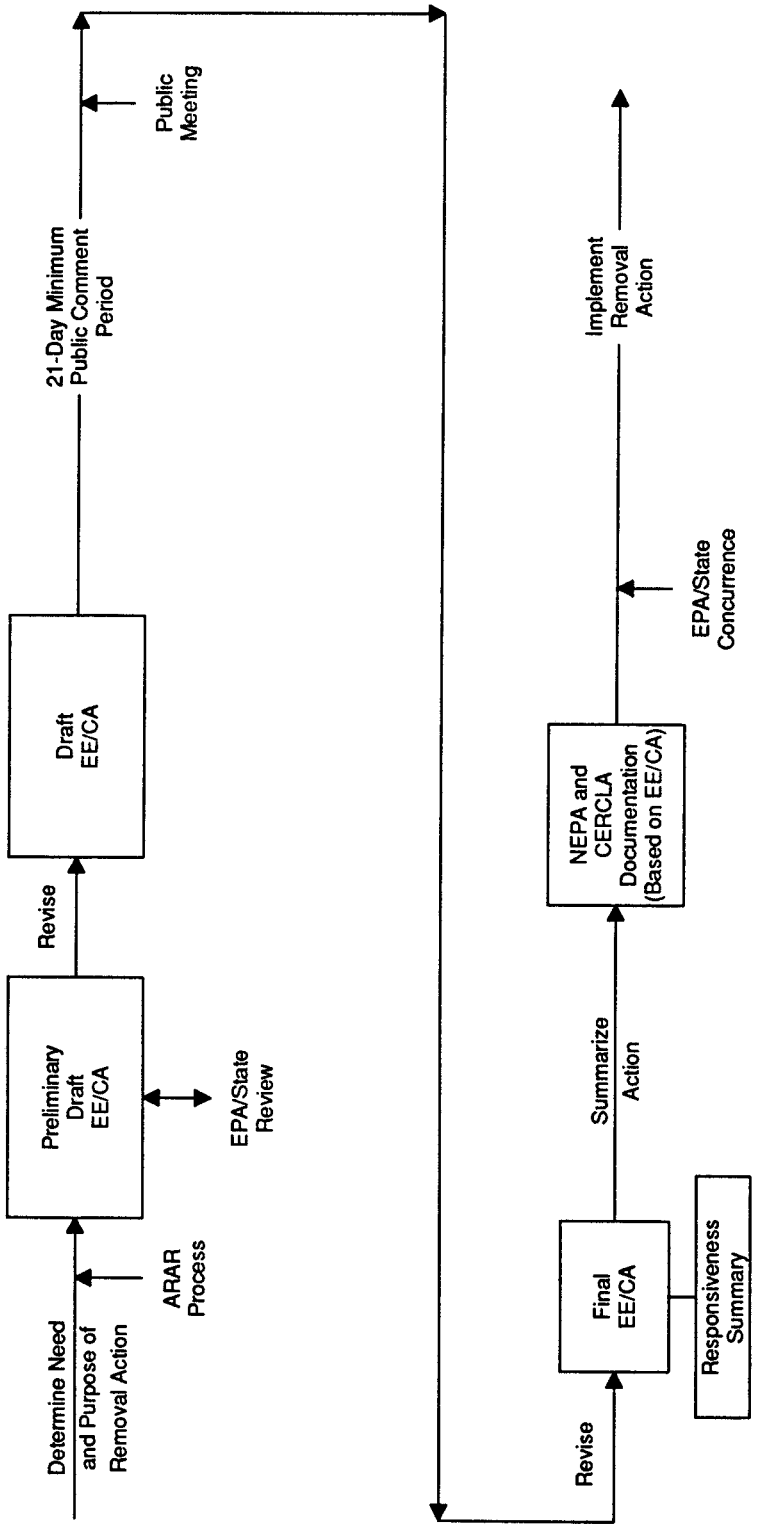


FIGURE 31 Flow Chart of the EE/CA Process

3.10.2.2 Construction of an Ash Pond Isolation Dike

Surface water runoff flowing from the east into Ash Pond, the lowest elevation on the site, is contaminated with uranium measured at levels up to 440 pCi/L. Water runoff from the south flows across a former dump area and into Ash Pond, such that the pond outflow into the Busch Wildlife Area is contaminated with uranium measured at levels up to 3,500 pCi/L. Construction of a dike and channels to divert surface runoff around the dump area and Ash Pond will minimize surface water intrusion and help control erosion. This action will reduce the levels of radioactive contamination leaving the site via surface water runoff.

Status: EPA and Missouri DNR comments received in December 1987.
Additional data were collected to address EPA and Missouri DNR concerns.
Revised documentation transmitted to EPA and state in June 1988.
Construction to begin October 1988; projected completion by November 1988.

3.10.2.3 Construction of Material Staging Area

A material staging area is needed to store, on a temporary basis, contaminated materials resulting from IRA activities at the chemical plant and vicinity properties. In addition to storage, the staging area will be used to classify and segregate materials for future disposal. This staging area will consist of approximately 1.2 ha (3 acres) of cleared ground. A low-permeability liner will be installed and a surface water diversion system and a leachate collection system will be provided. This action will facilitate the consolidation and screening of contaminated materials and will minimize potential threats to workers and the environment related to both the scattered materials and the temporary storage of the materials.

Status: To be developed.

3.10.2.4 Cleanup of Army Reserve Property A7

About 1.2 m^3 (1.5 yd^3) of radioactively contaminated soil was removed from Army Reserve vicinity property A7, which is located about 1 m (1 yd) north of Army Road No. 1 and 300 m (330 yd) west of a road intersection. The soil was placed in eight 55-gal drums, loaded onto a pickup truck, transported to the raffinate pits and chemical plant area, and then placed in storage in an on-site building. Vicinity property A7 was radiologically surveyed by an independent contractor to confirm that cleanup was effective in removing the radioactive material, thereby minimizing the potential threat to public health and the environment associated with this contaminated soil.

Status: EPA and state concurrence received in November 1987.
Removal action completed in January 1988.

3.10.2.5 Cleanup of Selected Locations on Department of Conservation Property

Radioactively contaminated soil will be removed from four isolated locations on Missouri Department of Conservation property (see Figure 29): one on the Busch Wildlife Area, north of the raffinate pits and chemical plant area (B3); and three on the Weldon Spring Wildlife Area, south of the raffinate pits and chemical plant area (B4, B5, and B8). The excavated soil will be stored in a designated, controlled-access area at the Weldon Spring site until final disposition. The current estimated volume to be removed is 400 m^3 (520 yd^3). This action will reduce potential threats to public health and the environment associated with this contaminated soil.

Status: To be developed.

3.10.2.6 Removal of Overhead Piping/Asbestos

Ten thousand linear meters (33,000 linear feet) of overhead piping and 500 structural supports, which hold 4,000 linear meters (13,000 linear feet) of asbestos-containing material, will be removed from the chemical plant area. The asbestos-containing material will be wrapped and dismantled, and soil contaminated with asbestos will be cleaned up. All materials will be surveyed and classified. Nonradioactive asbestos-containing material will be transported to an off-site licensed disposal facility; radioactive asbestos-containing material will be stored on-site. Reusable materials may be salvaged. This action will reduce potential off-site airborne releases of asbestos, reduce potential threats to the health and safety of on-site workers, reduce the volume of on-site materials requiring disposal, and facilitate future cleanup efforts.

Status: EPA and state concurrence received in November 1987.
Removal action to begin September 1988; projected completion by April 1989.

3.10.2.7 Disposal of Containerized Chemicals

There are 4,000 individual containers on-site in which 300 different types of chemicals are stored. The estimated volumes are 19,000 L (5,000 gal) of containerized liquids and 71 m^3 (93 yd^3) of containerized solids. The types of containers include laboratory vials and bottles, bags, cylinders, and drums. Although some of the containers are intact, others have deteriorated and are leaking. Radioactively contaminated materials will be stabilized and consolidated for future disposition. Nonradioactive materials will be sampled and tested for chemical compatibility, then stabilized, consolidated, and transported off-site by a licensed hauler to a licensed disposal facility. This removal will reduce the potential for future exposure of on-site workers to these chemicals and the potential for leakage of chemical containers during future cleanup activities, as well as reduce the volume of on-site materials requiring disposal.

Status: EPA and state concurrence received in November 1987.
Removal action to begin August 1988; projected completion by November 1988.

3.10.2.8 Removal of Electric Lines and Poles

All deenergized exterior power and telephone lines (an estimated 46,000 linear meters [150,000 linear feet] of cable and wire) and 300 timber poles, their cross beams, and supports have been removed from the chemical plant area. These inactive lines and poles were deteriorating, and many had fallen or were in danger of falling to the ground. All materials were radiologically surveyed and classified. Nonradioactive material was transported off-site for salvage; radioactive material is being stored on-site. Removal of these items has improved the safety conditions for on-site workers and reduced the volume of on-site materials requiring disposal; it also facilitates future cleanup activities (e.g., dismantling of area buildings).

Status: EPA and state concurrence received in November 1987.
Removal action completed in March 1988.

3.10.2.9 Consolidation of Debris

Following the inventory and characterization of containerized chemicals and the scanning of major items for radioactive contamination, action will be taken to consolidate debris (e.g., pipe, steel, and rubble) randomly scattered throughout the site. Placing this debris in one controlled area will improve environmental and safety conditions on the site. It will also facilitate groundskeeping and future dismantling and construction activities.

Status: EPA and state concurrence received in November 1987.
Awaiting construction of material staging area.

3.10.2.10 Dismantling of Building 409 (Administration)

The two-story, 3,500-m^2 (38,000-ft^2) former administration building (409) is badly deteriorated. Characterization of this building has identified the presence of asbestos pipe insulation, PCB contamination on floor surfaces, and radioactive contamination in the roofing material. The asbestos insulation and the PCB-contaminated material will be removed and transported off-site to appropriately licensed disposal facilities. The radioactively contaminated material will be containerized and stored on-site until final disposition. Internal equipment, walls, and the superstructure will then be dismantled and transported to an off-site licensed disposal facility or salvaged where feasible. This action will facilitate future cleanup activities, reduce the volume of on-site materials requiring disposal, and reduce the potential health and safety hazards to on-site workers associated with the deteriorating structure.

Status: EPA and state concurrence received in November 1987.
Removal action to begin August 1988; projected completion by April 1989.

3.10.2.11 Dismantling of Building 401 (Steam Plant)

The steam plant (Building 401) is a 1,600-m^2 (17,000-ft^2) building that contains asbestos and small radioactively contaminated areas. Asbestos from the building will be removed and transported to an off-site licensed disposal facility. The radioactively contaminated material will be containerized and stored on-site until final disposition. The equipment and building will then be dismantled and transported to an off-site licensed disposal facility or salvaged where feasible. This action will facilitate future cleanup activities, reduce the volume of on-site materials requiring disposal, and reduce the potential health and safety hazards to on-site workers associated with the structure.

Status: EPA and state concurrence received in November 1987.
Removal action to begin October 1988; projected completion by June 1989.

3.10.2.12 Construction of Southeast Drainage Dike

A dike will be constructed to isolate contaminated portions of the southeast drainage watershed from surface water intrusion. This dike, which will also provide erosion control, will be about 3.0 m (10 ft) high at its maximum elevation and about 300 m (1,000 ft) long. The southeast drainage watershed, which receives surface water as well as infiltration and inflow from the chemical plant sanitary and process sewers, flows to the Missouri River. Construction of the dike, and subsequent water management, will reduce the potential threat to public health and the environment associated with off-site discharges of contaminated surface water from this area.

Status: To be developed.

3.10.2.13 Cleanup of Army Reserve Properties A1, A2, and A3

More than 1,000 m^3 (1,400 yd^3) of radioactively contaminated soil material (up to approximately 280 pCi/g of uranium and 38 pCi/g of radium) is present on the Army Reserve property. This proposed cleanup consists of removing the contaminated soil material from vicinity properties A1, A2, and A3 (see Figure 29), hauling it to an on-site staging area at the raffinate pits and chemical plant area, verifying and certifying that the affected properties meet cleanup criteria, and then backfilling, regrading, and reseeding the disturbed areas. This action will consolidate the radioactive material in a controlled-access area at the Weldon Spring site, pending its final disposition, and will reduce potential threats to public health and the environment associated with this contaminated soil.

Status: To be developed.

3.10.2.14 Dismantling and Removal of Nonprocess Buildings, Structures, and Equipment

This action involves the dismantling and/or removal of nonprocess buildings, structures, and equipment that were not directly involved in the processing of materials and are therefore not expected to be heavily contaminated. However, many of these buildings, structures, and equipment are likely to be slightly contaminated with radioactive and chemical contaminants (including asbestos and some RCRA-hazardous materials) due to their former use to support activities at the plant and/or their close proximity to processing areas. Nonradioactive, chemically contaminated material will be transported to off-site licensed disposal facilities; radioactive material will be stored on-site. The following buildings, structures, and equipment will be addressed in this action:

Building or Area	Name/Function
104	Lime storage
109	West drum storage
110	East drum storage
202	Green salt tank farm
302	Magnesium building
406	Warehouse
407	Laboratory
408	Maintenance and stores
410	Services building
412	Electrical substation
413	Cooling tower and pump house
414	Salvage building
415	Process incinerator
417	Paint shop
426	Water tower
427	Primary sewage treatment plant
428	Fuel gas plant
430	Ambulance garage
431	Laboratory sewer sampler
432	Main sewer sampler
433-436	Storage buildings
437	Records retention building
438	Storage building
439	Fire training building
443	Fire training storage building
None	Rail and rail ties
None	Fuel tanks
None	Sewers in area

This action may be divided into several smaller actions to expedite the cleanup process. The action will facilitate future cleanup activities, reduce the volume of on-site

materials requiring disposal, and reduce the potential health and safety threat to on-site workers associated with deteriorating, contaminated facilities.

Status: To be developed.

3.10.2.15 Construction and Operation of Water Treatment System for the Quarry

Results of site characterization activities have indicated that the water currently contained in the quarry pond may be leaking from the quarry into local groundwater. It is proposed that this water be collected, treated, and then discharged after verifying that the effluent meets release limits that will be established in conjunction with EPA Region VII and the Missouri DNR. The water treatment system will be designed to continuously treat 0.0050 m^3/s (80 gpm). The initial volume of ponded water to be treated is estimated to be 11,000 m^3 (3,000,000 gal). This action will reduce the risk of contaminant migration to the nearby county well field, thereby reducing the potential threat to public health and the environment and will facilitate future remedial action at the quarry.

Status: An EE/CA for this action is currently being prepared.

3.10.2.16 Construction and Operation of Water Treatment System for the Raffinate Pits and Chemical Plant Area

Results of site characterization activities have indicated that the water currently contained in the raffinate pits is leaking from the pits into local groundwater. It is proposed that this water be collected, treated, and then discharged after verifying that the effluent meets release limits that will be established in conjunction with EPA Region VII and the Missouri DNR. The water treatment system will be designed to continuously treat 0.0063 m^3/s (100 gpm). The initial water volume to be treated is estimated to be 216,000 m^3 (57,000,000 gal). These pits contain the bulk of the surface water at the raffinate pits and chemical plant area. Additional contaminated water at the area, e.g., resulting from other IRA activities, will be treated in this plant on an as-needed basis. This action will reduce the risk of further contaminant migration to surrounding areas and groundwater, thereby reducing the potential threat to public health and the environment associated with contaminated soil and groundwater, and will facilitate future remedial action at the raffinate pits and chemical plant area.

Status: An EE/CA for this action is currently being prepared.

3.10.2.17 Decontamination of Area to Support Construction/Staging Activities at the Weldon Spring Site

Radioactively contaminated soil will be removed from an area of less than 0.4 ha (1 acre) at the quarry location currently planned for construction or staging activities. The contaminated soil will be stored in a designated on-site area until a final decision regarding waste disposal is reached. This action will permit planned activities to go

forward and will reduce the potential threat to on-site personnel that is associated with this contaminated soil.

Status: To be developed.

3.11 REMOVAL OF BULK WASTES FROM THE QUARRY

3.11.1 Proposed Action

The bulk wastes that are present in the quarry may pose a risk to both the health of the local population and the environment. Bulk wastes, as defined here, are wastes that can be removed using technologies such as excavation by standard construction equipment (e.g., backhoe and bulldozer), hydroblasting, and laser scarfing. Bulk wastes include structural debris, drums, sludges, and other solid materials. The DOE is proposing to remove these bulk wastes from the quarry and transport them to the raffinate pits and chemical plant area for temporary storage prior to the ROD for the project. The decision on the ultimate disposal of these bulk wastes will be included as part of the decision for management of the waste materials resulting from remedial action activities at the raffinate pits and chemical plant area.

Although the extent, pathways, and mechanisms of contaminant transport are not fully understood at this time, it can reasonably be concluded that the quarry wastes are the source of the contamination that has been detected in the quarry area. In addition, this contamination is of concern with respect to potential future adverse impacts to surface water and groundwater, which could subsequently represent a risk to public health and the environment. Expedited removal of the bulk wastes would mitigate these risks by eliminating the primary source of contamination and reducing the potential for migration.

Before a long-term remedial plan for the quarry can be developed, the geology, hydrogeology, and extent of residual contamination in and around the quarry must be adequately assessed. In order to accomplish this in a safe and effective manner, it is necessary to first remove the bulk wastes. Because of the nature of the quarry wastes (e.g., steel, rubble, and process equipment), conventional investigative techniques such as drilling or geophysics are infeasible. Additionally, there is a potential risk to the environment resulting from the investigation activities themselves. For example, even if boring through the wastes could be conducted successfully, the wastes could potentially migrate from the quarry via this pathway. All of these issues would be minimized or avoided if the bulk wastes were first excavated and detailed evaluation of the quarry residual materials were conducted as a follow-on activity.

Another reason for the removal and transport of these bulk wastes to the raffinate pits and chemical plant area is that such action would allow consolidation of wastes associated with the Weldon Spring site in one location, rather than their current location in two noncontiguous areas. This would enable DOE to better control access, prevent accidental releases, and provide for environmental monitoring. Finally, the removal of the bulk wastes would accomplish one step in the overall remediation of the

Weldon Spring site and would expedite the development and implementation of a long-term response action strategy at the quarry.

The public has expressed a concern that disturbing the wastes unnecessarily could result in the unintentional release of contaminants. The major mechanism for such release would be contaminant migration from the quarry via groundwater. The potential for this release would be reduced by lowering the water level in the quarry pond through pumping, treating, and discharging the effluent prior to excavation of the bulk wastes. The lowered water table would effectively turn the quarry into a sump, i.e., by reversing the gradient for groundwater movement, thereby greatly reducing the potential for contaminant migration. Treatment of this ponded water is being addressed as an IRA (see Section 3.10.2.15).

3.11.2 Documentation Requirements

Environmental compliance documentation must be prepared for the Weldon Spring site in accordance with the requirements of NEPA and CERCLA. The raffinate pits and chemical plant area and the quarry, although noncontiguous, are considered to be one site for the purpose of this remedial action project. A single, comprehensive analysis is usually prepared for each NPL site; however, it is possible to subdivide a large and/or complicated site into separate operable units to expedite the documentation and remediation processes. An operable unit is a discrete part of the entire site (or of a response action), whose management (or performance) decreases a release or threat of release, or limits a pathway of exposure. Implementation of response action at a separate operable unit must be consistent with the permanent remedy for the entire site, even though the action may be implemented prior to selection of the final remedy. By defining the quarry bulk wastes as a separate operable unit, it becomes possible to expedite this remedial action. The residual wastes (i.e., within bedrock fractures) and the groundwater will be managed as additional separate operable units after sufficient data have been obtained to define and evaluate appropriate remedial action alternatives. This can only be accomplished after the bulk wastes have been excavated and removed from the quarry.

3.11.2.1 RI/FS-EA Process

The proposed response action for this separate operable unit could be considered either a remedial action or a removal action. For CERCLA, a remedial action is supported by an RI/FS whereas a removal action is supported by an EE/CA. For this project, these two processes have been modified to allow for NEPA and CERCLA compliance with one set of documentation (see Sections 1.2 and 3.10.1). The RI/FS is a formal process that has specific data and documentation requirements. The EE/CA is a less formal process that generally focuses on one or two alternative actions and has somewhat flexible documentation requirements. Both processes consider all federal and state ARARs and stress the use of permanent solutions to the extent practicable.

A focused RI/FS is an administrative compromise between the full-scale RI/FS and EE/CA approaches for CERCLA compliance; it encompasses many of the procedural

advantages of an EE/CA while maintaining the formal nature of an RI/FS. The focused RI/FS is generally applicable to separate operable units that have limited alternatives and that subsequently allow a more simplified selection process and require only limited data gathering. When the action involves a separate operable unit rather than an entire site, EPA concurrence is in the form of an action memorandum. Otherwise, the process and format of a focused RI/FS generally comply with those of the conventional RI/FS.

The DOE is planning to use the concept of a focused RI/FS to document the removal and transport of the quarry bulk wastes to the raffinate pits and chemical plant area for temporary storage. This focused RI/FS process will be modified to include an assessment of environmental impacts associated with this action. The level of environmental review associated with an action of this nature would typically be included in an EA. The DOE is planning to use this hybrid documentation process, termed the RI/FS-EA process, for this action. Procedures for implementing this process are described in Section 3.11.7.

The two major alternatives to be evaluated in the RI/FS-EA process for quarry bulk waste removal are:

- Removing and transporting the bulk wastes to the raffinate pits and chemical plant area for temporary storage, and

- Leaving the bulk wastes in place, pending the ROD for the project.

Other alternatives will be considered, as appropriate; if detailed analyses of these alternatives are not included in the RI/FS-EA process, the reasons for not doing so will be documented. Within the removal alternative, a number of different technologies for each element of this alternative will be considered. The decision on ultimate disposition of the quarry bulk wastes will be included in the overall RI/FS-EIS process for the project.

3.11.2.2 Risk Evaluation

One of the key components of the RI/FS process is the risk assessment. This assessment is conducted for the baseline (no-action) case to determine the potential impacts to human health and the environment and to assist in the determination of the appropriate cleanup criteria. In addition, it provides a basis for evaluating the effectiveness of proposed remedial action alternatives. However, preparation of a comprehensive baseline risk assessment is not possible with the bulk wastes in place. Significant data gaps currently exist with respect to the extent, pathways, and mechanisms for contaminant migration from the quarry. These data gaps preclude the preparation of a comprehensive risk assessment for the proposed removal. Furthermore, much of this information cannot be obtained until after the wastes have been removed. To meet the risk assessment requirement for this process, DOE will prepare a limited baseline risk evaluation -- to the extent possible with existing information -- using as guidance the EPA risk assessment methodology provided in the *Superfund Public Health Evaluation Manual* (U.S. Environ. Prot. Agency 1986b). Current data are sufficient to

justify the need for this action and to allow for an assessment of environmental impacts associated with implementing the action. The need for additional cleanup at the quarry will be addressed after removal of the bulk wastes, at which time a comprehensive risk assessment will be prepared to assess potential impacts from residual materials on human health and the environment and to help establish cleanup criteria.

3.11.3 Additional Characterization

Collection of additional characterization data for the quarry would probably not significantly increase current knowledge concerning the quarry wastes. Also, the type and placement of buried materials make representative sampling difficult. Obtaining samples of the wastes, without altering their chemical properties during collection, is virtually impossible. In addition to the basic difficulty of drilling through the types of materials present and obtaining representative samples, the lubricating fluid required for drilling tends to wash and dilute the resultant samples. To conduct trenching studies of the nonhomogeneous materials would not permit characterization of the entire depth of the waste materials and would be of limited value. Therefore, it is proposed to remove the bulk wastes from the quarry on the basis of existing data regarding both the characteristics of the quarry wastes and the potential transport mechanisms and pathways.

A substantial amount of historical data currently exists on past disposal practices at the quarry, including analytical data regarding the heterogeneity of the wastes. Several characterization studies of the quarry wastes have confirmed the presence of radioactive and chemical contaminants consistent with the types of materials placed in the quarry. Radiological surveys of the quarry wastes have detected naturally occurring radionuclides of the uranium-238 and thorium-232 radioactive decay series, as well as metals associated with uranium-processing activities. The organic compounds that have been identified are those expected from past disposal activities, i.e., PCBs, PAHs, and nitroaromatic compounds. The chemical and radiological species in the quarry are not found in discrete, homogeneous areas; rather they are intermixed in a soil/rubble matrix at varying concentrations.

Additional characterization data regarding groundwater transport of hazardous contaminants from the quarry into the surrounding environment are needed to complete remedial action at the quarry. The groundwater transport is believed to occur through two distinct hydrological regimes: the bedrock and the alluvial aquifer. The bedrock regime involves the limestone walls and floor of the quarry. It is suspected that contaminated leachate migrates from the quarry through solution-enlarged joints and cracks. After passing through this first medium, contaminants are transported into an alluvial aquifer system. The mechanisms and pathways of transport at the interface between the bedrock and alluvial systems are not yet clearly defined. These pathways will be investigated in detail following removal of the bulk wastes.

In contrast, the alluvial aquifer system is fairly well understood. Past characterization and monitoring efforts have involved the drilling of a number of wells throughout the alluvial system. This has resulted in a well-documented subsurface lithology, and the aquifer transport characteristics have been modeled with a reasonable degree of confidence. Although contaminant transport through the quarry bedrock into

the alluvium has not yet been defined, the movement of the contaminants once they reach the alluvial system is well understood.

Detailed evaluation of the transport of contaminants from the quarry into the surrounding environment is not an essential part of this proposed response action. However, the RI/FS-EA process will include an assessment of the potential migration of contaminants into the limestone quarry, to the extent possible, during both the action period and the time period following bulk waste removal. A good understanding of the nature and extent of fracture joints and cracks can be developed only after the bulk wastes have been removed from the quarry and the limestone walls and floors have been exposed for study. The residual contamination in joints and cracks of the quarry -- and in the groundwater -- will be treated as separate operable units following the currently proposed waste removal effort.

3.11.4 Temporary Storage Requirements

Temporary storage of the quarry wastes at the raffinate pits and chemical plant area is a necessary component of the bulk waste removal action. Storage of the wastes will be temporary until the ultimate disposition of all Weldon Spring wastes is determined. The response action will be evaluated on the basis of compliance with potential ARARs, such as RCRA storage requirements given in 40 CFR Part 264, Subparts I and L. These regulations, which are discussed in greater detail in Sections 3.11.4.1 and 3.11.4.2, pertain to container storage and waste piles, respectively. Other requirements, e.g., those of 40 CFR Part 192 -- which provide groundwater and atmospheric protection standards with regard to the release of radioactive materials from uranium mill tailings sites -- will be considered in the determination of potential ARARs for this action.

3.11.4.1 Container Storage

In consideration of the container storage requirements of 40 CFR Part 264, Subpart I, container storage areas will be designed and operated on a base that will contain leaks, spills, and precipitation until the accumulated liquids can be analyzed and removed. The base will be sloped or the containers elevated to prevent contact of the containers with the accumulated liquids. The storage area will have sufficient volume to contain any anticipated surface water accumulation in addition to 10% of the volume of all containers that store wastes with free liquids. Accumulated liquids will be removed from the collection area in as timely a manner as is necessary to prevent overflow of the collection system.

3.11.4.2 Waste Piles

Regulations concerning waste piles (40 CFR Part 264, Subpart L) state that such a pile must be designed, constructed, and installed to prevent the migration of contaminants out of the pile at any time during its active life. Thus, the storage pile will have a containment structure composed of materials that are capable of preventing failure due to pressure gradients, stress of installation or operation, climatic conditions, or contact

with the wastes or waste leachate. It will be installed to cover all surrounding soil likely to be in contact with the wastes or leachate. If not enclosed, the waste pile will also have a leachate collection system that is designed, constructed, maintained, and operated to collect and remove leachate from the pile. To maintain the capacity of the containment system, a surface water runon/runoff control and management system will be developed, and the associated collection and holding facilities will be emptied expeditiously after storms. The pile will be covered or otherwise managed to control wind dispersal and will be inspected regularly for deterioration or malfunction.

3.11.5 Cleanup Criteria

The RI/FS process evaluates potential remedial alternatives with respect to their ability to meet cleanup criteria that have been established for each separate operable unit. These criteria are typically in the form of specific analytical parameters. Due to the sequence of events planned for the quarry, DOE proposes that the cleanup criteria be technology based rather than analytically based. The reason for this approach is recognition that the response action for this separate operable unit is only the first step in the overall remediation of the quarry. Immediately following excavation of the bulk wastes, the next phase will involve a comprehensive investigation of any residues remaining in the quarry and of the hydrogeological characteristics of the bedrock. Data gathered during this phase will support the evaluation and selection of a final remedial action for the quarry. Therefore, the establishment of temporary cleanup criteria that could change would result in no benefit and would also require the additional time and expense of a confirmatory sampling program. It is recommended instead that the final cleanup criteria for the quarry be defined pursuant to completion of the characterization efforts that will follow removal of the bulk wastes.

3.11.6 Water Treatment

Approximately 11,000 m^3 (3,000,000 gal) of ponded water is currently in the quarry. This water must be removed and treated prior to removal of the bulk wastes. Treatment of this water is being addressed as an IRA (see Section 3.10.2.15).

3.11.7 Compliance with NEPA and CERCLA

The DOE is proposing to address quarry bulk waste removal as a separate operable unit and will use the RI/FS-EA process to support this decision (see Section 3.11.2.1). This action is scheduled to occur prior to the ROD for the project. Implementation of the RI/FS-EA process will be as follows. The first two phases of the FS process will be completed concurrent with preparation of the RI and baseline risk evaluation. At this point, an assessment of environmental impacts will be performed consistent with the requirements of an EA in support of a finding of no significant impact (FONSI), if appropriate. If DOE determines that this action requires preparation of an EIS, the action will be included within the overall RI/FS-EIS process for the project, and removal of the quarry bulk wastes will not be undertaken prior to issuance of the ROD.

Because the EA is scheduled to be completed prior to issuance of the FS, the RI/FS process for the quarry bulk waste removal action will be completed only if a FONSI is issued. If an RI/FS for bulk waste removal is completed, DOE and EPA will issue decision documents under CERCLA to document the decision-making process.

4 SAMPLING AND ANALYSIS PLAN RATIONALE

The assessment of remedial action alternatives for the Weldon Spring Site Remedial Action Project involves two major phases: the RI and the FS-EIS. The RI phase consists of all activities necessary to collect data to assess the hazards at the site and to analyze various remedial action alternatives during the FS-EIS phase. In order to conduct the RI in an acceptable manner and to allow adequate oversight, review, and participation by EPA Region VII and the Missouri DNR, DOE is preparing a detailed sampling and analysis plan to define the procedures to be used in site characterization activities. The sampling and analysis plan consists of two parts: (1) a quality assurance project plan that describes the policy, organization, functional activities, and quality assurance and quality control protocols necessary to ensure that the collected data are valid for their intended use, and (2) field sampling plans that provide guidance for all field work by defining in detail the sampling and data-collecting methods to be used for the project.

4.1 QUALITY ASSURANCE PROJECT PLAN

The purpose of the quality assurance project plan (QAPP) is to focus on the programmatic steps employed during the RI phase to ensure precision and accuracy of data. The QAPP will consist of the following 16 elements:

1. Title page
2. Table of contents
3. Project description
4. Project organization and responsibilities
5. Quality assurance objectives for measurement
6. Sampling procedures
7. Sample custody
8. Calibration procedures
9. Analytical procedures
10. Data reduction, validation, and reporting
11. Internal quality control
12. Performance and systems audits

13. Preventive maintenance

14. Data assessment procedures (precision, accuracy, and completeness)

15. Corrective actions

16. Quality assurance reports

The title page will include the usual information. In addition, at the bottom of the title page, provision will be made for the signatures of approving personnel, as follows:

- Project director,
- Project manager,
- Project quality assurance manager,
- DOE project manager, and
- DOE quality assurance officer.

The table of contents will include an introduction, a serial listing of the QAPP elements, and a listing of any appendixes that are required to augment the QAPP. The end of the table of contents will include a list of the recipients of official copies of the QAPP.

The project description will consist of an introductory discussion of the proposed work and general objectives of the investigation. The location, size, and important physical features of the site will also be described. A chronological site history, including descriptions of site use, will be provided along with a brief summary of previous sampling efforts and an overview of the results. Finally, specific project objectives for this phase of data collecting will be listed, and the means by which the data will be used to address each of the objectives will be identified.

Project organization and responsibilities will be described in terms of identifying key personnel and/or organizations that are necessary for each data-collecting study. An organizational table or chart will be included.

The quality assurance objectives for measurement will be based on the intended use of the data, available laboratory procedures, and available resources. The field blanks and duplicate field sample aliquots to be collected for quality assurance purposes will be itemized for the contaminants identified in the project description. The selection of analytical methods requires a familiarity with regulatory requirements concerning data usage. Any regulations that mandate the use of certain methods for any of the sample matrices and parameters listed in the project description will be specified. The detection limits needed for the project will be reviewed against the detection limits of

the laboratory used. Quantitative limits will be established for the following quality assurance objectives:

1. Level of quality assurance effort,

2. Accuracy of spikes and reference compounds,

3. Precision, and

4. Method detection limits.

Completeness, representativeness, and comparability are quality characteristics that will be considered.

Sampling procedures will be submitted with the field sampling plans. For each major measurement, including pollutant measurement systems, a description of the sampling procedures to be used will be provided. Where applicable, the following will be included:

- Description of techniques or guidelines used to select sampling sites;

- Description of the specific sampling procedures to be used;

- Charts, flow diagrams, or tables delineating sampling program operations;

- Description of containers, procedures, and reagents used for sample collection, preservation, transport, and storage;

- Discussion of special conditions for the preparation of sampling equipment and containers to avoid sample contamination;

- Description of sample preservation methods;

- Discussion of the time considerations for shipping samples promptly to the laboratory;

- Examples of the custody or chain-of-custody procedures and forms; and

- Description of the forms, notebooks, and procedures to be used to record sample history, sampling conditions, and analyses to be performed.

Sample custody, which is an integral part of any good laboratory or field operation, is divided into three parts: (1) sample collection, (2) laboratory analyses, and (3) final evidence files. The QAPP will address all three areas of custody. In addition,

the QAPP will provide examples of chain-of-custody records or forms used to record the chain-of-custody for samples, laboratories, and evidence files.

Calibration procedures will be identified for each parameter measured and will include field and laboratory testing. The appropriate standard operating procedure will be referenced, or a written description of the calibration procedures to be used will be provided.

Analytical procedures will be developed using approved EPA procedures or their equivalent. For each measurement, either the applicable standard operating procedure will be referenced or a written description of the analytical procedures to be used will be provided.

The data reduction, validation, and reporting procedures to be used for all collected data will be described. These procedures will include a description of the equations used to calculate the concentration or value of a given parameter, based upon the collected data.

All specific internal quality control methods to be used will be identified. These methods include the use of replicates, spike samples, split samples, blanks, standards, and quality control samples. Ways in which the quality control information will be used to qualify the field data will be identified.

The internal and external performance and systems audits that will be used to monitor the capability and performance of the total measurement system will be described. The systems audits consist of evaluating the components of the measurement systems to determine their proper selection and use. These audits include a careful evaluation of both field and laboratory quality control procedures and are normally performed before or shortly after systems are operational. However, such audits should be performed on a regularly scheduled basis during the lifetime of the project.

A preventive maintenance schedule will be provided for the major preventive maintenance tasks that will be carried out to minimize the down time of field and laboratory instruments.

The precision and accuracy of data must be routinely assessed for all environmental monitoring and measurement data. The QAPP will describe specific procedures to accomplish this assessment. If enough data are generated, statistical procedures may be used to assess the precision, accuracy, and completeness. If statistical procedures are used, they will be documented.

Corrective actions, in the context of quality assurance, are procedures that might be implemented with respect to samples that do not meet quality assurance specifications. Corrective actions will be addressed on a case-by-case basis. The need for corrective actions is based on predetermined limits for acceptability. Corrective actions may include resampling or reanalysis of samples and recommending an audit of laboratory procedures. The QAPP will identify persons responsible for initiating these actions, procedures for identifying and documenting corrective actions, and reporting and follow-up procedures.

Quality assurance reports include results of performance audits, results of systems audits, and significant quality assurance problems encountered, along with recommended solutions. The QAPP will identify the method to be used to report the performance of measurement systems and data quality. The final report for the project will include a separate quality assurance section that summarizes the data quality information contained in the periodic reports.

4.2 FIELD SAMPLING PLANS

The purpose of the field sampling plans is to obtain data to confirm the presence or absence of contaminants, the contaminant sources, modes of transport, direction of contaminant migration, and the effect of the contaminants on public health and the environment. The field sampling plans include a description of objectives, work tasks, specific quality assurance procedures, and level of effort required for site characterization. It is the intent of the field sampling plans to provide a detailed sampling rationale -- including the sampling locations and the types and number of samples -- which, coupled with standard operating procedures and analytical methods/detection limits, will offer a well-defined approach. These plans are designed to permit detailed characterization of the wastes, soil, groundwater, surface water, and facilities at the Weldon Spring site. From these investigations, remedial measures can be identified, evaluated, and selected.

Five categories of field sampling plans will be prepared for the Weldon Spring Site Remedial Action Project:

- Soil investigation,
- Hydrogeologic investigation,
- Waste assessment,
- Geophysical/geotechnical investigation, and
- Other investigations.

4.2.1 Soil Investigation

The soil investigation sampling plan is designed to determine the extent and magnitude of chemically contaminated soil, evaluate contaminant migration pathways, document uncontaminated areas, establish background concentrations, and provide identification of soil contaminant concentrations in both qualitative and quantitative terms for the 88-ha (217-acre) raffinate pits and chemical plant area. The sampling plan delineates a review of historical information, identifies data needs and uses, and outlines sampling and analytical procedures, quality assurance procedures, data documentation requirements, and data reporting requirements for the soil investigation at the raffinate pits and chemical plant area. Specific soil sampling locations have been selected based

on association with the operation of either the ordnance works (explosives production) or the chemical plant (uranium processing). In addition, unbiased sampling over the raffinate pits and chemical plant area will be conducted in order to provide a statistically valid data base for soils characterization and to provide documentation for uncontaminated areas. The soil investigation will provide a data base sufficient to support consideration of remedial action options and preparation of the risk assessment. The subcontract for the soil investigation will be awarded in August 1988; sampling activities will commence immediately thereafter. Laboratory analysis and report preparation are expected to be completed by December 1988.

The radiological contamination investigation of the Weldon Spring site has already been completed. Preliminary radiological characterizations of the site have been conducted by Oak Ridge National Laboratory, Bechtel National, EG&G, and others. An extensive field program was also conducted by UNC-Geotech from April to July 1987 to characterize the horizontal and vertical extent of radioactive contamination in the raffinate pits and chemical plant area (Marutzky, Colby, and Cahn 1988). The UNC-Geotech field program included exposure-rate measurements taken at the ground surface and at one meter above the land surface to delineate areas of elevated exposure rates. At locations exhibiting elevated exposure rates, in-situ measurements of uranium, radium, and thorium-232 were taken. If in-situ measurements showed elevated concentrations, soil samples were collected and analyzed for these radionuclides. Samples were collected with a bucket auger at 15-cm (6-in.) intervals; additional boreholes were drilled where elevated concentrations extended below 45 cm (18 in.).

The UNC-Geotech field activities also included drilling 317 boreholes in the raffinate pits and chemical plant area. Samples collected from each borehole were scanned with a gamma-ray spectrometer. Selected samples were then analyzed for either total uranium, thorium-230, or both. Those samples for which the spectrometric results indicated no elevated activities were archived for possible future analysis.

4.2.2 Hydrogeologic Investigation

The purpose of the hydrogeologic investigation sampling plan is to characterize the groundwater and surface water conditions at the raffinate pits and chemical plant area. The sampling plan has been divided into subtasks that include groundwater monitoring, aquifer testing, analysis of karst hydrogeology, unsaturated zone characterization, assessment of surface water hydrology and quality, studies of regional hydrogeology and water balance, and computer modeling of the hydrologic regime.

Although substantial hydrogeologic data have been collected during past site characterization activities, a number of data deficiencies remain for the raffinate pits and chemical plant area that relate to the areal and vertical distribution of the data, the detail of the data, and the frequency of the data collection. To address these deficiencies, it is the intent of the sampling plan to accomplish the following objectives:

- Extend the monitoring well network in order to determine the vertical and horizontal extent of groundwater contamination, levels of contamination, and hydrogeologic conditions.

- Test the aquifer to (1) provide area and depth data on aquifer characteristics, such as hydraulic conductivity, transmissivity, and storativity; (2) provide information for prediction of long-term contaminant migration; and (3) assess contaminant migration effects that could result from pumping the upper limestone aquifer.

- Study the karst hydrogeology by conducting dye-tracing and streamflow studies to determine groundwater/surface water interactions and improve understanding of migration pathways and rates.

- Study the surface water hydrology and water quality to (1) define potential surface migration pathways; (2) determine the possible extent of migration; (3) define the concentration levels of contaminants in surface water; and (4) define the hydrologic characteristics associated with the surface water features.

- Characterize the unsaturated zone to (1) define chemical and physical characteristics in order to classify types and levels of contaminants; (2) estimate recharge to the groundwater system; and (3) define perched zones that may influence contaminant migration.

- Perform hydrogeologic and water balance studies to define (1) regional groundwater levels; (2) fluctuation features that influence groundwater movement and surface water/groundwater interaction; and (3) groundwater geochemistry relationships.

- Define the groundwater system through reasonably detailed and accurate computer models of groundwater flow and contaminant transport in order to predict future contaminant migration and to develop and evaluate the effectiveness of possible mitigative measures.

- Perform data evaluation analyses for the above tasks and previous studies in order to accomplish the field sampling plan objectives.

Field activities to meet the stated objectives of the hydrogeologic investigation are in various stages of completion, as described below.

- Thirty-three additional monitoring wells have been drilled on-site and nine additional wells are being drilled at various off-site locations. Well development is proceeding and is expected to be completed by September 1988. Sampling of these new wells will begin two weeks after their development is complete.

- The pumping and observation wells to test the local aquifer were completed in August 1988. The procurement activity to perform

the actual testing is under way, and the pump tests are expected to be performed in September and October 1988.

- The Missouri DNR has injected dye into four area wells and is continuing its observation of known springs and seeps for dye emergence.

- Drought conditions have generally precluded the study of surface water hydrology. Results of the Missouri DNR dye-tracing studies will be used to support the surface water hydrology investigation.

- The sampling plan to characterize the unsaturated zone has been prepared and is currently undergoing review.

- The USGS is continuing its routine monitoring of water levels in area wells and creeks. Additional monitoring equipment will be installed by the USGS in August and September 1988.

4.2.3 Waste Assessment

The purpose of the waste assessment sampling plan is to characterize the wastes, sludge, and sediment contained in the raffinate pits; and the wastes resulting from decontamination and decommissioning of the buildings and associated equipment at the chemical plant area.

The characterization of materials in the raffinate pits will include a radiological, chemical, and physical analysis of the following:

- Neutralized raffinates from uranium-refining operations, washed slag residues from uranium metal production operations, raffinate solids from the processing of thorium recycle materials, and contaminated rubble;

- Contaminated water ponded in each raffinate pit; and

- Contaminated clay and soil on the inner surfaces of the dikes surrounding the pits and underlying the pits.

Characterization of the sludge from the raffinate pits is necessary in order to define and evaluate treatment and disposal alternatives. Representative samples of the sludge will be collected and evaluated for chemical, radiological, and physical parameters. The data will then be used to support technical decisions for remedial action alternatives. The sampling of sludge in the raffinate pits began in July 1988. Subcontracts for sludge analysis are currently in place, and analytical results are expected to be available by October 1988.

A radiological characterization of the nonprocess buildings and the equipment inside the buildings will be conducted to determine what buildings and equipment can be released for unrestricted use or disposal. An asbestos and a chemical characterization of all buildings, pipelines, and equipment in the chemical plant area will also be performed. Procurement of the required radiological characterization subcontracts for the nonprocess buildings is currently in the bid cycle. Field activities to support this characterization effort are expected to begin in October 1988. Initial samples to support the asbestos and chemical characterization activities for the nonprocess buildings have been collected by the project management contractor. Full-scale characterization activities will be conducted concurrent with the radiological characterization efforts, i.e., beginning in October 1988.

4.2.4 Geophysical/Geotechnical Investigation

The purpose of the geophysical/geotechnical investigation sampling plan is to physically characterize the site soil, substrata, and bedrock; delineate the tests necessary to support the risk assessment; and evaluate on-site earthen materials proposed for suitability as a containment liner for the disposal cell. In addition, results of the sampling plan will be used to predict, from available data, the worst-case composition of a leachate that might contact the earthen liner upon failure of a primary flexible membrane liner if such a flexible membrane liner were used in the disposal cell. The inherent variability of soil and rock requires a quantitative standard for acceptability. A statistical sampling and testing plan will be developed to address the adequacy and representativeness of the sampling and testing effort. This activity is currently being performed under three separate subcontracts: geotechnical drilling and trenching, geotechnical laboratory testing, and geophysical surveying. These subcontracts are in various stages of implementation. Field activities associated with the investigation are scheduled to be completed in August 1988, and follow-up reports are expected to be available in October 1988.

4.2.5 Other Investigations

Other investigations include a lake and stream sediment characterization and a biouptake study. Additional investigations may be identified during a later stage of the RI/FS-EIS process if a specific need is determined. The purpose of the lake and stream sediment characterization is to determine the extent and magnitude of potential chemically and radioactively contaminated sediments in off-site streams and surface water bodies. The sampling effort will determine the concentrations of uranium, nitro-aromatic compounds, PCBs, semivolatile compounds, and metals in lake and stream sediments affected by drainage from the raffinate pits and chemical plant area. A statistically significant number of samples will be collected and analyzed to limit uncertainty and achieve the level of confidence required to evaluate the baseline (no-action) condition and various remedial action alternatives. Areas receiving direct runoff or subsurface recharge will be the focus of this study. Samples collected for this activity are currently undergoing laboratory analysis. The analysis is expected to be

completed in October 1988, and a characterization report is expected to be issued in November 1988.

The purpose of the biouptake study is to determine and characterize the level of potential human exposure to radionuclides, organic compounds (e.g., nitroaromatics and PCBs), and metals from food pathways in the vicinity of the Weldon Spring site. This is accomplished by sampling biota available for human consumption from various locations around and within the site. The biouptake study is expected to provide data on potential human exposure to contaminants via ingestion. The field collection activities and sample analysis for this study have been completed, and the report is currently in preparation.

4.3 HEALTH AND SAFETY PLANS

Health and safety plans have been developed to ensure the health and safety of on-site personnel during the performance of site characterization and response action activities. The plans include the safety standards that must be met by all personnel and subcontractors during the conduct of their assignments. Addressing the health and safety of on-site personnel will also serve to minimize any potential impacts to the general public and the nearby environment. Key elements of these plans are the use of appropriate protective equipment and safeguards and the performance of specific tasks under the supervision of trained technicians and safety specialists. On-site personnel are trained to be cognizant of all appropriate safety equipment and procedures, locations and types of on-site hazards, standard operating procedures, and procedures to be followed in emergency situations. Health and safety training and medical surveillance of all potentially exposed personnel are required elements of these plans. A copy of the health and safety plans will be appended to the QAPP.

4.4 COMMUNITY RELATIONS PLAN

The community relations plan describes the policy and procedures for the interaction of personnel responsible for implementing the Weldon Spring Site Remedial Action Project with the general public. The purpose of the community relations program is to ensure meaningful exchanges of information on such matters as potential health impacts, environmental issues, response action construction plans, project costs, and specific site activities. A copy of this plan will be appended to the QAPP.

4.5 EMERGENCY PREPAREDNESS PLAN

An emergency preparedness plan has been developed to provide on-site personnel with appropriate procedures for notification/reporting and organization of personnel in the event of an on-site emergency. This plan also includes the procedures for responding to potential credible emergencies that could result in the off-site release of hazardous materials. Such emergencies include fire, tornado, failure of a raffinate pits dike, and spills of hazardous materials. This plan fulfills the requirements of DOE Order 5500.2 and the applicable sections of CERCLA and the Toxic Substances Control Act. A copy of this plan will be appended to the QAPP.

4.6 SPILL PREVENTION, CONTROL, AND COUNTERMEASURES PLAN

A spill prevention, control, and countermeasures plan has been developed for the project. The plan is intended to protect navigable waterways (including groundwater and downstream habitats) from harmful oil spills and to ensure that operations at the Weldon Spring site comply with 40 CFR Part 112. A secondary goal of this plan is to minimize potential damage to the environment by identifying containment and control procedures that can be implemented rapidly. A major element of the plan is procedures for mobilizing on-site personnel to respond to a spill and for notifying appropriate federal, state, and local authorities of the spill. A copy of this plan will be appended to the QAPP.

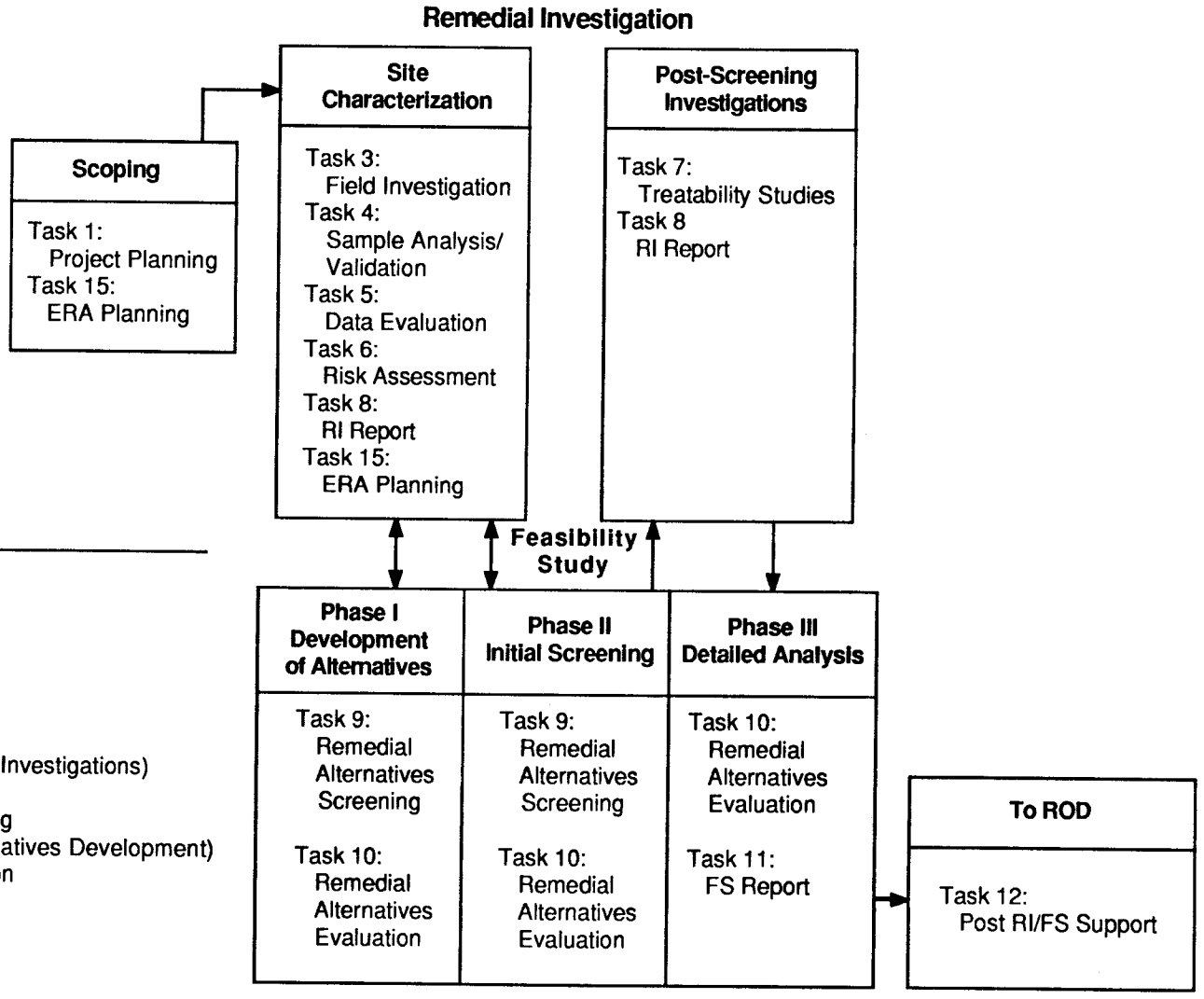
5 REMEDIAL INVESTIGATION/FEASIBILITY STUDY TASKS

Fifteen standard tasks have been defined by EPA as comprising the RI/FS process. This task structure will be used in implementing the RI/FS-EIS process for the Weldon Spring Site Remedial Action Project. This process should enhance coordination with and review by EPA Region VII, the state of Missouri, and local citizens and officials. The RI/FS tasks and the generic phased approach suggested by EPA are shown in Figure 32 and are briefly described in Sections 5.1 through 5.15. Reference is included to other sections of this work plan or other project documents to explain the means by which these 15 tasks are being implemented for this project.

5.1 TASK 1: PROJECT PLANNING

The project planning task initiates the RI/FS-EIS process and establishes the project basis by:

- Collecting and documenting scoping information (Sections 1 and 2),
- Collecting and evaluating existing data (Section 2.5),
- Compiling a list of potential ARARs (Section 3.1),
- Evaluating a conceptual exposure model (Section 3.2),
- Performing preliminary assessments of contaminant status (Sections 3.3 through 3.7),
- Developing conceptual response alternatives (Section 3.8),
- Identifying various feasibility studies to support the RI/FS-EIS process (Section 3.9),
- Identifying operable units and potential expedited (interim) response alternatives (Sections 1.2, 3.10, and 3.11),
- Establishing data quality objectives (Section 4.1),
- Identifying major project plans, including the field sampling plans (Sections 4.2 through 4.6),
- Documenting RI/FS-EIS tasks (remainder of Section 5),
- Developing schedules for completion of major project elements (Section 6), and
- Identifying project organization and project management (Section 7).



RI/FS Work Plan Standard Tasks

Task	Title
1	Project Planning
2	Community Relations*
3	Field Investigation
4	Sample Analysis Validation
5	Data Evaluation
6	Risk Assessment
7	Treatability Study/ Pilot Testing (Post-Screening Investigations)
8	Remedial Investigation Report
9	Remedial Alternatives Screening (Technology Screening/Alternatives Development)
10	Remedial Alternatives Evaluation
11	Feasibility Study Report
12	Post RI/FS Support
13	Enforcement Support*
14	Miscellaneous Support*
15	ERA Planning

* Tasks that can occur in any phase of the RI/FS

FIGURE 32 Relationship of RI/FS Tasks to the Phased RI/FS Approach

All of these elements are included in this work plan. Many elements are summaries of more comprehensive documents. Each of the summaries contained in this work plan reflects the current status of the respective task. This work plan will be updated in the future, as appropriate.

5.2 TASK 2: COMMUNITY RELATIONS

Task 2 incorporates all efforts related to the preparation and implementation of the community relations plan. Community relations are initiated at the beginning of the RI/FS-EIS process and will be completed when all community relations activities under Task 12 are complete. Task 2 does not include preparation of the responsiveness summary, which is part of Task 12. The following are typical components of Task 2:

- Community relations plan,
- Fact sheets,
- Public meeting support,
- Technical support for community relations, and
- Community relations implementation.

The DOE has already established a community relations plan for the Weldon Spring Site Remedial Action Project (see Section 4.4).

5.3 TASK 3: FIELD INVESTIGATION

Task 3 includes all efforts related to field work performed to conduct the RI phase of the RI/FS-EIS process so that adequate technical data will be available to support the development and evaluation of alternatives during the FS-EIS phase. The task begins with the procurement of subcontractors and is complete when all contractors and subcontractors performing portions of the site investigation task are demobilized from the field. The following activities are typically included in this task:

- Mobilization of field activities,
- Media sampling,
- Source testing,
- Geological/hydrological investigations,
- Geophysical investigations,
- Site surveys/topographic mapping,

- Field measurements/analyses,
- Procurement of subcontractor services, and
- RI waste disposal.

Plans for field investigations are documented in field sampling plans. Five categories of field sampling plans are being developed for the Weldon Spring site that cover the full range of contaminated and/or potentially contaminated areas at the site (see Section 4.2).

5.4 TASK 4: SAMPLE ANALYSIS/VALIDATION

Analyses of samples collected during the field investigation will be performed in accordance with the data quality objectives established for this project. The analyses will be performed by laboratories that participate in the EPA Contract Laboratory Program (CLP), using CLP analysis protocol where appropriate. Procedures to ensure quality control during sample analyses are described in EPA's CLP guidance document (U.S. Environ. Prot. Agency 1986a). Sample management and data validation will be performed using EPA-approved procedures and specifications.

Validation of measurements is a systematic process of reviewing a body of data to provide assurance that the data are adequate for their intended use. The validation process includes the following activities:

- Auditing measurement system calibration and calibration verification,
- Auditing quality control activities,
- Monitoring sample management,
- Monitoring non-CLP analyses and use of mobile laboratories (if appropriate),
- Screening data sets for outliers,
- Reviewing data for technical credibility,
- Reviewing chain-of-custody procedures, and
- Checking intermediate calculations.

Procedures that will be used to provide quality assurance for this project will be described in detail in the QAPP (see Section 4.1).

5.5 TASK 5: DATA EVALUATION

Task 5 includes efforts related to the analysis of data once the data have been verified, under Task 4, to be of acceptable accuracy and precision. Task 5 begins on the date that the first set of validated data is received and ends during preparation of the RI report when it is determined that no additional data are required. The following are typical Task 5 activities:

- Literature surveys (e.g., for relevant information on geology, hydrology, and remedial technology),
- Data evaluation,
- Data reduction and tabulation, and
- Environmental fate and transport modeling/evaluation.

These activities will lead directly to the development of the baseline risk assessment and the screening of remedial action alternatives in the FS-EIS. All calculations will be documented in calculation logs and checked by an independent reviewer prior to sign-off. Where computations are performed with computer programs, either validated software will be used or the calculation methods will be hand-verified.

5.6 TASK 6: ASSESSMENT OF RISKS

After the site information and characterization data have been validated and evaluated, a baseline risk assessment will be performed to determine the potential threats to public health and the environment in the absence of any remedial actions at the site. To determine the hazards posed by current site conditions, the assessment will analyze the environmental transport pathways to potential receptors from areas where radioactive and chemical contaminants are currently located. The risk assessment will also be used to assist in the screening of alternatives and to assist in determining acceptable levels of residual contamination (i.e., cleanup limits) for radioactive and chemical species. An overview of the risk assessment process is shown in Figure 33.

The first step in the risk assessment process is the selection of indicator chemicals and radionuclides that pose potential risks to public health and the environment. These indicator chemicals and radionuclides are those that represent the most toxic, mobile, and persistent species at the site, as well as those that are present in the largest amounts. These "highest risk" species are used to assess risks at the site. This list of indicator chemicals and radionuclides will be based on data obtained during field investigations and on usable data previously gathered. A quantitative risk analysis will be performed for all indicator species identified in this step.

The second step in the risk assessment process is the characterization of potential exposure pathways and the determination of exposure concentrations. Potential exposure pathways are described in Section 3.6. Possible pathways that will be

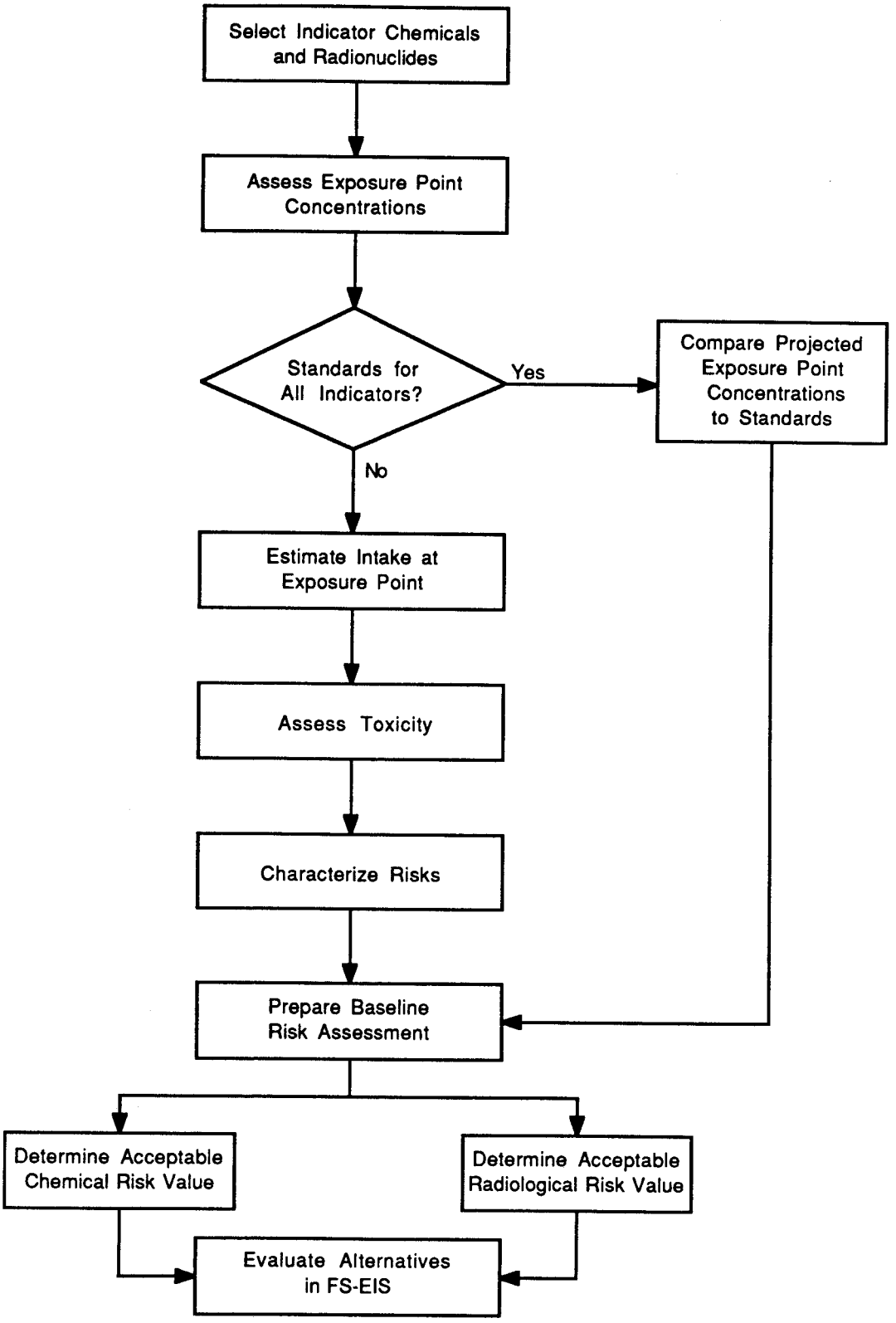


FIGURE 33 Overview of the Risk Assessment Process

evaluated include air, soil, sediment, groundwater, surface water, and biota. Site-specific exposure routes for the study area will be addressed in the evaluation. Initially, these exposure pathways will be the principal areas of focus; however, subsequent data collected during field investigations may warrant the inclusion of additional exposure pathways.

The concentrations of the indicator chemicals and radionuclides in environmental media at exposure points will be estimated using characterization and monitoring data and appropriate environmental fate and transport models. Several models are available for use. The models and input parameters to be used will be developed in cooperation with EPA Region VII and the state of Missouri. Information from the literature and prior studies regarding environmental chemistry and contaminant fates will be considered and incorporated, where valid and applicable, in all estimates of chemical and radionuclide concentrations. The estimated concentrations will then be compared to the potential ARARs. If health-based ARARs are available for all indicator chemicals and radionuclides, no further quantitative analysis of risk will be performed as part of the baseline risk assessment. The baseline risk assessment will evaluate existing data to confirm that the pollutant transport models adequately reflect conditions at the site and to determine where additional data are needed to properly characterize risks.

If health-based ARARs are not available for all indicator chemicals and radionuclides, quantitative analyses will be performed following the general procedures outlined in EPA's *Superfund Public Health Evaluation Manual* (U.S. Environ. Prot. Agency 1986b). The identification of sensitive receptors near the site will be based on demographic records and standard demographic statistical techniques. A population activity profile will be developed, based on area land use and population structure, to delineate exposure coefficients required for quantitative evaluation of exposure. The baseline risk assessment ends with the characterization of risks to human health and the environment in the absence of any remedial action at the site. The risk assessment process continues with an evaluation of risks associated with various remedial action alternatives.

The Weldon Spring site is contaminated with both radioactive and chemically hazardous substances. This situation is somewhat different than usual because most sites remediated under CERCLA are contaminated only with hazardous chemicals. Determining the significance of risks differs markedly for radiological and chemical contaminants because the radionuclides associated with the Weldon Spring site occur naturally in the environment whereas chemical carcinogens generally do not. For this reason, combining the two risks during the risk assessment process could mask distinct, relevant information. Therefore, the chemical and radiological risks associated with the various remedial action alternatives will be evaluated in parallel during the risk assessment process. This assessment will provide a mechanism for determining the range and extent of remedial action activities based upon comparison to acceptable levels of risk. The resultant risk from radioactive contaminants following remedial action activities will be evaluated as an incremental risk over that resulting from background sources of radiation whereas the residual risk from exposure to chemical carcinogens can be evaluated as an absolute risk because exposure to these chemical substances does not generally occur in our everyday environment.

The dose to any individual from background sources of radiation averages about 200 mrem/yr, which corresponds to a 70-year lifetime cancer risk of about 2×10^{-3} (this value exceeds the upper limit of the EPA acceptable risk range of 10^{-4} to 10^{-7}). This risk from background radiation sources may be contrasted to the hazards from exposure to chemical carcinogens that are not naturally present in our environment (e.g., PCBs and nitroaromatics). Using the EPA-recommended target risk value of 10^{-6}, with a range of 10^{-4} to 10^{-7}, is indeed appropriate for those types of contaminants.

Because the residual radiological risk can be interpreted only as an increment to the risk from background radiation, it is necessary to determine what an appropriate increment should be. Determination of the acceptable level of radiological risk can be developed using the "as low as reasonably achievable" (ALARA) philosophy for reducing radiation doses below acceptable limits. The point at which further reduction in radiation exposure (and hence risk) cannot reasonably be achieved is the increment in radiological risk (above the risk from background sources of radiation) that should be used to assess the scope of remedial action activities. The acceptable level of residual chemical risk will be determined consistent with EPA guidance. Hence, during the evaluation of various alternatives in the FS-EIS, radiological doses will be compared to a radiological risk value and chemical risks will be compared to a chemical risk value. The cumulative risk to potential receptors, i.e., the sum of the radiological and chemical risks, will be assessed in the FS-EIS.

5.7 TASK 7: TREATABILITY STUDIES

Task 7 is performed after alternatives have been screened in the FS-EIS phase. This task includes any efforts related to the performance of pilot and bench-scale treatability studies as well as associated procurement efforts. Such studies may be necessary to test volume reduction or treatment technologies for the waste materials at the Weldon Spring site that have not yet been proven reliable or effective in full-scale operation or on similar materials and to develop sufficient conceptual design information on which to base analyses in the FS-EIS. Several post-screening investigations have already been identified (see Section 3.9). Additional studies will be developed, as necessary, to support the screening of potential technologies with respect to availability and technical and administrative feasibility (see Section 5.9).

5.8 TASK 8: RI REPORT

Task 8 covers all efforts related to the reporting of RI findings once the data have been evaluated under Tasks 5 and 6. Task 8 covers all draft and final RI reports, and includes the following typical activities:

- Formatting data for reporting purposes,
- Writing the report,
- Preparing associated graphics,

- Providing and reviewing quality control efforts,
- Printing and distributing the report,
- Holding review meetings, and
- Revising the report based on reviewer comments.

5.9 TASK 9: SCREENING OF REMEDIAL ACTION ALTERNATIVES

Task 9 involves the screening of remedial action alternatives for the Weldon Spring Site Remedial Action Project. This evaluation is conducted subsequent to the screening of technologies and development of alternatives that is completed during the first phase of the FS-EIS process.

The objective of the Task 9 screening process is to narrow the range of alternatives that will undergo detailed evaluation. This process begins with the identification of remedial action objectives, proceeds through a screening of technologies based on implementability, and ends with the assembly of screened technologies into a set of remedial action alternatives (a preliminary set of alternatives for management of the contaminated materials at the Weldon Spring site is given in Section 3.8). Each of these alternatives may involve the application of a single technology or the combination of multiple technologies.

Task 9 consists of the following activities:

- Identifying remedial action objectives,
- Listing potential technologies,
- Screening technologies based on site-specific criteria,
- Assembling potential remedial action alternatives from the screened technologies, and
- Screening the candidate remedial action alternatives for detailed evaluation in Task 10 (Section 5.10).

5.10 TASK 10: EVALUATION OF REMEDIAL ACTION ALTERNATIVES

The candidate remedial action alternatives that pass the screening process will be evaluated in detail in Task 10. Three criteria will be used to evaluate the candidate alternatives: effectiveness, implementability, and cost.

In the effectiveness evaluation, two factors will be used for detailed analysis of candidate remedial action alternatives: (1) degree of protectiveness and (2) ability to reduce the toxicity, mobility, and/or volume of the contamination. The first factor,

protectiveness, involves the following set of subfactors, which are essentially short-term factors:

- Ability to reduce existing risks,
- Compliance with criteria, advisories, and guidelines that are pertinent to the site and have been identified during the ARAR process,
- Compliance with potential ARARs,
- Protection of the community and on-site workers during remedial action, and
- Time required until protection is achieved.

For the longer term, protectiveness involves:

- Magnitude of residual risk,
- Long-term reliability,
- Compliance with ARARs,
- Prevention of future exposure to residual contamination, and
- Potential need for future maintenance.

The second factor in the effectiveness evaluation deals with the long-term ability to bring about a permanent and significant reduction of toxicity, mobility, and/or volume of the contamination.

In the implementability evaluation, three factors will be used in the detailed analysis of candidate alternatives: (1) technical feasibility, (2) administrative feasibility, and (3) availability. Technical feasibility relates to the following, essentially short-term, subfactors:

- Ability to use the technology,
- Short-term reliability of the technology,
- Compliance with potential action-specific ARARs, and
- Status of the technology, i.e., whether or not proven.

For the longer term, technical feasibility relates to:

- Ease of undertaking additional remedial action, if necessary,

- Ability to monitor the effectiveness of the remedy, and
- Ability to perform maintenance activities.

Two subfactors will be considered in evaluating candidate alternatives with respect to administrative feasibility:

- Likelihood of favorable community response, and
- Compliance with specific ARARs.

Two subfactors will be considered in evaluating candidate alternatives with respect to availability.

- Availability and capacity of required treatment, storage, and disposal services, and
- Availability of necessary equipment and specialists.

These subfactors are expected to be reflected largely in the technology screening performed in Task 9 and generally will not be expected to be decisive in evaluating candidate alternatives.

The cost evaluation of each alternative will include capital and annual operating/maintenance costs, sensitivity of cost estimates, and present worth analyses. The total capital costs include both direct and indirect capital costs. The major direct capital cost components are based on the major functional facilities, equipment, and construction features. Operating costs for implementing temporary remedial actions and other capital costs incurred until the remedial action is completed will also be considered as part of the capital cost. Material quantities, labor, equipment, and installation costs are estimated on the basis of available sources and local wage rates. The indirect capital costs include overhead, legal fees, administrative costs, and contingency allowances.

Operating costs will be determined from estimates of labor and material requirements. Maintenance costs will be calculated as a percentage of the direct construction costs, based on standard costs and experience, but will reflect perpetual care considerations, costs of periodic reviews such as would be associated with nontreatment alternatives, and the potential for future remedial action costs.

The annual cost will be converted to a present worth capital expenditure. Inflation, discount, and interest rates will be estimated in accordance with current market values. Finally, a sensitivity analysis will be prepared of financial factors that could affect the overall costs of the various alternatives. The key financial factor to be considered is a change in the discount rate.

A summary for each alternative, including the no-action alternative, will be prepared using the criteria outlined in the preceding sections. The relative advantages and disadvantages will then be used to compare and evaluate the remedial action alternatives.

5.11 TASK 11: DRAFT RI/FS-EIS REPORT

The draft RI/FS-EIS report will contain descriptions of the activities, results, and associated conclusions for the entire RI/FS-EIS process. The report will also address those NEPA-related topics not typically addressed in an RI/FS, e.g., environmental consequences of taking each of the remedial action alternatives under consideration, long-term impacts, cumulative impacts, mitigative measures, unavoidable adverse impacts, potential impacts from loss of institutional controls, irreversible and irretrievable commitment of resources, and short-term uses and long-term productivity. The report will include a description of the screening process and a detailed evaluation of remedial action alternatives. The task is complete when the draft RI/FS-EIS is released to the public. The following are typical Task 11 activities:

- Formatting data for reporting purposes,
- Preparing associated graphics,
- Writing the report,
- Printing and distributing the report,
- Holding review meetings, and
- Revising the report based on reviewer comments.

5.12 TASK 12: FINAL RI/FS-EIS REPORT AND SUPPORTING ACTIVITIES

Task 12 includes efforts to prepare the responsiveness summary, revise the RI/FS-EIS report as necessary in response to public comments, support preparation of the ROD, and perform design engineering activities. All activities occurring after release of the draft RI/FS-EIS to the public, and prior to issuance of the ROD, should be covered under this task. The following are typical Task 12 activities:

- Attending public meetings,
- Writing/reviewing the responsiveness summary,
- Revising the RI/FS-EIS in response to public comments,
- Printing and distributing the final RI/FS-EIS,
- Supporting ROD preparation/briefings,
- Providing and reviewing task management and quality control efforts,

- Preparing the predesign report, and
- Completing the conceptual design.

5.13 TASK 13: ENFORCEMENT SUPPORT

Task 13 includes the activities associated with enforcement aspects of the project in terms of potentially responsible parties. Because DOE accepts responsibility for the waste materials that fall within the scope of this document, Task 13 is not applicable.

5.14 TASK 14: MISCELLANEOUS SUPPORT

Task 14 is used to report on work that is associated with the project but does not fall under any of the other established RI/FS-EIS tasks. Task 14 activities will vary, but may include the following:

- Specific support for review of activities of the Agency for Toxic Substances and Disease Registry,
- Special efforts related to public health assessments, and
- Support for review of special state or local projects.

5.15 TASK 15: EXPEDITED (INTERIM) RESPONSE ACTION PLANNING

Task 15 relates specifically to planning expedited response actions (ERAs), which are synonymous for this project with the term interim response actions (IRAs). The proposed IRAs for the Weldon Spring Site Remedial Action Project are discussed in Section 3.10.2 of this document.

6 SCHEDULE

6.1 RI/FS-EIS

The overall schedule for preparation of the RI/FS-EIS is shown in Figure 34. The RI/FS-EIS will address management of contaminated materials resulting from response action activities at the Weldon Spring site, including wastes from the raffinate pits and chemical plant area, bulk wastes from the quarry, and wastes from cleanup of contaminated vicinity properties. The RI/FS-EIS will also address groundwater restoration at the raffinate pits and chemical plant area. The project plan consists of the following:

- Completion of site characterization activities. Site characterization is currently being performed and is scheduled to be completed in early 1989.

- Completion of the RI/FS-EIS process consisting of an RI report, a baseline risk assessment, and an FS-EIS report. The RI/FS-EIS will be prepared with data obtained from the site characterization activities. A more detailed schedule for the baseline risk assessment is given in Figure 35. The first two phases of the FS-EIS will screen technologies and develop and screen alternatives to be evaluated in the third phase of the FS-EIS. Comments on the completed draft RI/FS-EIS will be addressed in the final RI/FS-EIS, which includes the responsiveness summary, following public review. The ROD for the RI/FS-EIS is projected to be issued in April 1991.

- Completion of the quarry bulk waste environmental process. This is described in more detail in Section 6.2.

- Development of design criteria and conceptual design information for remedial action activities at the raffinate pits and chemical plant area. The conceptual design will address location, size, layout, effluent controls, and general concepts of remediation to provide feasibility and comparative information. Remedial action activities at the raffinate pits and chemical plant area will begin in 1991, following issuance of the ROD.

- Treatment of surface water from the raffinate pits and other sources in the raffinate pits and chemical plant area. This treatment will be handled as an IRA and documented through the modified EE/CA process. Support facilities -- including utilities, decontamination station(s), and staging/parking areas -- will be designed and constructed as needed. These activities will be performed concurrently with the RI/FS-EIS process.

- Removal of the quarry bulk wastes. This action will be initiated in 1990 and should be completed by the end of 1992.

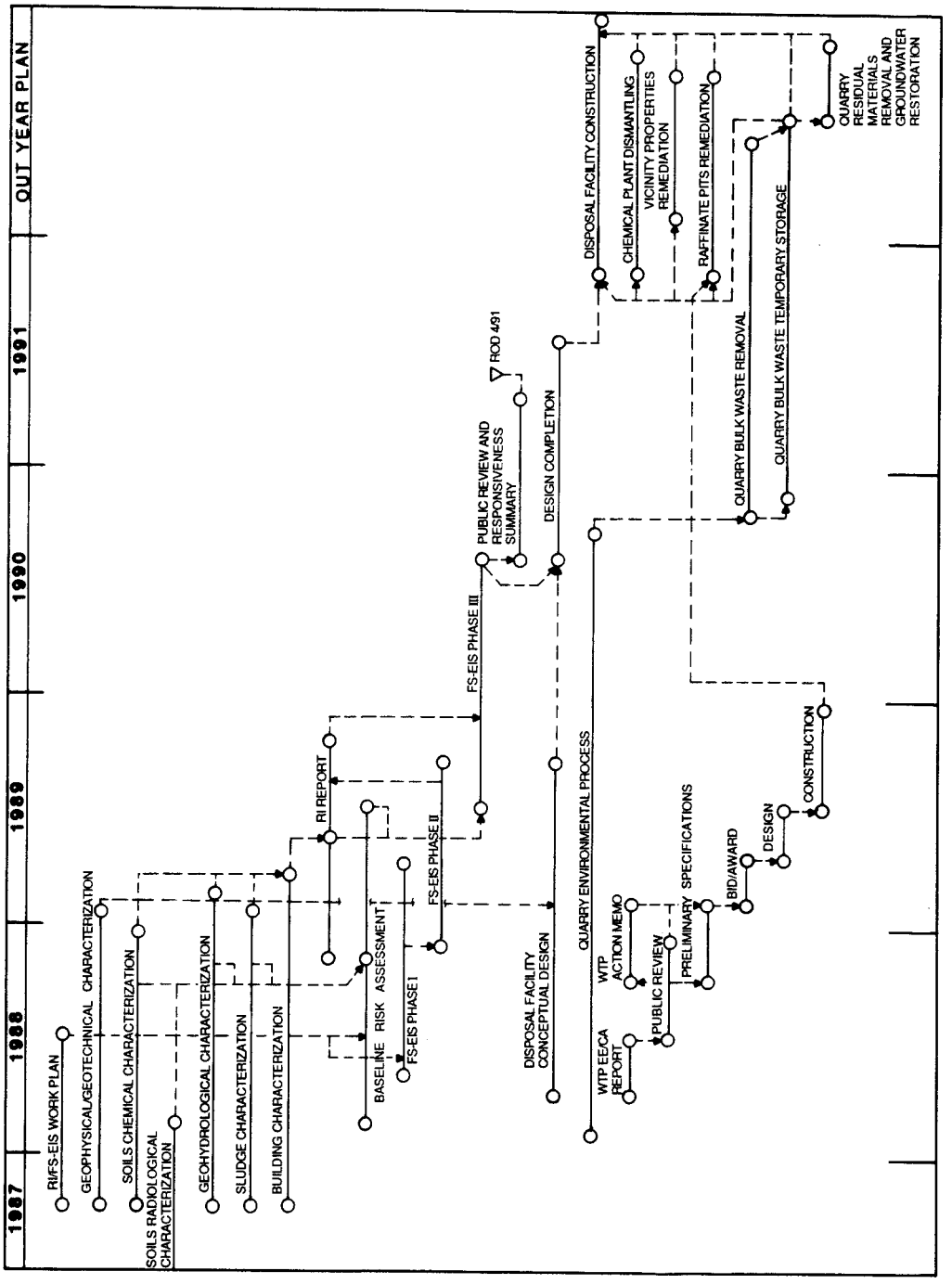


FIGURE 34 Overall Schedule for Completion of the RI/FS-EIS

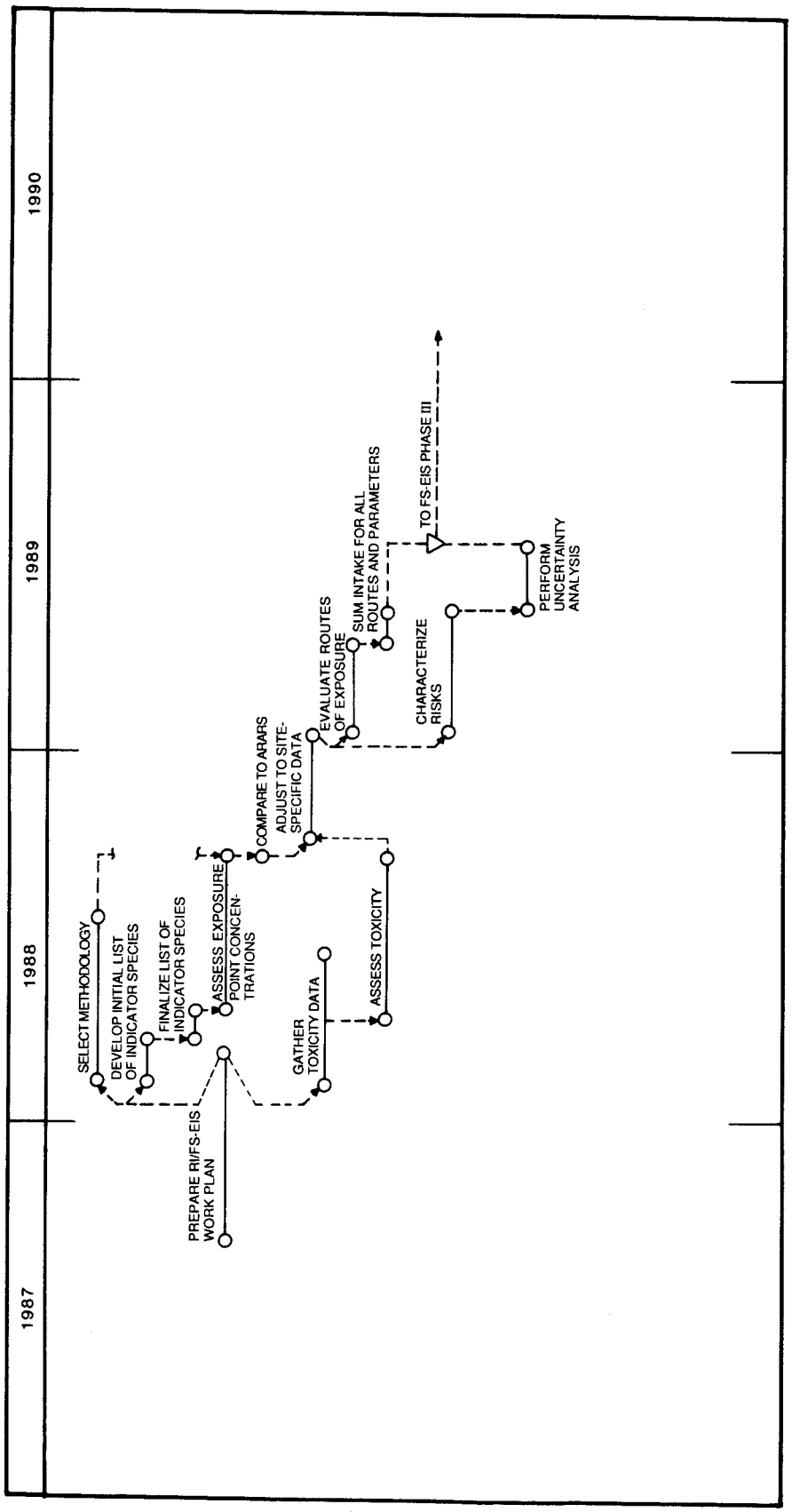


FIGURE 35 Schedule for Completion of the Baseline Risk Assessment

6.2 QUARRY

Removal of the bulk wastes from the quarry is planned to be undertaken as a separate operable unit within this project and to be documented using the RI/FS-EA process (see Section 3.11.2.1). The overall plan for implementation of activities in the quarry is shown in Figure 36. This plan consists of the following elements:

- Completion of an RI/FS for the bulk waste removal action consisting of an RI report, a risk evaluation, and an FS report. The RI/FS process will be completed using existing information on the quarry bulk wastes. Comments on the draft RI/FS will be addressed in the final RI/FS, which includes the responsiveness summary, following public review. The decision document for the RI/FS is projected to be issued in May 1990.

- Completion of an EA for the bulk waste removal action. The first two phases of the FS process will develop and screen alternatives that will be addressed in the EA. This EA, which will address environmental impacts associated with the proposed alternatives, will be issued prior to completion of the FS process.

- Development of the conceptual design for bulk waste removal activities concurrently with preparation of the RI/FS and EA. The conceptual design will include an excavation plan providing for operator controls to minimize the possibility of contaminant release during the excavation process.

- Development of design criteria and conceptual design information for the temporary storage area. The conceptual design will address location, size, layout, water runon/runoff management, and general concepts of the liner and/or cover systems.

- Treatment of the ponded water in the quarry. This treatment will be handled as an IRA and documented through the modified EE/CA process. Support facilities -- including roads/utilities, decontamination station(s), and water retention basins -- will be designed and constructed as needed.

This plan should allow for expedited removal of the bulk quarry wastes beginning in 1990.

It has not yet been determined if any residual material will have to be removed from the quarry following bulk waste removal or if groundwater restoration will be required at the quarry. Therefore, no schedules have been developed for these activities.

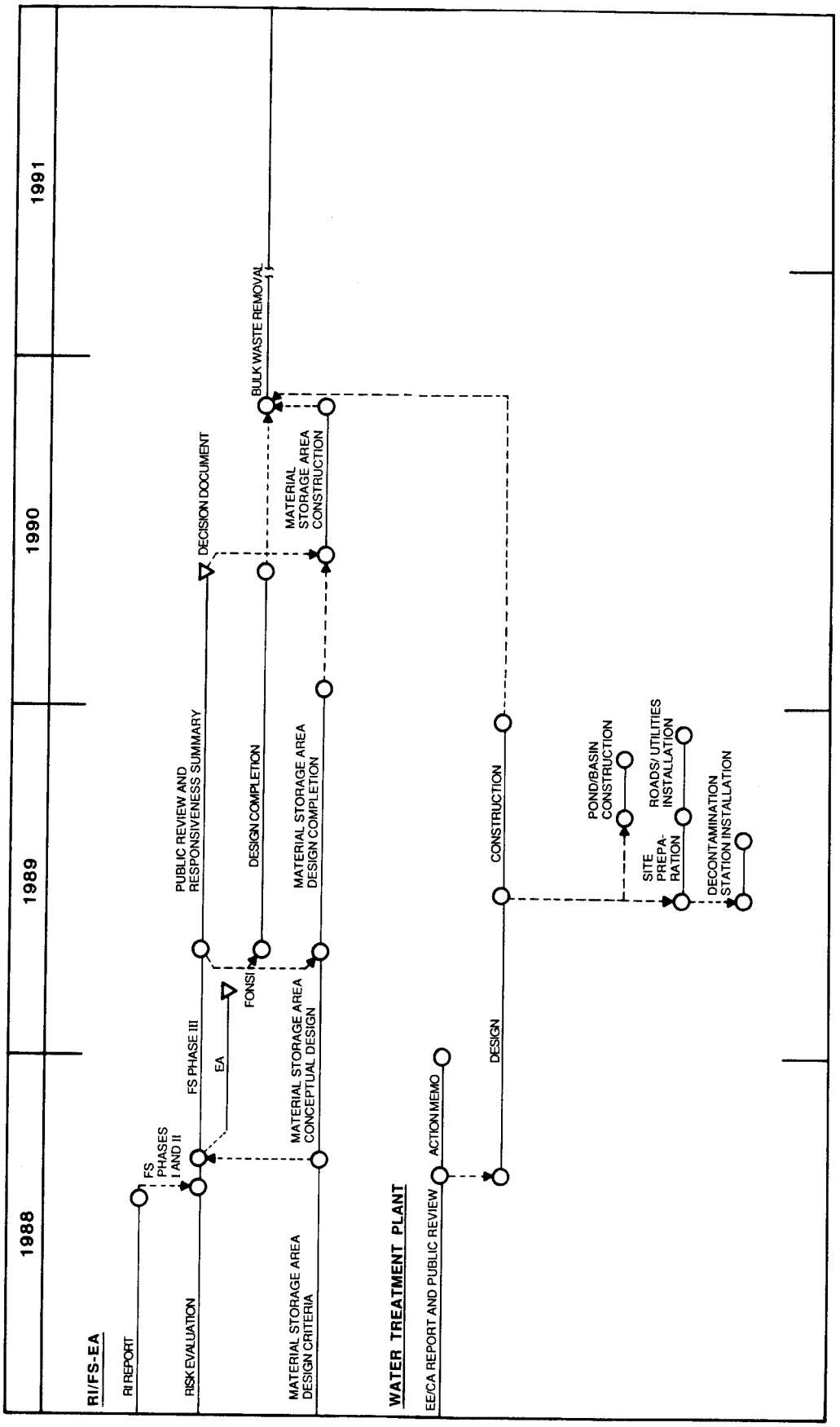


FIGURE 36 Schedule for Completion of the RI/FS-EA Process for Quarry Bulk Waste Removal

7 PROJECT MANAGEMENT

7.1 PROJECT ORGANIZATION

The Weldon Spring Site Remedial Action Project is being conducted by DOE under the SFMP, which is administered by the Division of Facility and Site Decommissioning Projects within the Office of Nuclear Energy (Figure 37). This division is responsible for policy decisions that impact the project and for coordination with the U.S. Department of the Army, which is sharing the cost of this project. The responsibility for management and technical direction of the response action activities has been delegated to the DOE Oak Ridge Operations Office, which has established a project office at the Weldon Spring site. This project office has responsibility for directing the conduct of response actions at the site.

Four separate organizations are under contract to DOE to support implementation of this project:

- MK-Ferguson Company is the project management contractor, assisting DOE in the planning and management of response action activities, and Jacobs Engineering Group, Inc., is under contract to MK-Ferguson to provide technical support for the project.

- Argonne National Laboratory, Energy and Environmental Systems Division, is the NEPA and CERCLA process management contractor and is responsible for directing preparation of appropriate environmental compliance documentation to support specific activities.

- Oak Ridge Associated Universities provides technical support, specifically for independent verification of completed response actions.

- PEER Consultants, Inc., provides administrative support to the DOE project office, and Dames & Moore has been retained by PEER to assist in this capacity.

7.2 PROJECT COORDINATION AND RESPONSIBILITIES

The response actions to be carried out by DOE at the Weldon Spring site are subject to EPA oversight under CERCLA. The oversight function is being carried out by EPA Region VII. The responsibilities of DOE and EPA are defined in the FFA signed in August 1986. This agreement, which was signed prior to the enactment of SARA in October 1986, may need to be revised to incorporate new requirements mandated by SARA. The need for such revisions is being discussed with EPA.

The state of Missouri has designated the Missouri DNR to coordinate state involvement in this project. The DNR is responsible for ensuring that the appropriate

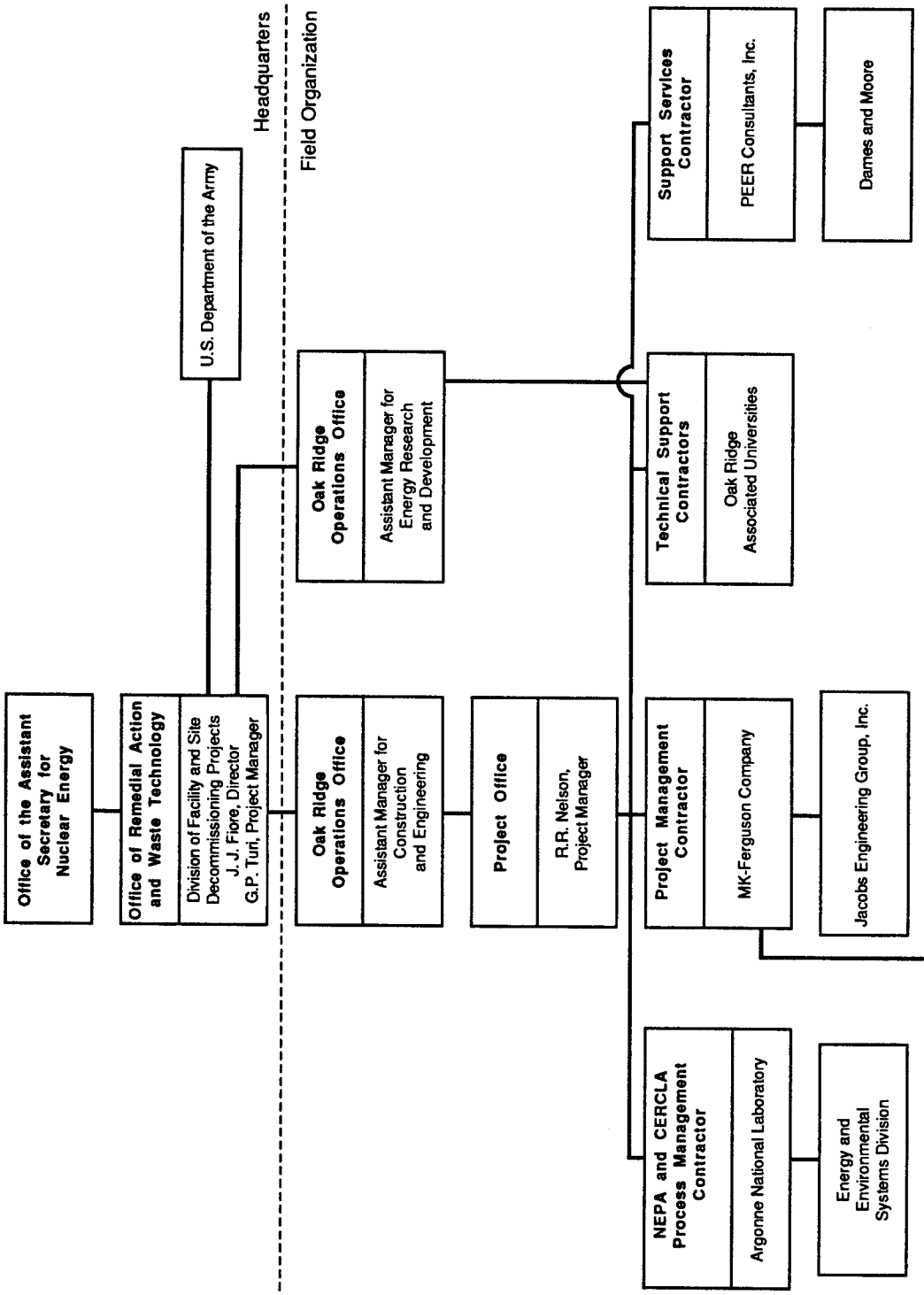


FIGURE 37 Organizational Chart for the Weldon Spring Site Remedial Action Project

state agencies are kept informed regarding project activities and that state concerns are properly reflected in project plans and actions. The relationship between DOE, EPA, and the Missouri DNR -- and the major responsibilities of each -- are shown in Figure 4 (Section 1.3).

The responsibilities of each of the major organizations under contract to DOE at the Weldon Spring site are identified as follows:

- MK-Ferguson Company (including Jacobs Engineering Group, Inc., as a subcontractor)
  - Provide overall project management support to DOE for the Weldon Spring Site Remedial Action Project.
  - Administer procurement and quality assurance functions.
  - Perform general administrative functions.
  - Administer all environmental, safety, and health programs at the site.
  - Direct all engineering activities.
  - Provide technical input to the preparation of environmental documents.
  - Perform community relations duties.
- Argonne National Laboratory, Energy and Environmental Systems Division
  - Perform environmental analyses for the RI/FS-EIS process.
  - Provide an independent analysis of environmental studies, engineering feasibility, and cost-effectiveness of response action alternatives performed by other DOE contractors.
  - Prepare additional environmental compliance documentation as needed.
- Oak Ridge Associated Universities
  - Conduct radiological surveys to identify and designate vicinity properties that require response action.
  - Conduct post-response action radiological surveys to provide an independent verification of the adequacy of cleanup and prepare associated verification reports.

- PEER Consultants, Inc. (including Dames & Moore as a subcontractor)

  - Provide technical and administrative support to the DOE project office.

  - Review environmental documents and advise the DOE project office on regulatory requirements.

  - Review and analyze resources as changes in funding and priorities occur.

  - Assist the DOE Project Office with the preparation and/or analysis of documents and reports for the annual budget process.

7.3 PROJECT CONTROLS

Project controls are implemented to provide detailed planning regarding cost, schedule, and technical performance. In this way, efforts towards achievement of project goals are maximized. A work breakdown structure is used to divide the total project into discrete work packages, thereby establishing the formal work organization and the planning and scheduling structure to permit identification of critical relationships and interdependencies among project tasks. The work breakdown structure also provides the framework for integrating budget requirements with schedule and technical performance. Finally, it establishes the management analysis and reporting structure to permit presentation of data to various levels of management.

Project controls are implemented in accordance with DOE cost and schedule control requirements. This provides a basis for assessing the quality of the cost and schedule controls used by the project participants; aids in ensuring effective planning, management, and control of project work; and provides a quick and effective means of measuring cost, schedule, and technical performance.

A project document control center is maintained at the Weldon Spring site to collect, register, distribute, and retain all documents associated with the project. This includes aerial photographs, topographic maps, reports on features of the site and its surrounding area, correspondence involving the site, findings of previous surveys, and analytical data obtained during site characterization. The types of characterization data that are on file include environmental contaminant data based on analysis of soil, groundwater, and surface water; borehole logging data; air sampling data; and information about geological and soil properties. Well construction data, field notebooks, and other documentation (e.g., chain-of-custody forms) are also on file in the document control center.

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APPENDIX A:

WORK PLAN SUPPLEMENT

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WORK PLAN SUPPLEMENT

A.1 BACKGROUND

As part of its Surplus Facilities Management Program (SFMP), the U.S. Department of Energy (DOE) issued a draft environmental impact statement (EIS) in February 1987 to assess the environmental impacts of alternatives for long-term management of contaminated materials associated with remedial action activities at the Weldon Spring site in Weldon Spring, Missouri (U.S. Dept. Energy 1987a). Based on public and technical scoping input, DOE decided to take the "tiered" approach recommended by the Council on Environmental Quality (CEQ) under its regulations for implementing the National Environmental Policy Act (NEPA). The EIS was intended to support the major decisions on cleanup and long-term management of the contaminated materials at the Weldon Spring site, which consists of the raffinate pits and chemical plant area and the quarry, and at contaminated vicinity properties. However, because many of the issues associated with decontamination and decommissioning of the chemical plant were not yet ready for a decision at the time the draft EIS was prepared, cleanup of the chemical plant was to be covered in a separate NEPA document tiered to the EIS.

Ongoing well monitoring at the Weldon Spring site has provided significant new information relevant to environmental concerns at the site that was not available in February 1987 when the draft EIS was published. Results from the Phase I water quality assessment program (U.S. Dept. Energy 1987b) show significant quantities of nitroaromatics, particularly 2,6-dinitrotoluene (2,6-DNT), and high nitrate and sulfate concentrations in the groundwater at the raffinate pits and chemical plant area. In response to these new findings, DOE announced in June 1987 its intent to issue for public comment a revised draft EIS on remedial action at the Weldon Spring site. Since that time, the U.S. Environmental Protection Agency (EPA) Region VII has formally requested that DOE prepare a remedial investigation/feasibility study (RI/FS) for this project, under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA). The DOE and EPA have agreed that the appropriate environmental review required by an RI/FS and an EIS can be accomplished by incorporating those elements required by an EIS into the format of an RI/FS; this integrated document is termed an RI/FS-EIS. This is the process DOE intends to carry out for the Weldon Spring Site Remedial Action Project. This appendix has been written to illustrate the process by which the RI/FS-EIS will be prepared in compliance with DOE regulations for preparation of an EIS, which is necessary because DOE must comply with NEPA regulations for this project.

The DOE has specific procedures for ensuring compliance with NEPA. An EIS implementation plan must be prepared prior to preparation of an EIS to state the procedures DOE intends to use to complete the EIS process. Guidance on the content of an EIS implementation plan is given in the DOE procedures for compliance with NEPA (U.S. Dept. Energy 1987c). Many elements of an EIS implementation plan are similar to those of an RI/FS work plan. This appendix was written to supplement the information

given in the main text of the work plan to demonstrate that all of the DOE requirements for an EIS will be met by the proposed environmental compliance process for this project.

A.2 PROPOSED ACTION AND DECISION TO BE MADE

In order for DOE to determine how to manage the contaminated materials at the Weldon Spring site, environmental impacts -- in addition to engineering, cost, and other considerations -- must be factored into the decision. Therefore, in accordance with NEPA and CERCLA, DOE is preparing an RI/FS-EIS to assess and compare the potential environmental impacts of various alternatives for management of the radioactively and chemically contaminated materials at the site and for remediation of contaminated groundwater at the raffinate pits and chemical plant area.

A.3 SUMMARY OF NEPA SCOPING PROCESS

The DOE issued a Notice of Intent in the *Federal Register* on March 2, 1984, announcing its intention to prepare an EIS to assess the environmental impacts of alternatives for disposal of existing radioactively and chemically contaminated materials at the Weldon Spring raffinate pits, chemical plant, vicinity properties, and quarry. In accordance with CEQ regulations and DOE guidelines for implementing NEPA, a scoping process was conducted to determine the alternatives to be analyzed in the EIS, the significant issues to be analyzed in depth, and the issues to be eliminated from further detailed study.

Public input to this scoping process included:

- Presentations at a public meeting held in the Francis Howell High School gymnasium, St. Charles, Missouri, on March 20, 1984, and

- Letters received by DOE regarding the scope of the EIS.

The persons and organizations who provided input during this public scoping process are listed in Table A.1. Considerable input was received from private citizens; organized citizen action groups (particularly the St. Charles Countians Against Hazardous Waste); local, state, and national political representatives; and state government agencies.

Technical input to the scoping process included:

- Preliminary engineering evaluations by Bechtel National, Inc., of several alternatives for disposition of the wastes at the Weldon Spring site;

- Meetings and correspondence between Argonne National Laboratory (ANL) and DOE Oak Ridge Operations Office (DOE-OR) regarding location and conceptual designs for long-term management of the wastes;

TABLE A.1 Participants in the Scoping Process

Oral Comments, Weldon Spring Public Scoping Meeting, March 20, 1984

Kenneth Rothman, Lt. Gov., State of Missouri
Joseph R. Ortwerth, State Representative, 18th District
Richard Roehl, State Representative, 21st District
Fred Lafser, Missouri Department of Natural Resources
Gary Elmestad, Staff Assistant to Congressman Robert A. Young, 2nd District
Fred Dyer, State Senator, 2nd District
John R. Crellin, Missouri Department of Health
Leann Stevens, St. Charles Countians Against Hazardous Waste
Mary A. Halliday, Defiance
Richard M. Green, St. Charles County Administrative Court
Peggy Coppage, St. Charles County Administrative Court
Thomas Glosier, St. Charles County Administrative Court
Meredith Bollmeier, St. Charles Countians Against Hazardous Waste
James Whitley, Missouri Department of Conservation
Dan Bolef, Washington University, St. Louis
Wallace Howe, Missouri Department of Natural Resources, Division of Geology and Land Survey
Pamela Armstrong, League of Women Voters of the St. Charles Area
Bobbie Judge, St. Charles Countians Against Hazardous Waste
Robert M. Wester, R.M. Wester & Associates
Thomas J. Aley, Ozark Underground Laboratory
William T. Rebore, Francis Howell School District
Dominick Ferranto, Jr., St. Peters
Kenneth F. Gronewald, St. Peters
Sandy Tabaka, St. Charles County
Sharon Rogers, Missourians Against Hazardous Waste, Warren County
Kay Drey, University City
Bernard Iffrig, St. Peters Old Town Association

Written Comments

Tom Nash, Columbia Field Office, U.S. Fish and Wildlife Service
Mary A. Halliday, Defiance
Kay Drey, University City
Charles Hajninian, U.S. Environmental Protection Agency, Region VII
Ann Hood, St. Charles Countians Against Hazardous Waste
Aimee Judge, St. Charles
Richard C. Rice, Missouri Emergency Management Agency
Al and Linda Hoenig, St. Peters
Bernard J. Iffrig, St. Peters
Robert A. Young, U.S. Congressman, 2nd District
Fred Dyer, State Senator, 2nd District
Richard O. Olson, Jr., St. Charles Clinic, Inc.
William T. Rebore, Francis Howell School District
Michael V. Garvey, St. Charles

- Meetings, correspondence, and review of alternatives and issues by SFMP program managers at DOE Headquarters (DOE-HQ) and DOE Operations Offices at Oak Ridge, Tennessee (DOE-OR), and Richland, Washington (DOE-RL);

- Preliminary evaluation by ANL and -- in consultation with Missouri state agencies, local government representatives, and members of the St. Charles Countians Against Hazardous Waste -- development of a conceptual design for an additional alternative of a new, above-grade disposal cell at the Weldon Spring site;

- Meetings with Missouri state agencies (e.g., Department of Natural Resources [DNR]) and elected officials; and

- Meetings with EPA Region VII.

The draft EIS was issued in February 1987 based, in part, on the input received during the NEPA scoping process. Many comments were received by DOE regarding the draft EIS, both by letter and at a public hearing held on April 10, 1987, at Hollenbeck Junior High School in Harvester, Missouri. The persons and organizations who provided comments on the draft EIS are listed in Table A.2. Responses to the major issues raised on the draft EIS are given in Appendix B of this work plan. All comments on the draft EIS are being treated as scoping input for the RI/FS-EIS.

A.4 ISSUES TO BE ADDRESSED IN THE RI/FS-EIS

The issues to be addressed in the RI/FS-EIS were developed based upon public and technical input. Some issues deal with potential environmental impacts, whereas others are factors that may influence or be influenced by remedial action activities. The issues have been separated into two categories: (1) primary issues to be analyzed in depth in the RI/FS-EIS and (2) secondary issues to be discussed in less detail.

A.4.1 Primary Issues

The primary issues will be analyzed more extensively than other issues. They are issues that were raised both during the initial scoping process in 1984 and during the public comment period on the draft EIS. Additional data that are being gathered on the radioactive and chemical contamination at the Weldon Spring site will be incorporated in the RI/FS-EIS. The primary issues to be analyzed in the RI/FS-EIS are as follows.

1. Potential radiological impacts

    - On people -- including workers and the general public, individuals and the total population, present and future generations.

TABLE A.2 Commenters on the Draft EIS

Oral Comments, Public Hearing on the Draft EIS, April 10, 1987

Fred Dyer, State Senator, 2nd District
Joseph Ortwerth, State Representative, 18th District
Craig Kilby, State Representative, 21st District
George Dames, State Representative, 17th District
Jane Schmidt, Western District Commissioner, St. Charles County
Nancy Becker, Eastern District Commissioner, St. Charles County
Tom Owens, Alderman, City of St. Peters
Thomas W. Brown, Mayor, City of St. Peters
Fred Brunner (for John Ashcroft, Governor)
Fred Brunner, Missouri Department of Natural Resources
Fred Bronson, St. Charles
John Crellin, Missouri Department of Health
William H. Dieffenbach, Missouri Department of Conservation
Leon Heath, Soil Consultants, Inc.
William Rebore, Francis Howell School District
Carl Johnson, Pierre, S.D.
John Shocklee, Human Rights Office, Archdiocese of St. Louis
Marty Hayden, Eastern Missouri Group, Sierra Club
Ann Hood, Wentzville
Leann Starr, O'Fallon
Bruce Thomas, St. Peters
George A. Behrens, Glendale
Roger Pryor, Coalition for the Environment
Stephen Kauffman, Coalition for the Environment
Michael Garvey, St. Charles
John C. Soucy, Jr., St. Charles
Evalena Wood, St. Charles County
Rao Ayyagari, Lindenwood College, St. Charles
Jack Sanford, St. Charles
Tom Aley, Ozark Underground Laboratory, Protem
Lisa Gruenloh, Francis Howell High School
Stan Pogue, St. Charles (for John Gofman)
Michael Hrdlicka, Francis Howell High School
Terry Mangan, New Melle
Meredith Bollmeier, St. Charles Countians Against Hazardous Waste
Lily Trimble, Coalition for the Environment
George Oliver, Chesterfield
Arlene Sandler, University City
Kay Drey, University City
Rebecca Selove, Community Mental Health Center, St. Charles
Mary Halliday, St. Charles Countians Against Hazardous Waste
Bobbie Judge, St. Charles
Beatrice Buder, Clayton
Byron Clemens, Academy of Mathematics and Science
Katherine McDaniel, St. Louis (for Rex Couture)
Dan Vornberg, Doe Run Company
Martin Pultman, Chesterfield

TABLE A.2 (Cont'd)

Oral Comments, Public Hearing on the Draft EIS, April 10, 1987 (Cont'd)

Lee Swendsen, St. Charles County
Katherine Swendsen, St. Charles County
Lucy P. Clements
Tom Henkey, Francis Howell High School
John Gestrich, St. Louis
David Lobbig, University City (for Lou P. Kimmell)
Marcus Jackman, Francis Howell High School
Daniel Romano, St. Louis

Written Comments

Frederick A. Brunner, Missouri Department of Natural Resources, Jefferson City
Allen W. Hatheway, Department of Geological Engineering, University of Missouri-Rolla
R. Roger Pryor and Stephen E. Kauffman, Coalition for the Environment, St. Louis
Virginia D. VandenBroek, St. Charles
Paul F. Larson, Soil Conservation Service, Columbia
Virgil Aubuchon
Mark and Sharon Cherry, Weldon Spring
Marcia L. Allmon, Marthasville
Cynthia Fels, Defiance
Michael V. Garvey, St. Charles
George A. Behrens, Glendale
Richard O. Olson and Gary J. Meltz, St. Joseph Health Center, St. Charles
Joan Beauchamp, Wentzville
Donna Owens, Harvester
Richard Christensen, St. Louis
Wayne Muri, Missouri Highway and Transportation Commission, Jefferson City
Charles L. Cronin, St. Peters
John C. Villforth, Food and Drug Administration, Rockville, Md.
Robert S. Wilkerson, Federal Emergency Management Agency, Washington, D.C.
John C. Soucy, Jr., St. Joseph Health Center-Hospital West, St. Charles
Harold L. Volkmer, House of Representatives, Washington, D.C.
Stephan G. Heitkamp, Clerk, Board of Trustees, Town of Weldon Spring Heights, St. Charles
Barbara J. Ritchie, Washington Department of Ecology, Olympia
Diane Warmann, St. Charles
Pat Allison, St. Charles
Sydney S. Koegler, Richland, Wash.
Robert G. Harmon, Missouri Department of Health, Jefferson City
Larry R. Gale, Missouri Department of Conservation, Jefferson City
Dean Olson, New Mexico Department of Finance and Administration, Santa Fe
Leann M. Starr, O'Fallon
Dennis Kehoe, Marthasville
Ruby E. Quarterman, St. Charles
Catherine Bell, St. Louis

TABLE A.2 (Cont'd)

Written Comments (Cont'd)

Thomas B. Reth, Department of the Army, Fort Leonard Wood
Ann Hood, Wentzville
Robert J. Toomey, Overland
David M. Cochran, Texas Department of Health, Austin
Margaret C. Burwell, St. Charles
Craig Kilby, Missouri House of Representatives, Jefferson City
Pat Allison, St. Charles
Rao Ayyagari, Lindenwood College, St. Charles
Evalena Wood, St. Charles
Sue Jerman, St. Peters
Robert P. Wuertenberg
Gary T. and Mary A. Callier, St. Charles
Terry M. Millard
Betty Ackermann, St. Charles
Shirley S. Foster, St. Charles County Extension Center, St. Charles
Carole Leriche, St. Charles County Extension Center, St. Charles
Lillie C. Trimble, Parkville
John C. Danforth, U.S. Senate, Washington, D.C.
Steven P. Adams, St. Charles
Mary A. Halliday, St. Charles Countians Against Hazardous Waste, Defiance
Jack C. Sanford, St. Charles
Leon W. Heath, Soil Consultants, Inc., St. Peters
Bobbie Judge, St. Charles
George A. Farhner, St. Charles
Meredith A. Bollmeier, St. Charles
Morris Kay, U.S. Environmental Protection Agency, Kansas City, Kans.
Bruce Blanchard, U.S. Department of the Interior, Washington, D.C.
Pamela J. Fish, St. Peters
Terry Sova, St. Charles
St. Charles County Commission, St. Charles

- On students and staff at nearby Francis Howell High School.
- In terms of both radiation doses and resulting health risks.
- Associated with various pathways to humans -- including soil; surface water and groundwater; gases, dust, and particulates; and the food chain.
- In the vicinity of the Weldon Spring site, along transportation routes, and near any alternative disposal site.
- Associated with both routine operations and accidents, including transportation accidents (using conservative assumptions with regard to potential accidents).
- Associated with off-site migration of radioactive materials.
- Of radionuclide releases due to natural forces such as erosion or seismic activity.
- Associated with human intrusion into the contaminated materials.
- On wildlife in the area.

2. Potential chemical impacts

   - Associated with the same categories as potential radiological impacts, consistent with the state of scientific knowledge regarding the toxicological effects of various chemical species.

3. Potential socioeconomic impacts

   - Associated with current and future uses of land and the St. Charles County well field located southeast of the quarry.
   - On patterns of development and population distribution.

4. Potential engineering and technical issues

   - Reasonable engineering technologies for management of the contaminated materials at the Weldon Spring site. The technologies will be systematically screened to obtain reasonable alternatives for remedial action.
   - Probable duration of isolation of the contaminated materials, and rate and magnitude of loss of containment -- including the ability to monitor and control seepage and contaminant

releases from the containment facility and the ability to repair weaknesses or failures in containment. This analysis will be performed in the context of time frames described in Section A.7.

- Site geology as related to engineering requirements.

- Characterization of the amounts and types of contaminated materials.

- Procedures to remediate contaminated groundwater at the raffinate pits and chemical plant area.

5. Potential geological and hydrological issues

   - Characterization of site-specific geological and hydrological conditions.

   - History of seismic activity in the area and discussion of potential future activity.

   - Potential contamination of groundwater from waste disposal activities and possible mitigative measures. Procedures to clean up current groundwater contamination at the raffinate pits and chemical plant area will also be assessed in the RI/FS-EIS.

6. Potential institutional issues

   - Project-specific criteria for decontamination, effluents, environmental concentrations, and release of a site for unrestricted or restricted uses. Cleanup criteria for radionuclides (e.g., uranium) and for chemical contaminants will be developed in cooperation with EPA Region VII and the state of Missouri, based on an assessment of risks to human health and the environment.

   - Compliance requirements for state and local laws and regulations.

   - Future institutional requirements related to monitoring and maintenance activities.

   - Institutional factors that need to be resolved before an alternative can be implemented.

   - Potential post-action uses of the Weldon Spring site.

7. Potential loss of institutional control

The list of ARARs to be included in the RI/FS-EIS will detail the institutional framework within which the project will be performed. Although EPA's standards and DOE's proposed remedial activities are based on continued federal ownership and control of the site, uncertainties regarding this issue increase significantly in the long term; it is reasonable to assume that federal control, including maintenance and monitoring, will be lost during the time that these wastes are hazardous. To address the impacts of loss of control (albeit unplanned and distant in time), the RI/FS-EIS will provide a systematic, but essentially qualitative, discussion of the longevity of the various containment systems and the potential failure modes that could lead to dispersal of the wastes and to human exposure following loss of institutional control at the site (including access control, monitoring, and maintenance). These include such possibilities as:

- Groundwater intrusion and leaching of wastes.
- Cap failure through cracking or differential settling.
- Erosion of cover (including gully erosion).
- Biotic intrusion (e.g., animal burrows and plant roots).
- Waste saturation and resulting releases.

The relative importance of these possibilities will be discussed to the extent possible. The estimated impacts to a resident intruder (an individual constructing a residence on the site following loss of access control, eating food from an on-site garden, and drinking water from an on-site well) will be analyzed using an appropriate pathway model. To place this in context, the likelihood of such a scenario will be addressed (qualitatively) in light of factors such as suitability for agriculture. Engineering and institutional measures to reduce the likelihood of loss of containment will be described. These generic descriptions will include a discussion of any differences that might be expected among the various alternatives.

8. Potential issues relative to mitigative measures and monitoring

- Measures to control dispersion of contaminants to the environment.
- Long-term monitoring and maintenance needs.
- Measures that could be taken to reduce impacts under each alternative.

A.4.2 Secondary Issues

Secondary issues are those that were deemed through scoping to be important, but to a lesser degree than primary issues. Secondary issues, which are analyzed in less depth than primary issues, include the following.

1. Potential socioeconomic impacts

   - On current and future local employment and industrial and commercial operations.
   - On local transportation systems.
   - On long-term use of site areas.
   - On local, municipal, and community services and organizations such as schools, government, and citizen action groups.

2. Potential engineering and technical issues

   - Specific maintenance needs.
   - Specific transportation routes, modes, and packaging.
   - Recovery of potentially valuable materials.
   - Effects of catastrophic natural events such as tornadoes, intense rains, droughts, and floods.
   - Methods for controlling surface water runoff from the site during construction.

3. Potential institutional issues

   - Costs of implementing and funding the various alternatives.
   - On-site enforcement of safety standards during remedial action.

4. Miscellaneous issues

   - Commitment or loss of resources (e.g., uranium, thorium, and energy).
   - Worker safety.
   - Site-specific meteorological conditions.
   - Mitigative measures to protect potential cultural resources.

A.5 ISSUES BEYOND THE SCOPE OF THE RI/FS-EIS

The DOE has determined that the following issues are beyond the scope of the RI/FS-EIS.

1. Psychological impacts -- In light of a U.S. Supreme Court case involving the proposed restart of one of the Three Mile Island reactors (Metropolitan Edison Company v. People Against Nuclear Energy [PANE] 103 S. Ct. 1556 [1983]), DOE considers only psychological impacts that bear a close causal relationship to the physical environment in an EIS. Psychological impacts raised to date relative to the Weldon Spring site do not bear such a relationship.

2. Impacts of past operations at the site -- The impacts of the various alternatives on the existing environment will be assessed in the RI/FS-EIS. In the above-mentioned Supreme Court decision, it was stated that "NEPA is not directed at the effects of past accidents and does not create a remedial scheme for past federal actions." Therefore, a detailed analysis of past operations, beyond that necessary to characterize the existing environment, is considered to be beyond the scope of the RI/FS-EIS.

3. Monitoring of health of students and staff at Francis Howell High School -- An ongoing environmental monitoring program is being conducted by DOE in the vicinity of the Weldon Spring site. This program includes the Francis Howell High School area. No additional monitoring studies of students and staff at the Francis Howell High School will be performed as part of the RI/FS-EIS process because the existing environmental monitoring program demonstrates that individuals at the high school are not being exposed to measurable levels of radioactive or chemical contaminants originating from the Weldon Spring site. However, potential health impacts on students and staff will be addressed in the RI/FS-EIS.

4. Excavation, transport, and temporary storage of quarry bulk wastes -- The DOE is proposing to address the removal of the quarry bulk wastes as a separate operable unit and will use the RI/FS-EA process to support this decision (see Section 3.11 of this work plan). This action will include excavation, transport, and temporary storage of the quarry bulk wastes at the raffinate pits and chemical plant area. Implementation of the RI/FS-EA process will be as follows. The first two phases of the FS process will be completed concurrent with preparation of the RI and baseline risk evaluation. At this point, an assessment of environmental impacts will be performed consistent with the requirements of an EA in support of a finding of no significant impact (FONSI), if appropriate. If DOE determines that this action requires preparation of

an EIS, the action will be included within the overall RI/FS-EIS process for the project, and removal of the quarry bulk wastes will not be undertaken prior to issuance of the ROD. Because the EA is scheduled to be completed prior to issuance of the FS, the RI/FS process for this action will be completed only if a FONSI is issued. If an RI/FS for bulk waste removal is completed, DOE and EPA will issue decision documents under CERCLA to document the decision-making process.

5. Removal of residual contamination from the quarry -- After the bulk wastes have been removed from the quarry, the quarry will be inspected to determine if additional remedial action is required. The need for any additional remedial action at the quarry cannot be determined prior to bulk waste removal and inspection of the resultant conditions in the quarry. This issue is therefore beyond the scope of the RI/FS-EIS.

6. Remediation of contaminated groundwater at the quarry -- A decision to remediate contaminated groundwater at the quarry is beyond the scope of the RI/FS-EIS. The DOE is proposing to address the issue of contaminated groundwater remediation following removal of the bulk wastes from the quarry.

7. Other radioactively contaminated sites in the St. Louis area -- EPA Region VII proposed in 1984 that DOE also consider the possibility of cumulative disposal at the Weldon Spring site of the radioactive wastes currently stored at various locations in Missouri. These wastes and their locations are as follows:

   - St. Louis Airport Site (SLAPS) and SLAPS vicinity properties -- previously used for storing ore residues, scrap, and equipment from uranium-processing operations.

   - Latty Avenue Site -- previously used for storing ore residues and wastes from uranium-processing operations.

   - St. Louis Downtown Site -- previously used to process uranium ore or concentrates to produce uranium dioxide, uranium trioxide, uranium tetrafluoride, and uranium metal; the site was also previously used for other activities associated with uranium metal and for extraction and concentration of thorium-230 from pitchblende raffinates.

   - West Lake Landfill -- previously used for disposing of soil from the Latty Avenue site.

The SLAPS, Latty Avenue, and St. Louis Downtown sites are already included in the DOE Formerly Utilized Sites Remedial Action Program; the West Lake Landfill is

under cognizance of the U.S. Nuclear Regulatory Commission. In the Congressional conference report that accompanied U.S. Public Law 98-360, DOE was directed to take the necessary steps to consolidate and dispose of the waste materials from the Latty Avenue and SLAPS vicinity properties. The report directed that the materials be disposed of locally by reacquiring, stabilizing, and using SLAPS in a manner acceptable to the city of St. Louis. Plans for disposal of wastes from the St. Louis Downtown site have not yet been formulated. The DOE has no plans to dispose of these wastes at the Weldon Spring site. Therefore, the cumulative impacts from disposal of the wastes from other sites in the St. Louis area at the Weldon Spring site will not be addressed in the RI/FS-EIS.

A.6 RELATED FEDERAL PROJECTS

The DOE has recently prepared EISs for other programs and other sites under its Remedial Action Program, including:

- U.S. Department of Energy, 1983, *Final Environmental Impact Statement, Remedial Actions at the Former Vitro Rare Metals Plant Site, Canonsburg, Washington County, Pennsylvania*, DOE/EIS-0096-F, 2 vol. (July).

- U.S. Department of Energy, 1984, *Final Environmental Impact Statement, Remedial Actions at the Former Vitro Chemical Company Site, South Salt Lake, Salt Lake County, Utah*, DOE/EIS-0099-F, 2 vol. (July).

- U.S. Department of Energy, 1985, *Final Environmental Impact Statement, Remedial Actions at the Former Vanadium Corporation of America Uranium Mill Site, Durango, La Plata County, Colorado*, DOE/EIS-0111F, 2 vol. (Oct.).

- U.S. Department of Energy, 1986, *Final Environmental Impact Statement, Remedial Actions at the Former Climax Uranium Company Uranium Mill Site, Grand Junction, Mesa County, Colorado*, DOE/EIS-0126-F, 2 vol. (Dec.).

- U.S. Department of Energy, 1986, *Final Environmental Impact Statement, Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site*, DOE/EIS-0109F (April).

In addition, the U.S. Nuclear Regulatory Commission and U.S. Environmental Protection Agency have prepared EISs on various related programs, proposed standards, and specific sites, including:

- U.S. Environmental Protection Agency, 1982, *Final Environmental Impact Statement for Remedial Action Standards for Inactive*

Uranium Processing Sites (40 CFR 192), Vols. 1 and 2; EPA 520/4/82-013-1, -2 (Oct.).

- U.S. Nuclear Regulatory Commission, 1983, *Final Environmental Statement Related to the Decommissioning of the Rare Earths Facility, West Chicago, Illinois, Docket No. 40-2061, Kerr-McGee Chemical Corporation*, NUREG-0904 (May).

- U.S. Environmental Protection Agency, 1986, *Final Environmental Impact Statement, Proposed Wastewater Treatment Facilities for Eastern St. Charles County, Missouri, Including: Duckett Creek Sewer District, St. Peters Sewer District, St. Charles Sewer District, Portage de Sioux Sewer District*, EPA 907/9-86-003 (May).

- U.S. Nuclear Regulatory Commission, 1987, *Draft Supplement to the Final Environmental Statement Related to the Decommissioning of the Rare Earths Facility, West Chicago, Illinois, Docket No. 40-2061, Kerr-McGee Chemical Corporation*, NUREG-0904, Supplement No. 1 (June).

A.7 TIME FRAME FOR COMPARATIVE ANALYSIS OF ENVIRONMENTAL IMPACTS

The potential environmental impacts will be analyzed over the following time periods:

- Action period (approximately 10 years) -- the period during which physical actions such as excavation, transportation, and stabilization will take place.

- Long-term period -- the time following the action period during which the disposal site will continue to be controlled. Human access to the disposal area will be limited, and the federal government will continue to own the area and use it solely for waste-disposal purposes. Containment structures will be maintained, any releases to the environment will be monitored, and corrective remedial actions will be taken as necessary. The cumulative impacts over 1,000 years will be assessed in the RI/FS-EIS. In addition, the RI/FS-EIS will describe the impacts that might peak after 1,000 years with continued site control and maintenance. Although the federal government intends to control the site, impacts that might occur if there was loss of institutional control will also be discussed.

The 1,000-year time frame is selected to be consistent with the time frames identified in EPA regulations for management of inactive uranium mill tailings (40 CFR Part 192). In these regulations, EPA identifies "the single most important goal of control

to be effective isolation and stabilization of tailings for as long a time period as is reasonably feasible, because tailings will remain hazardous for hundreds of thousands of years." Furthermore, "the longevity of control is governed by the possibility of intrusion by man and erosion by natural forces." After considering several time periods for control, EPA required that "control measures be carried out in a manner that provides reasonable assurance they will last, to the extent reasonably achievable, up to 1,000 years, and, in any case, for a minimum of 200 years." Uncertainties increase significantly beyond 1,000 years and it would not be reasonable to require assurances of control for longer time periods.

The naturally occurring radionuclides found in uranium mill tailings (principally the uranium-238 decay series) constitute the bulk of radioactivity in the Weldon Spring wastes. Because the 1,000-year time period has been deemed to be a reasonable basis for EPA's decisions regarding inactive uranium mill tailings and because it should also be adequate for addressing potential chemical impacts, DOE considers this time period to be a reasonable reference point for analyzing environmental impacts in the RI/FS-EIS to support DOE's decision on management of the contaminated materials at the Weldon Spring site.

A.8 COORDINATION OF NEPA AND CERCLA REQUIREMENTS

The response actions to be carried out by DOE at the Weldon Spring site are subject to EPA oversight under CERCLA. For this project, the oversight function is being carried out by EPA Region VII. The Weldon Spring Site Remedial Action Project can be described as consisting of seven separate environmental compliance components (see Section 1.2). The three major actions currently envisioned for the raffinate pits and chemical plant area are (1) management of the contaminated surface structures, raffinate pit wastes, surface water, and soils; (2) assessment of the need to restore contaminated groundwater; and (3) cleanup of contaminated vicinity properties. These three actions will be addressed in the RI/FS-EIS and supported by a single response decision. This decision will also include disposition of the bulk wastes currently in the quarry. The RI/FS-EIS to support the decision will be prepared in a format that provides the level of detail required by both NEPA and CERCLA, so that separate documentation for each act will not be required. This approach is intended to result in a single ROD by DOE and EPA. It is possible that the groundwater restoration issue will be ready for a decision at a different time than the waste disposal issue. If this is the case, DOE may handle groundwater restoration as a separate operable unit to satisfy the requirements of NEPA and CERCLA for this decision.

Four distinct response actions may be required at the quarry: bulk waste removal, removal of any residual materials following bulk waste removal, groundwater restoration, and cleanup of contaminated vicinity properties. The DOE is proposing to address removal of the quarry bulk wastes as a separate operable unit and will use the RI/FS-EA process to support this decision. This action is scheduled to occur prior to the ROD for the project. The procedure for implementation of the RI/FS-EA process is given in Item 4 of Section A.5.

The other two environmental compliance areas for the Weldon Spring project (i.e., residual material removal and groundwater restoration at the quarry) are not ready for assessment at this time. The appropriate level of environmental review will be determined as sufficient data become available to reach an informed decision. The DOE will involve EPA Region VII and the Missouri DNR in its determination regarding the need for response actions in these areas.

Prior to issuance of the ROD for the waste disposal action, various expedited response actions, i.e., interim response actions (IRAs), will be performed to mitigate actual or potential uncontrolled releases of radioactively or chemically hazardous substances to the environment. The scope of the IRAs will be limited to those actions that can be performed under CERCLA and within the constraints of CEQ regulations for NEPA (i.e., actions will be limited to those that do not have adverse environmental impacts or limit the choice of reasonable alternative for the ultimate disposition of the site). The environmental compliance process for the IRAs, developed to ensure compliance with NEPA and CERCLA, is described in Section 3.10.1 of this work plan.

A.9 TENTATIVE OUTLINE OF THE FS-EIS COMPONENT OF THE RI/FS-EIS

A tentative outline of the FS-EIS component of the RI/FS-EIS is given in Table A.3. This outline was developed by integrating those elements required by an EIS into the format recommended for an FS.

A.10 CONTRACTOR RELATIONSHIPS IN PREPARATION OF THE RI/FS-EIS

The DOE-OR has been delegated responsibility and authority for field management of the Weldon Spring Site Remedial Action Project; DOE-OR has established a project office at the Weldon Spring site (DOE-WSS). The DOE-WSS has responsibility for implementing the conduct of response action activities and also has functional responsibility for preparation of the RI/FS-EIS. The DOE-HQ will approve publication of the RI/FS-EIS.

MK-Ferguson Company is the project management contractor for response action activities at the Weldon Spring site. Jacobs Engineering Group, Inc., is under contract to MK-Ferguson Company to provide technical support for the project. The project management contractor will collect all necessary environmental data and perform requisite engineering and monetary cost studies to support the analyses given in the RI/FS-EIS. The project management contractor will oversee preparation of the RI.

The Energy and Environmental Systems Division of ANL will perform environmental analyses for the RI/FS-EIS process under contract to DOE-WSS and will oversee preparation of the FS-EIS phase of the RI/FS-EIS process. As part of this process, ANL will provide an independent analysis of the environmental studies, engineering feasibility, and cost-effectiveness of alternatives for remedial action at the Weldon Spring site performed by other DOE contractors. These environmental analyses will be performed using information supplied by the project management contractor and supplementing such information, as necessary, by site visits, meetings and consultations with other agencies, and review of existing documents.

TABLE A.3 Tentative Outline for the FS-EIS for Remedial Action at the Weldon Spring Site

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Executive Summary

1 Introduction

- 1.1 Site Background
- 1.2 Nature and Extent of Problems
- 1.3 Justification of Need for Proposed Action
- 1.4 Objectives of Remedial Action
- 1.5 Scoping
- 1.6 Related Federal Projects
- 1.7 Consultation with Other Agencies

2 Development of Remedial Action Alternatives

- 2.1 Definition of Remedial Action Objectives
- 2.2 Identification of Potential Technologies
- 2.3 Definition of Technical Evaluation Criteria
- 2.4 Identification of ARARs and Acceptable Exposure Levels
- 2.5 Technologies Screening
- 2.6 Assembly of Technologies into Remedial Action Alternatives
  - 2.6.1 No Action
  - 2.6.2 Alternative 2
  - • •
  - • •
  - • •
  - 2.6.n Alternative n

3 Initial Evaluation and Screening of Alternatives

- 3.1 Definition of Screening Criteria (effectiveness, implementability, and cost)
- 3.2 Screening of Alternatives

4 Detailed Analysis of Screened Alternatives (short- and long-term impacts)

- 4.1 Effectiveness
  - 4.1.1 Protectiveness of Human Health and the Environment (including reliability and compliance with ARARs)
  - 4.1.2 Reduction of Waste Toxicity, Mobility, and/or Volume
- 4.2 Implementability
  - 4.2.1 Resource Availability (including services and capacities, equipment, and personnel)
  - 4.2.2 Technical and Administrative Feasibility (including performance; ability to operate, monitor, and maintain; reliability; and compliance with ARARs)
  - 4.2.3 Institutional Issues (including compliance with ARARs and impacts of potential loss of institutional control)

TABLE A.3 (Cont'd)

4.3 Cost
4.3.1 Estimation of Operation and Maintenance Costs and Capital Costs (direct/indirect)
4.3.2 Present Worth Analysis
4.4 Sensitivity Analysis (effectiveness, implementability, and cost)
4.5 Comparative Analysis (relative performance of each alternative)
4.6 Environmental Consequences
4.6.1 Radiological Impacts
4.6.2 Chemical Impacts
4.6.3 Soils and Geology
4.6.4 Water Resources
4.6.5 Ecology
4.6.6 Air Quality
4.6.7 Socioeconomics
4.6.8 Historical and Archeological Issues
4.6.9 Institutional Issues
4.7 Potential Loss of Institutional Control
4.8 Cumulative Impacts
4.9 Mitigative Measures
4.10 Unavoidable Adverse Impacts
4.11 Irreversible and Irretrievable Commitment of Resources
4.12 Short-Term Uses and Long-Term Productivity
5 Summary of Alternatives
6 Recommended Remedial Action (optional)
7 Responsiveness Summary (final only)
8 References
Appendixes

A.11 PAGE LIMIT TARGETS

Because the RI/FS-EIS will address several complex alternatives and issues, it is anticipated that it will be longer than the CEQ-recommended page limit of 150 pages for an EIS but less than the recommended maximum of 300 pages. Supporting information will be included in appendixes and stand-alone documents to minimize the length of the RI/FS-EIS to that necessary to support the ROD. A preliminary outline for the FS-EIS component of the RI/FS-EIS is given in Table A.3.

A.12 TARGET DATES FOR FS-EIS PREPARATION

A schedule for preparation of the RI/FS-EIS is given in Section 6 of this work plan. The target dates for the RI/FS-EIS given below are extracted from the more detailed schedule shown in Figure 34.

Activity	Date
RI/FS-EIS work plan issued	August 1988
Draft RI/FS-EIS issued	July 1990
End of public comment period	September 1990
Final RI/FS-EIS issued	March 1991
Record of decision issued	April 1991

A.13 REFERENCES

U.S. Department of Energy, 1987a, *Draft Environmental Impact Statement, Remedial Action at the Weldon Spring Site*, DOE/EIS-0117D, Office of Remedial Action and Waste Technology (Feb.).

U.S. Department of Energy, 1987b, *Water Quality Phase I Assessment*, DOE/OR/21548-003, prepared by MK-Ferguson Company, St. Charles, Mo., for Oak Ridge Operations, Weldon Spring Site Remedial Action Project Office, St. Charles, Mo. (Dec.).

U.S. Department of Energy, 1987c, *Compliance with the National Environmental Policy Act (NEPA); Amendments to the DOE NEPA Guidelines*, Federal Register, 52(240):47662-47669 (Tuesday, Dec. 15).

APPENDIX B:

RESPONSES TO MAJOR ISSUES RAISED IN COMMENTS ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

APPENDIX B

RESPONSES TO MAJOR ISSUES RAISED IN PUBLIC COMMENTS ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

The draft environmental impact statement (EIS) for remedial action at the Weldon Spring site, Weldon Spring, Missouri, was issued by the U.S. Department of Energy (DOE) in February 1987. A public comment period followed issuance, as mandated by the Council on Environmental Quality regulations for implementing the procedural provisions of the National Environmental Policy Act (NEPA) (40 CFR Part 1503.1). As part of the public review process, a public hearing was held on April 10, 1987, at Hollenbeck Junior High School in Harvester, Missouri. Comments on the draft EIS were provided orally at the public hearing, in written material provided to DOE at the public hearing, and in individual letters sent to the DOE Weldon Spring Site Project Office. The names of individuals who provided comments on the draft EIS are listed in Appendix A, Table A.2. These comments are available for inspection at the project office during normal business hours.

The Weldon Spring quarry was listed on the National Priorities List of the U.S. Environmental Protection Agency (EPA) on July 30, 1987. On June 24, 1988, EPA proposed to expand the designation to include the raffinate pits and chemical plant area. This designation, along with promulgation of the Superfund Amendments and Reauthorization Act (SARA) in October 1986, has significantly altered the environmental compliance documentation process required to support the Weldon Spring Site Remedial Action Project. In conjunction with the EPA Region VII and the Missouri Department of Natural Resources (DNR), DOE has agreed that the appropriate environmental review for this project can be most expeditiously performed by incorporating those elements required by an EIS into the framework of the remedial investigation/feasibility study (RI/FS) process for remedial actions conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This integrated process is termed the RI/FS-EIS process.

This appendix has been prepared to address the major issues identified in comments on the draft EIS. These issues have been summarized from the various oral and written comments received during the comment period. The intent of the responses to these major issues is to illustrate the manner in which the issues will be addressed in the RI/FS-EIS process. A draft RI/FS-EIS will be issued for public review, and any significant issues concerning the draft RI/FS-EIS will be addressed in a responsiveness summary. A final RI/FS-EIS, including the responsiveness summary, will be prepared prior to issuance of the record of decision (ROD) for this project.

The major issues identified in comments on the draft EIS have been divided into five categories as follows:

1. Compliance with NEPA and CERCLA,

2. Engineering considerations,

3. Site characterization and suitability,

4. Environmental impacts, and

5. Scope and conduct of remedial action activities.

The comments and responses for these issues are presented in Sections B.1 through B.5, respectively. The issues are numbered consecutively through the five sections.

B.1 COMPLIANCE WITH NEPA AND CERCLA

B.1.1 Issue 1

Comment: The draft EIS does not have sufficient detail to allow for meaningful comment by the public. A supplement to the draft EIS should be issued for public comment. Additionally, the draft EIS does not adequately incorporate the RI/FS process under CERCLA as required by the Federal Facility Agreement (FFA) for this project.

Response: Since issuance of the draft EIS, EPA Region VII has formally requested that DOE prepare an RI/FS for this project. The DOE has committed to comply with this request. The RI/FS will be modified to include those elements of an EIS not typically contained in an RI/FS. A tentative outline for the FS-EIS component of the RI/FS-EIS is given in Appendix A, Table A.3. The RI/FS-EIS will not be issued for public comment until all site characterization activities have been completed. Hence, much more detail will be included in the RI/FS-EIS when issued for public comment than was included in the draft EIS.

B.1.2 Issue 2

Comment: The information contained in the draft EIS is too general to allow for meaningful estimation of the environmental impacts that may occur. Estimation of environmental impacts should be based on site-specific information and not national figures or hypothetical computations. The draft EIS, therefore, does not comply with NEPA regulations.

Response: Estimation of environmental impacts in the draft EIS was based on available information at the time the document was prepared. Assumptions were made for information that was not available. Because DOE will now be preparing an RI/FS-EIS, sufficient site-specific information will be available to allow for detailed estimation of environmental impacts. (See also Response to Issue 1, Section B.1.1.)

B.1.3 Issue 3

Comment: The draft EIS does not present sufficient details on the various alternatives. The draft EIS should analyze the impact of all significant and reasonable

alternatives, including combinations of design features. The alternatives presented in the draft EIS do not allow for assessment of all reasonable combinations.

Response: The procedure for developing alternatives in the RI/FS process will be used in the RI/FS-EIS. In this process, remedial action objectives are determined on the basis of existing site information regarding the nature and extent of contamination, along with potentially applicable or relevant and appropriate requirements (ARARs) and risk factors. Technologies are then screened to identify those that would be effective for the contaminants present at the site, taking into account the environmental setting of the site. Information developed for these two activities will be used to develop alternatives for assessment in the RI/FS-EIS. This approach will allow a systematic evaluation of various design features, and combinations of design features, in developing the alternatives.

B.1.4 Issue 4

Comment: The draft EIS ignored many issues brought up at the 1984 EIS scoping meeting. All of the issues brought up at that meeting, as well as those identified in comments on the draft EIS, should be addressed prior to the ROD.

Response: Issues raised at a public scoping meeting are one source of input considered in determining the scope of an EIS. Other sources of input include engineering feasibility; consultation with local, state, and federal officials; consultation with other federal agencies; and DOE policies and procedures. All issues raised at a public scoping meeting are considered in determining the scope of an EIS. However, if it is determined that an issue raised during scoping is not significant relative to the decision to be made, its inclusion in the EIS is not warranted. The DOE will reexamine all issues raised during the 1984 scoping process, as well as those raised on the draft EIS, to ensure that all significant issues are evaluated in the RI/FS-EIS.

B.1.5 Issue 5

Comment: Additional details should be provided on the "Nearby Site" as presented in the draft EIS. Potential use of the Callaway Nuclear Power Plant site should be addressed in this regard because this site will be contaminated into perpetuity. Without detailed information on the specific site to be addressed, it is impossible for an accurate comparative analysis to be performed.

Response: Under Alternative 3b in the draft EIS, the wastes are assumed to be transported to a "Nearby Site" in Missouri, within 160 km (100 mi) of the Weldon Spring site. The "Nearby Site" would be chosen to have more favorable conditions (e.g., thicker clay, lower hydraulic conductivity, deeper groundwater table, and/or higher sorption capacity) than the Weldon Spring site. This assessment was included to provide information on the feasibility of developing such a disposal site for the Weldon Spring wastes. The DOE did not undertake a detailed site-selection process to identify alternative disposal sites for wastes resulting from the Weldon Spring project in support of the draft

EIS, nor is such a detailed evaluation planned for the RI/FS-EIS. The DOE will consider the feasibility of a generic site within 160 km (100 mi) of the Weldon Spring site in the RI/FS-EIS. The use of this generic site will be analyzed according to the three screening criteria, i.e., effectiveness, implementability, and cost. Only if use of this generic site survives the screening evaluation and/or if the on-site disposal alternative is determined to be infeasible will DOE initiate off-site characterization studies as part of the post-screening investigations. It is incorrect to conclude that the Callaway Nuclear Power Plant site will be radioactively contaminated into perpetuity. Techniques for decontamination of equipment, structures, and soil are available to allow for this site to be returned to nonnuclear uses following its active lifetime.

B.1.6 Issue 6

Comment: The DOE is currently conducting geological studies at the Weldon Spring site to evaluate its suitability for waste disposal. Similar studies are not being conducted at other potential disposal sites. Not conducting such studies at alternative disposal sites could bias the decision-making process in favor of on-site disposal.

Response: A rather significant data base is needed for meaningful assessment of environmental impacts to support the RI/FS-EIS process. Data are currently being collected at the Weldon Spring site to support this process. This data-collecting process is necessary to allow for an informed assessment of current, and possibly future, environmental conditions (e.g., contaminant migration pathways). The DOE does not believe that it is necessary to perform such geological studies at other potential disposal sites at this time. (See also Response to Issue 5, Section B.1.5.)

B.1.7 Issue 7

Comment: The draft EIS should address all aspects of this project so that the full magnitude of environmental impacts is presented. Specific plans for decontaminating the buildings at the chemical plant area and the associated environmental impacts should be included in the EIS. It is not appropriate, under NEPA, to address this issue in a tiered document.

Response: When work was initiated on the draft EIS, the chemical plant area was under jurisdiction of the U.S. Department of the Army, and there was no indication at that time regarding the manner in which the Army intended to deal with this facility. Custody of the chemical plant area was transferred to DOE in October 1985. Because DOE was already in the process of preparing the draft EIS for long-term management of the contaminated materials located at the raffinate pits, quarry, and vicinity properties, DOE decided to include the impacts of disposing of the chemical plant wastes in the draft EIS. However, because characterization data to allow for assessment of the environmental impacts associated with decontamination and decommissioning of the chemical plant area were not available, inclusion of such data in the draft EIS would have unduly delayed issuance of the document. Therefore, DOE decided to implement the tiering concept for NEPA compliance. This is an acceptable use of tiering because the

main issue discussed in the draft EIS is waste disposal and the means by which the wastes are obtained from site-specific actions is a comparatively minor issue. It should be noted that decontamination and decommissioning of nonprocess buildings will be addressed as interim response actions (IRAs) for this project, as discussed in Section 3.10.2.14 of this work plan. Documentation of the proposed IRAs will be made available to the public prior to initiation of such actions. Decontamination and decommissioning of process buildings will be included in the RI/FS-EIS.

B.1.8 Issue 8

Comment: The draft EIS excluded issues from discussion that are essential to an informed decision. Additionally, not all pertinent information is included in the draft EIS, but only that information that supports DOE's preferred alternative. Therefore, the draft EIS does not comply with NEPA.

Response: The issues addressed in the draft EIS were those determined to be relevant to the decision to be made. All available information was reviewed for appropriateness relative to the analyses provided in the draft EIS. The DOE will reconsider all available information in preparation of the RI/FS-EIS, including those specific references cited in comments on the draft EIS. The DOE is currently in the process of conducting a thorough site characterization program. The results of this program will be included in the RI report and will allow for detailed estimation of environmental impacts.

B.2 ENGINEERING CONSIDERATIONS

B.2.1 Issue 9

Comment: The location of the disposal facility for the on-site alternative should be shown. The geology of the raffinate pits and chemical plant area is complex and variable. An assessment of the feasibility of on-site disposal cannot be made without knowing the exact location of the proposed containment cell.

Response: Existing borings and surface geophysical investigations have adequately characterized the unconsolidated and upper bedrock strata. Geotechnical and geophysical investigations to be conducted in the immediate future will extend our knowledge of the unconsolidated geology and the upper 60 m (200 ft) of the bedrock. These investigations will characterize the on-site areas capable of supporting a disposal facility. Results of these investigations will be discussed in the draft RI/FS-EIS issued for public comment.

B.2.2 Issue 10

Comment: The disposal facility must be designed to withstand natural forces (e.g., freeze-thaw cycles, differential settling and slumping, cracking of the cover in dry weather, burrowing animals, and vegetative root systems). The disposal facility must

also be designed to maintain its integrity against severe natural phenomena (e.g., seismic events, floods, tornadoes, heavy precipitation, water and wind erosion, and drought). A suitably designed leachate collection and monitoring system should be an integral component of cell design. A passive leachate collection system should be considered. The long-term stability of this facility must be guaranteed.

Response: The DOE is currently developing generic criteria for containment cell design. These criteria will include provisions to prevent contaminant migration as a result of natural forces and severe natural phenomena. The DOE is also evaluating the use of a leachate collection and monitoring system at this time. Such a system, if deemed appropriate, must be properly designed to ensure that it does not become a mechanism for contaminant release in the future. The DOE concurs with the need to guarantee the long-term stability of a disposal facility, wherever it is located. It should be noted that DOE is committed to monitor and maintain the disposal site for the foreseeable future.

B.2.3 Issue 11

Comment: Treatment of the wastes to reduce the potential for off-site migration should be addressed in greater detail. Special emphasis should be placed on those treatments that reduce the volume of wastes, result in recovery of usable materials, significantly reduce contaminant mobility, or result in permanent solutions.

Response: One of the first steps in the RI/FS-EIS process will be to evaluate treatment technologies for applicability to the Weldon Spring wastes (see also Response to Issue 3, Section B.1.3). These technologies will be evaluated for the parameters suggested in this comment. The DOE is currently planning numerous feasibility studies for this project (see Section 3.9 of this work plan). Additional studies may be performed as the project proceeds, pending the results of the RI phase, the development of new technologies, and the results of studies currently planned.

B.2.4 Issue 12

Comment: Various chemical species from the waste materials will be present in leachate, such as acids, organic solvents, and hexane. The effects of these chemicals on the underlying clay layer should be investigated to ensure adequate containment over long periods of time. Certain chemical species can greatly reduce the ion-exchange capabilities of clay liners. The feasibility of using synthetic geomembrane liners should be considered.

Response: The ion-exchange capabilities of clay can be greatly degraded by chemical species such as organic solvents. Tests will be performed on the wastes to determine the chemical characteristics of any leachate that may form. The feasibility of synthetic liners will also be assessed. Any containment cell would be designed to ensure that leachate would not degrade the selected liner to the extent that the liner could not adequately confine radioactive and chemical contaminants. Substances that are contaminated only with hazardous chemicals -- with no associated radiological

hazard -- will not be disposed of on-site. All such wastes will be sent for treatment or disposal to a hazardous waste facility (licensed according to requirements of the Resource Conservation and Recovery Act [RCRA]).

B.2.5 Issue 13

Comment: The draft EIS should describe in detail how contaminated water will be treated prior to disposal.

Response: The DOE is currently evaluating methods for treating the contaminated water at the raffinate pits and chemical plant area and the quarry prior to discharge. Treatment of the water is essential to the implementation of any remedial action alternative. These actions are currently being planned as IRAs (see Sections 3.10.2.15 and 3.10.2.16 of this work plan). The methods for treating the water will be detailed in engineering evaluation/cost analysis (EE/CA) reports that will be prepared to support these actions. These EE/CA reports will include an assessment of potential environmental impacts associated with water treatment alternatives. The EE/CA reports will be expanded and additional documents will be prepared, as necessary, to meet the requirements of NEPA. The DOE has consulted, and will continue to consult, EPA Region VII and the Missouri DNR regarding this issue. The public will also have the opportunity provide input on this topic.

B.2.6 Issue 14

Comment: Long-term protection of groundwater can best be guaranteed by above-grade disposal in which a synthetic membrane liner is used at the bottom of the containment cell. The 25- to 30-year lifetime of such a liner, as stated in the draft EIS, may be too short. A leachate collection and monitoring system is essential to preventing contaminant migration to groundwater.

Response: The DOE concurs that groundwater protection is an essential component of any waste disposal system. There are several means by which this goal could be accomplished. An alternative to collecting infiltrate and leachate from the wastes (such as the use of a bottom liner and leachate collection system) would be to dispose of the wastes in a manner that water is prevented from reaching the contained wastes (e.g., by use of a very impermeable cap) so that leachate is not generated. Even though the lifetime of a synthetic membrane can be longer than 25 to 30 years when not exposed to ultraviolet radiation from the sun (up to 100 to 200 years), its lifetime is very short compared to the half-lives of the radionuclides controlling the hazard of the Weldon Spring wastes. The DOE is currently evaluating various disposal system designs that would provide groundwater protection.

B.2.7 Issue 15

Comment: The disposal cell cap should be thick enough to prevent the migration of radon-222 gas into the environment. In addition, although using a lead sheet in the

cover may be technically feasible, there seem to be more disadvantages than advantages with regard to this design. The draft EIS indicates that the edge of the cover will have a slope of 20%. This slope seems excessive and could lead to slumping and increased erosion.

Response: The DOE is currently in the process of developing generic criteria for containment cell design. These criteria will lay the foundation from which various disposal cell designs could be developed and evaluated. The concerns raised in this issue will be addressed in the design criteria document. Adequate confinement of radon-222 gas is obviously required because the inventory of radium-226 (the immediate precursor of radon-222) will continue to increase for several thousand years. The use of a lead sheet in the cover, which was included in the draft EIS as a result of input obtained during the scoping process, will be reevaluated in the RI/FS-EIS. The 20% slope at the edge of the cover has been used at other sites with no apparent difficulties (e.g., the Niagara Falls Storage Site). The design of a containment cell has not yet been completed. Conceptual design information will be included in the draft RI/FS-EIS issued for public comment.

B.2.8 Issue 16

Comment: Performance standards and goals for waste confinement should be identified prior to the initiation of remedial action (i.e., regarding restricted versus unrestricted future use of the site and the potential for subsequent remedial action). It is not possible to evaluate the acceptability of the various alternatives without such performance standards.

Response: Performance standards will be developed as part of the ARAR process for the RI/FS-EIS (see Section 3.1 of this work plan). Any containment facility, whether on-site or off-site, would be designed to ensure conformance to these standards. The development and operation of an area as a disposal site would preclude its unrestricted use but not the implementation of subsequent remedial action.

B.2.9 Issue 17

Comment: The draft EIS refers to monitoring and inspecting the containment system following completion of remedial action. This is an important component of ensuring that the containment cell is performing as planned. The frequency and length of time DOE is planning to conduct monitoring, inspection, and corrective activities (as needed) must be defined. The parameters to be monitored and the party responsible for monitoring should also be identified.

Response: The DOE is committed to monitoring and maintaining the disposal site for the foreseeable future. It is premature to precisely define the parameters and the frequency with which monitoring and inspection should occur because a location for the disposal cell has not yet been identified and the disposal cell design has not been completed. Some systems may require more frequent inspections than others. At a minimum, inspections would occur annually. More frequent inspections (e.g., quarterly)

would be expected in the near term to verify the adequacy of the containment system performance.

B.2.10 Issue 18

Comment: The disposal cell should not be located in an area overlying contaminated groundwater. Otherwise, it will be impossible to monitor the performance of the disposal facility because there are no means to differentiate between current contamination and that resulting from migration of contaminants from the disposal cell.

Response: The DOE is currently evaluating the effect of groundwater contamination at the raffinate pits and chemical plant area on the ability to dispose of wastes in that area. A decision to dispose of wastes above contaminated groundwater in that area will not be made unless it can be demonstrated that either (1) remediation of the groundwater is not needed or (2) groundwater remediation can be performed without impairing the integrity of an on-site disposal facility. Disposal cell performance could be monitored by means other than environmental sampling of the contaminants currently in the groundwater. For example, different indicator species could be monitored or a leachate collection and monitoring system could be used.

B.2.11 Issue 19

Comment: The draft EIS should discuss the need for restoration of the contaminated groundwater at the Weldon Spring site. At a minimum, it should discuss mitigative measures that will be used to reduce or prevent further migration of chemical or radioactive contamination in groundwater.

Response: Insufficient data were available at the time the draft EIS was prepared to address the need for restoration of contaminated groundwater. The baseline risk assessment to be performed as part of the RI/FS-EIS process for this project will evaluate the current hazards posed by the contaminated groundwater at the raffinate pits and chemical plant area. This information will be used in assessing the need for groundwater restoration. The DOE is currently evaluating the mechanisms responsible for groundwater contamination at the raffinate pits and chemical plant area and is developing plans to ensure the safety of nearby potable water supplies. The need for groundwater restoration at the quarry will be addressed following removal of the bulk wastes.

B.2.12 Issue 20

Comment: The technology to isolate the wastes from the environment for the length of time that the wastes will be hazardous does not exist. Considering the half-lives of the radionuclides in the Weldon Spring wastes, the design life of 200 to 1,000 years is very short.

Response: Isolation of the wastes from the human environment can only be ensured through implementation of a properly designed and managed waste disposal program consisting of good engineering design, periodic monitoring and maintenance, and institutional controls. Use of a passive containment system (i.e., one not reliant on active maintenance), along with a planned monitoring and maintenance program and controls to site access, should provide for effective isolation of these wastes from the nearby environment. The 200- to 1,000-year design life for the containment system was selected to be consistent with the time frames identified by the EPA for management of inactive uranium mill tailings, which also consist of low concentrations of very long-lived naturally occurring radionuclides.

B.3 SITE CHARACTERIZATION AND SUITABILITY

B.3.1 Issue 21

Comment: The geology of the raffinate pits and chemical plant area is very complex and has not been thoroughly characterized. In addition, the geology of this area is such that long-term containment of wastes is not possible. Developing a disposal facility in an area of karst geology is not appropriate because this type of geology consists of numerous voids. The area is prone to sinkholes, solution channels, and geological instabilities.

Response: The DOE is in the process of conducting a thorough geological study of the raffinate pits and chemical plant area, the results of which will be provided in the RI report. The environmental assessment given in the RI/FS-EIS will be based upon information obtained from the detailed site characterization activities currently being conducted. No large voids have been observed in the bedrock as a result of characterization activities conducted to date. (See also Response to Issue 9, Section B.2.1.)

B.3.2 Issue 22

Comment: The raffinate pits and chemical plant area is not suitable for waste disposal because this area has numerous test wells, boreholes, and trenches that will provide additional pathways for contaminants to reach the groundwater.

Response: The geology of this area is the subject of a comprehensive, ongoing investigation (see Response to Issue 21, Section B.3.1). The raffinate pits and chemical plant area will not be used for waste disposal unless its suitability can be demonstrated. Although it is possible for test wells, boreholes, and trenches to provide pathways for contaminants, rigid protocols and procedures have been and will continue to be used to effectively eliminate this possibility (e.g., double casing of deeper wells and grouting of abandoned boreholes).

B.3.3 Issue 23

Comment: All characterization activities should be completed prior to engineering design. It is not possible to properly design a containment cell for a site that may have significant geological flaws. The containment cell must accommodate site-specific geological and hydrological characteristics.

Response: Evaluation of remedial action alternatives will utilize the RI/FS process developed by EPA for CERCLA. This is an iterative process in which site characterization (RI) activities are conducted parallel to, and have input into, the evaluation of alternatives (FS) phase. Conceptual engineering design, which occurs during the FS phase, feeds back into the RI phase as data gaps are identified for a specific technology or alternative. Conceptual design activities must therefore be initiated prior to completion of site characterization activities as required for the RI/FS-EIS. The design of any containment cell would accommodate site geological and hydrological characteristics that will be defined during the RI phase.

B.3.4 Issue 24

Comment: The raffinate pits and chemical plant area should be thoroughly characterized prior to modeling studies because the area hydrogeology is complex, consisting of features such as losing streams and springs. The on-site saturated layer may actually be a naturally occurring perched water table. Modeling studies conducted to date have not been in agreement with measured levels of contamination in groundwater at the raffinate pits and chemical plant area, indicating that there may be additional migration pathways. Local springs should be identified and analyzed for chemical contaminants. All surface water/groundwater connections at the Weldon Spring site should be identified.

Response: The DOE is currently characterizing the local hydrogeology and is working with the Missouri DNR to accurately identify the losing streams and springs in the area. The Missouri DNR expertise in conducting dye studies should be very helpful in identifying surface to subsurface water connections. The baseline risk assessment, an integral component of the RI/FS-EIS process, will address the risks associated with the contamination currently at the site and the various pathways to the potential receptors. The RI/FS-EIS will not be issued until all site characterization activities have been completed. Modeling studies to support the RI/FS-EIS process will be calibrated against current contamination conditions at the site.

B.3.5 Issue 25

Comment: The volumes and concentrations of contaminants in the waste materials must be thoroughly characterized for both radioactive and chemical species. The data presented in the draft EIS do not present sufficient detail to justify the calculations performed.

Response: The waste materials will be characterized for both radioactive and chemical species as part of the RI phase. This information will be used to determine the volumes, physical properties, specific contaminants, and hazards of the waste materials currently located at the Weldon Spring site. This information will be included in the draft RI/FS-EIS issued for public comment.

B.3.6 Issue 26

Comment: Site-specific data are needed regarding soil engineering (physical) and ion-exchange (chemical) properties and the depths of clay layers.

Response: The DOE agrees that additional site-specific data are needed to understand migration potential and to ensure that, if a containment cell is located on-site, it would be properly designed and constructed. The DOE is planning to obtain these data as part of the RI process. This information will be obtained, in part, from ongoing characterization activities. Additional data will be collected as needed.

B.3.7 Issue 27

Comment: Statements made in the draft EIS that the Weldon Spring site is located in a tectonically quiet region are incorrect. It is very likely that a significant earthquake will occur in this area in the near future.

Response: The DOE is reevaluating current data regarding the potential for seismic events that could affect the Weldon Spring area. This information will be given in the RI report. A design-basis seismic event will be defined for the Weldon Spring site. Alternatives for on-site disposal will be assessed for their ability to withstand such an earthquake without compromising the integrity of the containment cell.

B.4 ENVIRONMENTAL IMPACTS

B.4.1 Issue 28

Comment: The draft EIS should include worst-case scenarios in which either mitigative measures or engineered structures fail.

Response: The RI/FS-EIS will include an assessment of the environmental impacts associated with scenarios in which either mitigative measures or engineered structures fail. However, judgment will be used to ensure that this assessment is reasonable, i.e, only reasonably foreseeable scenarios will be evaluated.

B.4.2 Issue 29

Comment: Use of meteorological data from Lambert Airport in St. Louis to assess impacts at the Weldon Spring site may be inappropriate because the airport is about 48 km (30 mi) from the site. Data should be used that can be obtained from closer sources, such as the National Weather Service station in St. Peters. Additionally, the draft EIS should include the wind rose used in these calculations.

Response: Meteorological data will be obtained from a source closer to the Weldon Spring site than Lambert Airport. In addition to the National Weather Service station at St. Peters, data could be obtained from other points closer to the site. Current plans are to construct an on-site meteorological station, projected to be operational in late 1988. As the meteorological information provided by this station becomes available, it will be used in the RI/FS-EIS process. A 1985 annual wind rose for the Weldon Spring site is included as Figure 11 of this work plan.

B.4.3 Issue 30

Comment: The draft EIS must include the health impacts of all radioactively and chemically hazardous substances at the site. These impacts should not be limited to humans only, but should consider all living organisms. This is especially true because certain organisms, which may be eaten by humans, are known to concentrate certain radionuclides. Biouptake studies on local wildlife -- such as wild turkeys, geese, deer, largemouth bass, and algae -- should be performed as part of this project.

Response: One of the first steps in the baseline risk assessment is to identify the significant chemical and radioactive species at the Weldon Spring site with regard to potential health risks to nearby individuals. These indicator compounds -- which are selected on the basis of their abundance at the site, their toxicity to human health, and their mobility in the environment -- will be included in the analyses given in the RI/FS-EIS. The means by which these indicator compounds can move through the environment to potential human receptors, including their uptake by plants and animals in the human food chain, will be assessed in the RI/FS-EIS. The environmental impact analysis presented in the RI/FS-EIS will address the effects of radioactive and chemical contaminants on the local ecosystem. Biouptake studies are currently being performed on local wildlife (e.g., fish, squirrels, and rabbits), and the results will be reported as they become available. Biouptake studies on other wildlife -- such as wild turkeys, geese, and deer -- will not be performed unless studies of indicator animals determine such a need.

B.4.4 Issue 31

Comment: The DOE should reexamine its calculations of radiation doses because the projected doses are too low to be believable. Specific considerations include (1) the respirable fraction of dust, (2) the doses to internal organs from inhalation of radioactive particulates and radon gas, as well as the doses due to external exposure, and (3) the effect of alpha emitters being 20 times more hazardous than beta radiation. Specific concern should be given to exposure from radon gases (i.e., radon-219, radon-220, and

radon-222) because radon is estimated to cause 20,000 to 30,000 lung cancer deaths per year.

Response: The radiation doses in the draft EIS take into account all of the issues presented in this comment. However, DOE is intending to thoroughly reevaluate the estimation of radiation doses based upon the detailed site characterization activities currently being performed. Radon-219 is not a significant contributor to radiation exposure relative to radon-220 and radon-222 at the Weldon Spring site because of the low abundance of radionuclides that give rise to radon-219 and its very short half-life (approximately four seconds).

B.4.5 Issue 32

Comment: Because children are much more susceptible to radiation-induced illnesses than adults, the draft EIS should specifically address the potential doses and resultant health effects relative to children. Exposure to toxic substances should be addressed in a similar fashion. Both short-term and long-term health effects on children must be evaluated.

Response: The RI/FS-EIS will consider the toxicity of radionuclides and chemically hazardous substances on children. Data on age-specific effects will be used to the extent that they are available. Both short-term and long-term health effects on children will be assessed.

B.4.6 Issue 33

Comment: There is no safe level of radiation exposure. All exposures must be regarded as deleterious. Impacts include decreased life expectancy, genetic defects, and cancer. It should be noted that radionuclides can concentrate in certain organs, resulting in long-term radiation exposure. The people most susceptible to radiation-induced cancer are children and the elderly. The latency period for cancer induction can vary greatly in the general population.

Response: It is the policy of DOE to maintain all exposure to radiation at levels that are "as low as reasonably achievable" (ALARA). The DOE considers all radiation exposure above background to be hazardous and intends to minimize the doses incurred by both workers and the general public. The major health impacts to be addressed are cancer and genetic defects. Other impacts such as decreased life expectancy are very difficult to quantify but will be addressed to the extent possible. The calculation of radiation doses will consider organ uptakes, latency periods, and the greater susceptibility of children and the elderly.

B.4.7 Issue 34

Comment: The incidence of cancer in St. Charles County is greater than that expected in the general population. Although these data have not been substantiated by

the scientific community, they do represent a reason for concern. Specific forms of cancer that have been documented in this area include leukemia and testicular cancer. Releases from the Weldon Spring site could be responsible for these cancers. Even if the site is not responsible for past cancers, it is imperative that the site be remediated so that it is not responsible for any new cases of cancer.

Response: The incidence of cancer in St. Charles County is not greater than that in other parts of the United States. The Missouri Department of Health recently completed a retrospective study of childhood leukemia in the vicinity of the Weldon Spring site. Although this study indicated an increased level of childhood leukemia cases during the period 1975-1979, the incidence rate over the entire period of the study (i.e., 1970-1983) was not statistically different from that to be expected in the general population. The Department of Health was not able to establish a link between these leukemia cases and any specific causes. The DOE is committed to conducting the Weldon Spring Site Remedial Action Project in a manner that will minimize the likelihood for any deleterious health impacts. (See also Response to Issue 52, Section B.5.10.)

B.4.8 Issue 35

Comment: The draft EIS must explicitly evaluate the potential health impacts of response action activities on students and staff at Francis Howell High School, staff and visitors at the St. Charles County Extension Center, and residents in nearby communities such as Weldon Spring Heights. The DOE should relocate these facilities at government expense if it cannot be shown, with absolute assurance, that people using these facilities and nearby residents will be safe during conduct of response action activities at the Weldon Spring site.

Response: The impacts on nearby residents, the students and staff at Francis Howell High School, and the staff and visitors at the St. Charles County Extension Center will be explicitly evaluated in the RI/FS-EIS. All data and calculations to date show a very low risk to nearby individuals from proposed response action activities at the Weldon Spring site. (See also Responses to Issues 52 and 53 in Sections B.5.10 and B.5.11, respectively.)

B.4.9 Issue 36

Comment: The draft EIS does not accurately describe local groundwater users in the vicinity of the site. The St. Charles Countians Against Hazardous Waste (SCCAHW) has completed a survey of private wells in this area. This information, which indicates that many private wells in the area are drawing water from the shallow Burlington-Keokuk aquifer, was not incorporated in the draft EIS. Instead, the draft EIS lists only municipal and water district supply facilities. St. Charles County also contains subdivisions, mobile home parks, and institutions that are classified as users of public water supplies. Failing to use this information greatly underestimates the impact of this project on local groundwater supplies. The EIS should address actual water users.

Response: The DOE greatly appreciates the information supplied by the SCCAHW and the state of Missouri on nearby users of groundwater. This information has been very helpful to DOE in assessing the hazards associated with the groundwater contamination discovered in 1987 in the vicinity of the raffinate pits and chemical plant area. The data supplied by the SCCAHW and the state of Missouri will be used in the RI/FS-EIS to assess the environmental impacts of alternatives developed for detailed study.

B.4.10 Issue 37

Comment: The groundwater modeling results at the raffinate pits and chemical plant area are incorrect. The model used is too simple to adequately address the complex hydrogeology of this area. Nonuniform geology, possible barrier degradation, and flow through fractures and solution-enlarged cavities are factors that cannot be accurately or adequately considered using current modeling techniques. The modeling results performed to date do not agree with field-observed data.

Response: The DOE intends to conduct additional detailed groundwater modeling studies at the raffinate pits and chemical plant area following collection of relevant data. These results will be included in the RI/FS-EIS, as appropriate. Prior to performing these studies, the site geology will be thoroughly characterized. The modeling results will be calibrated to current measurements of radioactive and chemical contamination of the groundwater in the raffinate pits and chemical plant area. This should ensure that the modeling results are a reasonable representation of current conditions and can provide a meaningful estimation of future conditions.

B.4.11 Issue 38

Comment: The draft EIS underestimates the potential impact of increased use of nearby roads during response action activities on nearby facilities such as Francis Howell High School. There is a lot more traffic at the school than the draft EIS implies. In addition, contingency measures should be in place to respond to traffic accidents (such as an overturned truck transporting contaminated materials) and resultant releases of contaminants to the environment.

Response: The intersection of Missouri (State) Route 94 and U.S. Route 40/61 is very busy, especially during the morning and evening rush hours. There is also a lot of traffic at Francis Howell High School during the periods when students arrive for classes in the morning and depart in the afternoon. The DOE will coordinate all traffic associated with response action activities to minimize impacts on nearby facilities. The DOE will also require all subcontractors to develop contingency measures to deal with potential traffic accidents involving trucks transporting contaminated materials. (See also Response to Issue 51, Section B.5.9.)

B.4.12 Issue 39

Comment: The draft EIS states that the nonradioactive hazardous wastes will be transported to and disposed of at a RCRA-licensed hazardous waste facility. However, the draft EIS does not address the environmental impacts of handling and transporting the wastes.

Response: The DOE intends to dispose of all nonradioactive hazardous wastes off-site at a RCRA-licensed hazardous waste facility. The location of the facility cannot be identified until the characteristics of the wastes have been determined by the detailed waste characterization activities currently being performed by DOE. Also, because DOE is planning to perform various IRAs prior to the ROD, it is likely that much of the nonradioactive hazardous waste will be disposed of prior to the completion of the RI/FS-EIS. The environmental impacts associated with the handling and transportation of chemically hazardous wastes will be addressed in EE/CA reports or in the RI/FS-EIS, as appropriate.

B.4.13 Issue 40

Comment: The draft EIS understates the impacts of population growth in St. Charles County because most of this growth is in the direction of the Weldon Spring site. As population growth in this area continues, waste storage may prove to be a poor choice of land use. The draft EIS should include projected population estimates and a population distribution chart showing the population by sector and distance from the site.

Response: The RI/FS-EIS will include a population distribution chart showing the population by sector and distance from the site. The impact of population growth and local land use will be included for the various alternatives in the RI/FS-EIS. Projections of population growth are difficult to quantify beyond the near term because such growth is influenced by factors that cannot be estimated with any degree of precision (e.g., local economic growth and changes in land use patterns). The impacts of population growth will be assessed to the extent feasible.

B.4.14 Issue 41

Comment: The draft EIS does not adequately address the impact of the Weldon Spring site on current and long-term real estate values.

Response: The DOE is not planning to study the impact of the Weldon Spring site on local real estate values because such values can be affected by numerous factors. It is not possible to quantify the impact of the Weldon Spring site independently of other factors, such as population growth and local employment opportunities. Hence, it does not seem reasonable to address this issue in the RI/FS-EIS.

B.4.15 Issue 42

Comment: The DOE should consider the interim impacts of response action activities at the Weldon Spring site on adjacent lands owned by the Missouri Department of Conservation and should ensure that these activities will accommodate future public uses of surrounding lands and waters (including Lakes 34, 35, and 36 in the Busch Wildlife Area).

Response: The DOE will address interim impacts of response action activities in either EE/CA reports for IRAs (see Section 3.10 of this work plan) or in the RI/FS-EIS for the project. The DOE is committed to implementing response actions at the Weldon Spring site in a manner that will permit future public use of surrounding lands and waters.

B.5 SCOPE AND CONDUCT OF REMEDIAL ACTION ACTIVITIES

B.5.1 Issue 43

Comment: All areas in the vicinity of the Weldon Spring site that are contaminated with radioactive and chemical substances originating from the Weldon Spring site should be cleaned up. This includes soils, drainageways, Femme Osage Slough, and lakes and springs in the Busch Wildlife Area. At a minimum, all such areas should be clearly marked to warn people of these hazards.

Response: The DOE intends to clean up all areas in the vicinity of the Weldon Spring site for which it has responsibility that pose an unacceptable risk to public health and the environment. The DOE is continuing to work with the U.S. Department of the Army to identify off-site areas contaminated as a result of Army activities. The responsibility for cleanup of these areas rests with the Army. The DOE will inform the Missouri Department of Conservation of all contamination originating from the site that is detected in the wildlife areas administered by that department.

B.5.2 Issue 44

Comment: All of the wastes should be removed from the Weldon Spring site. This was done at the Vitro site in Salt Lake City, under similar circumstances. Under no conditions should additional wastes be brought to this site for disposal.

Response: The preference for total removal of the wastes from the Weldon Spring site is noted. The basis for the DOE decision relative to the Vitro site is provided in the ROD for remedial action at that site (U.S. Dept. Energy 1984). The DOE has no plans to move additional wastes to the Weldon Spring site for disposal.

B.5.3 Issue 45

Comment: The Weldon Spring site is responsible for current groundwater contamination. Of major concern is the quarry, which is located in very close proximity to the St. Charles County well field that supplies potable water for much of St. Charles County. Radioactive and chemical contaminants have been detected in monitoring wells between the quarry and the county wells. The groundwater in the raffinate pits and chemical plant area is also contaminated with nitrates, trinitrotoluene (TNT), and dinitrotoluene (DNT). The federal government should test all local water supplies in the vicinity of the Weldon Spring site to ensure the safety of local citizens.

Response: The DOE concurs that the Weldon Spring site is responsible for local groundwater contamination. The environmental monitoring program at the raffinate pits and chemical plant area and at the quarry includes many wells to monitor the status of groundwater contamination. One of the major components of the RI/FS-EIS will be an evaluation of the hazards posed by this contamination at the raffinate pits and chemical plant area. The DOE is planning to remove the bulk wastes from the quarry prior to the ROD to minimize the potential for increased groundwater contamination at the quarry (see Section 3.11 of this work plan). Removal of the source of this contamination should be an effective means of lowering the rate at which radioactively and chemically hazardous substances enter the groundwater in the area. The possible need to remediate the groundwater at the quarry will be addressed in the future (see Response to Issue 47, Section B.5.5). The DOE has tested several private wells in the proximity of the raffinate pits and chemical plant area and has found no contamination. The state of Missouri is responsible for ensuring that the water supplies in the vicinity of the Weldon Spring site are safe and has been carrying out this responsibility.

B.5.4 Issue 46

Comment: The draft EIS should provide specific details on how contaminated water will be treated prior to disposal. Of specific concern is the discharge of any contaminated water into the Missouri River because this is upstream of the water intakes for St. Louis City and St. Louis County. In addition, the state of Missouri has specific requirements for wastewater discharges that must be met.

Response: The DOE is addressing the treatment of contaminated water at the raffinate pits and chemical plant area and at the quarry as IRAs (see Sections 3.10.2.15 and 3.10.2.16 of this work plan). The treatment techniques to be used will be addressed in EE/CA reports prepared to support these actions. A major component of the EE/CA process will be determination of effluent limits and conditions of discharge. The DOE is working with the EPA Region VII and the Missouri DNR in developing these actions.

B.5.5 Issue 47

Comment: The DOE should commit to restoration of contaminated groundwater at both the raffinate pits and chemical plant area and the quarry.

Response: The need for groundwater restoration at the raffinate pits and chemical plant area will be addressed as part of the RI/FS-EIS process. Analysis of the groundwater contamination issue at the quarry will be addressed in a separate, but similar, process in the future. The DOE intends to address this issue for the quarry following removal of the bulk wastes and collection of sufficient data to allow for an objective decision to be made.

B.5.6 Issue 48

Comment: It is important to minimize the airborne release of radioactive particulates during response action activities. Use of water sprays during soil excavation may not be sufficient. All sources of dust should be addressed, e.g., from construction activities, building demolition, and/or truck traffic. Plans for detecting and minimizing dust releases should be developed prior to initiation of response action activities. In addition, all pertinent plans (i.e., those that address monitoring, response action, and waste storage) should be provided to the public.

Response: Use of water sprays has been shown to be an effective means of minimizing the amount of airborne particulates released during response action activities at similar sites. An aggressive environmental monitoring program will be implemented during construction-related activities to ensure a safe environment for workers and the nearby population. This program will rely primarily on air particulate monitors. All activities having the potential to generate airborne particulates will be reviewed to ensure that mitigative measures are in place prior to the initiation of field activities. The DOE intends to present its plans for conducting response action activities to the public. Included in these plans will be measures to minimize airborne particulate releases.

B.5.7 Issue 49

Comment: An important component of a remedial action plan is a determination of the mitigative measures that will be used to reduce environmental impacts. All potential exposure pathways must be identified and mitigative measures evaluated. Such mitigative measures should be detailed early in the process to allow for public review and comment.

Response: The DOE agrees that a comprehensive plan of mitigative measures is important to ensure that environmental impacts are minimized. Mitigative measures will be identified as specific actions are defined. These mitigative measures will address all potential exposure pathways. The public will have an opportunity to comment on these mitigative measures via the EE/CA and RI/FS-EIS processes.

B.5.8 Issue 50

Comment: The environmental monitoring program to be used must be defined at this time. This monitoring program should not only be in effect during the action period

but should also be maintained long after remedial action has been completed. Results of the monitoring program should be provided to local citizens upon request.

Response: The DOE currently has in place an environmental monitoring program consistent with DOE requirements. The results of this program are available to the public upon request. The DOE publishes an annual environmental monitoring report for the Weldon Spring site in May of each year. The environmental monitoring program for the project will be reevaluated annually to ensure that monitoring activities are commensurate with ongoing and planned activities. The monitoring program to be used during remedial action activities will be defined in the RI/FS-EIS process and will address both the action period and the period following completion of remedial action (see also Response to Issue 17, Section B.2.9).

B.5.9 Issue 51

Comment: Contingency plans must be developed to allow for quick enactment of emergency response measures in the event of an accidental release either on-site or during transportation off-site.

Response: The DOE has an emergency preparedness plan in place that is consistent with DOE requirements. This plan details the procedures to be used in case accidental conditions occur that could impact nearby individuals. The major thrust of the plan is immediate response and timely notification of local authorities responsible for protecting the health and welfare of the nearby population.

B.5.10 Issue 52

Comment: The DOE should establish a trust fund for an insurance program to pay medical expenses of local residents for treatment of diseases and illnesses that might be caused by exposure to radioactively and chemically hazardous substances at the Weldon Spring site. In addition, DOE should finance periodic medical monitoring of the students, faculty, and staff at Francis Howell High School.

Response: The DOE has in place an environmental monitoring program to assess the concentrations of radioactive and chemical contaminants in the nearby environment. The results to date do not indicate that releases from the Weldon Spring site could be responsible for any deleterious health effects. The monitoring program will continue for the duration of the project. The Missouri Department of Health recently completed a retrospective study of childhood leukemia in the vicinity of the Weldon Spring site and was unable to establish a link between these leukemia cases and any specific cause (see Response to Issue 34, Section B.4.7). Based on this information, there is no basis to perform periodic medical monitoring of the students, faculty, and staff at Francis Howell High School or to establish an insurance trust fund.

B.5.11 Issue 53

Comment: The DOE should conduct a comprehensive health study of individuals who live in the vicinity of the Weldon Spring site.

Response: The DOE does not believe that it is necessary to conduct a comprehensive health study of nearby residents. An environmental monitoring program is in place to measure the concentrations of radioactive and chemical contaminants in the local environment. Results of this monitoring program can be used to identify potential impacts of the project on the local environment. Additionally, the retrospective health study conducted by the Missouri Department of Health did not uncover any reasons to suspect that the Weldon Spring site has been responsible for an increased incidence of cancer in this area. The health impacts of remedial action activities will be included in the RI/FS-EIS. In addition, the Agency for Toxic Substances and Disease Registry will perform a public health assessment for this project. (See also Response to Issue 52, Section B.5.10.)

B.5.12 Issue 54

Comment: The citizens of St. Charles County deserve to have the Weldon Spring site cleaned up by the best available technology, regardless of cost. Cost should not be the overriding factor in decisions regarding the conduct of the remedial action project.

Response: The DOE is accountable to the taxpayers of this country. Therefore, DOE must consider costs in its decision. The cost of the project will be a factor, but not the overriding factor, in selecting an alternative. The most important factors to be considered will be the health and safety of persons potentially impacted by the project.

B.5.13 Issue 55

Comment: The DOE should do everything possible to maintain the viability of the rail transportation option. The impact of abandonment of the Missouri-Kansas-Texas (MKT) rail line between Machens and Sedalia, Missouri, should be addressed. The DOE should try to ensure the usability of this abandoned line.

Response: The issue of abandonment of the MKT rail line between Machens and Sedalia is beyond the scope of DOE's responsibility. The abandonment was approved by the Interstate Commerce Commission.

B.5.14 Issue 56

Comment: Alternative 3a in the draft EIS (disposal of the Weldon Spring wastes at the Hanford site in the state of Washington) should not be considered a viable alternative because the Hanford site leaks and it would not accept the wastes.

Response: The DOE agrees that disposal of the Weldon Spring wastes at the Hanford site is currently not a viable option based on all factors that affect the implementability of this alternative. These factors include the likelihood that the Weldon Spring wastes would not be accepted for disposal at the Hanford site, the distance of the Hanford site from the Weldon Spring site, the volume of wastes that would be transported, and the increased health and safety risks associated with the transportation effort.

B.5.15 Issue 57

Comment: Alternative 3c in the draft EIS (transporting the raffinate pit and quarry sludges to an existing uranium-processing facility in the southwestern United States) should not be considered viable because it is unlikely that any uranium mill would accept these materials, no economic benefit would accrue, and significant transportation impacts would result.

Response: The DOE concurs that, as evaluated in the draft EIS, the negative aspects of this alternative associated with transportation impacts outweigh any positive benefits that might accrue. However, DOE is evaluating the potential for reprocessing the raffinate pit and quarry sludges at either an on-site facility or an off-site facility to recover potentially usable materials and to reduce the toxicity, mobility, and/or volume of the contaminated materials as required by CERCLA.

B.5.16 Issue 58

Comment: All DOE actions should be subject to independent oversight and inspection by an unbiased, qualified organization because DOE's record on environmental protection, health, and safety is very poor. The DOE should also consider establishing a citizens' advisory board to monitor progress on this project.

Response: The EPA Region VII is providing independent oversight of the entire project, as mandated by CERCLA. The DOE is also working with the Missouri DNR to ensure that all state concerns are addressed. The DOE has an active community relations program to ensure that local citizens are kept informed of ongoing activities.

B.5.17 Issue 59

Comment: The draft EIS is vague regarding the standards and guidelines that will be used to direct the remedial action. It is not clear if DOE will use EPA, DOE, or state of Missouri regulations, some combination of these regulations, or the most restrictive regulations where duplication occurs. The draft EIS should discuss how each alternative implements the ALARA policy of minimizing radiation exposure.

Response: Determination of ARARs is a key element of both the EE/CA and RI/FS-EIS processes. The ARARs will define the specific requirements to be followed in conducting response action activities. The DOE will conduct the ARAR process in

cooperation with EPA Region VII and the Missouri DNR to ensure that all ARARs are determined. The DOE intends to develop an ALARA dose limit (see Response to Issue 60, Section B.5.18). The alternatives in the RI/FS-EIS will be assessed relative to this ALARA value.

B.5.18 Issue 60

Comment: The limits that DOE is using to allow release of facilities and equipment for unrestricted use will result in unacceptably high doses. Additionally, the DOE limit of 100 mrem/yr committed effective dose equivalent is too high. The International Commission on Radiological Protection (ICRP) recommended this limit for exposure from all sites and sources. This value is too high for exposure of individuals from a single site that is no longer providing any benefits to the public.

Response: The criteria DOE is using to determine release limits of facilities and equipment are based on published standards of the U.S. Nuclear Regulatory Commission and the EPA. These criteria have been used previously in similar circumstances by DOE and private industry. The DOE believes that the use of previously established criteria for this project is relevant and appropriate. The DOE dose limit for the general public is 100 mrem/yr committed effective dose equivalent for prolonged exposure; in addition, the dose must be ALARA. The DOE is intending to develop an ALARA value for the Weldon Spring Site Remedial Action Project. This value will include considerations of cost, implementability, and other relevant factors. This ALARA value will likely be much lower than 100 mrem/yr. (See also Response to Issue 59, Section B.5.17.)

B.6 REFERENCE

U.S. Department of Energy, 1984, *Compliance with the National Environmental Policy Act: Record of Decision for Remedial Actions at the Former Vitro Chemical Company Site, South Salt Lake, UT*, Federal Register, *49*(201):40436-40439 (Oct. 16).

APPENDIX C:

ENGLISH/METRIC - METRIC/ENGLISH EQUIVALENTS

TABLE C.1 English/Metric Equivalents

Multiply	By	To obtain
Acres	0.4047	Hectares (ha)
Cubic feet (ft^3)	0.02832	Cubic meters (m^3)
Cubic yards (yd^3)	0.7646	Cubic meters (m^3)
Degrees Fahrenheit (°F) - 32	0.5555	Degrees Celsius (°C)
Feet (ft)	0.3048	Meters (m)
Gallons (gal)	3.785	Liters (L)
Gallons (gal)	0.003785	Cubic meters (m^3)
Inches (in.)	2.540	Centimeters (cm)
Miles (mi)	1.609	Kilometers (km)
Pounds (lb)	0.4536	Kilograms (kg)
Square feet (ft^2)	0.09290	Square meters (m^2)
Square yards (yd^2)	0.8361	Square meters (m^2)
Square miles (mi^2)	2.590	Square kilometers (km^2)
Tons, short (tons)	907.2	Kilograms (kg)
Tons, short (tons)	0.9072	Tons, metric (t)

TABLE C.2 Metric/English Equivalents

Multiply	By	To obtain
Centimeters (cm)	0.3937	Inches (in.)
Cubic meters (m^3)	35.31	Cubic feet (ft^3)
Cubic meters (m^3)	1.308	Cubic yards (yd^3)
Cubic meters (m^3)	264.2	Gallons (gal)
Degrees Celsius (°C) + 17.78	1.8	Degrees Fahrenheit (°F)
Hectares (ha)	2.471	Acres
Kilograms (kg)	2.205	Pounds (lb)
Kilograms (kg)	0.001102	Tons, short (tons)
Kilometers (km)	0.6214	Miles (mi)
Liters (L)	0.2642	Gallons (gal)
Meters (m)	3.281	Feet (ft)
Square kilometers (km^2)	0.3861	Square miles (mi^2)
Square meters (m^2)	10.76	Square feet (ft^2)
Square meters (m^2)	1.196	Square yards (yd^2)
Tons, metric (t)	1.102	Tons, short (tons)

MISSOURI DEPARTMENT OF CONSERVATION

Comment 1

Page 2-7, Figure 2.3 - The map depicts a nature trail running down the drainage ditch that flows to the Missouri River. In 1984 we relocated the trail so it no longer is in that drainage ditch.

Response to Comment 1

The nature trail has been deleted from this figure.

Comment 2

Page 2-41, Table 2.8 - Data taken from Station SW-2009, located above Burgermeister Spring, should be reported if available. If no data is available, that should be reported.

Response to Comment 2

There was no flow at this location when samples were taken. We see no need to include this explanation in the work plan since the intent of this plan is to summarize current plans for implementation of this project, not to summarize all of the results of ongoing site characterization activities.

Comment 3

Page 3-36, Paragraph 3.6.2.5 - We would strongly urge the inclusion of site B-7 in the list of areas on our property for removal of radioactive contaminated soil. Hopefully, this is an oversight and will be corrected in the next edition of this report. If there has been a decision not to remove radioactive soil from B-7, we would appreciate learning the reasons for that decision.

Response to Comment 3

Vicinity properties will be cleaned up either as interim response actions (IRAs) prior to the project record of decision (ROD) or as part of remedial actions following the ROD. Vicinity property B7 all will not be cleaned up until all potential sources of contamination that feed this drainage ditch are eliminated. This will likely not occur until the ROD has been issued. Hence, this drainage ditch will be cleaned up following the ROD and not as an IRA.

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MISSOURI DEPARTMENT OF NATURAL RESOURCES

Comment 1

Pages 1-5 through 1-11: The Weldon Spring Site Remedial Action Project is divided into five compliance components. These components do not seem to address two issues: Analysis of whether remedial action will be necessary for the soil, sediment, surface water and groundwater in the slough and nearby areas. [Note: the second issue is given in Comment 2.]

Response to Comment 1

Figures 2 and 3 have been revised to include vicinity properties at both the raffinate pits and chemical plant area and at the quarry. The text in this section has been revised to include more discussion relative to vicinity properties cleanup. The need to clean up the slough and other areas near the quarry will be included as part of the NEPA and CERCLA processes for the residual materials and groundwater restoration operable units at the quarry following bulk waste removal. Using currently available data, it is not possible to conclude that remedial action is or is not warranted in the slough and nearby areas at this time.

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Comment 2

Analysis of long-term maintenance, monitoring and security requirements. Will the U.S. Department of Energy be responsible for these long-term actions? How long will such actions be necessary and how long will federal control last? It would seem that another compliance component is needed to address these and other issues.

Response to Comment 2

Assessment of long-term maintenance, monitoring, and security requirements will be included in the RI/FS-EIS. It is not possible to address these requirements in detail at this time because long-term monitoring and maintenance requirements depends upon the alternative selected. The DOE is committed to monitoring and maintaining the disposed site for the foreseeable future. (See Section B.2.9 of the work plan for additional discussion.)

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<u>Comment 3</u>

Page 1-12, Paragraph 2: The Missouri Geological Survey (MGS) no longer exists as a separate agency; under the 1974 reorganization of Missouri state government, the MGS became the Division of Geology and Land Survey (DGLS) within the Missouri Department of Natural Resources (MDNR).

<u>Response to Comment 3</u>

Reference to the Missouri Geological Survey has been deleted. Since reference to the Missouri Department of Natural Resources (DNR) has already been included in the work plan, there is no need to highlight the Division of Geology and Land Survey over other divisions within the DNR.

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<u>Comment 4</u>

Page 1-13, Figure 1.4: Add to the functions of the MDNR "coordinate review and response of other appropriate state agencies," "independent monitoring as appropriate," and "special studies as appropriate".

<u>Response to Comment 4</u>

These functions have been added to this figure.

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<u>Comment 5</u>

Page 1-14, Paragraph 2: The location and distance between the quarry and the St. Charles County public drinking water well field should be stated.

<u>Response to Comment 5</u>

The following sentence has been added to this paragraph: "A major source of probable groundwater in this area is the county well field located about 1.6 km (1 mi) southeast of the quarry in the Missouri River alluvium (U.S. Dept. Energy 1987a)."

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Comment 6

Page 1-14, Paragraph 3: The location and distance between the Francis Howell School and the chemical plant should be stated and the daytime population of this school provided.

Response to Comment 6

The following two sentences have been added to this paragraph: "The Francis Howell High School is located about 1 km (0.6 mi) east of the raffinate pits and chemical plant area on State Route 94. An estimated 2,300 persons are on campus daily during the school year (U.S. Dept. Energy 1987a)."

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Comment 7

Page 2-8, Figure 2.4: The St. Charles County Water Treatment Plant, the village of Weldon Spring Heights, the Busch Wildlife Area headquarters buildings, the Army Reserve headquarters buildings, the Missouri Highway Department buildings, and the St. Charles County Extension buildings should be on the map since all are locations of human activities at least during the daytime hours. Also, the new University of Missouri Research Center should be located.

Response to Comment 7

The work plan has been prepared to delineate the procedures DOE intends to follow in conducting the Weldon Spring Site Remedial Action Project. This plan is not intended to be an all inclusive presentation of relevant information associated with this project. Figures identifying the locations requested in this comment will be included in future project documents such as the baseline risk assessment and the FS-EIS. Certain locations have been included in figures in the work plan as landmarks to place perspective on site locations.

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Comment 8

Pages 2-19 and 2-22: All of the above-mentioned facilities should also be discussed in the section on local land use (Section 2.2.6).

Response to Comment 8

A discussion of all the areas identified in Comment 7 has been included in the section on local land use in the work plan.

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Comment 9

Page 2-32, Table 2.4: It would be useful to summarize the Curie content by isotope and by location in this table.

Response to Comment 9

Although we could summarize the Curie content by isotope in this table, such a summation might imply a greater degree of knowledge on the extent of radioactive contamination than may actually be true at this time. It is not correct to add the Curie content for the various locations to give an overall estimate of the total Curie content because there are numerous intermediate decay products in various stages of disequilibrium (see the decay series for uranium-238 and thorium-232 given in the work plan). Hence, we have not summarized the Curie content in this table as suggested.

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Comment 10

Page 2-36, Figure 2.10: Additional subsurface connections have been demonstrated in shallow groundwater studies by MDNR. A current map can be obtained from the Division of Geology and Land Survey.

Response to Comment 10

This figure has been updated based on current information developed by the Missouri DNR.

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Comment 11

Page 2-69, Paragraphs 1 and 2: Because of the proximity of the slough to the public drinking water well field, the distribution of uranium in the soil and groundwater in this area should be better defined.

Response to Comment 11

The DOE concurs on the need to better define the distribution of uranium in soil and groundwater in the vicinity of the quarry. It is not possible to evaluate remedial action alternatives at the slough with the current level of information. We are intending to gather this data as part of the NEPA and CERCLA documentation process for the residual materials and groundwater restoration operable units following bulk waste removal from the quarry.

Comment 12

Page 3-8, Paragraph 2: The impact of the ingestion of wild foods (e.g., mushrooms, berries, nuts, etc.,) collected from the Busch and Weldon Spring wildlife areas should be considered in the discussion of potential risks. Data on the collection of these foods should be available from the Missouri Department of Conservation.

Response to Comment 12

This paragraph has been revised to read: "Exposure through ingestion of food could occur if individuals in the area grow a significant fraction of plant foods for their own consumption or if they collect and eat contaminated wild foods (e.g., mushrooms, berries, and nuts) from the surrounding wildlife areas. Exposure could also occur if there are livestock (e.g., cows) that graze in areas of contaminated soil."

Comment 13

Page 3-9, Paragraph 2: Discussion of air monitoring at the quarry should be included.

Response to Comment 13

This paragraph has been revised to read: "... Air monitoring operations by DOE have sampled for asbestos, organic vapors, and airborne radioactive particles and gases. Measurements of external gamma exposure rates have also been performed as a part of the monitoring program. Except for the quarry, measurements of both on-site (outdoor locations at the raffinate pits and chemical plant area) and off-site values of these constituents have generally been at background levels. Elevated levels of radon gas and elevated external gamma exposure rates have been measured at the quarry. However, because these levels decrease rapidly with distance, background levels are reached within a relatively short distance (i.e., within about 0.4 km [0.25 mi]).

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Comment 14

Page 3-25, Section 3.5.4: Waste reprocessing should also be evaluated relative to reducing the toxicity and mobility of the wastes.

Response to Comment 14

The first sentence in this section has been revised to read: "The feasibility of reprocessing the raffinate pit sludge will be evaluated relative to recovering resources and reducing the toxicity, mobility, and volume of the sludge."

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Comment 15

Page 4-7, Section 4.2.1: The title of this section should be "Soil Investigations for Chemical Contaminants".

Response to Comment 15

Soil investigations include sampling for both radioactive and chemical contaminants. It is not correct to revise the title as suggested. It should be noted that the text in this section discusses the radiological characterization activities conducted to date.

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Comment 16

Page 8-1: Will a separate work plan be prepared for the proposed removal of bulk wastes from the quarry? Chapter 8 has been commented on previously in my letter to EPA of May 25, 1988, regarding the position paper on "Quarry Bulk Waste Removal" and in a memo to me from Nicholas Di Pasquale on June 2, 1988. These two documents are attached.

Response to Comment 16

We are not intending to prepare a separate work plan for removal of the bulk wastes from the quarry. The information contained in the work plan relative to this proposed action is sufficient to discuss how this action will be documented and implemented. State of Missouri comments on the position paper describing this action will be considered as the work progresses.

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Comment 17

Appendix A, Implementation Plan for the FS-EIS, pages A-3 through A-5, Section A.1: MDNR supports the combining of the feasibility study and the impact statement on the assumption that all the requirements of the National Environmental Policy Act (NEPA) are met and that this combined process provides at least the same level of opportunity for public review as the NEPA process.

Response to Comment 17

All NEPA requirements will be met in the RI/FS-EIS process that will be carried out for this project. The combined process will involve the same, if not greater, opportunity for public review and input as the NEPA process.

- -

Comment 18

Page A-13: The section "Potential Chemical Impacts" contains the phrase "consistent with the state of scientific knowledge". What will be the role of other agencies such as ATSDR and CDC in determining what is the "current state of scientific knowledge"?

Response to Comment 18

We intend to involve the ATSDR, Missouri Department of Health, and all other available information sources in assessing the risks posed by the hazardous chemicals at the Weldon Spring Site. This phrase was included as a cautionary note because we are not sure of the current state of scientific knowledge relative to the risks posed by the various hazardous chemicals at the site; by contrast, the risks associated with radiation exposure are very well known.

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Comment 19

Page A-13: What geographic area will be considered in assessing the potential socioeconomic impacts?

Response to Comment 19

Potential socioeconomic impacts will be limited to the area immediately affected by the proposed action. It is not possible to define this area with a great deal of confidence at this time because the alternatives to be addressed in the FS-EIS have not yet been developed. However, we would expect the area of concern to be rather limited, i.e., within a 10-mile radius, or so, of the action.

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Comment 20

Page A-15: It should be explained whether loss of federal control is intended or permitted under current federal law. What are examples of conditions which could lead to loss of federal control?

Response to Comment 20

The DOE is responsible for monitoring and maintaining the disposal site for as long as it is necessary to demonstrate that the site does not pose an unacceptable risk to the general public. Loss of federal control will be assessed in the FS-EIS only to evaluate the hazards posed by the site following completion of remedial action activities. There are no conditions that could lead to loss of federal control under current government policies.

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Comment 21

Page A-15: It is not clear what kind of "impacts of past operations at the site" are being excluded from analysis.

Response to Comment 21

All impacts associated with activities prior to implementation of the Weldon Spring Site Remedial Action Project will not be included in the RI/FS-EIS. This includes previous use of the site by the Army for ordnance production, AEC use of the site for uranium-processing activities, and all associated activities such as disposing of waste in the quarry.

U.S. ENVIRONMENTAL PROTECTION AGENCY

Comment 1

We recommend that additional discussion on the contaminants of concern, their potential health effects, and their environmental fate be added to Section 3, Initial Evaluation. This could be accomplished through addition of appropriate subsections.

Response to Comment 1

The document has been reorganized in response to EPA comments (see the revised outline attached to these comment responses.) The requested information is included in Section 3.

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Comment 2

In addition, this section does not contain a clear data gap analysis. An additional brief subsection listing all identified data gaps would be helpful.

Response to Comment 2

See Response to Comment 1.

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Comment 3

The discussion on remedial action alternatives should be carried one step further. The text, as it stands, only identifies the categories for remedial action alternatives recommended by the National Contingency Plan. We are not suggesting that the range of potentially applicable remedial alternatives be limited at this stage, but only that they be broadly identified.

Response to Comment 3

The discussion of remedial action alternatives has been expanded to include the following six general alternatives: (1) No Action, (2) On-Site Disposal, (3) Off-Site Disposal, (4) On-Site Treatment with On-Site Disposal, (5) On-Site Treatment with Off-Site Disposal, and (6) Off-Site Treatment with Off-Site Disposal. A brief description of each of these six general alternatives has been included in the work plan.

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Comment 4

Discussions on the groundwater contamination problem are noticeably absent from Section 3. Since this document is intended as a work plan for the entire Remedial Investigation/Feasibility Study stage of the project, we recommend that this element be incorporated.

Response to Comment 4

Discussion of groundwater contamination has been included in the work plan to the extent necessary to describe how this issue relates to the overall implementation of the project. Additionally, a new subsection has been added to the Feasibility Testing Section, entitled "Groundwater Treatment" (see attached revised outline).

- -

Comment 5

Sampling and Analysis Plan Rationale presents a good cross-section of the remedial investigation phase scope of work. This section could be strengthened by discussing the status of the various field investigations.

Response to Comment 5

The current status of the field sampling investigations has been added to Section 4.2.

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Comment 6

Remedial Investigation/Feasibility Study Tasks provides only general discussions of the various tasks to be performed. These tasks should be linked, in some manner, to the actual scope of work. For instance, Subsection 5.1 should show how certain objectives of Task 1, project planning, are being satisfied by the investigations identified in Section 4. Similarly, the descriptions of other tasks, where possible, should provide approaches specific to this project.

Response to Comment 6

Cross references to other sections of the work plan have been added to Section 5.

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Comment 7

Schedules should be expanded slightly to include the major field investigations. Also, the schedules should indicate key dependencies between related field activities. In particular, it should be demonstrated how activities related to interim storage of the quarry wastes will mesh with other activities in the chemical plant area.

Response to Comment 7

The schedules have been expanded to provide the requested information.

- -

Comment 8

Project Management could be improved if the organization chart were to link the various tasks described in Section 5 to the responsible organization.

Response to Comment 8

The responsibilities of each organization have been added to Section 7.2. However, these responsibilities have not been directly linked to the fifteen tasks in Section 5 since there is a significant amount of overlap of contractor responsibilities relative to these tasks.

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Comment 9

Proposed Removal of Bulk Wastes from the Quarry appears to be out of place. We believe that description of this action, being a remedial action alternative, would be appropriately incorporated into Section 3.

Response to Comment 9

The discussion has been moved to Section 3 (see attached revised outline).

U.S. DEPARTMENT OF ENERGY
ENVIRONMENT, HEALTH AND SAFETY

Comment 1

Page 1-4, second paragraph: State that "In their review ... 'EPA believed' rather than 'EPA determined'."

Response to Comment 1

The sentence in questions has been deleted.

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Comment 2

Page 1-5, first paragraph: State that "The DOE and EPA have agreed ..." rather than "have determined".

Response to Comment 2

The sentence has been revised as suggested.

- -

Comment 3

Page 1-5, first paragraph and elsewhere in the document: Refer to the integrated document as an RI/FS-EIS, not an FS-EIS.

Response to Comment 3

The work plan has generally been revised as suggested. However, there are some sections in the work plan where it is more correct to refer specifically to the RI or FS-EIS, e.g., screening of alternatives occurs in the FS-EIS, not the RI.

- -

Comment 4

Page 1-5, second paragraph and elsewhere in the document: Appendix A should be referred to as an EIS Implementation Plan Supplement, or a similar title, because Appendix A does not stand alone as an implementation plan.

Response to Comment 4

The title to Appendix A has been revised to read: "Work Plan Supplement." The sentence on which this comment is based has been revised to read: "The second part of this document (Appendix A) augments the information given in the body of the RI/FS-EIS work plan and contains information necessary to ensure compliance with DOE procedures for preparation of an EIS. This appendix was prepared in accordance with DOE guidance for an EIS implementation plan.

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Comment 5

Page 1-6, and many other places in the document, e.g., page 3-26, Appendix A, and particularly Appendix B: Current discussions presume disposal of raffinate pit and other waste, and creation of a disposal cell on site, yet elsewhere (e.g., page 3-13) in-situ treatment options are outlined and assessment of them is promised. Because the possibility exists that some waste could be stabilized in place (and the remaining volume of waste might be small enough to be taken to an existing DOE disposal site??), discussions of the need for a new disposal cell and disposal cell design and siting should be tentative.

Response to Comment 5

It is important to note that disposal of contaminated materials must occur under all scenarios. Whether this disposal occurs in-situ, in a new on-site disposal cell, or at an off-site facility has not yet been determined, but is the subject of the RI/FS-EIS process. The discussion of waste disposal in Appendix B is in response to comments on the draft EIS. Because waste disposal was the central element of the draft EIS, it is reasonable to expect a large number of comments on this issue. The work plan has been revised to address the issue of waste disposal in a more tentative manner where possible.

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Comment 6

Page 1-7, third paragraph, and elsewhere in the document: The focused FS should be referred to as an RI/FS-EA.

Response to Comment 6

The second sentence in this paragraph has been revised to read: "The DOE is proposing to address bulk waste removal as a separate operable unit and will prepare a separate RI/FS and environmental assessment (EA) to support this decision (see additional discussion in Section 3.11 of this work plan)."

- -

Comment 7

Page 1-8, second paragraph (see also pp. 3-28 through 3-44): In this paragraph, off-site properties that DOE will consider for cleanup are only described as "vicinity properties" or those with radioactive contamination. Elsewhere in the document, DOE's responsibility for chemical contamination is indicated (e.g., page 2-29). Discussion of DOE's responsibilities for off-site areas should be clarified and made consistent.

This paragraph should also be revised to indicate that impacts of vicinity property cleanup will be addressed in the RI/FS-EIS or in an EE/CA-NEPA document. Discussion should be explicit as to when and in what documentation (1) the need for and impacts of cleanup of vicinity properties associated with the quarry, the raffinate pit/chemical plant surface contamination, and the chemical plant area groundwater contamination will be presented and (2) the cumulative impacts from cleanup of surface-contaminated and groundwater-contaminated vicinity properties in the raffinate pit/chemical plant area. The discussion should also address coordination with the Army.

Response to Comment 7

The following paragraph has been added to Section 1.1: "Several areas in the vicinity of the raffinate pits and chemical plant area and the quarry, but outside of current fenced boundaries, are radioactively and chemically contaminated as a result of activities previously carried out at the Weldon Spring site. These contaminated areas are termed vicinity properties. The DOE has responsibility for the contaminated vicinity properties associated with previous uranium-processing activities conducted at the site. This contamination consists of radioactive constituents (i.e., uranium, thorium, and radium) and any chemicals associated with the processing of these materials. The DOE is also responsible for any chemical contamination that is mixed with radioactive contamination. The U.S. Department of the Army is responsible for contamination on vicinity properties resulting from its previous ordnance production activities. The DOE is continuing to work with the Army in identifying off-site areas contaminated as a result of Army activities. To minimize disturbance of the environment, DOE will coordinate the cleanup of vicinity properties with the Army."

The following paragraph has been added to Section 1.2: "Of the vicinity properties for which it is responsible, DOE is planning to clean up those that pose an unacceptable risk to the general public. Management of the resulting contaminated materials will be included in the record of decision (ROD) for disposition of the raffinate pits and chemical plant area (including the bulk quarry wastes). Appropriate NEPA and CERCLA compliance documentation will be prepared prior to cleanup of the vicinity properties. Those vicinity properties cleaned up prior to the ROD will be addressed per the modified engineering evaluation/cost analysis (EE/CA) process discussed in Sec. 3.10.1. The cleanup of any remaining vicinity properties at the raffinate pits and chemical plant area will be included in the RI/FS-EIS. A thorough study of the need for additional cleanup of vicinity properties in the quarry area will be included as part of the NEPA and CERCLA processes for the residual materials and groundwater restoration operable units at the quarry."

Comment 8

Page 1-9: Add chemical plant/raffinate pit and quarry vicinity property wastes to the diagram.

Add "completed before the ROD" to the footnote, as this waste removal is part of the EIS.

Response to Comment 8

Figures 2 and 3 have been revised to include vicinity properties at the raffinate pits and chemical plant area and the quarry. The footnote to Figure 3 has been deleted since the environmental compliance process for the quarry bulk waste removal action has been described in sufficient detail in other sections of the work plan.

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Comment 9

Page 1-11, first paragraph: An assessment of long-term impacts is also needed for the no-action alternative.

Response to Comment 9

The sentence in question has been deleted. The sentence had been included previously to indicate how the baseline risk assessment (which can be viewed as the final stage of the site characterization process) would feed into the analysis of alternatives phase of this process. This is now a moot point because the documentation process is being referred to as an RI/FS-EIS, not an RI and FS-EIS.

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Comment 10

Page 1-12, second line: Delete "the state of Missouri".

Response to Comment 10

The phrase "the state of Missouri" has been deleted as suggested.

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Comment 11

Page 1-13: Add DOE Headquarters to the chart.

Response to Comment 11

This figure is included to illustrate how the various governmental entities will interface on a working level. It does not seem necessary to add "DOE Headquarters" to this chart because it would then be necessary to add "EPA Headquarters", "Governor," etc. for consistency. A breakdown of DOE responsibility is given in Figure 7.1.

- -

Comment 12

Page 2-3, second paragraph: Clarify whether the waste in the raffinate pits is by-product or source and special nuclear material.

Response to Comment 12

The waste in the raffinate pits is by-product material by definition because it is largely material resulting from the extraction of uranium or thorium from an ore processed primarily for its source material content [10 CFR Part 40.4 (a-1)]. However, the paragraph in question has not been revised since it is an accurate representation of historical information.

- -

Comment 13

Page 2-24, third paragraph: Address whether the mussels could be found in the vicinity properties.

Response to Comment 13

The following sentence has been added to the end of this paragraph: "The mussel species would not be found in any of the aquatic areas that may be designated for response action (e.g., ponds, lakes, ditches, and drainageways) because their habitat is limited to larger rivers."

- -

Comment 14

Page 2-27, last paragraph: Explain how the Target Compound List compares to the Priority Pollutant List (e.g., see page 2-33).

Response to Comment 14

The primary difference between these two lists are the points of authority and the purpose for which they were developed. The Target Compound List (TCL), formerly known as the Hazardous Substance List, was developed under CERCLA for remediation of uncontrolled hazardous waste sites. The compounds on the TCL are given in 40 CFR Part 302.4. Priority pollutants were created to limit the concentrations allowed for discharge in industrial wastewaters. Priority pollutants were identified in response to a June 7, 1978, court settlement, which has commonly been referred to as the "EPA Consent Decree." Currently, it is proposed to remove about 43 chemicals from this list. Current and future studies will utilize the TCL. However, because historical information referenced priority pollutants, we need to accurately cite this information. We do not believe that it is necessary to include this discussion in the work plan.

- -

Comment 15

Page 2-43, first and second paragraphs: Provide a citation for the studies in which contamination has "recently been detected".

Response to Comment 15

Reference to the Water Quality Phase I Assessment has been added to the paragraph describing nitroaromatic contamination in surface waters. The other sentence in question has been deleted.

- -

Comment 16

Pages 2-46 and 2-47: Provide units.

Response to Comment 16

The units have been added to the figures. The nitrate concentrations are in mg/L as nitrate and the sulfate concentrations are in mg/L.

- -

Comment 17

Pages 2-72 through 2-74: Correct inconsistency between text (11 contaminated areas) and figure (17 areas), and explain how the 7 nondrainageway areas and 3 drainageway areas fit into the count.

Provide the criteria for unrestricted areas.

Response to Comment 17

The inconsistency in the work plan resulted from discussing areas that had been "designated" for remedial action (i.e., 11 contaminated areas) and all contaminated areas identified to date in the vicinity of the Weldon Spring Site (17 areas). The text has been revised to discuss all contaminated areas, and references to unrestricted use criteria have beem deleted because these criteria will be developed as part of the RI/FS-EIS process. The discussion of nondrainageway and drainageway areas has been revised for consistency with the rest of this section.

- -

Comment 18

Page 3-6, change the first sentence in Section 3.2.2 to read "all potential receptors" rather than "human receptors".

Response to Comment 18

The sentence has been revised as suggested.

- -

Comment 19

Page 3-8, first sentence, second paragraph: Clarify.

Response to Comment 19

The sentence has been revised to read: "Direct contact with contaminated materials is a hazard only in areas were contamination is immediately accessible (e.g., in soil and water)."

- -

Comment 20

Page 3-11: Add another bullet to read "terrestrial plant and animal populations and aquatic organisms."

Response to Comment 20

The following bullet has been added to this section: "Terrestrial and aquatic organisms." Although terrestrial plants can be impacted by remedial action activities, we do not view these as potential receptors as discussed in the work plan.

- -

Comment 21

Pages 3-15 and 3-16: If ocean disposal can be eliminated from any further consideration in the RI/FS-EIS process, so indicate.

Response to Comment 21

The ocean disposal alternative will likely be eliminated during the development and screening of alternatives phases of the RI/FS-EIS process. Ocean disposal cannot be dismissed from further consideration at this time.

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Comment 22

Page 3-17, Section 3.4.2.3: Cite Figure 6.1 [5.1?] for the definition of FS phases.

Response to Comment 22

Reference to Phase I of the FS-EIS process has been deleted from this sentence.

Comment 23

Page 3-28, second line: Define lixiviant.

Response to Comment 23

A lixiviant is a solution applied to an ore or other material to extract the soluble component by washing or percolation. The word "lixiviant" has been changed to "solution" for clarity.

Comment 24

Pages 3-28 through 3-44: All IRAs planned should be identified in the work plan (e.g., the 2/24/88 letter from Nelson to Wagoner listed 28 planned IRAs whereas the work plan only lists 17).

The EE/CAs submitted to date do not adequately address environmental impacts of taking the proposed action, although the outline in Table 3.4 suggests otherwise. The NEPA documentation for IRAs described in Sections 3.6.2.5, 3.6.2.6, 3.6.2.7, 3.6.2.8, 3.6.2.10, 3.6.2.11, 3.6.2.13, and 3.6.2.14 must include discussion of the storage areas and impacts from storage (e.g., worker exposure).

NEPA documentation for 3.6.2.5 must include discussion of impacts from land or stream bed disturbance on the ecosystems and impacts on workers and visitors to the wildlife areas. NEPA documentation for 3.6.2.13 must include discussion of cumulative work impacts, considering future Army work. NEPA documentation for 3.6.2.15 and 3.6.2.16 must consider the potential impacts from the waste that will be left behind (e.g., air exposures from dried surface waste).

Identify the status of IRAs described in Sections 3.6.2.1, 3.6.2.6, 3.6.2.7, 3.6.2.10, and 3.6.2.11.

The "c" footnote to Table 3.4 should state "A memorandum-to-file is a unique DOE mechanism that was established when DOE's NEPA guidelines (U.S. Dept. of Energy 1987d) were first issued in 1980. It was developed to avoid the need to prepare environmental assessment on a large number of DOE actions that, because of limited agency experience, had not yet been added to the list of categorical exclusions."

Response to Comment 24

The work plan includes all currently planned IRAs. The major difference between the number of IRAs in the work plan (17) and in the 2/24/88 letter from Nelson to Wagoner (28) is the consolidation of the IRAs associated with non-process buildings, structures, and equipment into one section (Section 3.6.2.14 in the draft work plan). The following sentence has been added to this section following the list of affected buildings or areas: "This action may be divided into several smaller actions to expedite the cleanup process."

Documentation to support IRAs will be developed in a manner consistent with the complexity of the action and the potential for impacting the environment. The IRAs planned and conducted to date have been relatively simple, with obviously no significant environmental impacts. Documentation necessary to reach this decision has been prepared. We believe that it is unnecessary to prepare lengthy documentation for relatively simple and routine tasks. The impacts associated with the storage of very small quantities of low-activity radioactive materials, including radiation exposure of workers, are obviously very small.

The documentation to support the IRAs discussed in Sections 3.6.2.5, 3.6.2.13, 3.6.2.15, and 3.6.2.16 of the draft work plan will address the issues given in this comment.

The status of all active (or completed) IRAs has been updated in the work plan.

Footnote "c" to Table 3.4 has been revised as suggested.

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Comment 25

Page 4-12: Describe the plans for assessing ecological effects of residual contamination and of remedial action.

Response to Comment 25

The purposes of the lake and stream sediment characterization and biouptake study are described in Section 4.2.5. The scope of the studies has been narrowly defined to yield specific information for the RI/FS-EIS process. Although these studies are not being performed to evaluate ecological impacts, useful ecological data will be generated from them.

- -

Comment 26

Pages 4-6 through 4-12: There is a need to assure that data collection and presentation is not only directed toward justifying the need for cleanup (i.e., contamination in relation to a standard, annual average values) but can allow analysis of impacts (e.g., comparisons to background, identification of contamination sources, prediction of migration).

Response to Comment 26

As stated in the last sentence of the first paragraph in Section 4.2, the purpose of the field investigations is to gather data so that "... remedial measures can be identified, evaluated, and selected." An integral component of evaluating remedial measures is analyzing the impacts associated with implementing such actions. Data are being obtained consistent with this need.

- -

Comment 27

Page 5-7, first sentence, first paragraph: Define indicator chemical.

Response to Comment 27

The following has been added to this paragraph: "These indicator chemicals and radionuclides are those that represent the most toxic, mobile, and persistent species at the site as well as those that are present in the largest amounts. These 'highest risk' species are used to assess the risks at the site."

- -

Comment 28

Page 5-14, top of page: Change sentence to read "... e.g., environmental consequences of taking each of the remedial action alternatives under consideration, long term impacts, cumulative impacts, mitigative ..."

The fourth bullet should point out the 45-day public review period.

The last bullet in Section 5.12 [5.11?] should be changed to read "Revising the report based on public and agency comments."

In Section 5.12 the title is misleading or else material is misplaced because the responsiveness summary is part of the RI/FS-EIS.

Response to Comment 28

The first change has been made as suggested. The titles for Sections 5.11 and 5.12 have been revised as follows:

"5.11 Task 11: Draft RI/FS-EIS Report"

and

"5.12 Task 12: Final RI/FS-EIS Report and Supporting Activities"

We believe that it is unnecessary to state the length of the public review period, so no change has been made in response to the second comment. The following bullet has been added to Section 5.12: "Revising the RI/FS-EIS in response to public comments." The fourth comment is accommodated with the title changes to Sections 5.11 and 5.12.

- -

Comment 29

Pages 6-1 and 6-4: Indicate the public review and comment periods for particular documents.

Response to Comment 29

Section 6 summarizes the schedule for completion of the RI/FS-EIS process (including the RI/FS and EA for the quarry bulk waste removal activity); this section was revised to include more information. We believe that it is unnecessary to highlight the public review and comment periods in these schedules. However, the schedules have been revised to note that the public review period and preparation of the responsiveness summary occurs between the draft RI/FS-EIS (and RI/FS for quarry bulk waste removal) and final RI/FS-EIS (and RI/FS).

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Comment 30

Page 8-3, second paragraph: Change this paragraph so that it is understood that an EE/CA document, supplemented for NEPA purposes, will either result in a memorandum-to-file, a finding of no significant impact, or a determination that an environmental impact statement must be prepared (i.e., the action will be included in the RI/FS-EIS).

Response to Comment 30

The sentence upon which this comment is based has been deleted. This comment is addressed in Section 3.11.7 of the work plan. (See also Response to Comment 34).

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Comment 31

Page 8-5, first paragraph: It is stated that current data should be sufficient to justify the need for this action. It should also be stated that current data should be sufficient to analyze the environmental impacts of taking the proposed action, if this is true, or plans for more data gathering should be described. It should also be stated that this analysis will consider impacts of placing the waste at the chemical plant/raffinate pit site, if it is later determined that a disposal cell cannot be sited there.

Second paragraph: Explain whether the quarry waste is sufficiently characterized for disposal.

Response to Comment 31

The sentence in question has been revised to read: "Current data are sufficient to justify the need for this action and to allow for an assessment of environmental impacts associated with implementing the action." The impacts associated with possible double handling of the wastes will be addressed in the RI/FS-EA process; however, this level of detail is not needed in the work plan. We also do not need to address the adequacy of current data relative to disposal requirements in the work plan. Additional waste characterization will be performed, if needed, prior to a disposal decision. Such characterization can be done during exhumation of the wastes, during placement of the wastes into interim storage, or during the interim storage period.

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Comment 32

Pages 8-6 and 8-7: When analyzing the impacts of removing the bulk quarry wastes, it will be necessary to address the effect of exposing the limestone walls and floors of the quarry to, for example, sunlight and precipitation, and therefore some characterization efforts regarding transport pathways may indeed be necessary. This should be stated.

Include polycyclic aromatic hydrocarbons in paragraph 1.

Response to Comment 32

The last paragraph in this section has been revised to read: "Detailed characterization of the transport of contaminants from the quarry into the surrounding environment is not an essential part of the proposed response action. However, the RI/FS-EA process will include an assessment of the potential migration of contaminants into the limestone quarry, to the extent possible, during both the action period and during the time period following bulk waste removal. A good understanding of the nature and extent of fracture joints and cracks can be developed only after the bulk wastes have been removed from the quarry and the limestone walls and floor have been exposed for study. The residual contamination in joints and cracks of the quarry -- and in the groundwater -- will be treated as separate operable units following the currently proposed waste removal effort."

The sentence on which the second part of this comment is based has been revised to read: "The organic compounds that have been identified are those expected from past disposal activities, i.e., PCBs, PAHs, and nitroaromatic compounds."

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Comment 33

Page 8-9, third paragraph: The bulk waste will not be stored only until a decision is reached regarding the disposition of all wastes at the Weldon Spring Site but would be stored until that decision is implemented. This should be stated.

Response to Comment 33

The sentence in question has been deleted.

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Comment 34

Page 8-10, top of page: Explain the implication of having cleanup criteria be technology based rather than analytically based.

Last sentence: Change to read "... DOE will either issue a 'finding of no significant impact' or determine that an environmental impact statement is needed."

Response to Comment 34

The implication of having cleanup criteria being technology based rather than analytically based is discussed in the remainder of the paragraph. The DOE is not claiming that the quarry will be in a condition acceptable for unrestricted release following this action, i.e., cleanup criteria for the quarry will not be determined prior to initiation of this action. Sufficient data for such a determination cannot be determined prior to removal of the bulk wastes. The implication of having technology-based cleanup criteria is the need to perform additional characterization and analysis following removal of the bulk quarry wastes.

Section 3.11.7 has been revised to read: "The DOE is proposing to address quarry bulk waste removal as a separate operable unit and will use the RI/FS-EA process to support this decision (See Section 3.11.2.1). This action is scheduled to occur prior to the ROD for the project. Implementation of the RI/FS-EA process will be as follows. The first two phases of the FS process will be completed concurrent with preparation of the RI and baseline risk evaluation. At this point, an assessment of environmental impacts will be performed consistent with the requirements of the EA in support of a finding of no significant impact (FONSI), if appropriate. If DOE determines that this action requires preparation of an EIS, the action will be included within the overall RI/FS-EIS process for the project, and removal of the quarry bulk wastes will not be undertaken prior to issuance of the ROD. Because the EA will be completed prior to completion of the FS, the RI/FS process for the quarry bulk waste removal action will be completed only if a FONSI is issued. If the RI/FS for bulk waste removal is completed, DOE and EPA will issue decision documents under CERCLA to document the decision-making process."

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Comment 35

Page A-3, first paragraph: Rewrite the second sentence because CEQ does not define "programmatic EIS".

Response to Comment 35

The second sentence of this paragraph has been revised to read: "Based on public and technical scoping input, DOE decided to take the 'tiered' approach recommended by the Council on Environmental Quality (CEQ) under its regulations for implementing the National Environmental Policy Act (NEPA)."

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Comment 36

Page A-8, first paragraph: Change to read "... based, in part, on the input ..." and "DOE and EPA have since agreed that the appropriate ..."

Response to Comment 36

The first part of this comment has been incorporated as suggested. The sentence on which the second part of this comment is based has been deleted.

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Comment 37

Page A-10: Consider moving Volkmer, Kilby, and Danforth higher in the list of commenters.

Response to Comment 37

The commenters are listed in the order in which written comments were received. This seems to be an appropriate means by which to list all individuals who provided written comments.

- -

Comment 38

Page A-17: Eliminate last bullet.

Change item 1 to read as follows: In light of a U.S. Supreme Court case involving the proposed restart of one of the Three Mile Island reactors ... DOE considers only psychological impacts that bear a close causal relationship to the physical environment in its EIS's. Psychological impacts raised so far do not bear such a relationship.

Response to Comment 38

The last bullet in Section A.4.2 has been deleted. Item 1 in Section A.5 has been revised as suggested with a few minor editorial changes.

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Comment 39

Page A-18: In item 3 explain why no monitoring studies of student and staff at the school are being performed.

Item 4 - excavation, transport, and interim storage of quarry wastes - is not beyond the scope of the EIS. These proposed actions were in the scope of the 1987 Draft EIS and will be in the RI/FS-EIS if attempts to treat them as a separate operable unit are unsuccessful. The actions are being taken as interim actions for the EIS and only if certain conditions pertaining to the EIS are satisfied. Change the language accordingly.

Item 5 - Removal of residual contamination from the quarry - was in the scope of the 1987 Draft EIS ("decontaminate the quarry"), so that an explanation should be given for the change in scope. Also, some analysis of residual contamination will be needed to assess impacts of the proposed interim action (item 4 above), so this item 5 is not entirely out of the scope of this EIS.

Response to Comment 39

The third and fourth sentences of Item 3 have been revised to read: "No additional monitoring studies of students and staff at Francis Howell High School will be performed as part of the RI/FS-EIS process because the existing environmental monitoring program demonstrates that individuals at the high school are not being exposed to measurable levels of radioactive or chemical contaminants originating from the Weldon Spring site. However, potential health impacts on students and staff will be addressed in the RI/FS-EIS."

Item 4 has been revised to read: "Excavation, transport, and temporary storage of quarry bulk wastes -- The DOE is proposing to address the removal of the quarry bulk wastes as a separate operable unit and will use the RI/FS-EA process to support this decision (see Section 3.11 of this work plan). This action will include excavation, transport, and temporary storage of the quarry bulk wastes at the raffinate pits and chemical plant area. Implementation of the RI/FS-EA process will be as follows. The first two phases of the FS process will be completed concurrent with preparation of the RI and baseline risk evaluation. At this point, an assessment of environmental impacts will be performed consistent with the requirements of an EA in support of a finding of no significant impact (FONSI), if appropriate. If DOE determines that this action requires preparation of an EIS, the action will be included within the overall RI/FS-EIS process for the project, and removal of the quarry bulk wastes will not be undertaken prior to issuance of the ROD. Because the EA is scheduled to be completed prior to issuance of the FS, the RI/FS process for the quarry bulk waste removal action will be completed only if a FONSI is issued. If an RI/FS for bulk waste removal is completed, DOE and EPA will issue decision documents under CERCLA to document the decision-making process."

Item 5 is not really a change of scope from the draft EIS. "Decontaminate the quarry," as used in the draft EIS, can properly be viewed as being the same as removal of the quarry bulk wastes. Note that the analyses given in the draft EIS for the action alternatives do include an assessment of residual contamination remaining in the quarry limestone and alluvium near the quarry, following removal of the quarry wastes. Item 5 has been added for clarification; this would have been addressed in the detailed engineering phase if the draft EIS had been finalized. An assessment of the impacts of the residual contamination remaining in the quarry will be included in the RI/FS-EA process for the interim time period following bulk waste removal and prior to a decision on the need to possibly remove some of this residual contamination. However, analysis of impacts associated with removal of this residual contamination is beyond the scope of the RI/FS-EIS.

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Comment 40

Pages A-20 and A-21: Change citation to Final EIS for Grand Junction, issued 12/86.

Response to Comment 40

The citation has been revised as suggested.

Comment 41

Page A-24, first paragraph: Change to read "... DOE will issue a 'finding of no significant impact' or determine that the action must be considered in the RI/FS-EIS."

Response to Comment 41

The paragraph in question has been revised to read: "Four distinct response actions may be required at the quarry: bulk waste removal, removal of any residual materials following bulk waste removal, groundwater restoration, and cleanup of contaminated vicinity properties. The DOE is proposing to address removal of the quarry bulk wastes as a separate operable unit and will use the RI/FS-EA process to support this decision. This action is scheduled to occur prior to the ROD for the project. The procedure for implementation of the RI/FS-EA process is given in Item 4 of Section A.5.

Comment 42

Page A-26: Between items 4.5 and 4.6 insert two new items, "Environmental Consequences" and "Cumulative Impacts". Identify the topics for which environmental consequences (include long-term and cumulative impacts) will be addressed for each action alternative (e.g., radiological impacts).

Response to Comment 42

The following has been added to the outline in Table A.3:

4.6	Environmental Consequences	4.6.7	Socioeconomics
4.6.1	Radiological Impacts	4.6.8	Historical and Archeological Issues
4.6.2	Chemical Impacts	4.6.9	Institutional Issues
4.6.3	Soils and Geology	4.7	Potential Loss of Institutional Control
4.6.4	Water Resources	4.8	Cumulative Impacts
4.6.5	Ecology		
4.6.6	Air Quality		

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Comment 43

Page A-27, first paragraph: Change to read "RI/FS-EIS. DOE-HQ will approve publication of the RI/FS-EIS." Clearly identify the contractor for the RI and baseline risk assessment.

Response to Comment 43

The first paragraph of Section A.10 has been revised to read: "... The DOE-WSS has responsibility for implementing the conduct of response action activities and also has functional responsibility for preparation of the RI/FS-EIS. The DOE-HQ will approve publication of the RI/FS-EIS."

The second paragraph of Section A.10 has been revised to read: "... The project management contractor will collect all necessary environmental data and perform requisite engineering and monetary cost studies to support the analyses given in the RI/FS-EIS. The project management contractor will oversee preparation of the RI."

The third paragraph of Section A.10 has been revised to read: "The Energy and Environmental Systems Division of ANL will perform environmental analyses for the the RI/FS-EIS process under contract to DOE-WSS and will oversee preparation of the FS-EIS phase of the RI/FS-EIS process. As part of the this process, ANL will provide an independent analysis of the environmental studies, engineering feasibility, and cost-effectiveness of alternatives for remedial action at the Weldon Spring Site performed by other DOE contractors. These environmental analyses will be performed using information supplied by the project management contractor ..."

The baseline risk assessment, which is the last phase of the RI process, will be performed by the project management contractor. However, as part of its responsibilities, ANL will provide an independent analysis of this assessment.

Comment 44

Page B-3, second sentence: Change NEPA reference to CEQ regulations and give citation.

Second paragraph: Change to "... (DNR), DOE has agreed that ..."

Response to Comment 44

The second sentence in the first paragraph in this section has been revised to read: "A public comment period followed issuance, as mandated by the Council on Environmental Quality regulations for implementing the procedural provisions of the National Environmental Policy Act (NEPA) (40 CFR Part 1503.1)."
The phrase "DOE has determined that" has been changed to "DOE has agreed that" in the third sentence of the second paragraph on page B-3.

Comment 45

Page B-4, first paragraph: Distinguish draft and final RI/FS-EIS.

Second paragraph: Identify the issues as those from the public comment period.

Response to Comment 45

The third paragraph in this section has been revised to read: "... The intent of these responses is to illustrate the manner in which these issues will be addressed in the RI/FS-EIS process. A draft RI/FS-EIS will be issued for public review, and any significant issues concerning the draft RI/FS-EIS will be addressed in a responsiveness summary. A final RI/FS-EIS, including the responsiveness summary, will be prepared prior to issuance of the record of decision (ROD) for this project."

The fourth paragraph in this section has been revised to read: "The major issues identified in comments on the draft EIS have been divided into five categories as follows:"

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Comment 46

Page B-7, first paragraph: Correct the discussion of the "Nearby Site", which was described in the Draft EIS as one chosen to have more favorable conditions (e.g., thicker clay, lower hydraulic conductivity, deeper groundwater table, and/or higher sorption capacity) than the Weldon Spring Site (see EIS, page 1-12).

Response to Comment 46

This response has been revised to read: "In Alternative 3b in the draft EIS, the wastes are assumed to be transported to a 'Nearby Site' in Missouri, within 160 km (100 mi) of the Weldon Spring Site. The 'Nearby Site' would be chosen to have more favorable conditions (e.g., thicker clay, lower hydraulic conductivity, deeper groundwater table, and/or higher sorption capacity) than the Weldon Spring Site..."

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Comment 47

Page B-9, response to issue 8: Eliminate second sentence.

Answer to issue 9 should be more responsive. Make the statement about complexity of geology/hydrogeology consistent with response to issue 24.

Response to Comment 47

The response to issue 8 has been revised to read: "The issues addressed in the draft EIS were those determined to be relevant to the decision to be made. All available information was reviewed for appropriateness relative to the analyses provided in the draft EIS. The DOE will reconsider all available information in preparation of the RI/FS-EIS, including those specific references cited in comments on the draft EIS. The DOE is currently in the process of conducting a thorough site characterization program. The results of this program will be included in the RI report and will allow for detailed estimation of environmental impacts.

The first sentence to issue 9 has been deleted. The answer is responsive to this issue in that reference to ongoing and planned geological characterization studies is discussed.

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Comment 48

Page B-12, response to issue 13: Refer to an EE/CA-NEPA document.

Page B-12, response to issue 14: Clarify whether a leachate collection/monitoring system is not used in conjunction with a cap.

Response to Comment 48

The response to issue 13 has been revised to read: "... The methods for treating the water will be detailed in engineering evaluation/cost analysis (EE/CA) reports that will be prepared to support these actions. These EE/CA reports will include an assessment of potential environmental impacts associated with water treatment alternatives." We have not used the term "EE/CA-NEPA" because the NEPA compliance document for this action will be the memorandum to file and the CERCLA compliance document will be the action memorandum (as shown in Figures 30 and 31 of the work plan). The EE/CA provides the basis for those determinations.

The third sentence in the response to issue 14 has been revised to read: "An alternative to collecting infiltrate and leachate from the wastes (such as the use of a bottom liner and leachate collection system) would be to dispose of the wastes in a manner that water is prevented from reaching the contained wastes (e.g., by use of a very impermeable cap) so that leachate is not generated."

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Comment 49

Page B-13, response to issue 15: Tell when the design criteria document will be prepared and how it will be available to the public. Change fifth sentence to read, "The use of a lead sheet in the cover, which was included in the draft EIS as a result of input obtained during the scoping process, will be reevaluated in the RI/FS-EIS."

Response to Comment 49

It is premature to give a date when the design criteria document will be completed because the disposal requirements have not yet been defined. The document will be made available for public inspection in the same manner as other project documents, i.e., the document will be filed in local repositories. The fifth sentence of the response has been revised as suggested.

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Comment 50

Page B-15, response to issue 19, last sentence: Add "in a separate NEPA/CERCLA process."

Response to Comment 50

This phrase has not been added since this point has been made numerous times in this document.

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Comment 51

Page B-17, response to issue 22: Change the end to read "procedures have been and will continue to be used to ..." Give examples of the rigid protocols and procedures.

Response to Comment 51

The last sentence to this response has been revised to read: "Although it is possible for test wells, boreholes, and trenches to provide pathways for contaminants, rigid protocols and procedures have been and will continue to be used to effectively eliminate this possibility (e.g., double casing of deeper wells and grouting of abandoned boreholes)."

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Comment 52

Page B-20, response to issue 28: Change to "only reasonably foreseeable" scenarios.

Page B-20, response to issue 29: State the status of the meteorological station.

Response to Comment 52

The phrase "only credible scenarios" has been changed to "only reasonably foreseeable scenarios" in the response to issue 28. The status of the meteorological station is described in the response to issue 29. Current plans are to construct an on-site meteorological station that is projected to be operational in late 1988.

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Comment 53

Page B-21, response to issue 30: Environmental impact analysis should not be limited to humans only. Change the response.

Response to Comment 53

The fourth sentence in this response has been deleted and replaced with the following sentence: "The environmental impact analysis presented in the RI/FS-EIS will address the effects of radioactive and chemical contaminants on the local ecosystem."

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Comment 54

Pages B-27 and B-28, response to issue 41: Change the response to indicate DOE will not consider real estate values.

Response to Comment 54

The response to issue 41 has been revised to read: "The DOE is not planning to study the impact of the Weldon Spring site on local real estate values because such values can be affected by numerous factors. It is not possible to independently quantify the impact of the Weldon Spring site independently of other factors such as population growth and local employment opportunities. Hence, it does not seem reasonable to address this issue in the RI/FS-EIS."

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Comment 55

Page B-28, response to issue 42 and page B-31, response to issue 46: Refer to EE/CA-NEPA documents.

Response to Comment 55

See Response to Comment 48. No change has been made to the work plan.

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Comment 56

Page B-29, response to issue 44: Correct the language so that the impression is not left that DOE will only move waste off-site if a state pays.

Response to Comment 56

The response to this comment has been revised to read: The preference for total removal of the wastes from the Weldon Spring site is noted. The basis for the DOE decision relative to the Vitro site is provided in the ROD for remedial action at that site (U.S. Dept. Energy 1984). The DOE has no plans to move additional wastes to the Weldon Spring site for disposal."

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Comment 57

Page B-36, response to issue 56: Clarify whether DOE agrees that the Hanford site leaks, as the commenter states.

Response to Comment 57

We do not believe that it is appropriate to address environmental conditions at the Hanford site beyond those directly affecting a decision on the Weldon Spring site. This comment falls into that category.

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Comment 58

Pages B-32 and B-33, response to issues 50 and 51: Clarify whether the monitoring plan and emergency preparedness plan will be open to public comment.

Response to Comment 58

The environmental monitoring program and emergency preparedness plan have been developed according to DOE requirements and are available for inspection in the public repositories. These plans have not been issued for public comment and there is no intention of doing so. However, members of the public can provide unsolicited comments.

- -

Comment 59

Reevaluate whether comments concerning spray irrigation, inadequacies in the dose estimates to man (worst case estimates), frequency of monitoring at the school, and emergency plans for the school have been adequately addressed.

Response to Comment 59

We have reevaluated comments raised on these topics and believe that they have been adequately addressed.

- -

Comment 60

Section 1 and elsewhere in the document, reference is made to disposal of wastes from the raffinate pits and bulk waste removal from the quarry. This presupposes site remedies and precludes in situ treatment as a viable alternative.

Response to Comment 60

Because treatment options will be addressed in the RI/FS-EIS process, the work plan will be revised to discuss waste disposal in a more tentative manner where possible (see also Response to Comment 5). In-situ treatment at the quarry is not deemed to be a viable alternative because, while the wastes are in place, it is not possible to conduct detailed investigations of the fractured limestone quarry to investigate the extent and hazards of contamination in the joints and cracks. This topic will be addressed in the RI/FS-EA process to support the quarry bulk waste removal action.

- -

Comment 61

On page 1-10, the plan states that the baseline risk assessment will be prepared concurrently with site characterization activities. Unless site characterization is nearly complete, it may be difficult to perform these activities concurrently.

Response to Comment 61

Sufficient information is currently available to perform a preliminary baseline risk assessment. This baseline risk assessment will be updated following completion of site characterization activities. This approach has been adopted in an attempt to expedite the schedule for completion of the RI/FS-EIS process.

- -

Comment 62

Section 2.4 describes the data collected at the site to date. However, it does not provide guidance on the methods to be used to determine the adequacy of the existing data or on procedures to be used to validate the data. Prior to conducting additional studies, the existing data should be evaluated for data gaps so these gaps can be filled. Evaluation areas should include (1) characterization of sources, transport pathways, and receptor impacts/effects; (2) data input requirements of models (e.g., engineering, hydrogeologic, air quality) and of statistical analyses; and (3) waste and site conditions that affect applicable types of treatment, as well as treatment effectiveness at the site.

Response to Comment 62

The information requested in this comment is included in the quality assurance project plan and the field sampling plans. These are briefly summarized in Sec. 4.1 and 4.2 of the work plan. A data gap analysis has been included in Section 3.

- -

Comment 63

Section 2.4.1 identifies the radionuclides of interest as "naturally occurring". Although they may be found in nature, they are not naturally occurring at the site in the concentrations reported.

Response to Comment 63

The phrase "naturally occurring" is used to distinguish the radioactive contamination at the site from other types of radioactivity (e.g., fission products, transuranics). The fact that these radionuclides are found in nature is of significance relative to determining cleanup limits and acceptable levels of risk.

- -

Comment 64

Section 2.4.2 describes several tanks. It is unclear if these are above ground or below ground tanks. Leakage and/or spillage from these tanks and associated piping is not described.

Response to Comment 64

The paragraph describing on-site tanks has been revised to read: "... Other tanks on-site appear empty but were previously used to store hydrofluoric acid, nitric acid, sulfuric acid, caustic soda solutions, propane, and hexane. All process tanks are located above ground; however, several underground storage tanks were previously used to store petroleum products." Leakage and/or spillage may have occurred from these tanks and associated piping during plant operations. Contaminated on-site areas are being identified in the soil investigation program (see Sec. 4.2.1 of the work plan).

Comment 65

In Section 2.4.3, some of the wastes are described as "mixed wastes" with the definition keyed to RCRA. Care should be taken to avoid suggestions of the applicability of RCRA to the quarry. If it has not received wastes since November 1980, then RCRA does not apply.

Response to Comment 65

This section notes that some of the wastes may be classified as mixed waste. Although RCRA may not be directly applicable to the quarry if the wastes are not moved, it will likely be considered relevant and appropriate. We believe it is inappropriate to conclude that RCRA will not apply to the quarry wastes if RCRA hazardous materials are found simply because the wastes were generated prior to November 1980.

Comment 66

Section 2.4.4 discusses the vicinity properties. Contamination above criteria for unrestricted use is mentioned. Contamination values could be better appreciated if the criteria were stated.

Response to Comment 66

Reference to "unrestricted use" criteria has been deleted from the work plan. Cleanup of vicinity properties to date has been limited to thorium and radium contamination. These areas have been decontaminated to criteria given in DOE's FUSRAP and remote SFMP guidelines (which were adapted from 40 CFR Part 192). Residual contamination criteria for other radionuclides (i.e., uranium) have not yet been established. These criteria will be determined based on the risk they pose to human health and the environment.

- -

Comment 67

Section 3.2.4 describes potential risks. In this discussion, the risks associated with asbestos are not mentioned. Also, the release and transport of windborne particulates from exposed, air-dried raffinate pit sludge may require additional consideration.

Response to Comment 67

The last sentence in the second paragraph of Sec. 3.2.3 has been revised to read: "The potential for inhalation of airborne particulates will increase if contaminated material is disturbed, such as will likely occur during response action activities (e.g., demolition of buildings or excavation of contaminated soils)."

- -

Comment 68

Section 3.4.2 discusses cost-effectiveness as a criterion for evaluating remedial alternatives. December 1986 internal EPA guidance on selection of Superfund remedies indicates that cost is an important factor when performing initial screening of alternatives which provide similar results (J.W. Porter memorandum to Regional Administrators, dated December 24, 1986). For example, cost may be used to discriminate among treatment alternatives but not between treatment and nontreatment alternatives. In selecting the remedy, EPA indicates that remedies must be cost affective. This finding requires ensuring that the results of a particular alternative cannot be achieved by less costly methods.

Response to Comment 68

Comment acknowledged.

Comment 69

Section 3.4.2.1 discusses innovative technologies. EPA guidance (referenced above) indicates that innovative technologies should be carried through the screening if there is reasonable belief that they offer potential for better treatment performance or implementability, few or lesser adverse impacts than other available approaches, or lower costs than demonstrated technologies.

Response to Comment 69

Comment acknowledged.

Comment 70

Section 4.2 discusses the field sampling plans to be developed. The discussion does not provide assurance that data gaps will be filled and that the three criteria for judging completeness of the data will be met (see Comment 62).

Response to Comment 70

See Response to Comment 62.

Comment 71

Sections 4.3 and 4.5 discuss the health and safety plan and the emergency preparedness plan, respectively. The text does not mention the OSHA requirements (provided at 29 CFR Part 1910) regarding health and safety for working on hazardous waste sites. The health and safety plan does not appear to contain all the requirements of a health and safety plan. Among other requirements, the health and safety risks associated with each site RI (or FS) task and personnel protective equipment/decontamination requirements may not be contained in the plan. It appears that the emergency preparedness plan could satisfy the requirements for a contingency plan, normally contained in the health and safety plan.

Response to Comment 71

Sections 4.3 and 4.5 are summaries of the health and safety plans and emergency preparedness plan; as such, they do not include detailed discussion of all elements of these plans. There are two health and safety plans for the project: (1) an environmental, safety and health plan and (2) a construction safety and health management program. These plans are currently being updated to include OSHA requirements for working on hazardous waste sites. On-site personnel have received the OSHA training requirements specified in 29 CFR Part 1910.120.

- -

Comment 72

Page 3-1, first sentence, first paragraph: Delete the phrase "to the extent practicable".

Page 3-1, third sentence, second paragraph: Change "at the site and if its use" to "at the site such that its use".

Response to Comment 72

The work plan has been revised as suggested.

CHEMICAL PLANT
201-1.08

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

January 17, 1989

ADDRESSEES

HYDROGEOLOGIC INVESTIGATIONS SAMPLING PLAN

Enclosed is Revision 0 of the "Hydrogeologic Investigations Sampling Plan" for the Weldon Spring Site. This plan has been revised to address comments received from U. S. Environmental Protection Agency and the Missouri Department of Natural Resources as indicated in the "Responsiveness Summary", also enclosed.

Sincerely,

R. R. Nelson

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosures:
As stated

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FIGURE 1-14

TOP OF BEDROCK CONTOUR MAP

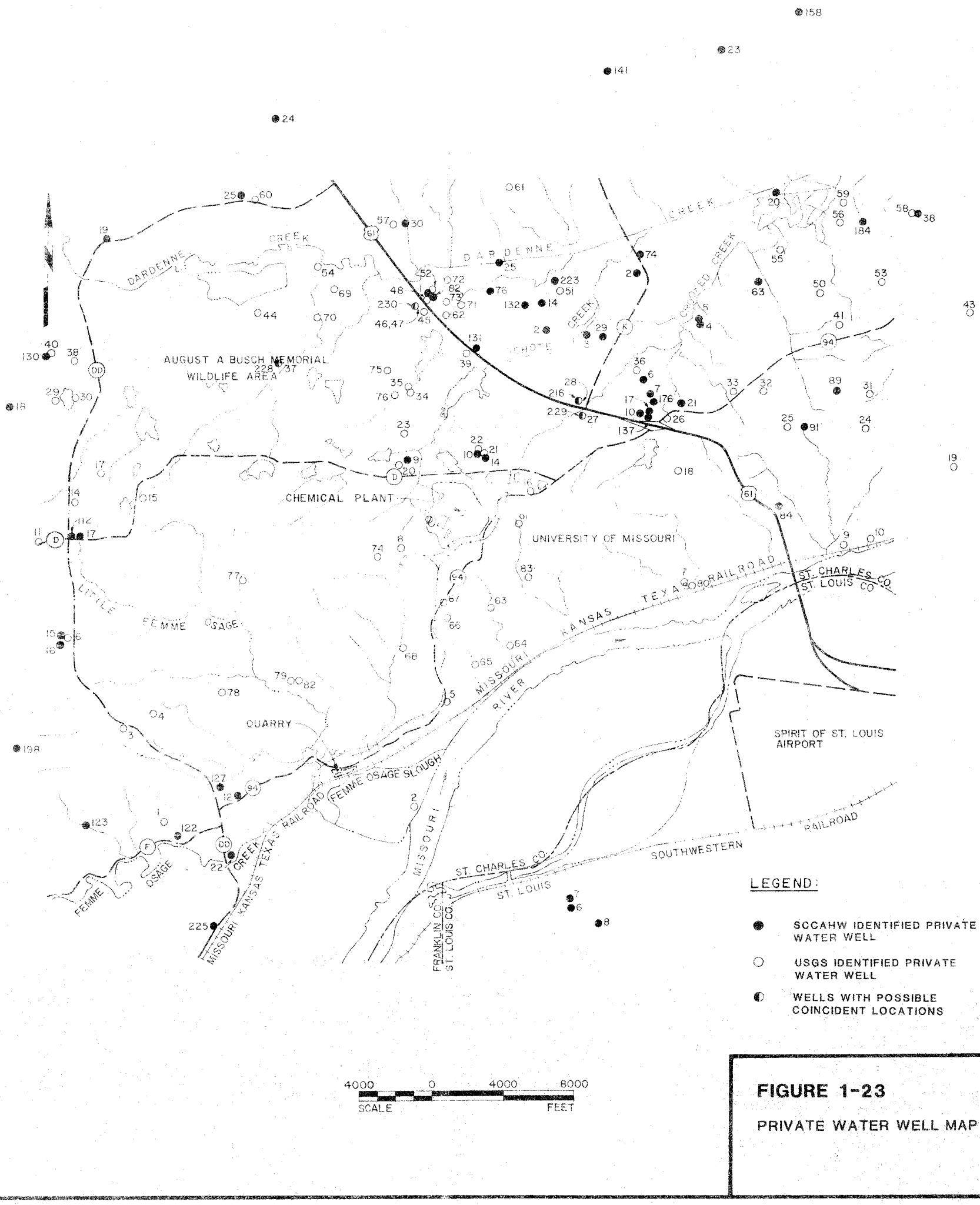

FIGURE 1-23

PRIVATE WATER WELL MAP

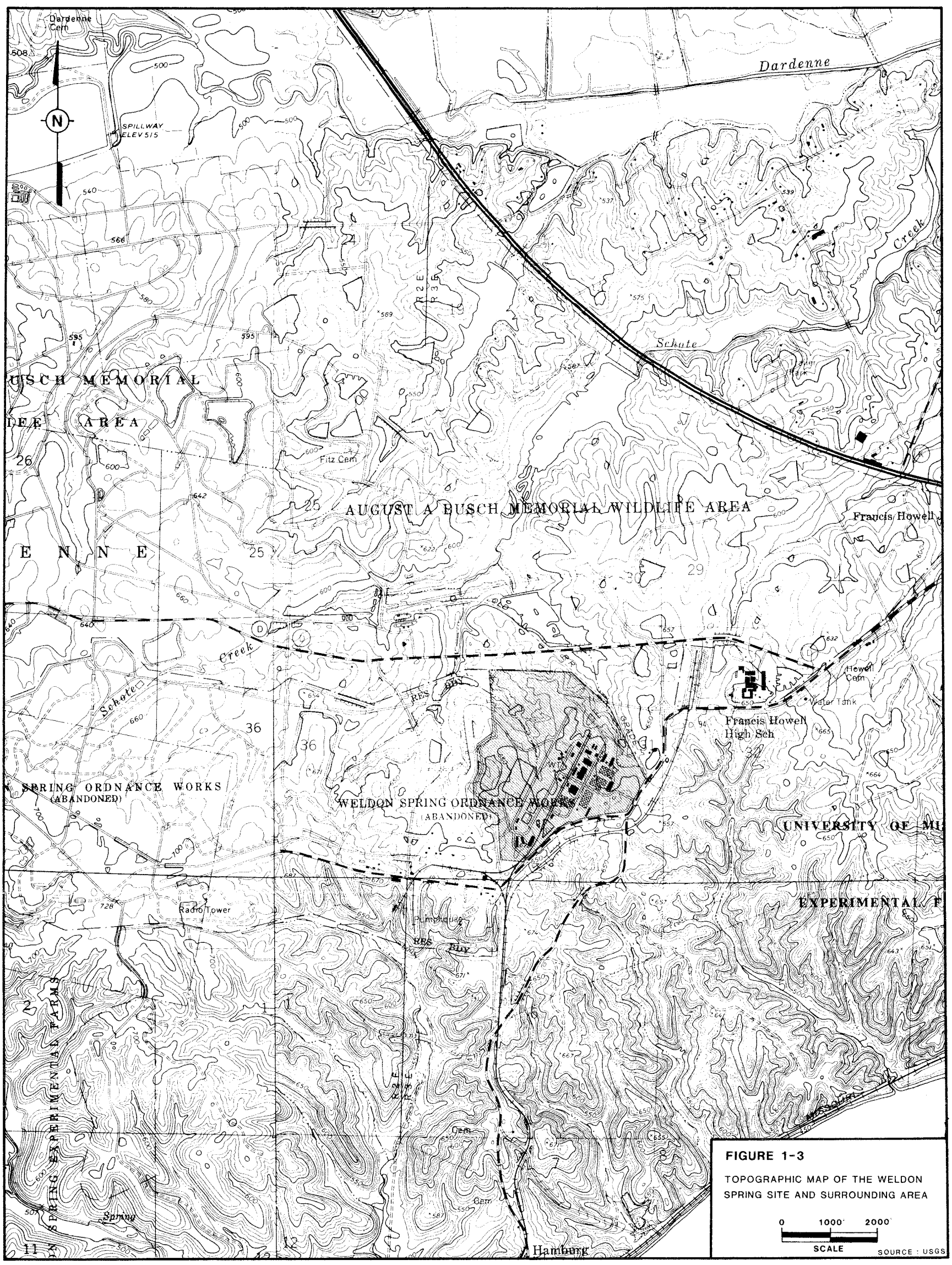

FIGURE 1-3

TOPOGRAPHIC MAP OF THE WELDON SPRING SITE AND SURROUNDING AREA

DOE/OR/21548-020

United States Department Of Energy

HYDROGEOLOGIC INVESTIGATIONS SAMPLING PLAN

REV. 0

NOVEMBER, 1988

WELDON SPRING SITE REMEDIAL ACTION PROJECT

HYDROGEOLOGIC INVESTIGATION

SAMPLING PLAN

PREPARED FOR:

U.S. DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

CONTRACT NO. DE-AC05-86OR21548

PREPARED BY:

MK-FERGUSON COMPANY

AND

JACOBS ENGINEERING GROUP, INC.

ROUTE 2, HIGHWAY 94 SOUTH

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REVISION 0

NOVEMBER 1988

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1.0 PROJECT DESCRIPTION

1.1 INTRODUCTION

The goal of this sampling plan is to identify and develop specific plans for those investigative actions necessary to: (1) characterize the hydrologic regime; (2) define the extent and impact of contamination; and (3) predict future contaminant migration for the Weldon Spring Site (WSS) and vicinity. The plan is part of the Weldon Spring Site Remedial Action Project (WSSRAP) sponsored by the U.S. Department of Energy (DOE) and has been developed in accordance with U.S. EPA Remedial Investigation (RI) and Data Quality Objective (DQO) guidelines. The plan consists of a sequence of activities including the evaluation of data, development of a conceptual model, identification of data uses and needs, and the design and implementation of a data collection program.

Data will be obtained to: (1) confirm the presence or absence of contaminants; (2) define contaminant sources and modes of transport; (3) delineate extent of contaminant migration and predict future migration; and (4) provide information to support the evaluation and selection of remedial actions.

This sampling plan is intended to supplement the Quality Assurance Program Plan (QAPP). It describes objectives, work tasks, quality assurance/quality control (QA/QC) procedures, and the level of effort required for site characterization and to support a feasibility study. Data developed through this sampling plan will also be used in the risk assessment evaluation.

The WSSRAP consists of remedial activities at the WSS, vicinity properties, and quarry. This sampling plan addresses activities required for the hydrogeologic investigation of the WSS. The quarry and vicinity properties associated with the quarry will be

addressed, in detail, in a separate site characterization report.

A comprehensive approach is planned for hydrogeological characterization. This includes monitoring well installation, water sampling and analysis, karst hydrologic studies, unsaturated zone studies, aquifer testing, regional studies, and groundwater modeling studies. Modeling will be performed in cooperation with the Missouri Department of Natural Resources, the U.S. Geological Survey, and the University of Missouri, Rolla.

1.2 REVIEW AND ASSESSMENT OF EXISTING DATA

Numerous studies have been performed at the WSS and vicinity. This section addresses site history and assesses those studies directly related to the WSS. The completeness, representativeness, and accuracy of collected data are briefly evaluated.

Maps, sections, and data presented in this section are, for the most part, based on information acquired prior to current (1988) characterization activities. Much of this information is not site-specific; therefore figures, tables, and data presented in this section will be modified as additional data are collected.

1.2.1 Site Background and Investigations

The WSS is located along Missouri Highway 94 in western St. Charles County, Missouri, approximately 30 miles west of St. Louis, and 2 miles southwest of the junction of U.S. Highway 40/61 and State Highway 94. The general location of the WSS is shown on Figure 1-1. An enlarged view of the site is shown on Figure 1-2. Figure 1-3 (in pocket) presents a topographic map of the Weldon Spring Site area.

The WSS described in this sampling plan consists of two adjoining

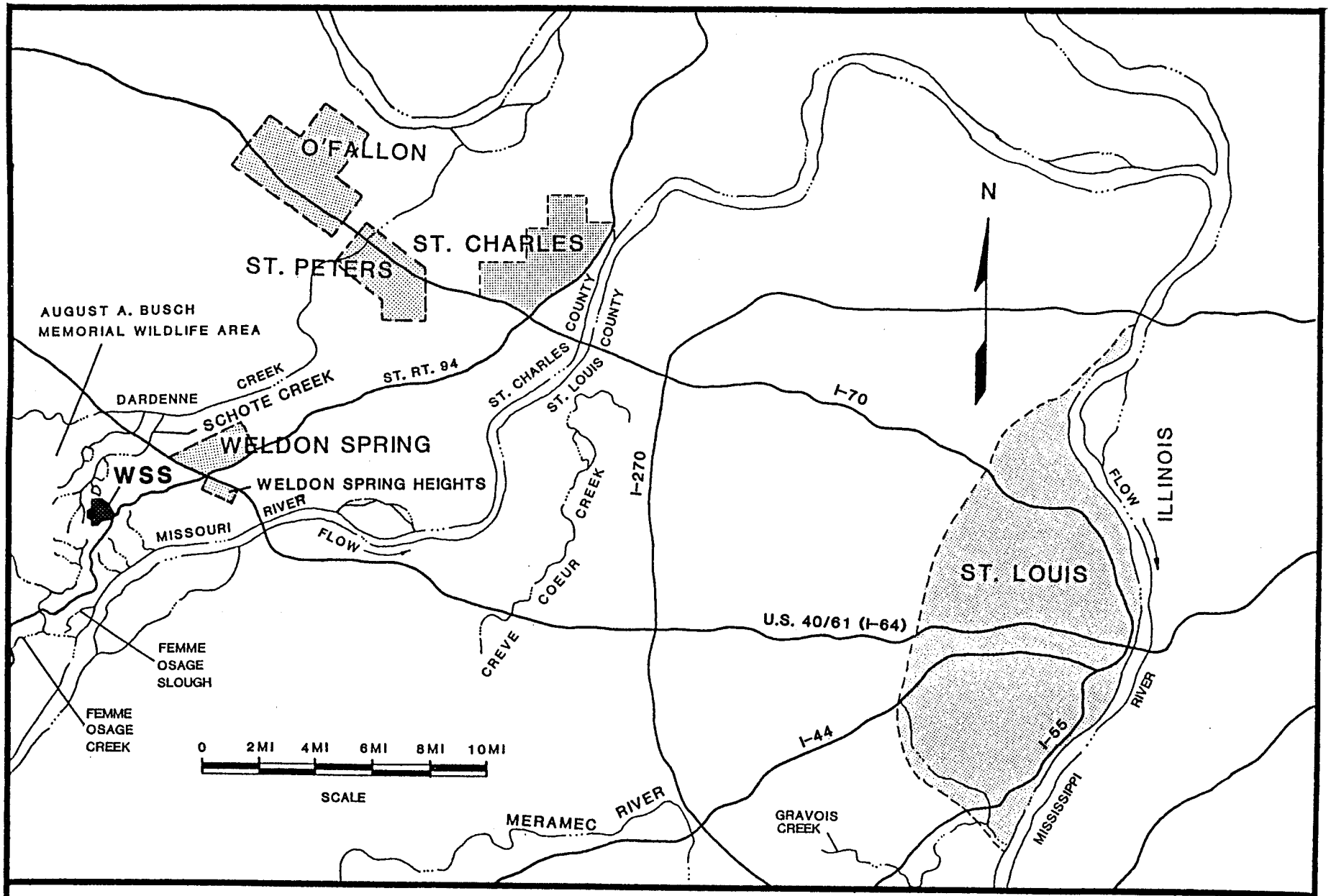
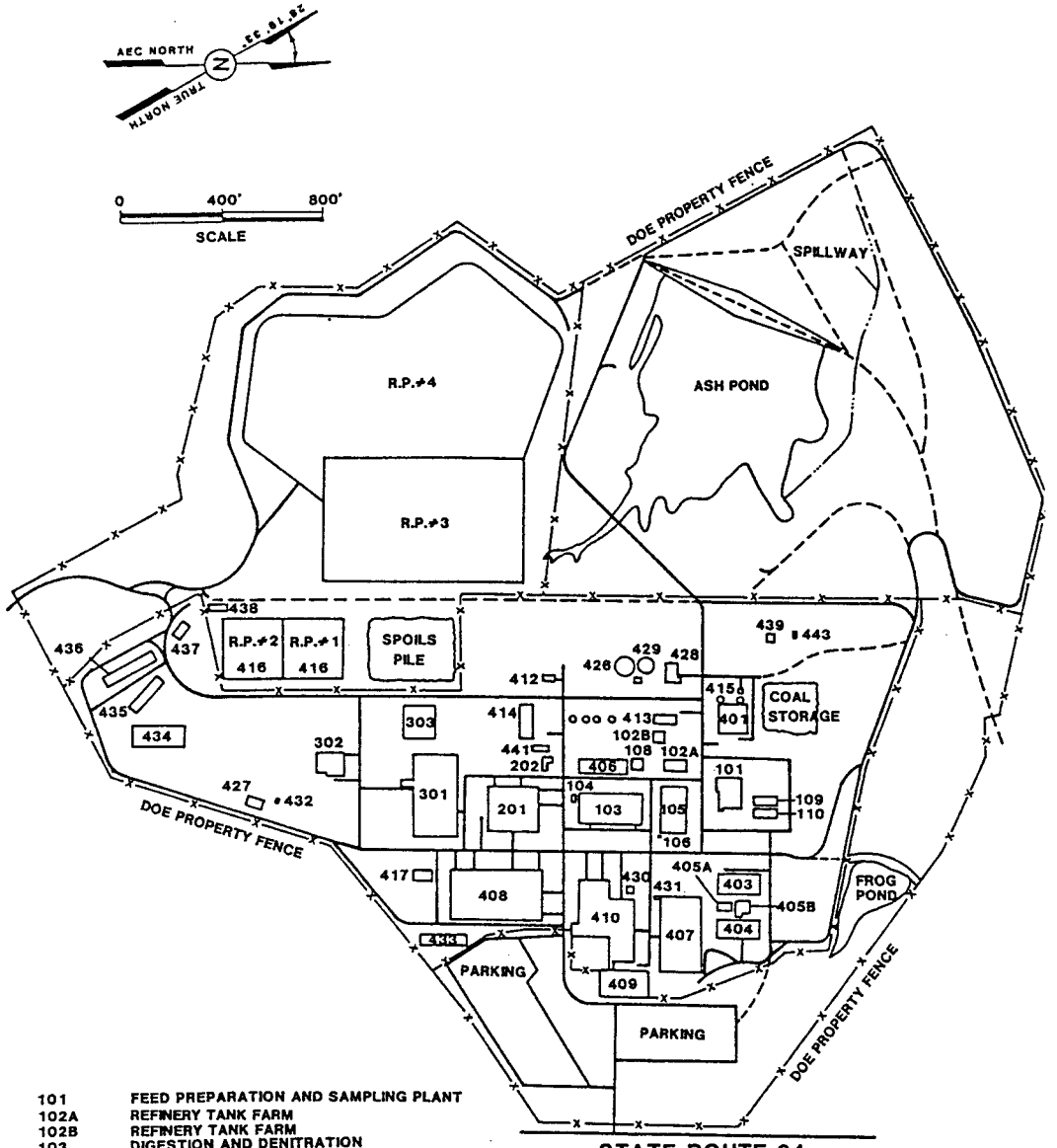


FIGURE 1-1

LOCATION OF THE WELDON SPRING SITE



101	FEED PREPARATION AND SAMPLING PLANT
102A	REFINERY TANK FARM
102B	REFINERY TANK FARM
103	DIGESTION AND DENITRATION
104	LIME STORAGE
105	TBP AND ETHER EXTRACTION
106	PROOF SAMPLER
108	NITRIC ACID RECOVERY
109	DRUM STORAGE
110	DRUM STORAGE
201	GREEN SALT PLANT
202	GREEN SALT TANK FARM
301	METALS PLANT
302	MAGNESIUM STORAGE BUILDING
303	CHIP STORAGE
401	STEAM PLANT
403	CHEMICAL PILOT PLANT
404	METALLURGICAL PILOT PLANT
405A	PILOT PLANTS AXILARY
406	WAREHOUSE
407	LABORATORY
408	MAINTENANCE AND STORES
409	ADMINISTRATION
410	SERVICES
412	ELECTRICAL SUBSTATION
413	COOLING TOWER AND PUMP HOUSE
414	SCRAP CLASSIFICATION AND EQUIPMENT STORAGE
415	CLAY BRICK INCINERATOR
416	RAFFINATE PITS 1 & 2
417	PAINT SHOP
426	ELEVATED WATER TANK
427	PRIMARY SEWAGE TREATMENT PLANT
428	PROPANE AND BUTANE GAS PLANT
429	RESERVE WATER FACILITIES
430	AMBULANCE GARAGE
431	PROOF SAMPLER
432	PROOF SAMPLER
433	STORAGE
434	STORAGE
435	STORAGE
436	STORAGE
437	STORAGE
438	STORAGE
439	FIRE TRAINING
441	CYLINDER STORAGE
443	FIRE TRAINING STORAGE

FIGURE 1-2

WELDON SPRING CHEMICAL PLANT AND RAFFINATE PITS (MAJOR BUILDINGS AND FEATURES)

areas: the Weldon Spring Raffinate Pits (WSRP) on the west, and the Weldon Spring Chemical Plant (WSCP) on the east, encompassing 51 and 166 acres respectively (MK-Ferguson -- MKF, 1987b). The 166-acre WSCP consists of 13 major buildings and approximately 30 support structures. The 51-acre WSRP area, located in the western portion of the site, contains four surface impoundments (raffinate pits) covering approximately 26 acres. These pits contain the residues of uranium and thorium processing from the former feed materials plant (MKF, 1987b).

Activities at the WSS have been varied. The U.S. Department of the Army (DOA) and predecessor agencies to the U.S. Department of Energy (DOE) have actively participated in developments at the site. A brief summary of these site activities is presented below.

The DOA acquired the site and surrounding areas, totaling more than 17,000 acres, in 1941 for an ordnance works to produce explosives. From 1941 to 1944, trinitrotoluene (TNT) and dinitrotoluene (DNT) were manufactured on the DOA property. Fishel and Williams (1944) reported the presence of red waste waters which were contaminating surface and groundwater during this period. At the end of World War II, the manufacturing operation was shut down and processing structures were abandoned. The Army conducted additional decontamination operations in 1946, destroying over 200 buildings and burning approximately 90 tons of nitroaromatics and residues (MKF, 1987). The ordnance works property was declared surplus in 1946, and during the next three years about 15,000 acres were transferred to other parties. By the end of 1949 only about 2,000 acres remained under the jurisdiction of the U.S. Army.

In 1956 the U.S. Army transferred about 205 acres to the U.S. Atomic Energy Commission (AEC) for the construction of a uranium feed materials plant on the Army's previous manufacturing site. The remaining TNT-processing equipment and structures were

demolished and removed to the Weldon Spring Quarry prior to construction of the AEC plant.

The AEC plant began operation in 1957. The plant converted impure uranium concentrates to pure uranium salts and metal. From 1958 to 1964 the plant operated at several times design capacity, overtaxing the facility and its waste disposal facilities, and resulting in radiological contamination of numerous buildings and land in the vicinity of the plant. Raffinate pits were excavated in 1958, 1959, and 1964 for disposal of wastes from processing uranium and thorium concentrates. Thorium oxide was processed at the plant during 1965 and 1966, with wastes being discharged to Raffinate Pit No. 4. Shutdown of the plant was initiated at the end of 1966; drums and trash were dumped into Raffinate Pit No. 4 during close-down operations.

In 1967, 166 acres of the plant site were transferred back to the Army for the intended manufacture of "Agent Orange." Some equipment removal and decontamination was accomplished for that purpose. The project was cancelled, however, in 1969. The U.S. Army Corps of Engineers took custody of the plant in 1969 after additional cleanup and shutdown work.

In 1975, the Army assessed the environmental conditions at the site and indicated that the site could not be released to unrestricted use without decontamination of the land and buildings. A similar conclusion was reached in a report to the U.S. Energy Research and Development Administration (ERDA) and recommendations were made for collection of additional data (Kleeschulte and Emmett, 1986).

The WSS remained under Army control until 1985 when custody was transferred to DOE (MKF, 1987b). Numerous efforts have been undertaken in recent years to assess the environmental problems associated with the WSS and to develop plans for remediation.

Studies providing site-specific geologic, hydrologic, and environmental information have been performed by several individuals and groups. Each investigation is briefly described in Section 5, References. In addition to these investigations, a number of environmental monitoring activities have been accomplished during the last 30 years. Data from some of these activities are included in reports by Mallinckrodt Chemical Works (1959-1965), DOA (1977-1985), Bechtel National, Inc. (BNI) (1983-1984), National Lead Company of Ohio (1981-1982), Shell Engineering (1983-1985), and MKF (1986-1987). These studies are evaluated and summarized in following sections.

1.2.2 Climate

The climate in the WSS area is continental, with moderately cold winters and warm summers. Alternating warm/cold, wet/dry air masses converge and pass eastward through the area almost daily (BNI, 1986b). Normal annual precipitation in the area is approximately 37 inches with the heaviest rainfall occurring in spring and early summer (DOE, 1987). The average temperature is 13°C (56°F), with the average daily minimum being 7°C (45°F) and the average daily maximum being 19°C (66°F). Wind speeds and directions recorded at the WSS during 1985 are summarized in Figure 1-4. Prevailing winds in the vicinity of the WSS are from the south during the summer and fall. Wind speeds during these months average 8.7 mph. Winds during the winter months are from the northwest and west-northwest, averaging 11 mph (MKF, 1987b).

The variability of the climate is demonstrated by records for the state. The range in temperatures for the 1888-1949 period was from a -40°F to 118°F and the range in annual precipitation was from less than 26 inches to more than 55 inches (Roberts, 1951). Summer rains frequently occur as thunderstorms, occasionally with hail and high winds. Locally, rainfalls can be very heavy, with 10 inches having been recorded

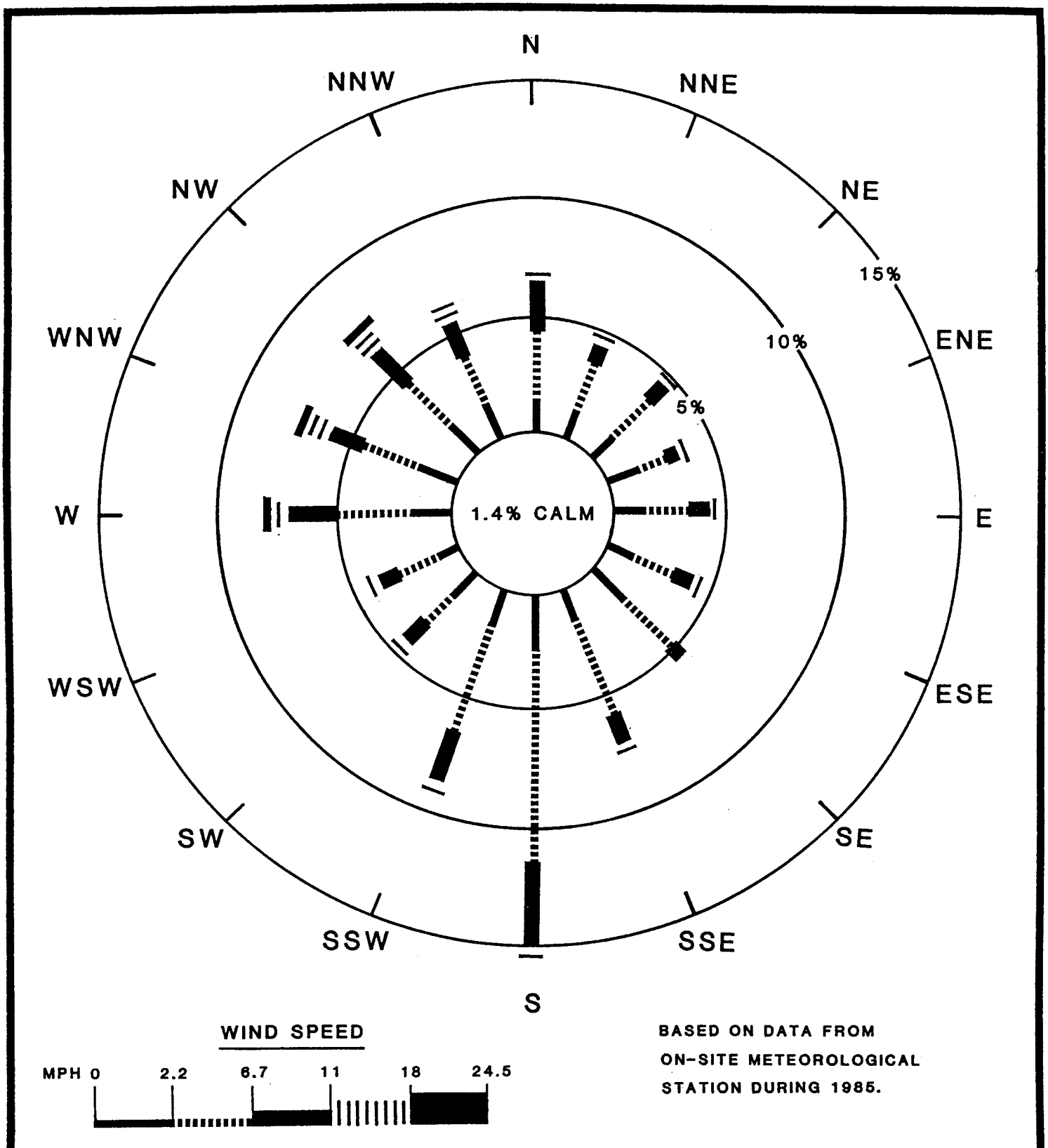


FIGURE 1-4

ANNUAL WIND ROSE FOR THE W S S, 1985.

in a 24-hour period. The three winter months are the driest, with the average precipitation totaling about 6 inches. The three spring months are typically the wettest with the average total approximately 12 inches (Ficker, 1981). Tornadoes occur in the St. Louis area once or twice per year, and occur most often in April and May (Sci. Appl., 1979).

Site-specific climatologic data are generally limited to the period beginning in April 1983 (BNI, 1986a; MKF, 1986).

1.2.3 Surface Features

The site is located on the drainage divide between the Mississippi and Missouri rivers. Drainage from the northern and western portions of the WSS trends northward to tributaries of Schote Creek, a tributary ultimately draining to the Mississippi River. The southeastern portion of the site drains generally southward to unnamed tributaries which flow to the Missouri River. Elevations on the site range from approximately 608 feet near the northern edge to approximately 672 feet near the southern edge. Land surface slopes are generally gentle except in the vicinity of embankments or levees for the raffinate pits and Ash Pond. There are no natural drainage channels traversing the site, though remnants of a channel through the Ash Pond area are present.

Figure 1-2 illustrates the current configuration of facilities on the site. In addition to the readily apparent ponds, pits, and buildings, there are numerous other features including drainage ditches and other topographic features that can influence the movement of contaminants. Some of the surface features are associated with man-made subsurface features, such as sewer lines, which can also influence the movement of contaminants. The changes that have taken place at the WSS over the years have added to the complexity of the site.

There are several localized depressions or ponding areas which have received natural runoff or process wastes over the years. These include the raffinate pits, Frog Pond, Ash Pond, the Imhoff tank (former wastewater treatment) and the Southeast Drainage Easement. Raffinate Pits 1, 2, 3, and 4 were constructed in the late 1950s and early 1960s for receiving process wastewaters. In addition to receiving process wastes, they have received precipitation and runoff. Also the topography of the raffinate pits influences the direction and rate of surface runoff originating or flowing in their vicinity. Frog Pond is a settling basin located near the east edge of the site. It receives runoff from the eastern portion of the site. Ash Pond is a major feature near the north edge of the site and receives runoff from the northern portion of the site. When runoff has accumulated sufficiently in Ash Pond, overflow occurs through its spillway with subsequent discharge from the site. The Ash Pond received ash slurry from the steam generating plant (Building 401). Another feature that influences the movement of contaminants is the Southeast Drainage Easement. Historically, contaminants have been discharged through the easement with treated wastewater. This easement is delineated on Figure 1-5.

The portion of the site that is not covered with structures or ponds is generally covered with vegetation (predominantly grasses) and gravel or asphaltic paved surfaces.

The August A. Busch Memorial Wildlife Area is located to the north of the WSS and the Weldon Spring Wildlife Area is located to the south and east of the site. These areas are predominantly covered with trees, brush, and grasses. U.S. Army Reserve property to the west of the site is predominantly covered with trees and grasses.

As indicated above, custody and operations at the site have changed over the years. Some of these changes have resulted in modifications of the buildings and other surface features. In

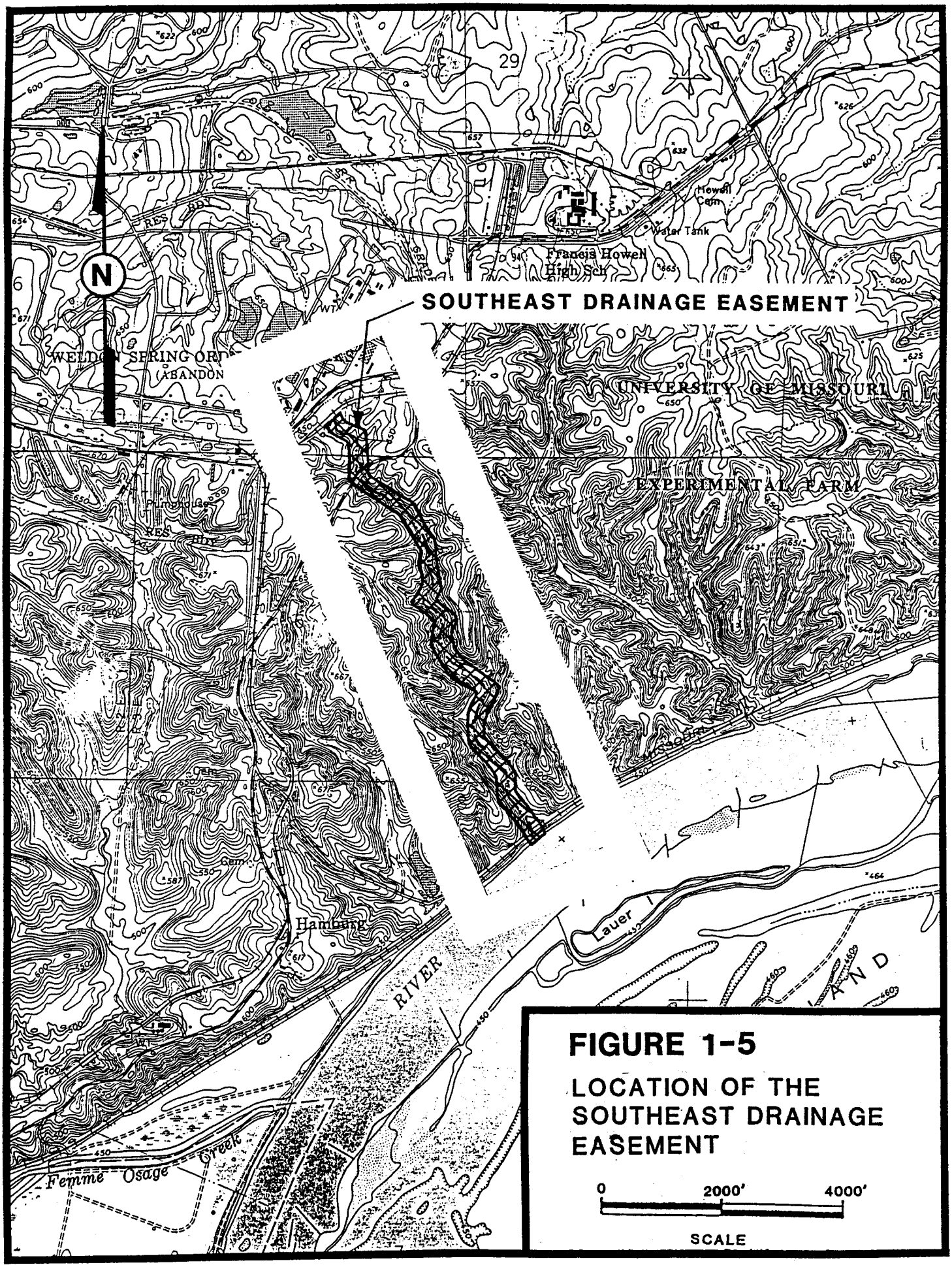


FIGURE 1-5

LOCATION OF THE SOUTHEAST DRAINAGE EASEMENT

turn, these modifications have influenced the present state and locations of contamination at and near the site.

1.2.4 Geology

The geology of the WSS has been described in some detail by BNI (1983c, 1984c, 1987) and in lesser detail by Fishel and Williams (1944), Roberts (1951), Krummel (1956), Moylan and Elser (1967), and Kleeschulte and Emmett (1986).

As indicated above, custody and operations at the site have changed over the years. Some of these changes have resulted in modifications of the buildings and other surface features. In turn, these modifications have influenced the present state and locations of contamination at and near the site. Fishel and Williams (1944) performed the first hydrogeologic investigation related to contamination at the site. This investigation was related to the Army's ordnance works operation during World War II. The investigation described the area's general geology, structural geology, groundwater conditions, and occurrences of contamination. Roberts (1951) further describes the geology in the area as it relates to groundwater movement. Krummel (1956) mapped the geology of the area just to the south of the WSS. Moylan and Elser (1967) describe the geology at the raffinate pits area. Kleeschulte and Emmett (1986) provide additional information on the stratigraphic and geologic structure in the vicinity of the raffinate pits. BNI (1983c, 1984c, 1987) provides borehole logs, geologic cross sections, and laboratory data from the chemical plant and raffinate pits areas. The following paragraphs and figures summarize and present an evaluation of the available geological information.

Table 1-1 presents a generalized stratigraphic column, which describes sediments and sedimentary rocks common to Central and East Central Missouri. This column is not to be considered site-specific due to varying thicknessess or absence of formation

TABLE 1-1
GENERALIZED GEOLOGIC STRATIGRAPHIC COLUMN
(After Kleeschulte and Emmett, 1986)

System	Series	Stratigraphic Unit	Depth from ground level to top of formation, in feet	Thickness, in feet	Typical 1/ thickness, in feet	Physical Characteristics	Remarks
Quaternary	Holocene	Alluvium	0	0-65	10-30	Gravelly, silty loam over occasionally gravelly, silty clay loam.	Deposits underlie tributaries to Missouri and Mississippi rivers.
				65-120	100-110	Silty loam, clay, and sand over sand and gravelly sand.	Deposits underlying Missouri and Mississippi river flood plains generally yield large quantities of water to wells. (600-2,600 gal/min).
	Pleistocene	Loess and glacial drift	0	0-150	5-30 30-60	Silty clay, silty loam, clay, or loam over residuum and bedrock, or both.	Yields little water to wells (<5 gal/min)
Pennsylvanian		Undifferentiated	0-120	0-75	--2/	Partly silty red shale with purplish-red to light gray clay.	Limited occurrence. Yields small quantities of water to wells (<1-10 gal/min.)
Mississippian	Meramecian	St. Louis Limestone	0-120	0-105	70-75	Limestone; white to light gray, lithographic to finely crystalline, medium to thick bedded. Contains some shale.	Individually, the rock units yield small to moderate quantities of water to wells (5-50 gal/min). Collectively, these units yield sufficient water to supply most domestic and stock needs.
		Salem Limestone	0-225	0-140	90-130	Limestone; light gray to white, fine to coarsely crystalline, cross-bedded. Some siltstone and shale in lower part.	
		Warsaw Formation	0-345	0-95	70-90	Calcareous shales and interbedded shaly limestone, grades downward to shaly dolomitic limestone.	

System	Series	Stratigraphic Unit	Depth from ground level to top of formation, in feet	Thickness, in feet	Typical 1/ thickness, in feet	Physical Characteristics	Remarks
Mississippian (cont.)	Osagean	Keokuk and Burlington Limestone	0-405	0-220	160-200	Limestone; white to bluish-gray, medium to coarsely crystalline, thick-bedded. Cherty.	(See Mississippian remarks on previous page).
		Fern Glen Limestone	0-500	0-85	50-70	Limestone; yellow-brown, fine grained medium to thick-bedded. Contains appreciable chert.	
	Kinderhookian	Chouteau Limestone	0-580	0-105	50-70	Dolomitic limestone; gray to yellowish-brown, fine-grained, thin to medium-bedded.	
Devonian	Upper	Bushberg Sandstone	0-625	0-20	5-15	Quartz sandstone; reddish-brown, fine to medium grained, friable.	Yields small to moderate quantities of water to wells (5-50 gal/min).
		Lower part of Sulphur Spring Group undifferentiated	0-625	0-60	35-40	Calcareous siltstone, and sandstone with oolitic limestone with some dark, hard, carbonaceous shale.	Group also includes Glen Park and Grassy Creek formations.
Ordovician	Cincinnatian	Maquoketa Shale	0-650	0-75	30-50	Calcareous or dolomitic shale, typically thinly laminated, silty, with shaly limestone lenses.	Yields small quantities of water to wells. (Missouri Geological Survey data indicate Maquoketa shale is absent at the Weldon Spring Site.)
	Champlanian	Kimmswick Limestone	0-710	0-140	90-100	Limestone; white to light gray, coarsely crystalline, medium to thick bedded. Cherty near base.	Yields small to moderate quantities of water to wells (10-50 gal/min).
		Decorah Formation	0-810	0-35	30	Interbedded green and yellow shale with thin beds of limestone.	
		Plattin Limestone	0-840	0-195	100-125	Limestone; light to dark gray, finely crystalline. Thinly bedded; weathered with pitted surface.	

System	Series	Stratigraphic Unit	Depth from ground level to top of formation, in feet	Thickness, in feet	Typical 1/ thickness, in feet	Physical Characteristics	Remarks
Ordovician (cont.)	Champlanian (cont.)	Joachim Dolomite	0-950	0-135	90-110	Dolomite; yellowish-brown, silty thin to thick-bedded. Grades into siltstone, shales common.	(Last remark applies to this unit also.)
		St. Peter Sandstone	0-1070	0-250	120-150	Quartz sandstone; yellowish white to white, fine to medium grained, massive bedded.	Yields moderate quantities of water to wells (10-40 gal/min). Everton formation discontinuous.
		Everton Formation	0-850	0-65	0	Sandy dolomite.	
	Canadian	Powell Dolomite	0-950	0-65	50-60	Dolomite; medium to finely crystalline, often sandy, occasionally cherty or shaly.	Generally yields small quantities of water to wells (<10 gal/min).
		Cotter Dolomite	0-1250	75-275	200-250	Dolomite; light gray to light brown, medium to finely crystalline, cherty. Argillaceous, interbedded with green shale.	
		Jefferson City Dolomite	100-1500	145-225	160-180	Dolomite; light brown to brown, medium to finely crystalline.	
		Roubidoux Formation	350-1700	150-170	150-170	Dolomitic sandstone.	Yields moderate to large quantities of water to wells (10-300 gal/min).
		Gasconade Dolomite	500-1850	250	250	Cherty dolomite; Gunter Member is arenaceous dolomite.	Gunter Member is about 30 feet thick.
Cambrian	Upper	Eminence Dolomite	750-2100	190	200	Dolomite; medium to massively bedded, light gray, medium to coarse-grained.	Yields moderate to large quantities of water to wells (10-500 gal/min).
		Potosi Dolomite	950-2250	100	100	Dolomite; massive, thickly bedded, medium to fine grained. Abundant quartz druse.	Freshwater only in southwest part of St. Charles County and saline water elsewhere in county.

System	Series	Stratigraphic Unit	Depth from ground level to top of formation, in feet	Thickness, in feet	Typical 1/ thickness, in feet	Physical Characteristics	Remarks
Cambrian (cont.)	Upper (cont.)	Derby and Doe Run Dolomites	1050-2350	140	150	Dolomite; thin to medium bedded alternating with thin bedded siltstone and shale.	Hydrologic characteristics unknown in St. Charles County. Is a confining bed elsewhere in state.
		Davis Formation	1200-2500	170	170	Contains shale, siltstone, fine-grained sandstone, dolomite, and limestone conglomerate.	
		Bonneterre Dolomite	1350-2650	430	400	Dolomite; typically a light gray, medium to fine grained, medium bedded.	Yields unknown in St. Charles County; however, water probably is saline.
		Lamotte Sandstone	1800-3100	460	450	Predominantly quartzose sandstone.	
Precambrian			2200-3500			Igneous rocks.	Yields no water.

1/ "Typical thickness" refers to thickness of formation normally encountered while drilling.

2/ -- indicates insufficient data for estimate.

at the WSS (Kleeschulte and Emmett, 1986). Data on water-yielding capabilities of the different formations or formation groups are included.

1.2.4.1 Overburden

Overburden, or unconsolidated materials, present at the site can be categorized into six units (BNI, 1984c and 1987):

- Fill/Topsoil
- Wind deposits (loess)
- Ferrelview Formation
- Clay till
- Basal till
- Residuum

The relative positions of the different units are listed above with fill/topsoil being the youngest sediments. BNI depicts the total thickness for the unconsolidated materials as well as that of some of the individual units on isopach maps (1987). The maps are reproduced here in Figures 1-6 through 1-9. The thicknesses depicted are based on boring logs from studies performed in 1983 and 1986 (BNI, 1984c, 1987). Additional boring information from further site characterization will allow for a more accurate delineation of the overburden materials and a modification of the contours. An examination of Figure 1-6 indicates that unconsolidated material underlies the entire site with thicknesses ranging from less than 20 feet to more than 55 feet. The overburden is thicker along the ridge top trending north-south through the middle of the chemical plant area. The thinner portions generally lie along the eastern and western flanks of the site.

Topsoil at the site varies in thickness from 0.5 to 3.5 feet, and is a black, organically rich, silty clay or clayey silt (BNI,

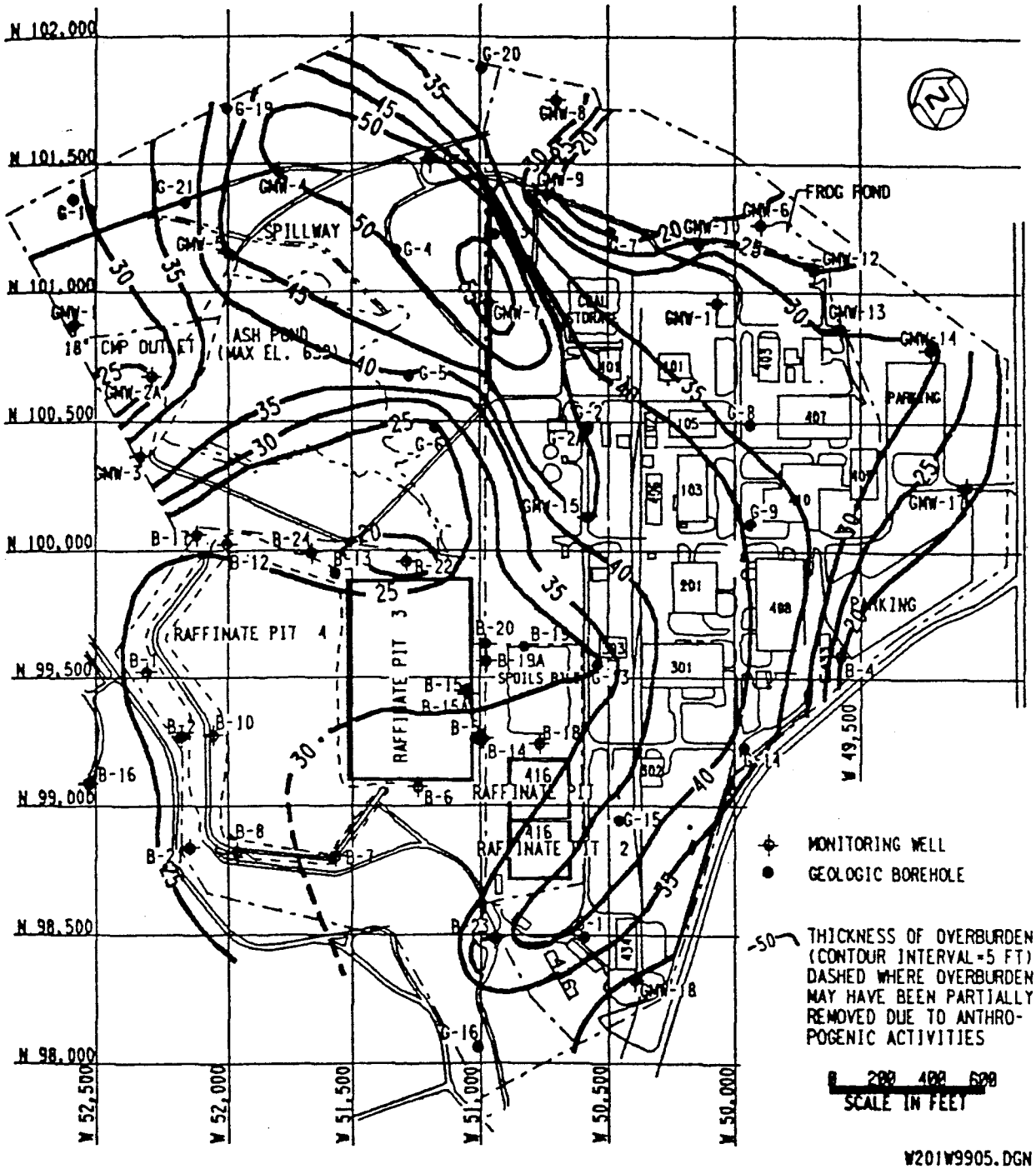


FIGURE 1-6

ISOPACH OF OVERBURDEN

SOURCE : BNI, 1987

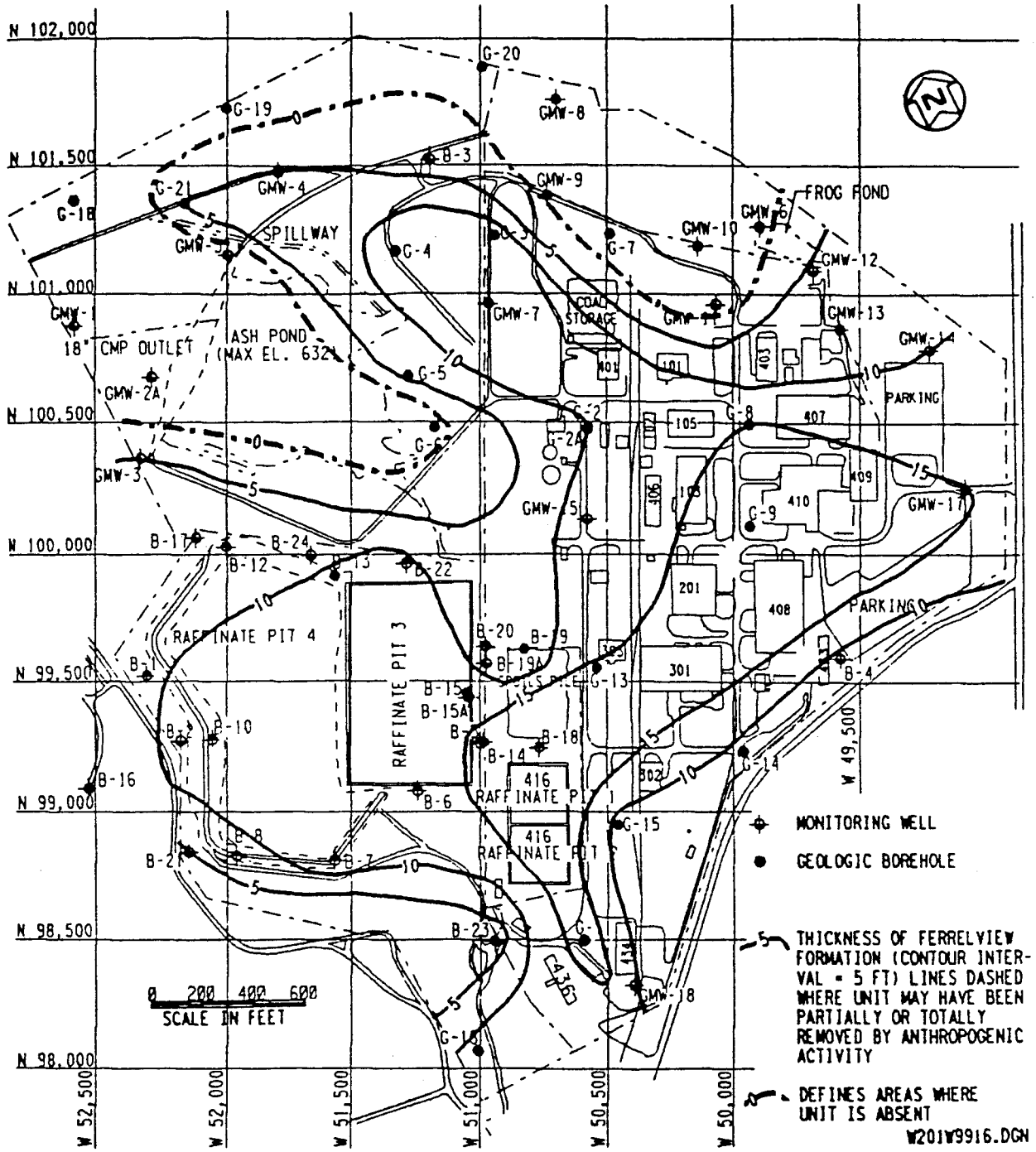


FIGURE 1-7

FERRELVIEW ISOPACH

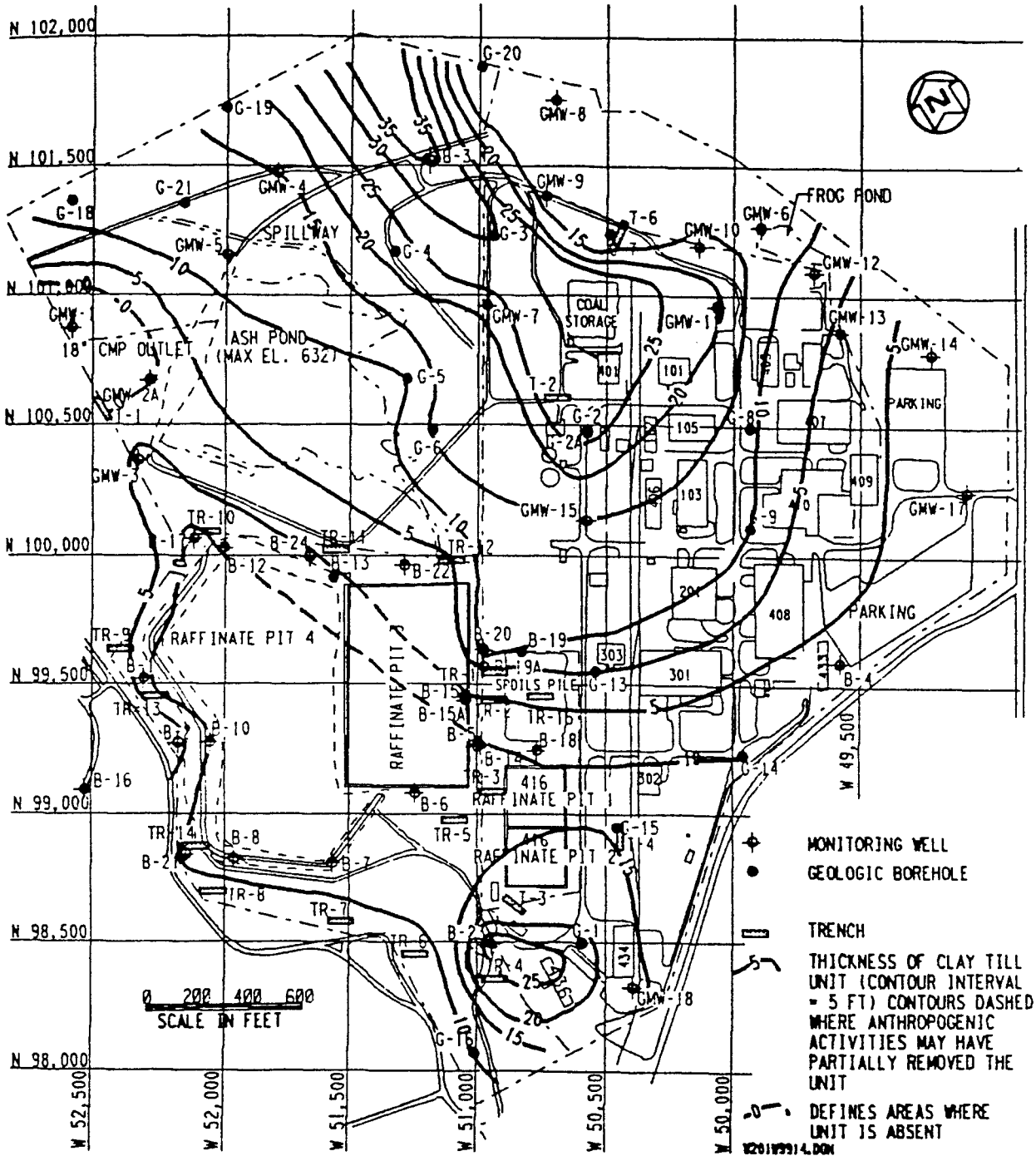


FIGURE 1-8

CLAY TILL ISOPACH

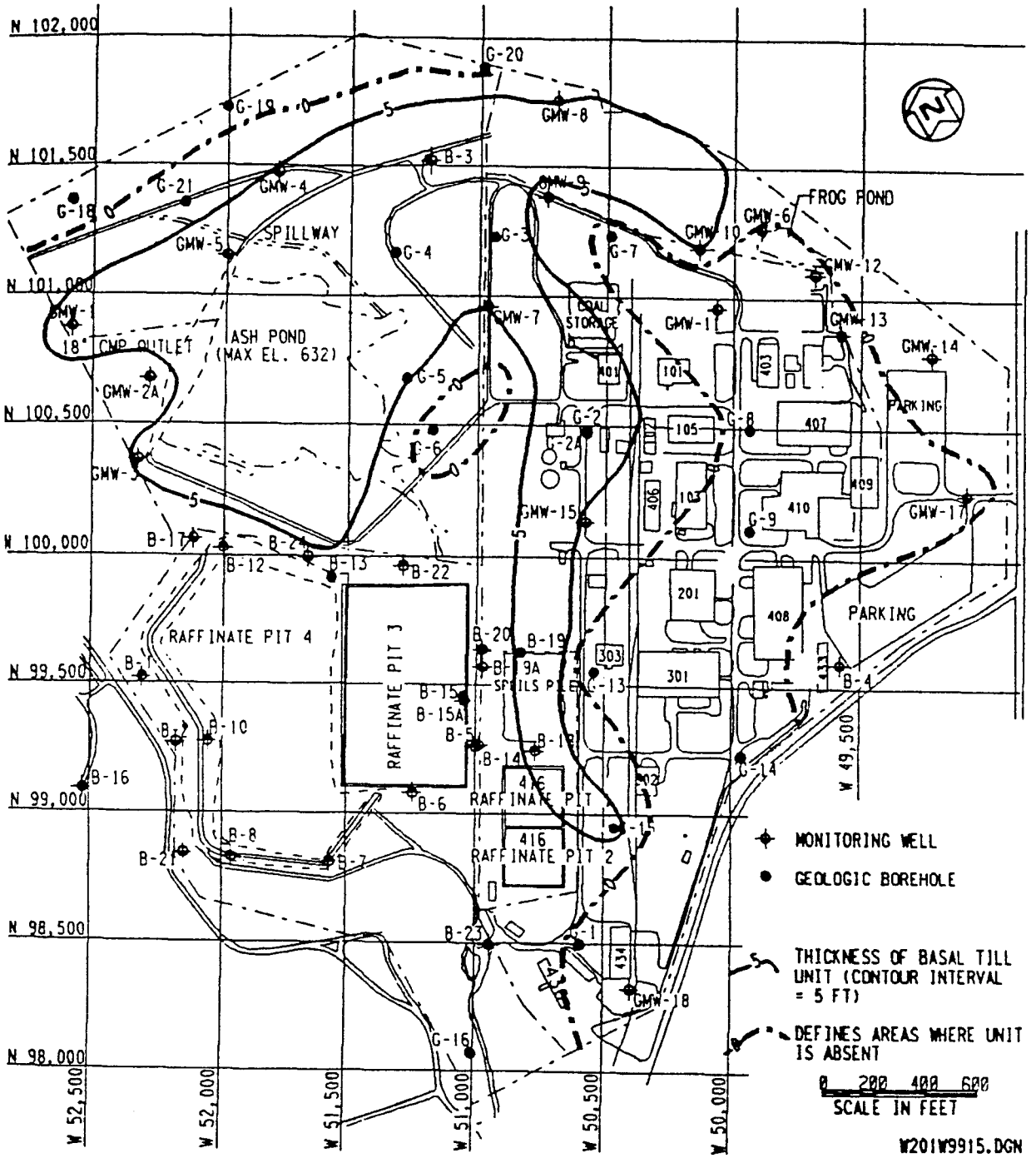


FIGURE 1-9

BASAL TILL ISOPACH

1984c and 1987).

The fill portion is quite variable in composition and thickness and is believed to be primarily local site soils which have been transported and recompacted. The thickest areas of fill are probably at the raffinate pits where up to 26 feet of fill are reported (BNI, 1987).

Loess deposits with thicknesses from 0 to 10.5 feet overlie the Ferrelview Formation or clay till across the site. The distribution and thickness of the loess in the area is quite variable and not well defined (BNI, 1987). Extensive re-working of these unconsolidated sediments occurred during original site construction.

Figure 1-7 illustrates thicknesses of the Ferrelview Formation at the WSS. The Ferrelview Formation is a dark yellowish-orange to brown silty clay to clayey silt with gray mottling. Iron oxide nodules and pyrolusite (manganese oxide) veins and stringers are common in the unit (BNI, 1987). The formation covers most of the site with thicknesses to more than 15 feet. The Ferrelview Formation is apparently absent under Ash Pond and along the northern edge of the site.

The clay till underlying the Ferrelview Formation is a yellowish-brown silty clay to clayey silt. The unit contains sand and gravel-sized particles and pyrolusite veins and stringers (BNI, 1987). Thicknesses of the unit are depicted in Figure 1-8. The unit apparently covers all of the site, except just north of Ash Pond. Thicknesses exceed 35 feet near the northernmost corner of the site.

The basal till unit underlies the clay till unit. Thicknesses of this unit are shown in Figure 1-9. The unit exceeds 5 feet in thickness under Ash Pond and the western portion of the WSCP and is absent beneath the main portion of the WSCP. The basal till

is a yellowish-brown sandy, clayey silt with angular chert gravel and cobbles (BNI, 1987).

The residuum, located at the base of the unconsolidated materials, is typically a red to yellow gravelly clay to gravelly silt. The thickness of the residuum ranges from 0 to approximately 23 feet at the WSS. The distribution and thickness of the residuum in the area is apparently related to localized weathering and erosion (BNI, 1987).

BNI gives summaries of soil testing data for samples from the different overburden units (1987). These data are summarized in Table 1-2. BNI provided the following discussion of the data:

> "Comparison of grain size distributions of the four units indicates that the basal till has the highest gravel content, the clay till has the highest sand and clay content, and the loess has the highest silt content. The Ferrelview Formation contains a higher percentage of silt than the clay till, yet the Ferrelview is thought to be derived from the clay till. The higher silt content of the Ferrelview may reflect loess deposited contemporaneously with the Ferrelview.
>
> "The parameters measured in the soil test program most directly related to the attenuation of radionuclides were effective cation exchange capacity (CEC) and distribution ratio. The clay till unit exhibited the highest cation exchange, followed by the Ferrelview Formation and finally the basal till. The loess unit was not examined in this study due to its limited areal extent on the site. The results of these tests are as could be expected from the percentages of clay in each unit. The clay till has the highest clay content and thus has the highest surface area and largest number of surface charged particles available for cation exchange reactions. The basal till has the least amount of clay and contains significant amounts of quartz and amorphous silica (chert) which provide less possibility for cation exchange sites.
>
> "Distribution ratios were measured using a 10.44 mg/l uranium source solution. The results of the distribution ratio tests indicate no correlation between absorption capacity for radionuclides and cation exchange capacity, with the basal till having the highest distribution ratio and the clay till having the lowest distribution ratio.

TABLE 1-2 OVERBURDEN TESTING SUMMARY (from BNI, 1987)

Unit	Statistic 1/	% of Grain Size				Liquid Limit 2/	Plasticity Index	Unified Soil Class.	Specific Gravity (g/cm^3)	Unit Weight (lb/ft^3)		Moisture Content (%)	Centrifuge Moisture Equiv.
		Gravel	Sand	Silt	Clay					Dry	Wet		
Loess	xa	0	4.4	64	31.6	30	13	CL	2.58	98.8	110.0	--	--
	s	0	1.3	3	4.0	--	--	--	--	7.1	12.4	--	--
	n	5	5	5	5	1	1	1	1	6	6	0	0
Ferrelview Formation	xa	2.8	9.8	49.6	39.6	52.2	35.1	CL-CH	2.61	101.3	122.3	24.7	45.4
	s	4.1	5.5	6.9	10.9	7.8	7.5	--	0.07	12.4	9.4	0.6	8.5
	n	10	10	10	10	8	8	8	11	8	8	7	5
Clay Till	xa	0.4	22.4	31.7	45.6	50.3	34.2	CL	2.60	104.8	123.8	19.3	39.7
	s	1.0	4.5	2.4	4.5	10.5	8.4	--	0.09	4.4	7.0	3.0	5.7
	n	18	18	18	18	16	16	16	18	14	14	15	13
Basal Till	xa	10.7	18.7	39.8	30.8	41.6	23.6	GC-CL	2.45	99.8	118.6	20.9	38.5
	s	17.1	14.3	23.0	8.1	14.1	11.7	--	--	7.8	8.1	3.8	2.1
	n	6	6	6	6	5	5	5	1	5	5	3	2
Fill	xa	20	48	19	13			SM	2.45				
	s	--	--	--	--			--	--				
	n	1	1	1	1			1	1				

1/ Statistics given are: xa - mean; s-sample standard deviation; n - number of test results in computation of statistic

2/ Blanks indicate data of the type indicated were not available in the Bechtel National (1987) reference.

3/ Void ratio = (specific gravity X unit weight of water -1)/dry unit weight

4/ Specific retention = centrifuge moisture equivalent X 0.80

5/ Specific yield = porosity - specific retention

6/ Saturation = (specific gravity X moisture content)/void ratio

7/ Activity = plasticity index/percent of clay

TABLE 1-2 OVERBURDEN TESTING SUMMARY (from BNI, 1987)(cont.)

Unit	Statistic 1/	Void Ratio 3/	Porosity (%)	Specific Retention (%) 4/	Specific Yield (%) 5/	Saturation 6/	Activity 7/	Effective Cation Exch. Cap. (meq/100G)	Distribution Ratio (ml/g)
Loess	xa	--	--	--	--	--	--	--	--
	s	--	--	--	--	--	--	--	--
	n	--	--	--	--	--	--	0	0
Ferrelview Formation	xa	0.61	38	36	2	100	0.89	60.3	54.8
	s	--	--	--	--	--	--	0.1	9.7
	n	--	--	--	--	--	--	2	2
Clay Till	xa	0.55	35	32	3	91.2	0.75	69.0	34.2
	s	--	--	--	--	--	--	11.7	6.2
	n	--	--	--	--	--	--	2	2
Basal Till	xa	0.53	35	31	4	96.6	0.77	29.0	206
	s	--	--	--	--	--	--	--	--
	n	--	--	--	--	--	--	1	1
Fill	xa	--	--	--	--	--	--		
	s	--	--	--	--	--	--		
	n	--	--	--	--	--	--		

1/ Statistics given are: xa - mean; s-sample standard deviation; n - number of test results in computation of statistic

2/ Blanks indicate data of the type indicated were not available in the Bechtel National (1987) reference.

3/ Void ratio = (specific gravity X unit weight of water -1)/dry unit weight

4/ Specific retention = centrifuge moisture equivalent X 0.80

5/ Specific yield = porosity - specific retention

6/ Saturation = (specific gravity X moisture content)/void ratio

7/ Activity = plasticity index/percent of clay

> Visual examination of the samples by laboratory personnel indicates that the basal till sample has the highest organic content of the samples tested. This suggests that the reactions observed in the basal till sample may be related to organic matter content rather than cation exchange capacity, since CEC measurements show the basal till has the lowest CEC. The implication of this reasoning is that the ability of the basal till to immobilize radionuclides is directly related to organic content and the geochemical environment and may vary both spatially and temporally."

Quartz, limonite, and calcium carbonate (limestone) were noted in particle size analyses of the overburden (BNI, 1987). These rock minerals are of interest as they influence solubility, groundwater chemistry, and possibly the physical nature of the unsaturated zone and the aquifer. In addition, the mineralogical composition is useful in assessing the leaching and/or attenuation of contaminants. The available data are not quantitative.

1.2.4.2 Bedrock

Geologic cross sections have been drawn to show the overburden materials and the upper part of the bedrock at the WSS with hydraulic conductivity (permeability) information. The locations of these cross sections are presented in Figure 1-10 and the cross sections are shown in Figures 1-11 through 1-13. Estimated thicknesses of the bedrock units are shown in Table 1-3. Cross-sections will be modified as additional data are obtained under this and other (e.g. soil, geotechnical, geophysical) investigative programs.

The near-surface rock units at the site are sedimentary. The first bedrock unit underlying the overburden is the Keokuk and Burlington Limestones or the Burlington/Keokuk Formation. This is a white to bluish-gray, medium to coarsely crystalline, thick bedded limestone containing chert. At the site, the Burlington/Keokuk Formation can be subdivided into two units. The uppermost unit is moderately to highly weathered and fractured,

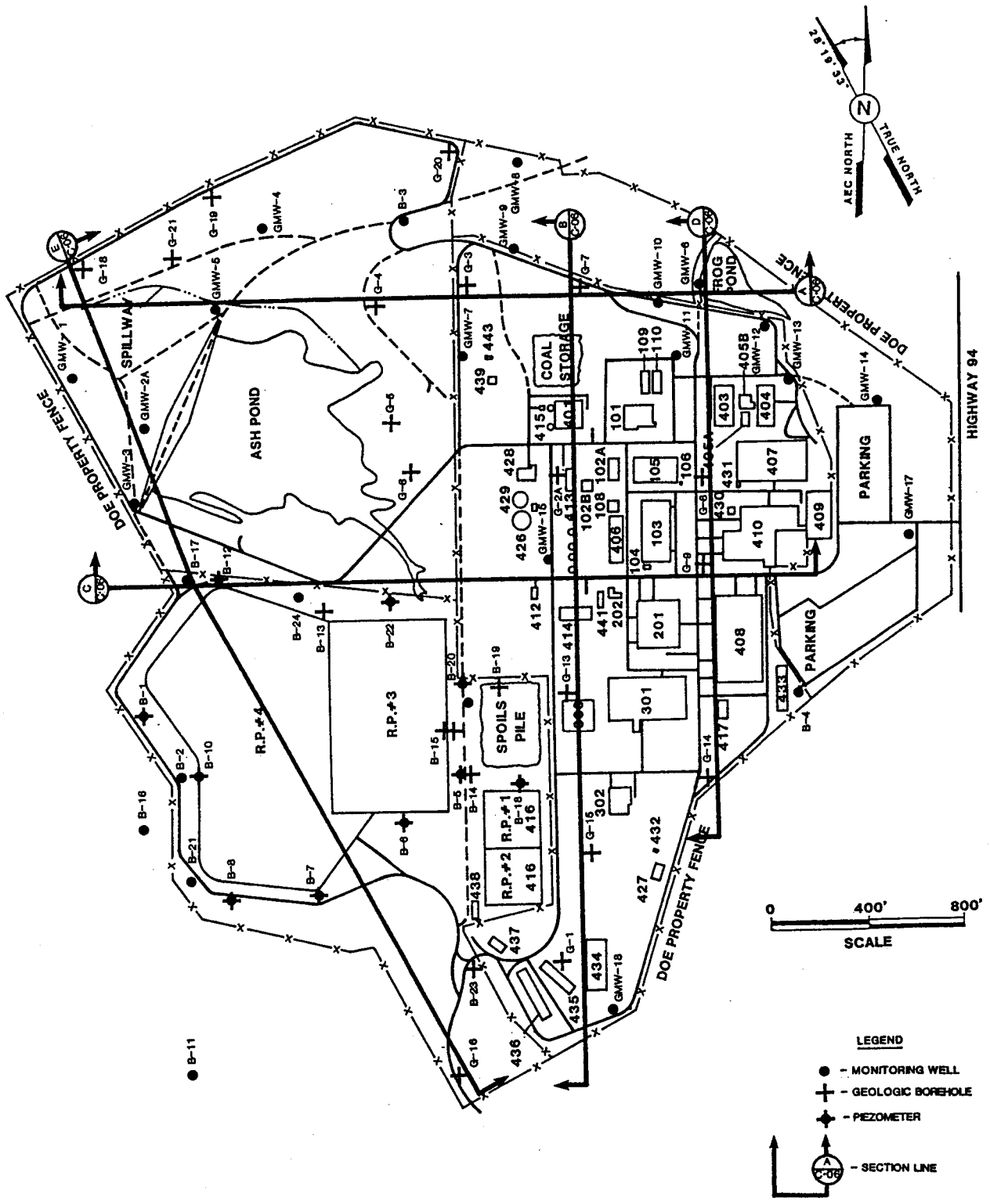


FIGURE 1-10

LOCATION OF CROSS SECTIONS

SOURCE : BNI, 1987

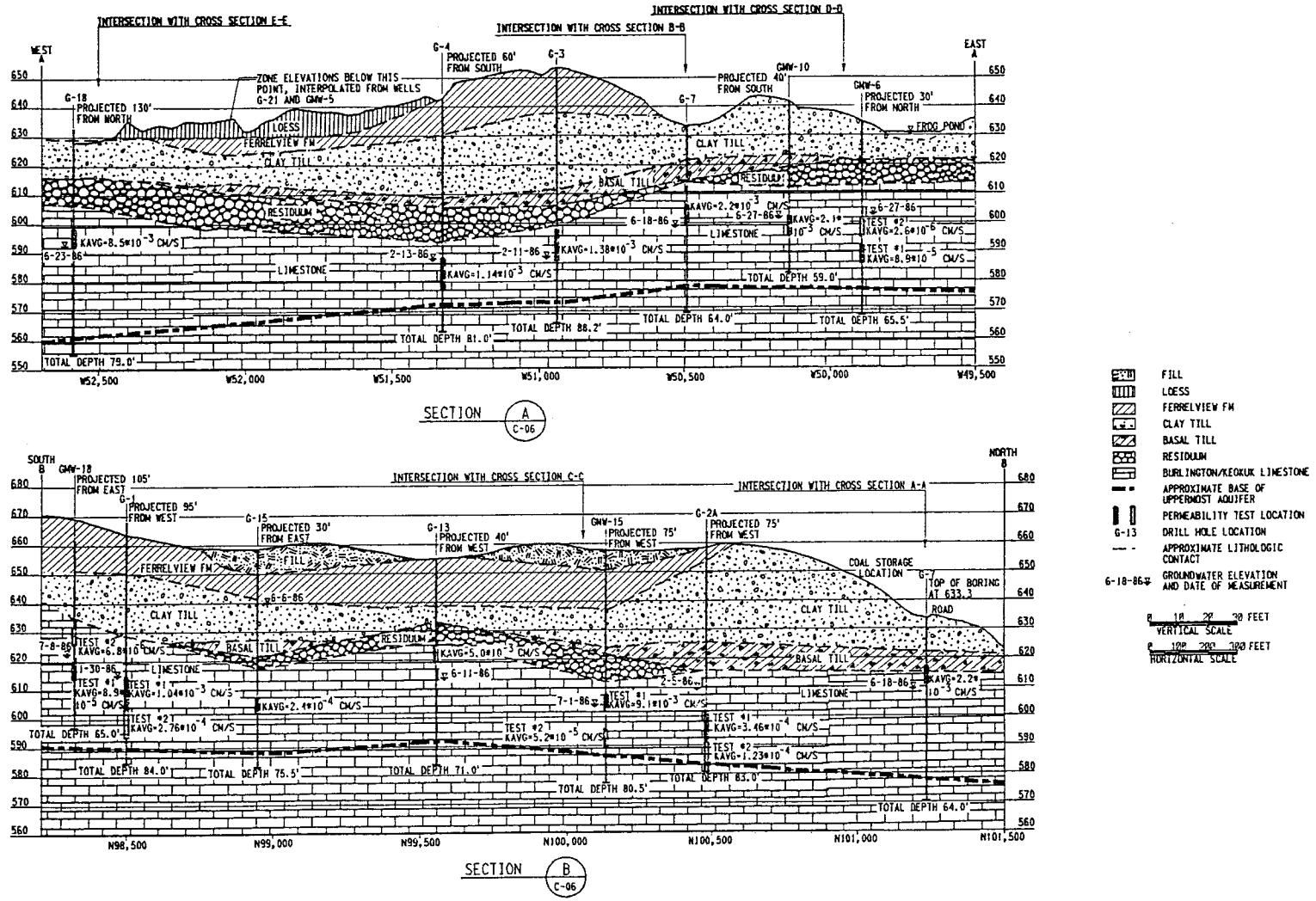


FIGURE 1-11

GEOLOGIC CROSS SECTIONS A-A AND B-B

SOURCE : BNI, 1987

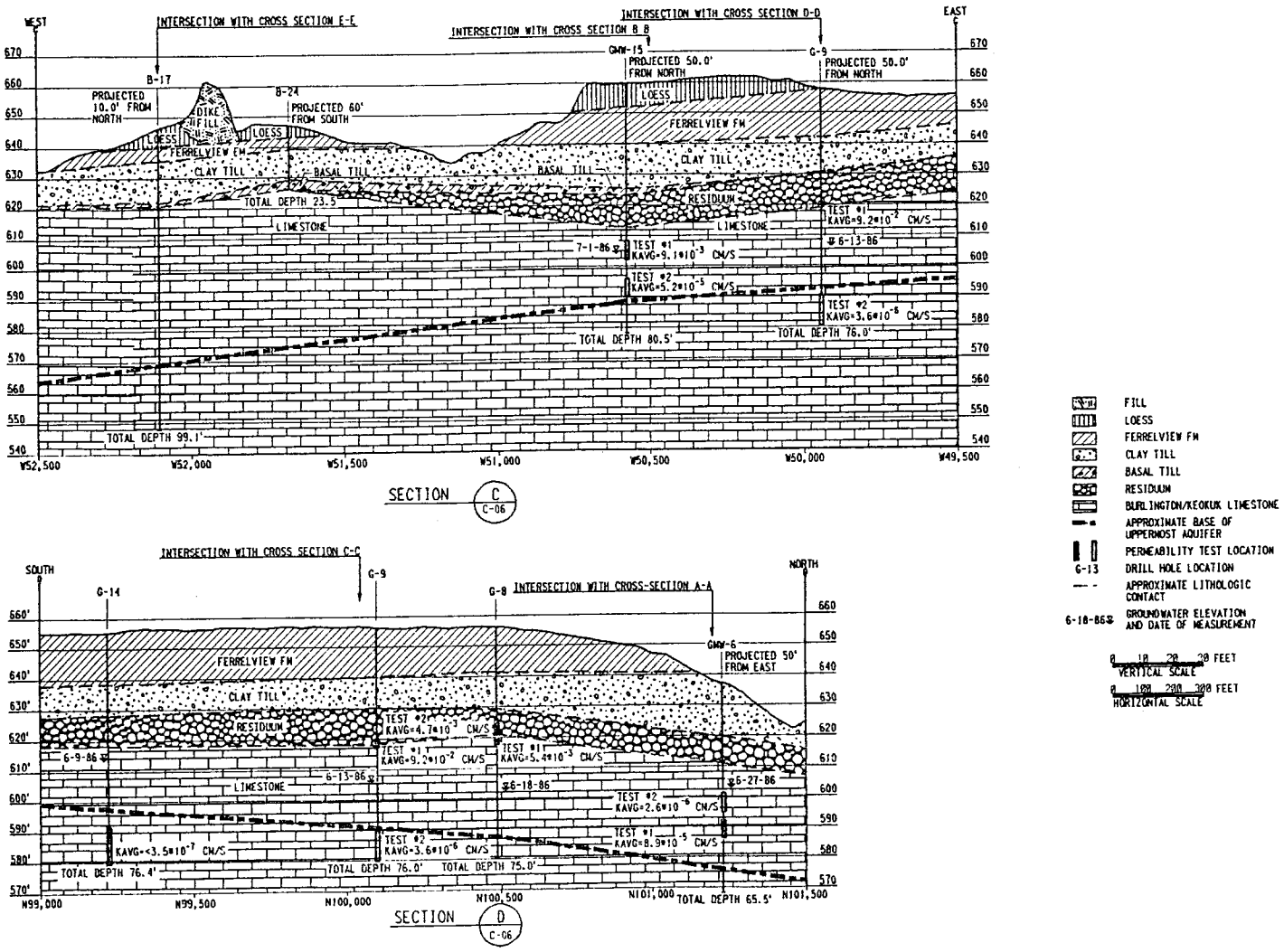
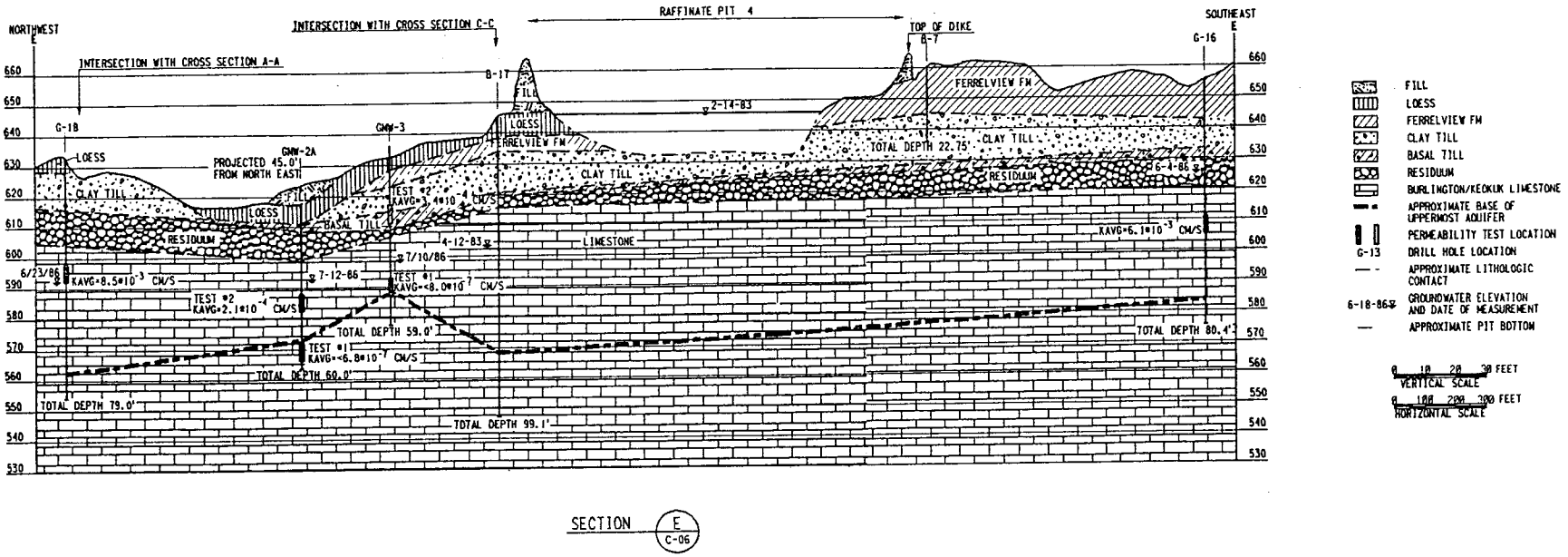


FIGURE 1-12

GEOLOGIC CROSS SECTIONS C-C AND D-D

SOURCE : BNI, 1987



SECTION E / C-06

W201W9909.DGN

FIGURE 1-13

GEOLOGIC CROSS SECTION E-E

SOURCE : BNL 1987

TABLE 1-3

ESTIMATED THICKNESSES OF BEDROCK UNITS AT WSS

Stratigraphic Unit	Estimated Thickness, ft
Burlington/Keokuk Formation	160
Fern Glen Limestone	50
Chouteau Limestone	20
Bushberg Sandstone	7
Kimmswick Limestone	90
Decorah Formation	30
Plattin Limestone	120
Joachim Dolomite	90
St. Peter Sandstone	135

yellowish brown to white and consists of approximately 50% chert. This unit contains solution features ranging from vugs (up to 2 in. diam.) to small cavities (up to 5 ft diam.).

These cavities are generally filled with sand/chert gravel mixtures. Solution features and predominant fractures appear to be oriented to the bedding. Figures 1-11 through 1-13 depict the estimated base of the uppermost unit as defined by lithologic logs and hydraulic conductivity testing (BNI, 1987). Thicknesses of this unit vary from approximately 20 ft to greater than 50 ft. The variability in thickness is attributed to a variance in the depth of weathering of the limestone. There is no defined base of the weathered zone.

The lower unit of the Burlington/Keokuk Formation is slightly weathered to fresh, slightly fractured, to brownish-gray to gray limestone, and contains approximately 30% chert.

From a study of the core samples the unit appears to be massive. Solution features are limited to occasional vugs in the upper portion. Pressure solution features and/or shale interbeds are common (BNI, 1987). The thickness of the unit is not defined, but is estimated to be approximately 130 ft, based on regional data presented in Table 1-1. A 30-ft thickness for the upper unit is assumed.

The formation underlying the Burlington/Keokuk at the WSS is the Fern Glen Limestone. This is a thin to thick bedded, crystalline to argillaceous limestone. Chert is common in this formation with the occurrence of occasional calcareous shale interbeds. The thickness of this unit at the site is estimated as approximately 50 ft.

Brief descriptions of the units from the base of the Fern Glen Limestone through the St. Peter Sandstone are as follows (after BNI, 1987):

Chouteau Formation	Conformably underlies Mississippian age, Osagean series which includes the Fern Glen Limestone and the Burlington/Keokuk Limestone. Thin-bedded limestone containing a few shale partings and localized argillaceous material and chert. Unconformably overlies the Bushberg Sandstone.
Bushberg Sandstone	Fine to medium-grained quartzose sandstone with variable carbonate content. Unconformably overlies the Kimmswick Limestone.
Kimmswick Limestone	Composed of thick-bedded, high-purity limestone with local concentration of chert.
Decorah Formation	Thin-bedded argillaceous limestone with intercalated calcareous shales. Thin bed of metabentonite separates the Plattin and Decorah formations.
Plattin Limestone	Thin to thick-bedded, microcrystalline to fine-grained limestone.
Joachim Dolomite	Thin to thick-bedded dolomite which grades into siltstone.
St. Peter Sandstone	Composed of fine to medium-grained, massive-bedded, quartzose sandstone.

Krummel (1956) provides more detailed descriptions of most of the bedrock units including their lithologies.

The Burlington/Keokuk Formation, as indicated above, contains solution features. Also the Kimmswick Limestone contains stylolites (pressure solution features), commonly along bedding planes, and is well jointed and may contain caverns (Krummel, 1956). The possible existence of migration pathways in the other bedrock is not defined. However, water for wells is obtained from the permeable zones of many of the formations (see Table 1-1). Dye tracing studies by Dean (1983a, 1983b, 1983c, 1984a, 1984b, 1985) indicate the presence of subsurface pathways.

Thicknesses of the deeper units at the site are unknown but can

be estimated from the regional data shown in Table 1-1.

Figure 1-14 (in pocket) represents the configuration of the upper surface of the Burlington/Keokuk Formation at the site, and is based on recent (1988) investigations. BNI and MKF have generated contour maps of the bedrock surface (BNI, 1987; MKF, 1987b). Those maps present a similar configuration of the bedrock surface.

The rocks in the area have a regional strike of N60o$_W$ and regional dip of approximately 1/2 degree to the northeast. The regional dip is predominantly from the Ozark Dome, though several other features may influence the dip. The Division of Geology and Land Survey of the MDNR has recently mapped a fault, trending east-west, about one mile north of the WSS. The fault has approximately 60 feet of vertical displacement (memo to Dave Bedan from Dave Hoffman, MDNR, June 10, 1988). Roberts (1951) has identified two major joint sets in the area; the first set trends between N30^{o}E to N72^{o}E and the other set trends between N30^{o}W to N65^{o}W. These joints are present in the Burlington/Keokuk, the Chouteau, and the Kimmswick (Roberts, 1951). Krummel (1956) and Kleeschulte and Emmett (1986) indicated they are vertical or nearly vertical.

1.2.5 Surface Water Hydrology

The site is located on the drainage divide between the Mississippi and Missouri rivers. The northern part of the WSS drains to Schote Creek, then to Dardenne Creek, and then to the Mississippi River. Drainage from the southern portion of the site flows to unnamed tributaries flowing into the Missouri River. Topographic maps are available for the site and vicinity. These include a range of map scales from 1:24000 (USGS, 1982) to 1:600 (Surdex Corp., 1983) and were produced in the period from 1982 to 1987.

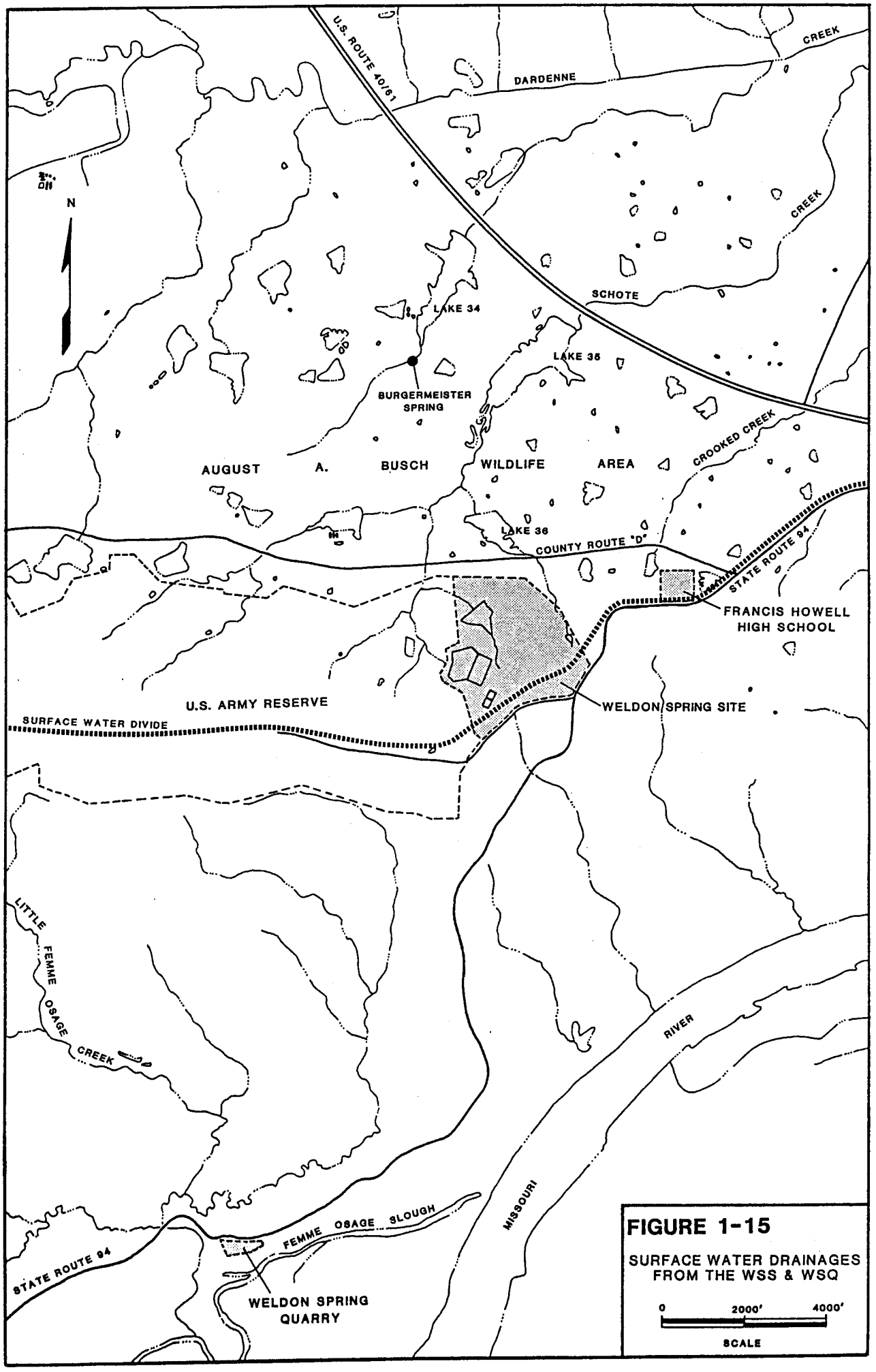
Surface water drainages from the WSS are shown in Figure 1-15. Surface water in the Mississippi River drainage is divided into three major drainage basins: Ash Pond area, Frog Pond area and raffinate pit vicinity. Both the Ash Pond and raffinate pit vicinity drainages enter an unnamed tributary to Schote Creek and flow on to Lake 35. Both streams lose water to the subsurface. Some of this lost flow resurfaces at Burgermeister Spring (Dean, 1985). Surface water from Frog Pond exits the WSCP and flows into Lake 36. Overflow from Lake 36 enters Schote Creek and flows into Lake 35.

Lake 35 has lost water to the subsurface since its construction (Meyer, 1987). Lake 35 overflows to Schote Creek only during extreme precipitation events. Schote Creek joins Dardenne Creek just east of Highway K.

In early 1987, a small swallow hole opened near the headwaters of Lake 35. Missouri Department of Natural Resources (MDNR) dye studies determined that some of the lost water resurfaces in Lake 34 and at a spring northwest of Lake 34 near Twin Island Lake. MDNR dye studies are discussed in Section 1.2.7.2. Subterranean flow surfacing at Burgermeister Spring flows into Lake 34. Lake 34 outflow enters an unnamed tributary of Dardenne Creek. Dardenne Creek flows northeast to the Mississippi River.

The 20 acres of the WSS that are in the Missouri River drainage are located in the southeast portion of the WSCP. Drainage is overland via the Southeast Drainage Easement, an intermittent stream valley approximately 1.5 miles long.

Estimates of recharge or discharge via these associated systems are not available. Kleeschulte et al, (1986) present results of streamflow measurements at 102 sites taken in April 1985 from Dardenne Creek tributaries for seepage run determinations. Other streamflow measurements for the vicinity of the WSS are also included. Further discussion of this surface-subsurface


U.S. ROUTE 40/61
DARDENNE CREEK
N
SCHOTE CREEK
LAKE 34
LAKE 35
BURGERMEISTER SPRING
AUGUST A. BUSCH WILDLIFE AREA
CROOKED CREEK
LAKE 36
COUNTY ROUTE "D"
STATE ROUTE 94
FRANCIS HOWELL HIGH SCHOOL
U.S. ARMY RESERVE
WELDON SPRING SITE
SURFACE WATER DIVIDE
LITTLE FEMME OSAGE CREEK
RIVER
MISSOURI
FEMME OSAGE SLOUGH
STATE ROUTE 94
WELDON SPRING QUARRY
FIGURE 1-15
SURFACE WATER DRAINAGES FROM THE WSS & WSQ
0 2000' 4000'
SCALE

interrelationship is included in Section 1.2.7.

Runoff from the southern portion of the site and much of the chemical plant area flows southward to the Missouri River. Some of the rainwater and snow melt enter various man-made drains in the chemical plant area. These drains flow into the process sewer which exits southward from the site to a drainage ditch and flows to the Missouri River.

As discussed earlier, four raffinate pits exist at the site -- Raffinate Pits 1, 2, 3, and 4. These are described in Table 1-4. They have served as sources of contamination (Section 1.2.8) and also provide some driving head for moving contaminants into the subsurface system. Recharge estimates for water in the raffinate pits are available for months April through October over a 3-year period (1983-1985) (BNI, 1986a). Water balance studies indicated total water losses to be on the order of one and one-half to two millimeters drop in elevation per day. Cumulative changes over a 7-month period were substantial enough to document loss of water, though magnitude of loss on a per-day basis was close to the accuracy of the monitors used. The BNI report notes that a 2 mm loss would translate to a permeability rate of 10^{-7} cm/sec. When evapotranspiration is accounted for, an average loss from the pits of less than 1 mm depth per day or less than one gpm/acre of pit area is estimated.

The U.S. Army Corps of Engineers has developed some preliminary estimates of hydrologic parameters for Schote Creek at the site (DOE, 1987). The 100-year and 500-year flood peak discharges for the main stem of Schote Creek are 2,100 and 2,700 cfs, respectively. The 500-year flood elevation near the raffinate pits was determined to be about 530 feet, which is considerably lower than the elevation of the site (DOE, 1987).

TABLE 1-4

APPROXIMATE RAFFINATE PIT SIZES (MKF, 1987b)

Pit No.	Design Capacity (c.y.)	Sludge Vol. (c.y.)	Ponded Water (gal.)	Surface Area (ac.)	Surface Water Elevations (ft. MSL)	Avg. Water Depth (ft.)
1	18,500	17,400	1,600,000	1.2	661.3	4
2	18,500	17,400	1,600,000	1.2	661.5	4
3	166,700	129,600	9,700,000	8.1	659.5	3.7
4	444,400	55,600	43,200,000	15.0	646.4	8.8

1.2.6 Vadose Zone

Downward movement of water from the surface or near surface typically would pass through an unsaturated zone of soil, defined as the vadose zone, before proceeding to a predominantly saturated zone. Lateral movement of this water can also occur. The upper portion of the vadose zone is the soil water zone or the soils zone. The soils zone extends from the land surface to a depth corresponding to the predominant root depth for vegetation in the area, which typically is no more than a couple of feet at the WSS.

Because of local and seasonal variations in recharge and discharge, the vadose zone thickness is expected to vary locally, seasonally, and from year to year. A comparison of Figures 1-16 and 1-17 gives an indication of the seasonal variation of vadose zone thickness. Additional monitoring data will allow for a more accurate delineation of seasonal variation of groundwater levels as outlined in Section 2. Specific yield (effective porosity) in limestones, in zones with limited fracturing and solution cavities, can be assumed to range from <5 to 10%. Therefore, moderate precipitation events, perhaps in recharge areas southwest of the site can be responsible for seasonal variations in water levels as illustrated in Figures 1-16 and 1-17. An examination of cross sections in Figures 1-10 through 1-13 shows the groundwater elevations in the summer of 1986 as being typically 10 ft below the top of bedrock. The vadose zone thickness variation from more than 30 ft to more than 65 ft at different locations in the WSS is also governed, in part, by topographic and manmade features.

Also, the geological environment at the WSS exhibits complex saturated-unsaturated conditions occurring within the vadose zone. Saturated regions within the vadose zone (perched groundwater bodies) result from the presence of a lower hydraulic conductivity layer in a higher hydraulic conductivity formation.

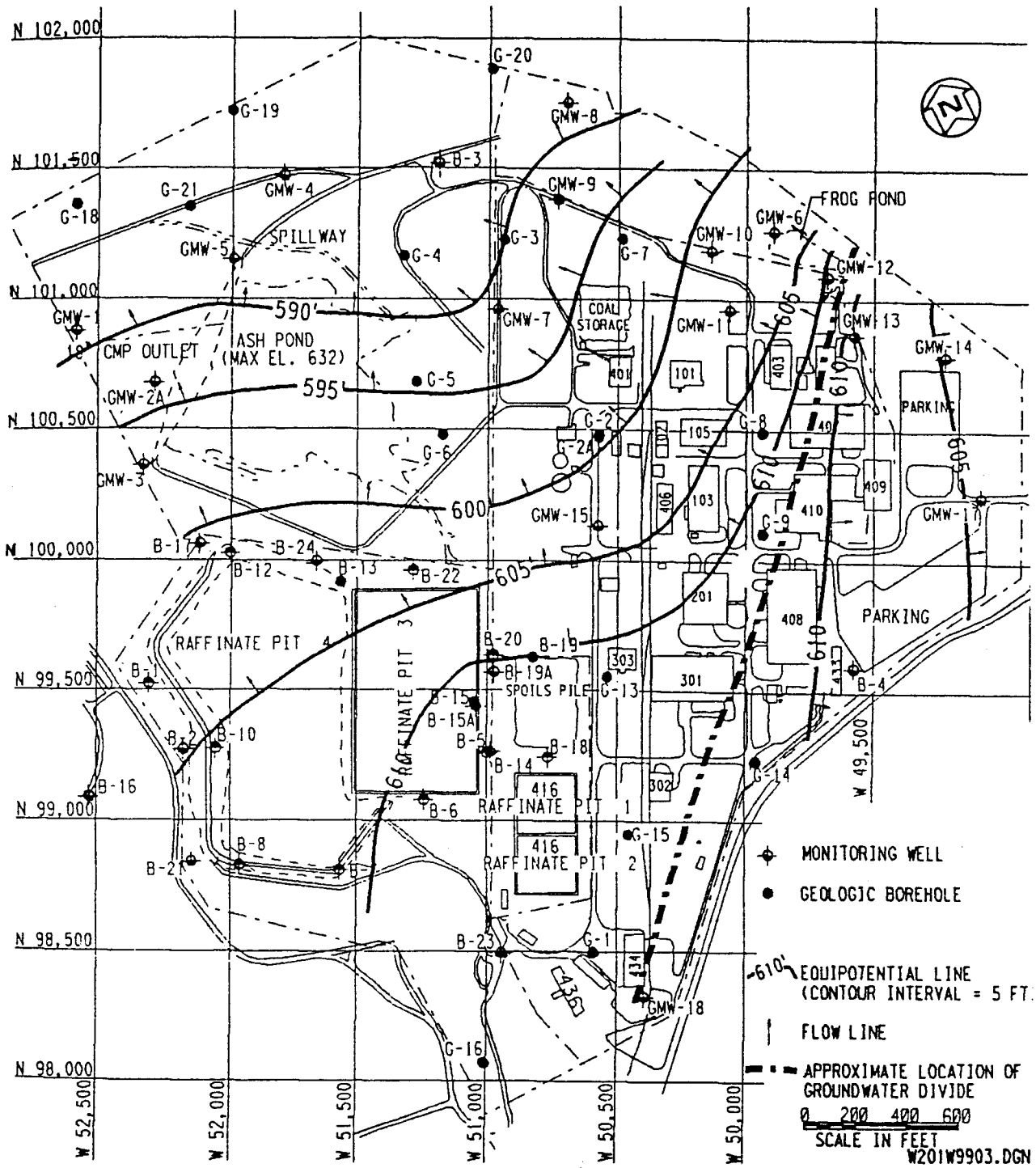


FIGURE 1-16

GROUNDWATER ELEVATIONS AND CONTOURS WSCP/WSRP

NOVEMBER 1986

SOURCE : BNI, 1987

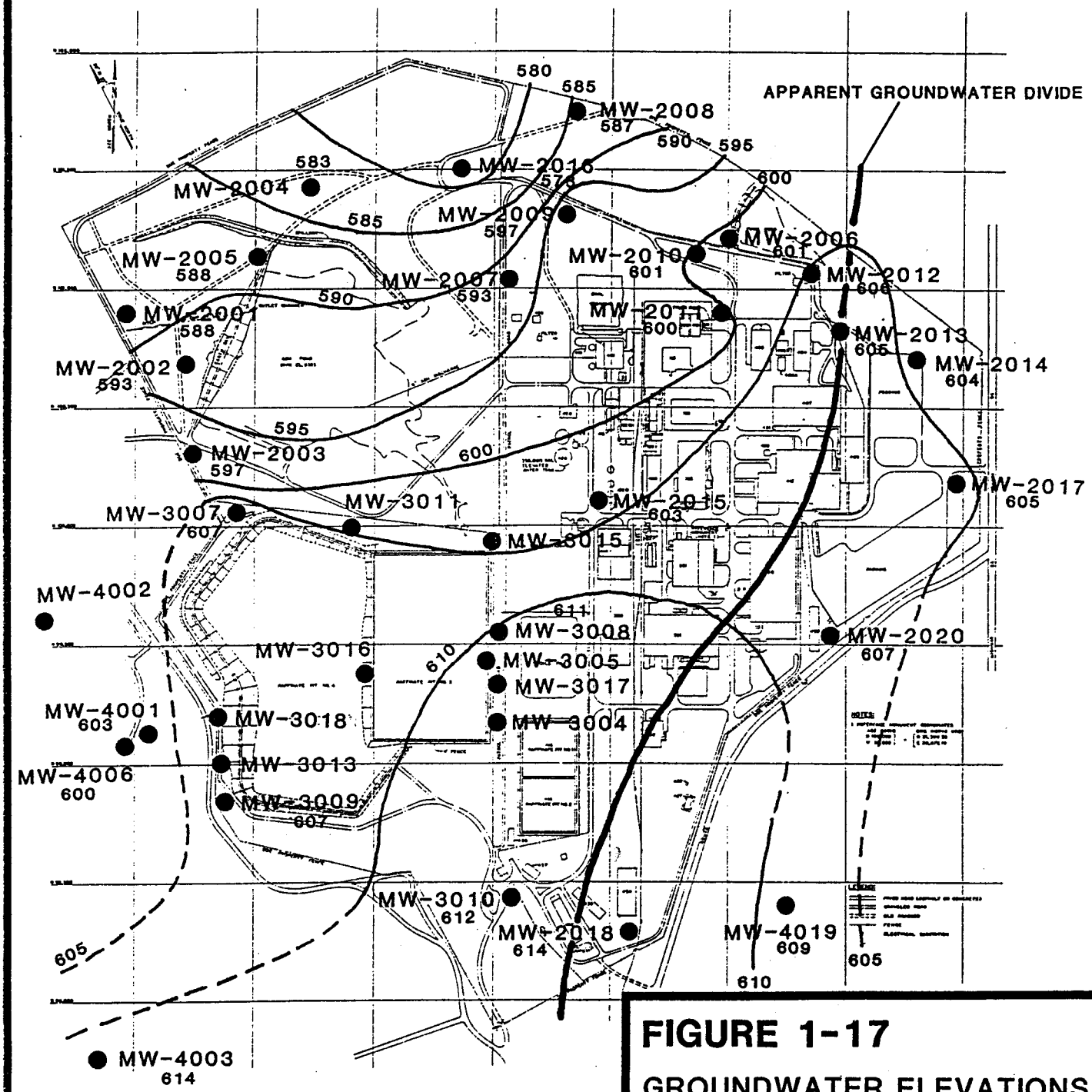


FIGURE 1-17

GROUNDWATER ELEVATIONS AND CONTOURS ON UPPER BURLINGTON-KEOKUK FORMATION WSCP/WSRP

MARCH 1987

SOURCE: MK-FERGUSON 1987

The result is the formation of discontinuous saturated lenses above the lower hydraulic conductivity clay layer, with unsaturated conditions existing both above and below these lenses.

Previous exploratory drilling investigations conducted at the WSS indicated areas of anomalously high groundwater elevations or perched groundwater in the vicinity of the raffinate pits (Lawrence Berkeley Laboratories, 1980, BNI 1984, and UNC Geotech July 1987). Fourteen observation wells and 10 vibrating-wire piezometers were installed in the overburden over the course of three investigations. Completion data for these installations is shown on Table 1-5. Wells were renumbered by WSSRAP staff along with bedrock monitoring wells at the beginning of WSSRAP efforts, prior to separation of bedrock aquifer and overburden monitoring programs. Wells to be used in further overburden studies are discussed in Section 2.4.

Of the 24 installations, 6 indicated saturated conditions during the original investigations. Pore-pressure measurements from Piezometers B-5 and B-22 indicated saturated conditions. Wells B-2 and B-14 originally penetrated saturated soils, although B-14 went dry near the end of the BNI investigation and has remained dry. Well W-2, installed by Lawrence Berkeley Laboratories, penetrates soils which are seasonally saturated. Well B-16 was installed in saturated residuum overlying bedrock on the Weldon Spring Training Area at a relatively remote location from the raffinate pits. Well B-15A, installed on the east berm of Raffinate Pit 3, was dry during the original investigation but has contained water continuously during WSSRAP efforts. Water level elevation in this well is approximately 630 feet, compared to a water level elevation of 611 feet in MW-3008 approximately 120 feet to the northeast, indicating significant, although perhaps localized mounding. Water level elevation in W-2, on the west side of Raffinate Pit 4 is approximately 612 feet, compared with a water level elevation of 607 feet in MW-3007 to the north and MW-3009 to the south, indicating a smaller degree of mounding

TABLE 1-5

OVERBURDEN WELL AND PIEZOMETER DATA SHEET
WELLS AND PIEZOMETERS INSTALLED DURING PREVIOUS INVESTIGATIONS

NEW WELL NUMBER	OLD WELL NUMBER(S)	APPROXIMATE COORDINATES NORTH	WEST	ELEVATION OF TOP OF CASING NGVD*	TOTAL DEPTH FT BGL**	CASING DIAMETER IN	SCREEN LENGTH FT
	B-1	99507	52283	N/A	18.5	N/A	0.5
	B-2	---	---	633.08	26.8	2	3.0
	B-5	99235	50977	N/A	18.8	N/A	0.5
	B-6	99050	51224	N/A	19.5	N/A	0.5
	B-7	98764	51596	N/A	21.3	N/A	0.5
	B-8	98750	51969	N/A	28.5	N/A	0.5
	B-10	99257	52044	N/A	23.8	N/A	0.5
	B-12	100003	51968	N/A	29.0	N/A	0.5
OMW-3503	B-14	99236	50965	655.62	21.8	2	5.0
	B-15A	99410	51021	665.66	32.0	2	5.0
MW 4006***	B-16	99014	52513	623.06	28.5	2	5.0
	B-18	99218	50750	N/A	23.4	N/A	0.5
	B-20	99597	50956	N/A	29.0	N/A	0.5
	B-22	99931	51266	N/A	13.0	N/A	0.5
	B-24	99965	51635	652.14	26.5	2	3.0
	W-1	**			33.0	4	
OMW-3504	(W-2) (MW-3018)**				22.0	4	
	W-3	**			25.0	4	
	W-4				20.0	4	
	W-5				32.5	4	
	W-6				51.0	4	
	W-7				35.0	4	

* NGVD - Natural Geodetic Vertical Datum of 1929
** BGL - Below Ground Level
*** MW-4006 is included in the bedrock monitoring well network

in this area. Further studies will more closely examine hydrogeologic conditions at the residuum/bedrock interface. Additional investigations by BNI included conducting geophysical surveys which detected seismic velocity layers of 5000 ft/s at approximately 10 feet below ground surface in the areas within, beneath, and surrounding Raffinate Pit 3. This velocity is generally indicative of saturated conditions. Figure 1-18 presents a contour map of the surface of this 5000 ft/s layer and indicates a mounding effect from Raffinate Pit 3 (BNI 1984). Two shallow overburden monitoring wells were installed in July 1987 by UNC Geotech to investigate perched groundwater due to shallow seepage from the raffinate pits. One well, OW-3501, located immediately to the north of Raffinate Pit 1, indicated a shallow saturated zone approximately 1 foot below the surface. A similar installation (OW-3502) on the north side of Raffinate Pit 3 has remained dry since installation.

A total of 10 lysimeters were installed in 3 boreholes during the period July 7-10, 1987 during the course of radiologic site characterization by UNC Geotech Inc. These multiple lysimeter installations were planned as a preliminary assessment of contaminant transport by unsaturated flow. Locations were selected from examination of color aerial photographs on which areas of dark green vegetation indicated potential seepage of raffinate pit waters with high nitrate concentrations. Figure 1-19 presents the locations of the lysimeters installed by UNC Geotech. Results of analyses for inorganic constituents from soil pore-water samples obtained on Sept. 17, 1987 indicate elevated concentrations of nitrate, calcium, and sodium at all three locations. The sample containing the highest concentrations of these parameters, especially nitrate (8,976 mg/l), was obtained from lysimeter LY-3608 at a depth of 5.5 feet. The lysimeter is located north of Raffinate Pit 1 (Figure 1-19) in an area exhibiting saturated conditions near the surface. The analytical results coupled with the saturated

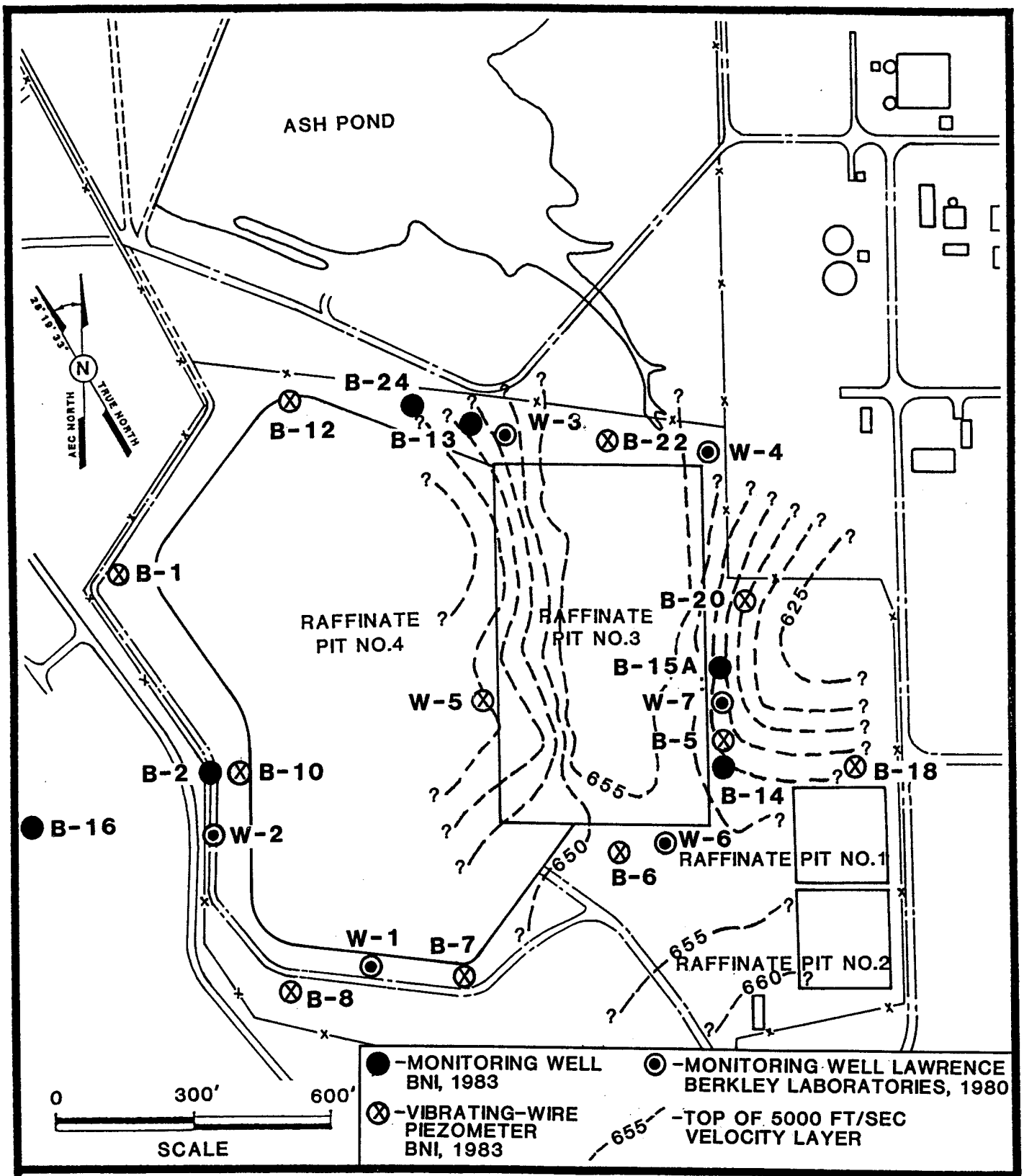


FIGURE 1-18

OVERBURDEN MONITORING WELLS AND PIEZOMETERS

INSTALLED DURING PREVIOUS INVESTIGATIONS
SOURCE : BNI, 1984

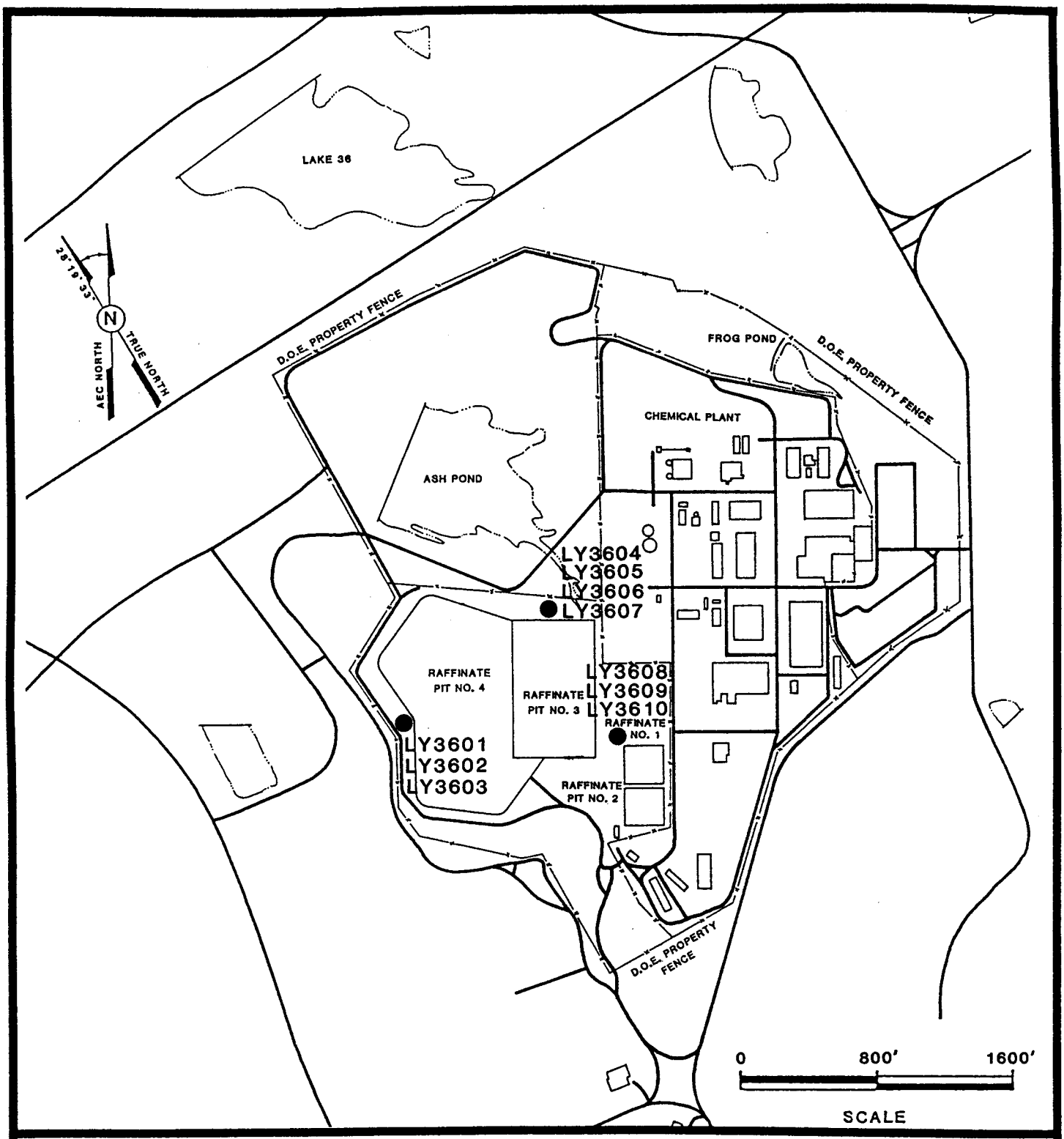


FIGURE 1-19

EXISTING LYSIMETER LOCATIONS

surface conditions indicate seepage is occurring from Raffinate Pit 1. Additional lysimeter monitoring points will be required in order to evaluate contaminant migration.

1.2.7 Hydrogeology

This section summarizes information available in existing reports related to the hydrogeology of WSS and adjacent areas. Information on groundwater occurrences and flow and their variations is presented along with a discussion of potential areas of recharge and discharge at the WSS and vicinity. Quantitative information on background water quality and an evaluation of the adequacy of the data are also presented.

1.2.7.1 Groundwater Occurrences

As discussed in previous sections, the land surface slopes outward from the site. The sediments consist of unconsolidated material overlying slightly dipping bedrock formations of varying complexity and importance.

The USGS delineates three principal aquifer systems in the general area: the alluvial aquifers, the shallow bedrock aquifer system, and the deep aquifer system (Kleeschulte and Emmett, 1986). The alluvial aquifers include the saturated sands, gravels, and silts in the alluvium of the Missouri and Mississippi rivers and the alluvium of tributary creeks where significant groundwater yields can occur. The shallow bedrock system primarily consists of saturated rock of Mississippian and Devonian age which includes formations at the WSS from the Burlington/Keokuk Limestone down through the Bushberg Sandstone. At the WSS the shallow bedrock aquifer is subdivided into upper and lower zones. The upper zone is the weathered and fractured portion of the Burlington/Keokuk Formation. The deep aquifer system primarily consists of Ordovician and Upper Cambrian saturated rocks which include sediments from the St. Peter

Sandstone down through the Potosi Dolomite. The shallow and deep aquifers are separated by a leaky confining layer from the base of the Bushberg Sandstone down through the Joachim Dolomite (Kleeschulte and Emmett, 1986). Individual units or zones in this layer may be classified as low yielding aquifers (Kleeschulte and Emmett, 1986).

The upper zone of the shallow bedrock aquifer, as defined by the USGS, is the main emphasis and concern at the site for several reasons. First, it is in close proximity to contaminant sources. Second, it is weathered, fractured, and of higher hydraulic conductivity than deeper, unweathered zones. Finally, it is the zone most likely to permit contaminant migration.

Kleeschulte and Emmett (1986) present regional maps of the shallow and deep bedrock aquifer potentiometric surfaces. These maps are reproduced here in Figures 1-20 and 1-21. The shallow aquifer data, Figure 1-20, show a groundwater divide running approximately E-W through the vicinity of the raffinate pits monitoring wells (represented by the four dots within the delineated Army Property). The potentiometric surface elevations ranged from more than 650 ft near the west boundary of the original DOA property to less than 425 ft near the Mississippi River.

Figures 1-16 and 1-17 give site-specific groundwater levels taken from monitoring wells completed primarily in the upper portion of the Burlington/Keokuk Formation (BNI, 1987; MKF, 1987b). The monitoring well numbering system shown in Figure 1-16 differs from that of Figure 1-17. However, for the most part, the same wells have been used in providing data for the preparation of both maps. Both maps indicate a groundwater divide trending approximately SW-NE across the southeastern portion of the WSS site. The detailed shapes of the two sets of contours are different but the general trend is the same. The differences are due to the use of different monitoring wells, the seasonal and

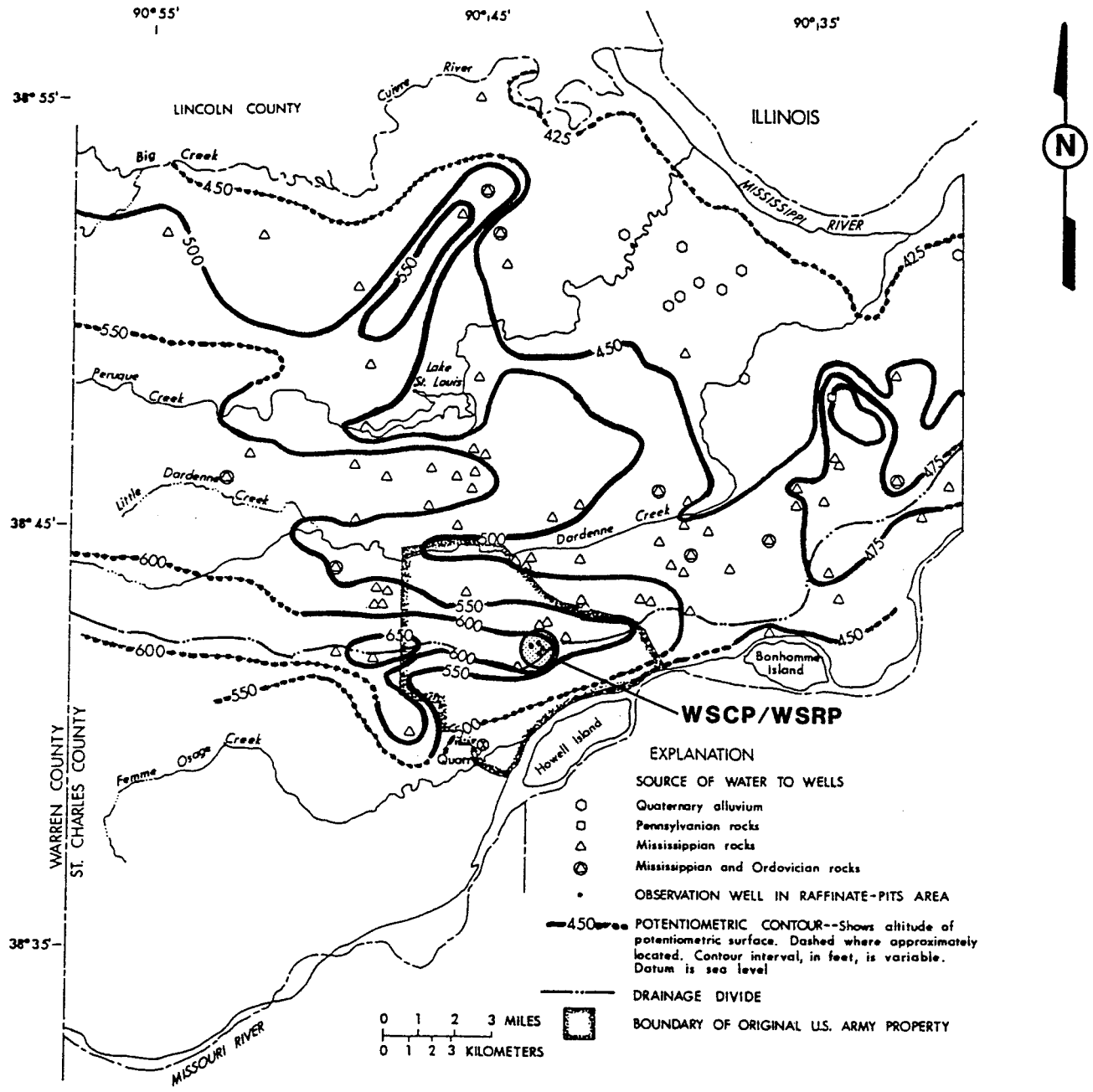


FIGURE 1-20

POTENTIOMETRIC SURFACE OF THE SHALLOW BEDROCK AQUIFER, SUMMER 1984 (MISSISSIPPIAN AND DEVONIAN SEDIMENTS)

SOURCE : KLEESCHULTE & EMMETT, 1986

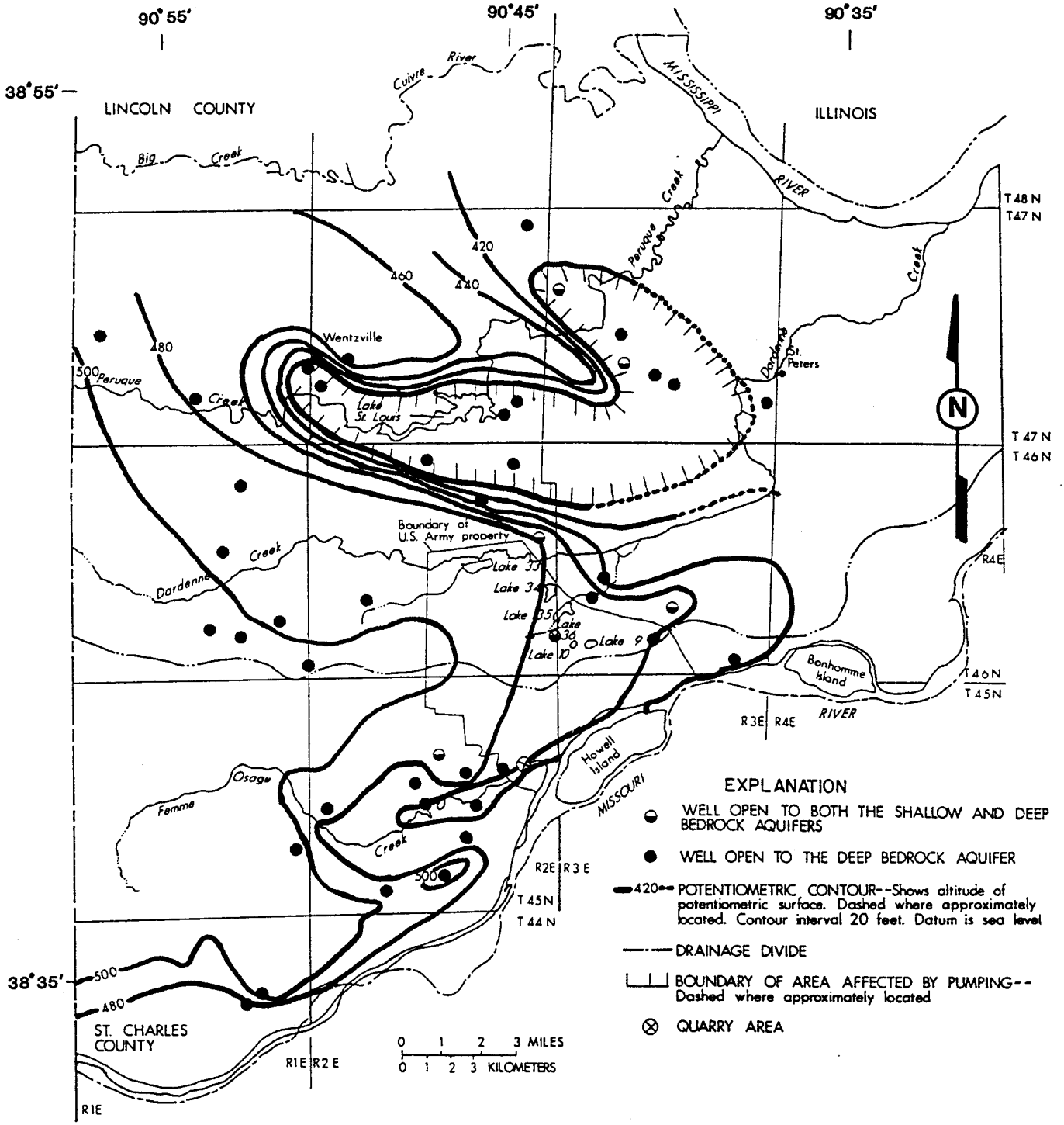


FIGURE 1-21

POTENTIOMETRIC SURFACE OF THE DEEP BEDROCK AQUIFER, SUMMER 1984

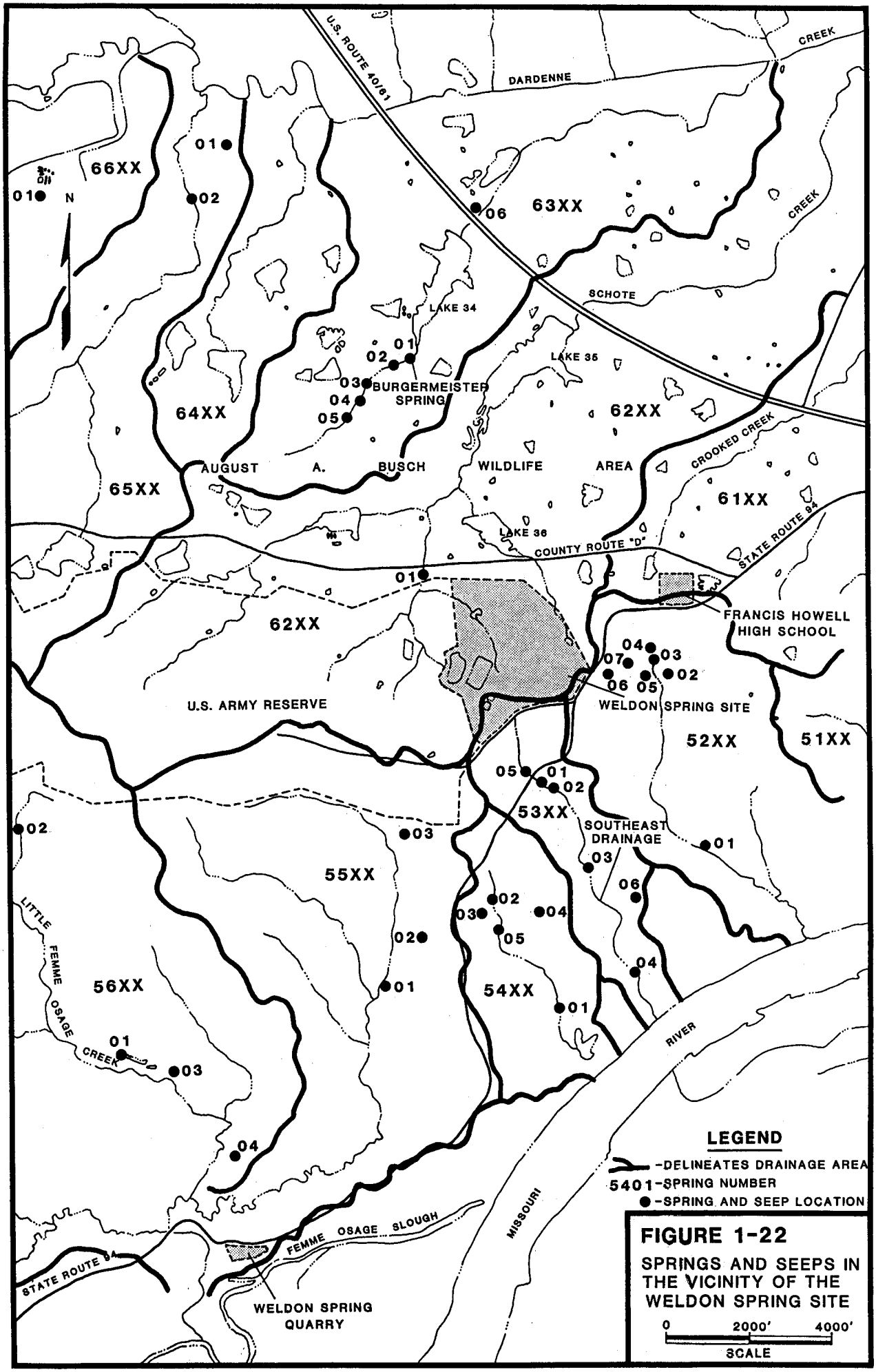
SOURCE : KLEESCHULTE & EMMETT, 1986

annual variations represented by the data, and the differences in interpretation by the individual map preparers. The range in elevations is from more than 610 ft to less than 580 or 590 ft, depending on the map. Inspection of the cross sections in Figures 1-11 through 1-13 indicates that depths to groundwater vary from about 30 to 65 ft. BNI indicates a minimum depth of 18-20 ft below Raffinate Pit 4 (BNI, 1984c).

Alluvial aquifers are found along the Missouri and Mississippi rivers and major tributaries (BNI, 1987). Groundwater is present at some locations in the unconsolidated formations in the vicinity of the site. On site, groundwater is present in the overburden in areas bordering Raffinate Pits 3 and 4. This indicates that these surface-water impoundments are leaking and forming a groundwater mound in the immediate area surrounding these pits.

Groundwater in the "deep bedrock aquifer system" is represented by the regional map (Figure 1-21) of Kleeschulte and Emmett. For reference, note the boundary of the U.S. Army Property compared to that in Figure 1-20. A groundwater divide exists just north of the WSS with a large groundwater depression 4 or 5 miles further north of the divide. The aquifer system represented in Figure 1-21 includes the Ordovician shale, limestone, dolomite, and sandstone from the Maquoketa Shale to the base of the Potosi Dolomite. The approximately 350-ft-thick upper portion of the system which extends to the Joachim Dolomite is less permeable than the approximately 1000-ft-thick lower portion and tends to form a confining layer (Kleeschulte and Emmett, 1986).

Lateral boundaries of aquifer systems in the vicinity of the site are not fully delineated in the available reports. Groundwater discharges can be observed locally from the bedrock aquifer in or near gullies, at least intermittently, as seeps and springs (Dean, 1984a, 1984b, 1985). Figure 1-22 shows the locations of local springs. This map is also presented in Section 2.3.2.1


U.S. ROUTE 40/61
DARDENNE CREEK
66XX
01
02
N
06
63XX
SCHOTE CREEK
LAKE 34
01
02
03
04
05
BURGERMEISTER SPRING
LAKE 35
64XX
62XX
AUGUST A. BUSCH WILDLIFE AREA
CROOKED CREEK
65XX
61XX
LAKE 36
COUNTY ROUTE "D"
STATE ROUTE 94
01
62XX
FRANCIS HOWELL HIGH SCHOOL
04
03
07
02
06
05
U.S. ARMY RESERVE
WELDON SPRING SITE
52XX
51XX
05
01
02
53XX
SOUTHEAST DRAINAGE
02
03
01
03
55XX
06
02
03
04
05
02
04
LITTLE FEMME OSAGE CREEK
56XX
01
54XX
01
01
03
RIVER
04
LEGEND
-DELINEATES DRAINAGE AREA
5401-SPRING NUMBER
-SPRING AND SEEP LOCATION
MISSOURI
FEMME OSAGE SLOUGH
STATE ROUTE 94
WELDON SPRING QUARRY
FIGURE 1-22
SPRINGS AND SEEPS IN THE VICINITY OF THE WELDON SPRING SITE
0
2000'
4000'
SCALE

(Figure 2-6) along with a description of the WSSRAP numbering system for these springs. During the summer and fall of 1987 a complete reconnaissance survey of the area surrounding the WSS was performed to locate springs and seeps which are potentially affected by the WSS. This survey was performed by Missouri Department of Natural Resources (MDNR) and WSSRAP geologists. A total of 30 springs and seeps were identified and located on USGS 7.5-minute topographic maps. Fishel and Williams (1944) indicate that Dardenne Creek Valley intercepts flow from the shallow bedrock system. Hence, the extent of the upper and lower zones of the shallow aquifer are partially defined in the area.

There are boundaries tending to inhibit vertical transfer of water. These include the upper 350-ft-thick portion of the deep bedrock aquifer system described above, and the lower portion of the Burlington/Keokuk as previously discussed (see Section 1.2.4). Also, the Meramecian Series, where present regionally, may be a confining layer for water in the lower portion of the shallow bedrock aquifer (Kleeschulte and Emmett, 1986). Units that may minimize vertical movement of groundwater below the Burlington/Keokuk and above the Maquoketa Shale are not defined.

Porosity of the bedrock aquifers at the site is a combination of primary and secondary porosity. Primary porosity is that portion of the bedrock void space that is present within the matrix of the rock itself. Secondary porosity consists of fractures, solution channels, and fine interconnected fractures in the limestone bedrock (MKF, 1987b). The Burlington/Keokuk Formation and the Fern Glen Limestone may be deeply weathered in outcrop areas and may transmit water primarily through solution openings and joints (Kleeschulte and Emmett, 1986).

Porosity in the deep bedrock aquifer includes solution-enlarged joints in the Kimmswick Limestone (Kleeschulte and Emmett, 1986) and primary porosity in the St. Peter Sandstone. The types of porosity in the other bedrock aquifer formations are uncertain.

1.2.7.2 Groundwater Movement

Groundwater flow in the upper, weathered portion of the Burlington/Keokuk Formation occurs in two distinct flow regimes: Darcian flow and conduit flow. Darcian flow occurs through the fine fractures of the formation, which comprise an equivalent porous medium. Conduit flow occurs where subsurface groundwater pathways have developed selectively within the fracture network. These conduits are generally dendritic or trellised. Conduits typically discharge into springs, seeps or other surface water bodies such as streams, rivers or lakes. Darcian flow is dispersive, while flow in conduit systems is convergent (Quinlan and Ewers, 1985).

Figure 1-17 implies the general direction of groundwater movement in the shallow bedrock aquifer at the WSRP/WSCP. For a continuous medium which is isotropic with respect to hydraulic conductivity, the groundwater flow direction would be at right angles to the contours. However, for an anisotropic medium, such as one with conduit flow, the flow could be oblique to contours. The general flow directions for the discussion below will be estimated based on flow in an isotropic continuous medium.

Groundwater flow directions in the upper Burlington/Keokuk Formation are defined by the position and orientation of the groundwater divide. Referring to Figure 1-17, the flow is to the north from most of the WSS; in the southeastern portion of the site the flow is to the southeast or east. The regional potentiometric surface for the shallow bedrock aquifer (Figure 1-20) shows a similar pattern, indicating opposing flow directions depending on location relative to the divide.

Fishel and Williams (1944) described red water leakage from a lagoon located 100 yards east of Frog Pond and its detection at two springs north and northwest of the WSS (see Section 1.2.8).

The Missouri Department of Natural Resources further defined groundwater movement through subsurface water tracing dye studies, conducted in 1983, 1984, and 1985 (Dean 1983, 1984a, 1984b, 1985). Dean's findings are summarized below.

Rhodamine WT dye and fluorescein dyes were injected into three drill holes (B-3, now MW 2016, B4, now MW 2020, and B17, now MW 3007) in February and March 1983. No positive identification of water tracing dyes was detected at charcoal packet monitoring locations placed, primarily in stream channels, at locations to the North and South of the WSRP/WSCP.

Rhodamine WT dye was placed into surface drainage west of Raffinate Pit 4 of February 1984. This drainage is an unnamed tributary of Schote Creek draining to Lake 35. Dye was detected in packets placed at five monitoring locations:

1) At Burgermeister spring
2) At a resurging sink immediately south of Burgermeister spring,
3) At a spring south of Pond C upstream of Lake 34
4) At a creek channel 50 ft west of 2 (above) and downstream of 3 (very weak trace)
5) In the watershed just upstream of the tail waters of Lake 35 (very weak trace - negative on Feb. 17, 1984).

Dean concluded that plant area runoff trending north via the drainage west of Raffinate Pit 4 can be expected to flow underground and emerge at or in the vicinity of Burgermeister Spring, a straight line flow distance of approximately 6500 feet. Time of travel was not accurately determined but initial arrival was estimated to be 48-72 hours and would be dependent upon precipitation events.

In June 1984, Rhodamine WT dye was injected at the process sewer outfall (Southeast Drainage Easement). Dye was detected at two

springs (SP5301 and SP5303) along the drainage easement toward the Missouri River, approximately 0.25 and 0.50 miles downstream, respectively. This test established flow connection to the south of the groundwater divide.

In March 1985, Rhodamine WT dye was introduced into a sink in the Ash Pond outflow stream west of DOE property. With the detection of dye traces at the Burgermeister Spring and vicinity, a subsurface connection was established between the outflow stream drainage downstream of Ash Pond and the Burgermeister Spring area.

Additional dye tracing tests are being conducted at this time. Data received from these tests will be presented in subsequent reports.

Flow directions in the deep bedrock aquifer system are shown on Figure 1-21. Flow in the vicinity of the site in 1984 was to the northeast and southeast. Flow to the north eventually enters the groundwater depression produced by pumping of municipal wells in Wentzville and O'Fallon. The eventual discharge point(s) of flow to the south is unknown.

The potential for vertical movement of groundwater is implied by a comparison of groundwater levels in Figures 1-20 and 1-21. In 1984, there was an approximate 125-ft head differential between the deep and shallow groundwater aquifers in the vicinity of the site, with the deep aquifer system having the lower levels. Groundwater will tend to move downward with this head differential. However, the effective hydraulic conductivity between the two aquifers is unknown.

Recharge and discharge locations and quantities typically have an effect on groundwater movement. Recharge to alluvial aquifers occurs from precipitation on the alluvium; from flooding that causes surface water to go into bank storage; from flows from

contiguous bedrock aquifers; and from induced flow into the aquifer as a result of groundwater pumping (Kleeschulte and Emmett, 1986). Discharge from alluvial aquifers occurs from natural discharge via evapotranspiration (through phreatophytes), from recession periods which result in return flow from bank storage, from wells tapping the aquifer, and from discharges into the contiguous bedrock. Recharge and discharge from alluvial aquifers near the site potentially affect the aquifers at the site, as they can affect the subsurface flow between aquifers.

Discharge and recharge sources similar to those for the alluvial aquifer apply to the shallow bedrock aquifer at the WSS and vicinity with the addition of recharge from losing streams and discharge to springs. Discharge/recharge mechanisms for the deep bedrock aquifer include: recharge from precipitation directly on the area where the deep bedrock aquifer outcrops or is overlain by permeable soils; recharge from losing streams which penetrate the aquifer; downward leakage from the shallow bedrock aquifer; extraction by wells tapping the aquifer; evapotranspiration, and seepage to springs and streams (Kleeschulte and Emmett, 1986).

Groundwater usage in the Weldon Spring area has been summarized by BNI (1987). The principal groundwater extraction areas in the region of the site are the St. Charles County well field (located in the Missouri River flood plain approximately 5 miles southwest of the site), and the cities of Wentzville, O'Fallon, and St. Peters. St. Charles County and St. Peters extract groundwater from the alluvial aquifer while the cities of Wentzville and O'Fallon withdraw groundwater from the deep bedrock aquifer. The city of St. Peters formerly utilized wells in the deep bedrock aquifer. The St. Charles County well field produces approximately 10.5 mgd, and in 1985 Wentzville, O'Fallon, and St. Peters extracted 0.59, 1.22, and 2.9 mgd, respectively (Kleeschulte, 1988). The groundwater contour maps presented previously reflect the composite effect of discharges and recharges to the aquifer systems plus the hydraulic properties.

Figure 1-21 specifically identifies a groundwater depression in the deep bedrock aquifer that is a result of groundwater pumping.

There are also domestic wells being utilized in the vicinity of the site. On June 5, 1984 the St. Charles Countians Against Hazardous Waste (SCCAHW) completed a groundwater inventory of wells and springs in St. Charles, Defiance, Weldon Spring, St. Peters, Wentzville, O'Fallon, Augusta, and New Melle. The study was representative of the combined efforts of the St. Charles County Administrative Court, the Missouri Division of Health, the Missouri Department of Natural Resources (MDNR), the Missouri Department of Conservation, and SCCAHW. Figure 1-23 (in pocket) represents a compilation of private well information received from SCCAHW and recently acquired data forwarded by the USGS.

The map shown on Figure 1-23 covers the area used for the WSSRAP Groundwater Classification Study currently being prepared (October 1988). The well numbers shown on the map are those used in listings of private wells by USGS and SCCAHW. Many private wells are no longer in use and have been omitted from this map. Wells located within the present boundaries of the Busch Wildlife and Weldon Spring Wildlife areas are assumed to have been abandoned around 1941, when private properties were sold to the U.S. Government for the WSOW. These wells, which have recorded locations but no record of water samples or water-level measurements, have been omitted. It is likely that many private wells in residential areas are no longer in use due to expansion of public water systems. Future WSSRAP efforts will seek to verify locations and usage of private wells.

Table 1-6 presents information pertaining to well yields in the area around the WSS bounded by the Mississippi River (10-15 miles north), and the Missouri River (3 to 4 miles to the south and east of the site). The table lists the major aquifers which supply municipalities, communities, farms and industries. It also illustrates which productive zones are more susceptible to

TABLE 1-6 DOMESTIC WELL DATA
WELLS LISTED BY USGS

No. (See Map)	Latitude (Degrees-Minutes-Seconds)	Longitude	USGS Location	Altitude of Land Surface (ft above sea level)	Well Depth (ft)	Casing Depth (ft)	Altitude of Water Level (ft above sea level)	Formations Open To Well(1)
1	38 39 02	90 47 15	T45N RO2E SWSWSW 15	560	250	44	--	DCRH-STRP
2	38 39 10	90 44 17	T45N RO3E SENWSW 18	460	114	--	445	--
3	38 39 57	90 47 40	T45N RO2E NESWSW 10	725	485	20	624	MISS-STPR
5	38 40 08	90 43 52	T45N RO3E NWNWSE 7	615	535	55	515	JCHM-STPR
6	38 40 45	90 48 20	T45N RO2E SWSWSE 4	732	505	66	642	BRLG-STPR
9	38 41 35	90 39 16	T46N RO3E SWSWSE 35	490	702	169	460	ALVM-STPR
10	38 41 38	90 38 51	T46N RO3E SENESE 35	580	790	--	400	OSGE-JLNM
11*	38 41 39	90 48 42	T46N RO2E SESWSW 33	740	--	--	695	MISS
12*	38 41 44	90 49 53	T46N RO2E NESWSW 32	740	210	90	647	MISS
14	38 42 01	90 48 18	T46N RO2E SWSWNE 33	690	275	--	630	BRLG-KMCK
15	38 42 03	90 47 28	T46N RO2E SWSWNW 35	--	622	--	--	MISS-STPR
16*	38 42 06	90 42 51	T46N RO3E NESENW 32	652	275	--	595	KKKB-FRGL
18	38 42 19	90 37 52	T46N RO3E SWSESE 25	620	811	359	460	WRSW-EVRN
19	38 42 19	90 37 52	T46N RO3E SWSESE 25	640	771	--	--	WRSW-STPR
20*	38 42 21	90 44 25	T46N RO2E NENENE 36	620	330	84	324	KKKB-KMCK
21*	38 42 28	90 43 30	T46N RO3E SWSESE 30	637	--	--	587	MISS
22*	38 42 29	90 43 30	T46N RO3E NWSESE 30	640	260	--	569	KKKB
24*	38 42 40	90 38 54	T46N RO3E NWNESE 26	643	300	--	462	MISS
25	38 42 41	90 39 49	T46N RO3E NWNWSW 26	595	350	--	--	WRSW-BBRG
26*	38 42 47	90 41 15	--	540	--	--	--	--
27*	38 42 48	90 42 14	T46N RO3E SESENE 29	573	--	--	537	MISS
28*	38 42 55	90 42 21	T46N RO3E NWSENE 29	570	215	41	532	KKKB-FRGL
29*	38 42 57	90 48 30	T46N RO2E SWSENW 28	622	265	84	592	MISS
30*	38 42 58	90 48 16	T46N RO2E SWSWNE 28	628	185	--	583	MISS
31	38 42 59	90 38 51	T46N RO3E SESENE 26	590	375	--	--	WRSW-CHUT
32*	38 43 01	90 40 06	T46N RO3E SWNENE 27	597	0	--	553	WRSW-KKKB
33*	38 43 01	90 40 28	T46N RO3E SENENW 27	542	125	41	519	KKKB
36	38 43 13	90 41 35	T46N RO3E NENWNE 26	555	255	--	498	WRSW-FRGL
37*	38 43 19	90 45 54	T46N RO2E NENWNE 26	595	360	--	535	MISS
38*	38 43 19	90 48 16	T46N RO2E SESWSE 19	612	105	62	568	KKKB
39	38 43 23	90 43 38	T46N RO2E SWSESW 21	585	300	75	510	WRSW-KDRK
40*	38 43 24	90 48 32	T46N RO2E SWSESW 21	650	228	--	589	MISS
41*	38 43 24	90 48 32	T46N RO3E SWSWNE 23	600	275	40	442	SLEM-KKKB
42	38 43 40	90 49 53	T46N RO2E SENWSW 20	625	325	--	525	KKKB-DCRU

* SOURCE OF DATA = 1984 SURVEY

(CONTINUED)

TABLE 1-6 DOMESTIC WELL DATA (cont.)

No. (See Map)	Latitude (Degrees-Minutes-Seconds)	Longitude	USGS Location	Altitude of Land Surface (ft above sea level)	Well Depth (ft)	Casing Depth (ft)	Altitude of Water Level (ft above sea level)	Formations Open To Well(1)
43*	38 43 45	90 37 39	T46N R03E NESENE 24	487	150	40	470	WRSW-KKKB
45	38 43 47	90 44 06	T46N R03E SESWNW 19	545	125	48	465	KKKB
46	38 43 48	90 44 12	T46N R03E SWSWNW 19	550	220	60	--	OSGE
47*	38 43 48	90 44 12	T46N R03E NWSWNW 19	551	305	45	500	KKKB-BBRG
48*	38 43 51	90 44 07	T46N R03E NESWNW 19	545	--	--	495	MISS
49*	38 43 53	90 49 47	T46N R02E SESWNW 20	647	325	55	577	KKKB-KMCK
50*	38 43 56	90 39 25	T46N R03E SWNENW 23	559	225	28	481	SLEM-KKKB
51*	38 43 58	90 42 30	T46N R03E NWNWNE 20	531	300	22	476	KKKB-BBRG
52*	38 43 59	90 44 01	T46N R03E SWNENW 19	518	--	--	478	MISS
53*	38 44 02	90 38 42	T46N R03E SESESE 14	555	560	67	456	WRSW-KMCK
55*	38 44 20	90 39 55	T46N R03E SESESE 15	485	200	52	466	WRSW-KKB
56	38 44 36	90 39 12	T46N R03E NWSWNE 14	520	235	--	--	KKKB
57	38 44 36	90 44 28	T46N R02E SWSENE 13	545	690	205	495	OSGE-STPR
58*	38 44 40	90 38 20	T46N R03E NWSENW 13	498	100	--	470	MISS
59*	38 44 47	90 39 10	T46N R03E SWNWNE 14	515	165	41	468	KKKB
60*	38 44 50	90 46 08	T46N R02E NESENW 14	555	205	46	531	KKKB-FREL
61*	38 44 56	90 43 07	T46N R03E NWNWNW 17	553	130	43	510	KKKB
62	38 43 34	90 43 51	--	485	--	--	--	--
71	38 43 50	90 43 40	--	560	230	--	--	--
72	38 43 50	90 43 50	--	485	630	--	--	--
73	38 43 52	90 43 51	--	525	111	--	--	--
75	38 43 13	90 44 33	--	590	107	--	--	--
80	38 41 13	90 40 57	--	460	--	--	--	--

* SOURCE OF DATA = 1984 SURVEY

(1)

ALVM, alluvium
PENN, Pennsylvanian System, exact formation unknown
STSL, St. Louis Limestone
WRSW, Warsaw Formation
KKKB, Keokuk and Burlington Limestones
FRGL, Fern Glen Limestone
CHUT, Chouteau Limestone
MISS, Mississippian System, exact formation unknown
BBRG, Bushberg Sandstone of Sulphur Springs Group
SSPG, Sulphur Springs Group
KMCK, Kimmswick Limestone
DCRH, Decorah Formation
PLTN, Plattin Limestone
JCHM, Joachim Dolomite
STPR, St. Peter Sandstone
PWLL, Powell Dolomite
CTTR, Cotter Dolomite
JFRC, Jefferson City Dolomite
RBDX, Roubidoux Formation
GSCD, Gasconade Dolomite
ODVC, Ordovician System

contamination by vertical migration of contaminants and shows the position of shales and zones of low hydraulic conductivity that provide a barrier to vertical groundwater flow (as a confining layer). Table 1-6 was compiled from USGS data (Kleeschulte, 1988).

Hydraulic or aquifer parameters of potential importance to the WSS assessment of groundwater and contaminant movement are hydraulic conductivity (permeability), transmissivity, storativity, porosity, and dispersivity. Aquifer tests made on wells tapping the Kimmswick to the St. Peter in St. Charles County gave specific capacities of 0.07 to 0.25 gpm/ft of drawdown (Kleeschulte and Emmett, 1986). Wells penetrating deeper formations had specific capacities ranging from 0.53 to 2.64 gpm/ft of drawdown (Kleeschulte and Emmett, 1986). No estimates of transmissivities or hydraulic conductivities of these zones are available from field tests.

Hydraulic characteristics of the overburden at the WSS were also evaluated and discussed in the BNI, November 1984, and July 1987 reports. The upper few feet of overburden (mostly topsoil) are poorly drained. The materials underlying the topsoil are unsaturated. Disturbed and undisturbed samples of the major overburden units were submitted to a laboratory for soil testing. The hydraulic conductivities and moisture content of both dike fill and foundation materials were determined. The hydraulic conductivity values are generally low and range from 1.6×10^{-9} cm/s (4.5×10^{-6} ft/day) to 3×10^{-6} cm/s (8.5×10^{-3} ft/day). Hydraulic conductivity values for the silty clays and clayey silts are the highest measured. The geometric mean of the test results is 1.3×10^{-7} cm/s (3.7×10^{-4} ft/day). The moisture content of the samples ranged from 15 to 30%, indicating the materials are unsaturated. Test results for the clay materials obtained from a depth of about 3 m (10 ft) indicate a hydraulic conductivity range from 1.7×10^{-8} cm/sec

(4.82×10^{-5} ft/day) to 6.4×10^{-9} cm/sec (1.81×10^{-5} ft/day). Some laboratory test results for overburden samples from the site are summarized in Table 1-2. These indicate specific yields ranging from 1% to 12%. Borehole hydraulic conductivity test results for the overburden; and unsaturated and saturated bedrock are summarized in Table 1-7. These show hydraulic conductivities for unsaturated materials on the order of 10^{-3} to 10^{-2} cm/sec. Some of the results are also given on Figures 1-11 through 1-13 where locations of the test intervals are indicated. The types of tests were constant head, double and single packer pressure tests (BNI, 1987). Details of the specific testing procedures employed are not given.

The mean hydraulic conductivity in the weathered saturated zone was on the order of 10^{-3} cm/sec with considerable variation from the mean value; hydraulic conductivity in the slightly weathered to fresh bedrock zone averaged near 10^{-6} cm/sec with a variation of approximately one order of magnitude.

Comparison of hydraulic conductivity values in the weathered and unweathered portions of the bedrock indicate that values in the unweathered bedrock are three orders of magnitude lower than the weathered bedrock. The results indicate that the bedrock is of variable hydraulic conductivity in the horizontal plane and generally becomes less permeable with depth, due to decreased weathering and associated solution activity (BNI, July 1987).

BNI developed some estimates of hydraulic gradients and average interstitial velocities (1987). Referring to Figure 1-16, a range of hydraulic gradients exists at the site from zero at the groundwater divide to approximately 0.05 near Frog Pond. BNI estimates an average interstitial groundwater velocity of 0.04 ft/day, with an effective porosity of 30%, and a low hydraulic conductivity of 8.9×10^{-5} cm/sec (1987). Walton (1985) presents effective porosity values for limestones ranging from 1% to 24%. Assuming the above aquifer parameters, and applying more

TABLE 1-7
BOREHOLE HYDRAULIC CONDUCTIVITY TEST DATA FOR
UNSATURATED AND SATURATED BEDROCK
(BNI, 1987)

UNSATURATED BEDROCK	SATURATED BEDROCK
Test on overburden/rock interface:	Tests on weathered, fractured bedrock:
Number of Tests = 4	Number of Tests = 22
Depth Range = 29.0 to 41.5 ft	Depth Range = 30.1 to 77.7 ft
Mean = 3.7×10^{-2} cm/sec [1]	Mean = 1.6×10^{-3} cm/sec
Standard Deviation = $\pm 4.3 \times 10^{-2}$ cm/sec [1]	Standard Deviation = $\pm 2.8 \times 10^{-3}$ cm/sec
Test on weathered, fractured bedrock:	Tests on slightly weathered to fresh bedrock:
Number of Tests = 10	Number of Tests = 5
Depth Range = 23.0 to 66.7 ft	Depth Range = 52.0 to 76.0 ft
Mean = 2.7×10^{-3} cm/sec [1]	Mean = 5.7×10^{-6} cm/sec
Standard Deviation = $\pm 2.0 \times 10^{-3}$ cm/sec [1]	Standard Deviation = $\pm 6.5 \times 10^{-6}$ cm/sec

[1] Numbers shown are statistics given in Table 8-1 of the reference.
Use of the individual values in Table 8-1 gives slightly different statistics than presented.

realistic effective porosity values of 5%, 10% and 20%, interstitial velocities of 0.25, 0.13 and 0.06 feet per day respectively are estimated. Many components of the hydrogeologic model are to be refined, e.g., recharge areas, aquifer parameters, surface run-off, groundwater levels, geology, and geochemistry, and a fuller understanding of the regime will occur with the acquisition of additional data under this plan. Velocity estimates, however, are based on the assumptions that the aquifer behaves as an equivalent porous medium. Groundwater flow velocities along preferential flow paths, such as along larger fracture openings or along solution channels, could be much higher. With a definition of time of contaminant release, these data and calculations can be used to estimate and predict rate of contaminant movement. Conversely, with a definition of the contaminant plume and a knowledge of rate of contaminant migration, possible sources can be delineated.

Seasonal variations of groundwater elevation are apparent from an examination of available groundwater level measurements. Table 1-8 gives three sets of measurements for the uppermost aquifer, two taken by BNI in 1986 approximately four months apart (BNI, 1987) and one taken by MKF in early 1987 (MKF, 1987b). The locations of the monitor wells are shown in Figure 1-16. The measurements represent three different seasons. Wells GMW-7, GMW-8, GMW-12, GMW-13, B-3, B-17, and B-19A exhibited changes in groundwater elevations of almost 2 ft to more than 7 ft for the time period represented. There was no consistent trend in the changes throughout the area.

1.2.7.3 Groundwater Quality Aspects

Water quality of the different aquifer systems is discussed by Kleeschulte and Emmett (1986). Water from alluvial aquifers is predominantly a calcium bicarbonate type, typically with high hardness and iron concentrations. The total dissolved solids (TDS) concentration is variable.

TABLE 1-8

GROUNDWATER ELEVATIONS (from BNI, 1987; MKF, 1987b)

NEW Well Number	OLD Well Number	Elevations in ft above MSL 7/24-30/86	11/01/86	3/20/87
MW-2001	GMW-1	588.86	589.15	588.55
MW-2002	GMW-2A	593.71	594.13	593.35
MW-2003	GMW-3	597.98	597.92	597.94
MW-2004	GMW-4	584.56	583.97	583.73
MW-2005	GMW-5	588.26	588.23	588.95
MW-2006	GMW-6	601.54	601.85	601.00
MW-2007	GMW-7	590.36	590.26	593.20
MW-2008	GMW-8	585.98	585.91	587.63
MW-2009	GMW-9	597.96	597.81	597.51
MW-2010	GMW-10	600.46	600.85	601.03
MW-2011	GMW-11	600.72	600.80	600.57
MW-2012	GMW-12	610.43	612.12	606.80
MW-2013	GMW-13	605.26	607.98	605.82
MW-2014	GMW-14	604.45	604.25	604.53
MW-2015	GMW-15	603.99	603.54	603.00
MW-2016	GMW-17	605.51	604.85	605.28
MW-2017	GMW-18	615.43	614.80	614.94
MW-2018	B-3	580.41	574.49	578.18
MW-2019	B-4	607.92	607.60	607.38
MW-2020	B-17	599.61	600.42	607.67
MW-2021	B-19A	608.70	610.84	611.63
MW-2022	B-21	607.77	607.22	607.53
MW-2023	B-23	612.84	612.23	612.14

Water quality of the shallow bedrock aquifer in St. Charles County varies from a calcium magnesium bicarbonate type to a sodium sulfate, bicarbonate, or chloride type. TDS and chloride concentrations increase from west to east. Large sulfate concentrations are limited to areas underlain by Pennsylvania shale, sandstone, and siltstone (Kleeschulte and Emmett, 1986).

The water quality of the deep bedrock aquifer varies with depth and lateral extent. Samples from the confining portion of the aquifer (the Maquoketa-Joachim sequence) have TDS values ranging from 305 to more than 4,700 mg/l. Water in the north and northeast portions of St. Charles County has high TDS and is a sodium chloride type, while water to the west is generally a calcium magnesium bicarbonate type. Water samples from the more permeable portion of the deep bedrock aquifer (the St. Peter-Gasconade sequence) had a TDS ranging from 252 to 915 mg/l. The eastern half of the county yields highly mineralized sodium chloride type water, while the western half yields moderately mineralized calcium magnesium bicarbonate type water (Kleeschulte and Emmett, 1986).

The dissolution potential of the bedrock underlying the site is variable as evidenced by the differences in solution features of the various bedrock units.

1.2.8 Contaminant Sources

Past operations and waste handling practices at the WSS have resulted in several potential sources for contamination of surface water, groundwater, and soil.

Fishel and Williams (1944) provided one of the first records of contamination sources. Their report stated that there were seven lagoons receiving wastewater from the Army's operation. At various times, wastewater was discharged directly into surface streams. There were also a number of catchment tanks receiving

wastewater from the production lines. These would apparently overflow into small gullies flowing into nearby streams.

Also, red water leaking from a waste storage lagoon located 100 yards east of Frog Pond reportedly re-surfaced at springs SP6303 and SP6501, known as the Francis Howell Cemetery Wet Weather Spring and the 500-foot contour spring, respectively (Fishel and Williams, 1944; Hoffman, 1988).

Ryckman, Edgerly, Tomlinson, and Associates (RETA, 1978) indicated that wastewaters containing sulfate derivatives from DOA operations are known to have contaminated Schote and Dardenne creeks. They further indicated that explosives production resulted in chemical contamination of structures, concrete foundations, soil, underground transport lines, and catch basins. Some of the processing equipment, buildings, appurtenances, and contaminated soil were removed prior to AEC construction activities at the site. During the AEC's operation, radiological contamination of five major process buildings, most of the support buildings, and terrain behind the plant resulted from equipment being operated beyond design capacity, limitations of raffinate disposal facilities, and poor onsite "housekeeping" activities. During the decontamination operation in 1968 for conversion of part of the facility (Buildings 103 and 105) to herbicide ("Agent Orange") production, barrels of concrete and debris were left near Raffinate Pit 4 and in the Ash Pond area. These barrels have rusted, are partially deteriorated and have spilled their contents on the ground (RETA, 1978).

MKF (1987b) reported some additional contaminant sources during their Water Quality Phase I Assessment Report (1987b). Nitroaromatics and residues were burned during decontamination efforts by the Army in 1946. MKF (1987b) described potential nitroaromatic source areas associated with the Ordnance Works which are shown in Figures 1-24 and 1-25. A former surface impoundment northwest of the Missouri Highway Department was used

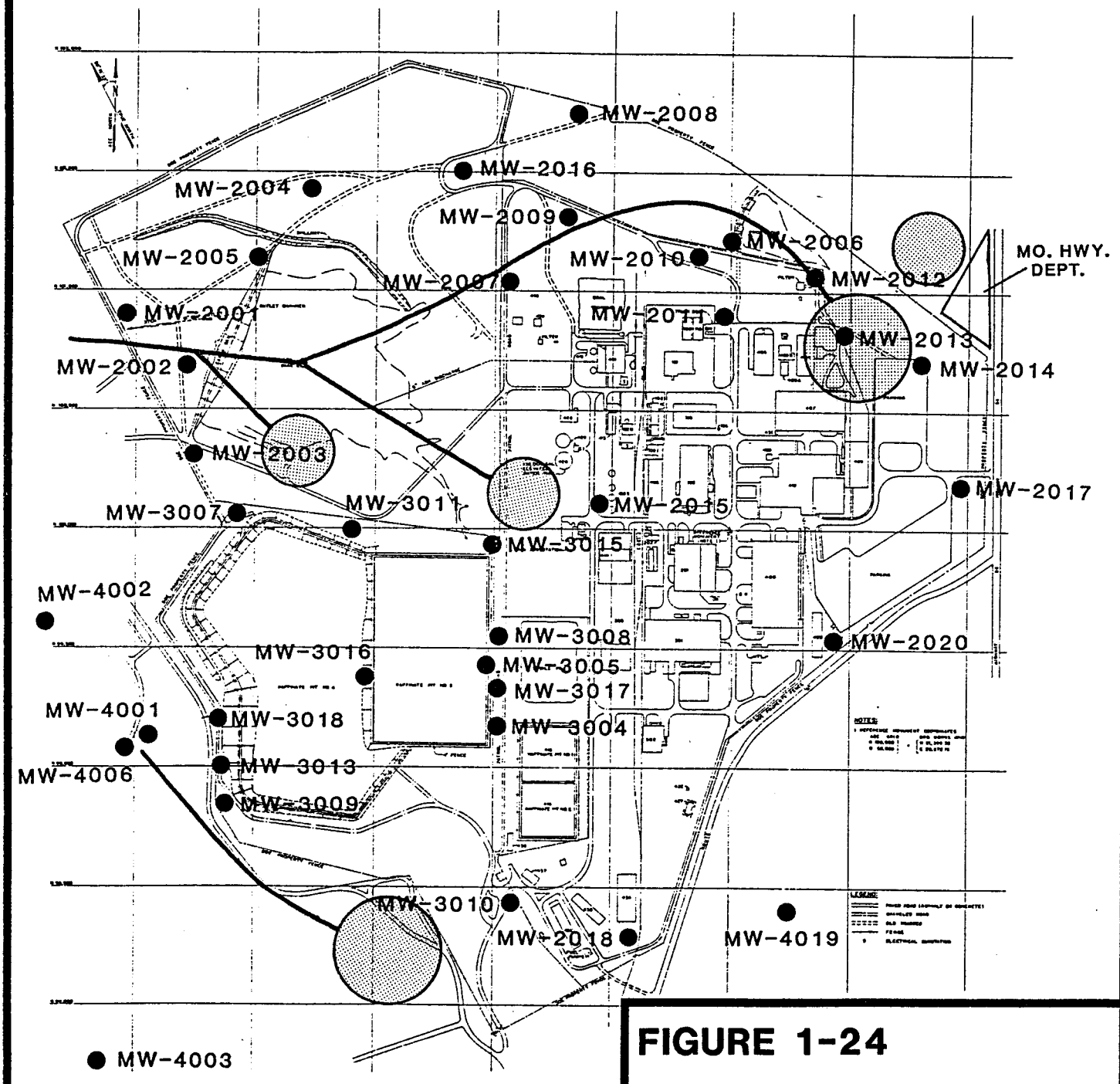


FIGURE 1-24

POTENTIAL NITROAROMATIC SOURCE AREAS AND MONITORING WELLS AT THE WSCP/WSRP

SOURCE : MK-FERGUSON 1987

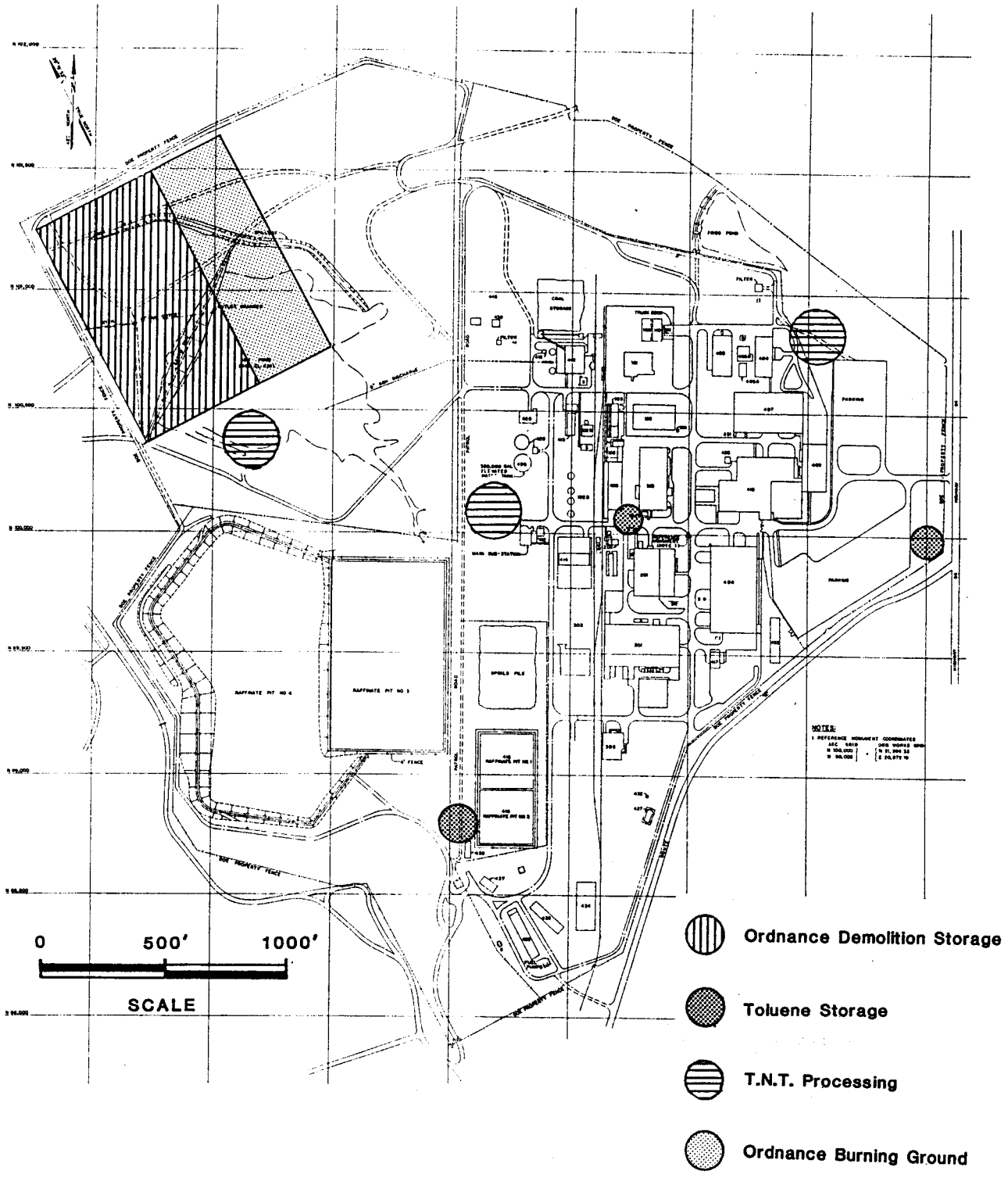


FIGURE 1-25

POTENTIAL CHEMICAL CONTAMINATION SOURCE AREAS ASSOCIATED WITH THE FORMER WELDON SPRING ORDNANCE WORKS

as a wastewater retention basin for the Weldon Spring Ordnance Works.

MKF (1987b) has also identified potential source areas for specific contaminants associated with radioactive materials processing. These are listed in Table 1-9 and illustrated in Figure 1-26. MKF also analyzed water quality in the raffinate pits. These results are shown in Tables 1-10 and 1-11. These data confirm that Pits 1 and 3 are potential nitrate sources while Pits 2 and 3 are potential sources of sulfate.

1.2.9 Potential Migration Pathways

The previous subsection has discussed potential contaminant sources. Whenever sufficient quantities of the contaminant are present, migration of some of the contaminant is likely. There are three general pathways that may be applicable at any site: air, surface, and subsurface.

Air migration pathways exist for the WSS and historically have played a role in transport of some contaminants, but documentation is limited. RETA (1978) reported that the air pathway is not a major route because there is no longer any active source of materials available for air transport. During the 1959-1965 period, environmental air sampling in the vicinity of the site indicated that the levels of uranium detected were typically less than 10% of the maximum permissible concentration (Mallinckrodt, 1959-1965).

Surface water probably was and is an important pathway for movement of contaminants from the site. The potential for distant migration of contamination via overland flow is minimal because of the generally gentle slopes. Migration via channelized flow over appreciable distances, however, is much more likely. A surface channel remnant exists through the Ash Pond area. There are also numerous relatively small drainage

TABLE 1-9

POTENTIAL GROUNDWATER CONTAMINATION SOURCE AREAS ASSOCIATED WITH THE WELDON SPRING SITE (MKF, 1987b)

Potential Source Areas	Contaminant
Nitric Acid Recovery Plant (Area 100) Digestion & Denitration Plant (Bldg. 103) Refinery Tank Farm (Area 102) Spills from above areas Process line & sewer leaks Past management practices Raffinate Pits sludge HNO3 used in production of TNT/DNT Spills & poor waste management practices during the World War II production effort	Nitrates
Raffinate Pits sludge which contains sulphur	Sulfates
Green Salt Plant (Bldg. 201); Green Salt Farm (Area 202); Metal Pilot Plant (Bldg. 404); Raffinate Pits sludge	Fluoride
	Metals
Metals Plant (Bldg. 301) Magnesium Bldg. (Bldg. 302)	Magnesium
Metal Pilot Plant (Bldg. 404)	Lithium
Raffinate Pits Water	Chromium
Raffinate Pits Water	Nickel
Raffinate Pits Water	Vanadium

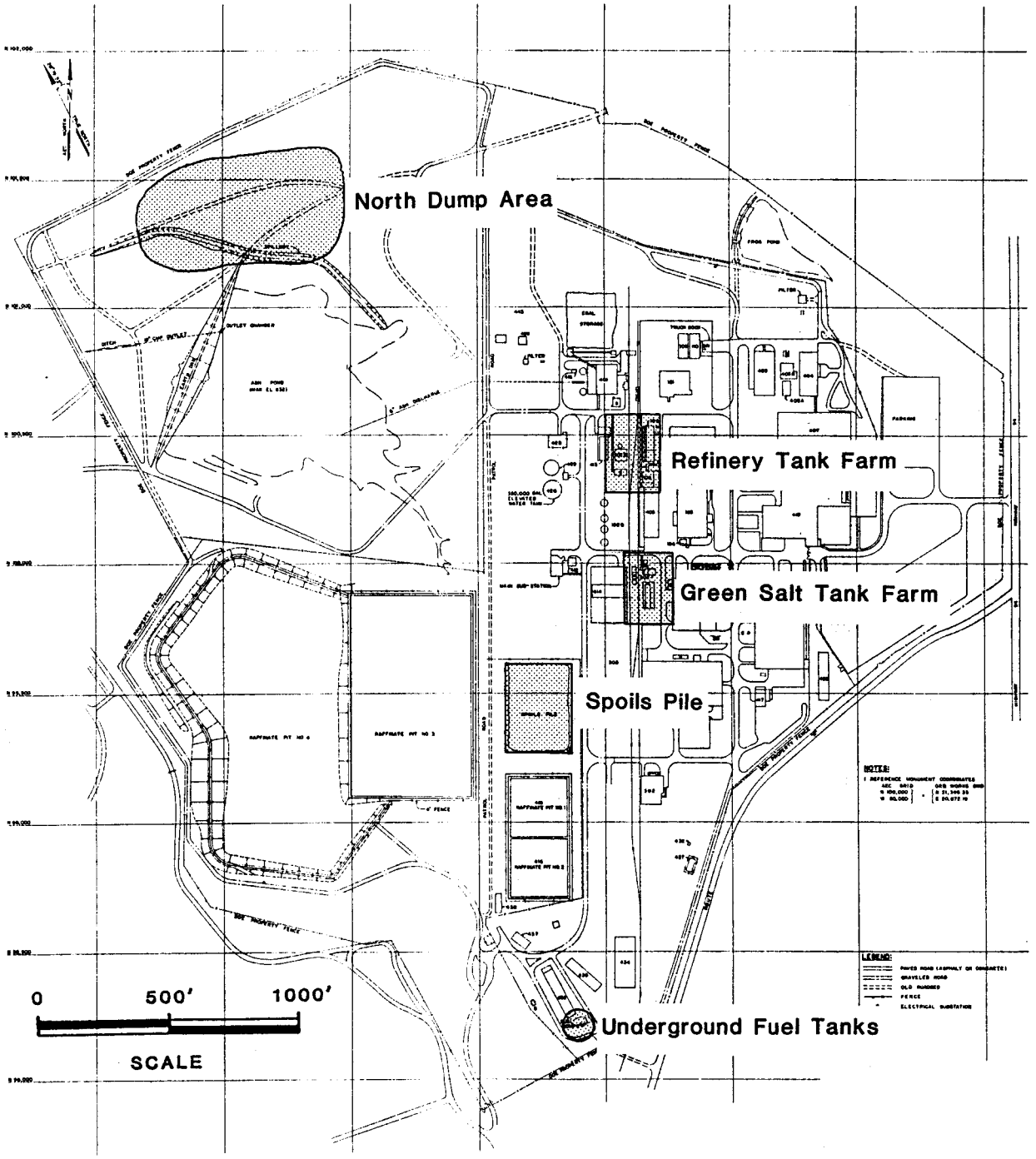


FIGURE 1-26

POTENTIAL CHEMICAL CONTAMINATION SOURCE AREAS ASSOCIATED WITH THE WSCP/WSRP

TABLE 1-10

INORGANIC ANION AND WATER QUALITY DATA FOR THE RAFFINATE PITS

	Concentration (mg/L)								
U.S. E.P.A. Primary/Secondary Drinking Water Standard	Nitrate (as N) 10	Sulfate 250	Chloride 250	Fluoride 2	Hardness 500	TDS S	TOC S	Cyanide CWA* 0.2	Phenol Standard 3.5
Raffinate Pit 1 (SW-3001) 4/24/87	422	231	1.50	1.90	872	3160	12	0.032	<0.005
Raffinate Pit 2 (SW-3002) 4/24/87	10.1	493	2.34	1.57	422	818	8	0.025	<0.005
Raffinate Pit 3 (SW-3003) 4/24/87	947	704	3.37	4.84	2107	6390	6	0.027	<0.005
Raffinate Pit 4 (SW-3004) 4/24/87	46.6	136	5.69	4.69	252	694	8	0.032	<0.005

S - No Drinking Water Standard *CWA - Clean Water Act Source: WSSRAP, 1987

TABLE 1-11
CLP METALS CONCENTRATIONS IN THE RAFFINATE PITS (4/24/87)

Concentration (ug/L)

U.S. E.P.A. Primary/Scndry Drinking Water Standard (ug/L)	Al	Sb	Ar	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
	--	--	50	1000	--	10	--	50	--	1000	300	50	--	--	50	2	--	--	10	50	--	--	S	5000
*CRDL - (ug/L)	200	60	10	200	5	5	5000	10	50	25	100	5	--	5000	15	0.2	40	5000	5	10	5000	10	50	20
Location No.																								
Raffinate Pit # 1 (SW-3001)	405	U	22	71	8	0.5	254000	85	U	45	109	22	U	15400	17	U	11	28400	U	25	388000	U	2090	9
Raffinate Pit # 2 (SW-3002)	279	102	38	31	7	U	105700	83	U	12	220	U	U	40800	14	U	48	14300	U	10	113000	U	1800	15
Raffinate Pit # 3 (SW-3003)	517	395	5	86	3	U	260500	194	33	30	433	257	U	196000	33	U	174	78200	U	40	900000	U	535	26
Raffinate Pit # 4 (SW-3004)	230	U	U	102	U	U	11600	31	U	19	101	358	U	39400	10	U	33	15200	U	8	172000	U	89	19

Source WSSRAP, 1987

* - Contract Required Detection Limits, US EPA Contract Laboratory Program
U - Undetected at Contract Required Detection Limits

channels that would tend to spread contaminants from their place of origin. Some of these drainage channels include pipelines for portions of their alignment. Section 1.2.3 briefly discussed other surface drainage features that could permit the migration of contaminants. These include the spillway for Ash Pond and the channels draining to the Southeast Drainage Easement, and channels draining to Frog Pond.

Potential subsurface migration pathways at WSS include: buried sewer and process pipelines, particularly those that have deteriorated; natural subsurface features such as relatively impervious layers that tend to impede the downward movement of water and therefore result in lateral spreading; permeable pathways that are relatively isolated but continuous laterally or vertically, such as solution channels, caverns, or joint-sets; and permeable media of a relatively continuous nature, such as permeable limestone with a combination of fractures, joints, and solution enlarged features. All of these subsurface pathways exist at the site, to some degree.

1.2.10 Contaminant Levels/Migration

Fishel and Williams (1944) presented historical accounts of observed contamination of surface and groundwater by TNT manufacturing wastes in the vicinity of the WSS. Later measurements of water quality parameters indicate contamination of the surface water and groundwater at the site and immediate vicinity. Numerous environmental monitoring reports have been produced over the years by Mallinckrodt Chemical Works (1959-1965), DOA (1977-1985), BNI (1983-1986), National Lead Company of Ohio (1981-1982), Shell Engineering (1983-1985), and MKF (1986). Other historical data are summarized in the Draft Environmental Impact Statement for remedial action at the site (DOE, 1987).

Kleeschulte and Emmett (1986) and Kleeschulte, et al (1986)

present 1984 and 1986 water quality data for the site and vicinity for groundwater and surface water. These analyses were for a limited set of parameters. Analytical results indicate elevated levels of calcium, magnesium, sodium, sulfate, nitrate, lithium, strontium, and uranium for wells near the raffinate pits with nitrate (as N) concentrations of 53 to 990 mg/l. Uranium concentrations for wells near the raffinate pits ranged from 6 to 86 ug/l. Surface water sample results showed elevated levels of TDS, nitrate, and uranium for the raffinate pits, Frog Pond tributary, and Burgermeister Spring (a spring located approximately 7000 ft north of Raffinate Pit 4).

Figure 1-27 illustrates the locations of existing monitoring wells. Well numbers, location coordinates (based on original AEC plant grid), depths, and other information are presented on Table 1-12. The 28 monitoring wells described include only those wells that are suitable for water level measurements and groundwater sampling; wells that are dry, damaged, or destroyed are excluded. Twenty-one wells are located in the raffinate pits and chemical plant area. Four wells are located outside the site boundaries in the Weldon Spring Training Area (WSTA) which is owned by the U.S. Department of the Army, and one well is located in the Weldon Spring Wildlife Area which is administered by the Missouri Department of Conservation. Monitoring wells with a 2000 series number are located within the chemical plant area; wells with a 3000 series number are located in the raffinate pits area, and wells with a 4000 series number are located outside of the site boundaries.

The wells were installed in 1983 and 1986 during hydrogeological studies by Bechtel National, Inc. (BNI). Six wells - MW-2020, MW-4002, MW-4003, MW-3007, MW-3008, MW-3009, and MW-3010 - penetrate from 21 to 76 feet of the saturated thickness of the Burlington-Keokuk aquifer. These six were constructed with 4-inch diameter PVC casing through the unconsolidated soil and an uncased open borehole in the bedrock. Although groundwater

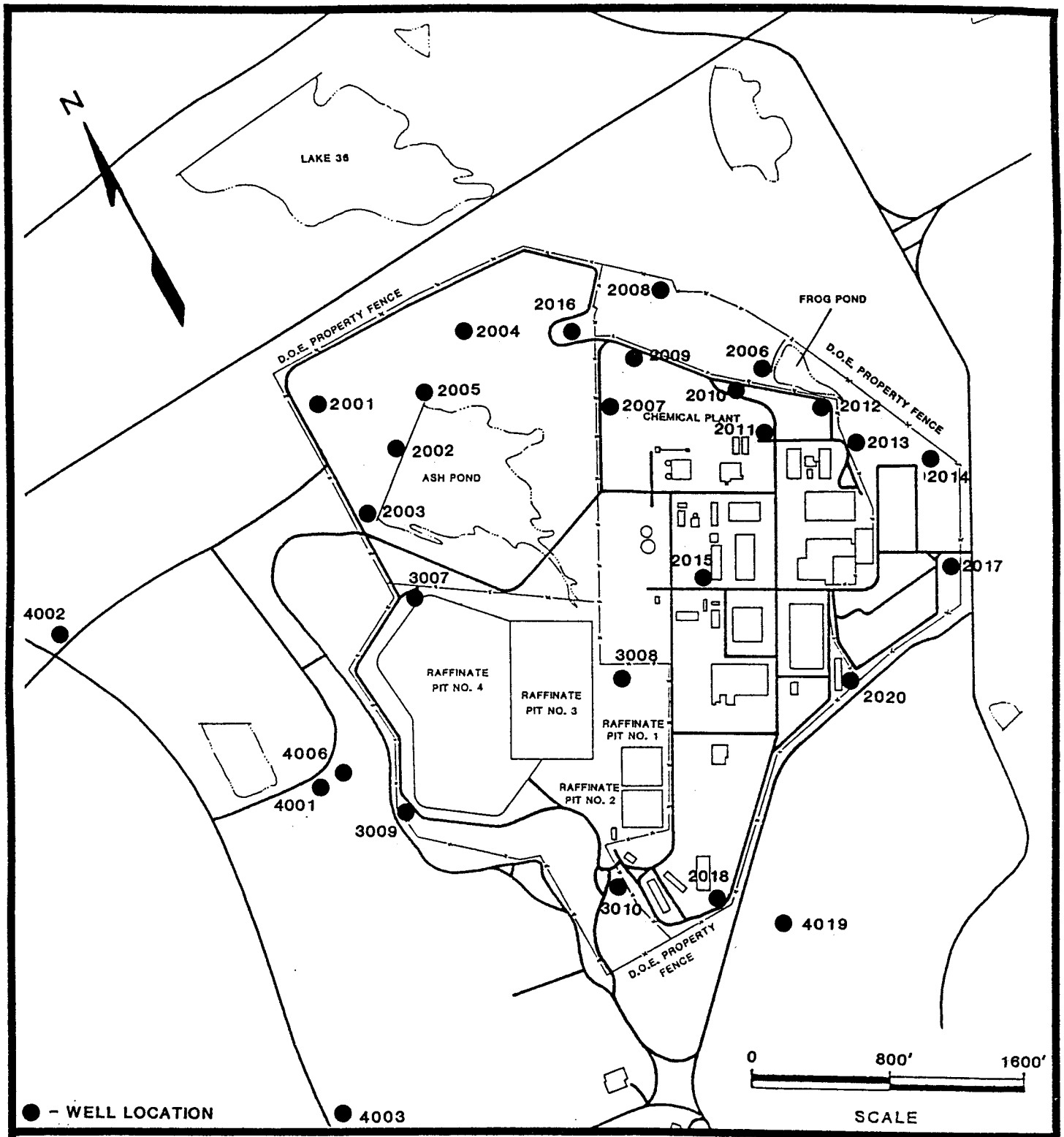


FIGURE 1-27

EXISTING MONITORING WELLS

TABLE 1-12

GROUNDWATER MONITORING WELL DATA SHEET

WSCP/WSRP AND VICINITY

WELL NUMBER	OLD WELL NUMBER	APPROXIMATE LOCATION COORDINATES NORTH	WEST	TOTAL WELL DEPTH FT. BTOC	APPROX. ELEV. OF GROUND SURFACE NGVD	ELEV. OF TOP OF CASING NGVD	BOTTOM WELL ELEV. FT. NGVD	SCREEN LENGTH FT.	BOTTOM OF FILTER PACK ELEVATION NGVD	LENGTH OF FILTER PACK	BOREHOLE DIAMETER IN.	CASING DIAMETER IN.	CLUSTERED WELL NUMBER	DEPTH TO STATIC WATER LEVEL FT. BTOC	STATIC WATER LEVEL ELEV.	APPROX. ELEV. OF TOP BEDROCK NGVD	APPROX. SATURATED THICKNESS PENETRATED BY WELL FT.
MW 2001	GMW-1	100858	52554	61.0	612	613.45	552.5	10	547.5	32.5	8.5	2		25.42	588.03	586.0	36
MW 2002	GMW-2	100658	52253	61.0	626	625.65	564.7	10	559.7	32.3	8.5	2	MW 2020	32.60	593.05	595.0	28
MW 2003	GMW-3	100347	52299	61.0	637	638.74	577.7	10	552.7	22.5	8.5	2		40.96	597.78	598.0	20
MW 2004	GMW-4	101450	51750	78.5	642	644.73	566.2	10	565.7	22.7	8.5	2	MW 2029	61.04	583.69	592.0	17
MW 2005	GMW-5	101131	51950	78.5	635	637.45	559.0	10	554.5	31.0	8.5	2	MW 2022	49.90	587.55	591.0	29
MW 2006	GMW-6	101223	49852	68.5	634	636.00	567.5	10	563.0	44.0	8.5	2	MW 2026	36.42	599.58	611.0	32
MW 2007	GMW-7	100928	50933	96.0	652	653.70	557.7	10	552.7	36.7	8.5	2		60.81	592.89	590.0	35
MW 2008	GMW-8	101720	50659	58.5	623	624.73	566.2	10	562.7	29.0	8.5	2	MW 2025	36.19	588.54	588.0	22
MW 2009	GMW-9	101350	50700	61.0	637	638.71	577.7	10	577.7	31.4	8.5	2		41.32	597.39	616.0	20
MW 2010	GMW-10	101150	50100	61.0	642	644.75	583.8	10	578.8	26.8	8.5	2		44.79	599.96	609.0	16
MW 2011	GMW-11	100916	50030	76.0	653	655.37	579.4	10	574.2	42.4	8.5	2		54.58	600.79	621.0	21
MW 2012	GMW-12	101050	49643	61.0	636	637.70	575.7	10	565.2	40.2	8.5	2		32.32	604.38	611.0	29
MW 2013	GMW-13	100819	49539	70.9	645	647.12	576.2	10	570.2	43.7	8.5	2	MW 2027	42.88	604.24	618.0	37
MW 2014	GMW-14	100735	49186	61.0	647	649.33	588.3	10	583.3	27.0	8.5	2		45.40	603.93	614.0	16
MW 2015	GMW-15	100100	50550	81.0	657	659.90	578.9	10	571.4	38.7	8.5	2	MW 2028	56.28	603.62	612.0	25
MW 2016(2)		101532	51176	152.4	635	636.89	484.5	GROUTED	----------					57.88	579.01	585.0	--
MW 2017	GMW-17	100200	49050	66.1	658	659.84	593.7	10	588.7	39.0	8.5	2		54.62	605.22	634.0	12
MW 2018	GMW-18	98297	50382	66.1	665	663.44	597.3	10	592.3	31.6	8.5	2	MW 2019	48.51	614.93	629.0	18
MW 2019		98287	50391	117.2	662	663.17	546.0	10	545.7	13.3	8.5	4	MW 2018	71.49	591.68	618.0	44
MW 2020	B-4	99548	49549	121.4	655	656.88	535.5	--		--	3.0	OPEN		47.47(1)	609.41(1)	637.0	74
MW 2021		100635	52263	112.2	624	626.07	513.9	10	513.6	14.75	8.5	4	MW 2002	37.39	588.68	602.0	74
MW 2022		101154	51946	127.1	636	637.28	510.2	10	510.1	14.0	8.5	4	MW 2005	51.67	585.61	591.2	76
MW 2023		101551	51141	92.2	636	637.38	544.6	20	543.6	23.0	8.5	2	MW 2024	53.88	582.91	583.0	21
MW 2024		101552	51186	151.4	635	636.79	485.4	10	485.4	12	8.5	4	MW 2023	69.12	568.26	583.0	96

TABLE 1-12 (Cont'd)

GROUNDWATER MONITORING WELL DATA SHEET

WSCP/WSRP AND VICINITY

WELL NUMBER	OLD WELL NUMBER	APPROXIMATE LOCATION COORDINATES		TOTAL WELL DEPTH FT. BTOC	APPROX. ELEV. OF GROUND SURFACE NGVD	ELEV. OF TOP OF CASING NGVD	BOTTOM WELL ELEV. FT. NGVD	SCREEN LENGTH FT.	BOTTOM OF FILTER PACK ELEVATION NGVD	LENGTH OF FILTER PACK	BOREHOLE DIAMETER IN.	CASING DIAMETER IN.	CLUSTERED WELL NUMBER	DEPTH TO STATIC WATER LEVEL FT. BTOC	STATIC WATER LEVEL ELEV.	APPROX. ELEV. OF TOP BEDROCK NGVD	APPROX. SATURATED THICKNESS PENETRATED BY WELL FT.
		NORTH	WEST														
MW 2025		101688	50649	108.6	622	624.05	515.5	10	515.3	13.0	8.5	4	MW 2008	40.24	583.81	593.0	68
MW 2026		101215	49861	120.3	631	633.44	513.1	10	513.0	12.5	8.5	4	MW 2006	46.04	587.40	611.4	72
MW 2027		100858	49546	121.8	646	646.83	525.0	10	524.6	15.0	8.5	4	MW 2013	52.51	594.32	619.0	68
MW 2028		100092	50543	132.8	658	659.65	526.8	10	526.3	15.5	8.5	4	MW 2015	64.17	595.48	613.5	67
MW 2029		101453	51734	103.1	643	645.24	542.1	10	542.1	12.5	8.5			62.69	582.55	592.0	38
MW 3001		99100	51250	77.2	664	664.20	589.2	20	586.2	25.3	8.5	2	MW 3002	53.94	610.26	610.0	23
MW 3002		99100	51240	147.5	664	664.00	519.2	10		13.5	8.5	4	MW 3001			611.0	--
MW 3003		100046	52094	90.8	644	645.91	555.1	10	554.8	13.8	8.5	2	MW 3006	48.14	597.77	617.0	43
MW 3006		100049	52071	136.2	646	647.05	511.2	10	510.7	15.5	8.5	4	MW 3003	56.96	590.09	614.0	79
MW 3007(2)	B-17	100043	52683	99.9	645	647.72	547.8	GROUTED						45.55	602.17	621.0	--
MW 3008	B-19A	99546	50954	104.0	645	646.43	542.4	--		--	3.0	OPEN		36.06	609.97	617.0	68
MW 3009	B-21	98832	52123	101.5	645	646.43	544.9	--		--	3.0	OPEN		37.92	608.51	615.0	64
MW 3010	B-23	98471	50936	92.6	665	666.94	574.3	--		--	3.0	OPEN		58.79	608.15	627.0	34
MW 3019		97933	50946	85.5	660	661.94	576.4	10	576.4	13.7	8.0	2		56.21	605.73	633.0	28
MW 4001	GMW-16	99049	52567	41.8	661	622.74	580.9	10		13.6	8.5	2	MW 4007	20.66	602.08	610.0	22
MW 4002	B-9	99848	54284	87.4	634	635.32	547.9	--		--	3.0	OPEN		66.32	569.00	612.0	21
MW 4003	B-11	96958	52459	108.1	670	671.67	563.6	--		--	3.0	OPEN		58.79	612.88	653.0	49
MW 4004		97749	51689	76.4	652	653.06	576.7	10	576.7	12.0	8.0	2		41.26	611.80	630.0	34
MW 4005		97710	52372	79.3	657	657.25	577.9	10	577.7	14.7	8.5	2		47.74	609.51	627.0	31
MW 4006(3)	B-16	99084	52513	29.8	620	622.96	593.2	5		8.0	6.0	2		20.39	602.57	603.0	9
MW 4007		99069	52545	92.2	623	624.06	531.9	10	531.5	13.0	8.5	4	MW 4001	28.27	595.79	610.0	62
MW 4008		98669	53180	84.6	637	637.26	552.7	10	552.5	13.0	8.5	2		40.12	597.14	605.0	43
MW 4009		99517	52672	78.2	624	625.82	547.6	10	547.4	12.8	8.5	2		31.68	594.14	607.0	45
MW 4010		100103	53030	78.5	629	630.68	552.2	10	552.0	10.2	8.5	2		41.58	589.10	614.3	35

TABLE 1-12 (Cont'd)

GROUNDWATER MONITORING WELL DATA SHEET

WSCP/WSRP AND VICINITY

WELL NUMBER	OLD WELL NUMBER	APPROXIMATE LOCATION COORDINATES NORTH	WEST	TOTAL WELL DEPTH FT. BTOC	APPROX. ELEV. OF GROUND SURFACE NGVD	ELEV. OF TOP OF CASING NGVD	BOTTOM WELL ELEV. FT. NGVD	SCREEN LENGTH FT.	BOTTOM OF FILTER PACK ELEVATION NGVD	LENGTH OF FILTER PACK	BOREHOLE DIAMETER IN.	CASING DIAMETER IN.	CLUSTERED WELL NUMBER	DEPTH TO STATIC WATER LEVEL FT. BTOC	STATIC WATER LEVEL ELEV.	APPROX. ELEV. OF TOP BEDROCK NGVD	APPROX. SATURATED THICKNESS PENETRATED BY WELL FT.
MW 4011		100550	52780	77.0	626	627.20	551.1	10	549.2	14.6	8.5	2		38.10	589.10	596.0	38
MW 4012		101642	53034	77.2	615	617.32	540.1	10	539.9	12.8	8.5	2		46.83	570.49	584.0	29
MW 4013		101916	52193	61.3	607	608.65	547.3	20	547.3	22.0	8.5	2		48.14	560.51	574.0	12
MW 4014		102267	51592	66.6	608	609.10	542.5	20	542.5	22.0	8.5	2		47.73	561.37	567.0	17
MW 4015		102150	50509	64.7	618	619.58	554.9	20	554.7	23.2	8.5	2		38.17	581.41	607.0	27
MW 4016		102003	49982	84.6	643	644.03	559.2	10	559.2	12.3	8.5	2		54.32	589.71	614.0	29
MW 4017		101612	49287	85.0	649	649.97	565.0	20	565.0	22.2	8.5	2		56.66	593.31	601.0	28
MW 4018		101233	48677	76.4	648	649.93	573.5	10	568.5	18.0	8.5	2		52.23	597.70	606.0	22
MW 4019	GMW-19	98063	50161	61.0	645	647.17	586.2	10		19.0	8.5	2		35.58	611.59	623.0	26
MW 4020		99933	48704	78.3	658	659.16	580.9	10	580.7	12.0	8.5	2		54.06	605.10	623.0	23
MW 4021		99170	49188	72.8	650	651.86	579.1	20	579.1	22.0	8.5	2		44.11	607.75	625.0	26
MW 4022		97460	50447	90.4	666	667.91	577.5	20	577.3	20.0	8.5	2		71.17	596.74	633.0	19
MW 4023		98718	49845	55.0	646	648.48	593.5	20	592.5	22.5	8.5	2		33.71	614.77	620.0	31

NOTES: Static Water Levels measured 07/23/88 except as noted.

(1) Measured 06/07/88
(2) Measured 04/30/87
(3) Overburden Monitoring Well included in bedrock water level monitoring program.
(4) Wells MW 2001 through MW 2018 have one foot of blank casing below screen. Other wells are capped at base of screen.

Tabulated data are preliminary - based on partially validated data. New well designations established October 1986.

samples and water level measurements can be collected from these wells, they are not representative of discrete zones within the aquifer. It is not possible to determine vertical flow patterns or vertical distribution of contaminants from these wells.

Monitoring well MW-4006 was installed to a depth of 28.5 feet below ground surface. This well was constructed with a 2-inch PVC casing and has 0.040-inch opening factory slotted screens.

Nineteen wells (MW-2001 through MW-2015, MW-2017, MW-2018, MW-4019, and MW-4001) are screened in the upper, weathered portion of the Burlington/Keokuk Formation, penetrating from 12 to 37 feet of saturated thickness.

BNI sampled groundwater and raffinate pits water in September and October 1986 for chemical and radiological analyses. These data suggest leakage from the pits: groundwater analyses for wells upgrade of the raffinate pits are significantly different from sample analyses from the pits, while analyses from wells downgrade of the pits are of similar water quality (BNI, 1987). None of the previously mentioned data and reports contain sufficient information regarding sample collection, preservation and analytical methodologies to allow the presented data to be validated according to the data validation procedures in the QAPP. However, these data are useful as background information.

MKF presents the first comprehensive water quality assessment for groundwater and surface water systems at WSS and vicinity in the Phase I Water Quality Assessment (1987b). This assessment consisted of sampling 50 monitoring wells and 23 surface water locations. Groundwater samples were analyzed for the complete hazardous substance list, nitroaromatics, selected inorganic anions, water quality indicators, and radionuclides. Surface water samples were analyzed for radionuclides, selected inorganic anions, water quality indicators, and metals as listed on the EPA Contract Laboratory Program (CLP) list.

Conclusions from the Assessment (MKF, 1987b) include:

- Raffinate Pit 3 appears to be contributing nitrate and dissolved metals to the groundwater.
- Raffinate Pit 4 appears to be contributing sulfate to the groundwater.
- Nitroaromatics are present in groundwater at high concentrations (400 ppb total) under the northeast corner of the WSS.
- General low-level nitroaromatic contamination exists over most of the WSS.
- Three lakes on the Busch Wildlife Area receive radiological contamination from the site.

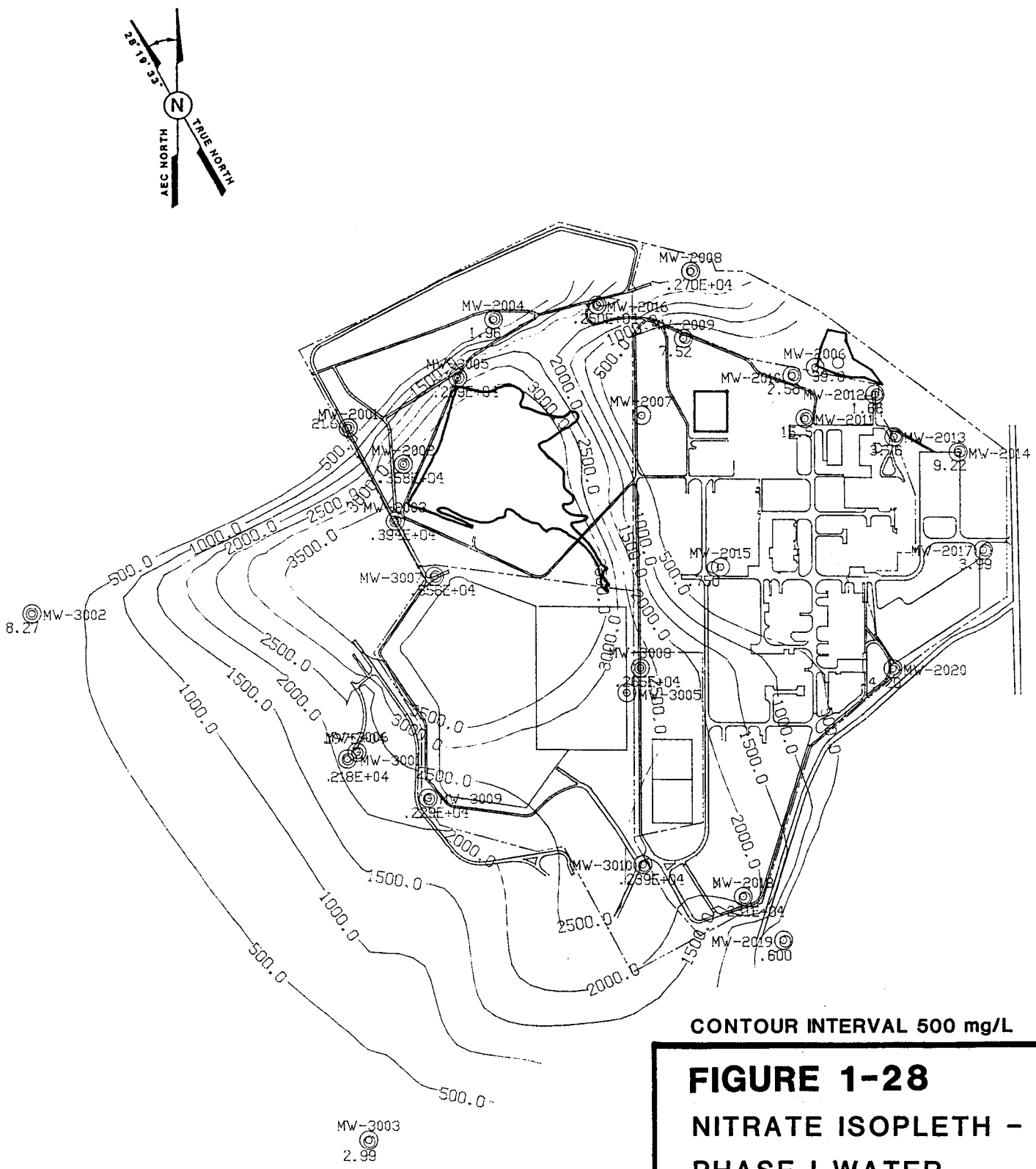
Nitrate concentrations in monitoring wells are shown in Table 1-13. Sample numbers correspond with monitoring well numbers. Nitrate isopleths are presented in Figure 1-28.

The apparent contamination source for the nitrate is Raffinate Pit 3. This conclusion was drawn by correlating metals (antimony, chromium, magnesium, and vanadium) and nitrate concentrations in Raffinate Pit 3 water and sludge with concentrations in monitoring wells. Concentrations of nitrate in the plume do not decrease gradually as would be expected, but decline rapidly between the northern edge of the raffinate pits and the northern site boundary. It is possible that this decline is due to a hydrogeologic discontinuity such as a series of solution-enlarged joints or fractures which intercept the plume. Elevated sulfate concentrations were detected in the western portion of the site, centered under Raffinate Pit 4 (see Table 1-13). Sulfate contamination may occur from water percolating through raffinate pit sludges, known to contain high

Table 1-13
INORGANIC ANION DATA FOR GROUNDWATER AT THE WSCP/WSRP

		Concentration mg/L								
U.S. E.P.A. Primary/Secondary Drinking Water Standard	mg/L	Nitrate (as N) 10	Sulfate 250	Chloride 250	Fluoride 2	TDS 500	TOC S	Hardness S	Cyanide CWA* 0.2	Phenol Standard 3.5
Sample No.	Date Sampled									
GW-2001	3/3/87	4.8	22.5	5.12	<0.25	362	<1	307	U	U
GW-2002	3/4/87	806	198	23.2	14.9	1360	1	664	U	U
GW-2003	3/4/87	886	223	33.2	14.7	2724	16	985	U	U
GW-2003-D	3/4/87	945	232	32.8	14.6	2520	<1	1331	U	U
GW-2004	3/3/87	0.4	6.26	1.14	<0.25	374	63	305	U	U
GW-2005	3/5/87	605	172	4.43	1.01	1562	2.12	419	U	U
GW-2006	3/2/87	8.8	31.4	87.1	<0.25	570	7	411	U	0.016
GW-2007	3/2/87	<0.1	17.9	1.34	<0.25	320	<1	312	U	U
GW-2008	3/4/87	608	166	64.2	17.0	622	1	375	U	0.013
GW-2009	3/3/87	1.7	38.2	8.04	<0.25	596	2	448	U	U
GW-2010	3/3/87	0.6	56.8	32.2	<0.25	590	2	374	U	U
GW-2011	3/3/87	3.5	11.3	4.44	<0.25	314	1	279	U	U
GW-2012	3/3/87	0.4	74.2	32.2	<0.25	546	57	352	U	U
GW-2013	3/2/87	0.9	26.9	8.62	0.40	688	6	415	U	U
GW-2014	3/2/87	2.2	34.5	2.83	0.28	570	3	460	U	U
GW-2015	3/6/87	0.2	158	2.46	<0.25	570	3.26	502	U	0.011
GW-2015-D	3/6/87	<0.1	158	2.12	0.25	568	2.96	514	U	U
GW-2016	3/4/87	562	112	18.1	15.3	656	2	328	U	U
GW-2017	3/2/87	0.9	462	10.8	0.62	1000	1	735	U	U
GW-2018	3/5/87	519	18.8	2.45	0.54	642	0.98	352	U	U
GW-2020	3/6/87	0.9	241	38.4	<0.25	680	8.21	434	U	U
GW-3007	3/4/87	1251	866	52.2	12.4	5260	10	2594	U	U
GW-3008	3/10/87	597	100	31.7	1.51	6028	2.06	3482	U	0.014
GW-3009	3/5/87	515	34.2	1.64	0.58	728	2.20	478	U	0.020
GW-3010	3/5/87	296	23.8	2.21	0.38	500	1.85	322	U	U
GW-3010-D	3/5/87	537	23.0	2.34	0.55	506	1.55	333	U	U
GW-3013	3/5/87	468	915	2.30	1.09	1436	3.51	997	U	U
GW-4001	3/5/87	491	159	1.48	0.55	652	14.1	367	0.018	0.011
GW-4002	3/6/87	1.9	25.0	2.16	<0.25	232	24.8	219	U	U
GW-4003	3/6/87	0.7	36.0	7.40	<0.25	308	8.78	294	U	U
GW-4006	3/5/87	444	129	0.78	0.44	402	17.7	226	U	0.011
GW-4019	3/6/87	0.1	9.01	0.91	<0.25	278	3.77	280	U	0.026

S = No Drinking Water Standard
D = Duplicate Sample
*CWA = Clean Water Act
Source: WSSRAP, 1987



CONTOUR INTERVAL 500 mg/L

FIGURE 1-28

NITRATE ISOPLETH - PHASE I WATER QUALITY REPORT

SOURCE : MK-FERGUSON-1987

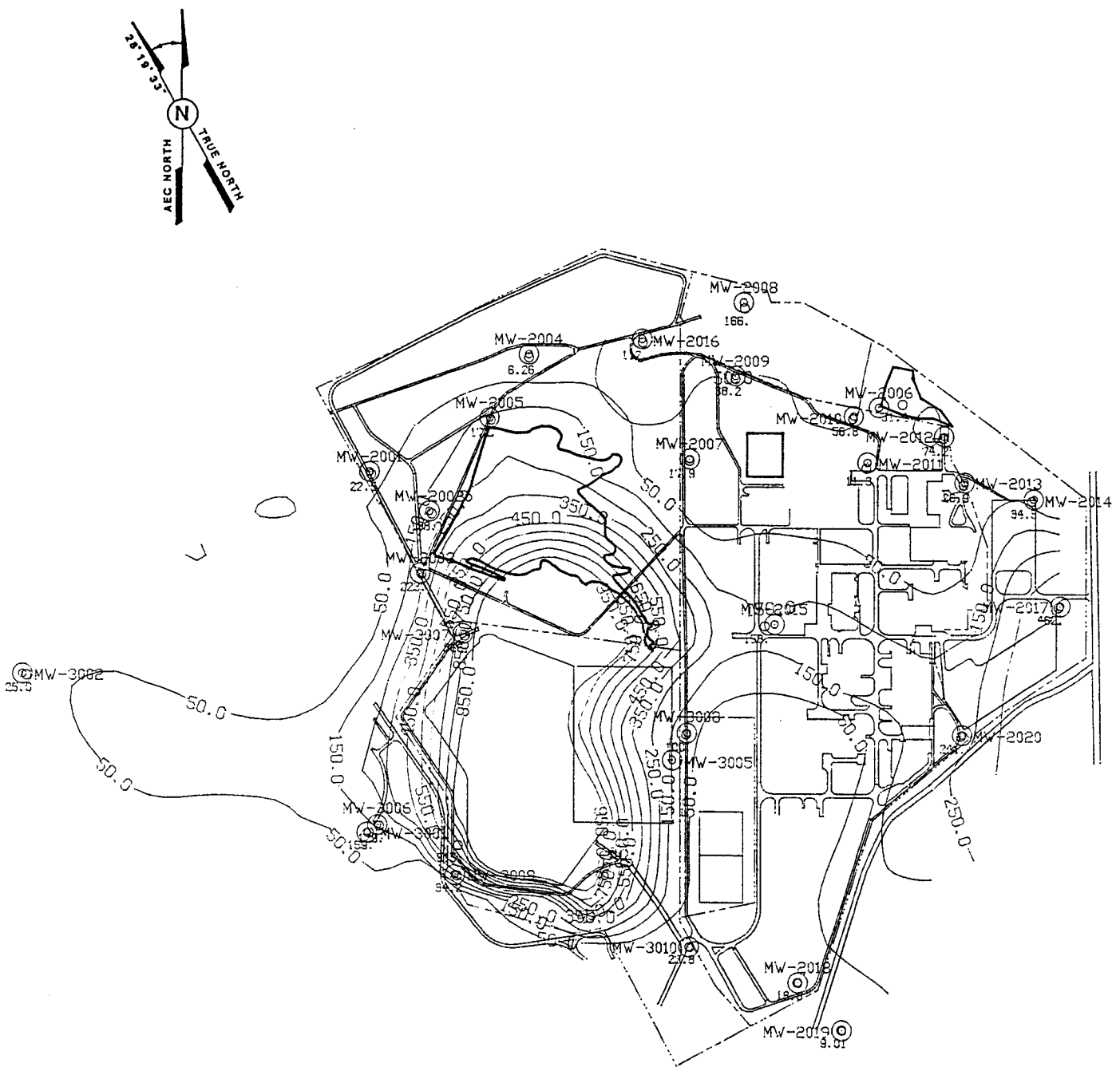
NOTE : NITRATE SHOWN AS NO3

concentrations of sulfur. Computer-generated sulfate isopleths are presented in Figure 1-29. Sulfate concentrations gradually decrease with distance from the source, also suggesting a different source from the nitrate contamination.

Figures 1-28 and 1-29 depict nitrate and sulfate contamination. These isopleths are computer generated, based on limited data, and shape configuration is governed by reading monitor wells in existence in March 1987. Other factors that may modify configuration include rock fracture orientation, gradient, the existence of perched groundwater zones, and the chemical, physical and biological processes in the vadose zone and aquifer. They present only a general representation of extent of contamination.

Nitroaromatics were detected at low ug/L concentrations in most monitoring wells sampled during the Phase I Assessment (see Table 1-14). Nitroaromatics were also observed at high concentrations in the northeast portion of the WSCP. The highest concentrations were present near the final production area of TNT Line No. 1, which is a potential source area. Another potential source is the former site of the Weldon Spring Ordnance Works wastewater lagoon, located just north of the site boundary and immediately west of the Missouri Highway Department's maintenance facility. Soil sampling performed in 1987 indicated nitroaromatic concentrations as high as 1% by weight in soil samples from the old waste lagoon.

Surface water sampling at and near the WSCP/WSRP confirmed earlier monitoring results which concluded that Busch Wildlife Area Lakes 34, 35, and 36 receive direct or indirect uranium-contaminated runoff from the WSCP/WSRP. No significant chemical contamination attributable to the WSCP/WSRP was observed in any surface water. Slightly elevated nitrate levels were observed in Burgermeister Spring which receives water from at least two losing streams draining the site.



CONTOUR INTERVAL 100mg/L

FIGURE 1-29

SULFATE ISOPLETH - PHASE I WATER QUALITY REPORT

MK FERGUSON-1987

TABLE 1-14

NITROAROMATIC CONCENTRATIONS IN THE GROUNDWATER AT THE WSCP/WSRP

Sample No.	Date Sampled	2,4,6-TNT (ug/L)	2,4 DNT (ug/L)	2,6 DNT (ug/L)	Nitro benzene (ug/L)	1,3,5-Trinitro benzene (ug/L)	1,3-Dinitro benzene (ug/L)
MW-2001	3/3/87	<0.5	2.1	2.4	1.0	0.05	<0.4
MW-2002	3/4/87	0.6	<0.2	<0.6	<0.6	<0.03	<0.4
MW-2003	3/4/87	<0.5	0.3	0.7	<0.6	<0.03	<0.4
MW-2003-D	3/4/87	<0.5	0.4	0.7	<0.6	<0.03	<0.4
MW-2004	3/3/87	<0.5	<0.2	0.6	<0.6	<0.03	<0.4
MW-2005	3/5/87	<0.5	0.4	0.9	<0.6	0.1	<0.4
MW-2006	3/2/87	<0.5	3.7	50.1	8.3	4.6	0.5
MW-2007	3/2/87	<0.5	0.3	<0.6	<0.6	<0.03	<0.4
MW-2008	3/4/87	<0.5	<0.2	<0.6	<0.6	0.04	<0.4
MW-2009	3/3/87	<0.5	0.4	0.9	0.6	<0.03	<0.4
MW-2010	3/3/87	1.7	0.3	0.9	<0.6	0.06	<0.4
MW-2011	3/3/87	<0.5	2.2	25.8	<0.6	<0.05	<0.4
MW-2012	3/3/87	1.8	1.3	<0.6	<0.6	0.6	<0.4
MW-2013	3/2/87	29	172	138	<0.6	4.9	0.5
MW-2014	3/2/87	<0.5	1.1	1.5	4.0	0.6	<0.4
MW-2015	3/6/87	<0.5	0.2	<0.6	<0.6	<0.03	<0.4
MW-2015-D	3/6/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4
MW-2016	3/4/87	<0.5	<0.2	1.0	<0.6	<0.03	<0.4
MW-2017	3/2/87	<0.5	0.2	<0.6	<0.6	<0.03	<0.4
MW-2018	3/5/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4
MW-2020	3/6/87	<0.5	0.2	<0.6	1.7	<0.03	<0.4
MW-3007	3/4/87	<0.5	1.8	3.3	<0.6	0.1	<0.4
MW-3008	3/10/87	<0.5	0.4	<0.6	<0.6	<0.03	<0.4
MW-3009	3/5/87	<0.5	0.5	<0.6	<0.6	0.05	<0.4
MW-3010	3/5/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4
MW-3010-D	3/5/87	<0.5	<0.2	<0.6	<0.6	<0.03	<0.4
MW-3013	3/5/87	<0.5	0.3	<0.6	<0.6	<0.03	<0.4
MW-4001	3/5/87	37	1.4	4.2	<0.6	18.3	<0.4
MW-4002	3/6/87	2.7	0.7	1.3	<0.6	<0.03	<0.4
MW-4003	3/6/87	<0.5	0.3	0.8	<0.6	<0.03	<0.4
MW-4006	3/5/87	1.2	<0.2	3.0	2.5	1.7	<0.4
MW-4019	3/6/87	<0.5	0.2	<0.6	<0.6	<0.03	<0.4

Note: Nitroaromatics Analysis Following USATHAMA Method (HPLC)

Besides detecting the previously described contamination, the Phase I Water Quality Assessment established the absence of organic (other than nitroaromatics) and significant metals contamination in WSCP/WSRP groundwater. Due to limited organic compound usage in processes at the WSCP/WSRP, their absence in groundwater was expected.

The Phase I Water Quality Assessment detected groundwater contamination and has partially defined the horizontal extent. Additional investigations are required to define the horizontal and vertical extent of contamination, define aquifer properties, and establish chemical contamination source areas.

1.3 CONCEPTUAL MODEL

Data collected from prior and current sampling operations, including that presented in the Phase I Water Quality Assessment Report (MKF, 1987), have been subjected to QA/QC evaluation. Those data evaluated for adequacy and validity have been utilized, with the incorporation of available areal geological, hydrological, climatological and other information as presented in Section 1.2 of this report, to establish the physical and chemical characteristics of the site and used to construct a conceptual model to describe the WSS.

The hydrogeological components of this WSCP/WSRP model illustrate the following known and potential groundwater and surface water contaminants, their sources, known affected aquifers and surface impoundments, routes of migration, and potential receptors.

- Potential or known contaminants are:

    1) Radiological constituents, including radium-226, radium-228, thorium-230, thorium-232 and uranium.
    2) Inorganic anions including nitrates, sulfates, and fluoride

3) Nitroaromatics, primarily 2,6-DNT, 2,4-DNT, 2,4,6 TNT and 1,3,5 Trinitrobenzene.

- o Potential or known sources include the WSRP, WSCP, Ash Pond, Frog Pond, and drainage from the plant area and nearby properties. Source areas are depicted on Figures 1-24 to 1-26.
- o Potential affected aquifers are the fractured and solutioned limestones, other consolidated sediments, and unconsolidated sands and gravels deposited in stream valleys. These are depicted on Figure 1-30.
- o Potential migration routes include surface drainage ways from the site, pervious and semi-pervious zones in the unconsolidated overburden that mantles bedrock, and the fractured and solutioned limestone bedrock which underlies the WSS as depicted on Figures 1-10 to 1-13, 1-30, and 1-31.
- o Potential receptors include users of the Busch Wildlife Lakes, and the local streams, springs, and wells serving nearby farms, rural homes, schools, and local communities. (A detailed exposure evaluation will be presented in the RI/FS work plan.)

Significant preliminary conclusions can be interpreted from this model. They are:

1) A N-NE trending groundwater divide traverses the eastern third of the WSS. Groundwater flow is primarily northwest and southeast away from the divide toward the Mississippi and Missouri rivers, respectively.

2) Perched and mounded groundwater zones are present in the vicinity of the raffinate pits, which suggests leakage at these pits and variable horizontal and vertical hydraulic conductivities in the overburden materials.

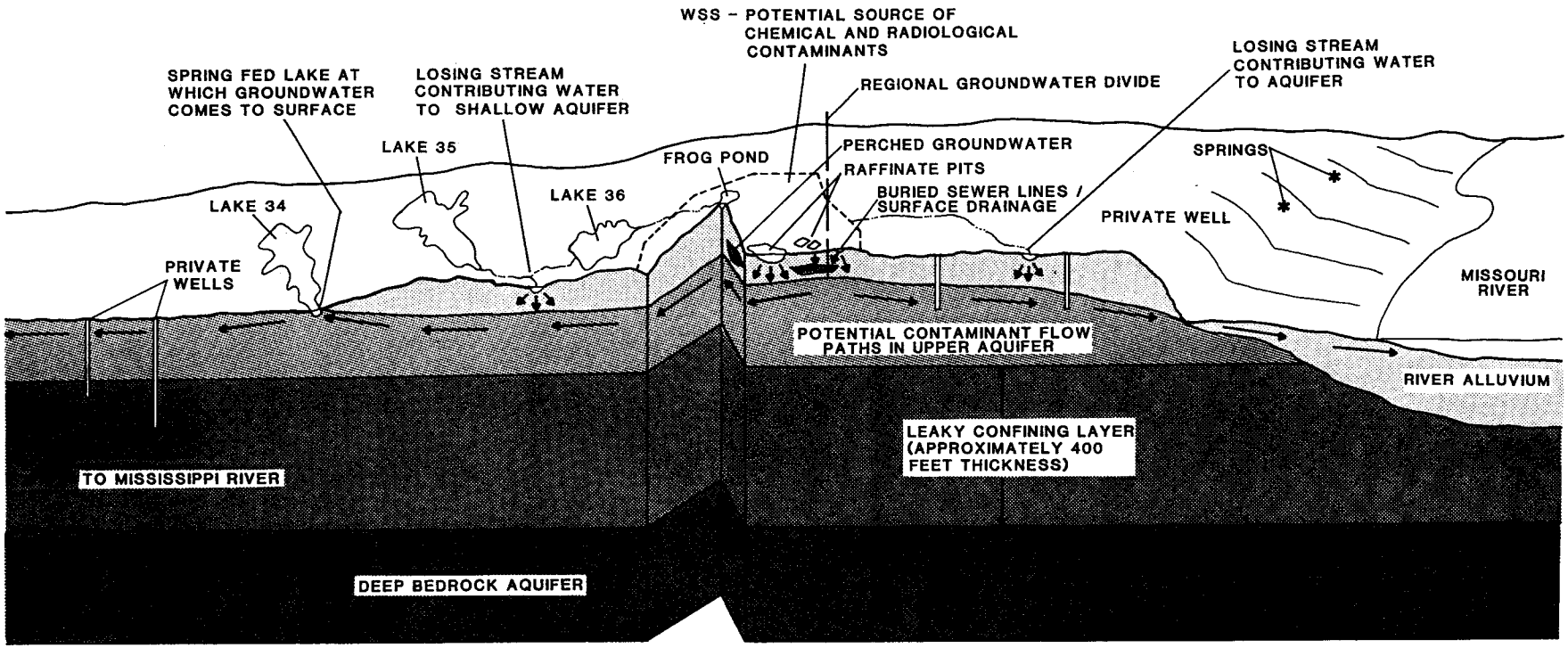


FIGURE 1-30

PRELIMINARY ILLUSTRATION FROM THE WSS OF POTENTIAL SUBSURFACE FLOW PATHS

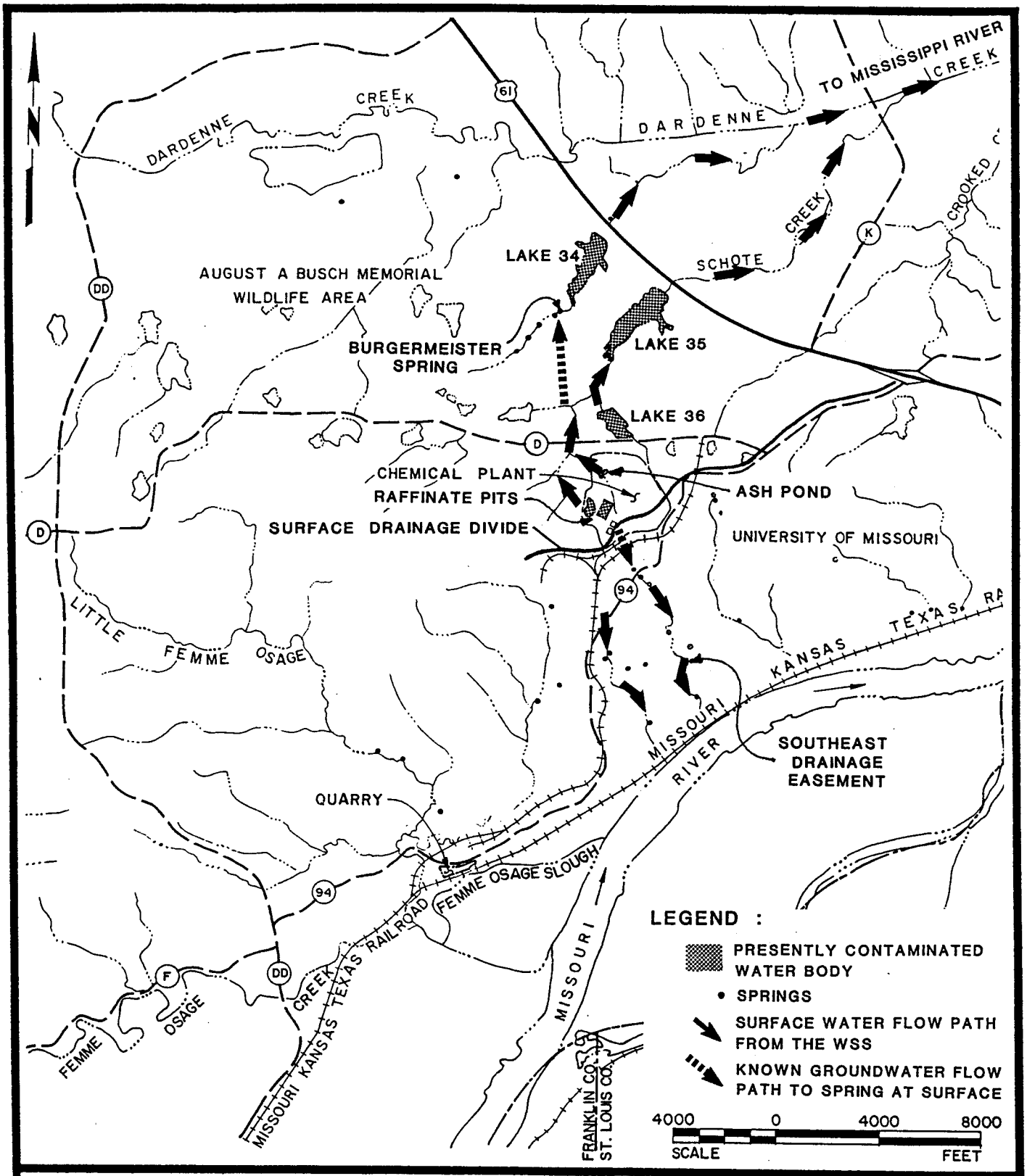


FIGURE 1-31

PRELIMINARY ILLUSTRATION OF POTENTIAL SURFACE FLOW PATHS FROM THE WSS

3) The raffinate pits appear to be contributing nitrates, sulfates, and dissolved metals to the groundwater. Nitrate contaminated groundwater is issuing from Burgermeister Spring, approximately 7000 feet north of Raffinate Pit 3, a possible source.

4) Nitroaromatics and radiological constituents are also present at Burgermeister Spring. The probable sources are surface waters from Ash Pond and other areas of the WSCP.

5) The major groundwater aquifer to be affected by contaminants and to allow contaminant transport is the upper weathered and fractured zone of the Burlington/Keokuk Formation.

6) Vertical migration of contaminants will be impeded by a thick sequence of sedimentary rocks, classified by the USGS (1986) as a leaky confining bed of low hydraulic conductivity. These rocks, including the Kimmswick Limestone, shales in the Decorah Formation, and underlying Ordovician siltstone, limestones and dolomites, would tend to preclude contamination of deep productive aquifers, e.g. St. Peter Sandstone.

7) Surface water pathways and storm sewers present at the site (e.g. Southeast Drainage Easement; Frog Pond and Ash Pond spillways and appurtenances) contribute contaminants to groundwater and surface waters (e.g. Busch Wildlife Lakes).

8) Overburden, or unconsolidated materials, mantles WSS bedrock units. It ranges in thickness from 20 to more than 55 feet and has variable chemical and physical characteristics. Those gravelly clay and silt materials at the overburden-bedrock contact are classified as residuum and are the result of bedrock weathering and erosion.

9) Surface water features displaying hydraulic connection to groundwater contaminant migration pathways are Burgermeister Spring, Busch Wildlife Lakes No. 34, 35, and 36, the Southeast Drainage Easement and associated springs.

The preliminary conceptual model of the site has utilized the hydrogeologic data obtained from previous sampling operations. Data obtained from future sampling activities described in this plan (Section 2.0) will be incorporated into the conceptual model which, upon refinement, will allow for a better definition of site conditions. This refined conceptual model and more sophisticated computer models more thoroughly portray:

- The physical characteristics of the site, i.e. the environmental setting, surface features, hydrology, geology, meteorology, overburden and aquifer parameters, contaminant pathways, and other factors related to the hydrogeologic regime.

- The source of contaminants and the chemical and physical characteristics of that source.

- The nature and extent (horizontal and vertical) of contamination. This is established after an analysis of physical, chemical, and source studies described above and includes analysis with the use of computer models. Additional data relating to contaminant release times and rate of migration will be incorporated into these models.

1.4 DATA USES/NEEDS

Previous sections of this Hydrogeologic Investigation Sampling Plan have described known existing conditions on the site and have partially defined areas or investigative categories where data are deficient. The EPA has provided guidelines and

requirements through the Data Quality Objective (DQO) process (Data Quality Objectives for Remedial Response Activities, 540/G-87/003, March 1987) and RI/FS guidance documents for the delineation of data uses and needs.

Analysis of existing data under the DQO process, as applied on the Weldon Spring Project, has provided for: 1) a limited physical and chemical characterization of the site; 2) the construction of a preliminary conceptual model; 3) the identification of data needs and uses; and 4) the initial scoping of additional sampling and data collection activities. A component of the process includes the identification of potential remedial technologies. At the WSS there has been a preliminary delineation of possible hydrogeologic-related Expedited Response Actions (ERA's), e.g., construction of drainage dikes, design and construction of contaminated water treatment plants, and removal of possible contaminant sources. Selected ERA's have been submitted to EPA for approval as Interim Response Actions (IRA's).

General data use categories, such as risk assessment and remedial design, are presented in the DQO manuals. These categories are applicable for the Weldon Spring Project and previous investigations have provided information for the following RI/FS hydrogeologic or other related components: 1) site characterization; 2) health and safety; 3) risk assessment; 4) remedial alternatives evaluation and design (including expedited response actions); and 5) community relations plans. Additional data collection activities conducted at the WSS will provide information for the refinement or revision of the foregoing RI/FS use categories.

Section 2.0 describes sample collection and rationale for the various components of the program. Listed below are the data needs and rationale for correcting data deficiencies on the WSS, as follows:

- The surface hydrology of the site and vicinity has been partially defined. Additional data pertaining to possible contaminant transport mechanisms, source areas, stream recharge/discharge and pond storage capacity are needed to fully define the hydrogeological regime. Data gathered from this study will also be included as a component of the water balance study which will be incorporated into USGS computer models of the site.

- A review of the available climatologic data indicates site-specific climatologic data are lacking. Extension of this data base to include precipitation, temperature, evaporation, wind, and relative humidity will be needed for water balance and contaminant migration studies.

- The geologic investigation will further define the bedrock geology at the site and immediate vicinity for zones underlying the upper portion of the Burlington/Keokuk Formation. More data on the competency of the lower unit of the Burlington/Keokuk will be obtained. Site-specific data on underlying bedrock units are needed for definition of thicknesses, physical character, and potential migration pathways, including further definition of solution channels and impervious strata or zones. Specific lithologic data and potentiometric head data on Ordovician and Devonian formations underlying the Burlington/Keokuk Formation is needed to define direction of groundwater movement.

- The thickness of the overburden units is well defined. The physical properties affecting water and contaminant presence, movement, storage, and migration in the vadose zone require additional definition and verification. These data are needed for determination

of the effect of the overburden materials in immobilizing, attenuating, or slowing contaminant transport. Also, localized saturated contaminated lenses have been identified in the overburden in the raffinate pit area. Geophysical surveys have identified other potential contaminated zones. Additional data are needed to fully define the nature and extent of these zones.

- Two groundwater flow regimes are prevalent on the WSS, i.e. Darcian flow and conduit flow. Numerous studies have been completed within both groundwater flow regimes. Definitive modeling of groundwater flow and contaminant migration specific to each regime has not been completed. Aquifer parameters have not been defined. Hence, field tests are needed to provide hydraulic conductivity, transmissivity, storativity, and recharge/discharge data. For the conduit flow regime, specific site-related connections to several discharge points have been verified. A more thorough inventory of potential discharge points and verification of any additional site-related connections is needed. Refinement of the predictive models of the groundwater migration pathway will improve understanding of the impact of groundwater contamination and facilitate the endangerment assessment.

- The karst hydrogeology needs to be fully characterized. Seeps, springs, solution cavities, channels, and possible ancestral sink areas need to be defined as they are potential conduits for contaminant flow to nearby surface impoundments, e.g. Lake 36 on Busch Wildlife Area, and to springs.

- Several groundwater contaminant plumes have been identified beneath and in the vicinity of the site. Refinement and definition of the lateral and vertical extent of these plumes is needed. Data are lacking to confirm which nearby areas are not affected.

- The Water Quality Phase I Assessment Report (MKF Dec. 1987) recommends the acquisition of additional water quality data, including stream, lake, and groundwater sampling and analyses. These data, coupled with soil and sediment analyses, are needed to fully characterize existing and potential contamination and contaminant transport and fate.

1.5 SAMPLING PLAN OVERVIEW

There are eight major tasks designed to acquire the needed data described above. They are:

- Extend network of monitoring wells in order to determine vertical and horizontal extent of groundwater contamination, the levels of contamination, and the hydrogeologic conditions at the WSS.

- Perform aquifer testing to: (1) provide area and depth data on aquifer characteristics, such as hydraulic conductivity, transmissivity, and storativity; (2) to provide information for prediction of long-term contaminant migration; and (3) assess effects of pumping the upper limestone aquifer.

- Study the karst hydrogeology by including dye tracing and stream flow studies to determine groundwater/surface water interactions and improve understanding of migration pathways and rates of flow.

- Study surface water hydrology and water quality to: (1) define potential surface migration pathways; (2) determine the possible extent of migration; (3) measure concentrations of contaminants in surface water; and (4) define the hydrologic characteristics associated with the surface water features.

- Characterize unsaturated zone to: (1) define chemical and physical characteristics of the media for classifying types and levels of contaminants; (2) estimate recharge to the groundwater system; and (3) define perched zones that may influence contaminant migration.

- Perform hydrogeologic and water balance studies to define: (1) regional groundwater levels; (2) groundwater fluctuations; (3) features that influence groundwater movement and surface water/groundwater interaction; and (4) groundwater chemistry relationships.

- Develop computer models of the groundwater flow and contaminant transport in order to predict future contamination migration and evaluate the effectiveness of possible mitigation measures.

- Perform evaluation analyses from the above tasks and previous studies in order to accomplish the sampling plan objectives described in this section.

2.0 HYDROGEOLOGIC SUBTASKS

Complementary hydrogeologic investigations will be conducted by the WSSRAP, MDNR and the USGS on a site-specific and regional basis. The WSSRAP program (described in Sections 2.1 through 2.5) will investigate surface and subsurface hydrogeologic conditions at the WSS. The USGS will investigate regional groundwater flow, water balance, and water chemistry (as summarized in Section 2.6). Although the investigations will be performed independently by WSSRAP and the USGS, the programs have been designed cooperatively to be consistent, so that information from each study can be utilized for incorporation into a consistent interpretive model.

2.1 GROUNDWATER MONITORING

Groundwater monitoring is part of an integrated program designed to characterize the hydrogeologic regime at the Weldon Spring Site (WSS) and its immediate vicinity. Other aspects of this program are discussed in subsequent sections. The groundwater monitoring efforts described in this section will focus on the bedrock aquifer in the Burlington-Keokuk Formation.

Groundwater monitoring for Remedial Investigation (RI) activities will include installation and sampling of new monitoring wells as well as continued monitoring of existing wells. These efforts are designed to more accurately define the extent and magnitude of groundwater contamination which was indicated by previous studies (MK-F, 1987).

In the first quarter of 1987, Weldon Spring Site Remedial Action Project (WSSRAP) initiated an Environmental Monitoring Program. This program is more comprehensive than previous monitoring programs. Water quality monitoring includes: (1) sampling of monitoring wells primarily near the site perimeter; (2) sampling of surface water bodies potentially affected by runoff from the

site; and (3) sampling of runoff under provisions of a NPDES permit.

A Phase I Water Quality Assessment conducted during March 1987 began assessing the overall quality of groundwater at the WSS. Results of the Phase I Water Quality Assessment indicated a plume of contaminated groundwater containing high nitrate and sulfate concentrations underlying the western half of the site and a plume containing high nitroaromatic concentrations in the northeast corner of the site. These results are discussed in detail in the Phase I Water Quality Assessment Report (December 1987) and summarized above in Section 1.2.10. Plans for additional groundwater monitoring, as discussed in the following sections, are based on results of the Phase I Water Quality Assessment and review and interpretation of other existing information.

2.1.1 Extended Monitoring Well Network

2.1.1.1 Existing Monitoring Wells

The existing monitoring wells described in this section will be retained to monitor water levels and groundwater contamination. Combined with the additional monitoring wells described in the following section, the existing wells will form an extended monitoring well network for determination of groundwater quality and flow parameters.

Locations of existing monitoring wells are illustrated on Figure 2-1. In order to provide a consistent identification system for existing and future monitoring wells, new 4-digit well numbers have been assigned to all existing wells. New and old well numbers, location coordinates (based on original AEC plant grid), depths, and other information are presented on Table 1-12. Monitoring wells to remain in service are listed on Table 2-1. The 26 monitoring wells to remain in service include only those

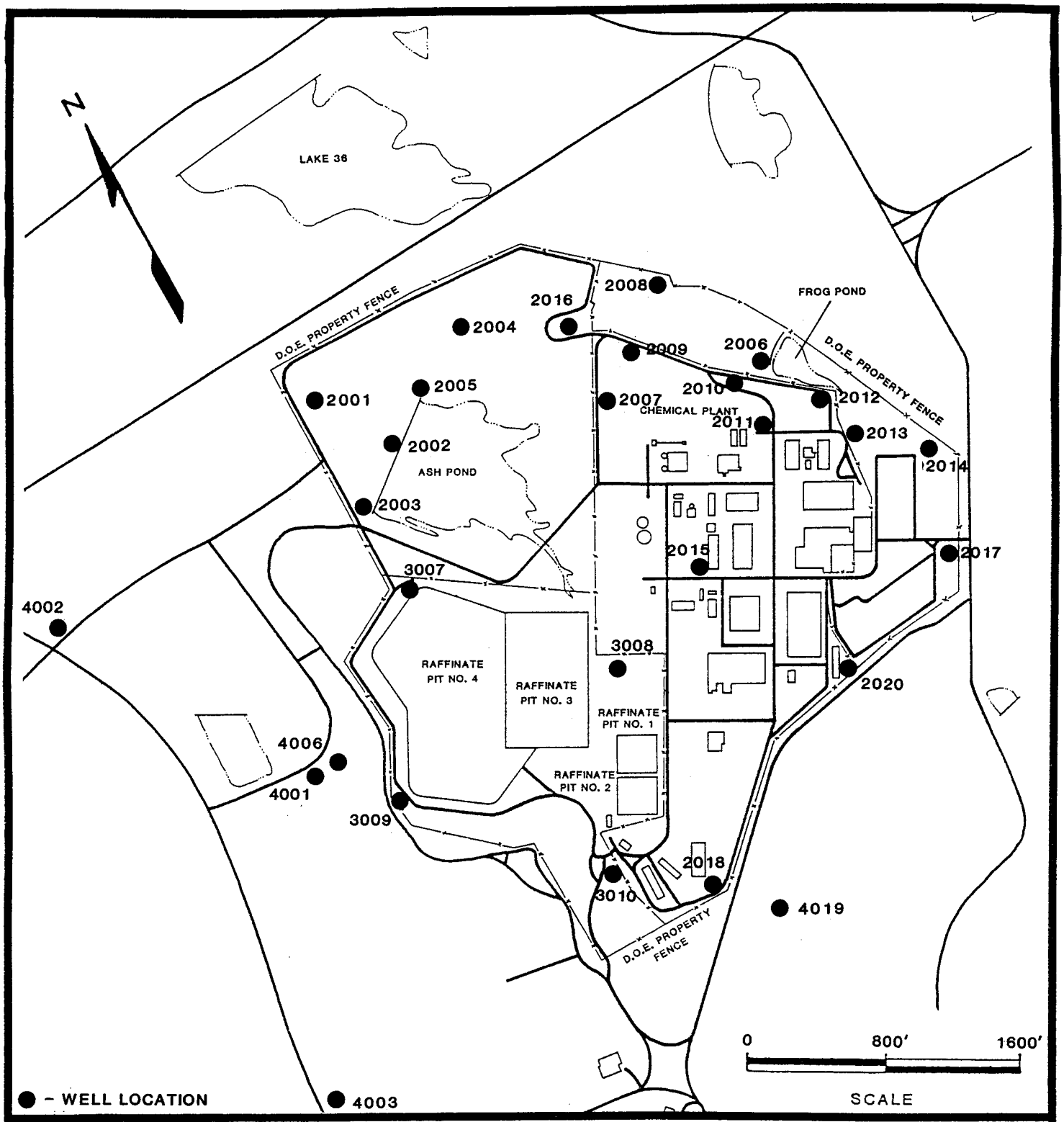


FIGURE 2-1

EXISTING MONITORING WELLS

TABLE 2-1

EXISTING MONITORING WELLS SUITABLE FOR CONTINUED MONITORING

MW-2001	MW-2011	MW-2020
MW-2002	MW-2012	MW-4001
MW-2003	MW-2013	MW-4002
MW-2004	MW-2014	MW-4003
MW-2005	MW-2015	MW-4006
MW-2006	MW-2017	MW-3008
MW-2007	MW-2018	MW-3009
MW-2008	MW-4019	MW-3010
MW-2009		
MW-2010		

wells which are suitable for water level measurements and groundwater sampling; wells that are dry, damaged, or destroyed are excluded. Monitoring wells with a 2000 series number are located within the chemical plant area, wells with a 3000 series number are located in the raffinate pits area, and wells with a 4000 series number are located outside of the site boundaries.

Of the 29 wells that were sampled for the Phase I Assessment study, 28 are screened in the bedrock aquifer. Existing monitoring wells are included in the extended monitoring well network based on the following criteria:

- Complete lithologic log and construction details.
- Screened in the bedrock aquifer.
- Documentation of quality control/decontamination procedures.
- Factory-slotted PVC or wire-wound stainless steel screens (open borehole in bedrock with casing grouted through the unconsolidated soils is of limited use, but acceptable).
- Filter pack (sand or gravel) surrounding screen.
- Bentonite seal above the filter pack.
- Grout to surface.
- Locking protective casing.

Existing monitoring wells that will be included in the extended monitoring well network were installed in 1983 (seven wells) and 1986 (nineteen wells) during hydrogeological studies by Bechtel National, Inc. (BNI).

Six of the monitoring wells installed in 1983 were constructed with 4-inch diameter PVC casing through the unconsolidated soil and an uncased open borehole in the bedrock. The six wells include: MW-2020, MW-4002, MW-4003, MW-3008, MW-3009, and MW-3010. Although groundwater samples and water level measurements can be collected from these wells, these samples and

measurements are not representative of discrete zones within the aquifer. It is not possible to determine vertical flow patterns or vertical distribution of contaminants from these wells. Monitoring well MW-4006 was also installed in 1983 by BNI to a depth of 28.5 feet below ground level. This well was constructed with 2-inch PVC casing and has a 0.040-inch opening factory-slotted screen.

Monitoring wells MW-2001 thru MW-2015, MW-2017, MW-2018, MW-4019, and MW-4001 were installed in 1986 by BNI. These wells were constructed with 2-inch diameter, Type 316 L Schedule 40 stainless steel casing and .010-inch opening wire-wound screen. The wells are predominantly located in the upper, weathered portion of the Burlington-Keokuk Formation penetrating from 12 to 36 feet of saturated thickness.

Saturated overburden (perched and mounded conditions) will be addressed in Section 2.4, Overburden Hydrogeology; existing overburden wells are not included in the extended monitoring well network. Due to poor construction, two original wells (MW-2016 and MW-3007) were plugged and each was replaced with a two-well cluster.

Of the 26 remaining bedrock wells, 21 wells are located in the raffinate pits and chemical plant area, four wells are located outside the site boundaries in the Weldon Spring Training Area (WSTA) owned by the U.S. Department of the Army, and one well is located in the Weldon Spring Wildlife Area which is administered by the Missouri Department of Conservation.

2.1.1.2 Additional Monitoring Wells

Additional monitoring wells have recently been installed to further investigate the vertical and horizontal extent of groundwater contamination and characterize groundwater flow patterns. These wells are a component of the overall site

characterization program initiated in 1988. Well installation was scheduled to allow for early acquisition of additional data. These supplementary data, incorporated into hydrogeologic and other models, will also allow for the delineation of additional data needs. It should be noted that these monitoring and pumping wells have been designed and placed to monitor and test the Darcian flow regime beneath and near the site. Darcian flow occurs through the pores and fine fractures in the bedrock formation and is considered the transport mechanism for the contaminant plumes beneath and in the vicinity of the site. Conduit flow occurs through enlarged or preferential fractures and conduits and is considered to be the transport mechanism for the contaminants found in off-site springs and seeps. The conduit flow regime will be investigated through dye tracing studies and off-site spring, seep, and stream monitoring discussed in Section 2.3.

Locations and depths of additional monitoring wells to complete the extended monitoring-well network have been selected to accomplish several goals:

- Critical areas will be monitored for horizontal and vertical contaminant migration. These areas include known contaminated areas, areas downgradient from contaminated areas, and areas in which contaminant migration is not expected, to confirm that it is not occurring.

- Monitoring wells are located in a consistent horizontal and vertical network. Wells are evenly spaced horizontally, and at depths related to those nearby upgradient wells, as described below.

- Well installation and sampling can be accomplished within a reasonable period of time.

The additional wells include: (1) deep wells installed in clusters with existing wells where elevated concentrations of contaminants have been detected; and (2) wells installed downgradient of the farthest documented extent of contaminant plumes to determine the horizontal extent of contamination.

Groundwater flow in the shallower, more highly weathered zones of the Burlington/Keokuk Formation is likely to be predominantly horizontal, eventually discharging to nearby springs and streams. The existing monitoring wells and additional shallow wells will effectively monitor this zone. A portion of the flow could also migrate to deeper zones within the aquifer below the elevation of the known discharge points. The deep monitoring wells are installed to monitor deeper zones below the apparent flow paths to springs and streams.

Locations of additional monitoring wells are shown on Figure 2-2. Criteria for the location of these wells include:

- All individual wells and well clusters have been located within 500 to 1000 feet of two or more other well or well-cluster locations to effectively map groundwater flow patterns by comparing three or more water-level elevations.

- Deep monitoring wells are located adjacent to selected wells in which contaminant concentrations above U.S. EPA Drinking Water Standards were detected in Phase I Water Quality Assessment samples.

- Screened intervals of deep monitoring wells are set approximately 50 feet below the screened intervals of adjacent shallow wells.

- Shallow wells are located downgradient from existing wells and areas with significant groundwater

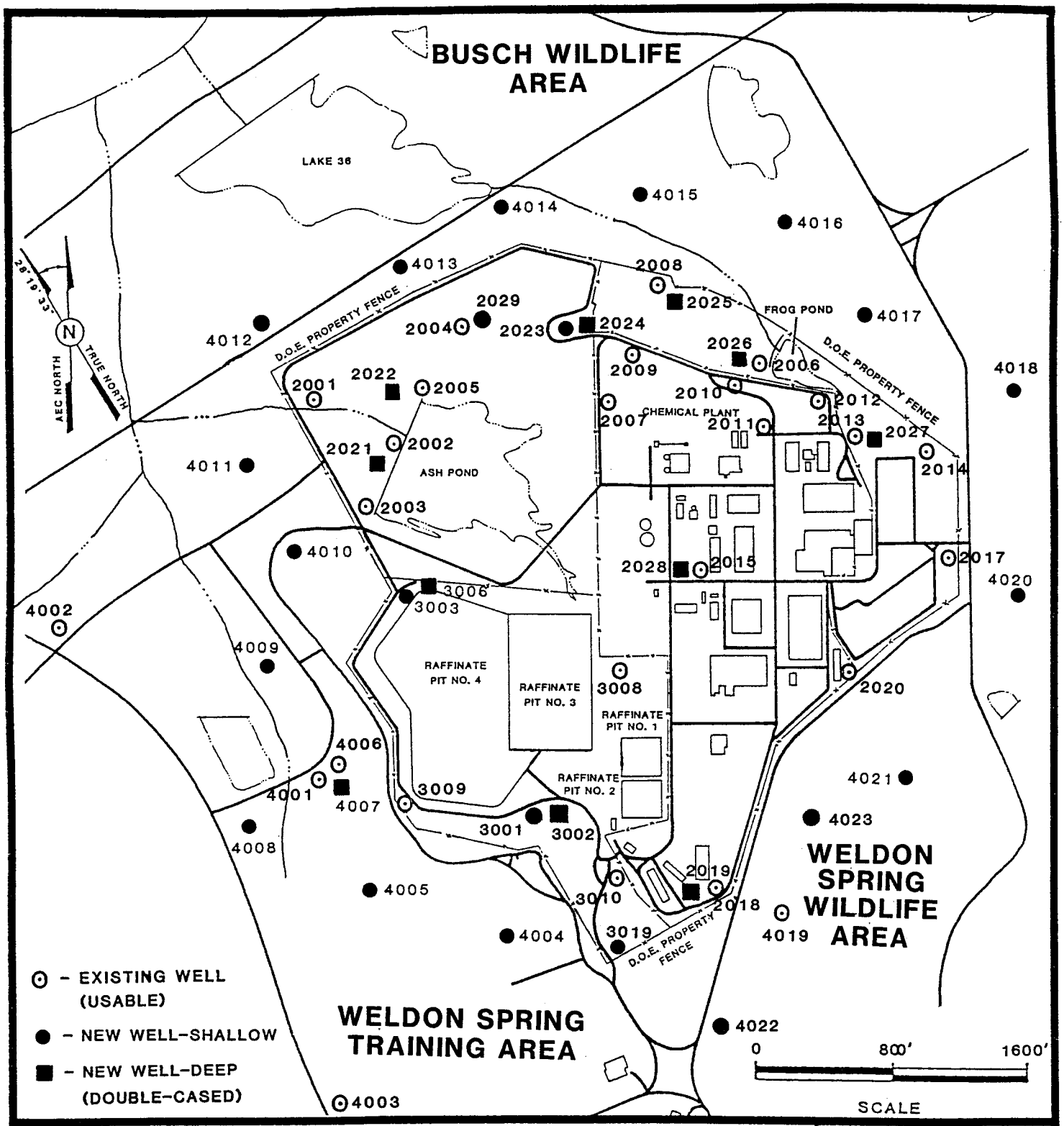


FIGURE 2-2

EXTENDED MONITORING WELL NETWORK

contamination.

- Screened intervals of shallow wells are set in permeable fractured zones of the bedrock aquifer as observed from downhole video surveys or as defined by an analysis of rock cores, water level data, and information obtained from nearby wells which have screened sections in permeable zones.

These criteria have been modified as necessary when selecting individual well locations and/or depths. A total of 33 new monitoring wells have been installed. This total includes 11 deep wells and 20 shallow wells. Rationale for well placement is presented in Table 2-2.

Two of the existing monitoring wells, MW-2016 and MW-3007 (Figure 2-1), have been plugged and replaced with two-well clusters. MW-3007 has an open borehole extending through approximately 54 feet of saturated thickness in the bedrock. The highest nitrate concentrations in the Phase I Water Quality Assessment were detected in this well. MW-2016 was constructed using 2-inch diameter PVC casing with a screen 7 feet in length and a filter pack 88 feet in length. This well is the deepest of the existing monitoring wells and also had a high nitrate concentration during the Phase I Water Quality Assessment. At each of these locations, it is critical to establish the depth of nitrate contamination and to measure the vertical gradients which could be producing downward migration of contaminants. The clustered replacement wells, each monitoring a discrete depth interval, will allow these determinations.

The locations of the additional monitoring wells placed downgradient from wells with known groundwater contamination have been selected anticipating that they will be beyond the extent of contaminant plumes. This selection was based on the known distribution of groundwater contamination and assuming Darcian

Table 2-2

ADDITIONAL MONITORING WELLS

LOCATIONS AND RATIONALE

WELL NUMBER	LOCATION	RATIONALE
MW-2019	Clustered with MW-2018 at southern end of site	Deep well to monitor vertical gradients and vertical extent of contamination detected in MW-2018
MW-2021	Clustered with MW-2002 to the north of Ash Pond	Deep well to monitor vertical gradients and vertical extent of contamination detected in MW-2002
MW-2022	Clustered with MW-2005 at northeast corner of Ash Pond	Deep well to monitor vertical gradients and vertical extent of contamination detected in MW-2005
MW-2023	Northern edge of site, midway between Frog Pond and Ash Pond; at location of MW-2016 (B-3)	Monitor contamination detected in MW-2016; MW-2016 will be replaced by 2-well cluster to monitor discrete shallow and deep intervals
MW-2024	Clustered with MW-2023 as described above	Deep well to monitor vertical gradients and vertical extent of contamination at this location
MW-2025	Clustered with MW-2008 on northeast edge of site	Deep well to monitor vertical gradients and vertical extent of contamination at this location
MW-2026	Clustered with MW-2006 on north side of Frog Pond	Deep well to monitor vertical gradients and vertical extent of nitroaromatic contamination detected in MW-2006
MW-2027	Clustered with MW-2013 approximately 500 feet south of Frog Pond	Deep well to monitor vertical gradients and vertical extent of nitroaromatic contamination detected in MW-2013
MW-2028	Clustered with MW-2015 near center of Chemical Plant Area	Deep well to provide vertical gradient data from center of monitoring well network near apparent groundwater flow divide; document presence or absence of contamination in deeper zones
MW-2029	Clustered with MW-2004 between Ash Pond and DOE Property Fence	Anomalously low nitrate concentrations detected in MW-2004, which penetrates only 18 feet of saturated thickness. MW-2029 installed to determine presence or absence of contamination at slightly greater depths, still within upper zone of aquifer

Table 2-2

ADDITIONAL MONITORING WELLS

LOCATIONS AND RATIONALE

WELL NUMBER	LOCATION	RATIONALE
MW-3001	Southern end of Raffinate Pit 3	Detect potential contamination and monitor water levels in center of Raffinate Pits Area
MW-3002	Clustered with MW-3001 at southern end of Raffinate Pit 3	Deep well to provide vertical gradient data in center of Raffinate Pits Area; detect potential contamination in deeper zones
MW-3003	Northern end of Raffinate Pit 4, at location of MW-3007 (B-17)	Monitor contamination previously detected in MW-3007; MW-3008 has been replaced by 2-well cluster monitoring discrete shallow and deep intervals
MW-3006	Clustered with MW-3003 as described above	Deep well to monitor vertical gradients and vertical extent of contamination previously detected in MW-3007
MW-3019	Southern end of site, approximately 500 feet west of MW-2018/MW-2019 cluster, approximately 500 feet southwest of MW-3010	Detect contaminant migration from immediate vicinity of MW-3010; define contaminant levels and flow patterns near apparent groundwater flow divide
MW-4004	Southwest of site boundary along Raffinate Pits, approximately 600 feet west of MW-3010	Detect westward extent of contaminant migration in conjunction with other monitoring wells beyond southwestern edge of site
MW-4005	Southwest of site boundary along Raffinate Pits, approximately 500 feet southwest of MW-3009	Detect westward extent of contaminant migration in conjunction with other monitoring wells beyond southwestern edge of site
MW-4007	Clustered with MW-4001 west of Raffinate Pit 4	Deep well to monitor vertical gradients and vertical extent of contamination detected in MW-4001
MW-4008	Southwest of site boundary along Raffinate Pits; approximately 500 feet west of MW-4001/MW-4007 cluster	Detect westward extent of migration of contaminants detected in MW-4001

Table 2-2

ADDITIONAL MONITORING WELLS

LOCATIONS AND RATIONALE

WELL NUMBER	LOCATION	RATIONALE
MW-4009	Beyond site boundary west of Raffinate Pits Area, approximately 800 feet north of MW-4001/MW4007 cluster	Detect westward extent of contaminant migration in conjunction with other monitoring wells
MW-4010	Beyond site boundary west of Ash Pond, approximately 600 feet northwest of MW-3003/MW-3006 cluster	Detect westward extent of contaminant migration in conjunction with other monitoring wells to west of site
MW-4011	Approximately 800 feet west-northwest of MW-2002/MW-2021 cluster	Monitor extent of contaminant migration in the upper part of Burlington-Keokuk aquifer from Raffinate Pits and Ash Pond area
MW-4012	Outside northern corner of site near Highway D	Detect northward extent of contaminant migration in conjunction with other downgradient wells
MW-4013	Near Highway D along northern edge of site, approximately 800 feet north-northwest of MW-2005/MW-2022 cluster	Detect northward extent of contaminant migration in conjunction with other downgradient wells
MW-4014	North of site boundary near Highway D and drainage from Frog Pond to Lake 36, approximately 800 feet north of MW-2023/MW-2024 cluster	Detect northward extent of contaminant migration in conjunction with other downgradient wells
MW-4015	North of site boundary and north of the drainage from Frog Pond to Lake 36, approximately 600 feet north of MW-2008/MW-2025 cluster	Detect north and northeastward extent of contaminant migration; possibly delineate eastern edge of contaminant plume
MW-4016	North of site boundary, approximately 1000 feet north of Frog Pond	Detect north and northeastward extent of contaminant migration from Frog Pond Area; possibly delineate eastern edge of contaminant plume

Table 2-2

ADDITIONAL MONITORING WELLS

LOCATIONS AND RATIONALE

WELL NUMBER	LOCATION	RATIONALE
MW-4017	North of site boundary, approximately 500 feet east-northeast of Frog Pond	Detect northeastward extent of contaminant migration from Frog Pond Area; detect contamination in immediate vicinity of former Ordnance Works waste impoundment
MW-4018	Beyond northeastern corner of site, on east side of Highway 94, approximately 800 feet east of MW-2013/MW-2027 cluster	Detect contaminant migration east and south from Frog Pond Area; further delineate groundwater flow divide
MW-4020	East of site boundary on east side of Highway 94, approximately 600 feet south-southeast of MW-2017	Detect potential contaminant migration to the southeast; define groundwater flow patterns and gradients southeast of site
MW-4021	Southeast of site boundary, approximately 1000 feet south of MW-2020, between site boundary and Highway 94	Detect potential contaminant migration to the southeast; define flow patterns and gradients southeast of site
MW-4022	Southeast of southern end of site, approximately 800 feet south of MW-2018/MW-2019 cluster, between site boundary and Highway 94	Detect potential migration to the southeast of contamination detected in MW-2018 and MW-3010; define groundwater flow patterns
MW-4023	East of southern end of site. Approximately 800 feet southwest of MW-4021.	Detect potential contaminant migration at the upper end of the southeast drainage. MW-2020, approximately 1000 feet north has yielded samples which indicate the presence of uranium in the groundwater

flow conditions in an equivalent porous medium. Small fractures were observed during downhole video surveys. No major fractures or conduits were observed.

Although it is anticipated that the additional wells will provide "negative documentation" serving to delineate the limits of contaminant plumes, it is possible that some of the additional wells may have elevated concentrations of contaminants. Such conditions could occur due to migration of a contaminant plume further than anticipated, or "breakthrough" of contaminants through zones of higher permeability. If such conditions occur, additional monitoring wells may be installed to monitor contaminant migration in the specific areas affected. Installation of additional downgradient wells is not warranted at this time. The areas of potential contaminant migration beyond the planned extended monitoring-well network cannot readily be predicted. The hydrogeologic regime beyond the extended monitoring-well network may vary from on-site conditions in regard to Darcian vs. conduit flow conditions, gradients, and flow patterns. This is of particular concern to the north of the site where artificial lakes in the Busch Wildlife Area may produce mounding effects and recharge from losing streams could alter flow patterns. The necessity for installation of additional downgradient wells will be evaluated following receipt of initial sampling results from the extended monitoring-well network.

Similar considerations apply to monitoring of vertical distribution of contaminants utilizing the clustered monitoring wells. The monitoring-well clusters installed as part of the extended monitoring-well network will provide information on vertical distribution of contaminants and vertical gradients. The actual vertical extent of contamination and vertical gradients producing downward migration can only be determined following initial sampling and water level measurements.

Following receipt of the sampling results, the necessity for any additional deep monitoring wells will be evaluated.

2.1.2 Well Installation

Monitoring well drilling, installation, and development was performed in accordance with accepted procedures as discussed in the U.S. EPA RCRA Technical Enforcement Guidance Document (1986). Standard Operating Procedures have been developed for WSSRAP based on EPA guidelines. A supervising geologist was present to document well drilling, installation, and development.

2.1.2.1 Decontamination

All drill bits, drill rods, casing, well logging and measurement equipment, and miscellaneous hand tools were decontaminated by hot steam-cleaning prior to use and between boreholes. Equipment damageable by steam cleaning, e.g., video cameras, was rinsed with potable water from on-site supplies. The entire drilling rig was decontaminated upon arrival on-site, and upon completion of drilling activities. Interior portions of equipment, such as pumps and hoses, which are not accessible for cleaning with a steam-cleaner were thoroughly cleaned and flushed with potable water.

Screen and casing was also decontaminated inside and out by steam-cleaning and wrapped or covered. The screen and casing was stored above ground to avoid contact with potentially contaminated soils prior to installation.

All surge blocks, bailers, and other development equipment were decontaminated by steam-cleaning before development begins at each well.

2.1.2.2 Drilling Methods

Drilling has been performed using rotary techniques or a combination of hollow-stem auger and rotary techniques. A supervising geologist has recorded a lithologic log for each borehole. When drilling through unconsolidated soils at new locations, split-spoon samples have been collected at intervals of 5 feet. All contaminated cuttings not sampled for laboratory analysis were collected and retained on the site. In drilling the boreholes for shallow monitoring wells, a 7-inch minimum diameter borehole was drilled to the bedrock surface. The bedrock was then cored to define weathered - unweathered limestone contact (generally less than 100 feet below ground surface). After completion of coring, the boreholes were reamed to a final diameter of 8.5 inches. Table 1-12 lists well location coordinates, elevation, depth, and other relevant well data. The shallow wells were screened in the upper, weathered portion of the Burlington/Keokuk Formation, as defined by an analysis of cores and down-hole video surveys.

The deep monitoring wells were double-cased through zones of known groundwater contamination to prevent contaminants from being transported downward during drilling and well installation. A 12-inch diameter borehole was drilled to a depth of at least 10 feet below the depth of the adjacent well. A 10-inch diameter steel outer casing was placed in the borehole and the annular space outside of the casing sealed with cement-bentonite grout to surface. The bottom of the casing was backfilled with at least four feet of grout which was allowed to set for a minimum of 72 hours before work continued. The drilling sequence of coring and reaming continued through this outer casing to a depth ranging from 108 to 150 feet. The deep wells were screened in the unweathered portion of the Burlington-Keokuk Formation.

2.1.2.3 Monitoring Well Construction

Monitoring wells were constructed using Type 316 stainless steel, threaded, flush-jointed screen and casing. Shallow wells (generally less than 100 feet deep) were constructed using 2-inch inside diameter (ID) screen and casing. Deep wells were constructed using 4-inch ID screen and casing to assure that pumps and other sampling and measuring devices can be readily lowered into and removed from the wells. Screen was of wire-wound construction with 0.010-inch slots. Screen length was 10 feet. Only non-hydrocarbon-based lubricants, such as silicon or Teflon, were permitted for use on pipe threads or drilling rods.

Continuous bedrock cores were collected from the top of bedrock to the total depth of the borehole in the shallow wells. In the deep wells, coring of the bedrock commenced at the base of the outer casing and continued for the total depth of the hole. This method of coring assured a detailed and accurate log of the bedrock at each monitoring-well location. When drilling through the interval that was cased off in the deep monitoring wells, grab samples of the drill cuttings were collected at intervals of five feet as drilling proceeds. Cores were inspected by a geologist for the presence of fractures and voids. Drilling rates, fractures, and voids detected by the driller were noted.

The core samples will be used to determine bedrock lithology, mineralogy, permeability, porosity, and evidence of bedrock contamination. Because lithologic logs were already available, coring was not done in the replacement wells (MW2023, MW2024, MW3006, and MW3003) that are adjacent to the wells that were abandoned (MW3007 and MW2016).

The screen and casing were lowered into the borehole using centralizers to insure that the casing was plumb and centered in the borehole. A filter pack of coarse (20-40 mesh) sand was

placed around the screen by tremie pipe to a point 2 to 4 feet above the top of the screen.

A bentonite pellet seal was placed above the filter pack. The minimum thickness was 3 feet of dry pellets. The pellets were allowed to set for at least one hour before work continued. The annular space was sealed to the frost level with cement/bentonite grout.

A steel protective casing was set in a 2.5-foot square concrete pad at ground surface. The protective casing has a gas vent installed and will be locked. The concrete pad has a minimum thickness of 6 inches and slopes away from the casing. Concrete extends down the borehole to the frost level. Three protective iron posts filled with concrete were installed approximately 3.5 feet from the protective casing and 120° apart.

Well-construction details are illustrated on Figure 2-3. Further details on well installation were stipulated in the drilling specifications developed for the drilling subcontractors.

2.1.2.4 Well Development

Monitoring well development was completed in September 1988. Development techniques included downhole pumps (hand-operated or mechanically driven), bailers, and double-tube air-lift devices. Any equipment placed down the well was constructed of stainless steel, teflon, PVC, or tygon. No glues, solvents, pipe dope, or adhesive tapes have been used on any development equipment which is placed down a well. All air-lift devices utilized a separate air line and discharge line and are operated in such a manner that air cannot be injected into the filter pack or formation. The air lines have an in-line oil filter between the compressor or air tank and the air line entering the well.

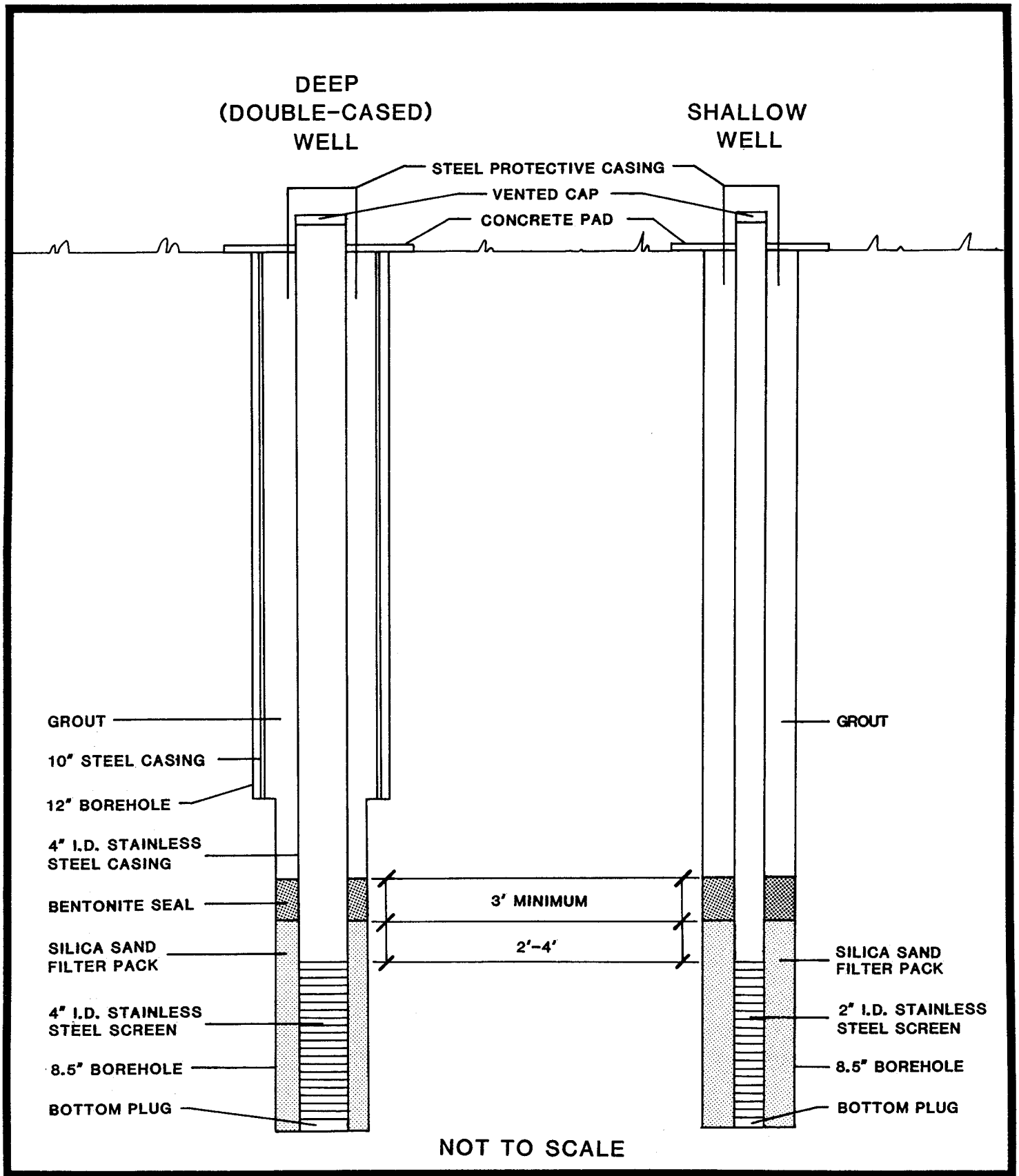


FIGURE 2-3

TYPICAL MONITORING WELL CONSTRUCTION

Each well was developed for a minimum of four hours or until clear, sediment-free water was produced as determined by the supervising hydrogeologist. The standard for clear, sediment-free water will be five Nephelometric Turbidity Units (NTU) determined by field or laboratory measurement. In all cases, a minimum of five volumes of standing water in the well and filter pack is being removed.

If water pumped from a monitoring well remains visibly turbid after five well volumes have been removed, measurements of pH, conductivity, and temperature were used to determine completeness of development. Three (3) additional volumes were then removed from each well. The pH, temperature, and conductivity were measured at the completion of removal of each well volume. For wells that were pumped or bailed dry and that recharge slowly, these measurements may be performed after completely purging the well after at least 50% recharge. Development was considered complete when three consecutive measurements showed conductivity to be stable within plus or minus 20%, pH stable within plus or minus 0.2 standard units, and temperature stable within 1 degree Celsius.

2.1.2.5 Abandonment of Wells and Boreholes

Any boreholes which were unsuitable for monitoring-well installation due to misalignment, contamination, lost drilling tools, or other reasons were abandoned by grouting.

Cement-bentonite grout was pumped into the borehole using a tremie pipe. The tremie pipe was placed initially at the bottom of the borehole and gradually raised as the borehole is grouted to the surface.

MW-2016 was abandoned by drilling out the PVC casing and filter pack using a four-inch minimum diameter roller bit. The borehole was then grouted to the surface as described above. The steel

protective casing was removed.

MW-3007, which consists of an open borehole in bedrock with four-inch diameter PVC casing through the overburden, was abandoned by grouting as described above. The steel protective casing was removed.

2.1.3 Groundwater Sampling

Groundwater sampling will be performed in conjunction with and will expand the quarterly monitoring program described in the 1987 Environmental Monitoring Program Plan. At present, quarterly sampling is primarily concerned with monitoring of existing wells at the site perimeter to detect off-site migration of contaminants. For the remedial investigation, groundwater sampling will include the entire extended monitoring-well network including existing and additional wells as described above. The purpose of the sampling is to further define: (1) horizontal and vertical extent of contamination; (2) potential sources; (3) migration pathways; and (4) potential future contaminant migration.

2.1.3.1 Sampling Techniques

WSSRAP has developed detailed procedures for groundwater sampling and sample handling to insure that samples are representative and analytical results are accurate and defensible. The WSSRAP Environmental, Safety, and Health SOP No. 4.04.01 describes sampling equipment and step-by-step procedures for groundwater sample collection. These procedures are summarized below; the complete SOP is in the WSSRAP procedures manual as referenced in the Quality Assurance Program Plan (QAPP).

Submersible bladder pumps will be used for well purging and sample collection. Dedicated bladder pumps are in place in 20 existing monitoring wells which are sampled quarterly as part of

the WSSRAP Environmental Monitoring Program. The pumps are constructed of stainless steel with Teflon bladders and Teflon lined discharge tubing. The new monitoring wells will be sampled using portable bladder pumps of similar construction which will be thoroughly decontaminated before reinstallation in monitoring wells.

Following two quarterly rounds of sampling from the extended monitoring-well network, additional dedicated bladder pumps will be installed, as appropriate, for future sampling operations. Five volumes of the well casing will be purged prior to sample collection. Field personnel will measure temperature, pH, and conductivity when beginning purging and immediately before sample collection. A SOP for each of these measurements is in the WSSRAP procedures manual as referenced in the QAPP. Samples will be collected in appropriate containers directly from the pump discharge. Samples will be placed in coolers immediately and will arrive at the laboratory within eight hours of collection. Groundwater sample labels, field forms, and chain-of-custody procedures are discussed in Section 3.3.

Internal quality control checks include checks on both laboratory and field activities. The QA/QC procedures for groundwater sampling have been developed in accordance with EPA protocols. Quality control samples for groundwater sampling will consist of duplicates, field blanks, and trip blanks.

Duplicate samples will be collected from 10 percent of the monitoring wells during each round of sampling. Duplicate samples will be collected and submitted for analysis at the same time as the original sample.

At least two field blanks will be collected during each round of groundwater sampling. These blanks will consist of distilled, deionized water pumped through the portable bladder pump, collected in the appropriate sample container, and submitted for

analysis. These blanks will confirm the effectiveness of decontamination procedures and the absence of cross-contamination in sampling procedures.

Trip blanks will consist of distilled, deionized water placed in sample containers in the on-site laboratory, sealed, and transported with the samples in the field and to the laboratory.

2.1.3.2 Sample Analysis

All groundwater samples will be picked up and preserved on a daily basis by the analytical laboratory, metaTRACE, Inc. The lab is located in St. Louis County, Missouri and is approximately 20 miles from the WSS. Where applicable, the analytical procedures employed by metaTRACE will conform to CLP Methodologies. The laboratory procedures manual contains the analytical methods that will be followed and their respective detection limits.

Table 2-3 contains a listing of the analytical parameters, sample containers supplied by the laboratory, and the preservation methods used by the laboratory. The analytical parameters were selected based on the constituents detected by the Phase I Water Quality Assessment (1987). The radiologic parameters, nitroaromatics, and inorganic anions were either present at elevated concentrations in groundwater samples from the Phase I Water Quality Assessment or are present at on-site source areas.

2.1.4 Groundwater Level Monitoring

Static water levels will be measured monthly in all of the wells in the extended monitoring-well network. The water level measurements will be taken in accordance with SOP No. 4.04.02 located in the WSSRAP procedures manual as referenced in the QAPP. Generally measurement accuracy is achieved to 0.01 foot. Potentiometric surface elevations will be calculated from the

TABLE 2-3

GROUNDWATER SAMPLE ANALYSIS AND PRESERVATION

Analytical Parameter	Sample Container	Sample Preservative Used by Lab
TOC	1-8 oz amber jug	HCL to pH <2.0 and refrigerated
Inorganics		
Nitrate Sulfate Fluoride Chloride Total Dissolved Solids	1-500 ml polyethylene plastic jug	refrigerated
Nitroaromatics		
2,4,6 trinitrotoluene 2,4 dinitrotoluene 2,6 dinitrotoluene 1,3,5 trinitrobenzene 1,3 dinitrobenzene Nitrobenzene	1 gallon amber jug	refrigerated
RAD Parameters		
Natural uranium (dissolved) Radium 226 Radium 228 Thorium 230 Thorium 232 Gross Alpha Gross Beta	1 gallon polyethylene plastic jug	HNO3 or HCL to pH <2.0 and refrigerated

static water level measurements. Representative potentiometric surface maps will be constructed to illustrate the groundwater flow patterns present on site. Through interpretation of the data a more accurate delineation of the groundwater divide and of specific horizontal groundwater flow directions will be possible as well as seasonal or temporal changes in flow patterns. Additional refinement of the current understanding of the on-site recharge and discharge dynamics of the upper bedrock aquifer is also anticipated. Gradients on the potentiometric surface combined with interpretation of vertical gradients measured in the clustered wells will provide information regarding the hydraulic gradients on site.

2.2 AQUIFER TESTING

Aquifer testing will consist of single-well hydraulic conductivity (permeability) tests, and pumping tests to define the hydraulic characteristics of the aquifer to aid in predicting contaminant migration and assessing groundwater remediation alternatives.

2.2.1 Single-Well Hydraulic Conductivity Tests

Single-well hydraulic conductivity tests ("slug tests") will be performed to provide information on areal variations in permeability within the Burlington-Keokuk Formation.

2.2.1.1 Test Design

Slug tests will be performed in each new monitoring well installed as described in Section 2.1. These tests will also be performed in selected existing monitoring wells to verify the results of packer tests performed during well installation. Existing monitoring wells selected for slug tests are:

MW2002	MW2013
MW2005	MW2015
MW2006	MW2018
MW2008	MW4001

Criteria for selecting monitoring wells for slug testing were: 1) availability of packer test data on original boreholes; 2) presence of recently completed monitoring wells in close proximity to original boreholes; and 3) screened intervals of original and newly installed wells. These wells provide an evenly spaced distribution for confirming the packer test results. In addition, deep monitoring wells to be installed adjacent to each of these wells will be tested, allowing for comparison of hydraulic conductivity values at varying depths.

Slug tests are performed by displacing, adding or removing a known volume of water within the well. The volume change is produced as close to instantaneously as possible, and the volume is controlled to a premeasured amount. Readings of water levels within the well during the test will be made using a pressure transducer and electronic data logger, which will permit measurements to be made at one-second intervals during the early part of the test.

Slug tests, analyzed with formulae derived by Cooper, Bredehoeft, and Papadopulos, Ferris and Knowles, and Skibitzke, provide the most valid information when conducted in confined aquifers. In unconfined aquifers the Bouwer and Rice or Hvorslev procedures are applicable. In all cases, assumptions for application of formulae and analysis of data are not satisfied in the unconfined, anisotropic, fractured finite aquifer present on site. Also, slug testing procedures are applicable in an equivalent porous medium and are not valid if solution cavities exist and conduit flow is prevalent. Hydraulic conductivity values (K) yielded by slug tests primarily reflect K in horizontal directions. Therefore, only representative,

approximate values are expected from slug tests on site.

Lohman (1979) suggests the applicability of slug testing in wells penetrating aquifers of rather low transmissivity, and presents a value of less than 7000 ft^2/day. At the Weldon Spring Site, an arbitrary upper hydraulic conductivity (K) limit for slug testing is considered to be on the order of 0.05 cm/sec. Formations with K values higher than 0.05 cm/sec will exhibit rapid recovery; hence, the acquisition of accurate recovery measurements is likely not feasible.

2.2.1.2 Test Performance

To begin the test, a pressure transducer will be installed in the well and static water level will be measured by wetted tape to calibrate pressure transducer readings. The water levels will be observed to ensure that the aquifer is under steady-state conditions. The volume change will take place within the well and water levels will then be measured as the well recovers to the static water level.

Slug tests will be performed by inserting a solid rod or similar object slightly smaller than the well diameter below the water level in the well in order to displace the water to a higher level. Water levels will be measured frequently as the water level falls to the original level. At this point the rod will be removed and water levels will be measured as the water level rises to the original level. The use of this test method allows for both falling head and rising head measurements. A tripod apparatus will be used to raise and lower the slug in the deep, 4-inch diameter monitoring wells.

Field measurements collected by the electronic data logger will be transferred to a computer data base. If warranted, after an analysis of data received from the slug tests, other tests such as borehole dilution and tracer tests may be deemed necessary to

define aquifer parameters.

Borehole dilution or point dilution tests may be applicable to estimate linear velocity in selected wells. This test can be performed in a segment of the well screen which is isolated by packers. A tracer is introduced which is diluted by lateral groundwater flow which mixes and removes the tracer from the well bore. Dilution versus time relationship is determined and the linear velocity is computed by analytical formulae (Freeze and Cherry, 1979).

2.2.1.3 Data Analysis

The data will be analyzed to determine a hydraulic conductivity value using a standard formula such as the Hvorslev method. The hydrologic formula will be chosen to fit the conditions in the aquifer and well being tested. A qualified hydrogeologist will determine conditions of the aquifer and well, the formulae to be used, and the data points for the hydraulic conductivity calculation.

2.2.2 Pumping Tests

Long-term pumping tests will be performed at three locations on-site in order to determine aquifer properties such as transmissivity and specific yield. Also, anisotropic aquifers are prevalent at the Weldon Spring Site. The size, shape, orientation and spacing of fractures and the presence of solution cavities affect the aquifer yield and drawdown by distortion of the distribution of flow. The distortion is related to the distance to the observation wells, aquifer thickness, the ratio of the horizontal thickness, and vertical hydraulic conductivities and to the degree of aquifer penetration by the pumping well. Theoretical methods for determining hydraulic conductivity values from analysis of pumping test data have been developed (Kruseman and Ridder 1976). The results of long-term

pumping tests will allow prediction of contaminant migration and assessment of the effects of pumping on groundwater flow patterns and contaminant levels. Pumping tests affect a much larger portion of the aquifer than the single-well tests and consequently yield more accurate hydraulic conductivity values. Transmissivity, specific yield, and anisotropy can be determined accurately only from pumping tests.

2.2.2.1 Pumping Test Design

Pumping tests have been designed based on the known characteristics of the Burlington-Keokuk Formation. The upper, weathered zone of the formation comprises an unconfined aquifer. Yields are expected to be relatively low, based on reported yields of 5-50 gallons per minute (gpm) for wells in this formation (USGS, 1986). Recently acquired data, on site, indicate well yield will be less than 10 gpm. Locations for pumping and observation wells are shown on Figure 2-4. The locations were selected to determine aquifer conditions in areas where contaminants have been detected in the groundwater and could potentially migrate off-site, and also at a location adjacent to the site proposed for the disposal facility for final remedial actions. Pumping Well 1 (PW-1) is located to the north of the apparent groundwater flow divide in the area where relatively high concentrations of nitroaromatic compounds were detected in groundwater samples. Pumping Well 2 (PW-2) is located adjacent to the proposed disposal facility near the southern end of the site. Results from the pumping tests at this location will allow for an assessment of aquifer conditions under this disposal cell site. The pumping and observation wells are located adjacent to, rather than within, the disposal cell area in order to minimize the number of wells and other boreholes within the disposal cell area that would need to be drilled out and grouted prior to disposal cell construction. Pumping Well 3 (PW-3) is located in the area where the highest nitrate concentrations were detected in groundwater samples from the

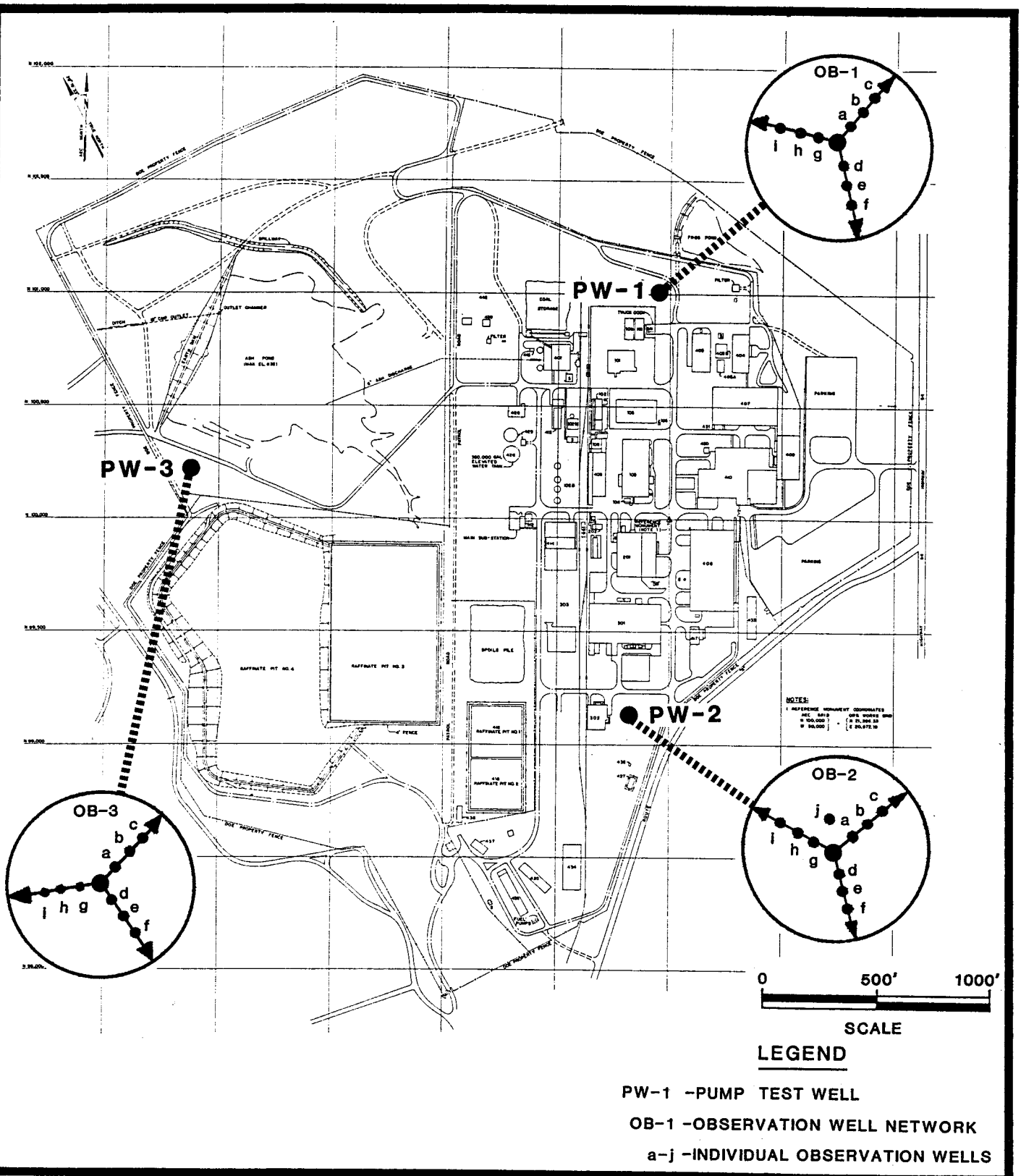


FIGURE 2-4

PUMPING AND OBSERVATION WELL LOCATIONS

Phase I Assessment.

The pumping wells are designed to be fully penetrating (continuously screened) through approximately 40 feet of saturated thickness of the Burlington-Keokuk Formation. This interval has been selected to encompass the weathered, more permeable zone in which groundwater contamination has been detected. This weathered zone will be defined from an analysis of cores and from observations by video survey. The test interval is limited to avoid providing vertical pathways through which contaminants could migrate into deeper zones in the aquifer when these wells are not being pumped. The fully screened interval will allow for the application of standardized techniques for pumping-test interpretation and calculations.

Each pumping test will utilize 9 or 10 observation wells oriented so as to determine the distribution of drawdown due to pumping of the aquifer. A set of nine observation wells, labeled "a" to "i" on Figure 2-4, have been completed at the same depth within the Burlington-Keokuk Formation, with the same screened interval as the pumping well. These wells are placed on three lines radiating from each pumping well with 120 degrees of arc between lines. One line is placed on a bearing of N60^{o}E, aligned with the predominant northeastward orientation of fractures in the Burlington-Keokuk Formation. The other two lines are located relative to this primary line. Following installation and development of the pumping well, a step-drawdown pumping test was performed to determine the optimum distance from the pumping well for placement of the observation wells and optimum pumping rate for long-term pumping tests. Water levels were measured in nearby monitoring wells during the step-drawdown test to allow for a modification of the observation well network configuration. Pumping rates will be relatively low and all observation wells are within 100 feet of the pumping well.

One additional observation well (designated "j" on Figure 2-4)

has been installed in a lower zone in the Burlington-Keokuk Formation at the PW-2 location. This well is placed approximately 40 feet north of the pumping well, equidistant from the shallow observation hole lines in order to prevent grout migration between wells. It is screened from 40 to 50 feet below the bottom of the pumping well. This well is double-cased and grouted to a depth below the weathered, fractured, upper aquifer, as defined by an analysis of core borings and video surveys in order to prevent transport of contaminants to lower zones during drilling operations and to avoid providing new, artificial vertical channels in the formation. Drawdown measurements in this well will allow for a determination of the degree of hydraulic connection between shallow and deeper zones in the Burlington-Keokuk Formation.

During the pumping tests, water levels will also be measured in monitoring wells within a radius of approximately 500 feet from the pumping well in order to observe any effects of pumping at greater distances.

The pumping tests will be 10 days (240 hours) in duration to allow for observation of delayed-yield effects, determination of specific yield, and observation of other effects of long-term pumping. Recovery measurements will continue until full recovery, or for a minimum of 24 hours under any circumstances. The duration of any individual pumping test may be modified by the project hydrogeologist as the test proceeds, based on drawdowns observed and determination of whether sufficient data has been collected. Water pumped from wells will be collected and stored on-site in Raffinate Pit 4 until remedial action activities commence.

The pumping tests have been designed primarily to assess aquifer properties of the upper, weathered zone of the Burlington-Keokuk Formation. The aquifer properties determined from these tests will be primarily applicable in assessing horizontal contaminant

migration in the upper zone. Drawdown measurements from the deeper observation well (j) will indicate the extent of hydraulic communication between shallow and deeper zones in the bedrock. This information, combined with single-well test results and groundwater sampling results, will permit an assessment of the extent and/or potential for downward migration of contaminants. If substantial vertical migration or potential migration is present, further aquifer testing of deeper zones may be necessary. Additional testing could include further pumping tests, single-well tests, and/or packer tests. The necessity for further testing, and the type, locations, and depths of testing will be determined from the results of pumping tests, single-well tests, and groundwater sampling.

Aquifer parameters obtained from pumping tests will be based on the assumption that the aquifer is an equivalent porous medium. Therefore, pumping tests and the accompanying monitoring program are not specifically designed to trace discrete fracture flow. If major vertical fractures or solution channels are encountered during drilling operations, specific analytical models may be used as both predictive and parameters-boundary evaluation tools under water-table conditions with these fractured rock systems. Tracer tests and point dilution tests may be applicable if conduit flow is indicated or suspected.

2.2.2.2 Pumping and Observation Well Installation

Drilling operations for pumping well installation have included hollow-stem auger boring and bedrock coring to provide an accurate lithologic log of the formation at each pumping test location, followed by reaming to the final diameter by air-rotary techniques. Split-spoon samples were collected at intervals of five feet during auger drilling in the unconsolidated soils. The bedrock was cored from the bedrock surface to the total depth of the well. The log was recorded by a supervising hydrogeologist.

The borehole was reamed to a final diameter of 10 inches. The well was constructed using 6-inch inside diameter (ID) Schedule 40 PVC screen and casing. Screen length is 40 feet, encompassing the entire saturated thickness penetrated by the pumping well. Screen slot size is 0.020 inch. A filter pack consisting of 6-20 mesh silica sand was emplaced through a tremie pipe to a point 2 to 4 feet above the top of the screen. A bentonite seal, a minimum of 3 feet thick, was emplaced above the filter pack, after which the annular space was grouted to the surface using a tremie pipe.

Observation wells were installed using air-rotary techniques to drill from the land surface to the total depth. The borehole diameter is 5.5 inches. Wells were constructed using 2-inch ID Schedule 40 PVC screen and casing. Screen length for the observation wells at equal depth with the pumping well is 40 feet; slot size is 0.020 inch. A filter pack was emplaced around the screen and the annular space sealed with bentonite and grouted to the surface as described above for the pumping well.

In drilling the borehole for the deep double-cased observation well, a 10-inch diameter borehole was drilled to a depth of 10 feet below the bottom of PW-2. A 6-inch ID PVC casing was placed in the borehole for the total depth. The annular space was grouted and a grout plug at least 4 feet thick was emplaced to seal the bottom of the borehole. Drilling operations continued after the grout had set for a minimum of 72 hours. The borehole was drilled to the final depth and diameter of 5.5 inches without coring. The observation well was then installed as described above. Typical construction for pumping and observation wells is illustrated on Figure 2-5.

After each pumping or observation well installation was complete and the grout had set for a minimum of 72 hours, each well was developed to produce clear, sediment-free water and to insure hydraulic communication between the well and formation for

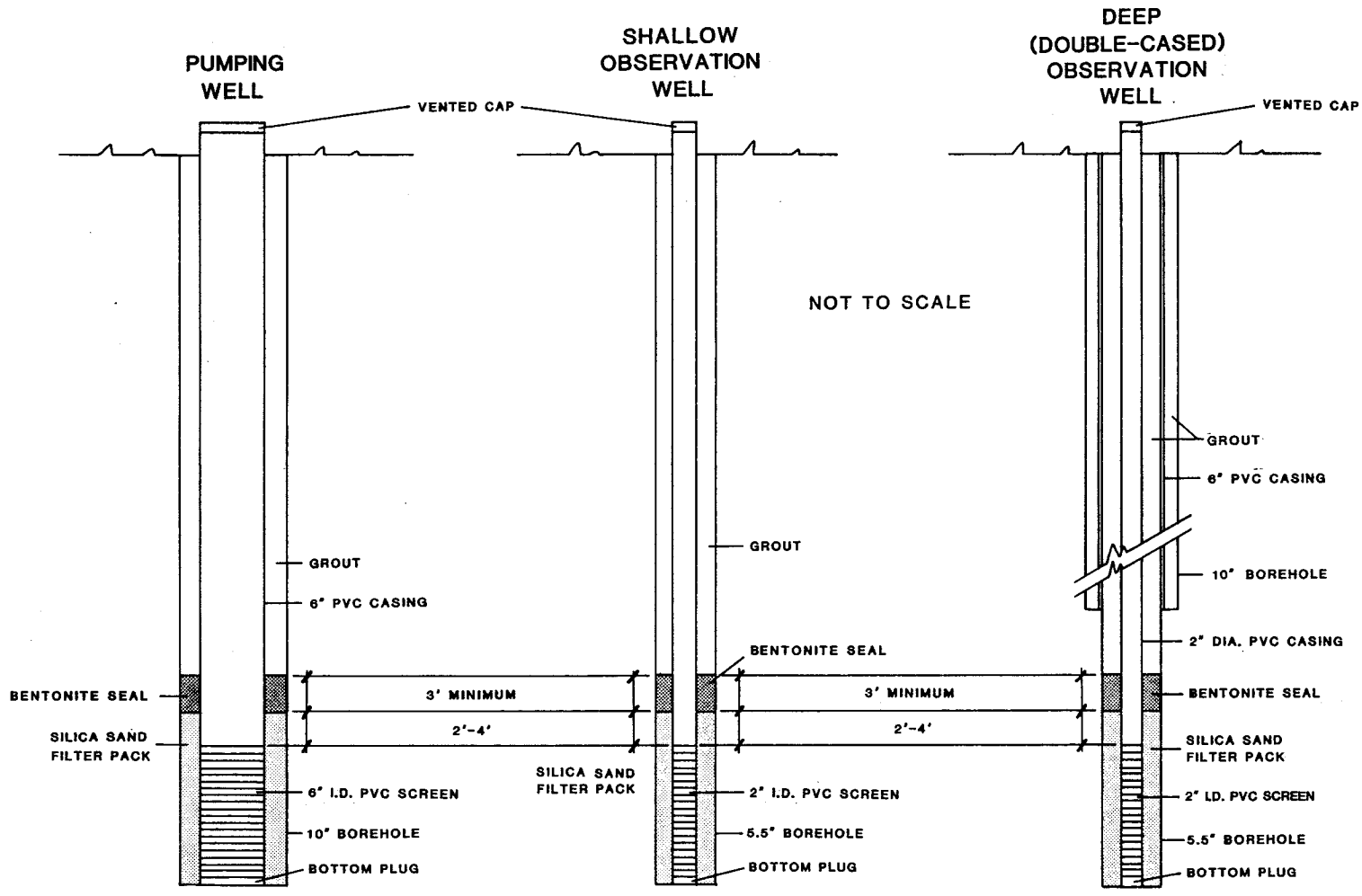


FIGURE 2-5

PUMPING AND OBSERVATION WELL CONSTRUCTION

accurate drawdown and recovery measurements.

Well development is accomplished by surging and pumping. Due to the low yield of the formation, potable water was added selectively to produce more rapid, complete surging of the filter pack. This water was pumped out immediately to avoid infiltration into the formation. The 5 NTU standard was applied as a goal for completion of development and the same decontamination procedures as used for monitoring well development were followed.

2.2.2.3 Pumping Test Performance

Electric submersible pumps will be used for the pumping tests. Discharge will be held at a constant rate through the use of a gate valve. Pumping rates less than 10 gpm will be measured with a calibrated container and stop watch. Flow measurements will be recorded hourly throughout the duration of the test. During pumping the well water will be discharged to a holding tank, after which it will be pumped and transported by tank truck or pipeline to Raffinate Pit 4. Water pumped from PW-1 will be discharged through a carbon adsorption unit to remove nitroaromatics prior to discharge to Raffinate Pit 4. All raffinate pit waters will be treated prior to discharge during remedial action.

Each pumping test will begin by recording static water level measurements in the pumping well, observation wells, and nearby monitoring wells including a minimum of one well outside the radius of influence. Static water levels will be monitored for at least 48 hours prior to beginning each pumping test to ensure that steady-state conditions are present. During pumping, water levels in the pumping well will be measured and recorded using a pressure transducer and electronic data logger. Water levels in observation and monitoring wells will be measured using an electrical water level indicator or wetted tapes. Multichannel

data loggers with pressure transducers in observation wells will be utilized as appropriate. Water level measurements will be recorded to the nearest 0.01 foot.

Water level measurements in the observation wells will be measured at logarithmic time intervals as pumping progresses, beginning with measurements at 1-minute intervals and increasing to 2-hour intervals after eight hours of pumping. Water levels in the pumping well will be recorded by the data logger at 1-second intervals initially, followed by a logarithmic increase in time intervals that will coincide with the observation well measurements after one hour of pumping.

After 240 hours of pumping, the pump will be shut off and recovery measurements will be collected as the aquifer recovers to the initial static water levels. Measurements will be collected during recovery at the same logarithmic time intervals used during the pumping period. Measurements will continue until all wells have recovered to the original static water levels. It is expected that the recovery period will be a minimum of 24 hours.

2.2.2.4 Data Analysis

The collected data will be analyzed to determine aquifer characteristics including hydraulic conductivity, storage parameters, anisotropy, and boundaries. Data analysis will begin by correcting the drawdown data recorded during the test for antecedent water level trends (as determined during monitoring of static water levels), partial penetration, residual drawdown (recovery data) and barometric pressure variations, and effect of precipitation events. Barometric pressure and other meteorological data are available from a National Oceanic and Atmospheric Administration (NOAA) meteorological station approximately 12 miles northeast of the WSS, the Spirit of St. Louis Airport (compiled and available upon request from National

Climatic Center, Asheville, NC) and from meteorological stations at Busch Wildlife Area Headquarters and at a utility plant approximately 10 miles to the southwest. The corrected data will be plotted for type curve analysis using methods such as those developed by Boulton and Neuman for unconfined aquifers. A qualified hydrogeologist will determine the appropriate hydrologic analyses to be performed.

In addition to calculating aquifer parameters from pumping test results, a qualitative analysis will estimate the degree to which the fractured bedrock responds to pumping as an equivalent porous medium. This will indicate the reliability of the calculated parameters. Recent publications on pumping tests in fractured bedrock will be consulted and applied as appropriate to both the quantitative and qualitative analyses.

Observation well configuration was intended to accommodate the anisotropic aquifer test analysis described by Papadopulos (1965) and Hantush and Thomas (1966). Also, Walton (1985) describes those analytical models useful in the analysis of fractured rock aquifer-test data. He presents formulae governing drawdowns with constant pumping which have been derived by Boulton and Streltsova, (1976, 1978). Recent publications pertaining to the analysis of pumping test data in fractured rock aquifers will be reviewed; and analytical models, structured to solve partial differential equations governing the flow of groundwater to wells, will be applied to evaluate data and define aquifer parameters. Neuman, at a recent (1987) NWWA symposium, described and distributed recent publications pertaining to flow in fractured rocks which may prove applicable to analysis of data obtained at the site.

The combination of quantitative and qualitative analyses will allow pumping test results to be used in conjunction with groundwater monitoring data to predict contaminant migration, and also to predict the effects of future pumping on groundwater flow

patterns and contaminant concentrations.

2.3 KARST HYDROGEOLOGY

Studies of karst hydrogeology related to the WSS will be performed by the Missouri Department of Natural Resources (MDNR)--Division of Geology and Land Survey in cooperation with WSSRAP staff. MDNR efforts will focus on conduit flow from the site to local springs, both from the aquifer immediately underlying the site and from losing stream reaches draining the site. WSSRAP efforts will include sampling of springs under varying climatic conditions to determine the presence and magnitude of contaminant migration through conduit flow.

2.3.1 Flow Studies

This investigation will be divided into three phases. The most intensive efforts will occur during Phase I; Phases II and III will refine the initial findings and will aid the design of long-term monitoring and remediation programs. The conclusion of the first two phases will be followed by interim reports which will present the basic data and interpretations, including refinements of the conceptual model of the hydrogeology of the shallow bedrock aquifer system. At the conclusion of Phase III, a final report will be published as a Missouri Department of Natural Resources, Department of Geology and Land Survey (DGLS) Open File Report. This report will contain the compiled basic data with interpretations including a conceptual model of the shallow groundwater system, maps and drawings illustrating the locations of:

- Groundwater basins and divides
- Discrete and diffuse recharge areas
- Springs
- Gaining and losing stream reaches
- Conduits and voids

- o The relative volume of spring flow arising from areas of discrete versus diffuse infiltration
- o The relative volume of spring flow arising from conduit flow versus Darcian flow
- o Recommendations for refinements and improvements in the groundwater monitoring system at WSS

2.3.1.1 Recharge and Discharge

Recharge to the shallow aquifer, which includes the karst conduit system, occurs by discrete recharge primarily from losing streams; and by diffuse recharge from general infiltration through the surficial materials. The most significant discharge from the shallow aquifer occurs through spring flow.

Field reconnaissance of all streams draining the site plus the adjacent drainage basins will be made to locate gaining stream segments, losing stream segments, springs, and seeps. Visual observations during repeated visits under differing climatic conditions will be used to identify significant springs and to classify all stream segments as either gaining or losing. More than 40 springs and seeps have already been located, of which about 20 are considered significant.

Some stream segments may not be easy to classify visually as gaining or losing. Seepage runs on these stream segments will be made to aid the classification effort. The seepage run simply consists of a series of discharge measurements made along a stream segment during a short time period to see if the flow consistently increases in the downstream direction, as would be expected for a gaining stream. If flow decreases in the downstream direction, then the stream is losing water to the subsurface and groundwater system. Seepage runs can also be used to locate groundwater discharge points where significant increases to the stream flow occur.

An effort will be made to determine what portion of the shallow aquifer discharge near the site is contributed directly by losing streams (discrete recharge) and what portion comes from infiltration of the surficial materials (diffuse recharge). This will be done by using water tracing with fluorescent dyes (see Section 2.3.1.3) to identify the springs which have groundwater drainage basins under or adjacent to the site. Gaging stations, consisting of a calibrated weir in a small dam and a water level recorder, will be established at these springs to continuously monitor their flow. Stream gaging stations will also be placed upstream of all losing stream segments that water tracing has shown are contributing to the identified springs. The difference between the total discharge at a spring and the sum of the discrete recharges (losing streams) tributary to that spring should equal the diffuse recharge component for the groundwater basin contributing to that spring.

Stream gaging stations will also be placed along the lower stretches of losing stream segments to measure flow during high runoff events when all flow is not lost to the subsurface. (During normal or low flow conditions most losing stream segments lose all of their flow to the subsurface.)

The difference between the flow entering a losing stream segment and the flow leaving it represents the maximum loss capacity of that stream segment. By using gaging stations upstream and downstream of the losing segment, recharge to the spring flow can be determined during different climatic conditions.

The diffuse recharge component of spring flow is of particular interest because it could potentially contain contaminants contributed by infiltration at the chemical plant and raffinate pit site, i.e. from contaminated groundwater plumes under the site which are connected to the karst conduit system. The discrete recharge could contain contaminants from the site but they would have to first be transported off site by surface flow

to the losing stream segments. An understanding of these flow characteristics coupled with spring water quality results should suggest the probable migration pathway for contaminants.

2.3.1.2 Conduit Flow Paths

Major fractures and voids encountered during drilling for monitoring well installation will be investigated using a combination of borehole video cameras, borehole still cameras taking stereo photography, and borehole sonar mapping equipment. The results will be compared to bedrock cores. These techniques will allow better definition of the size, shape, orientation, and extent of voids and fractures.

Up to four boreholes with major voids or fractures will be used for conducting water tracing tests. Fluorescent dyes will be injected into the boreholes and significant down-gradient springs will be monitored for dye resurgence. Water tracing techniques are discussed further in the following subsection.

Spontaneous potential (SP), a geophysical technique, will be used in an attempt to locate shallow karst groundwater conduits which contain flowing water. The flowing water in the subsurface conduit creates an electrical charge surrounding the conduit. This in turn sets up a voltage potential in the ground. A digital voltmeter connected to electrodes placed in the ground is used to measure the natural voltage potential in the subsurface. A conduit containing flowing water is associated with high negative voltage readings, which are usually measured in millivolts. A square, rectangular, or concentrically circular array of electrodes is driven in the ground along with one reference electrode. The voltmeter is connected successively between the reference electrode and each electrode in the array. If a conduit with flowing water exists, it is located beneath or near the array electrodes with the most negative readings. On a map of the electrode array, a line connecting the electrodes with

the most negative readings would indicated the approximate course of the conduit.

This technique will be applied to Burgermeister Spring and its subsurface tributaries. If the conduit supplying Burgermeister Spring can be successfully located, SP surveys will trace conduits upstream toward the chemical plant and raffinate pits. This effort is directed toward determining the relative contribution to flow at Burgermeister Spring from on-site and off-site sources.

As part of the geophysical/geotechnical program, geophysical surveys are planned to: 1) define depth to bedrock, 2) locate, if possible, karstic features, 3) delineate perched water zones, and 4) augment geotechnical, geological, and hydrogeological data gathered from the soils and groundwater monitoring drilling program. Data from these surveys will be evaluated and used to identify anomalies and, therefore, possible locations for additional monitoring wells. Details of geophysical, geotechnical, and soils investigation programs are presented in individual sampling plans.

Angled boreholes will be drilled under the geotechnical investigation program. Cores and logs obtained from this operation will be evaluated under the hydrogeologic plan.

2.3.1.3 Water Tracing

Water tracing using fluorescent dyes will be conducted from losing streams and from boreholes. These tracer tests will confirm, expand, and refine the understanding of the conduit flow regime developed in previous studies. Two sets of water traces are anticipated for Phase I; traces from surface locations (losing streams), and traces from subsurface locations (boreholes). The results of Phase I tests will be reported in an interim report by the MDNR and incorporated into WSSRAP RI/FS

documentation. Additional water tracing tests during Phase II and Phase III will involve injection and possibly monitoring points not used for previous water tracing tests and will repeat previous traces under different climatic conditions.

Water tracing is performed by injecting fluorescent dye into the groundwater system via losing streams (where surface water streams discharge water to the subsurface) or direct injection into boreholes. Down-gradient springs or gaining stream segments are then monitored to see if the dye is present in these groundwater resurgences. Normally the groundwater discharge is sampled by anchoring packets of activated coconut charcoal in springs or in the flow of gaining stream segments. The charcoal packets, usually referred to as "bugs," are made by folding a 6-inch by 6-inch piece of nylon window screening in half and stapling the three cut edges. About 2 cubic inches of charcoal is placed inside the packet before the last edge is stapled closed. Dye is absorbed onto the charcoal as the dye-containing water flows through the bug. This sampling technique is qualitative but relatively inexpensive. A large number of locations can be continuously sampled while unattended. Bugs are periodically picked up for analysis and replaced by new ones to continue the sampling.

An alternative sampling technique is to use an automatic water sampler to take raw water samples at specified intervals. This technique allows quantitative testing to be done and more precise time of travel determinations to be made. This technique will be used at loctions where travel times are of particular interest.

Analysis for the presence of dye is done with a synchronous scanning spectrofluorometer. In the case where raw water samples are available, the raw water itself is analyzed. When charcoal bugs have been used, the dye is elutriated from the charcoal using a solution of 5% ammonium hydroxide and 95% ethyl alcohol. The elutriant is then analyzed using the spectrofluorometer.

The synchronous scanning spectrofluorometer shines an excitation light beam through a sample. When a fluorescent material is present and excited by light of the proper wavelength, the material will emit light at a longer wavelength. The wavelength and intensity of emitted light is measured by a light detection system within the spectrofluorometer. The wavelength of both the excitation light and the light being measured by the detection system (the emitted light) are varied simultaneously (synchronously scanned) over a range which includes the known characteristic excitation and emission wavelength(s) of the fluorescent material being investigated. For each sample the emission wavelength and intensity data are recorded and plotted as emission spectra. Peaks in the emission spectra can be correlated to the known wavelength peak(s) for individual dyes. The peak intensity can be correlated with the dye concentration.

The spectrofluorometer results can identify a specific dye type or types in the sample. In the case of raw water samples it can also give a quantitative concentration. In the case of charcoal bug elutriant samples, the intensity of the peak only yields a qualitative estimate of the dye concentration emerging from a spring because of variables associated with adsorption and release of dye from the charcoal and the potentially changing concentration of dye in the spring water during the sampling interval.

Before dye is injected, background samples are collected from all monitoring points and spectrofluorometric analysis is completed to record background fluorescent spectra. Dye is then injected only if the background spectra indicate there is nothing in the water that would interfere with detection of the dye to be injected. After dye has been injected and detected at one or more springs, monitoring and sampling is continued to verify that the dye pulse is decaying with time. After the groundwater system is purged of the dye or flushed and diluted to a low concentration, another injection of the same dye at a different

location may be made. Experience with conducting water traces in the Weldon Spring area has shown that it usually takes about 4 months for a dye to be flushed out of the karst spring systems.

The dye type issuing from a spring can be analytically verified. However, the water tracing and sampling technique normally used provides only a qualitative result because the relative concentration is normally all that is determined. Sample chain of custody is not an issue because all sampling and testing is done in-house by the same MDNR technician or, on occasion, by another technician working with him. No special preservation of the charcoal bug is needed other than sealing each labeled bug in a separate plastic bag. Raw water samples require no preservation techniques other than keeping them protected from sunlight because the fluorescent dyes photodecay in sunlight. The plastic water sampler housing and the locking steel antitheft and antivandalism cabinet for the water sampler provide the necessary protection from sunlight. Normally, blank samples and duplicate samples are not taken. Charcoal bugs from springs outside the groundwater basin being tested serve the same purpose as a blank sample.

Standard concentrations of dye are periodically tested to calibrate the spectrofluorometer. In order to minimize the potential for contamination of the charcoal bugs with dye, the dye is always handled and injected by someone other than the technician who collects and analyzes the bugs. The dye is always sealed in a plastic bag and placed inside a second container during transportation to the injection site in order to minimize the potential for contamination of the vehicle and subsequent contamination of the bugs. At the state office building, dye is stored in a locked closet well away from the laboratory where sample preparation and spectrofluorometric analysis is done. Signs are posted on the laboratory door that indicate that no raw dye is to be taken into the laboratory.

The fluorescent dyes that will be used most extensively are Fluorescein and Rhodamine WT. Each has an approximate detection limit of 50 parts per trillion (ppt) using the spectrofluorometer and peak emission wavelengths of approximately 512 and 572 nanometers (nm) respectively. Other fluorescent dyes that will be used to a lesser extent are Tinopal CBS-X and Pyranine Impurity. These dyes have approximate detection limits of 100 and 500 ppt respectively and peak emission wavelengths of 427 nm for Tinopal and two peaks of 381 and 400 nm for Pyranine Impurity.

Because of the limited number of dyes available, the relatively long time required to flush a dye from the karst spring system, and the short window of availability (a few hours) for dyeing a monitoring well borehole before the well is constructed, not all boreholes can be dyed. Of the 33 new monitoring well boreholes, probably only four can be dyed. Therefore, a system for selecting the boreholes to be dyed has been established. The selection procedure identifies boreholes which have a high potential for open connection(s) to the karst conduits and therefore rapid movement of dye and water away from the borehole, into the karst conduits, and then to a local spring or springs. Boreholes with high potential are dyed on a first found, first dyed basis until all four dyes have been used. Subsequent boreholes with high potential will not be dyed unless additional acceptable dyes can be identified or the dye from earlier tests have been flushed from the groundwater system.

Selecting boreholes with a high potential for open connection(s) to the karst conduits is based on a review of drilling logs, examination of rock cores, and a downhole video camera examination of the borehole. The drilling logs and core are examined to locate potentially permeable zones which may be indicated by poor or no core recovery, lost circulation of drilling fluid, and fractured or solutioned rock. The video camera is then used to examine the in-situ condition of the bedrock, especially in the zones of poor or no recovery.

Presence of solution openings, highly fractured zones, and zones of groundwater inflow to the borehole are features that indicate that a borehole has a high potential for connection(s) to the karst conduits. These boreholes are then injected with dye and the dye is flushed out of the borehole, into the surrounding bedrock, and into the assumed nearby karst conduits by a follow-up injection of one to several thousand gallons of water. In some cases water may be injected before the decision is made to inject dye. In these cases, the water is used to test the ability of the borehole to accept and distribute water to the surrounding bedrock, thereby providing further information about the potential for conducting a successful tracer test.

Dye detector packets (charcoal bugs) have been placed in the perennial springs and some of the more significant wet weather springs in all the drainage basins surrounding the site. In addition, in some basins where significant springs do not exist or are located in places that are hard to monitor, dye detectors have been placed in gaining stream segments. These locations and the rationale for monitoring them are given in Table A (in Appendix) and are shown on Figure 2-6.

2.3.2 Spring and Seep Sampling

During the summer and fall of 1987, a complete reconnaissance survey of the area surrounding the WSS was performed to locate springs and seeps which are potentially affected by the WSS. This survey was performed by MDNR and WSSRAP geologists.

2.3.2.1 Sampling Locations

A total of 30 springs and seeps were identified and located on USGS 7.5-minute topographic maps. Locations of known springs and seeps and drainage divides are shown on Figure 1-22. The numbering system operates as described below.

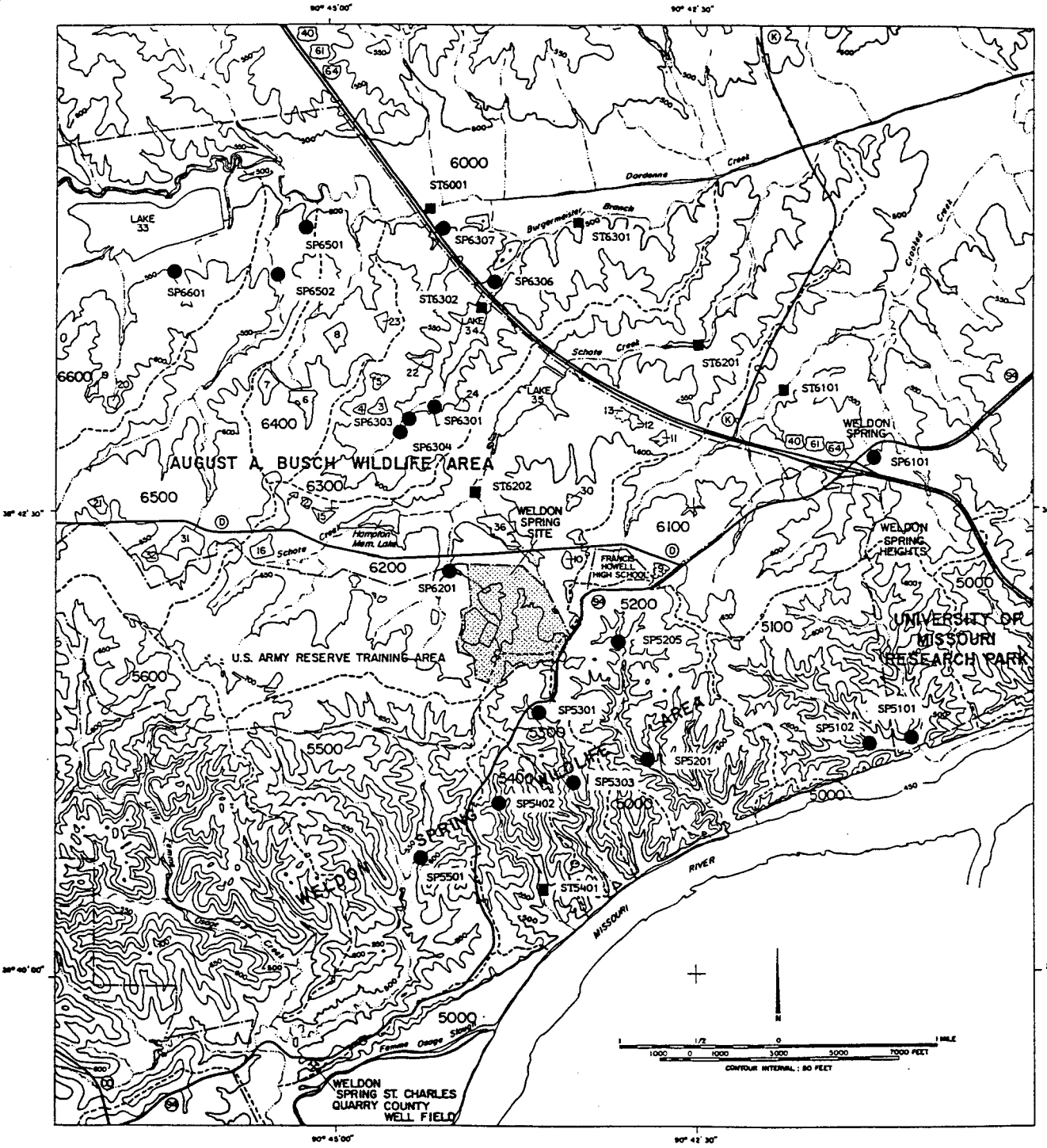


FIGURE 2-6

WATER TRACING SAMPLE LOCATIONS

Due to the uncertainty associated with the detection of contaminants and unpredictable intermittent flows at each spring, a flexible numbering system has been developed. This has been accomplished by subdividing the area-of-concern, covering over 30 square miles, into logical, discrete units. The units are defined by the surface drainage divides.

- The numbering system is in accordance with the existing WSSRAP Environmental Numbering System S.O.P.
- The prefix "SP-" denotes that the number refers to a spring or seep.
- The site and surrounding area-of-concern drain to both the Missouri and Mississippi rivers. The Missouri River drainage area is numbered along the 5000 series; the Mississippi River drainage area is numbered along the 6000 series (Figure 1-22).
- Within each thousand series, the major drainages are numbered as a hundred series from east to west as shown on Figure 1-22.
- Finally, within each drainageway, springs are numbered lowest in the series (from 1 to 99) according to permanence and volume of flow. For example, Spring Number SP-5201 represents Missouri River drainage Number 2, spring Number 1.
- Those features of concern which do not lie within one of the numbered drainages are to be placed in the zero hundred series for the appropriate thousand series. Individual spring numbers will be assigned in the chronological order of discovery of that feature.

Perennial springs are numbered first by rough estimate of greatest flow volume, the lowest number corresponding to the highest flow in each drainageway. The seeps and wet-weather springs are then numbered in order of relative flow volume. This

approach will reduce the number of "holes" which can be expected to develop in the numbering sequence due to infrequent wet-weather flow or misidentification of wet-weather features. Additional springs or seeps which may be discovered at a later date in any given drainage will be numbered in chronological order of discovery.

2.3.2.2 Spring and Seep Sampling Strategy

The strategy for sampling springs and seeps to determine the volume of contaminants discharged by way of conduit flow is a dynamic program. Sampling points, frequency, and analytical parameters will be adjusted as each round of spring sampling results is interpreted.

The Phase I Spring and Seep Assessment has been undertaken to provide an initial assessment of water quality of springs and seeps. This assessment will consist of two rounds of sampling of all identified springs and seeps. One round will occur under low-flow conditions following approximately one week of no significant precipitation or snowmelt; the other round will consist of samples collected under high-flow conditions during or immediately after a significant precipitation event.

Phase I Spring and Seep samples will be analyzed for the parameters listed on Table 2-4.

The high-flow sampling was performed on December 8 and 9, 1987, following more than 24 hours of continuous rainfall. Samples were collected from 27 springs. Samples were not collected from seeps with insufficient flow or springs emerging in streambeds which were obscured by surface flow.

Low-flow sampling was performed between February 24 and 26, 1988. A Phase I Spring and Seep Assessment report presenting and interpreting analytical results from both the high-flow and

TABLE 2-4

ANALYTICAL PARAMETERS FOR SPRING AND SEEP SAMPLES

Uranium (natural)	Fluoride
Radium 226	Hardness
Radium 228	Total Dissolved Solids
Thorium 230	Total Organic Carbon
Thorium 232	*CLP Metals
Gross Alpha	Lithium
Gross Beta	*CLP Organics
Nitrate	**USATHAMA Nitroaromatics
Sulfate	Pesticides
Chloride	

* Contract Laboratory Program

** United States Army Toxic and Hazardous Material Agency

low-flow sampling events is presently in draft form.

Results of the Phase I Spring and Seep Assessment and results of previous dye traces will be used to design a continuing sampling strategy. Selected springs with elevated levels of contaminants may be included in routine quarterly monitoring under the WSSRAP Environmental Monitoring Program (EMP). (Burgermeister Spring and the adjacent wet-weather spring are currently included in the EMP.) Further spring and seep sampling will include sampling during and following storm events as well as routine sampling to accurately characterize the range and peak concentrations of contaminants discharged at springs (Quinlan and Alexander, 1987). Sampling strategy will be re-evaluated as results of new dye traces are received.

2.4 OVERBURDEN HYDROGEOLOGY

Studies of overburden hydrogeology will be performed to determine whether contaminants present in an unsaturated flow regime or in perched or mounded zones represent a continuing source for groundwater contamination. These studies will focus on determining the presence of contaminants and of unsaturated flow conditions which could transport contaminants to the groundwater. The results will be used for computer modeling of unsaturated flow, groundwater flow, and contaminant transport.

The materials comprising the overburden at the site include the upper 10-20 feet of weathered limestone bedrock, a well developed layer of residuum in most areas, basal till, clay till, silty clay, loess, and topsoil/fill. Total overburden thickness ranges from 20 feet to 50 feet. The overburden is generally unsaturated. A detailed description of the overburden material is presented in Section 1.2.4.1

2.4.1 Unsaturated Flow Conditions

The movement of water through unsaturated soils is a function of gravity and tension (or suction) forces. Tension forces are referred to as the tension head or suction head, and are expressed in terms of negative atmospheric pressure.

To estimate the rate of flow through unsaturated soils, the modified form of Darcy's equation may be used:

$$V = -K(\theta)\, H$$

Where V is the flux, K is the hydraulic conductivity at a specific moisture content θ (unsaturated hydraulic conductivity is a function of moisture content), and H is the hydraulic gradient vector, which is the sum of the soil-water pressure head and the gravity (elevation) head expressed as a vector. Moisture content may be used as an estimate of the pore space available for flow. Thus, the above equation is divided by the moisture content to obtain an estimate of the average linear velocity (v) through a particular soil. The equation then becomes:

$$v = \frac{-K(\theta)\, H}{\theta}$$

In order to use this equation to estimate flow rate, the unsaturated hydraulic conductivity, moisture content, and the hydraulic gradient must be determined by field and laboratory measurements.

Previous efforts to characterize the saturated hydraulic conductivity of the vadose zone were performed by Bechtel National, Inc. (1987). Section 1.2.6 presents a summary of these tests on the vadose zone. Packer tests in the unsaturated bedrock zones indicate variations in saturated hydraulic conductivity of up to four orders of magnitude ranging from 6.8 x

10^{-6} to 8.5 x 10^{-3} cm/s. The results indicate that the bedrock is of variable hydraulic conductivity in the horizontal plane and generally becomes less permeable with depth, due to decreased weathering and associated solution activity (BNI, July 1987). Overburden characteristics at the WSSRAP were also evaluated and discussed in the BNI, November 1984, and July 1987 reports. The upper few feet of overburden (mostly topsoil) are poorly drained. The materials underlying the topsoil are unsaturated. Disturbed and undisturbed samples of the major overburden units were submitted to a laboratory for soil testing. The saturated hydraulic conductivities and moisture content of both dike fill and foundation materials were determined. The saturated hydraulic conductivity values are generally low and range from 1.6 x 10^{-9} cm/s (4.5 x 10^{-6} ft/day) to 3 x 10^{-6} cm/s (8.5 x 10^{-3} ft/day). Saturated hydraulic conductivity values for the silty clays and clayey silts are the highest measured. The geometric mean of the test results is 1.3 x 10^{-7} cm/s (3.7 x 10^{-4} ft/day). The field moisture content of the samples range from 15% to 30%. This is approximately 90-100% saturated moisture content. Test results for the clay materials obtained from a depth of about 3 m (10 ft) indicate a saturated hydraulic conductivity range from 1.7 x 10^{-8} cm/s (4.82 X 10^{-5} ft/day) to 6.4 X 10^{-9} cm/s (1.81 x 10^{-5} ft/day).

Comparison of grain size distributions of the four units indicates the basal till has the highest gravel content, the clay till has the highest sand and clay content, and the loess has the highest silt content (Table 1-2). The clay till exhibited the highest cation exchange capacity, followed by the Ferrelview Formation and lastly, the basal till (BNI, July 1987).

Relevant soil parameters measured by the laboratory for the Ferrelview Formation, the clay till unit, and the basal till unit are discussed in Section 1.2.4.1. Table 1-2 presents a summary of the overburden test results. These data indicate that the

Ferrelview Formation has the highest saturation, specific retention, and activity, and the lowest specific yield (BNI, 1987).

2.4.1.1 Unsaturated Zone Storage Potential

The physical properties of the vadose zone that influence water storage potential include: (1) thickness, (2) porosity, (3) bulk density, (4) water content, (5) soil-water characteristics, (6) field capacity (specific retention), (7) specific yield, and (8) fillable porosity (Everett, 1984). The evaluation of these parameters is necessary to properly assess the hydraulic properties of the unsaturated zone in order to predict contaminant migration.

- Thickness

  A determination of the thickness of the vadose zone will be based on borehole information and current water level measurements from existing and proposed monitoring wells. In areas underlain by perched groundwater, the depth to the perched water table will be used as the depth of the vadose zone.

- Bulk Density and Porosity

  Bulk density values are required for the estimate of total water storage in the vadose zone.

  Bulk density and porosity results from previous studies by BNI will be combined with new data from the geotechnical investigation efforts to produce a body of data suitable for unsaturated flow calculations and model calibration.

- Water Content

  The total porosity (n) of the unsaturated zone materials corresponds to the upper limit for water storage in the unsaturated zone. However, for $\theta<n$, the available porosity for liquid flow is a function of the water content. Field techniques for determining water content of the unsaturated zone will utilize tensiometers and neutron moisture probes. A more detailed discussion of the use and field implementation of these instruments is presented in Section 2.4.1.3.

- Soil-Water Characteristics

  The relationship between soil-water tension and water content is referred to as the soil-water characteristic curve. As a soil drains, a range of soil-water content values are possible, depending on the various forces acting on the soil-water system. These forces include matric forces, osmotic forces, and gravity. Usually, the matric force is dominant. When expressed on a unit volume basis, the energy associated with these forces is termed soil-water pressure (Everett, 1984).

  Tensiometers will be used to measure the soil suction negative pressure head in the field at a specific point in the soil column. Tensiometers may be used only when soil-water negative pressures are greater than -0.8 bar (i.e. between -0.7 and 0.0 bar) (Everett, 1984). They must also be correlated to measurements of soil moisture. This can be done by reference to an existing soil-moisture characteristic curve. If such a curve is not available, it must be developed from additional laboratory testing. Field sampling and measurement may also be used to supplement laboratory testing. The soil may be sampled at the time of tensiometer

installation and the moisture content of this sample compared to the initial tensiometer reading. However, this will supply only one point on the curve relating soil moisture and soil suction.

In the case of the WSS, a soil-moisture characteristic curve is not available. A combination of field and laboratory methods will be used to develop a soil-characteristic curve for the soils at the WSS which relates moisture content and soil suction. Laboratory testing using pressure plate analysis or other methods must be used to determine additional points along the curve relating soil moisture and soil suction. Once this relationship has been established, the soil characteristic curve can be used to determine the soil moisture based on future tensiometer readings.

- Field capacity (specific retention)

Field capacity is related to the volume of water that a unit volume of soil will retain against the force of gravity. Approximate values of field capacity (on a mass/mass basis) vary from 4% in heavy clays up to 100% or more in organic soils. In terms of matric potentials, values for sands range from 0.1 to 0.15 bar at field capacity. For medium- to fine-textured soils, the corresponding range is 0.3 to 0.5 bar (Everett, 1984).

- Specific yield

Estimates of the specific yield values for areas near the water table and perched areas of saturation in the vadose zone will be obtained from water content profiles as determined from neutron moisture logs. The neutron moisture data will be used to determine the

volume of water drained during the decline in the water table.

- o Fillable porosity

  The fillable porosity is the volume of water that an unconfined aquifer stores during a unit rise in the water table per unit surface area. Neutron moisture logs may be used to estimate the fillable porosity of sediments near the water table.

2.4.1.2 Unsaturated Flow Potential

The vadose zone flow regime at this site may be characterized as two flow regimes, Darcian (capillary) flow and macropore flow. Darcian flow describes a uniform, slowly advancing wetting front, while macropore flow is the relatively rapid transmission of free water through large, continuous pores or channels (such as root channels, desiccation cracks, or fractures). The principal unsaturated flow parameters that need to be evaluated at this site are: 1) infiltration, 2) the amount of water moving into the lower vadose zone, 3) the direction of unsaturated water movement, 4) hydraulic gradients, 5) the unsaturated hydraulic conductivities, and 6) flow rates (flux).

The method to be used at the site to estimate infiltration is the instantaneous rate method which involves measuring seepage loss over a short time interval at an excavated impoundment.

The determination of direction of water movement and hydraulic gradient in the unconsolidated material will rely primarily on neutron probe measurements. Measurements will be taken by inserting the neutron probe into the infiltration tubes and recording the neutron response to moisture content of the soils at various depths. Using this method, the neutron source and neutron counter are contained in the same unit and high energy

neutrons, which have about the same mass as hydrogen, are emitted from the source into the soil. As these neutrons collide with hydrogen they lose part of their energy and are counted as they are scattered back toward the probe. The number of counts that are recorded in a specified time can be related to the hydrogen content of the soil, which is primarily the soil moisture content.

A soil characteristic curve is then used to estimate the soil suction (negative pressure head). One tensiometer nest will also be used as a correlation of field measurements. Tensiometers are used to measure the soil suction or negative pressure head at a specific point in the soil column. A soil characteristic curve is then used to estimate the moisture content of the soil (see 2.4.1).

In order to characterize the direction of unsaturated water movement in the vadose zone, an array of three neutron probe infiltration tubes will be installed at each selected location to determine variations in soil moisture with respect to depth. A nest of three tensiometers will be installed at one infiltration tube location with individual cups terminating at varying depths. This will be located as close as possible to the location of the infiltration tube. Disturbance of soils will be minimized. Correlation between the neutron soil moisture readings and the tensiometer soil suction can be made at this location and the results used at other points in the vadose zone monitoring network.

Hydraulic gradients will be used to estimate flux in the vadose zone. The hydraulic gradients in the vadose zone will be derived from tensiometer and neutron probe data. Soil-characteristic curves derived from lab and field data will be used to relate negative pressure measurements (from tensiometers) or the moisture content measurements (from neutron probes) to water content and unsaturated hydraulic conductivity (Everett et al,

1984).

2.4.1.3 Site Monitoring

The vadose zone monitoring network is designed to investigate the vertical and horizontal extent of contamination and to provide insight into the potential for movement of fluids in the vadose zone. Monitoring of the vadose zone will involve a combination of field and laboratory techniques. Neutron probes will be the primary technique used to measure moisture content at most locations in the vadose zone. Neutron moisture logging will provide detailed information on the relationship between moisture content and negative pressure. Advantages of the neutron probe are its abilities to obtain soil moisture measurements over a wider range of soil moisture content than tensiometers and to allow measurements of a continuous soil moisture profile (with depth). A tensiometer nest will be used to correlate the in-situ soil suction or pressure head with the soil moisture measurements (determined by neutron probe measurement) at one monitoring point in the vadose zone. The data derived from the tensiometers and neutron probes will facilitate the determination of hydraulic gradients and, indirectly, fluid movement (flux) in the vadose zone.

At the time of installation of the in-situ devices, the moisture content of the soil from the neutron probe access wells and the tensiometer cup locations will be determined from undisturbed samples (see Section 2.4.1.5 for sampling technique). These data will be used to supplement laboratory data to create a soil-water characteristic curve which can then be used to estimate the moisture content of the soil and allow subsequent neutron probe and tensiometer readings to be used to estimate flux.

2.4.1.4 Location and Rationale

This section presents the proposed locations and rationale for

vadose zone monitoring points and for the field implementation of the monitoring program. The goals of the vadose zone monitoring program are to:

(1) Investigate vadose zone processes in and near suspected source areas for continuing groundwater contamination.

(2) Provide information for the evaluation of contaminant migration in the vadose zone.

(3) Provide representative data on vadose zone parameters throughout the site for input to computer models.

(4) Provide long-term monitoring data to allow for the estimation of seasonal variation of potential paths of migration.

(5) Evaluate the effectiveness of the soil zone in terms of the degradation, transformation, or immobilization of contaminants.

Proposed locations for the neutron probe monitoring network are presented on Figure 2-7. The locations were selected to determine unsaturated flow conditions in areas where contaminants have been detected in the groundwater and could potentially migrate off-site, and also at a location adjacent to a possible site for the proposed disposal facility. In general, the locations of the neutron probe arrays correspond to the pumping and observation well locations. As shown in the detailed enlargement on Figure 2-7, each location will contain an array of three neutron probe infiltration tubes. The tubes will be located 25 feet apart. These three points describe an equilateral triangle. Array 1 (IT-1) is located north of the apparent groundwater divide in the area where relatively high concentrations of nitroaromatic compounds were detected in groundwater samples. Array 2 (IT-2) is located adjacent to a

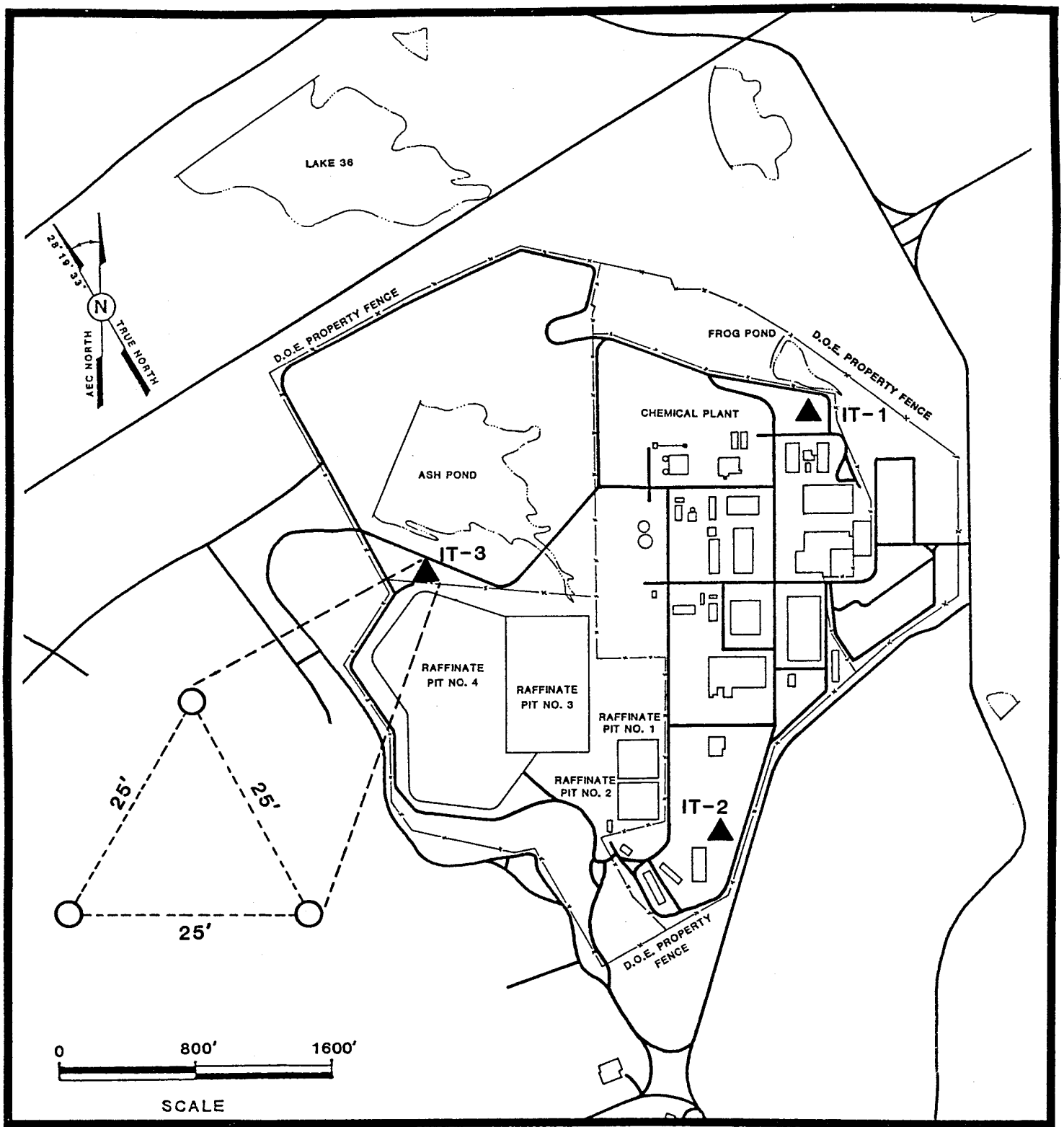


FIGURE 2-7

LOCATION OF INFILTRATION TUBE NETWORK

possible site for a proposed disposal cell area near the southern end of the site. Array 3 (IT-3) is located in the area where the highest nitrate concentrations were detected in groundwater samples from the Phase I Water Quality Assessment. At location IT-2, one array will contain a tensiometer nest containing three tensiometer cups at three different depths.

There may be some variations in correlation between the neutron probe soil moisture measurements and the tensiometer soil suction measurements. This is expected due to hysteresis effects during the wet-dry cycle in unsaturated conditions. To insure that the neutron probe is accurately reflecting field conditions, it will be calibrated at least once yearly using a standardized field installation.

Additional neutron probe monitoring tubes will be installed at each existing and proposed lysimeter location. This will allow localized in-situ soil moisture measurements so that lysimeter sampling can be optimized.

A phased approach to neutron probe monitoring tube/lysimeter installation will be used for the proposed locations. Neutron probe soil moisture measurements will be taken for approximately three months prior to lysimeter installation. Moisture profile data from these measurements will allow more precise depth location of each lysimeter.

2.4.1.5 Drilling and Installation

All drilling activities to be conducted for the installation of the tensiometer nest and neutron moisture logging infiltration tubes will be in accordance with SOPs (WSSRAP procedures manual).

Drilling operations will utilize hollow-stem augers to advance and sample boreholes. Undisturbed samples will be obtained from intervals which will, at a minimum, correspond to the horizons

monitored by the tensiometers (10, 20, and 30 feet). The supervising geologist will maintain a complete log of each soil boring. Sampling intervals will be adjusted to intercept seams of differing soil type and those intervals which appear to contain abundant soil moisture. Thin-walled tube (Shelby Tube) sampling will be used to obtain undisturbed samples of the unconsolidated overburden materials.

Each infiltration tube borehole will be drilled to a depth of 30 feet. The infiltration tube is constructed by hydraulically driving a 2 3/8 inch core barrel into the soil. The core barrel is advanced 4 feet at a time after which the soil sample is removed. When the advancement of the core barrel reaches a depth of 30 feet, a 2 3/8 inch OD aluminum pipe is inserted into the hole. At ground surface bentonite is placed around the tube to prohibit water from percolating into the annular space and affecting the measurements made with the neutron probe. A secure cap with controlled access should be installed over the infiltration tube to prevent entry of debris, water or contaminants (Figure 2-8). The neutron probes will be calibrated by comparison to laboratory measurement of the moisture content of soil samples that were removed during the installation of the infiltration tube.

Tensiometer measurements are effective only in unsaturated soils where soil-water pressures are between -0.8 bar and 0.0 bar. Pressures below -0.8 bar will be correlated to soil moisture content using lab testing and neutron logging.

Tensiometers will be installed in a nest with individual cups terminating at varying depths throughout the region of interest. The tensiometer nest will consist of three tensiometers (Figure 2-9). The A1 tensiometer cup will terminate at the upper or horizon 1 level; the A2 will terminate at the middle or horizon 2 level; and A3 will terminate at the lower or horizon 3 level. These levels correspond to depth intervals of 10, 20, and 30 feet

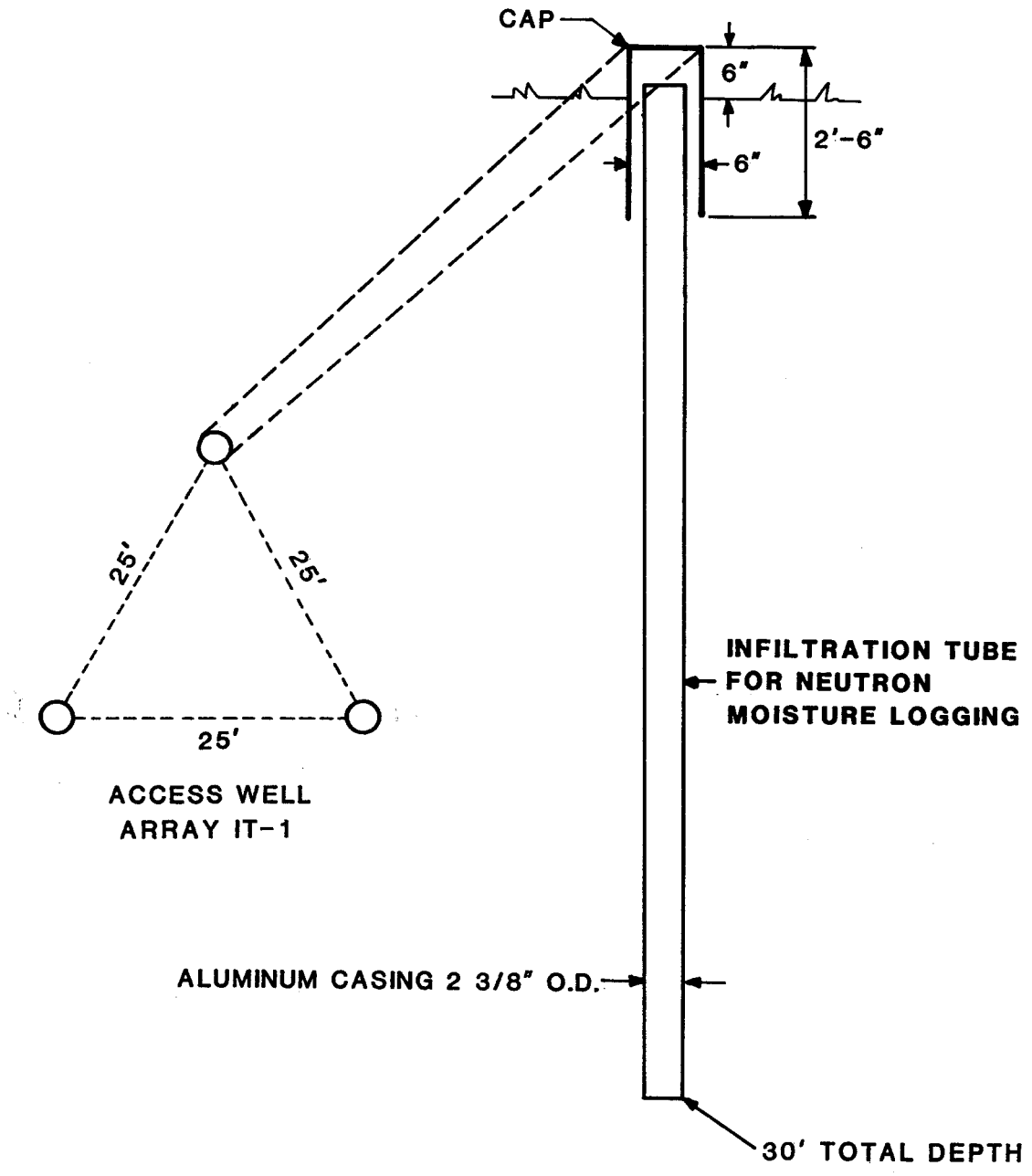


FIGURE 2-8

TYPICAL INFILTRATION TUBE DIAGRAM

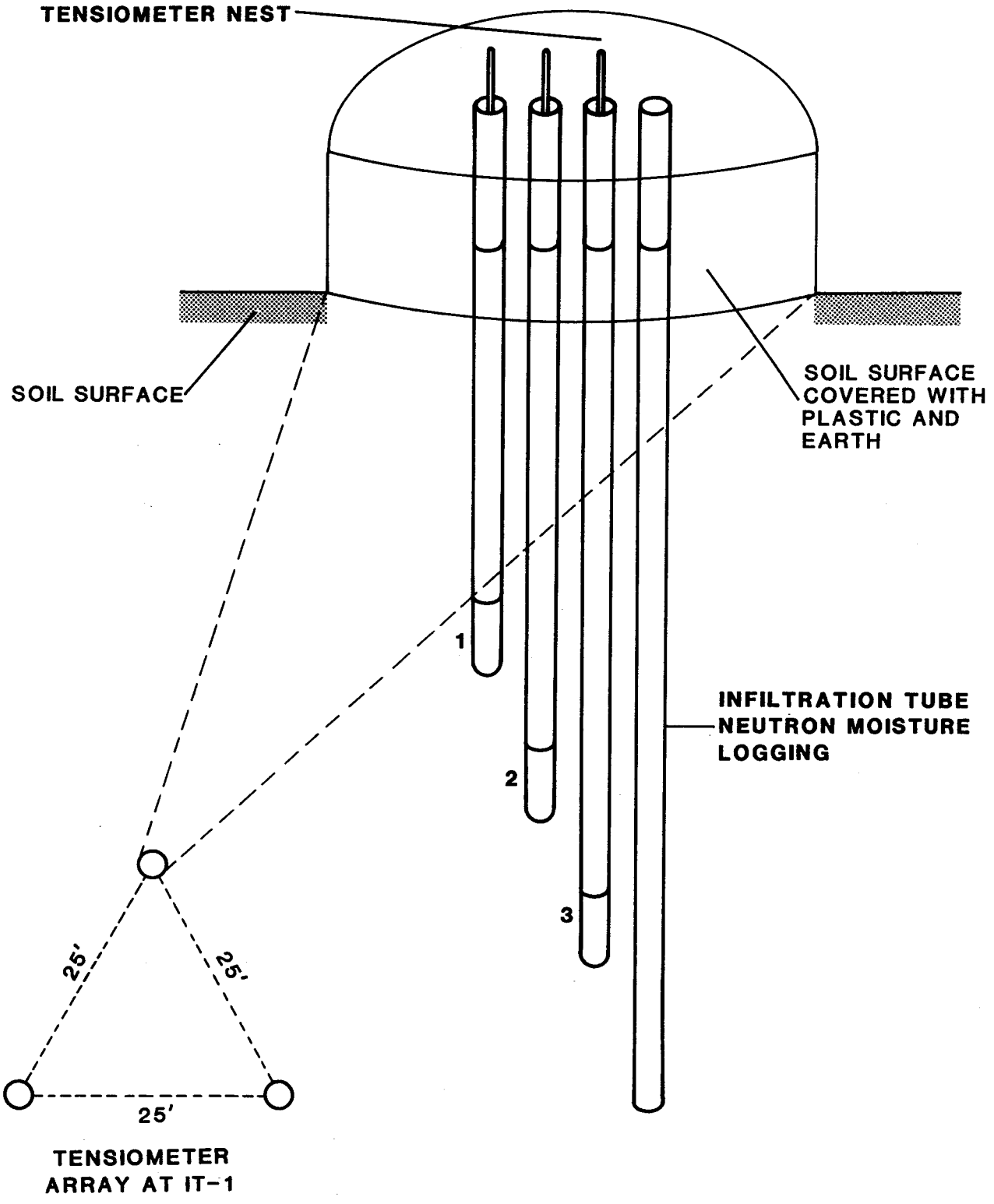


FIGURE 2-9

PROPOSED TENSIOMETER ARRAY DIAGRAM

respectively. The intervals will be adjusted, based on field observations, to intercept zones where moisture is accumulating.

The borings to complete the tensiometer nest will be spaced four feet apart (Figure 2-10). Adjustments in spacing may be necessary to accommodate actual site constraints. Care will be taken to minimize disturbance of adjacent borings when drilling the closely-spaced holes for the tensiometer nest.

Tensiometers will be immersed in water during transport to the field. Silica flour (200 mesh) will be tremmied to the bottom of the hole. The tensiometer cup will then be forced into the silica flour and the tube carefully backfilled with soil to prevent surface water leaking down the tube (Everett et al, 1984).

2.4.2 Contaminant Distribution in the Vadose Zone

Soil pore-liquid sampling will be performed to evaluate the efficiency of the soil processes that degrade wastes, and to detect the migration of hazardous constituents through unsaturated flow.

The sampling of unsaturated soil pore-liquids will utilize vacuum pressure lysimeters. Usually, vacuum lysimeters will collect liquid only at pressures above -0.8 bar, limiting the effective range of soil moisture where samples can be obtained. Soil moisture will be monitored by installing neutron probe access wells in close proximity to each lysimeter location. Figure 2-11 shows a typical single vacuum-pressure lysimeter (EPA, Oct. 1986).

2.4.2.1 Existing Lysimeters

Figure 1-18 presents the location of the existing lysimeter network installed by UNC Geotech in July 1987. Analysis of soil pore water from these lysimeters indicated elevated concentrations of nitrate, calcium, and sodium.

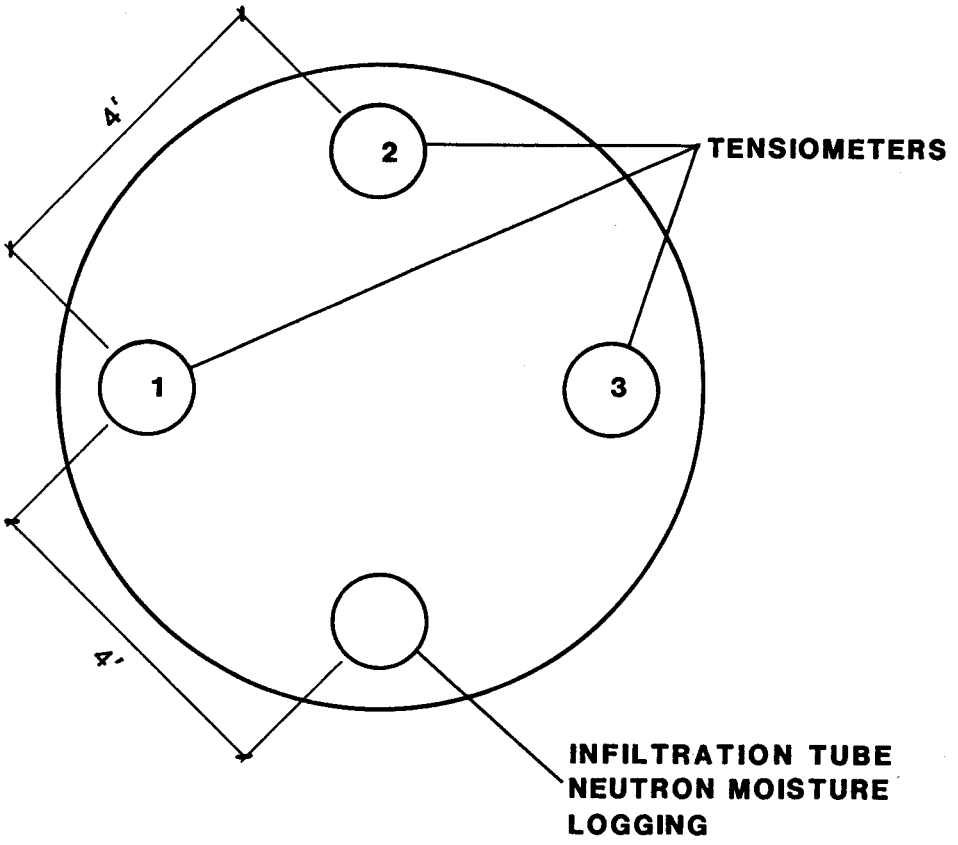


FIGURE 2-10

PROPOSED TENSIOMETER NEST DIAGRAM

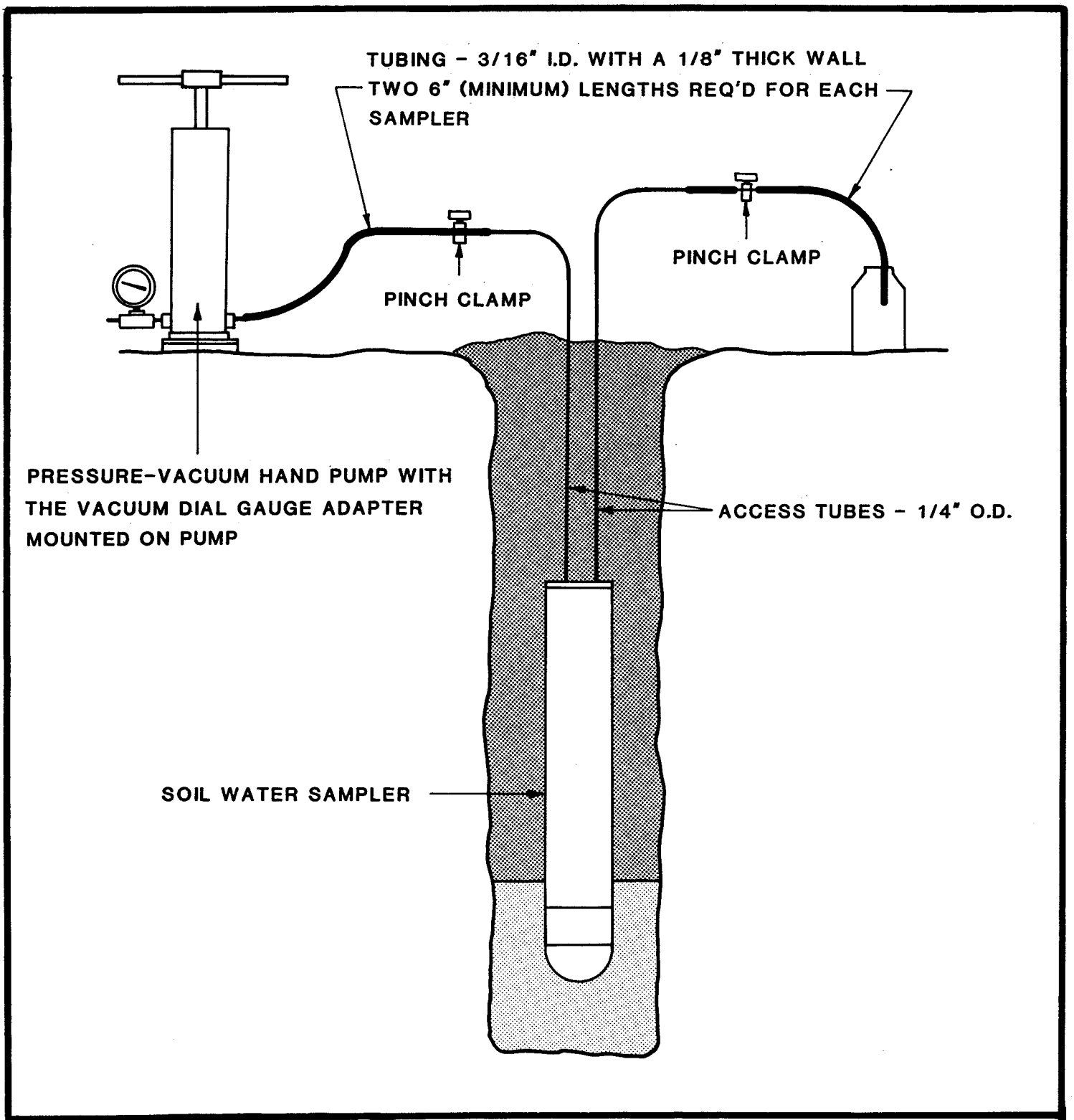


FIGURE 2-11

TYPICAL VACUUM - PRESSURE LYSIMETER

The proposed overburden monitoring program includes installation of neutron probe access wells and continued collection and analysis of samples from these existing lysimeter locations. Also additional neutron probe/lysimeter arrays will be installed and monitored at select locations to evaluate contaminant transport by unsaturated flow.

2.4.2.2 Additional Lysimeters

The location and rationale for additional multiple lysimeter installations were established by reviewing: (1) documented evidence of areas exhibiting soil and/or groundwater contamination, and (2) potential contaminant source areas.

The proposed locations for additional multiple lysimeter installations are shown in Figure 2-12. Table 2-5 lists the rationale for lysimeter placement. The intervals to be monitored at each location are listed in Table 2-6. This table also includes a lithologic description of the interval which is based on the log of the nearest boring. These intervals will be adjusted, based on field observations, in order to intercept zones where moisture is accumulating.

The characteristics of the residuum and unsaturated bedrock will be defined under the geotechnical investigation plan. Lysimeter locations presented on Figure 2-12, supplemented by existing lysimeters, represent a minimal vadose zone monitoring network. This focused operation may be expanded, if necessary, with the acquisition and analysis of data from drilling and sampling programs, including the chemical soils investigation, monitoring, geophysical/geotechnical investigation, waste characterization (e.g. raffinate pit sludge analysis) and the drilling and sampling programs delineated in this plan.

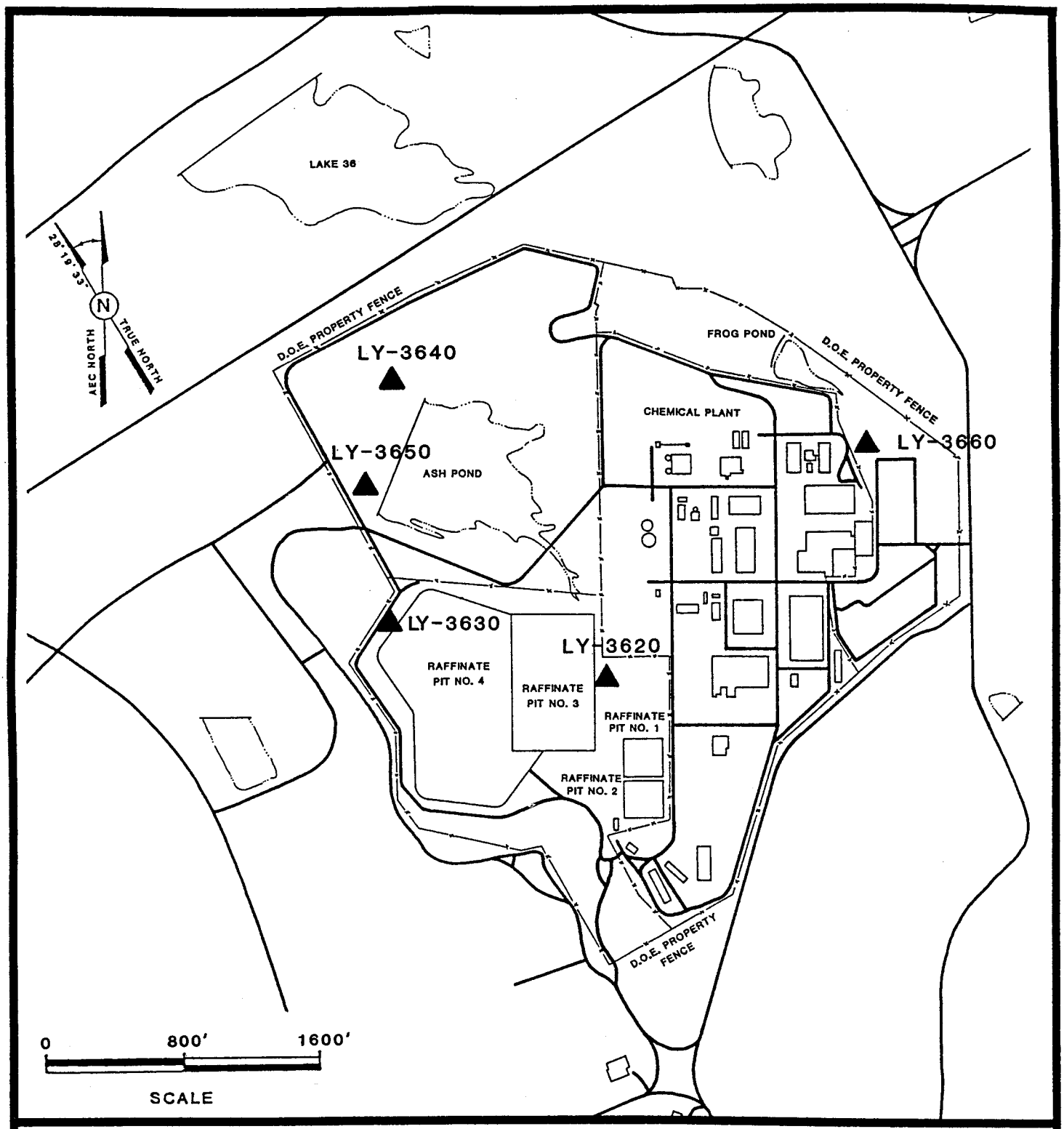


FIGURE 2-12

ADDITIONAL MULTIPLE LYSIMETER INSTALLATION LOCATIONS

T A B L E 2-5

LYSIMETER PLACEMENT RATIONALE

Lysimeter Location Number	Location	Rationale
LY-3620	E. of Raffinate Pit 3	Area of dark green vegetation may indicate leakage from Raffinate Pit 3, or potential migration extending from Raffinate Pit 1.
LY-3630	N.W. of Raffinate Pit 4	Previous drilling in this area encountered very moist zones. Potential seepage from Raffinate Pit 4.
LY-3640	N.W. of Ash Pond near north dump area	Previous drilling operation in this area encountered a very sandy silt. Area delineated as ordnance demolition storage area. Also, saturated materials were encountered during BNI drilling and testing activities.
LY-3650	S.W. of Ash Pond down-stream toe of embankment.	Area of nitrate & sulfate contamination, and ordnance demolition storage area. Area also exhibiting saturated soil during BNI drilling & testing activities.
LY-3660	N. of Bldg.407, near monitoring well MW-2013	Area of 2,6 DNT contamination and area delineated as potential nitroaromatic source from TNT processing. Also area exhibiting saturated soil during BNI drilling & testing activities.

TABLE 2-6
MULTIPLE LYSIMETER INSTALLATION SUMMARY

Lysimeter Location/ Borehole	Depth Interval	Description
LY-3620		
LY-3621	10.0 - 12.0	Clay, silty, brownish-gray to med. gray, moist oxidized zones
LY-3622	18.0 - 20.0	Clay, silty, med. gray, moist, some sub-rounded fine gravel, trace very fine-grain sand, oxidized zones, pyrolusite stringers
LY-3623	23.0 - 25.0	Clay, gravelly, dark yellowish orange, moist, hard, angular chert gravel, pyrolusite lenses, trace very fine-grain sand
LY-3630		
LY-3631	10.0 - 12.0	Clay, silty, gravelly, lt. gray w/orange mottling, some angular chert fragments
LY-3632	17.0 - 19.0	Clay, silty, orange/gray, moist, some chert pebbles
LY-3633	22.0 - 24.0	Clay, silty, gravelly, dk. brown w/orange, moist, red angular chert fragments
LY-3640		
LY-3641	5.0 - 7.0	Silt, orange & greenish gray, some clay, black modules, very stiff
LY-3642	10.0 - 12.0	Clay, silty, mottled orange & gray, very stiff
LY-3643	18.0 - 20.0	Clay, silty, yellowish orange-orange & gray mottled, very stiff to hard, black manganese oxide staining common
LY-3650		
LY-3651	6.0 - 8.0	Silt, clayey, tan to light brown, some black manganese oxide staining
LY-3652	11.0 - 13.0	Clay, mottled orange-brown-gray, stiff, minor manganese oxide staining
LY-3653	18.0 - 20.0	Clay, silty, mottled orange, yellowish-brown and gray w/fine-grain sand & weathered angular chert gravel, black manganese oxide staining & fillings common
LY-3660		
LY-3661	6.5 - 8.5	Silt, clayey, mottled tan & gray, very soft
LY-3662	11.0 - 13.0	Silt, clayey, mottled, stiff, common dark reddish brown iron nodules
LY-3663	18.0 - 20.0	Clay, silty, mottled, very stiff, w/white sand sized chert fragments, occasional black manganese oxide staining and fillings mottled orange & light olive gray

*Descriptions based on nearest logged boring

2.4.2.3 Drilling and Installation

A phased approach to neutron probe infiltration tube/lysimeter installation will be used for the proposed lysimeter locations. Neutron probe soil infiltration tubes will be installed first and moisture measurements will be taken for approximately three months prior to lysimeter installation. Moisture profile data from these measurements will allow more precise depth location of each lysimeter.

All lysimeter drilling and installation activities will be conducted in accordance with the Standard Operating Procedures (SOPs) developed for borehole logging and lysimeter installation and sampling. Drilling operations will utilize hollow-stem auger techniques.

Undisturbed samples will be obtained from the intervals corresponding to the horizons or intervals to be monitored by the lysimeter. Thin-walled tubes will be used to obtain undisturbed samples of the unconsolidated overburden materials. These samples will be retained for possible future chemical analysis. The supervising geologist will maintain a complete log of each soil boring.

In general, lysimeter installation will consist of placing enough silica flour (200 mesh) into a borehole at the proper lysimeter depth interval to form a six- to twelve-inch thick layer. After lowering the sampler into the hole, additional silica flour will be added to cover the sampler to a point at least two inches above the top of the porous cup. The sampler will then be rotated into the silica flour to insure the porous cup is in good contact with the silica flour. The hole will then be backfilled with tamped native soil. A bentonite seal is required above and below each lysimeter in multiple sampler installations (Figure 2-13).

MULTIPLE INSTALLATION

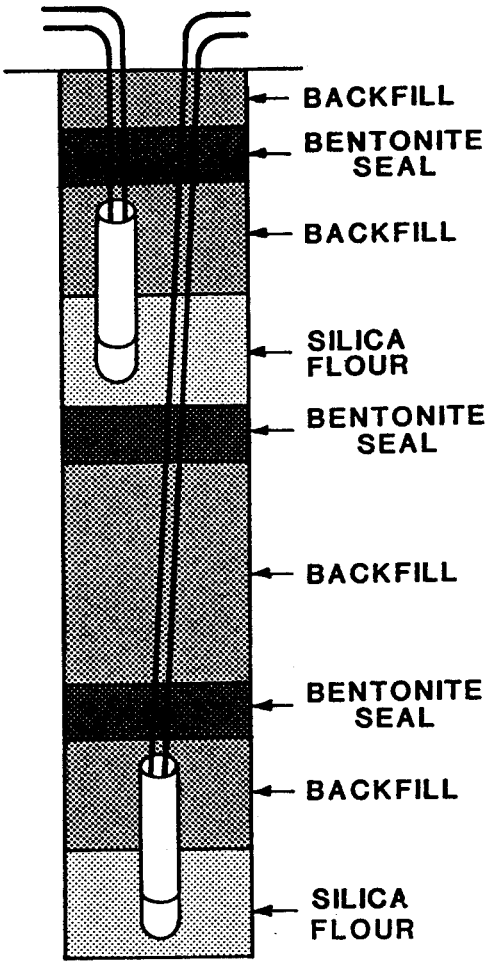


FIGURE 2-13

TYPICAL MULTIPLE LYSIMETER INSTALLATION

2.4.2.4 Soil Water Sampling

Soil water sampling will be performed in conjunction with the quarterly monitoring described in the 1987 Environmental Monitoring Program Plan. Sample collection techniques are described in detail in the WSSRAP Standard Operating Procedures. Repeated sampling over a period of time may be required to collect sufficient sample volume for a complete analysis. The order in which the constituents are analyzed may be prioritized, with analyses for contaminants of greatest concern performed first. Soil water samples will be analyzed for the parameters listed previously in Table 2-3. Analytical results will be entered into a computer data base.

2.4.3 Perched and Mounded Groundwater Zones

The geological environment at the WSS exhibits complex saturated-unsaturated conditions occurring within the vadose zone. Saturated regions within the vadose zone (perched groundwater bodies) result from the presence of a lower permeability layer in a relatively higher permeability formation, or from seepage into a low permeability, poorly drained soil. The result is the formation of discontinuous saturated lenses with unsaturated conditions existing below these lenses and above the water table.

Investigations of perched and mounded zones will focus on the immediate vicinity of the raffinate pits. Previous exploratory drilling investigations conducted at the WSS indicated areas of anomalously high groundwater elevations or perched groundwater (see Section 1.2.6).

Monitoring of perched groundwater at the WSS will be accomplished by the use of overburden monitoring wells. Discrete zones within the overburden are to be monitored.

Previously installed monitoring wells that will be retained in the network are illustrated on Figure 2-14. Overburden monitoring wells OW-3501 and OW-3502 were installed by UNC Geotech in 1987 to allow monitoring of shallow seepage from Raffinate Pits 1 and 3. OW-3503 was installed as a monitoring well in 1983 by BNI and designated B-15A, later designated MW-3005 by WSSRAP staff prior to the development of separate monitoring strategies for saturated overburden and the bedrock aquifer. OW-3504 was installed in 1980 by Lawrence Berkeley Laboratories and designated W-2, later designated MW-3018. The overburden surrounding the screened interval of this well is seasonally unsaturated. OW-3508 was installed in May 1988 incidental to other drilling activities near Raffinate Pit 3. This location will serve to monitor potential mounding from Raffinate Pit 3.

Other monitoring wells installed in the overburden during the course of previous investigations in the raffinate pits area have either remained continuously dry or have been damaged and abandoned.

Additional overburden monitoring wells will be installed in areas previously identified as exhibiting potentially perched or mounded groundwater conditions in the overburden.

2.4.3.1 Location and Rationale

The overburden monitoring network is designed to further investigate the vertical and horizontal extent of contamination in perched groundwater zones and to evaluate leakage from the raffinate pits.

The location and rationale for monitoring well installation were established by reviewing the results from previous subsurface investigations by Bechtel National, Inc. and UNC Geotech. Figure 2-15 presents the proposed overburden monitoring well

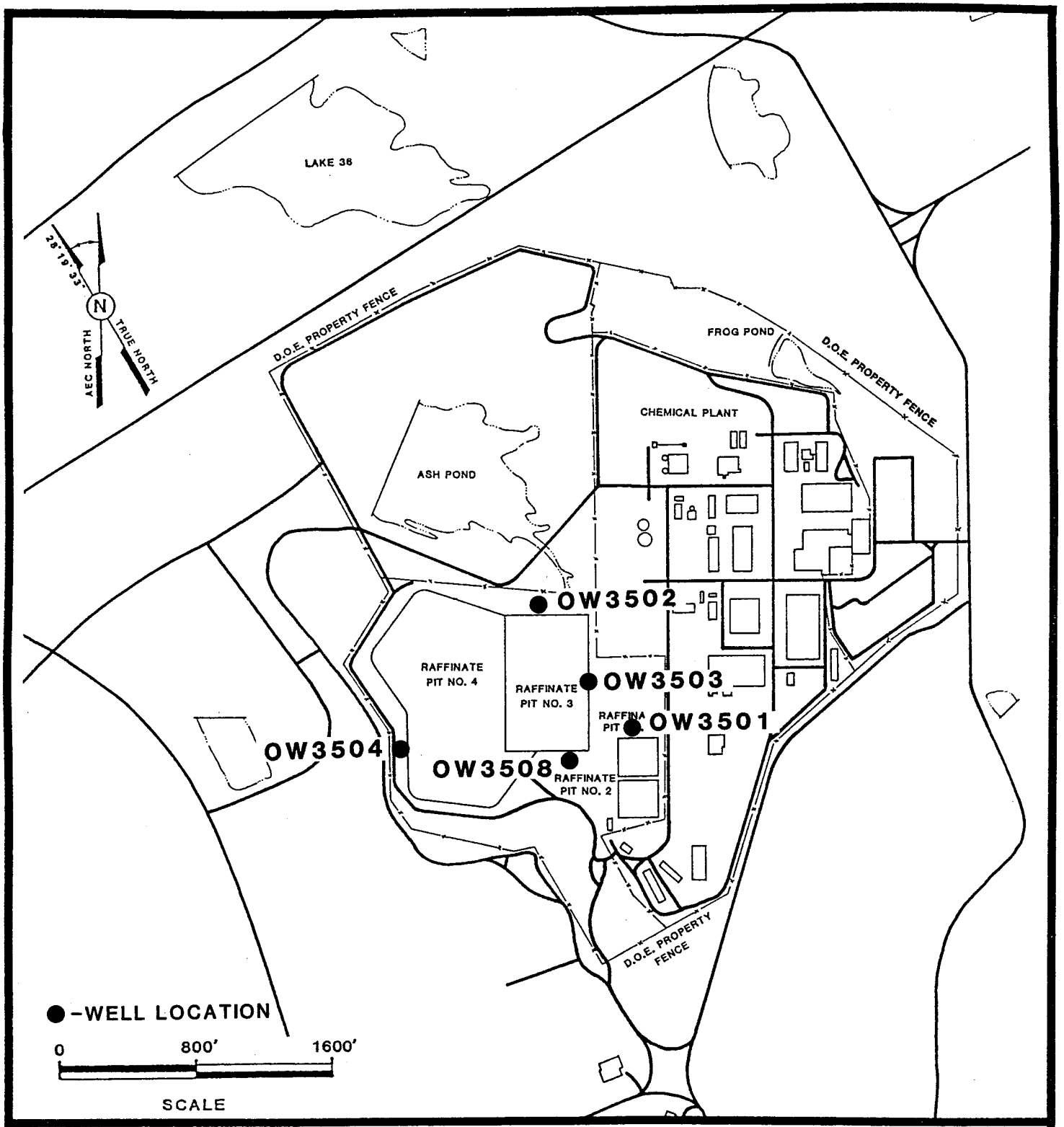


FIGURE 2-14

EXISTING OVERBURDEN MONITORING WELL LOCATIONS

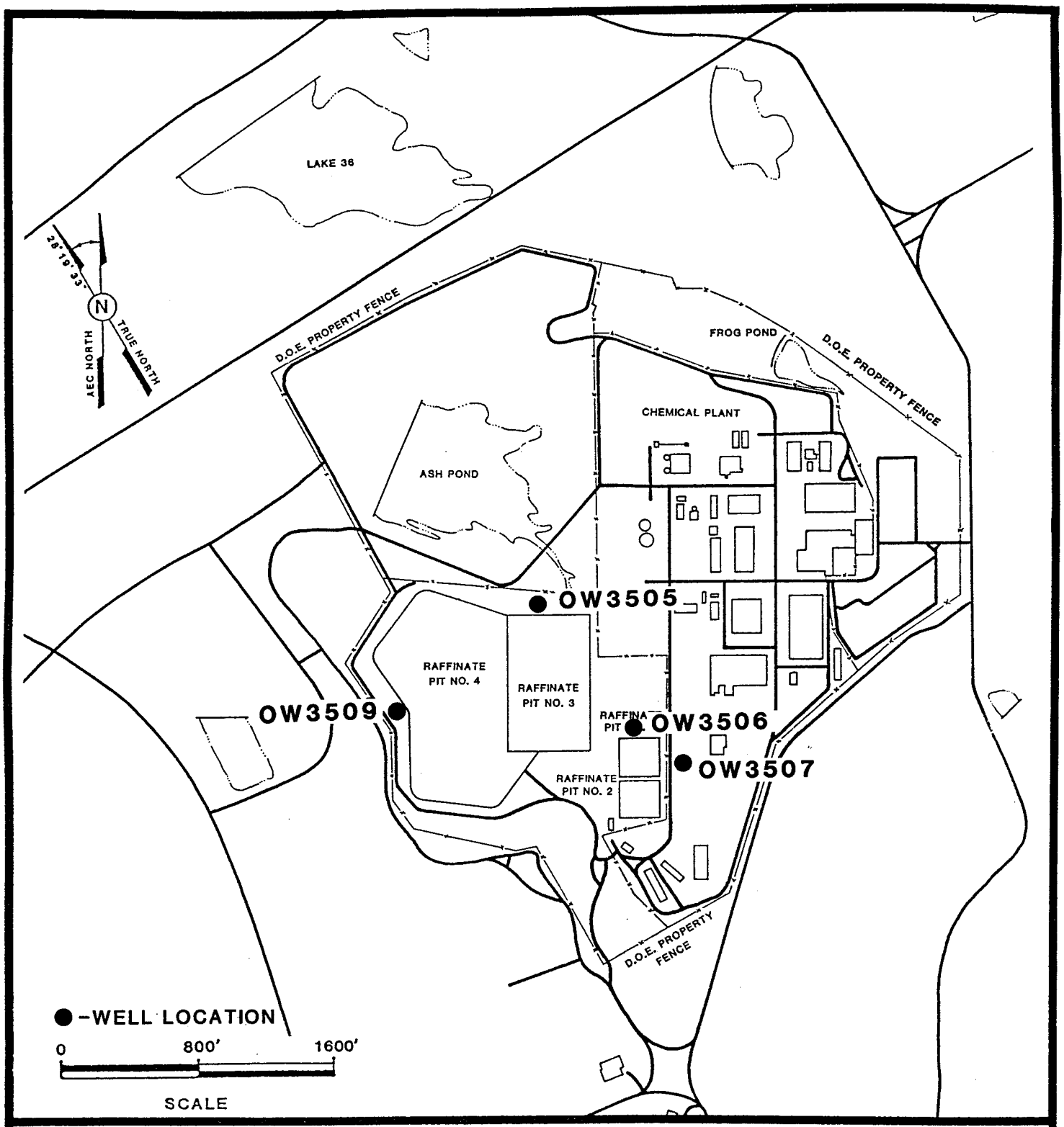


FIGURE 2-15

PROPOSED OVERBURDEN MONITORING WELL INSTALLATION LOCATIONS

installation locations. These areas generally correspond to areas receiving recharge from leaking surface impoundments and/or areas disturbed by previous construction or landfilling activities. Table 2-7 presents a summary of overburden monitoring locations and rationale.

2.4.3.2 Drilling and Installation

Drilling operations for installation of overburden monitoring wells will be performed using hollow-stem augering methods. A supervising geologist will record a lithologic log for each borehole. Split-spoon samples will be collected at intervals of 5 feet, or where cuttings indicate particularly moist zones. Well depths will be adjusted based on field observations.

All drill bits, drill rod, casing, and hand tools will be decontaminated by steam-cleaning prior to beginning drilling and between boreholes. The entire drilling rig will be decontaminated upon arrival on-site.

Wells will be constructed using 2-inch inside diameter (ID) Schedule 40 PVC threaded, flush-jointed screens and casing. Screens will be slotted with 0.010-inch slots. Screen length will be 5 feet to allow sampling of a discrete saturated interval. PVC well materials were selected, since contaminants of concern are not deleterious to PVC and PVC is more readily removable when the wells are abandoned during final remedial action at the site.

Screens and casing will be decontaminated by steam-cleaning and wrapped or covered prior to installation. Screens and casing will be stored above ground to avoid contact with potentially contaminated soils.

The screen and casing will be lowered into the borehole using centralizers to insure that the well is plumb and centered in the

TABLE 2-7
OVERBURDEN MONITORING WELL PLACEMENT RATIONALE

Overburden Monitoring Well	Location	Rationale
OW-3505	North of Raffinate Pit 3, adjacent to OW-3502	Monitor mounding effects from Raffinate Pit 3; OW-3502, installed to monitor shallow seepage, is currently dry
OW-3506	North of Raffinate Pit 1, adjacent to OW-3501	Monitor mounding effects from Raffinate Pit 1; in combination with OW-3501 monitoring shallow seepage
OW-3507	Southeast side of Raffinate Pits 1 and 2	Monitor mounding effects from Raffinate Pits 1 and 2
OW-3509	West of Raffinate Pit 4	Monitor mounding effects from Raffinate Pit 4

borehole. A filter pack of coarse (20-40 mesh) sand will be placed around the screen by tremie pipe to a depth of 2 to 4 feet above the top of the screen.

A bentonite pellet seal will be placed above the filter pack. The minimum thickness will be 3 feet of dry pellets. The pellets will be allowed to set for at least one hour before work continues. The annular space will be sealed to the surface with cement/bentonite grout. A steel protective casing will be set in a concrete pad at the surface. Well construction details were presented previously in Figure 2-3.

2.4.3.3 Overburden Monitoring Well Development

After each well installation is complete and the grout has set for a minimum of 72 hours, each overburden monitoring well will be developed by bailing or pumping. All development equipment will be decontaminated by steam-cleaning before development begins and between wells.

A minimum of five volumes of standing water in the well and filter pack will be removed.

2.4.3.4 Groundwater Sampling

Groundwater sampling of perched and mounded zones will be performed in conjunction with the quarterly monitoring described in the Environmental Monitoring Program Plan. At least two rounds of sampling will be performed for inclusion in final reports and modeling efforts.

Groundwater samples will be collected using submersible bladder pumps and bailers according to WSSRAP Standard Operating Procedures. Measurements of pH, temperature, and specific conductance will be made in the field at the time of sampling.

Groundwater samples will be analyzed for the parameters listed above in Table 2-3.

2.5 SURFACE WATER STUDIES

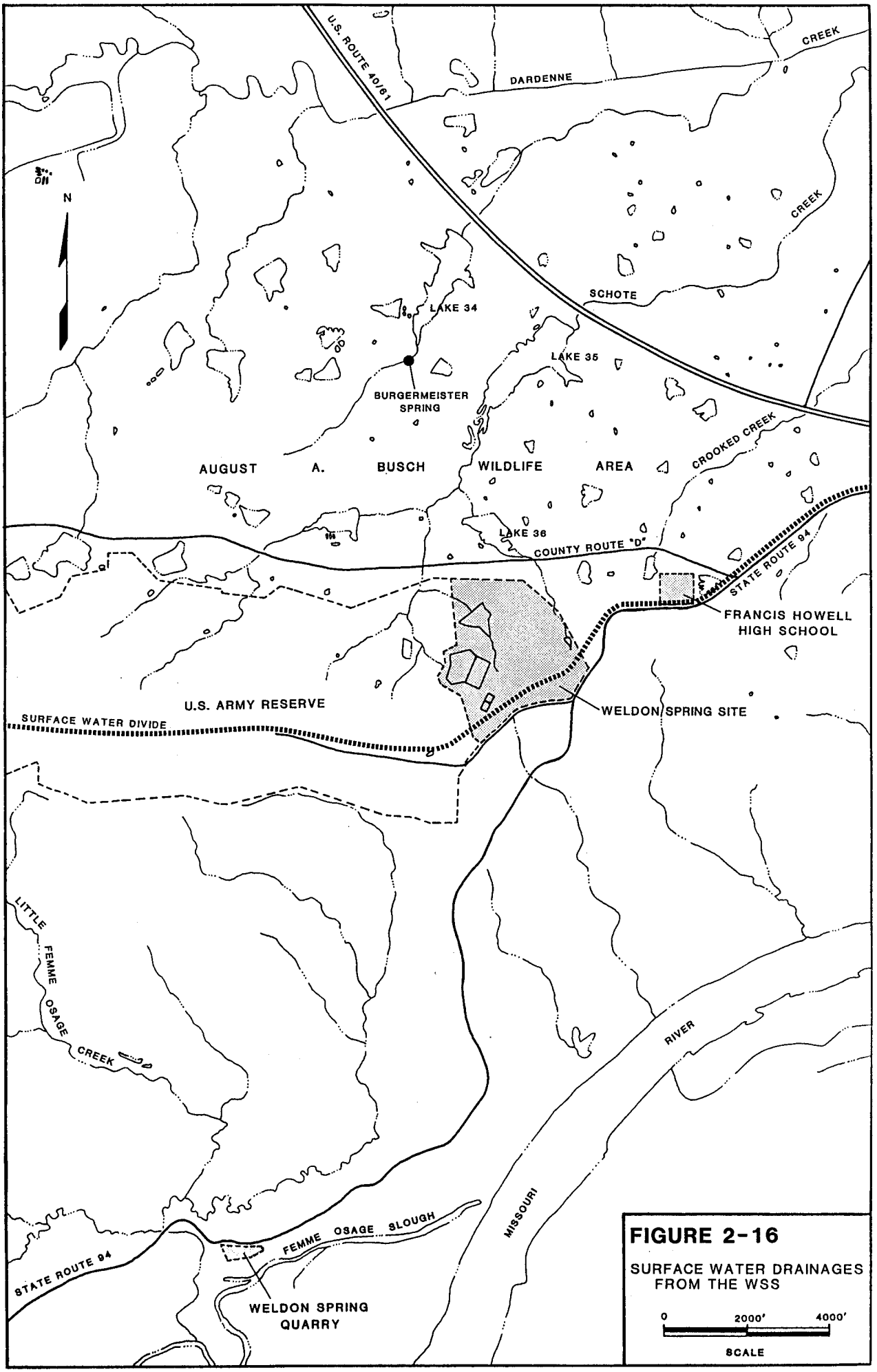
Results from the Environmental Monitoring Program (EMP) sampling performed in 1987 and 1988 will be incorporated into the overall hydrogeologic characterization and used to determine the impact to surface water bodies of contaminants that may migrate from the WSS through runoff following precipitation or snowmelt. The following sections describe the surface water regime, and present known surface/subsurface connections; sample locations and analytical parameters are also given.

2.5.1 Surface Water Regime - WSCP/WSRP

Surface waters at the WSCP consist of Ash Pond, Frog Pond, and all drainages from both the WSCP and WSRP areas. Surface runoff from approximately 166 acres of the WSCP/WSRP area ultimately flows to the Mississippi River. Twenty-two acres drain toward the Missouri River. Drainages from the WSS are shown on Figure 2-16. The raffinate pits, comprising 27 acres, are impounded within the site, with no discharge.

Surface water from the 166 acres in the Mississippi River drainage is divided into three major drainage basins: Ash Pond area, Frog Pond area and the Raffinate Pits area. Both the Ash Pond area and the west side of Raffinate Pit No. 4 drain to an unnamed tributary to Schote Creek which flows to Lake 35. Both streams lose water to the subsurface. Some of this lost flow resurfaces at Burgermeister Spring (Dean, 1985). (Burgermeister Spring is considered "surface water" in the EMP.) Surface water from the Frog Pond exits the WSCP and flows into Lake 36. Overflow from Lake 36 enters Schote Creek and flows into Lake 35.

Lake 35 has lost water to the subsurface since its construction


U.S. ROUTE 40/61
DARDENNE CREEK
N
CREEK
SCHOTE
LAKE 34
LAKE 35
BURGERMEISTER SPRING
AUGUST A. BUSCH WILDLIFE AREA
CROOKED CREEK
LAKE 36
COUNTY ROUTE "D"
STATE ROUTE 94
FRANCIS HOWELL HIGH SCHOOL
U.S. ARMY RESERVE
SURFACE WATER DIVIDE
WELDON SPRING SITE
LITTLE FEMME OSAGE CREEK
RIVER
MISSOURI
FEMME OSAGE SLOUGH
STATE ROUTE 94
WELDON SPRING QUARRY
FIGURE 2-16
SURFACE WATER DRAINAGES FROM THE WSS
0
2000'
4000'
SCALE

(Meyer, 1987). Lake 35 overflows to Schote Creek only during extreme precipitation events. Schote Creek joins Dardenne Creek just east of Highway K.

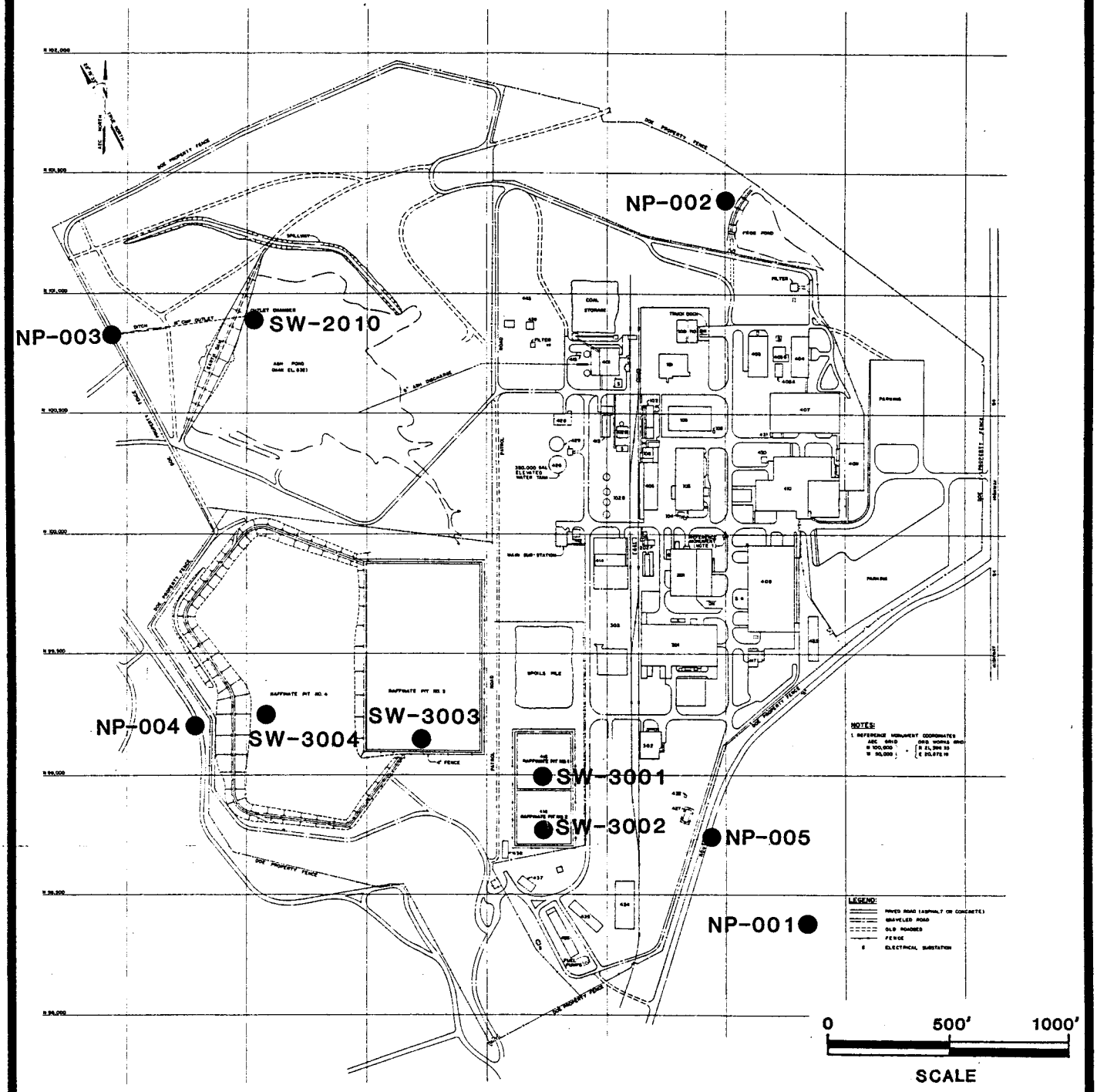
In early 1987, a small swallow hole opened near the headwaters of Lake 35. Missouri Department of Natural Resources dye studies determined that some of the lost water resurfaces in Lake 34 and at a spring just north of Lake 34. Subterranean flow surfacing at Burgermeister Spring flows into Lake 34. Lake 34 outflow enters an unnamed tributary of Dardenne Creek (Figure 2-16). Dardenne Creek flows northeast to the Mississippi River.

The 20 acres of the site that is in the Missouri River drainage is located in the southeast portion of the WSCP. Drainage is via the Southeast Drainage Easement, an intermittent stream valley approximately 1.5 miles long.

Surface water sampling programs have also been performed to support National Pollution Discharge Elimination Standard (NPDES) permits associated with sanitary waste and storm-water runoff. One permit for discharge of sanitary waste through the Imhoff tank expired on December 31, 1986. Sampling consisted of bi-monthly sampling for nitrate, BOD, pH and total suspended solids. In 1986 the DOE applied for a storm-water runoff NPDES permit for the WSCP/WSRP. This permit application is for storm water only; no process waste or other routine discharges occur. Samples collected monthly from five storm-water outfalls are analyzed for gross alpha, natural uranium, nitrate, total suspended solids, total settleable solids and pH. These results are reported to the MDNR according to NPDES procedures. NPDES surface water sampling points are shown on Figure 2-17.

2.5.2 Surface Water Sampling Program

Surface water samples will be collected from 19 locations as shown in Figures 2-17 and 2-18. The rationale for each location



NP - NPDES SAMPLING LOCATION

FIGURE 2-17

ON-SITE SURFACE WATER SAMPLING POINTS

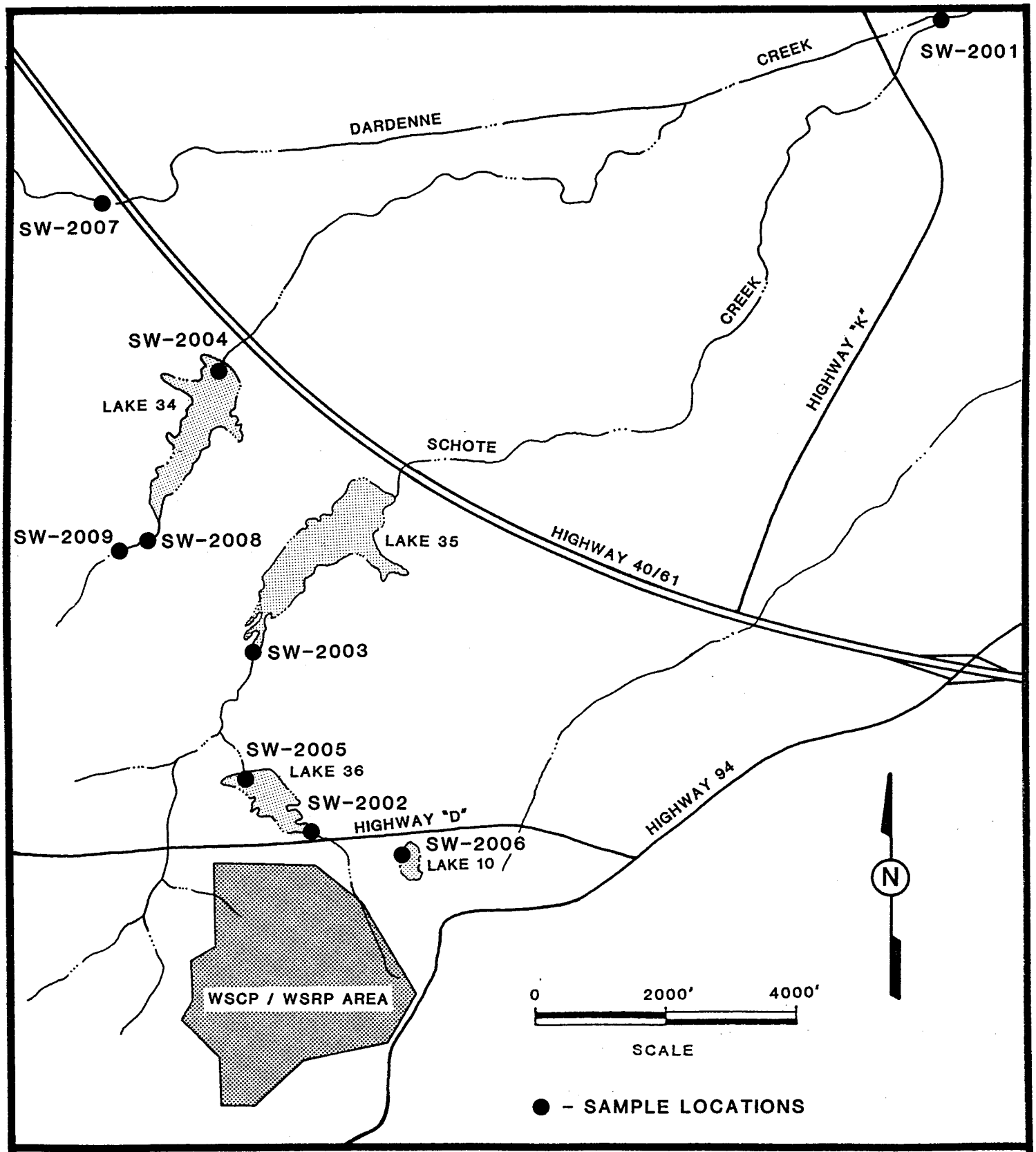


FIGURE 2-18

SURFACE WATER SAMPLING LOCATIONS NEAR THE WSS

is presented in Table 2-8. Samples will be collected concurrently with quarterly groundwater sampling to provide point-in-time comparisons of groundwater and surface water sampling results.

These locations include the five NPDES storm-water discharge points which are currently sampled monthly, nine locations currently sampled under the EMP, the four raffinate pits and Ash Pond. The analytical results will provide water quality information for streams draining the site (some of which lose water to the subsurface), springs discharging potentially contaminated groundwater, and on-site source areas.

Samples will be collected in accordance with procedures outlined in the WSSRAP SOPs.

Analytical parameters for surface water samples include: nitroaromatics, metals, inorganic anions and radionuclides. Parameters were selected based on the results presented in the Phase I Water Quality Assessment, known processes at the WSCP and previously collected data. Complete analytical parameters are presented in Table 2-9.

2.6 REGIONAL HYDROGEOLOGY AND WATER BALANCE

The U.S. Geological Survey (USGS) will perform studies of regional hydrogeology and water balance culminating in the development by the USGS of a three-dimensional regional groundwater flow model. Additional USGS efforts will focus on site-related water quality issues and will serve to provide third-party verification of WSSRAP efforts.

2.6.1 Regional Groundwater Flow and Water Balance

USGS studies will provide further refinement of regional hydrogeology as presented in previous USGS publications and

TABLE 2-8

PROPOSED SURFACE WATER SAMPLING LOCATIONS

SAMPLE NUMBER	LOCATION	RATIONALE
NP-001 to NP-005	NPDES outfall (5)	Assess off-site releases due to precipitation events
SW-2001	Dardenne Creek (at junction with Schote Creek)	Assess downstream water quality-receives groundwater discharge from vicinity of WSS
SW-2002	Schote Creek (downstream of WSCP immediately upstream of Lake 36)	Assess creek water quality - receives direct surface run-off from WSCP
SW-2003	Lake 35 (Busch Area-upstream side of bridge at head of Lake 35)	Assess lake water quality - receives direct surface run-off
SW-2004	Lake 34 (Busch Area, midpoint of dam)	Assess lake water quality - leaving lake to Dardenne Creek
SW-2005	Lake 36 (Busch Area, midpoint of dam)	Assess lake water quality - leaving lake to Schote Creek
SW-2006	Lake 10 (Busch Area, midpoint of dam)	Assess lake water quality
SW-2007	Dardenne Creek (at upstream side of Highway 40-61 bridge)	Establish background water quality upstream of WSCP
SW-2008	Burgermeister Spring	Assess water quality of spring discharge
SW-2009	Overflow Spring	Assess water quality of spring discharge

TABLE 2-8 (cont.)

PROPOSED SURFACE WATER SAMPLING LOCATIONS

SAMPLE NUMBER	LOCATION	RATIONALE
SW-2010	Ash Pond	Assess on-site water quality
SW-3001	Raffinate Pit 1	Assess potential source area
SW-3002	Raffinate Pit 2	Assess potential source area
SW-3003	Raffinate Pit 3	Assess potential source area
SW-3004	Raffinate Pit 4	Assess potential source area

TABLE 2-9

SURFACE WATER ANALYTICAL PARAMETERS

pH *
Temperature *
Conductivity *
Total Uranium (Natural)
Total Radium-226
Total Thorium-230
Gross Alpha
Gross Beta
Nitrate
Sulfate
Fluoride
Chloride
Nitroaromatics
CLP Metals

*Field Measurement

comprehensive water balance measurements. The USGS will combine these results with WSSRAP data obtained from the field programs outlined in Sections 2.2 through 2.5, to produce a regional groundwater flow model encompassing the shallow aquifer in the Burlington-Keokuk Formation, the leaky confining layer, and deep aquifers in the sequence from the St. Peter Formation through the Potosi Dolomite.

Potentiometric surface maps will be derived from water-level measurements in groundwater monitoring wells installed on-site by WSSRAP, from USGS monitoring wells located on the Busch Wildlife Area to the north of the site, and from various private wells around the site that are suitable for monitoring and sampling. These maps will extend beyond the immediate vicinity of the site covered by the WSSRAP potentiometric surface maps discussed above in Section 2.1.3.

Continuous water level recorders will be installed on six wells near the groundwater flow divide south, east, and northeast of the raffinate pits (Figure 2-19). Daily fluctuations in the groundwater levels will be correlated with precipitation, evapotranspiration, infiltration and barometric fluctuations in order to evaluate and determine the role of each of these factors on the water balance of the plant site. Also, data collected will be used to define the direction of groundwater flow. The locations of the six wells are subject to change as new data are received and analyzed from the drilling program.

Twelve aluminum infiltration tubes (2 3/8 inch OD) will be installed in various soils on the WSS and vicinity properties as shown on Figure 2-20 in order to measure soil moisture content. Use of a neutron probe is a nuclear method of determining moisture content and porosity of soil as described in Sections 2.4.1.2, 2.4.1.3 and 2.4.1.4.

The data that is obtained from neutron probe measurements will be

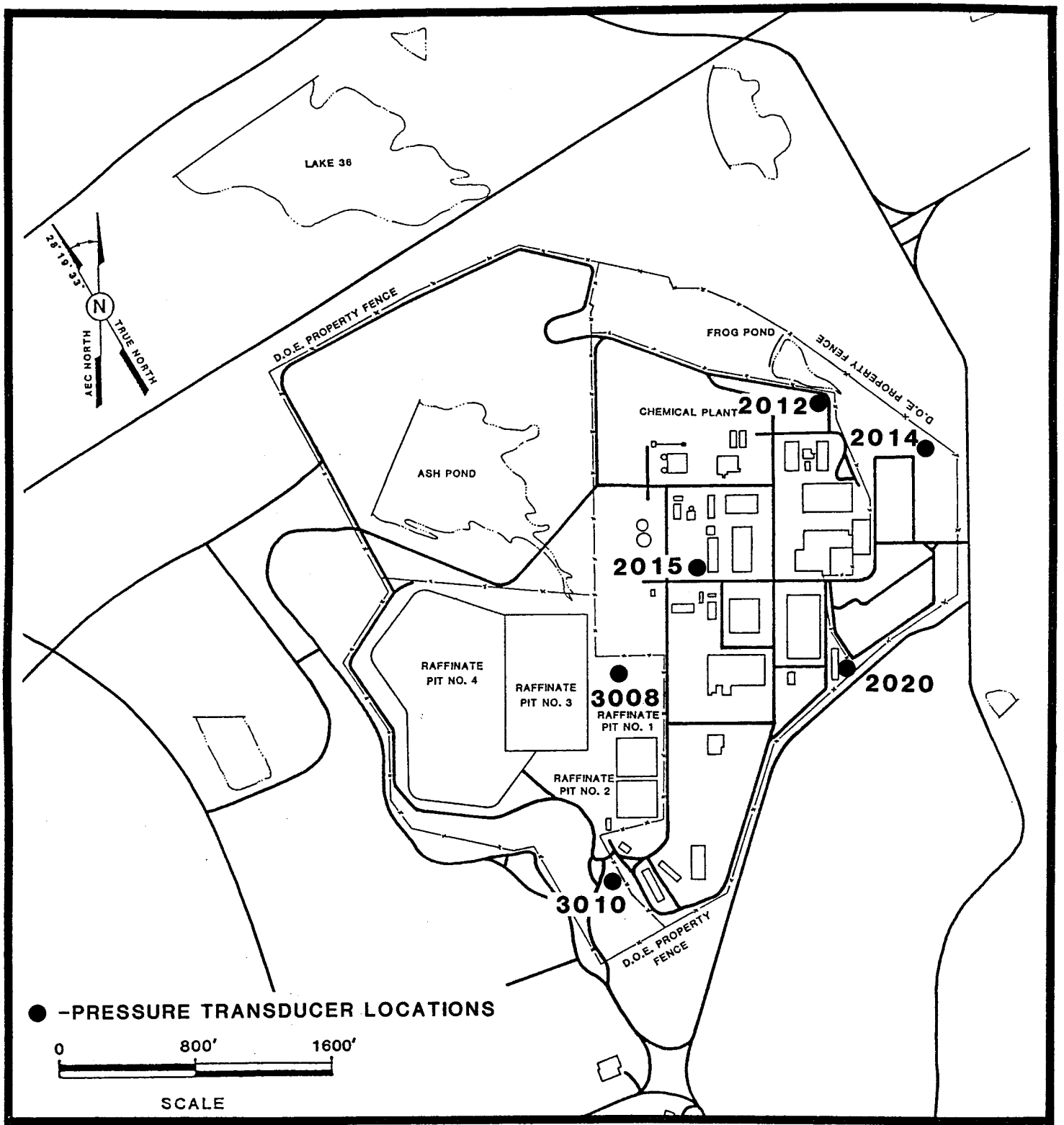


FIGURE 2-19

EXISTING MONITORING WELLS TO BE EQUIPPED WITH CONTINUOUS WATER LEVEL RECORDERS

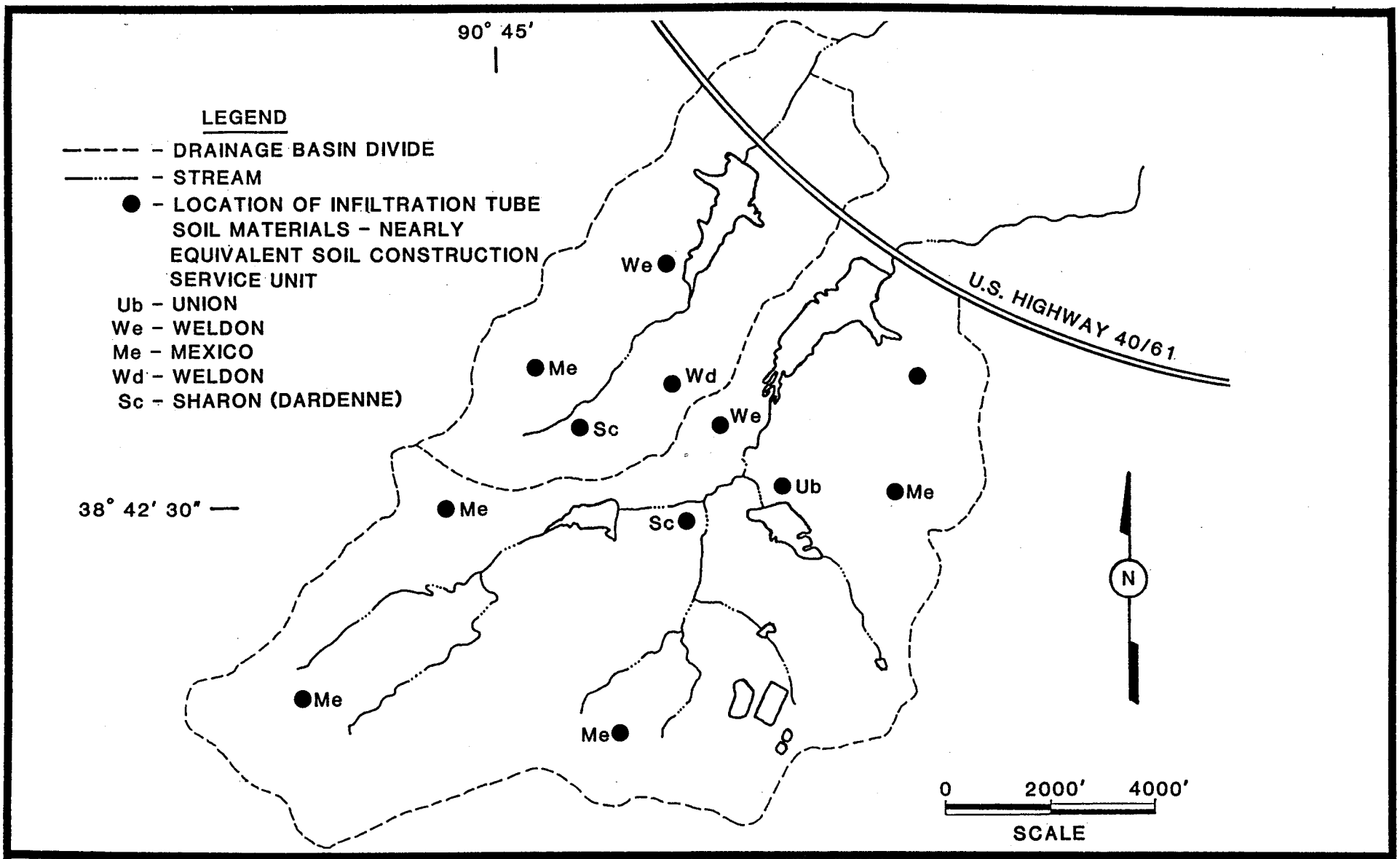


FIGURE 2-20

LOCATION OF INFILTRATION TUBES

used to monitor the saturation of unconsolidated overburden and provide an estimate of evapotranspiration. These data will allow an estimate of the quantity of water that infiltrates into the aquifers and, when compared with precipitation data, will assist with the determination of the water balance.

The regional groundwater flow study will include the installation of two clusters of deep monitoring wells by WSSRAP at the locations shown on Figure 2-21 in order to determine vertical gradients between the shallow and deep aquifers underlying the site. Water samples from various depths and aquifers will be analyzed to determine water quality differences. One well cluster will be located immediately south of the site near the groundwater flow divide. This location was selected to monitor vertical gradients near the groundwater flow divide, which will constitute a no-flow zone (at least in the Burlington-Keokuk Formation) in the regional groundwater model. The second well cluster will be located near Dardenne Creek which is at a lower topographic elevation and is considered to be a hydrogeologic boundary for shallow groundwater flow. Monitoring of vertical gradients at this location will help to determine the depth to which regional groundwater flow in the shallow aquifer, leaky confining layer, and deep aquifer is affected by discharge to Dardenne Creek. Comparison of differences in vertical gradients between the immediate vicinity of the site and Dardenne Creek will allow for accurate calibration of the regional flow model.

Each observation well cluster will consist of one well with the screened sector in the Burlington-Keokuk Limestone Formation at a depth of approximately 100 feet, one well with the screened sector in the Kimmswick Limestone Formation at a depth of approximately 300 feet, and one well with the screened sector in the St. Peter Sandstone Formation at a depth of approximately 700 feet. The cluster immediately south of the site will consist of two deep wells clustered with an existing monitoring well screened in the Burlington-Keokuk Formation (MW-4019). A

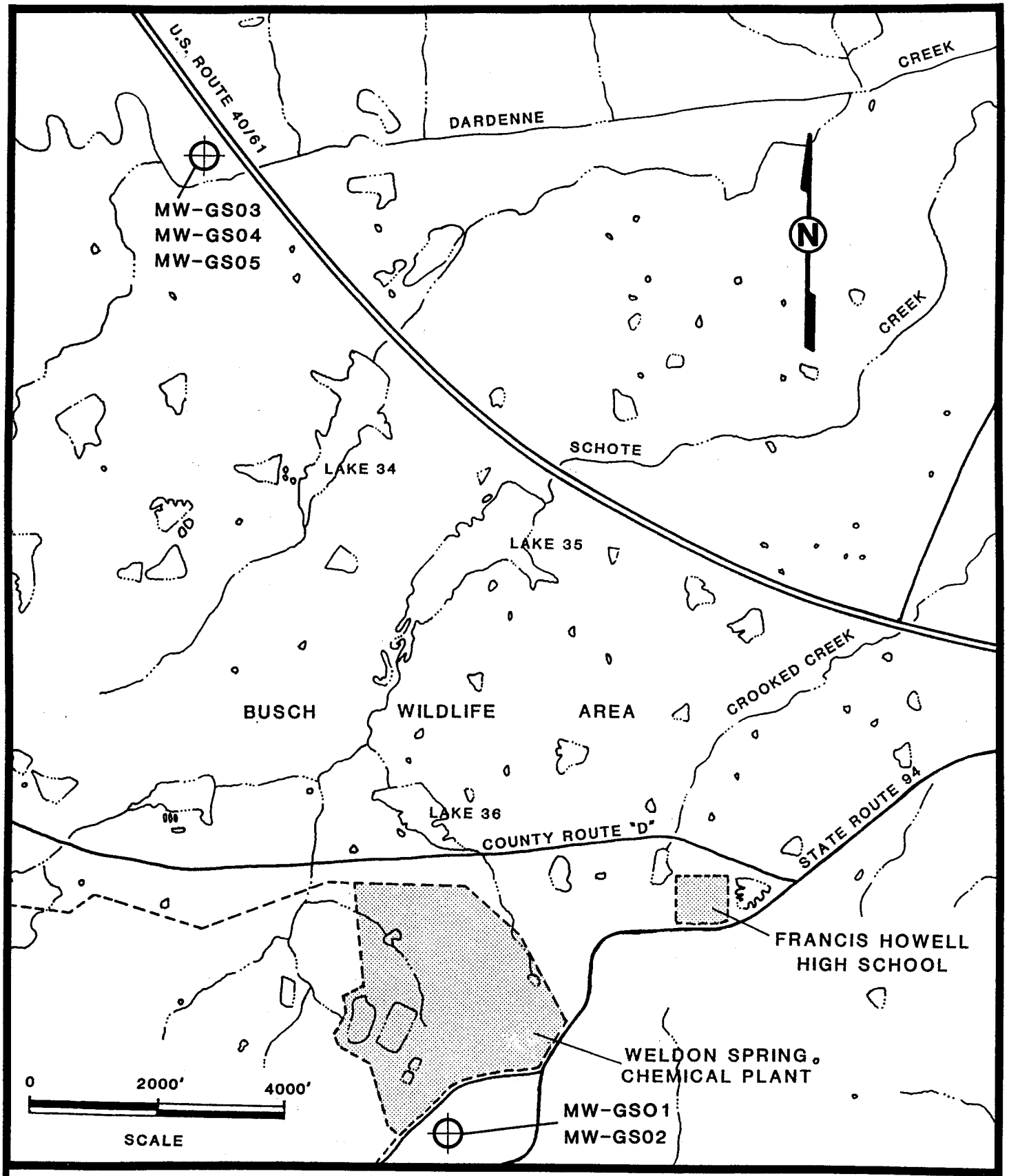


FIGURE 2-21

MONITORING WELL CLUSTER LOCATIONS

geologist will monitor drilling progress, collect rock samples from cores and drill cuttings and ensure compliance with WSSRAP Standard Operating Procedures.

Surface features that relate to groundwater accumulation, movement, or quality will be investigated in depth for the purpose of developing the groundwater flow model. Springs, seeps, losing stream segments, gaining stream segments, karst features in limestone bedrock, fractures, joints, geological structures and any additional phenomena which may become evident during the course of field efforts will be investigated for the purpose of determining effects on water balance and flow characteristics. This portion of the investigation will be performed in cooperation with the Missouri Department of Natural Resources, Division of Geology & Land Survey.

Remote sensing, aerial photographs, side-looking radar, infrared photography and other methods may be employed to delineate surface features. A field reconnaissance program will be conducted in order to locate and define these features and to quantify their effects.

Flow and discharge data from the continuously recording stream gauging stations currently in place on Schote Creek and the unnamed Dardenne Creek tributary which contains Burgermeister Spring will also be used in water balance studies.

Continuous discharge monitoring of Burgermeister Spring will permit comparison of the effects of various weather conditions on spring discharge and chemical quality. Surface water discharge will be compared with other monitored parameters including water table fluctuations, barometric changes, precipitation, temperature, humidity, evapotranspiration and infiltration.

Precipitation amounts will be measured during the spring, summer, and fall months with 19 catch rain gages located in the basins of

Schote Creek and the unnamed tributary that contains Burgermeister Spring (Figure 2-22). The total area of these two basins is about 4.6 square miles. Because of the variability of precipitation during localized thunderstorms during these months, these 19 rain gages are needed. During the winter when storms are regional in nature, the number of rain gages will be reduced to nine. Rainfall amounts will be calculated using both the isohyetal and Thiessen methods. The rainfall data will be used to accurately determine the amount of precipitation within these two basins for utilization in water balance calculation and groundwater flow modeling calibration.

The regional groundwater flow model will be constructed using the USGS 3-Dimensional Groundwater Flow Model (MOD). Vertical extent of the model will be from the surface (Burlington-Keokuk Formation) to the base of the Potosi Dolomite. Tentative horizontal boundaries are constant-head or constant-flow boundaries at the Missouri River and Dardenne Creek to the north and south and no-flow boundaries along major drainage divides to the east and west. Data used to construct the model will include the potentiometric surface and water balance data discussed above and aquifer testing data from WSSRAP efforts discussed above in Section 2.2.

2.6.2 Water Quality

USGS studies include both surface and subsurface water sampling. Water samples will be collected on a quarterly basis from USGS monitoring wells in the Busch Wildlife Area, selected private wells, and selected surface water locations. These data will be combined with WSSRAP data for a regional analysis. The statistical analysis of water quality data will form the data base for the description of the groundwater chemistry. The preliminary list of analytical parameters to be tested is presented on Table 2-10.

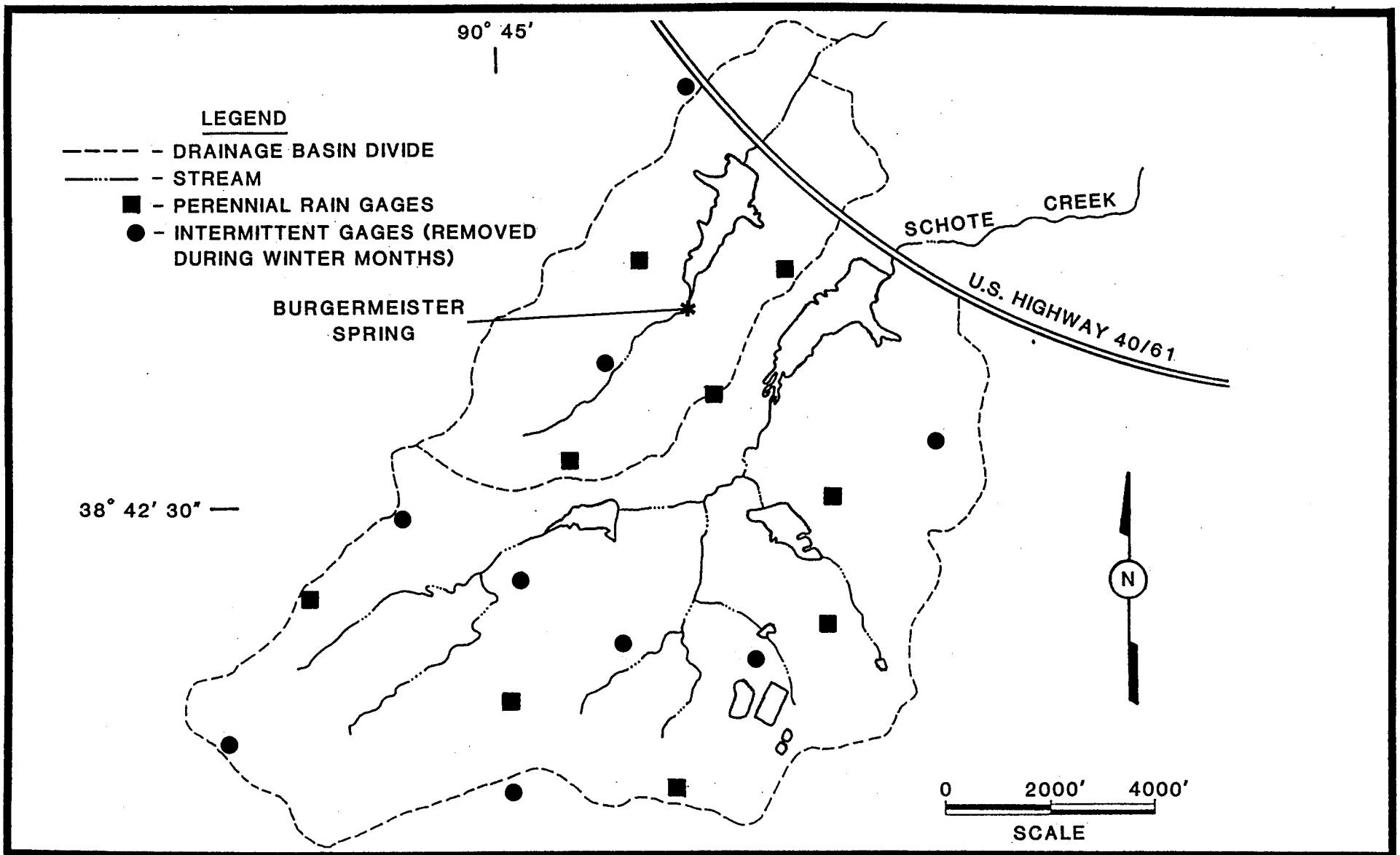


FIGURE 2-22

LOCATION OF USGS RAIN GAGES

TABLE 2-10

ANALYTICAL PARAMETERS FOR USGS WATER QUALITY STUDIES

Specific Conductance
pH
Temperature
Total Organic Carbon
Dissolved:

Calcium	Carbonate
Magnesium	Bicarbonate
Potassium	Sulfate
Lithium	Nitrate
Strontium	Chloride
Uranium	Fluoride
Radium-226	Solids
Sodium	

In addition to the listed parameters, samples will be analyzed for tritium, radium-228 and nitroaromatics on a one-time-only basis unless elevated concentrations are discovered. In the event of the identification of samples containing concentrations above background level, additional sampling and analysis would be conducted in order to further define the extent and concentration of the contaminants in the areas affected.

Continuously recording temperature and specific conductance monitors ("mini-monitors") were installed at Frog Pond, Ash Pond and Burgermeister Spring in 1987 (Figure 2-23). These monitoring sites will continue to be operated to determine how water quality varies with time, climatic conditions and remedial action activities conducted on the site.

The geochemistry of the natural unconsolidated overburden sediments on the site will be investigated in order to determine its effect on contaminant migration. Once the water balance has been determined, these data will be instrumental in determining the locations of contaminant plumes and predicting the direction and rate of plume migration.

2.6.3 Computer Modeling of Chemical and Mineralogical Balance

Geochemical models including WATER and BALANCE will be used in determining the normal chemical balance for groundwater underlying the Weldon Spring Site. WATER calculates the equilibrium distribution of inorganic aqueous species of both major and minor chemical elements. BALANCE defines and quantifies the reactions that will occur between groundwater and naturally occurring minerals in the aquifers.

Data required for these programs include aqueous chemistry and quantitative mineralogy. The aqueous chemical data will be derived from the analysis of the water samples collected from

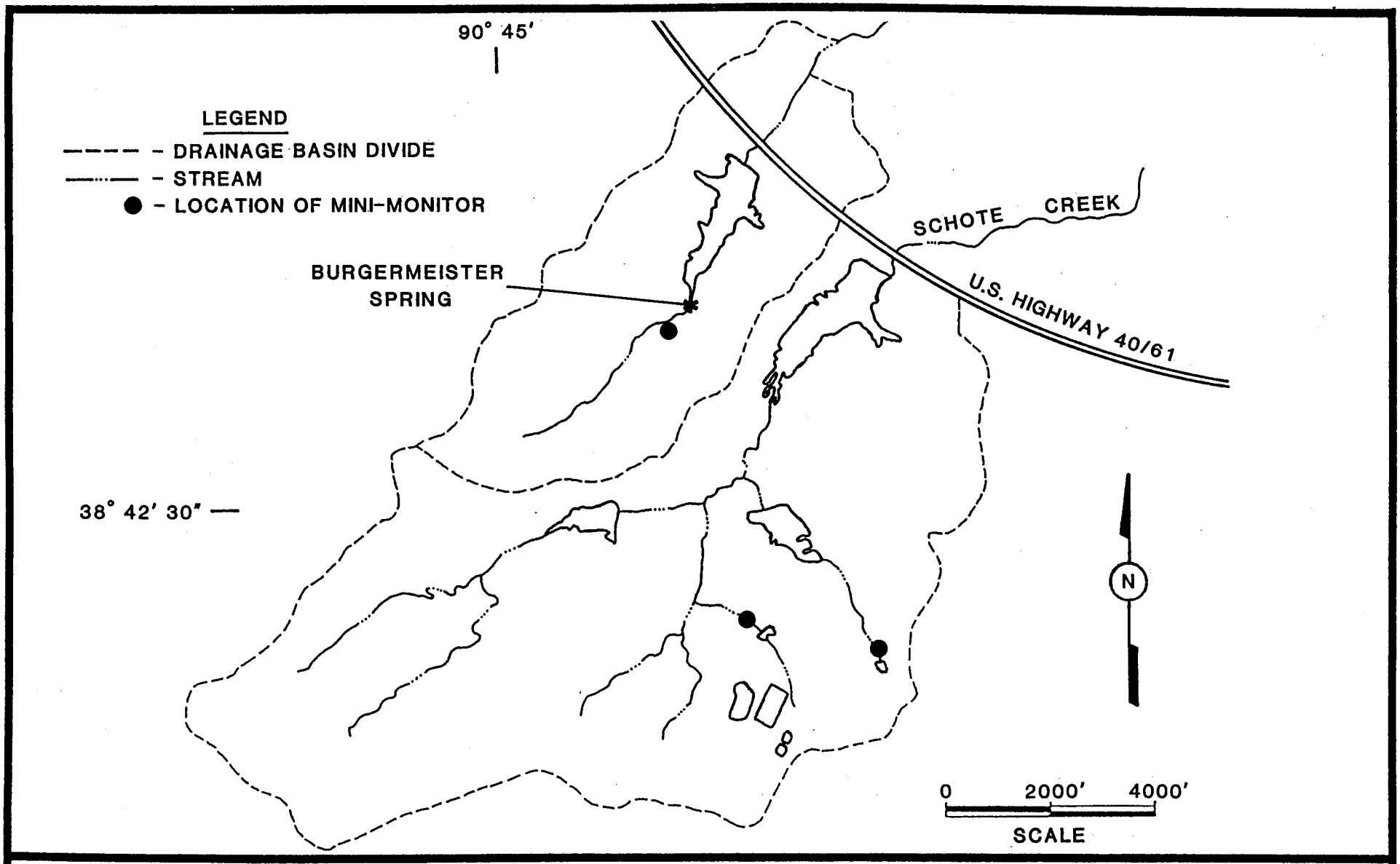


FIGURE 2-23

LOCATION OF USGS MINI-MONITORS

groundwater monitoring wells, and springs and streams on and near the site. The quantitative mineralogy will be determined from cores and overburden samples from wells drilled and trenches cut in both the unconsolidated overburden sediments and the bedrock formations underlying the Weldon Spring Site. The percent of clay minerals and non-clay minerals, as well as the types of clays present at the Weldon Spring Site will be determined. Soil samples will be collected from each of the soil horizons present at approximately a dozen locations distributed throughout the site. Mineralogic analyses will be performed by USGS laboratories.

2.7 COMPUTER MODELING OF GROUNDWATER FLOW SYSTEMS

Groundwater flow models will be developed in order to define and describe the flow regime in the shallow bedrock aquifer underlying the Weldon Spring Site and to predict contaminant migration in this flow regime. These models will be developed by the Department of Geological Engineering of the University of Missouri-Rolla in cooperation with WSSRAP staff. This site-specific modeling is designed to complement the regional modeling performed by USGS.

Models of unsaturated flow, groundwater flow, and contaminant transport will be calibrated to match the field parameters at the Weldon Spring Site. Statistical analyses including probability and uncertainty will be performed to establish reliability of the groundwater flow models.

2.7.1 Computer Programs

Three simulation programs have been chosen for the project because each has certain desirable properties that fit the groundwater flow system at the Weldon Spring Site. Use of these programs will help to identify groundwater flow direction and contaminant transport. The models include the following software:

- o A Modular Three-Dimensional Finite-Difference Groundwater Flow Model (MOD).

- o Saturated and Unsaturated Transport Flow Model (SUTRA).

- o Three-Dimensional Flow and Transport Model (SWIP).

MOD and SWIP are three-dimensional models and SUTRA is a two-dimensional model. Should new parameters arise during the course of field work which are not applicable to MOD, SWIP, or SUTRA, additional software is available to accommodate any additional parameters.

2.7.2 Model Design

Three basic steps are required for the general model design process including: (1) development, (2) calibration, and (3) verification. The development step involves the determination of which parameters are available from the compilation of field studies and which parameters must be derived during the process of calibration and tuning of the program to produce verifiable results.

Calibration is accomplished by modifying and adjusting the undefined parameters until the computed water levels match historical field water levels as measured during a discrete period of time. Unspecified aquifer parameters may include dispersivity, hydraulic conductivity, storativity and others. Field data will not provide perfect definition of all parameters. For some parameters the models will exhibit high sensitivity, while others will have minimal effect on model results. Sensitivity analysis is accomplished by slightly varying a single parameter while all other parameters are held constant. The variation may be repeated over differing typical ranges of a given parameter's value. Models which are essentially insensitive to a given parameter do not require

extensive field data. Models which are very sensitive to a given parameter may ultimately require both extensive and intensive field studies in order to adequately calibrate the computer model.

Verification is accomplished by employing a period of historical water level data which was not used in the model calibration process. The model is verified when the computed and measured water levels match. A poor match requires additional calibration until such time as repeatable verification can be established.

2.7.3 Model Application

Practical application of the computer modeling effort is divided into three separate phases based on the hydrogeologic conditions at the Weldon Spring Chemical Plant and Raffinate Pits sites.

- Phase 1 will focus on the contaminant transport in the shallow unsaturated zone using SUTRA which is a two-dimensional unsaturated transport model. This model will be calibrated and verified and the results will be used to predict recharge rates, which will be used to develop constant flow boundary conditions for use in Phase 2.

- Phase 2 will use MOD, a three-dimensional flow model, to predict contaminant transport in the saturated, fractured bedrock aquifer system. This aquifer will initially be modeled as an equivalent porous medium. The fracture system in this bedrock formation will ultimately be accounted for by imbedding high conductivity zones within the less conductive equivalent porous medium matrix. This model will be calibrated and verified and the results will be used in the development of the Phase 3 model.

- Phase 3 will evaluate contaminant transport along

vertical sections of the fractured and saturated bedrock aquifer using SWIP, a three-dimensional contaminant transport model. Results from Phases 1 and 2 will be used in the development of the Phase 3 model. The Phase 1 model will supply boundary data and the Phase 2 model will provide steady-state flow conditions, which are parameters necessary for the development of the Phase 3 contaminant transport model.

Parameters needed for the purpose of accurate model calibration include:

- o Vertical variation of soil contamination: This will be determined by soil sampling and analysis.

- o Flow characteristics in the unsaturated zone: This will be measured by neutron probes and tensiometers as discussed in Section 2.4.1.

- o Transmissivity in the fractured bedrock aquifer: Field methods for the determination of aquifer transmissivity by pumping tests are discussed in Section 2.2.2.

- o Major conduit forming fractures or fracture zones: The location, orientation and configuration of bedrock fracture systems will be determined through the integration and interpretation of all available subsurface surveys, both direct and indirect.

Open fracture systems will constitute the major controlling geological feature in any groundwater flow system in which they occur and must be incorporated into the flow model. The size and extent of such features should be mapped as accurately as possible. Aperture width, fracture spacing and the nature of any filling materials should be measured as accurately as practicable

within the limitations of the current prevailing field technology.

The final verified models will be used to evaluate the potential for significant contaminant migration in the shallow bedrock aquifer from the Weldon Spring Chemical Plant and Raffinate Pits sites to adjacent areas of beneficial use. The models will also be utilized in the planning, evaluation and development of various subsurface restoration/mitigation options that may be considered in future site remediation plans.

2.7.4 Model Uncertainty

Model uncertainty is an inherent quality that is directly related to the sophistication of the model design. The more variable parameters that are properly recognized, treated and manipulated in the model design, development and calibration, the more accurately the model will imitate the natural phenomena under investigation.

An important aspect of model uncertainty is the quality of the raw field data used as input to the modeling process. It is imperative that as many variable parameters as possible be identified and accurately measured in the field. Field investigations are an integral aspect of the program in progress at the site. Field research includes soil and water quality sampling from groundwater monitoring wells, water quality and discharge measurement from several surface streams and springs and continuous recording of water levels in several ponds and streams.

The additional groundwater monitoring wells installed during 1988 will better define areas of contamination and flow patterns (Section 2.1.1.2). Slug tests (Section 2.2) and pumping tests (Section 2.2.2) will be employed in the determination of hydraulic conductivity, transmissivity, storativity and anisotropy--parameters which will be utilized in the process of

calibrating the computer models.

A site-specific investigation of the fractured limestone bedrock aquifer will include the identification of controlling fractures, fracture zones and fracture systems. The fracture system will be studied by means of field identification, measurement and mapping, and analysis of aerial photographs and topographic maps. The effect of fractures on the groundwater flow regime will be determined by comparing the configuration of the piezometric surface of the shallow bedrock aquifer to the orientation of the individual components of the integrated fracture system. Direct comparisons of these parameters will help to clarify their relationship and interdependence within the shallow groundwater aquifer.

Statistical analysis of the field and laboratory data used as input to the models will give some quantification of parameter uncertainty. Simple analytical and numerical approaches may be used to evaluate the uncertainty of predictions of groundwater flow and contaminant transport predictions. The statistical analyses of input parameters (i.e., groundwater velocity, initial source concentration, etc.) will be used to qualitatively and quantitatively evaluate the reliability of predicted flow and concentrations at a particular location and time. These measures of uncertainty, though based on simplified solution models, will provide additional information for utilization in field data acquisition and planning of remedial actions.

3.0 DOCUMENTATION

All field activities performed by WSSRAP staff and subcontractors will be thoroughly documented by a combination of chronological field notes encompassing all field activities, photographs of field activities, and data forms for drilling, well installation, specific sampling activities and field measurements. Field activities performed by other governmental agencies (Missouri Department of Natural Resources--Division of Geology and Land Survey and U.S. Geological Survey) will be documented under procedures established by those agencies.

3.1 FIELD NOTEBOOKS

During the course of monitoring-well installation and development, pumping-test-well installation and development, field implementation of unsaturated zone monitoring instruments, and aquifer testing, a designated field geologist or engineer will record daily activities in a permanently bound, waterproof and paginated notebook. Entries in this notebook will include:

- The date
- Weather conditions
- All personnel involved, including subcontractor and governmental agency personnel
- Chronological record of the day's activities. A description of each activity, and the time (24-hour clock) will be entered. Any measurements or other information that are not recorded on designated field forms will be recorded in the field notebook.

All entries will be made in waterproof ink. When errors are made, they shall be crossed out with a single line and initialed by the designated field geologist or engineer. The field geologist or engineer will sign the notebook at the end of each day.

3.2 PHOTOGRAPHS

Photographs will be taken of representative activities for each hydrogeologic subtask. Photographs will be taken of activities at each stage of each subtask: installation, sampling, logging of core, testing, measurements, etc. Log entries will be made in the field notebook that identify the location and activity depicted in each photograph. Each entry into the field notebook photographic log will include the name of the photographer, the date, the location, description of activities, and identity of each person in the photograph. Photographs will be retained in WSSRAP Document Control.

3.3 FIELD FORMS

Field data forms have been developed for borehole logging, well installations, well development, and sampling activities under this Hydrogeologic Sampling Plan. Instructions for completing each form are included in the WSSRAP Standard Operating Procedure (SOP) for each activity. A brief description of the information to be documented on each form is presented below.

3.3.1 Borehole Logging

This subsection presents a description of the documentation procedures for borehole logging activities at the WSSRAP. Borehole logs are used to keep a detailed record of drilling and exploratory excavations on a prepared form, and include geological descriptions of both soil and rock.

A borehole log form (Figure 3-1) will be used when drilling in both soils and rock. The following information will be entered on the heading of each log sheet:

- Boring or well number
- Location

WELDON SPRING SITE REMEDIAL ACTION PROJECT
BOREHOLE LOG

PAGE _____ OF _____

SITE ID: _____ LOCATION ID: _____
SITE COORDINATES (FT.): _____
N _____ E _____
GROUND ELEVATION (FT. MSL): _____
DRILLING METHOD: _____
DRILLING CONTR.: _____
DATE STARTED: _____
DATE COMPLETED: _____
FIELD GEOLOGIST/ENGINEER: _____

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (FT.)

LOCATION DESCRIPTION _____
_____
SITE CONDITION _____
_____

DEPTH	SAMPLE INTERV.	SAMPLE RECOV.	CPM (OPT.)	BLOWS PER 6 IN.	N VALUE	VISUAL CLASSIFICATION

COMMENTS: _____
_____
_____
_____

FIGURE 3-1: WSSRAP BOREHOLE LOG

- Elevation
- Name of drilling contractor
- Drilling method and equipment
- Water levels
- Start and finish (time and date)
- Name of geologist/engineer responsible for logging
- Description of site conditions

The following technical information is recorded on the logs:

- Depth of sample below surface
- Sample/core interval
- Length of sample recovered
- Counts per minute (cpm) as recorded by a Geiger-Mueller Pancake Detector (optional - used in areas with potential radiological contamination)
- Standard Penetration Test (ASTM-D1586) results as applicable
- Visual classification containing a soil or lithologic description
- Total depth of the borehole

All pertinent observations about drilling rate, equipment operation, or unusual conditions will be recorded.

Soil descriptions will be in accordance with the Unified Soil Classification System (USCS) as described in ASTM D 2487-69 (1975) and should stress major constituents and characteristics. The following format for soil descriptions will be used:

1. Soil name
2. Gradation or plasticity
3. Particle size distribution
4. Color
5. Moisture content

6. Relative density or consistency
7. Soil texture and structure
8. Relative permeability
9. Local geologic name
10. USCS classification

Rock descriptions will include the following:

1. Lithology and texture
2. Color
3. Hardness
4. Weathering
5. Grain size
6. Description of bedding and/or jointing
7. Discontinuity descriptions
8. Local geologic name
9. Percent recovery of core
10. RQD of core samples

3.3.2 Well Completion Diagrams

A monitoring-well completion diagram (Figure 3-2) will accompany each monitoring well installed. The form will contain the following information:

- Well number
- Location
- Geologist or engineer
- Well installation date
- Drilling contractor

Monitoring-well construction details to be included on the diagram are as follows:

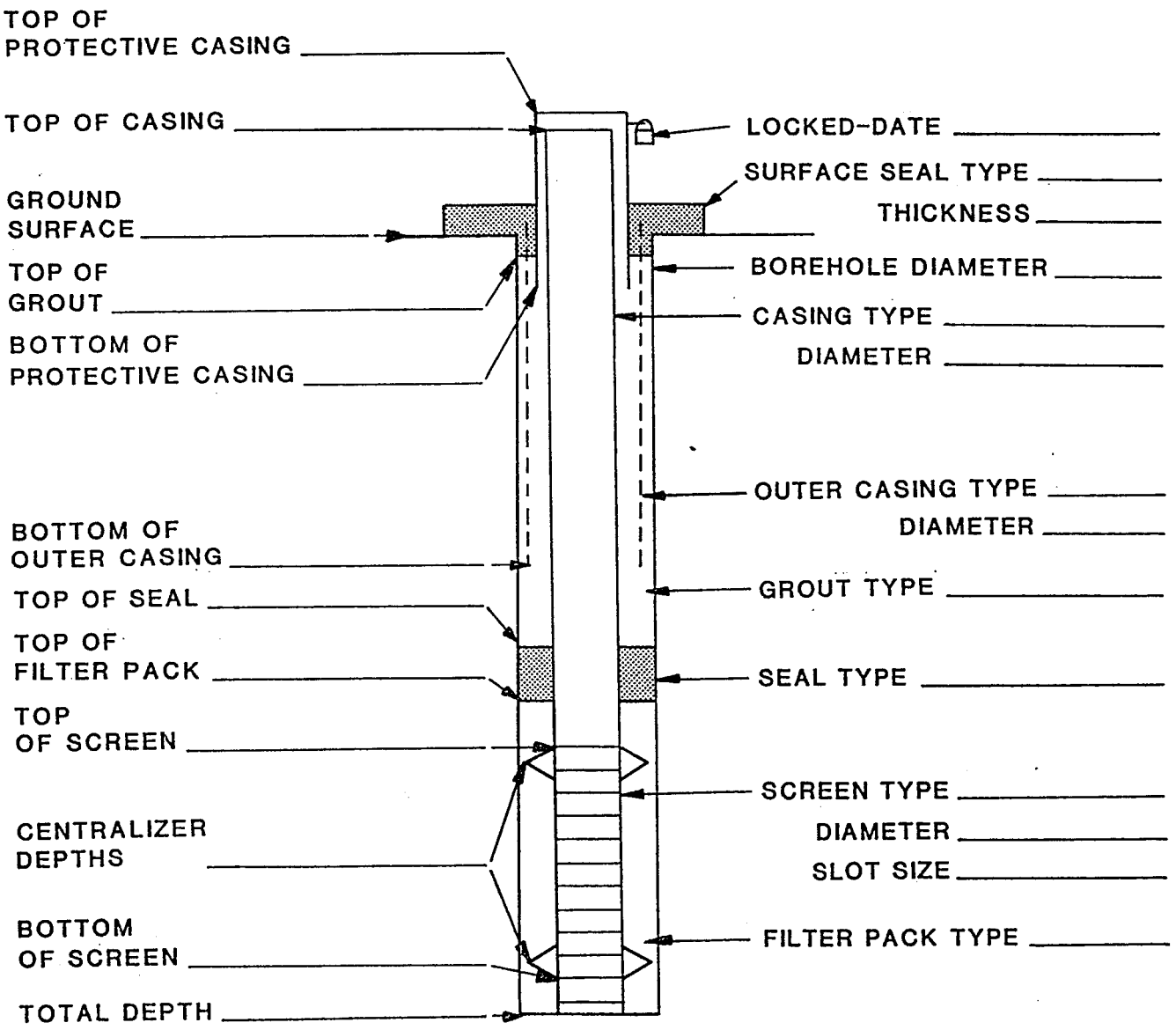
- Borehole diameter
- Casing dimensions and type

WELDON SPRING SITE REMEDIAL ACTION PROJECT

WELL COMPLETION RECORD

WELL NUMBER _____ DATE INSTALLED _____

PMC REPRESENTATIVE _____ DRILLER _____



COMMENTS _____

PMC REPRESENTATIVE SIGNATURE _____ DATE _____

FIGURE 3-2: WSSRAP WELL COMPLETION RECORD

- Screen length and slot size
- Filter pack interval
- Seal details
- Grout type and interval
- Elevations (top of casing, ground surface)
- Stick-up of well casing above ground surface
- Protective casing details

3.3.3 Well Development

Well development entails surging, pumping, and/or bailing of wells in order to restore the natural hydraulic conductivity, remove foreign sediment and fluids introduced during drilling, and to assure collection of representative groundwater samples for water quality analyses.

A well development form (Figure 3-3) will be filled out upon completion of development for each well. The form will contain the following information:

- Water levels (static and final) measured to the nearest one-hundredth foot (0.01')
- Well depth measured to the nearest one-tenth foot (0.10')
- Well volume (casing and filter pack)
- Beginning and ending times recorded in a 24-hour clock format
- Description of water conditions (i.e., clarity, color, and description of sediments)
- pH
- Water temperature
- Specific conductance
- Comments (e.g. pumping rates, duration of surge and pump sequences, variations in flow/recharge rates, etc.)
- Total volume removed

WELDON SPRING SITE REMEDIAL ACTION PROJECT
WELL DEVELOPMENT FORM

PAGE _____ OF _____

WELL NUMBER _____ DATE _____

FIELD PERSONNEL _____

STATIC WATER LEVEL _____ TOTAL DEPTH _____

WELL VOLUME (CASING AND FILTER PACK) _____

DEVELOPMENT METHOD(S) _____

_____

BEGINNING TIME _____

INITIAL WATER CONDITIONS _____

_____

_____

RECHARGE RATE _____

END TIME _____

TOTAL VOLUME REMOVED _____ GALS.

TOTAL WELL VOLUMES REMOVED _____ GALS.

FINAL TURBIDITY MEASUREMENT _____ NTU

FINAL WATER LEVEL _____ FINAL DEPTH _____

COMMENTS _____

_____

_____

PMC REPRESENTATIVE SIGNATURE _____ DATE _____

FIGURE 3-3: WSSRAP WELL DEVELOPMENT FORM

- PMC Representative (field geologist or engineer) signature

The completed well development forms will be given to the project hydrogeologist or designee who will maintain a file on each monitoring well.

3.3.4 Sample Documentation

Standard sample handling and chain-of-custody documentation will be employed and maintained for all surface, vadose zone and groundwater samples collected for WSSRAP.

Sample documentation will include field data sheets (Figures 3-4 thru 3-6) and preprinted container labels (Figure 3-7).

The sampling team leader (WSSRAP environmental technican) will be responsible for all documentation. All documentation will be filled out with pens containing waterproof ink. The field data sheets will be completed at the time of sample collection. The field data form for groundwater sampling will include the following information:

- Monitoring well number/Sample number
- Date
- Sampling personnel
- Static water level
- Well volumes purged
- Water conditions
- Temperature
- pH
- Conductivity
- Time of sample collection
- Fractions collected

WELDON SPRING SITE REMEDIAL ACTION PROJECT (WSSRAP)
Route 2, Highway 94 South, St. Charles, MO 63303
Telephone (314) 441-8086 Telecopy (314) 447-0803

GROUNDWATER SAMPLING FIELD DATA FORM

WELL # _____ DATE: _____

SAMPLE TYPE: R D FB JB DIB PERSONNEL: _____

_____

TIME _____

_____ WELL SECURE YES NO TOTAL DEPTH _____ FT.

_____ STATIC WATER LEVEL _____ FT.

LENGTH OF WATER COLUMN _____ FT.

DIAMETER OF WELL 2" 4" 6"
VOLUME OF WATER COLUMN
.16L FOR 2" .65L FOR 4" 1.5L FOR 6" _____ GAL.

_____ BEGIN EVACUATION/RATE _____

RATE OF RECHARGE V. SLOW SLOW MOD. FAST V. FAST

_____ NUMBER OF VOLUMES REMOVED: _____

_____ TEMPERATURE _____

pH _____

CONDUCTIVITY _____

WATER CONDITIONS _____

_____ COMPLETED SAMPLING

_____ TEMPERATURE _____

pH _____

CONDUCTIVITY _____

_____ FINAL WATER LEVEL _____ FT.

ANTECEDENT CONDITIONS:

FIGURE 3-4: WSSRAP GROUNDWATER SAMPLING FIELD DATA FORM

WELDON SPRING SITE REMEDIAL ACTION PROJECT (WSSRAP)
Route 2, Highway 94 South, St. Charles, MO 63303
Telephone (314) 441-8086 Telecopy (314) 447-0803

SURFACE WATER SAMPLING FORM

Sample Number: _____

Location: _____ Date: _____

Personnel: _____

_____

Type of surface water: Lake Stream Outfall River Other ____

Flow Estimate: _____

Method of Estimation: _____

Time _____

_____ Collect Sample Type: _____

_____ pH _____

Temperature _____

Conductivity _____

Diagram:

FIGURE 3-5: WSSRAP SURFACE WATER SAMPLING FORM

WELDON SPRING SITE REMEIDAL ACTION PROJECT

SPRING AND SEEP WATER SAMPLING FIELD SHEET

Sample Number: _____

Location: _____ Date: _____

Sampling
Personnel: _____

_____

Type of feature: Spring, wet weather, Seep, Other _____

Flow Estimate: _____

Method of Estimation: _____

Time:

_____ Collect Sample Type: _____

_____ pH _____

Temperature _____

Conductivity _____

No. of Containers

1 gal plastic _____
1 gal amber _____
VOA vials _____
Other _____
_____

Parameters _____

_____

Field Filtered Yes ____ No ____

Field Preserved Yes ____ No ____

Diagram/Comments:

FIGURE 3-6: WSSRAP SPRING AND SEEP WATER SAMPLING FIELD SHEET

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample Number:

Location: WSCP / WSRP / WSQ / WSVP
Parameter:
Matrix:
Collected By:
Date: Time:

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample Number:

Location: WSCP / WSRP / WSQ / WSVP
Parameter:
Matrix:
Collected By:
Date: Time:

FIGURE 3-7: WSSRAP PREPRINTED LABEL FORMS

All original field data forms will be retained in the project files.

3.3.5 Sample Packaging, Labeling and Preservation

All samples will be transferred into the appropriate bottles (Table 2-3) with Teflon-lined caps. Bottles and caps are supplied and decontaminated prior to use by an approved laboratory. Each container will have a preprinted label. The label is marked with a unique serialized number and the parameter(s) to be analyzed are identified on it. After labeling, the sample containers will be placed on ice in a secured cooler.

All samples will be packaged, labeled and preserved according to standard U.S. EPA Region VII procedures and Department of Transportation regulations as required in 49CFR.

3.3.6 Chain-of-Custody

The WSSRAP standard Chain-of-Custody form (Figure 3-8) will accompany a sample or group of samples as custody of the sample(s) is transferred from the original custodian to subsequent custodians. The custody record will provide the necessary information to cross-reference the sample number to the specific sampling location and will provide the date of collection as well as documentation of custody. Detailed components and procedures are described in the Groundwater Sampling SOP (ES&H SOP #4.01.01). The samples obtained by the field sampling team will be picked up by a laboratory courier on a daily basis. The field sampling team will offer a completed chain-of-custody form for signature to the sample receiver and will retain a copy of the completed form. Chain-of-custody procedures are applied to all samples collected for site characterization as described in Section 6.0 of the QAPP. Copies

WELDON SPRING SITE REMEDIAL ACTION PROJECT (WSSRAP)
Route 2, Highway 94, St. Charles, MO 63303
Phone (314) 441-8086 Telex (314) 447-0803

ENVIRONMENTAL SAMPLE CHAIN OF CUSTODY FORM

WSSRAP Contact: _____ WSSRAP File NO.:_____
Phone Extension: _____ Date Samples: _____
Laboratory Receiving Samples:_____

Sample Number	No. of Containers	Description	Parameters	Turnaround Time Required

Samplers' Signatures: _____

Relinquished by:	Received By:	Date	Time	Reason for Transfer

Figure 3-8: WSSRAP ENVIRONMENTAL SAMPLE CHAIN OF CUSTODY FORM

of all chain-of-custody forms will be maintained in project files at WSS.

3.4 COMPUTER DATA BASE

A large amount of data will be generated during site characterization. Those field measurements and other data collected and analyzed during the hydrogeologic investigation will be reduced for input into the computerized data base maintained by the WSSRAP Environmental, Safety, and Health Department. The data will include logs, tracking forms, and results of laboratory analyses. Computer software is protected and documentable.

4.0 DATA ANALYSIS

4.1 INTRODUCTION

All data collection activities are in accordance with the Data Quality Objective (DQO) process as defined in EPA 540/G-87/003. The three-stage DQO process ensures that data collected are sufficient and of adequate quality for their intended uses. A major component in the Stage 1 DQO process will be the review and analysis of measurement data collected in the RI and those data collected during prior investigations.

A conceptual model has been constructed, with the utilization of existing data, in accordance with the Stage 1 DQO development process. This model, with known and potential sources, migration pathways, and receptors, has been described in Section 1.3 of this sampling plan. The Stage 1 process also recommends the delineation of specific objectives and goals of the investigative program. These are presented in Section 1.0.

Other sections in this plan address the subsequent stages of the DQO process. For example, Stage 2 components include:

- Delineation of specific objectives (Section 1.0)
- Identification of data uses and needs (Section 1.4)
- Identification of data quantity and quality needs (Section 2.0)
- Approach to sampling and analysis, including testing devices and procedures (Section 2.0 of this plan; WSSRAP and laboratory procedures manuals

Stage 3, the data collection process, is described in detail in Section 2.0.

Precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters are major considerations of the

DQO process for: reviewing and evaluating data (Stage 1); defining sampling options (Stage 2); and establishing goals for the Stage 3 data collection or sampling program.

Data adequacy, i.e. data validity and data sufficiency, then, is established after consideration of PARCC parameters. The quality of data is assured for PARCC by adherence to SOPs and utilizing external measures of quality. Data validation work tasks are considered by EPA to be a component of the sample analysis. EPA approved and/or best available methodology is used for data quality assessment.

Data collected under Stage 3 of the DQO process will be compiled, subjected to the Quality Assurance/Quality Control (QA/QC) element evaluations, incorporated initially into the conceptual model and ultimately to meet remedial action objectives of the study, into computer models. With the input of detailed chemical and physical hydrogeologic data, the models will allow for an evaluation of contaminant flow and transport mechanisms, and will permit a definition of the extent of contaminant plume migration as a function of time.

4.2 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance (QA) on the Weldon Spring project is in accordance with EPA guidelines and is defined as the total integrated program for assuring the reliability of monitoring data. Quality control (QC) is the routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process (U.S. EPA, 1980). The DQO process developed by EPA (March 1987) stipulates requirements for the preparation of a Quality Assurance Project Plan (QAPP). The process relies upon the incorporation of the 16 QA elements in the QAPP, Standard Operating Procedures (SOPs) and other documents, e.g., laboratory analytical methods and CLP procedures. Table 4-1 presents, in accordance with the DQO

guidelines, the 16 QA elements and a reference to those documents that address QA issues which are applicable to this plan.

The DQO staged process has been addressed in the QAPP (Section 2.0). The overall objective of the data collection stage is to ensure that all data used to support decisions made by DOE meet the requirements imposed by federal and state agencies.

The quality assurance (QA) program is conducted for both routine environmental monitoring and characterization activities and is composed of two components: field and analytical QA evaluations.

The field QA program for field activities includes the following:

- Preparation of site-specific sampling plans and sampling procedures for collection of all environmental samples
- Annual audit of all field procedures with follow-up corrective action programs, if required
- Proper documentation of sample collection including sample collection forms, field notebooks and chain of custody records
- The routine collection and analysis of QC blanks including trip blanks and equipment blanks

The analytical QA program for laboratory analyses makes use of a number of different types of quality control samples to document the validity of the data generated. These samples include:

TABLE 4-1

QUALITY ASSURANCE PROJECT PLAN ELEMENTS AS RELATED TO WSSRAP HYDROGEOLOGIC INVESTIGATIONS SAMPLING PLAN (HISP)

QAPP Elements	Information Provided In
1. Title Page	HISP
2. Table of Contents	HISP
3. Project Description	QAPP
4. Project Organization and Responsibility	QAPP
5. Quality Assurance Objectives for Data Measurement	QAPP HISP
6. Sampling Procedures	SOPs HISP
7. Sample and Document Custody	HISP QAPP SOPs Analytical Methods/Detection Limits (Laboratory Procedures Manual)
8. Calibration Procedures	SOPs Analytical Methods/Detection Limits QAPP
9. Analytical Procedures	Analytical Methods/ Detection Limits
10. Data Reduction, Validation, and Reporting	HISP QAPP SOPs
11. Internal Quality Control	HISP QAPP SOPs Analytical Limits/ Detection Methods
12. Performance and System Audits	QAPP

TABLE 4-1 (cont.)

QUALITY ASSURANCE PROJECT PLAN ELEMENTS

QAPP Elements	Information Provided In
13. Preventive Maintenance	QAPP SOPs Analytical Limits/ Detection Methods
14. Specific Routine Measures Used to Assess Data Precision	SOPs HISP QAPP
15. Corrective Action	QAPP
16. Quality Assurance Reports to Management	QAPP

- Method Blanks (one per batch, batch not to exceed 20 samples). Method blanks contain all the reagents used in the preparation and analysis of samples to assess contamination rising from reagents, glassware and other materials used in the analysis.

- Laboratory Control Samples/Spiked Blanks (LCS - one per batch, batch not to exceed 20 samples). These samples are prepared by adding known quantities of compounds of interest to deionized water and are used to establish that an instrument or procedures were controlled.

- Calibration Check Samples (as needed, or per method). Calibration standards are periodically used to verify that the original calibration is still valid.

- Duplicate and Spike Samples (5% duplicate; 5% spike). Analysis of duplicate samples is performed to enable an estimate of the precision of the analytical procedures. Spike samples are measured to determine the accuracy of the analytical procedure and access matrix effects. For analyses conducted according to the Contract Laboratory Program (CLP) methodology, these controls are termed matrix spike and matrix spike duplicate samples.

- Blind QC Samples (one per 20 samples). Blind QC samples are inserted into the sample load in a fashion unrecognizable to the laboratory analyst. These samples, in addition to the standard duplicate sample analysis discussed above, are used to assess analytical precision.

- EPA Laboratory Performance Evaluation (PE) (Annually). In order to assess overall performance of the primary analytical laboratory, spike samples are submitted annually by EPA Region VII to the PMC primary laboratory.

- o Interlaboratory Evaluation (Annually). In order to assess comparability of data, sample splits are shipped to different laboratories to provide a measure of analytical or method bias.

The specific monitoring activities include surface water and groundwater analyses for various organic, inorganic, and radioactive species.

These quality control measures are to assure that data collected from project sampling tasks are valid and meet the highest practical attainable level of precision and accuracy. These criteria, combined with the adherence to representativeness, completeness, and comparability requirements and guidelines (Section 4, QAPP) will allow for an accurate characterization of the site and the evaluation and delineation of remedial measures. The QA objectives for the hydrogeological characterization program will be met, in part, by the use of periodic audits of field sampling and laboratory analysis activities. The results of audits and technical quality control procedures, as well as other program QA documentation and reports described in this plan will be maintained to meet DOE and EPA requirements.

4.3 RI PLAN ELEMENTS

4.3.1 Groundwater Monitoring Well Network

Monitoring data gathered to date indicate the presence of a groundwater divide beneath the site. Sulfate, nitrate, nitroaromatics and uranium contaminant plumes have been identified. Data gathered in the future from monitoring wells will be used to refine the conceptual model, and the groundwater contour, contaminant plume, and isopleth maps of the WSS. Additional monitoring data will further define contaminant source and recharge areas and flow directions, and will delineate the

extent of vertical and horizontal migration of contaminants.

4.3.2 Aquifer Testing

Data generated from the aquifer testing program described in Section 2.2 of this sampling plan will be analyzed by the use of commonly applied analytical formulae and computer programs. These data, displayed on a series of matching curves, graphs, tabulations and computer print-outs will be incorporated into conceptual and computer models, superimposed on or compared with groundwater contour and contaminant plume maps to determine the degree, extent, and impact of groundwater contamination. The data interpretation process will likely include the preparation of maps and cross-sections to depict anisotropy, zones of primary and secondary hydraulic conductivity, and other aquifer characteristics.

4.3.3 Bedrock Hydrogeology

Data gathered during the aquifer testing program will be expanded with the inclusion of hydrogeologic data gleaned from published geologic and environmental reports and maps from federal, state, and local agencies (e.g. USGS, MDNR, St. Charles County, and others) and from previous site studies. These data, and additional information gathered from planned soils, geological, geophysical, and hydrogeological investigations, will be reduced and compiled in the form of tabulations, maps, stratigraphic sections, cross-sections and drawings. These data will be used as additional components of the models to illustrate the extent and nature of fractures and jointing, weathering, structural and lithologic features, solution channels and other bedrock characteristics common to a karstic environment, and to define recharge and source areas.

4.3.4 Overburden Hydrogeology

This sampling plan describes the methods to be implemented to further characterize these zones. The vadose-zone monitoring operations in the overburden, sampling of soil for chemical and physical parameters, definition of perched groundwater zones, and soil attenuation studies will provide data which, upon analysis, will allow for the description of: 1) contaminant source areas; 2) the extent of overburden contamination migration routes; and 3) the rate of contaminant migration. Also the ultimate fate of contaminants can be predicted and possible remedial measures can be assessed. This characterization effort will also provide data for the determination of a suitable site for a disposal cell--a remedial action under consideration at the WSS.

4.3.5 Surface Water

Groundwater recharge and contaminant source studies coupled with a detailed hydrological and climatological study will provide data for conceptual and computer models. These models will allow for a better understanding of the water balance, description of surface water and contaminant flow from the site and area drainageways, and the identification of potential receptors of contaminants, e.g. Busch Wildlife Lakes, area ponds and streams, and springs and seeps resulting from the interaction of surface and groundwater flow mechanisms. Surface drainage features and facilities plotted on topographic and geologic maps will also allow for the consideration of ERA's (IRA's) to preclude further contaminant migration. Sludge and sediment samples collected from lakes, creeks and ponds can, upon analysis, provide a further understanding of source areas.

4.3.6 Other Analyses

Supplemental hydrogeological studies may include biological, chemical and geochemical, climatological and meteorological and

other research or field studies necessary to fulfill the objectives of the RI. The DQO process provides a framework for data collection under the RI program and evaluation of data in accordance with Stage 1 DQO guidelines. The field data collection program delineated in Section 2.0 is intended to provide sufficient, valid hydrogeologic data to characterize the site and meet stated objectives.

4.4 DATA SYNTHESIS

All data analysis efforts are directed to the development and refinement of the site conceptual model. These data will include source characteristics, the nature and extent of contamination, contaminant migration and transport mechanisms, and environmental and health impact. In this process, quantitative results will be applied to the conceptual model.

The models, with accompanying maps, tabulations, cross-sections, graphs, logs and other back-up data will, in accordance with EPA's RI/FS guidelines, allow for the description of: 1) the environmental setting of the site, e.g., surface features, soils, geology, hydrology, meteorology, and ecology; 2) source location, types, quantities, and concentrations of contaminants; 3) the nature and extent of contamination; and 4) an analysis of contaminant fate and transport.

The type of models to be used will be ascertained upon receipt of data and after its incorporation into existing simplified models which will dictate the need for, and the selection of, more complex analytical or numerical models.

With the acquisition, analysis, and synthesis of additional data gathered under this and other work plans, the concurrent FS will proceed with the development and refinement of remedial measures in accordance with the phased RI/FS approach as mandated by CERCLA/SARA.

4.5 HYDROGEOLOGIC CHARACTERIZATION REPORTING

The results of analyses of the hydrogeologic data described above will be compiled into a report or reports, components of which can be extracted for the overall RI/FS-EIS process. Information from the hydrogeologic characterization study along with information from reports produced by the MDNR and the USGS will be incorporated into the site RI report.

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APPENDIX

TABLE A
WATER TRACING SAMPLE LOCATIONS

ITEM	SAMPLE NUMBER	LOCATION TYPE	LOCATION NAME	LOCATION DESCRIPTION	LATITUDE	LONGITUDE	APPROXIMATE ELEVATION (FEET MSL)
1	SP5101	Spring	Boys Town Camp Spring	About 1 mile south of Weldon Spring Heights; near the mouth of drainage 5100; flows from a concrete basin.	38° 41'58"	90° 40'58"	465
2	SP5102	Spring	West Tributary Junction Spring	In southeast draining branch of drainage 5100; just above mouth of east draining tributary about 1/4 mile upstream of Missouri River; spring rises from the bed or the creek.	38° 41'14"	90° 41'15"	470
3	SP5201	Spring	Rock Ledge Spring	About 1 mile south of Francis Howell High School and 3/4 mile upstream of the mouth of drainage 5200; spring flows from bedrock and cascades from a rock ledge.	38° 41'09"	90° 42'52"	490
4	SP5205	Spring	Peter's Spring	About 1/3 mile east-northeast of Weldon Spring Chemical Plant entrance; flows from west valley wall on top of alluvial terrace.	38° 41'48"	90° 43"'02"	565
5	SP5301	Spring	Highway 94 Spring	About 1/2 mile south of Weldon Spring Chemical Plant; flows from east side of drainage 5300 about 100 yards downstream of Hwy 94.	38° 41' 23"	90° 43'36"	570

TABLE A (CONTINUED)
WATER TRACING SAMPLE LOCATIONS

ITEM	SAMPLE NUMBER	LOCATION TYPE	LOCATION NAME	LOCATION DESCRIPTION	LATITUDE	LONGITUDE	APPROXIMATE ELEVATION (FEET MSL)
6	SP5303	Spring	Southeast Drainage Perennal Spring	About 1 mile south-southeast of Weldon Spring Chemical Plant; flows from east valley wall and across alluvial terrace via a 50 yard long spring branch.	38° 41'03"	90° 43'22"	520
7	SP5402	Spring	Natural Bridge Spring	About 1 mile south of Weldon Spring Chemical Plant; flows from east edge of valley 5400; spring branch is interrupted by a very small "natural bridge".	38° 40'24"	90° 43'51"	560
8	ST5401	Stream	Hamburg Quarry	About 1 1/2 miles south of Weldon Spring Chemical Plant; stream channel just below spring fed pond and upstream of quarry (just downstream of Springs SP5401 and SP5406).	38° 40'27"	90° 43'32"	475
9	SP5501	Spring	Deer Spring	About 1 1/2 miles south-southwest of Weldon Spring Chemical Plant; flows from creek bed adjacent to east valley wall; frequented by deer during dry times.	38° 40'37"	90° 44'24"	515
10	ST6001	Stream	Dardenne Creek	Dardenne Creek at bridge for Highways I-64, US 40, and US 61.	38° 44'05"	90° 44'23"	470

TABLE A (CONTINUED)
WATER TRACING SAMPLE LOCATIONS

ITEM	SAMPLE NUMBER	HORIZONTAL DISTANCE FROM SITE* (MILES)	VERTICAL DISTANCE FROM SITE* (FEET)	GRADIENT FROM SITE* (FT/MI)	ESTIMATED FLOW RATE (GPM) MAXIMUM	MINIMUM	GEOLOGIC FORMATION	RATIONALE
6	SP5303	0.85	90	106	200+	1	Burlington Limestone	Perennial spring partially supplied by losing stream segment 300 to 500 yards upstream; only perennial spring in drainage 5300.
7	SP5402	1.00	50	50	50+	?	Burlington Limestone	Closest moderate flow spring to the site in drainage 5400.
8	ST5401	1.50	135	90	200+	?	Fern Glen Formation (Limestone)	Combined flow of a large flow spring, a moderate flow spring, and moderate surface flow near the mouth of drainage 5400.
9	SP5501	1.45	95	66	200+	100+	Fern Glen Formation (Limestone)	Spring with largest flow in drainage 5500.
10	ST6001	2.75	140	51	Enormous	Large	Burlington Limestone	Combined surface water drainage and groundwater discharge from a large area north and west of site.

* Measured from the groundwater divide location at elevation 610 under Building 408.

TABLE A (CONTINUED)
WATER TRACING SAMPLE LOCATIONS

ITEM	SAMPLE NUMBER	HORIZONTAL DISTANCE FROM SITE* (MILES)	VERTICAL DISTANCE FROM SITE* (FEET)	GRADIENT FROM SITE* (FT/MI)	ESTIMATED FLOW RATE (GPM) MAXIMUM	MINIMUM	GEOLOGIC FORMATION	RATIONALE
1	SP5101	2.45	145	59	1000+	?	Burlington Limestone	Large flow perennial spring; major source of flow in drainage 5100.
2	SP5102	2.20	140	64	100+ to 200+	?	Burlington Limestone	Moderate flow spring; secondary source of flow in drainage 5100.
3	SP5201	0.95	120	126	200+	Nil	Burlington Limestone	Largest spring in drainage 5200; source of all flow in downstream half of drainage.
4	SP5205	0.55	45	82	5+	?	Burlington Limestone	Small to moderate flow spring; one of the closest springs to the site.
5	SP5301	0.40	40	100	100+	0	Burlington Limestone	Wet weather spring supplied by water lost into swallow hole about 200 yards upstream; one of the closest springs to the site.

* Measured from the groundwater divide location at elevation 610 under Building 408.

TABLE A (CONTINUED)
WATER TRACING SAMPLE LOCATIONS

ITEM	SAMPLE NUMBER	LOCATION TYPE	LOCATION NAME	LOCATION DESCRIPTION	LATITUDE	LONGITUDE	APPROXIMATE ELEVATION (FEET MSL)
11	SP6101	Spring	Weldon Spring	In village of Weldon Spring; spring flows from concrete basin along road ditch on south side of Highway 94.	38° 42'47"	90° 41'15"	520
12	ST6101	Stream	Crooked Creek	About 1/2 mile northwest of the village of Weldon Spring; at bridge on gravel road.	38° 43'07"	90° 41'52"	525
13	SP6201	Spring	Army Reserve Fence Spring	About 1/4 mile northwest of Ash Pond; spring flows from stream bed about 25 feet upstream of Army Reserve Fence.	38° 42'11"	90° 44'12"	585
14	ST6201	Stream	Lower Schote	At bridge over Schote Creek about 1 mile downstream of highways I-64, US 40 and US 61.	38° 43'23"	90° 42'22"	495
15	ST6202	Stream	Schote Creek at Frog Pond Branch	About 1/2 mile northeast of August A. Busch Wildlife Area Headquarters.	38° 42'34"	90° 44'00"	555
16	SP6301	Spring	Burgermeister Spring	About 1 to 1 1/2 miles north of the site; spring flows from concrete basin in alluvium of valley bottom; spring branch flows to Burgermeister Branch to the north.	38° 43'02"	90° 44'17"	532

TABLE A (CONTINUED)
WATER TRACING SAMPLE LOCATIONS

ITEM	SAMPLE NUMBER	HORIZONTAL DISTANCE FROM SITE* (MILES)	VERTICAL DISTANCE FROM SITE* (FEET)	GRADIENT FROM SITE* (FT/MI)	ESTIMATED FLOW RATE (GPM) MAXIMUM	MINIMUM	GEOLOGIC FORMATION	RATIONALE
11	SP6101	2.45	90	37	100+	10	Burlington Limestone	Spring with the largest flow in drainage 6100.
12	ST6101	2.20	85	39	Large	0	Burlington Limestone	Combined surface water flow of fork of drainage 6100; no known springs in this fork of the drainage.
13	SP6201	0.70	25	36	10+	0	Burlington Limestone	Only known spring in drainage 6200; one of the closest springs in drainage 6200.
14	ST6201	2.10	115	55	Enormous	Nil	Burlington Limestone	Combined flow of drainage 6200; no significant springs in drainage 6200.
15	ST6202	1.00	55	55	Enormous	0	Burlington Limestone	Combined flow of upper portion of drainage 6200 (normally no flow); includes the normally small flow leaking from Lake 36 on Frog Pond Branch.
16	SP6301	1.60	78	49	2000+	30	Burlington Limestone	Largest spring known in drainage 6300; water tracing tests confirm connection from losing streams adjacent to the site to this spring site contaminants detected at this spring.

* Measured from the groundwater divide location at elevation 610 under Building 408.

TABLE A (CONTINUED)
WATER TRACING SAMPLE LOCATIONS

ITEM	SAMPLE NUMBER	LOCATION TYPE	LOCATION NAME	LOCATION DESCRIPTION	LATITUDE	LONGITUDE	APPROXIMATE ELEVATION (FEET MSL)
17	SP6303	Spring	Francis Howell Cemetery Wet Weather Spring	About 1 to 1 1/2 miles north-northwest of the site; about 100 feet upstream of Busch Wildlife Area Road C along Burgermeister Branch; on alluvial terrace at east valley wall.	38° 42'59"	90° 44'28"	544
18	SP6304	Spring	Francis Howell Cemetery Spring	About 1 to 1 1/2 miles north-northwest of the site; about 150 yards upstream of Busch Wildlife Area Road C along Burgermeister Branch; in streambed by large sycamore tree.	38° 42'56"	90° 44'29"	544
19	SP6306	Spring	Twin Island Lake Spring	At Twin Island Lake Camp; about 2 miles north of the site; flows from alluvium on west bank of Burgermeister Branch about halfway between Twin Island Lake and Highways I-64, US 40 and US 61.	38° 43'43"	90° 43'52"	485
20	SP6307	Spring	Rangeline Spring	Along Highways I-64, US 40, and US 61 just south of Dardenne Creek.	38° 43'59"	90° 44'15"	480
21	ST6301	Stream	Lower Burgermeister Branch	About 2 miles northwest of the village of Weldon Spring; at bridge on gravel road.	38° 44'01"	90° 43'19"	475

TABLE A (CONTINUED)
WATER TRACING SAMPLE LOCATIONS

ITEM	SAMPLE NUMBER	HORIZONTAL DISTANCE FROM SITE* (MILES)	VERTICAL DISTANCE FROM SITE* (FEET)	GRADIENT FROM SITE* (FT/MI)	ESTIMATED FLOW RATE (GPM) MAXIMUM	MINIMUM	GEOLOGIC FORMATION	RATIONALE
17	SP6303	1.60	66	41	50+	0	Burlington Limestone	Water tracing tests confirm connection to this spring from losing streams adjacent to the site; contaminated by red water during World War II TNT production.
18	SP6304	1.55	66	43	50+	5-	Burlington Limestone	Contaminated by red water during World War II TNT Production.
19	SP6306	2.25	125	56	100+	?	Burlington Limestone	Water tracing test confirmed connection from swallow hole in Busch Wildlife Lake 35 to this spring; contaminated by red water during World War II TNT production.
20	SP6307	2.65	130	49	5+	?	Burlington Limestone	Small perennial spring discharging groundwater to Dardenne Creek; near area of most significant red water contamination from World War II TNT production.
21	ST6301	2.60	135	52	Large	?	Burlington Limestone	Combined flow of drainage 6300 (Burgermeister Branch).

* Measured from the groundwater divide location at elevation 610 under Building 408.

TABLE A (CONTINUED)
WATER TRACING SAMPLE LOCATIONS

ITEM	SAMPLE NUMBER	LOCATION TYPE	LOCATION NAME	LOCATION DESCRIPTION	LATITUDE	LONGITUDE	APPROXIMATE ELEVATION (FEET MSL)
22	ST6302	Stream	Lake 34 Spillway	About 2 miles north of site; entrance to drop-inlet spillway pipe.	38° 43'34"	90° 43'59"	520
23	SP6501	Spring	500-Ft Contour Spring	About 1/2 mile east of Busch Wildlife Area Lake 33 near Dardenne Creek; spring flows from streambed of short tributary to Dardenne Creek.	38° 44'02"	90° 45'10"	500
24	SP6502	Spring	511-Ft Contour Spring	About 1/2 mile southeast of Busch Wildlife Area Lake 33; flows from gravel streambed of drainage 6500; about 75 yards upstream of Busch Wildlife Area Road C.	38° 43'46"	90° 45'23"	511
25	SP6601	Spring	Fish Hatchery Spring	About 200 yards south of Busch Wildlife ARea Lake 33; feeds fish-rearing ponds.	38° 43'47"	90° 46'06"	521

TABLE A (CONTINUED)
WATER TRACING SAMPLE LOCATIONS

ITEM	SAMPLE NUMBER	HORIZONTAL DISTANCE FROM SITE* (MILES)	VERTICAL DISTANCE FROM SITE* (FEET)	GRADIENT FROM SITE* (FT/MI)	ESTIMATED FLOW RATE (GPM) MAXIMUM	MINIMUM	GEOLOGIC FORMATION	RATIONALE
22	ST6302	2.10	90	43	Large	25 to 50	Burlington Limestone	Combined flow of upper part of drainage 6300 (Burgermesiter Branch); water tracing test confirmed connection from shallow hole in Busch Wildlife Lake 35 to Lake 34 (but not to Burgermeister Spring which is upstream of Lake 34); a large spring is rumored to be in the bottom of
23	SP6501	2.95	110	37	200+	50-	Burlington Limestone	Contaminated by red water from wastewater lagoon Number 1 during World War II TNT production.
24	SP6502	2.80	99	35	500+	?	Burlington Limestone	Water tracing test confirmed connection from losing stream segment about 1 mile upstream; combined flow of most of drainage 6500.
25	SP6601	3.25	89	27	200+	?	Burlington Limestone	Moderate to large flow spring in drainage 6600.

* Measured from the groundwater divide location at elevation 610 under Building 408.

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SUPERCEDED

PLAN FOR MONITORING RADIONUCLIDE EMISSIONS OTHER THAN RADON AT WELDON SPRING SITE CRITICAL RECEPTORS

For the
Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

Prepared by MK-Ferguson Company and Jacobs Engineering Group

MAY 1990 REV. 0

U.S. Department Of Energy
Oak Ridge Operations Office
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Weldon Spring Site Remedial Action Project

Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors

May 1990

Revision 0

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U.S. DEPARTMENT OF ENERGY
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Under Contract DE-AC05-86OR21548

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ABSTRACT

During the course of the Weldon Spring Site Remedial Action Project (WSSRAP) radionuclides may be emitted to the air. Emissions of radionuclides are regulated by the U.S. Environmental Protection Agency in 40 CFR 61. It is clear in 40 CFR 61 that, for sites being remediated according to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), no monitoring or reporting of radon emissions is required prior to completion of temporary or permanent disposal sites, other than that already required under CERCLA. For radionuclides other than radon, however, it is not clear whether 40 CFR 61 requires sites being remediated according to CERCLA to implement additional monitoring and reporting prior to completion of disposal facilities. Because the U.S. Department of Energy is committed to protection of the public and environment, a plan has been formulated which defines how the WSSRAP will implement a monitoring program for radionuclides other than radon. This plan adheres to the specifications contained in 40 CFR 61.

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1 INTRODUCTION

1.1 SITE HISTORY

The Weldon Spring Site is located in St. Charles County, Missouri, about 30 miles west of St. Louis on land formerly used by the Department of Army (DA) as a trinitrotoluene (TNT) and dinitrotoluene (DNT) ordnance works. The site consists of a 9-acre former limestone quarry; a 51-acre raffinate disposal area; and a 166-acre uranium feed materials plant. The feed materials plant was built in 1955-1957 by the Atomic Energy Commission (AEC), the predecessor to the U.S. Department of Energy (DOE), and operated by Mallinckrodt Chemical Works for the AEC from 1957 through 1966. The plant processed uranium ore concentrates and recycled scrap to pure uranium trioxide, uranium tetrafluoride, and uranium metal. Thorium ore concentrates were also processed. The raffinate residues from this processing were disposed of in four large open pits. During the plant's operational period, the buildings, the equipment, the immediate terrain, the process sewer system, and the drainage easement to the Missouri River became contaminated with uranium, thorium, and their decay products.

During the period 1943-1957, the DA disposed of rubble and soils contaminated with TNT and DNT in a former limestone quarry about 4 miles from the ordnance works. Later, from 1959 through 1966, the AEC disposed of building rubble and soils contaminated with thorium and uranium and their decay products in the same quarry. The quarry now contains about 95,000 cubic yards of contaminated materials, including quarry materials contaminated by this radioactive waste.

In 1967, the feed materials plant site was selected to be converted to a herbicide production facility. Except for the materials stored in the raffinate pits, the site was transferred

back to the DA and renamed the Weldon Spring Chemical Plant (WSCP). The DA began a major effort to decontaminate three process buildings for herbicide production. The cleanup was not totally successful, and in 1969, reduced requirements for the herbicide and increased cleanup costs resulted in cancellation of the project. The 51 acres encompassing the Weldon Spring Raffinate Pits (WSRP) were transferred back to the AEC in 1971.

On November 27, 1984, the DOE was directed by the Office of Management and Budget to assume responsibility for the decontamination of the WSCP and to integrate work with other DOE remedial actions proposed for the Weldon Spring Quarry (WSQ), and the WSRP. In 1987 the WSQ was placed on the National Priorities List (NPL). The WSCP/WSRP were placed on the NPL in 1989. These NPL sites are being remediated according to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Environmental Policy Act (NEPA).

During cleanup of the Weldon Spring Site (WSS) a temporary storage area (TSA) for wastes from the WSQ is proposed. In addition, the DOE-preferred alternative for all wastes at the WSQ and WSCP/WSRP is to build a permanent disposal site at the WSCP/WSRP.

1.2 REGULATIONS PERTAINING TO RADIOACTIVE EMISSIONS

Because of the radioactive materials present at the WSCP/WSRP and WSQ, radon is emitted to the atmosphere as are other radionuclides from the U-238, U-235, and Th-232 natural decay series. Atmospheric emissions of radon and radionuclides other than radon are regulated by the U.S. Environmental Protection Agency (EPA). The regulations are contained in 40 CFR 61 which was updated and became effective on December 15, 1989. It is clear in Section G of 40 CFR 61 that, for DOE

facilities being remediated according to CERCLA, radon monitoring or reporting programs required through the CERCLA program are sufficient to protect the public health until temporary or permanent storage facilities for Ra-226-containing byproduct material are completed. Once all wastes have been placed and completely covered at the TSA, radon flux monitoring will be performed at the TSA. If a permanent disposal site is constructed at the WSCP/WSRP, radon flux monitoring will be performed after construction of the disposal site is completed. Radon flux monitoring will be performed according to 40 CFR 61, Appendix B, Method 115.

However, it is not clear in those sections of 40 CFR 61 that pertain to radionuclide emissions other than radon whether DOE sites being remediated according to CERCLA are required to monitor and report emissions prior to completion of temporary or permanent storage facilities.

1.3 MONITORING RADIONUCLIDE EMISSIONS OTHER THAN RADON

The DOE is currently determining through discussions with EPA whether the monitoring and reporting requirements for radionuclide emissions other than radon contained in 40 CFR 61, Subpart H apply to CERCLA sites prior to completion of permanent or temporary storage facilities. Regardless of whether 40 CFR 61, Subpart H applies to the WSS during remediation, the DOE is committed to protection of the public and environment. Therefore, a monitoring and quality assurance program sensitive enough to detect concentrations of radionuclides other than radon at levels specified in 40 CFR 61 will be initiated at the WSS.

Results of the monitoring will be reported in annual site environmental reports. These reports are intended to allow EPA

oversight of radionuclide emissions during remediation according to CERCLA/NEPA. The monitoring, reporting, and quality assurance program is discussed below.

2 METHODS OF EMISSION EVALUATION

The national emission standard for radionuclides other than radon is set so that no member of the general public receives an effective dose equivalent greater than 0.10 mSv (10 mrem) per year. 40 CFR 61 Subpart H requires that radionuclide emissions other than radon be measured and effective dose equivalents estimated by computer models. If the emission monitoring and modeling specified in Subpart H is impractical, alternate procedures may be acceptable. As an alternate to modeling dose equivalents, air concentrations can be monitored at critical receptors.

After evaluating the methods of assessing effective dose equivalents from radionuclides other than radon, it was determined that monitoring air concentrations at critical receptors was the most accurate means of assessing effective dose equivalents to maximally exposed individuals. This plan describes how the Weldon Spring Site Remedial Action Project will use monitoring results to estimate effective dose equivalents to members of the public resulting from emissions of radionuclides other than radon.

3 SCOPE

This plan discusses the monitoring, reporting, and quality assurance program requirements that will be used to estimate and document the effective dose equivalent from airborne emissions of radionuclides other than radon at locations of highest potential offsite exposure. The monitoring plan, including rationale for the monitoring program as well as sampler location, description, analytical methods, and frequency is discussed in Section 4. This monitoring program meets the specifications in 40 CFR 61, Subpart H. Also contained in Section 4 is a description of the annual reporting system.

Section 5 contains the quality assurance plan. This plan meets the requirements of 40 CFR 61, Appendix B.

4 PLAN

The Weldon Spring Site (WSS) is currently being remediated according to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Environmental Policy Act (NEPA). It no longer operates as a uranium and thorium processing plant and has been in mothball status since about 1966. Therefore, radionuclides are no longer emitted from the types of sources (i.e. stacks, vents, or pipes) described in 40 CFR 61, Subpart H.

Airborne emissions of radionuclides at the WSS result from wind dispersal of surface soils or dust and dirt within deteriorating buildings and from fugitive dust generated during remedial actions. Monitoring these types of emission sources is not practical because of the inability to adequately characterize the emission inventory. The amount of entrainment can be estimated from fugitive dust emission factors developed by the U.S. Environmental Protection Agency (EPA) for various materials handling activities, but it is generally recognized that those estimates contain gross uncertainties. Measurement of the entrainment and emissions inventory is also extremely difficult and results are uncertain at best, because the emissions are highly variable both over time and location. Accurate measurements of area or volumetric fugitive emissions can only be made with complete knowledge of the micro-meteorology in and around the source and the use of many (usually greater than 10) concentration or measurement locations. Therefore, modeling of downwind dispersion and subsequent dose calculations using either assumed or measured emission rates leads to extremely uncertain results. The most accurate method of dose calculation at nearby receptor points is through the use of actual concentration measurements at these locations.

An assessment of the effective dose equivalents at critical receptors will be documented by environmental measurements of radionuclide air concentrations. Critical receptors are defined as those locations at which individuals abide or reside where the highest potential offsite concentrations of radionuclides other than radon are likely to occur during remediation of the Weldon Spring Site (WSS). The proposed monitoring and sample analysis plan is presented in Section 4.1. Section 4.2 describes how the monitoring meets the specifications in 40 CFR 61.

4.1 MONITORING PLAN

This section describes sampler locations, discusses rationale for selecting critical receptor locations, establishes occupancy times at critical receptor locations, describes the samplers, presents sampling frequency, and presents sample analytical techniques. Also included in Section 4.1.4 is a discussion of how the monitoring results will be reported.

4.1.1 Sampler Locations

The WSS includes the Weldon Spring Raffinate Pits (WSRP), the Weldon Spring Chemical Plant (WSCP), and the Weldon Spring Quarry (WSQ). Eleven air particulate samplers are in use at the WSS. Five samplers are located on the WSCP/WSRP perimeter. Four are located offsite, one of which measures background air. Two are at the WSQ perimeter. Sampler locations with respect to the WSCP/WSRP and WSQ are shown on Figures 4-1 through 4-3.

Sampler location AP-4007 at the Busch Wildlife Area office measures background concentrations for the WSS. This station is located 1.1 km (0.7 mile) from the WSCP perimeter. The forested and gently rolling terrain between the WSCP and this sampling

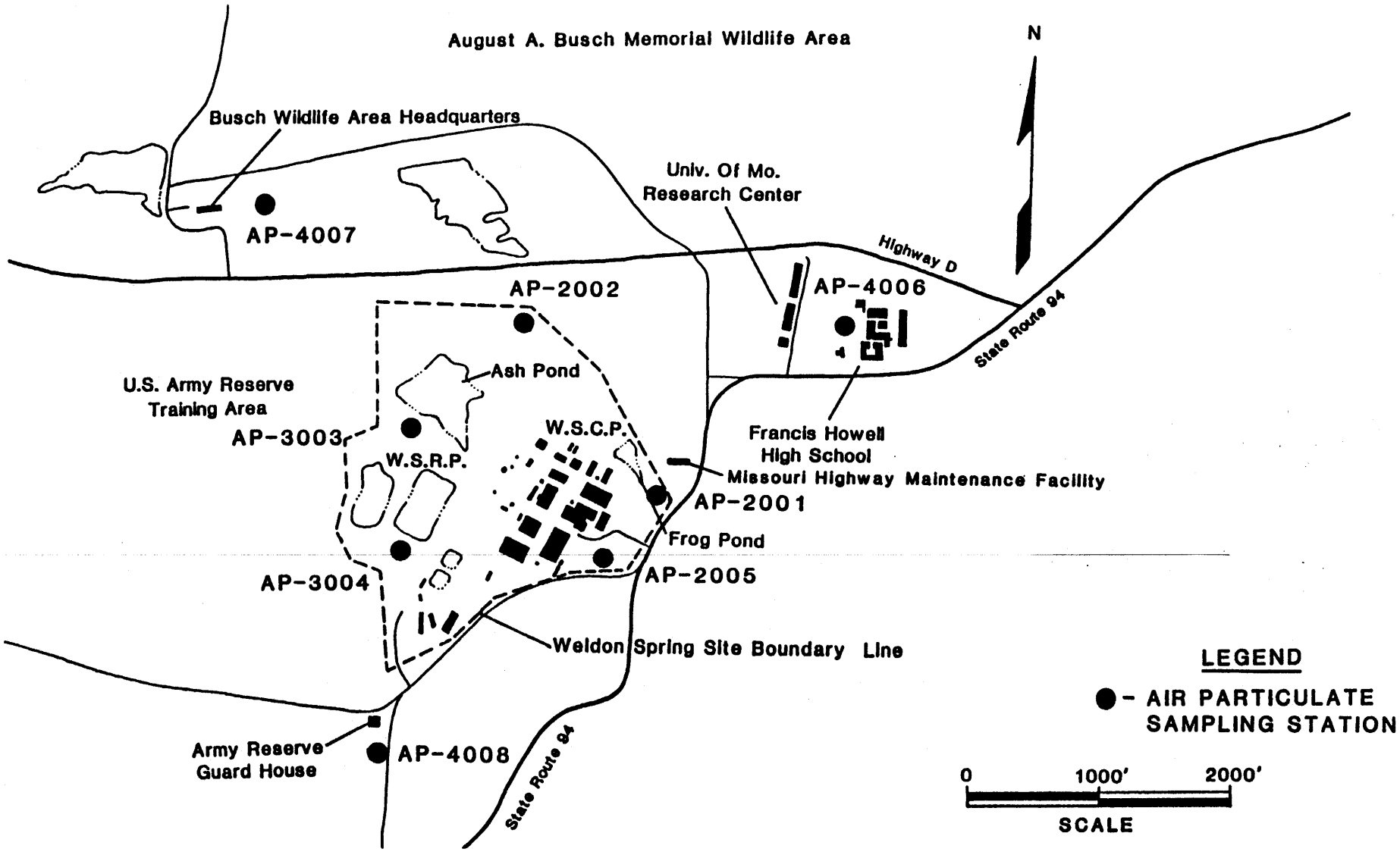


FIGURE 4-1

AIR SAMPLER LOCATIONS SURROUNDING THE WSCP/WSRP

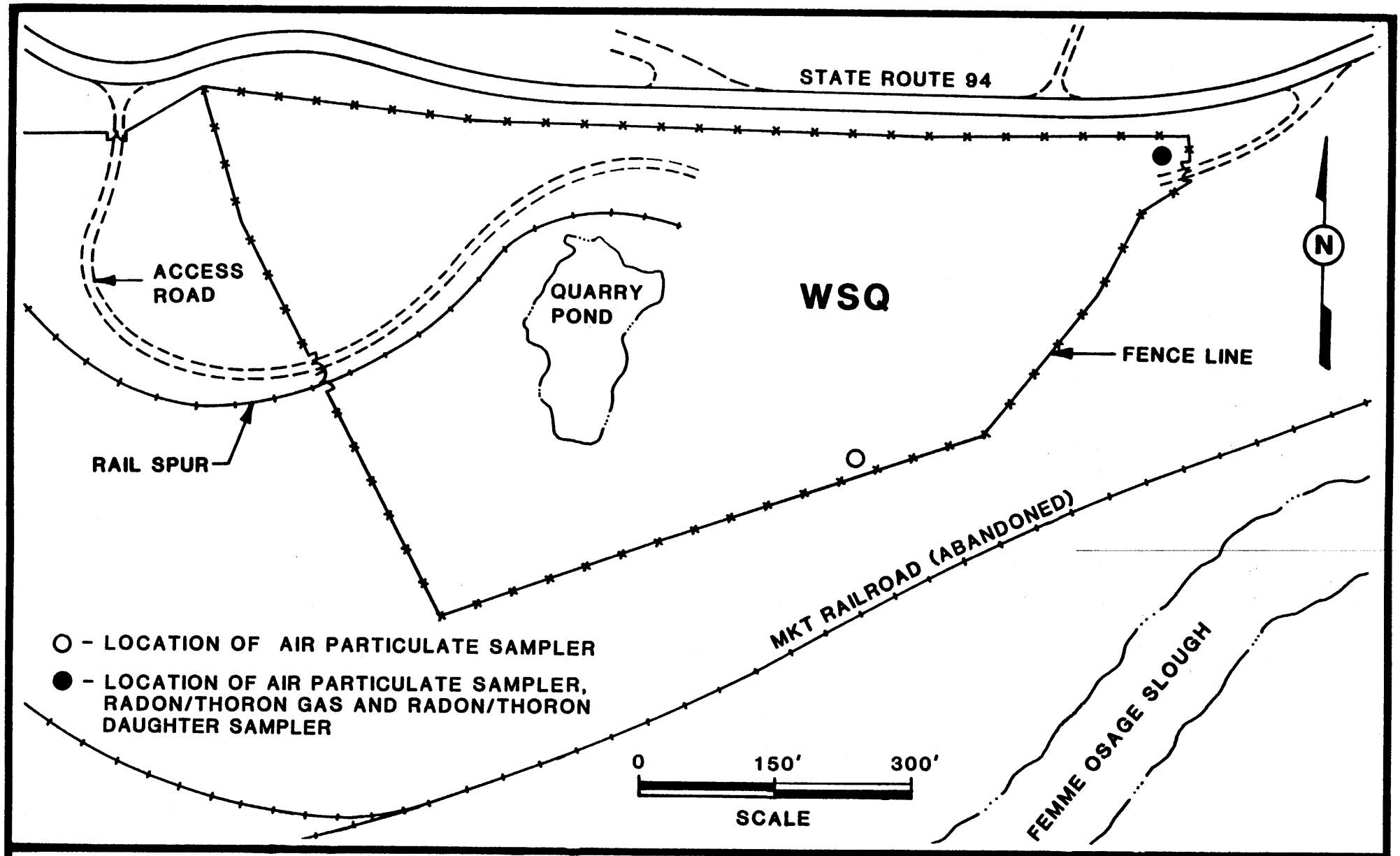
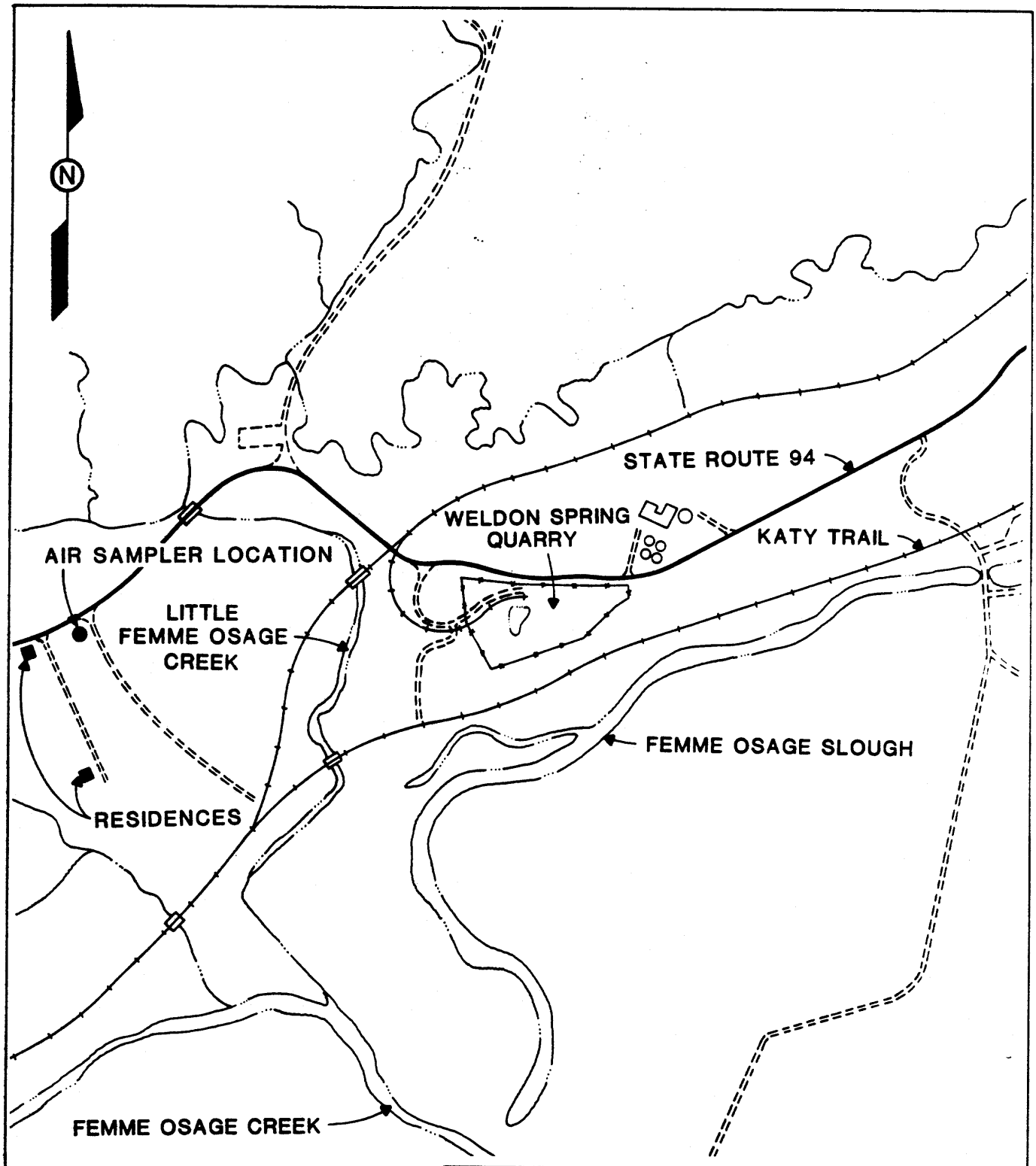


FIGURE 4-2

WSQ AIR MONITORING LOCATIONS



SCALE

FEET

0 800 1600

0 243.8 487.7

METERS

QUARRY MONITORING STATION

FIGURE 4-3

REPORT NO. DOE/OR/21548-127	DRAWING NO.: A/VP/012/0590	
ORIGINATOR: SG	DRAWN BY: GLN	DATE: 5/90

station provides a significant physical barrier to airborne particulates originating from the site.

As shown in Figure 4-1, sampler stations AP-2001, AP-4006, AP-4008, and AP-2005 are strategically located to measure radioactive air particulate concentrations around the WSCP/WSRP at the point where a maximally exposed individual resides or abides. Station AP-2001 is at the common boundary of the WSCP and Missouri Highway Maintenance Facility. Station AP-4006 is located at the Francis Howell High School. Station AP-4008 is on the Weldon Spring Army Reserve Training Area. Station AP-2005 is located between the WSCP and the Weldon Spring Site Remedial Action Project (WSSRAP) Administration Building.

Located 0.8 km (0.5 mi) west of the quarry is a residence. This residence is within 150 meters (0.1 mi) and directly in line with the quarry monitoring station (Figure 4-3).

These sites were selected as critical receptor locations because they are located within 1.0 km (0.62 mile) of the WSS where members of the public may spend at least eight hours per day for a significant fraction of a year. Other facilities (for example the St. Charles County Water Treatment Plant and the Weldon Spring Heights Subdivision) are located near the WSS; however, no other facility is closer than 2.5 km (1.6 mile) from the WSS. Because of this greater distance these facilities were not considered critical receptors.

At the one critical receptor that is a residence, occupancy will be assumed to be continuous. The number of individuals at the other receptors and typical occupancy patterns are discussed below.

There are nine workers at the highway maintenance facility. A typical worker is at the facility less than 40 hours per week, 50 weeks per year.

There are approximately 1,800 students, faculty and staff members at the high school. Faculty and staff generally spend more time at the school than do students. A typical employee spends 45 hours per week, 50 weeks per year at the school. One janitor lives on the school grounds. Occupancy for this person will be assumed to be continuous.

A remedial investigation is being conducted at the Army Reserve Training area. Subcontract workers perform site characterization tasks intermittently. One employee of the Department of the Army works at most 40 hours a week, 50 weeks per year at the office on the Army Reserve property.

Currently there are approximately 110 workers at the WSSRAP Administration Building. Workers typically spend less than 50 hours per week, for 50 weeks per year, at the facility.

4.1.2 Sampler Description and Sampling Frequency

Air particulate samplers are low volume, self adjusting carbon-vaned, oil-less air pumps at the three quarry locations, and low volume, self-adjusting, twin diaphragm, oil-less air pumps at the five WSCP/WSRP site perimeter locations and at the other three offsite locations. Each sampler is mounted in a weather-protective housing with a 110-volt outlet and a thermostat-controlled fan for cooling. Each sampler will have a timer to document the operational periods. Samplers also have a flow meter and vacuum gages to automatically maintain constant flow.

Air filters are mounted approximately 1 meter (3 feet) above ground surface. The sampling head is on the side of the protective housing opposite the cooling fan exhaust. This prevents the cooling fan exhaust from disturbing the air being drawn through the filter.

All air samplers will run continuously at a flow rate of approximately 40 liters per minute. Samples are collected on 47 millimeter diameter 0.8 micron pore size mixed ester cellulose filter paper. Filters are exchanged weekly.

4.1.3 Sample Analysis

Air samples obtained at the common perimeter of the WSCP and the highway department, the high school, the Army training area, near the WSSRAP Administration Building, by the nearest WSQ resident, and at the Busch Wildlife Area Headquarters will be used to assess effective dose equivalents to a maximally exposed individual. Other sampling locations do not represent potential locations for maximum public exposure because public occupancy times at these locations is negligible.

Each filter, representative of approximately 403,200 liters of air (40 liters per minute times 10,080 minutes per week) will be analyzed for gross alpha concentration. Following gross alpha analysis filters will be cut into three equal sections, with each section placed in an individual envelope. The filters will be cut in thirds for quality assurance. This will allow an evaluation of analytical precision. Three pieces are used because, if an error caused a difference in analytical results between two filter portions, the third portion will allow a determination of which result was erroneous.

In January of each year the three sections of 52 weekly filters will form three composite samples for each of the five

critical receptor locations and the Busch Wildlife Area background station. The 18 composite samples (filter thirds from six sampler locations) will be analyzed for isotopic thorium, isotopic uranium, Ra-228, and Ra-226. Analysis for this suite of radionuclides allows a determination of the concentration of all radionuclides at the Weldon Spring Site which could contribute more than 10 percent of the total effective dose equivalent. Radon and daughters are not included because they are not regulated by 40 CFR 61, Subpart H.

Yearly analyses of the filters is considered acceptable because it meets the intent of 40 CFR 61. The primary method given in 40 CFR 61 of determining effective dose equivalents is through computer modeling. The computer modeling exercise is to be performed and reported annually. Monitoring of airborne concentrations is also allowable. Therefore, a yearly determination of the airborne concentrations and associated effective dose equivalent at critical receptors meets the specifications of 40 CFR 61.

4.1.4 Reports

Reports of environmental monitoring for radionuclide emissions other than radon have been made for calendar years 1986 through 1988 in Annual Environmental Monitoring Reports (DOE, 1986; DOE, 1987a; DOE, 1988). These monitoring reports were transmitted to EPA Region VII. Although the monitoring at critical receptor locations was not sensitive enough to distinguish an annual effective dose equivalent of 0.10 mSv (10 mrem) above natural background, results for years 1986 through 1988 detected no significant difference at the 95 percent confidence level between gross alpha concentrations at critical receptors and the background monitoring station. This was as expected because no significant activities occurred at

the WSS during these years that generated airborne radionuclide emissions.

Beginning with air samples collected during calendar year 1990, results of the monitoring performed as specified in Section 4.1 of this plan and an assessment of the effective dose equivalent at critical receptor locations will be reported in the 1990 Annual Site Environmental Report. These annual reports meet the requirements of 40 CFR 61 because the WSS is being remediated according to CERCLA. This allows EPA oversight which is sufficient to protect the public health by providing EPA Regional Office VII with all the information it needs to assess potential impacts on public health as a result of remediating the WSS.

4.2 COMPARISON TO 40 CFR 61 SPECIFICATIONS

In order to satisfy the sensitivity requirements of 40 CFR 61 through environmental monitoring the following must be met:

1. The air at the point of measurement must be continuously sampled for collection of radionuclides.

2. Those radionuclides released from the facility that are major contributors to the effective dose equivalent must be collected and measured as part of the environmental measurement program.

3. Radionuclide concentrations which would cause an effective dose equivalent of 10% of the standard must be readily detectable and distinguishable from background.

4. Net measured radionuclide concentrations must be compared to the concentration levels in Table 2,

Appendix E of 40 CFR 61. In the case of multiple radionuclides being released from a facility, it must be demonstrated that the value for all radionuclides is less than the concentration level in Table 2, and the sum of the fractions that result when each measured concentration value is divided by the value in Table 2 for each radionuclide is less than 1.

5. A quality assurance program must be conducted that meets the performance requirements described in Appendix B, Method 114 of 40 CFR 61.

This subsection describes how the monitoring program at the WSS will satisfy items 1 through 4. Item 5 is addressed in Section 5.

Items 1 and 2 have been addressed previously. Samplers will run continuously and all major contributors to effective dose equivalent will be collected and measured.

Regarding Item 3, the sampling protocol at the critical receptor locations will be followed at the background monitoring station. Assuming typical Th-232 soil concentrations of 40 Bq/kg (1 pCi/g) and a typical rural airborne dust loading of 16 $\mu g/m^3$ (EPA, 1980), airborne Th-232 concentrations in background air would be 6×10^{-13} MBq/m^3 (2×10^{-17} Ci/m^3). (Th-232 was chosen for this example because it is the greatest contributor to effective dose equivalent.) Assuming continuous inhalation at 20 m^3/day (Cember, 1983) for 365 days/year and using a committed effective dose equivalent conversion factor of 4.43×10^{-4} Sv/Bq (EPA, 1988), a committed effective dose equivalent of 2×10^{-3} mSv (0.2 mrem) is predicted. Since the committed effective dose equivalent for Th-232 is received over a 50-year period the effective dose equivalent received in any single year would be at least a factor of ten lower. For these

TABLE 4-1 Sensitivity Analysis

Radionuclide	Required Sensitivity MBq/m³	(Ci/m³)	Ratio
U-238	3.1E-10	(8.3E-15)	0.018
U-234	2.9E-10	(7.7E-15)	0.020
Th-230	1.3E-10	(3.4E-15)	0.044
Ra-226	1.2E-10	(3.3E-15)	0.045
Th-232	2.3E-11	(6.2E-16)	0.242
Th-228	1.2E-10	(3.1E-15)	0.048
Ra-228	2.2E-10	(5.9E-15)	0.025
		SUM	0.442

reasons the annual effective dose equivalents for each radionuclide in background air is much less than 1×10^{-2} mSv (1 mrem). Monitoring results which attain the sensitivity requirements of Item 4 would, therefore, be readily detectable and distinguishable above background.

The sensitivity of the monitoring method meets the criteria in Item 4. A radiochemical detection limit for each radionuclide of 40 mBq (1 pCi) can be attained (Horton, 1990). By dividing this detection level by the 700 m³ drawn through the filter thirds in each composite sample, an airborne concentration of 5.28×10^{-12} MBq/m³ (1.5×10^{-16} Ci/m³) can be detected. Listed in Table 4-1 are the radionuclides for which monitoring will be performed, the analytical sensitivity specified in Table 2, Appendix E of 40 CFR 61, and the ratio of achievable sensitivity to the required sensitivity. Since the

ratio of the sensitivities for each radionuclide is less than 1.0 and the sum of the ratios is less than 1.0, the proposed analytical method meets the requirements of 40 CFR 61.

5 QUALITY ASSURANCE

This section discusses the quality assurance program that will be conducted to ensure that emission measurements are representative and are of known precision and accuracy. Also included are administrative controls to assure prompt response when measurements indicate unexpectedly large emissions. In addition to complying with all requirements contained in this section, this monitoring program will also comply with the Weldon Spring Site Quality Assurance Program Plan (QAPP) (DOE, 1987b).

5.1 ORGANIZATIONAL STRUCTURE

The responsibility for implementing the emission monitoring program lies within the Environmental, Safety and Health (ES&H) Department. As such, the ES&H Manager has overall responsibility. Actual sampling protocol will be carried out within the Radiation Protection Group under the guidance of the Radiation Protection Manager. Audits will be conducted by the Quality Assurance Department which reports directly to the MK-Ferguson Company Quality Assurance Director. Any corrective actions which require modifications in the way remedial actions are performed at the Weldon Spring Site (WSS) are the responsibility of the Operations Department Manager. The lines of responsibility are shown in Figure 5-1.

5.2 SAMPLE COLLECTION AND ANALYSIS PROCEDURES

Project procedures exist for all phases of sample collection and analysis except for the method of dividing individual filters in thirds and the means of compositing samples. This procedure is currently being drafted and will be forwarded upon completion.

FIGURE 5-1 Lines of Authority

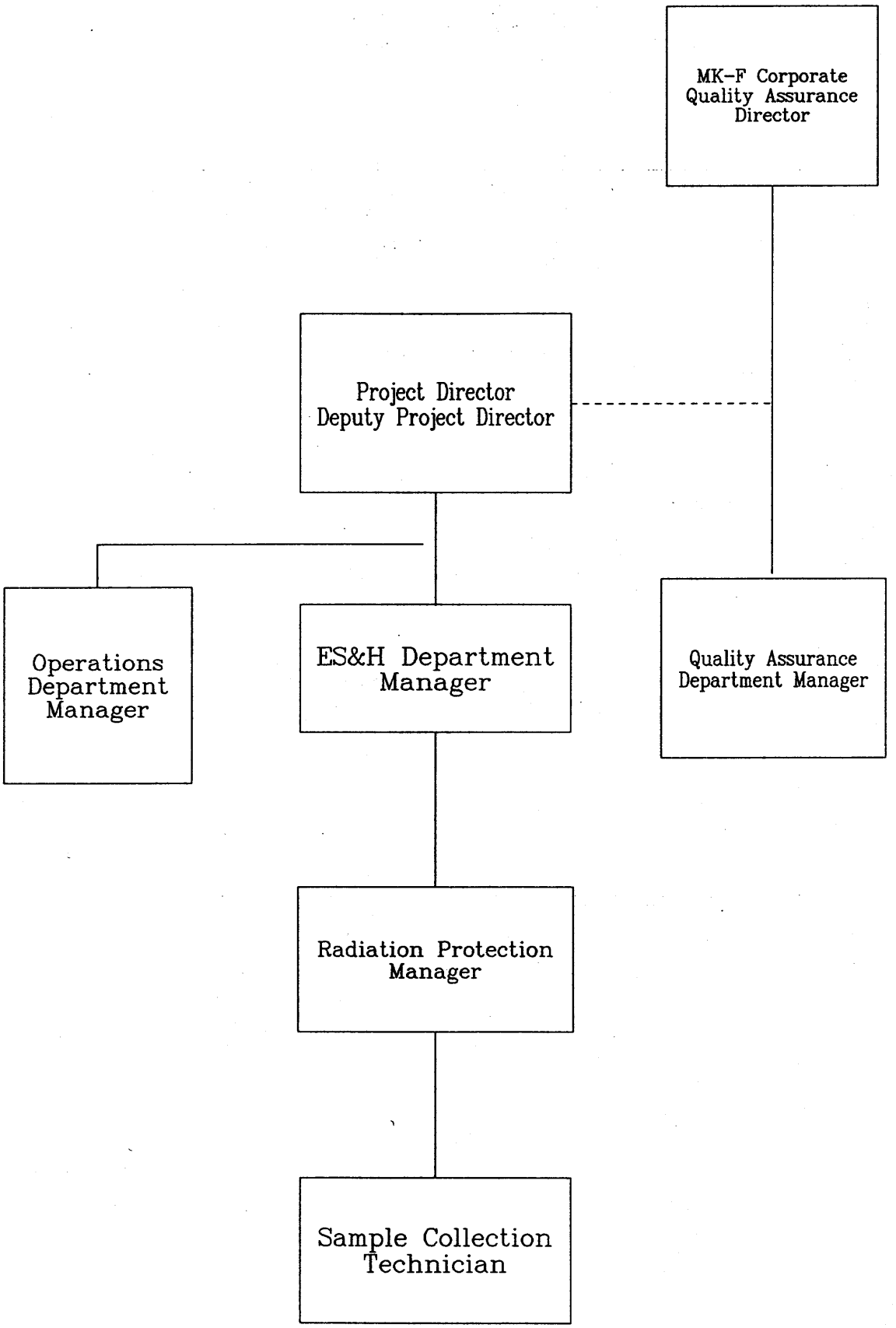


Table 5-1 presents a list of procedures and aspects of the sampling program which they govern. Each procedure is attached to this plan for reference.

Actual radioanalytical procedures are not performed at the site but at a subcontractor laboratory. The radioanalytical procedures used are specified in Table 5-2.

TABLE 5-1 Sampling Procedures

Procedure Number	Title	Sampling Program Aspects
ES&H 2.6.4	Ludlum Model 2000 Scaler and Model 43-10 Detector: Gross Alpha Measurement Operator and Calibration	Gross alpha analysis of air filters. Detector calibration, operational check, and usage.
ES&H 4.1.2	Chain-of-Custody	Chain-of-Custody for samples sent for radiochemical analysis
ES&H 4.6.4	Constant Flow Air Sampler Operation	Air filter change outs, filter handling, air sampler calibration and operation.

TABLE 5-2 Radioanalytical Procedures

Nuclide	Method
U-238	EPA-908
U-234	EPA-908
Th-232	EERF[(a)]-06
Th-230	EERF-06
Th-228	EERF-06
Ra-228	EPA-903.1
Ra-226	EPA-904

(a) Eastern Environmental Radiation Facility

5.3 ADMINISTRATIVE CONTROLS

Assurance that increased radionuclide emissions due to unplanned or unforeseen circumstances can be detected and controlled is achieved through weekly gross alpha analyses of each filter. Isotopes of thorium are the alpha-emitters at the WSS that have the highest potential to cause radiation dose at critical receptor locations. Isotopes of thorium are most prevalent in the quarry and in the raffinate pits. For other site areas such as Weldon Spring Chemical Plant (WSCP) buildings, uranium is the primary contaminant. At the quarry, Th-230 comprises, on average, 33 percent of the total alpha activity contributed by those radionuclides that will be measured at critical receptor locations. At the raffinate pits, Th-230 comprises, on average, 87 percent of the total alpha activity contributed by those radionuclides that will be

measured at critical receptor locations. Clearly, Th-230 has the highest potential to cause a radiation dose at critical receptor locations.

If the potential for a person to receive a yearly effective dose in excess of 0.10 mSv (10 mrem) can be detected on a weekly basis, sufficient control over radionuclide emissions can be attained. This is achieved if a dose equivalent rate of 0.002 mSv (0.2 mrem) per week can be detected. Given a typical weekly occupancy time of five 8-hour days for persons closest to the site where the highest potential airborne concentrations are expected to occur, a quantity of air inhaled during eight hours at work of 10 m^3 (Cember, 1983), and a Th-230 committed effective dose equivalent conversion factor of 8.8×10^{-5} Sv/Bq (EPA, 1989), a dose equivalent of 0.002 mSv/week (0.2 mrem/week) corresponds to an airborne concentration of 4.4×10^{-10} MBq/m^3 (1.2×10^{-14} Ci/m^3).

A natural background gross alpha concentration of $2 \times 10^{-10} \pm 1.2 \times 10^{-10}$ MBq/m^3 at two standard deviations ($5 \times 10^{-15} \pm 3.26 \times 10^{-15}$ Ci/m^3) has been documented at the site (DOE, 1988). It can be seen that a committed effective dose equivalent rate due entirely to Th-230 of 0.002 mSv/week (0.2 mrem/week) can be resolved above natural background gross alpha concentrations. In fact, an effective dose equivalent rate much lower than 0.002 mSv/week (0.2 mrem/week) can be resolved above natural background gross alpha concentrations.

The wastes at the WSS contain a mixture of alpha emitters. Although some of the detected alpha activity will be due to Th-232 and Th-228, which have a higher potential to cause internal dose, a larger percentage of alpha emitters with lower internal dose delivery potential will also be present. This is based on measured radionuclide concentrations in waste

materials. In addition, a Th-230 concentration of 4.4×10^{-10} MBq/m^3 (1.2×10^{-14} Ci/m^3) would result in a committed effective dose equivalent of 0.002 mSv/week (0.2 mrem/week). The effective dose equivalent would be much less because the dose equivalent from inhalation of Th-230 in any given year is spread out over a period of more than 10 years.

To ensure that remedial actions do not result in unplanned or unforeseen airborne radionuclide concentrations at critical receptor locations, a "sliding weekly average" gross alpha concentration will be computed for each critical receptor monitoring station. The sliding weekly average gross alpha concentration will be computed by summing all weekly gross alpha concentrations and dividing by the number of weeks of sampling during a calendar year. As successive weekly samples are analyzed, the results will be used to recompute the sliding weekly average concentration. If a sliding weekly average gross alpha concentration at critical receptor locations in excess of natural background is detected with 95 percent confidence, site operations which may have caused the elevated concentration will be evaluated to determine whether all reasonably achievable dust control measures have been implemented.

A weekly sampling frequency is adequate to control radiation exposures because the 0.10 mSv (10 mrem) level specified in 40 CFR 61 is a long-term standard (i.e. yearly). A response time of one week to control unplanned or unforeseen emissions will be adequate to maintain control over emissions.

5.4 QUALITY CONTROL

The quality control program will include spikes, duplicates, blanks, and control charts. This program is designed to meet the requirements of 40 CFR 61, Appendix B.

With each group of filters sent for radiochemical analysis, two filters will be spiked with known activities of Th-230 and two filters will be spiked with known activities of natural uranium (U-238, U-235, and U-234 in natural activity ratios).

Since each filter composite collected at critical receptor locations is cut into thirds, these filter thirds will serve as duplicates. Five percent of all gross alpha analyses are repeated to verify detector performance.

Field blanks are used each week when air filters are exchanged. These will be composited and analyzed radiochemically following analysis for gross alpha activity. In addition, each week an unused filter is analyzed for gross alpha activity. These filters will be composited and analyzed radiochemically.

Control charts are maintained to verify gross alpha detector performance. A control chart is generated to track daily detector background and daily certified standard source checks. Daily background and source counts must fall within three standard deviations of values posted when the detectors undergo semiannual calibration (MKF and JEG, 1989).

In addition to the system of spikes, duplicates, blanks, and control charts the radioanalytical analyses will be evaluated for internal consistency. At the WSS, U-238 and U-234 are in secular equilibrium. Uranium concentrations on air filters should also be in equilibrium. When radioanalytical results are provided, the degree of equilibrium will be evaluated. In most cases, Th-228 and Ra-228 are also in equilibrium. Equality between these radionuclides will also be evaluated.

5.5 DATA QUALITY OBJECTIVES

Accuracy and precision of radiochemical analyses will be measured at the 85 percent confidence level. Accuracy, as determined with the results of spiked samples, will be considered acceptable if analytical results of spiked samples are within $\pm$50 percent of known values for 85 percent of all samples. Precision will be determined by averaging the results of the three duplicate analyses. Precision will be considered acceptable if the standard deviation of duplicate analyses is within $\pm$50 percent of the average for 85 percent of the duplicate data sets. Analytical precision will also be calculated for U-238/U-234 for each composite sample. Precision will be considered acceptable if the standard deviation of the U-238/U-234 results for each composite sample are within $\pm$ 50 percent of the average for 85 percent of all samples.

Accuracy and precision of gross alpha analyses will be measured at the 95 percent confidence level. Accuracy, as determined by the daily source counts, will be considered acceptable if 95 percent of all daily values fall within three standard deviations of the certified standard source. Precision, as determined by the results of duplicate analyses, will be considered acceptable if 95 percent of the duplicate counts are within three standard deviations of the original count.

5.6 AUDITS

Internal audits will be conducted yearly by the WSSRAP Quality Assurance Department in accordance with the WSSRAP QAPP. The primary purpose of the audits will be to assure that sample collection, sample compositing, gross alpha analyses, and sample chain of custody are performed according to standard operating procedures. The internal audits will also ensure

conformance with this overall "Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors."

External audits of the radioanalytical laboratory will also be performed annually by the WSSRAP Quality Assurance Department. These audits will ensure conformance of the radioanalytical laboratory to standard operating procedures.

5.7 CORRECTIVE ACTIONS

If data quality objectives are not met, the Radiation Protection Manager will provide a report evaluating the reasons for noncompliance and providing a statement of required corrective actions. The Environmental Safety and Health Manager will ensure the appropriateness of the recommended corrective actions and ensure that corrective actions are implemented in a timely manner.

If results of gross alpha analyses indicate detectable emissions of radioactive particulates at critical receptor locations the Radiation Protection Manager shall inform the Operations Department Manager. The Operations Department Manager will be responsible for ensuring that emissions are controlled to a level which is as low as reasonably achievable.

5.8 REPORTS

Emissions measurement program results including assessment of data quality, results of internal audits and corrective actions, if any, shall be prepared annually.

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CHEMICAL PLANT
201-1.10

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

June 14, 1990

Addressees

ENVIRONMENTAL DATA ADMINISTRATION PLAN

Enclosed for your review and comment are two copies of the above plan. The Environmental Data Administration Plan (EDAP) identifies the approach and conduct of all activities related to the collection, analysis and administration of documentation of all data gathered at the Weldon Spring Site. The EDAP discusses methods used for acquiring data, programs for quality assurance, and maintenance of the data. This includes sampling plan preparation, data verification and validation, data base administration and data archiving.

Please provide any comments by July 6, 1990.

Sincerely,

Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As Stated

cc w/o enclosure:
Action Item Log
R. E. Hlavacek, PMC

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DOE/OR/21548-119

(CONTRACT NO. DE-AC05-86OR21548)

SUPERCEDED

ENVIRONMENTAL DATA ADMINISTRATION PLAN

For the
Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

Prepared by MK-Ferguson Company and Jacobs Engineering Group

MAY 1990 REV. 0

U.S. Department Of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

ATTENTION!!

ZZ-217 DOE/OR/21548-119

IS NOW OBSOLETE

DOE/OR/21548-119

Weldon Spring Site Remedial Action Project

Environmental Data Administration Plan

May 1990

Revision 0

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63303

Prepared for

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

EDAP/TXTJOANN

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ABSTRACT

Environmental monitoring and surveillance activities at Weldon Spring Site Remedial Action Project (WSSRAP) result in data and documentation that is used to develop remedial action alternatives and demonstrate compliance with U.S. Department of Energy (DOE) environmental protection policies.

This Environmental Data Administration Plan (EDAP) summarizes standard operating procedures and data quality objectives developed for use in the collection and analysis of environmental data. Data quality review programs are conducted to ensure data integrity and validity. The EDAP describes administration procedures adopted at WSSRAP to manage the use of environmental data.

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1 INTRODUCTION

Environmental monitoring, surveillance, and characterization activities are conducted at the Weldon Spring Site (WSS) as part of the Weldon Spring Site Remedial Action Project (WSSRAP). These activities are described in detail in numerous sampling plans, monitoring programs, and permits. Environmental monitoring activities are conducted at the WSS to ensure that any potential public exposure is documented and quantified in an effort to protect the health and safety of the public. These activities are also required to demonstrate compliance with regulatory requirements and U.S. Department of Energy (DOE) environmental protection policies (MKF and JEG, 1990a).

Two major types of information are collected and evaluated during the environmental monitoring activities: documentation (field notes, data quality reviews) and data (analytical). The information collected is used to support an evaluation of alternative remedial actions. Future environmental sampling activities will provide data on which to evaluate remedial efforts, public and worker safety and protection of the environment.

Data quality objectives (DQOs) have been established in accordance with Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) guidelines for environmental data. DQOs are qualitative and quantitative statements which specify characteristics of the data required to support U.S. Environmental Protection Agency (EPA) decisions during remedial action activities (EPA, 1987). The DQOs identify specific goals for WSSRAP data which include Precision, Accuracy, Representativeness, Completeness and Comparability (PARCC). The DQO plan reviews these goals and is presented in Appendix A. The WSSRAP DQOs are standard in their application and are used as a guideline for WSSRAP.

Standard Operating Procedures (SOPs) have been developed to provide consistency in methodology, reporting of data, and documentation of environmental activities. SOPs include procedures for sample collection and identification and for data quality review. SOPs are detailed in controlled copies of the WSSRAP Procedures Manual (MKF and JEG, 1989). The procedures are reviewed periodically and updated as necessary to record changes in procedures. All manuals are updated and distributed as changes are made.

1.1 PURPOSE

The purpose of this Environmental Data Administration Plan (EDAP) is to identify the approach and conduct of all activities related to the collection, analysis and administration of documentation and data gathered to make environmental decisions at WSSRAP.

The EDAP discusses methods used for acquiring technical data, programs for quality assurance and maintenance of documents and data. The plan establishes a foundation for gathering and examining data prior to its incorporation for use at WSSRAP.

1.2 SCOPE

The EDAP provides guidance on the management of environmental documentation and data resulting from monitoring, surveillance, and characterization at the WSSRAP. All phases of data collection, analysis, and quality are performed as detailed in this plan. This includes sampling plan preparation, data verification and validation, database administration, and data archiving. This plan does not govern worker protection monitoring activities or the quality of data as a result of these activities.

1.3 HISTORICAL OVERVIEW

Analytical data collected from 1987 to 1989 by the Project Management Contractor (PMC) have been managed on an investigation-by-investigation basis. Sampling plans included quality control measures to ensure data integrity. Under the DQO program, data were examined by PMC personnel to test their adherence to PARCC requirements. This review provided a first step to addressing data quality under the DQO program.

While data from 1987 to 1989 were reviewed for PARCC compliance, a separate effort to assess and document the validity of analytical results was also made. The results of this effort are currently being presented in a document scheduled for issue in October 1990: "Data Validation Review."

Data verification and validation programs described in this EDAP were initiated in 1989 for environmental sampling activities. These programs establish additional quality control measures and are detailed in this plan.

1.4 MAINTENANCE

The EDAP will be reviewed annually and revised as necessary to ensure compliance with DOE orders and the overall mission of the WSSRAP. All documents and data will be maintained in accordance with procedures described in Section 4.0 of this plan.

2 DATA COLLECTION

2.1 SAMPLING AND ANALYSIS PLANS

Sampling and analysis plans are developed and prepared for all site activities requiring field collection and laboratory analysis of samples. These plans range in size from one-page memos to multi-paged, self-supporting documents. The plans are activity-specific, describing the objectives and details of the individual sampling efforts and the ultimate uses of the data generated. Sampling and analysis plans specify the types, locations, and frequency of samples to be collected, as well as the sampling protocol and procedures. The plans also detail the specific QA/QC measures to be taken during sampling and analysis effort and reference the requirements of the Quality Assurance Program Plan (QAPP) for the Weldon Spring Site Remedial Action Project (WSSRAP). Sampling plans specify detailed Data Quality Objectives (DQOs) which may take precedence over the standard DQOs.

2.2 SAMPLE COLLECTION AND DOCUMENTATION

Samples are collected using standard operating procedures (SOP) from specific, preplanned locations as detailed in the WSSRAP sampling plans.

Two forms of documentation are used during sample collection to define data reporting requirements that characterize sampling efforts and ensure consistent data records. The field log books are maintained by the field sampling personnel to record details such as dates, times, personnel, weather conditions, deviations from sampling protocol or any other information potentially impacting the specific sampling event. The level of detail should be sufficient to

understand and re-create the activity at a later date, even in the absence of the field personnel.

The sampling field data form is completed for each sample location at the time of sample collection. These forms are specific to the common types of samples collected at the WSSRAP, i.e., soils, groundwater, surface water, etc. The field sampling forms record the sample identification numbers assigned to the sample collected based on location and date (SOP ES&H 4.1.1). This unique ID number is used throughout documentation and reporting of data. The forms also initiate the tracking of laboratory performance and evaluation of data quality. Additionally, these forms document that field personnel collected samples in accordance with WSSRAP procedures, preserved samples properly, and collected QA/QC samples, and other vital information. An example of a typical sampling field data form is shown in Figure 2-1.

2.3 CHAIN-OF-CUSTODY

Sample custody is an integral part of quality and field laboratory operations. Sample possession must be traceable from the time each is collected until it is disposed of or placed in final storage. A sample is under custody if one or more of the following criteria are met:

- the sample is in the actual possession of the responsible party

- the sample is in the view of the responsible party, after being in possession

- the sample was in the responsible party's possession and then that person locked it up or sealed it to prevent tampering

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7295 Highway 94 South, St. Charles, MO 63303
Telephone (314) 441-8080 Telecopy (314) 447-0803

GROUNDWATER SAMPLING FIELD DATA FORM 4.4.1.1

WELL #: MW-2010 DATE: MAY 4, 1990 SAMPLE ID#: GW-2010-QZ90
PERSONNEL: JWD

TIME
0810 Well secure: (yes) no Total depth: 79.10 ft.

0812 Static water level: 53.42 ft.
Length of water column: 25.68 ft.
Diameter of well: (2") 4", or 6"
Volume of water column:
16L for 2", .65L for 4", 1.5L for 6" 4.1 gal.

0822 Begin evacuation Method: DEDICATED PUMP (BLADDER)
Rate of recharge: v. slow, (slow) mod. fast, or v. fast

0930 Number of volumes removed: 3+ (14.5 GAL)

0935 Temperature: 12.4 C Instrument used:
pH: 6.89 Ø11
Conductivity: 540 RC-16C
Water conditions: CLEAR

1005 Completed sampling Method: SAME AS ABOVE

1007 Temperature: 12.6 C Instrument used:
pH: 6.77 Ø11
Conductivity: 525 RC-16C

1012 Final water level: 68.44 ft.
Comments/Duplicates:
TOOK DUPLICATE ⇒ GW-2110-QZ90

Parameters collected: NAT. URANIUM, NITROAROMATICS
Samples filtered: yes no
Samples preserved: X Radiological pH<2 (HNO_3)
___ Metals pH<2 (HNO_3)
X Others packed in ice

FIELD DATA FORM

FIGURE 2-1

REPORT NO.: DOE/OR/21548-119	DRAWING NO.: A/PI/001/0490	
ORIGINATOR: JMH	DRAWN BY: GLN	DATE: 4/90

- o the sample is in a designated and identified secure area under control of the ES&H Department.

All samples are collected according to SOPs for the particular sample type. The field personnel are responsible for the collection, care and custody of the sample until the sample is properly transferred or dispatched. An Environmental Chain-of-Custody form (Figure 2-2) is completed for each sample or group of samples. The Chain-of-Custody (COC) form includes sample identification numbers, number of containers, sample matrix, analytical parameters requested, turnaround time required, samplers' signatures and a section for tracking sample possession.

When the samples are shipped to the lab for analysis the individuals relinquishing and receiving the samples sign, date, and note the time and reason for transfer on the COC. The completed original form is then placed inside the shipping container. The laboratory documents receipt of the samples on the COC and notify the shipper and the WSSRAP in the event that samples are damaged, tampered with, or missing.

Corrections necessary in completing COC forms are made by a single strike-mark through the error. The person making the correction initials and dates each correction.

2.4 REQUEST FOR ANALYSIS

Samples collected in the field commonly require analysis by an off-site laboratory subcontracted by the WSSRAP. In order to authorize testing on the samples, PMC personnel complete a Laboratory Services Authorization Form. These forms are specific to each sample matrix (i.e., water, soil, etc.). They include such information as laboratory name, sample identification numbers, number of containers, analytical

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ST. CHARLES, MO 63303

TELEPHONE (314) 441-8086 TELEX (314) 447-0803

ENVIRONMENTAL SAMPLE CHAIN OF CUSTODY FORM

WSSRAP CONTRACT: _____ REQUEST NO: _____

PHONE EXT.: _____ DATE SAMPLED: _____ LABORATORY RECEIVING SAMPLES: _____

SAMPLE NUMBER	NO. OF CONT.	MATRIX	PARAMETERS	PRESERVATIVES

SAMPLERS' SIGNATURE: _____

RELINQUISHED BY	RECEIVED BY	DATE	TIME	REASON FOR TRANSFER	SEAL INTACT (YES/NO)	COOLER TEMP.

ENVIRONMENTAL CHAIN OF CUSTODY FORM

FIGURE 2-2

REPORT NO.: DOE/OR/21548-119	DRAWING NO.: A/PI/027/0590	
ORIGINATOR: JMH	DRAWN BY: GLN	DATE: 5/90

parameters, turnaround time requested and required number. The Laboratory Services Authorization Forms authorize analytical service and provide a mechanism for tracking analytical laboratory budgets and performance. An example form is presented in Figure 2-3.

2.5 SAMPLE SHIPMENT

Samples are packaged and shipped to analytical laboratories in accordance with WSSRAP standard operating procedures. These procedures detail the requirements of packaging and shipping for common types of samples in order to protect the samples during shipment. All samples shipped off-site are accompanied by a Shipping Order Form (Figure 2-4). This form is completed by the Subcontract Administrator when the Chain-of-Custody and Laboratory Services Authorization Forms are reviewed and approved. These three forms are combined, placed in a plastic bag, and accompany the sample being shipped.

2.6 SAMPLE TRACKING

Sample shipments to analytical laboratories are inventoried and controlled by the use of a laboratory contract request number. When a sample shipment is made, sample information from the documentation is entered into a computerized database, the Environmental Sample Tracking (EST) system.

EST allows timely inventory of the status of analytical samples from collection through receipt of data results. The EST system also serves an accounting function by calculating analytical costs, assists in invoice payment authorization and provides budget reporting.

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(314) 441-8086

WATER ANALYSIS

Page 1 of 1

LABORATORY SERVICES AUTHORIZATION FORM

Lab: ABC — Request No: 32

Requisitioner: JOHN DOE — Dept: ES&H

Cost Code: EMP — P.O. No: 3589-1002-00001

Need Date: 6/1/90 — C.O.C. No: ____

___ Emergency ___ Urgent
___ Priority X Standard

Sample Id.	Containers	Matrix
GW-2010-Q290	2	GROUNDWATER
GW-2110-Q290	2	11

Authorization:

William Williams — 5/4/90
MK-F Procurement — Date

John W. Doe — 5/4/90
ES & H — Date

Shipping: Initial _____ Date: _____

Receiving: Initial _____ Date: _____

PRIMARY ANALYSES

___ [101] Charge Mass Balance
___ [102] Chromium, Hexavalent
___ [103] Chromium, Trivalent
___ [104] Dioxins, Class Specific
___ [105] HSL Metals + Lithium +Mo
___ [106] Nitroaro., GC/MS
___ [107] Nitroaro., Modi. Usathame
X [108] Nitroaro., Usathame
___ [109] NO3,Cl,SO4,F
___ [110] Oxygen Demand, Chemical
___ [111] PCB's
___ [112] pH
___ [115] TCL Semi-Volatile Orgs
___ [116] TCL Volatile Organics
___ [117] Total HSL
___ [118] Total Organic Carbon
___ [119] Total Suspended Solids

RADIOCHEMICAL

___ [201] Gross Alpha
___ [202] Gross Beta
___ [203] Isotopic Actinium
___ [204] Isotopic Radium
___ [205] Isotopic Thorium
___ [206] Isotopic Uranium
___ [207] Lead - 210
___ [208] Polonium - 210
___ [209] Radium - 226
___ [210] Radium - 228
___ [211] Thorium - 230, 232
X [213] Uranium-Natural

___ [321] Extraction, EP Toxicity
___ [323] Extraction, TCLP
___ [113] Sample Filtration
___ [114] Sample Preservation
___ [120] NPDES Quaterly Analysis
___ [121] NPDES Annual Analysis
___ Metals Analysis Attachment

SECONDARY ANALYSES

___ [301] 2378 TCDD
___ [302] Acidity, Total
___ [303] Alkalinity, Total
___ [304] Arsenic
___ [305] Ash Content
___ [306] Bacteria, Fecal Coli
___ [307] Bacteria, Fecal Strep
___ [308] Bacteria, Total Coli
___ [311] Bromide
___ [312] BTU Value
___ [314] Chlorine
___ [316] Corrosivity
___ [317] Cyanide
___ [318] Cyanide Reactive
___ [319] Cyanide Total
___ [326] Hardness
___ [331] Nitrate
___ [332] Nitrite
___ [334] Nitrogen, Ammonia
___ [335] Nitrogen, Ejeldahl
___ [336] Nitrogen, Organic
___ [337] Oil & Grease (TCTFE)
___ [338] Organic Halide, (TOX)
___ [339] Oxygen Demand, Biochem
___ [340] Phenols
___ [341] Phosphorus, Ortho
___ [342] Phosphorus, Total
___ [343] Solids, Volatile
___ [344] Specific Gravity
___ [346] Sulfide Reactive
___ [347] Sulfide Total
___ [348] Sulfite
___ [349] Sulfur Content
___ [350] TCL Pesticides/PCB
___ [351] TDS
___ [352] Turbidity (J.T.U.)
___ [353] Viscosity
___ [354] Zirconium

LABORATORY AUTHORIZATION FORM

FIGURE 2-3

REPORT NO.: DOE/OR/21548-119	DRAWING NO.: A/PI/003/0490	
ORIGINATOR: JMH	DRAWN BY: GLN	DATE: 4/90

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

NO. 5000

SHIPPING ORDER

SHIPPED FROM
CONTRACT NO 00001
LOCATION W. S. P.
DATE SHIPPED 5/4/90
PURPOSE OF SHIPMENT
SALE ☐ TRANSFER ☒
RETURN FOR CREDIT ☐
FOR REPAIR ☐
OTHER

SHIPPED TO
ABC LABS INC.
1234 INDUSTRIAL DR.
WELDON SPRING, MO 63303
ATTN: JOE DUPONT
1-919-323-4001

SHIPPED VIA FEDERAL EXP.

B. L. NO. DATE 5/4/90

PREPAID ☒
COLLECT ☐

00001-00001
P. O. NO. ASSIGNED

QUANTITY	UNIT	DESCRIPTION	SERIAL NO. OR SPECIAL MARK
		REQUEST # 32	
1	COOLER	CONTAINING FOUR(4) SAMPLES FROM TWO(2) IDENTIFICATION NUMBERS	
		★ STANDARD TURNAROUND	

CLAIMS FOR SHORTAGES MUST BE MADE WITHIN 10 DAYS

SHIPMENT OF ITEMS LISTED ABOVE WERE MADE IN THE MANNER NOTED.
William Williams
WAREHOUSEMAN

SHIPMENT OF ABOVE ITEMS FOR PURPOSE DESIGNATED IS HEREBY APPROVED
Bill Thompson
PROJECT MANAGER WAREHOUSE MANAGER

FORM WH115 Rev 5-82

SHIPPING ORDER FORM

FIGURE 2-4

REPORT NO.: DOE/OR/21548-119	DRAWING NO.: A/PI/004/0490	
ORIGINATOR: JMH	DRAWN BY: GLN	DATE: 4/90

3 DATA QUALITY

All data and documentation from sampling activities are reviewed under Environmental Data Administration Plan (EDAP) data quality programs. Data received from analytical laboratories are also reviewed for completeness and quality. The data quality programs, data verification and data validation examine documents and data prior to its use at WSSRAP.

3.1 DATA VERIFICATION PROGRAM

The verification program is primarily designed to ensure that documentation and data are reported in compliance with established Data Quality Objectives (DQOs) and Standard Operating Procedures (SOPs) and to evaluate the completeness of data. The Data Verification Program consists of six verification tests Two tests are associated with data delivery and analytical costing. Four tests compare actual procedures to Weldon Spring Site Remedial Action Project (WSSRAP) DQOs, analytical protocol and SOPs. Elements reviewed are sample preservation and identification, Chain-of-Custody (COC) completion, analytical hold times, and data review. The results of the verification tests are documented with a verification checklist (Figure 3-1).

3.1.1 Data Delivery

Delivery of analytical data is tracked to ensure that the requested laboratory services are performed in an accurate and timely manner.

Analytical results are delivered in two formats: a formal report with QA/QC paperwork and an electronic copy. Current contracts with two analytical laboratories require delivery only

WELDON SPRING SITE REMEDIAL ACTION PROJECT (WSSRAP)
VERIFICATION CHECKLIST
FORM 4.9.1.2

Request Number:_____
Date Sampled:_____
Date Shipped:_____
Date laboratory received samples:_____
Date WSSRAP received analytical results:_____
Turnaround time requested: ___S(28 days) ___P(14 days)
___U(5 days) ___E(48 hrs.)
Were turnaround times met? ___yes ___no If not, specify/explain:
_____
Laboratory name:_____
Sample ID numbers:_____
_____
_____
Parameters requested:_____
_____
_____
_____
_____
Samples preserved and labelled at WSSRAP according to applicable procedure:
___yes ___no
Chain of custody completed according to established procedure:
___yes ___no
Extraction holding times met? ___yes ___no
Comments:_____
_____
Analytical holding times met? ___yes ___no
Comments:_____
_____
Data reviewed by:_____

Verification Checklist completed by:

_____ _____
Signature Date

DATA VERIFICATION CHECKLIST

FIGURE 3-1

REPORT NO.: DOE/OR/21548-119	DRAWING NO.: A/PI/005/0490	
ORIGINATOR: JMH	DRAWN BY: GLN	DATE: 4/90

of formal analytical reports. Future laboratory service contracts will require delivery of data in both formats.

Analytical results from subcontract laboratories are received at WSSRAP and are logged and dated by the Project Management Contractor (PMC) Subcontract Administrator. All analytical results are forwarded to the PMC Data Administration Section. The receipt of data is recorded in a manual sample tracking log.

The data formats are reviewed to determine if all formats have been received according to contract requirements. In addition, data are reviewed to confirm that all parameters are received for the analytical tests. If additional data are required to complete the laboratory request, a discrepancy form (Figure 3-2) is completed and sent to the Subcontract Administrator for handling.

As discussed in Section 2.4, when samples are shipped, a lab authorization form is completed. The laboratory authorization form indicates a turnaround time for delivery of analytical results. The standard turnaround time is 28 calendar days.

Analytical services are also available within premium turnaround times ranging from 48 hours to 2 weeks. These services are usually reserved for special sampling events or National Pollutant Discharge Elimination System (NPDES) monthly reports.

When the data are received by the PMC, the date is recorded on the laboratory report. This date is compared with the shipping date for the sample to determine a total turnaround time. If a turnaround time is greater than the requested time, a verification discrepancy form is completed to record the

VERIFICATION DISCREPANCY DOCUMENTATION
FORM 4.9.1.4

Date:_____

WSSRAP Sample ID:_____

Laboratory performing analysis:_____

Laboratory ID:_____

Describe discrepancy:_____

_____

_____

_____

_____

Corrective Action Taken:_____

_____

_____

_____

_____

Signature:_____ Date:_____

VERIFICATION DISCREPANCY FORM

FIGURE 3-2

REPORT NO.: DOE/OR/21548-119			DRAWING NO.: A/PI/006/0490		
ORIGINATOR: JMH		DRAWN BY: GLN		DATE: 4/90	

turnaround time. The potential effects of negligence in meeting turnaround times may include failure to comply with analytical hold times on analyses.

3.1.2 Sample Preservation and Identification

Documents prepared during sample collection are reviewed to verify compliance in identification and preservation of samples. According to procedures, consistent numbering of sample location is necessary for sample identification. Sample IDs are checked for proper use of sample type identifiers, location number/coordinates, date codes and QA/QC coding.

Preservation of samples is required under certain analytical methods. Sample preservation required prior to shipment is documented on field data forms. The forms are reviewed for completeness and accuracy in preservation during the verification tests.

3.1.3 Chain-of-Custody

Copies of COC records are returned to the PMC with the analytical results. The COC records are reviewed for compliance with procedures as described in EDAP Section 2.3 and WSSRAP SOPs. The COC is reviewed for possession and signatures status of the samples, for any samples that may have been damaged, and for clarity of information provided on the COC form.

3.1.4 Analytical Holding Times

WSSRAP DQOs incorporate analytical methods under U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) protocol. These methods designate maximum analytical holding times, the period between sample collection

and analysis. Some methods also specify extraction procedures and extraction holding times.

When analytical results are received, the date of extraction and date of analysis for each analyte is reported. The extraction and analysis dates are compared with the sample collection date to determine total holding time for the sample. The sample's holding time is compared to the holding time for the analytical method as defined by the WSSRAP DQOs. Holding times are recorded for each analysis. A discrepancy form is completed for sample holding times that exceed DQO protocol.

3.1.5 Data Review

All analytical data are reviewed as a final verification test. The data review process evaluates comparability of sample data with other previously reported concentrations for the sample location. Sample data is also compared to the QA/QC samples, field blanks, and laboratory duplicate samples collected on the same sample date. The data review reports inconsistencies in concentrations, sampling procedure, sample identification, etc.

The data review form (Figure 3-3) is completed by the PMC personnel. The data reviewer will designate the data as "acceptable" or "unacceptable" and include qualifying comments on the data review sheet for all data designated as unacceptable. Unacceptable data will be considered for data validation activities as presented in Section 3.2.

3.1.6 Verification Documentation

The verification checklist is completed by the Data Administration Section based on results of each verification

WELDON SPRING REMEDIAL ACTION PROJECT (WSSRAP)

DATA VERIFICATION DATA REVIEW SHEET
FORM 4.9.1.1

Laboratory:_____

Request Number(s):_____

_____

Date Received:_____

Reviewer(s):_____

Review Date:_____

_____

Data is: Acceptable:____ Unacceptable:____

Comments:_____

_____

_____

_____

_____

Signature:_____

Date Returned:_____

REVIEWER: THIS SHEET SHOULD BE RETURNED TO THE VERIFICATION DEPARTMENT WITHIN 2 WORKING DAYS OF DATE RECEIVED.

DATA REVIEW FORM

FIGURE 3-3

REPORT NO.: DOE/OR/21548-119			DRAWING NO.: A/PI/007/0490		
ORIGINATOR: JMH		DRAWN BY: GLN		DATE: 4/90	

test. Overall integrity of the data is measured and documented with the verification checklist.

All data will be assigned a verification status code of A (approved) or S (significant). If no discrepancies exist from the verification review, a status of A, approved will be assigned to the data. If significant discrepancies exist, such as samples that exceed holding times, a status code of S will be assigned to the data. Data with a status code of S will be considered for validation review as part of the non-random data validation program that is further detailed in Section 3.2.

All data regardless of status code will be considered available for use by WSSRAP. The verification status does not disqualify data from use. The verification tests are used to determine compliance with WSSRAP DQOs and SOPs and prequalify sample data for data validation review.

3.2 DATA VALIDATION

Data validation is the process of reviewing the analytical data, using laboratory records, to assess laboratory performance as compared to quality control (QC) criteria, data quality objectives, and procedural requirements. The purpose of validation is to document the quality and usefulness of the data and documentation developed during sample analysis.

The validation of data is divided into the following three tasks: (1) identification of data to be validated, (2) actual validation, and (3) documentation. These tasks are discussed in the following sections.

3.2.1 Identification

The identification of data to be validated is accomplished in two ways. The first consists of routine validation. Approximately 5% of the samples collected will be validated as soon as the analytical data is received from the lab. These data points are identified in the sampling plans that detail their collection. An additional 5% of the data will be selected following completion of the data review portion of the verification process. Additional data points may be identified for validation based on the criticality and sensitivity of the data. For example, data that contribute to risk assessments or final remedial action decisions may be identified for validation. Requests for validation are made on data validation request and tracking log forms (Figure 3-4).

3.2.2 Validation

The actual data validation process is detailed in an Engineering SOP (ENG-9). This process consists of reviewing and evaluating the data resulting from laboratory analyses. The review consists of two phases. The first deals with the analytical process itself. Laboratory analytical records are reviewed and evaluated to assure compliance with the procedures governing the analysis. These records may include but are not limited to: sample custody records, sample preparation logs, instrument printouts, calibration checks, initial calibration data, etc.

The second phase of the data validation process consists of evaluating the data for precision, accuracy, and completeness. Precision, accuracy and completeness are evaluated by comparing the data to data quality objectives in sampling plans.

CONTROL NO: _____

DATA VALIDATION REQUEST FORM

REQUESTOR: _____

WBS CODE: _____

DEPARTMENT: _____

DATE: _____

USE ONE FORM PER LABORATORY. LAB NAME: _____

REQUEST NO: _____

SAMPLES RECOMMENDED FOR VALIDATION:

WSSRAP ID	LAB ID	SAMPLE DATE	PARAMETER	FOR REVIEW USE

FOR REVIEW USE:

DATE REC'D: _____

SUBMITTED TO VALIDATION: _____

DATE OF REQUEST TO LAB: _____

DATE COMPLETED: _____

VALIDATION REQUEST FORM

FIGURE 3-4

REPORT NO.: DOE/OR/21548-119	DRAWING NO.: A/PI/026/0590	
ORIGINATOR: JMH	DRAWN BY: GLN	DATE: 5/90

The primary end result of the validation process is a qualifier which denotes the quality of the data point. These qualifiers range from "acceptable with no limitations" to not acceptable. This qualifier enables data evaluation personnel to incorporate data quality into interpretations. A list of data qualifiers is shown in Figure 3-5.

3.2.3 Documentation

Data validation activities will be recorded in several documents. These documents include a detailed validation checklists specific to analysis. An example of validation documentation for a semi-volatiles analysis is shown in Appendix B. Data validation summary reports will be generated for each validation request and will provide information substantiating the assignment of qualifiers.

As a result of validation activities, at least 10% of the WSSRAP data will be directly validated (validation that results out of a specific request from data users). However, for some analyses, a portion of the database will also be validated indirectly (or "by association") as a consequence of the "sample batching" nature of most analytical procedures. Such indirect validation is possible for most metals analyses, most miscellaneous inorganic analyses, some anions, and some radiological procedures since the data documentation for these analyses is typically presented for the entire analytical batch or lot (which may include WSSRAP samples that were not specifically requested for validation).

DATA VALIDATION QUALIFIER LIST

QUALIFIER	PURPOSE
Primary	
N	Sample not scheduled for data validation
P	Data validation in Progress (Pending)
A+	Data useable; no further qualifiers
A[*]	Data useable; with qualifiers
R[*]	Data Rejected; with explanation
O[**]	Data validation ON-HOLD (additional info requested from lab)
Secondary *	
>	high bias
<	low bias
L	Lab Control Sample (LCS) outside acceptance range (accuracy)
B	Blank contamination (integrity)
M	MS/MSD outside acceptance range (accuracy/precision)
D	Dup. Relative % Difference outside acceptance range (precision)
S	Surrogates outside acceptance range (accuracy)
I	Internal Standards (GC/MS) outside acceptance range (quantification)
H(#/#)	Holding times exceeded (integrity)
C	Calibration criteria not met (quantification)
T	GC/MS Tune criteria not met (qualification)
F	Interferences present (matrix related)
?	Other (see data validation notes)
J	Estimated value
Y	Shipping delay to lab (greater than 1 day)
G	Typographical error (significant)

Tertiary **

c	calibration	i	instrument printouts
s	sample preparation	l	control charts
t	tune	d	data summary sheets
q	QC samples/information	n	notebook entries
u	custody transfer record	e	corr. action/exception reports
p	standards preparation	?	other (see data validation notes)
m	mass spectra		

EXAMPLES:

A[L>,H(5)] - means the data point is useable, but the value may be slightly high (per the LCS); and the holding time was exceeded by 5 days.

A[F,J] - means the data point appears useable, but there are sample-related interferences present that resulted in an estimated value.

R[S<] - means the data are not useable because the surrogate recoveries were too low to rely on the value.

P - means this sample/analyte is scheduled for data validation, but the validation tasks are not yet complete.

DATA VALIDATION QUALIFIERS

FIGURE 3-5

REPORT NO.: DOE/OR/21548-119	DRAWING NO.: A/PI/028/0590	
ORIGINATOR: JMH	DRAWN BY: GLN	DATE: 5/90

4 DATA ADMINISTRATION

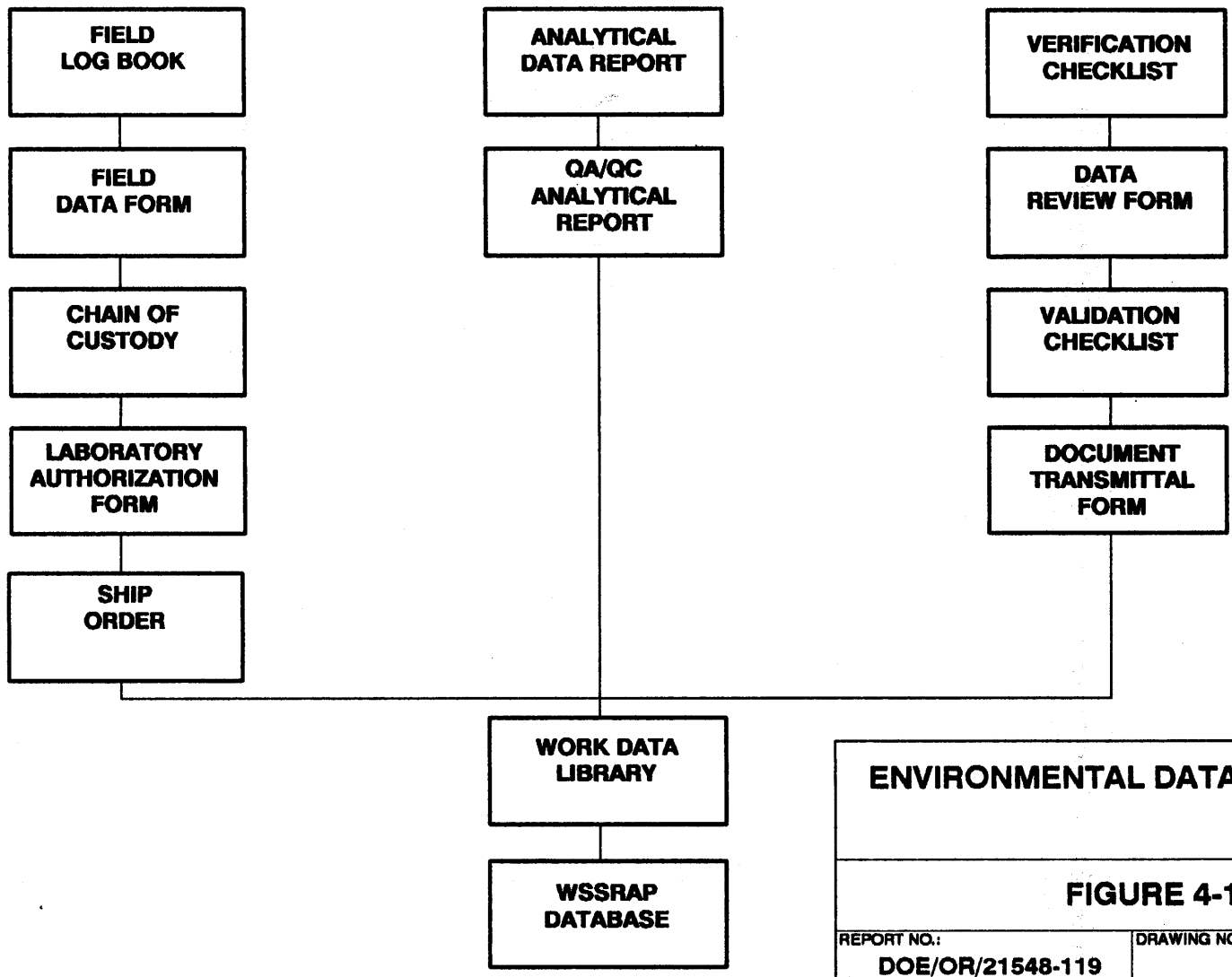
All documentation and data generated through the environmental monitoring activities are managed and maintained by the data administration plan of the Environmental Data Administration Plan (EDAP). Each document created from sampling to data quality review provides information and support for environmental decisions at Weldon Spring Site Remedial Action Project (WSSRAP). The standardization of forms and documents as directed by Standard Operating Procedures (SOPs) provides a source of information that is complete yet unique for each sample. The full set of data and documents is termed the data audit trail. Figure 4-1 summarizes the data and documentation in the audit trail. The administration of data includes the maintenance of all documents and data in the audit trail, providing the information to WSSRAP in an organized, flexible manner and incorporating a system to archive data.

In this discussion of data administration plans, all environmental data and documentation from sampling, analysis and quality review programs are collectively referred to as records.

4.1 RECORD MAINTENANCE

Environmental records are maintained in two formats: hard copy records and electronic records. Hard copy records include all documents and data preserved in written, typed or instrument-printed form. All environmental records originate in hard copy format.

Electronic records are defined as computerized records of environmental data. Currently, only analytical data are maintained in electronic format. Approximately 60% of the subcontract laboratories transcribe analytical reports into electronic format. Analytical results not reported in



ENVIRONMENTAL DATA AUDIT TRAIL

FIGURE 4-1

REPORT NO.:	DRAWING NO.:	
DOE/OR/21548-119	A/PI/021/0590	
ORIGINATOR: JMH	DRAWN BY: JHB	DATE: 5/90

electronic format are transcribed to electronic records by the Project Management Contractor (PMC).

4.1.1 Hard Copy Records

All original records are received by the PMC. When the original is received, a copy of the document is made. A copy of the record is filed in the Work Data Library.

The Work Data Library is a centralized library system that contains all documents and data from environmental monitoring activities. The library is primarily organized by record type: data or documentation. Each record type is then classified and filed according to sample type. Sample types were mentioned in Section 2.1 as a manner in which to assign sample identification numbers. Functionally, sample types also form the basis for data interpretation and, therefore, sample types are used in record management. Table 4-1 lists the sample type categories in use.

When a record is submitted to the library files, it is assigned an index number based on record and sample type number. An example of the index record number is ES-19-01-02. The first four characters (ES-19) identify the document as an environmental record. The fifth and sixth digits (01) designate the record as analytical data. The seventh and eighth digits (02) designate the sample type as surface water. A current Work Data Library index is presented in Table 4-2. The index is updated periodically to incorporate new records.

When record copies are made for the Work Data Library, the originals are forwarded to Quality Assurance for secured storage. An internal document transmittal form is completed to accompany the document transfer (Figure 4-2). All original

TABLE 4-1 WSSRAP Environmental Data Sample Type Categories

AA	Ambient Air
AP	Air Particulate
BA	Bulk Asbestos
BG	Biological
BZ	Breathing Zone
IN	Insulation
LY	Lysimeter
MW	Monitoring Well
NP	NPDES
OT	Industrial Hygiene
PZ	Piezometer
RD	Radon Cup
RS	Radiation Safety
SD	Sediment/Sludge
SO	Soils Phase I
S2	Soils Phase II
SW	Surface Water

TABLE 4-2 Work Data Library Index

ES-19-01	TECHNICAL DATA
ES-19-01-01	Groundwater Data
ES-19-01-02	Surface Water Data
ES-19-01-03	Spring/Seep Data
ES-19-01-04	Radon Data
ES-19-01-05	TLD Data
ES-19-01-06	NPDES Data
ES-19-01-07	Industrial Hygiene Data
ES-19-01-08	Radiation Lab Data
ES-19-01-09	Air Particulate Data
ES-19-01-10	Sludge Data
ES-19-01-11	Sediment Data
ES-19-01-12	Soils Data
ES-19-01-13	Biological Data
ES-19-02	QUALITY ASSURANCE
ES-19-02-01	metaTRACE QA Reports
ES-19-02-02	Acculab QA Reports
ES-19-02-03	JTC QA Reports
ES-19-02-04	Inhouse Calibration Records
ES-19-02-05	AEHA QA Reports
ES-19-02-06	IT QA Reports
ES-19-02-07	Other Labs QA Reports
ES-19-02-08	Training Records
ES-19-02-09	Document Transmittal
ES-19-02-10	Audits/Reviews/Performance
ES-19-03	DOCUMENTATION
ES-19-03-01	Field Sheets
ES-19-03-02	Log Books
ES-19-03-03	Chain of Custody Records
ES-19-04	CORRESPONDENCE - REPORTS & LETTERS
ES-19-04-01	DOE/PMC Correspondence
ES-19-04-02	Laboratory Correspondence
ES-19-04-03	EPA Correspondence
ES-19-04-04	USGS
ES-19-04-05	MoDNR
ES-19-04-06	SCCAHW
ES-19-04-07	DOE/PMC Reports
ES-19-05	DATA VERIFICATION RECORDS
ES-19-05-01	Data Review Sheets
ES-19-05-02	Verification Checklists
ES-19-05-03	Verification Summaries
ES-19-05-04	Discrepancy Forms

MK-FERGUSON CO.
A MORRISON KNUDSEN COMPANY

INTERNAL DOCUMENT TRANSMITTAL

BSGRAP-IDT-9-89

TRANSMITTAL NO.

WORK PKG NO.	CONTRACT NO. 3589	DATE

TO.	FROM
ATTENTION	SIGNATURE

ACTION REQUESTED:	STATUS	
	APPROVED - FOR CONSTRUCTION	A
	DISAPPROVED - REVISE AND RESUBMIT	D
	APPROVED WITH COMMENTS - FOR CONSTRUCTION	E

PROCEDURE, SPECIFICATION, DRAWING OR ITEM NUMBER	REV NO.	NO. COPIES	TITLE OR DESCRIPTION	STATUS

ADDRESSEE:

RECEIPT ACKNOWLEDGEMENT REQUIRED ☐
PLEASE RETURN ONE COPY OF THIS TRANSMITTAL TO DOCUMENT CONTROL WITHIN ___ WORKING DAYS

RECEIPT ACKNOWLEDGEMENT NOT REQUIRED ☐

THE ABOVE LISTED DOCUMENTS HAVE BEEN RECEIVED BY:

SIGNATURE

DATE RECEIVED

INTERNAL DOCUMENT TRANSMITTAL FORM

FIGURE 4-2

REPORT NO.: DOE/OR/21548-119	DRAWING NO.: A/PI/009/0490	
ORIGINATOR: JMH	DRAWN BY: GLN	DATE: 4/90

documents are inventoried by Quality Assurance and stored in fireproof safes at the WSS.

4.1.2 Electronic Records

Electronic records are maintained in a computerized database system termed the WSSRAP database. The WSSRAP database is a microcomputer based system utilizing dBASE III Plus software. Analytical records are organized into database files by sample type such as groundwater. The database files contain in database fields specific information on the sample. The fields maintained in the WSSRAP database include sample identification number, sample date, analytical date, parameter, etc. The list of all database fields and a description of field information is presented in Table 4-3.

Analytical results reported by the subcontract laboratory in electronic format are submitted on a 5 1/4" floppy diskette. Each diskette contains a dBASE III Plus file recording specific sampling information. The diskette is received by the PMC and copied to the WSSRAP database during verification tests. After the disk transfer is completed, a control number is assigned to each diskette and recorded on a disk record log maintained by the PMC. All diskettes are filed in a fireproof safe located at the WSS.

4.2 RECORD USE

The Work Data Library and the WSSRAP database provide an centralized source for information to be used in preparing environmental reports and remedial action alternatives. The environmental records are organized to provide data that are readily retrievable and convenient for use. Environmental records are required for use by on-site and off-site personnel.

TABLE 4-3 WSSRAP Environmental Database Fields

Field	Description of Information
WSSRAP ID	Sample identification number
Lab ID	Analytical laboratory identification number
Sample Date	Date of sample collection
Matrix	Sample type
Category	Compound or group of parameters analyzed
Parameter	Compound analyzed - chemical or radiological
Concentration	Identified amount of parameter
Units	Standard of measurement of parameter analyzed
Error	Range of error in measurement of concentration. Used mainly in radiological analyses.
Analysis Date	Date of analysis of sample
Extraction Date	Date of sample extraction if applicable under analytical method
Method	Analytical method used by laboratory in analysis of sample
Detection Limit	Minimum reportable concentration of compound defined by data quality objectives
Verification	Verification code assigned reflecting analytical status of sample
Qualifier	Validation code assigned to sample reflecting usability of data

4.2.1 Use of Work Data Library

The Work Data Library is located at the WSS. All personnel have full access to records in the library for use and/or copying. Personnel requiring use of records must sign the documents out on a library log maintained by the PMC to record such use of records. A maximum check-out period of one day is allowed and only on-site use of records is permitted. The Data Administration Section manages the use of the Work Data Library.

4.2.2 Use of WSSRAP Database

The electronic record database is more widely used for review of analytical data by WSSRAP personnel. Database use is managed by a customized software program called the Generic Universal Report Utility (GURU). The GURU program was developed by the PMC for use in accessing the WSSRAP database. GURU is a compiled dBASE program written for the IBM PC network system.

The GURU program provides a tool for easy and flexible access to data records. The GURU is also defined as a data extraction program since data can be selected and sorted based on sample identification number, parameter or any other field definition. Selected data can be extracted or copied to other computerized formats or as a printed report.

The GURU program also provides a method to secure data contained in the WSSRAP database. Data are made available to the user without risking the integrity of the data. Users are allowed to view or copy records, but records cannot be modified or deleted within the GURU system.

On-site use of the WSSRAP database is provided by accessing the WSSRAP local area network system. Users requiring access to the database must complete a user registration form with the PMC

Management Information System (MIS) Coordinator. A user name and password is assigned to each user and specifies access to the WSSRAP database and GURU system.

Off-site use of the WSSRAP database and the GURU system is available for WSSRAP participants. Access to the database will be provided by a modem connection. The modem capability allows off-site users to dial in on standard phone lines and connect to a computer at the WSS. The modem connection allows the same convenience and security features of on-site use. Off-site users requiring access to the database must complete a users' registration form with the PMC MIS Coordinator. A user name and password is assigned to each user and off-site access may be specified.

4.3 DATA ARCHIVING

A system of archiving environmental data is necessary due to the volume of data and duration of WSSRAP. Formats of data documentation -- hard copy, originals, and electronic -- will be archived. Archiving of data will be allowed only after all EDAP data quality activities have been completed on the data to be archived. Specifically the data must be verified and validated under the EDAP program.

All original documents are transferred to Quality Assurance and are archived under DOE contract requirements. The original documents are stored in the WSSRAP Quality Control area in a fireproof safe. The original documents will be maintained by Quality Control for the duration of the project. Work Data Library and Electronic data records are maintained by the Data Administration sections. These records will be archived. Archival of records is performed annually.

Work Data Library documents will be inventoried and will be boxed and stored at WSSRAP for a one-year period in archive status. After one year in archive, the Work Data Library documents will be destroyed.

Electronic data records will also be archived after five years. All archive data will be transferred to new historic data record files. The archive files will be backed up with magnetic tapes and stored in the fireproof safe in Quality Assurance. The archive data files will be available for use by the WSSRAP GURU program but not in conjunction with active data files. Original electronic data reporting disks from the laboratory will be destroyed after five years.

5 REFERENCES

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APPENDIX A
Data Quality Objectives

Specific Data Quality Objectives (DQOs) for the Weldon Spring Site Remedial Action Project (WSSRAP) have been developed according to the U.S. Environmental Protection Agency (EPA) Guidance Document. These site-specific DQOs include Precision, Accuracy, Representativeness, Completeness and Comparability (PARCC) goals for future data collection activities. Each of these goals is discussed in the following paragraphs.

PRECISION AND ACCURACY

Precision and accuracy goals for analytical data are presented in the following table. Analytical methods, detection limits and precision and accuracy goals are presented by analytical parameter and media for both soil and water. Generic precision and accuracy goals are also presented.

REPRESENTATIVENESS

The representativeness of data collected will be ensured by proper selection of sampling locations and by ensuring that Standard Operating Procedures are followed during sample collection.

COMPLETENESS

Completeness is the percentage of measurements that are valid. The goal for completeness at the WSSRAP is 85%.

COMPARABILITY

By establishing precision and accuracy goals and monitoring analytical performance, comparability evaluations can be made with previous data for which precision and accuracy data are available.

The DQOs presented herein are to be used for future monitoring and characterization activities. As future characterization activities are identified, these DQOs will be reviewed. If the existing DQOs are acceptable and appropriate, they will be applied. If not, new DQOs will be developed. The DQOs presented in this summary will be reviewed annually and updated as appropriate.

DATA QUALITY OBJECTIVES FOR THE WSSRAP
PRECISION AND ACCURACY GUIDLINES
FOR ROUTINE MONITORING AND CHARACTERIZATION

CATEGORY	ANALYTICAL PARAMETER	ANALYTICAL LEVEL	ANALYTICAL METHOD b	MDC b UG/G	PRECISION (soil)	ACCURACY (soil)	MDL b UG/L	PRECISION (water)	ACCURACY (water)	COMMENTS
RADIATION SCREENING	GROSS ALPHA	I	2.6.4 *	NA	NA	NA	NA	NA	NA	ES&H SOP
	GROSS BETA/GAMMA	I	2.6.3 *	NA	NA	NA	NA	NA	NA	ES&H SOP
FIELD MEASUREMENTS	pH	I	4.5.1 *	NA	NA	NA	NA	20	NA	ES&H SOP
	TEMPERATURE	I	4.5.1 *	NA	NA	NA	NA	20	NA	ES&H SOP
	CONDUCTIVITY	I	4.5.2 *	NA	NA	NA	NA	20	NA	ES&H SOP
	SPECIFIC IONS	I	4.5.5 *	NA	NA	NA	NA	20	NA	ES&H SOP
	ORGANIC VAPORS	I	3.1.1 *	NA	NA	NA	NA	20	NA	ES&H SOP
	SETTLEABLE SOLIDS	I	4.5.7 *	NA	NA	NA	0.1	20	NA	ES&H SOP
	TH-230, TH-232	II	UNC	2 pCi/g	50	50	NA	NA	NA	
ONSITE RADIOLOGICAL MEASUREMENTS	U-238, U-235,	III	901.1	1 pCi/g	50	30	NA	NA	NA	
	RA-226, RA-228	III	901.1	1 pCi/g	50	20	NA	NA	NA	
	TH-230, TH-232	II	UNC	2 pCi/g	50	20	NA	NA	NA	
	GROSS ALPHA	III	2.4.3*	NA	NA	NA	NA	NA	NA	ES&H SOP
OFFSITE RADIOLOGICAL MEASUREMENTS	NAT. URANIUM	III	EPA 908.0	1 pCi/g	50	30	1 pCi/l	20	20	
	RADIUM-226, -228	III	EPA 903.1	1 pCi/g	50	30	1 pCi/l	20	20	
	THORIUM-230, -232	III	EERF 00/07	1 pCi/g	50	30	1 pCi/l	20	20	
	GROSS ALPHA	III	EPA 900.0	3 pCi/g	50	30	3 pCi/l	40	40	
	GROSS BETA	III	EPA 900.0	3 pCi/g	50	30	8 pCi/l	40	40	
NITROAROMATIC COMPOUNDS	TNT	III	USATHAMA	1.2	e	e	0.03 d	f	f	
	2,4-DNT	III	USATHAMA	0.75	e	e	0.03 d	f	f	
	2,6-DNT	III	USATHAMA	1.41	e	e	0.01 d	f	f	
	1,3,5-TNB	III	USATHAMA	0.57	e	e	0.03 d	f	f	
	1,3-DNB	III	USATHAMA	0.9	e	e	0.09 d	f	f	
	NITROBENZENE	III	USATHAMA	1.44	e	e	0.03 d	f	f	
MISC.	TSS	III	EPA 160.2	NA	NA	NA	2	20	20	
	TDS	III	EPA 160.2	NA	NA	NA		20	20	
	TOC	III	EPA 415.1				0.1	20	20	
	LITHIUM	III	EPA 200.7	5	50	50	50	20	20	
	MO	III	EPA 200.7	4	50	50	4	20	20	
	ZR	III	EPA 200.7	20	50	50	20	20	20	
	CR+3	III	EPA 200.7		50	50	10	20	20	
	CR+6	III	COLORIMETRIC		50	50	5	20	20	
	TOX	III	EPA 450.0	5	50	50		20	20	
	NO3	III	300.0/353.2c	0.5	50	50	0.25/0.1c*	20	20	MG/L
	SO4	III	300.0/375.4c	5	50	50	1.0/1.0c*	20	20	MG/L
	CL	III	300.0/325.1c	1.5	50	50	0.25/0.2c*	20	20	MG/L
	FL	III	300.0/340.2c	1.25	50	50	0.25/0.6c*	20	20	MG/L
	NO2	III	300.0	0.5	50	50		20	20	MG/L
	% MOISTURE	II	ASTM	NA	50	NA	NA	NA	NA	
	pH (SOIL)	III	EPA 160.2	NA	50	NA	NA	NA	NA	
	ASBESTOS-PCM/TEM	III	3.1.4	NA	NA	NA	NA	NA	NA	ES&H SOP
CLP-VOA		IV	CLP	CRDL	AS REQUIRED BY CLP		CRDL	AS REQUIRED BY CLP		

DATA QUALITY OBJECTIVES FOR THE WSSRAP
PRECISION AND ACCURACY GUIDLINES
FOR ROUTINE MONITORING AND CHARACTERIZATION

CATEGORY	ANALYTICAL PARAMETER	ANALYTICAL LEVEL	ANALYTICAL METHOD b	MDC b UG/G	PRECISION (soil)	ACCURACY (soil)	MDL b UG/L	PRECISION (water)	ACCURACY (water)	COMMENTS
CLP-SEMIVOA -	BNA	IV	CLP	CRDL	AS REQUIRED BY CLP		CRDL	AS REQUIRED BY CLP		
CLP-PEST/PCB		IV	CLP	CRDL	AS REQUIRED BY CLP		CRDL	AS REQUIRED BY CLP		
CLP-METALS	AL	IV	CLP-ICP	20	AS REQUIRED BY CLP		200	AS REQUIRED BY CLP		
	AS	IV	CLP-ICP	1	AS REQUIRED BY CLP		10	AS REQUIRED BY CLP		
	BE	IV	CLP-ICP	0.5	AS REQUIRED BY CLP		5	AS REQUIRED BY CLP		
	CD	IV	CLP-ICP	0.5	AS REQUIRED BY CLP		5	AS REQUIRED BY CLP		
	CR	IV	CLP-ICP	1	AS REQUIRED BY CLP		10	AS REQUIRED BY CLP		
	CU	IV	CLP-ICP	2.5	AS REQUIRED BY CLP		25	AS REQUIRED BY CLP		
	PB	IV	CLP-AA	0.5	AS REQUIRED BY CLP		5	AS REQUIRED BY CLP		
	HG	IV	CLP-CV	0.1	AS REQUIRED BY CLP		0.2	AS REQUIRED BY CLP		
	NI	IV	CLP-ICP	4	AS REQUIRED BY CLP		40	AS REQUIRED BY CLP		
	NA	IV	CLP-ICP	500	AS REQUIRED BY CLP		5000	AS REQUIRED BY CLP		
	ZN	IV	CLP-ICP	2	AS REQUIRED BY CLP		20	AS REQUIRED BY CLP		
	BA	IV	CLP-ICP	20	AS REQUIRED BY CLP		200	AS REQUIRED BY CLP		
	AG	IV	CLP-ICP	1	AS REQUIRED BY CLP		10	AS REQUIRED BY CLP		
	FE	IV	CLP-ICP	10	AS REQUIRED BY CLP		10	AS REQUIRED BY CLP		
	K	IV	CLP-ICP	500	AS REQUIRED BY CLP		5000	AS REQUIRED BY CLP		
	MN	IV	CLP-ICP	1.5	AS REQUIRED BY CLP		15	AS REQUIRED BY CLP		
	MG	IV	CLP-ICP	500	AS REQUIRED BY CLP		5000	AS REQUIRED BY CLP		
	SE	IV	CLP-AA	0.5	AS REQUIRED BY CLP		5	AS REQUIRED BY CLP		
	VA	IV	CLP-ICP	5	AS REQUIRED BY CLP		50	AS REQUIRED BY CLP		
	TL	IV	CLP-AA	1	AS REQUIRED BY CLP		10	AS REQUIRED BY CLP		
	SB	IV	CLP-ICP	6	AS REQUIRED BY CLP		60	AS REQUIRED BY CLP		
	CA	IV	CLP-ICP	500	AS REQUIRED BY CLP		5000	AS REQUIRED BY CLP		
	CO	IV	CLP-ICP	5	AS REQUIRED BY CLP		50	AS REQUIRED BY CLP		
OTHER PARAMETERS NOT LISTED		II,III,IV	TBD	TBD	50	50	TBD	20	20	SEE NOTE

* - SEE COMMENT SECTION
TBD - TO BE DETERMINED
NA - NOT APPLICABLE
ACCURACY = PERCENT BIAS = PERCENT RECOVERY - 100
a - ACCURACY AND PRECISION DATA PRESENTED FROM EPA DQO GUIDANCE DOCUMENT - SPECIFIC PRECISION AND ACCURACY TO BE NEGOTIATED WITH THE LABORATORY
b - DETECTION LIMITS AND METHODS FROM EXISTING CONTRACT WITH metaTRACE - NEW DETECTION LIMITS AND/OR METHODS TO BE ESTABLISHED WITH NEW LABORATORY
c - JTC METHODS AND DETECTION LIMITS
d - ARMY ENVIRONMENTAL HYGIENE AGENCY (AEHA) DETECTION LIMITS
e - TO BE NEGOTIATED WITH THE LABORATORY
f - TO BE PROVIDED BY AEHA
NOTE: GENERIC DQOS APPLY TO MEDIA AND/OR ANALYTICAL METHODS NOT LISTED IN THIS TABLE. SPECIFIC DQOS MAY BE DEVELOPED AS A PART OF FUTURE SAMPLING AND ANALYSIS PLANS

APPENDIX B
Data Validation Documentation

SEMI-VOLATILES BY GC/MS - CHECKLIST PAGE 1 OF [ ]

Data Set #:	Related Datasets:	Analysis Date:

SAMPLES IN ANALYSIS SET:

WSSRAP ID	Lab ID	Lab File No.	Date Sampled	Date Rec'd	Date Extracted	HT OK?	Qualifiers
a.							
b.							
c.							
d.							
e.							
f.							
g.							
h.							
i.							
j.							
k.							
l.							
m.							
n.							
o.							
p.							
q.							
r.							
s.							
t.							

ANALYSIS SEQUENCE: (sample/FRN/time)

Dates: to

1.	16.
2.	17.
3.	18.
4.	19.
5.	20.
6.	21.
7.	22.
8.	23.
9.	24.
10.	25.
11.	26.
12.	27.
13.	28.
14.	29.
15.	30.

Date _____ Reviewer (printed) _____ Signature _____

SEMI-VOLATILES BY GC/MS - CHECKLIST PAGE 2 OF [ ]

DFTPP TUNE		Dataset #:	
Tune File #:		Seq. #:	Instr. ID:
DFTPP Inj. Date:		DFTPP Inj. Time:	

m/e	Ion Abundance Criteria	% Rel. Abundance
51	30.0 - 60.0% of mass 198	
68	Less than 2.0% of mass 69	( )1
69	Mass 69 relative abundance	
70	Less than 2.0% of mass 69	( )1
127	40.0 - 60.0% of mass 198	
197	Less than 1.0% of mass 198	
198	Base Peak, 100% relative abundance	
199	5.0 - 9.0% of mass 198	
275	10.0 - 30.0% of mass 198	
365	Greater than 1.00% of mass 198	
441	Present, but less than mass 443	
442	Greater than 40.0% of mass 198	
443	17.0 - 23.0% of mass 442	( )2

1 - value is % mass 69 2 - value is % mass 442

MATRIX SPIKE/ MSD		Sample ID:				Matrix:	
COMPOUND	SEQ. NO.	SPIKE ADDED	SAMP CONC	MS CONC	MS % REC	REC limits Water	REC limits Soil
Phenol						12-89	26-90
2-Chlorophenol						27-123	25-102
1,4-Dichlorobenzene						36-97	28-104
N-Nitroso-di-n-prop.						41-116	41-126
1,2,4-Trichlorobenzene						39-98	38-107
4-Chloro-3-methylphenol						23-97	26-103
Acenaphthene						46-118	31-137
4-Nitrophenol						10-80	11-114
2,4-Dinitrotoluene						24-96	28-89
Pentachlorophenol						9-103	17-109
Pyrene						26-127	35-142
COMPOUND	SEQ. NO.	SPIKE ADDED	MSD CONC	MSD % REC	% RPD	RPD limits Water	RPD limits Soil
Phenol						42	35
2-Chlorophenol						40	50
1,4-Dichlorobenzene						28	27
N-Nitroso-di-n-prop.						38	38
1,2,4-Trichlorobenzene						28	23
4-Chloro-3-methylphenol						42	33
Acenaphthene						31	19
4-Nitrophenol						50	50
2,4-Dinitrotoluene						38	47
Pentachlorophenol						50	47
Pyrene						31	36

RPD: _____out of _____ outside limits.

Spike recovery: _____out of _____outside limits.

COMMENTS:

SEMI-VOLATILES BY GC/MS - CHECKLIST PAGE 3 OF [ ]

INITIAL CALIBRATION					Date(s) performed:				
Instrument ID:					Calib.#:				
Data Set #:	Calc. Chk	MEAN RRF	% RSD	RT Chk		Calc. Chk	MEAN RRF	% RSD	RT Chk
2-Fluorophenol					3-Nitroaniline				
Phenol-d6					Acenaphthene		#	*	
Phenol			*		2,4-Dinitrophenol		#		
bis(2-Chloroethyl)ether					4-Nitrophenol		#		
2-Chlorophenol					Dibenzofuran				
1,3-Dichlorobenzene					2,4-Dinitrotoluene				
1,4-Dichlorobenzene			*		2,6-Dinitrotoluene				
Benzyl Alcohol					Diethylphthalate				
1,2-Dichlorobenzene					4-Chlorophenyl-phenylether				
2-Methylphenol					Fluorene				
bis(2-Chloroisopropyl)ether					4-Nitroaniline				
4-Methylphenol					*2,4,6-Tribromophenol*				
N-Nitroso-di-n-propylamine		#			4,6-Dinitro-2-methylphenol				
Hexachloroethane					N-Nitrosodiphenylamine			*	
Nitrobenzene-d5					4-Bromophenyl-phenylether				
Nitrobenzene					Hexachlorobenzene				
Isophorone					Pentachlorophenol			*	
2-Nitrophenol			*		Phenanthrene				
2,4-Dimethylphenol					Anthracene				
Benzoic Acid					Di-n-butylphthalate				
bis(2-Chloroethoxy)methane					Fluoranthene			*	
2,4-Dichlorophenol			*		Pyrene				
1,2,4-Trichlorobenzene					*Terphenyl-d14*				
Naphthalene					Butylbenzylphthalate				
4-Chloroaniline					3,3'-Dichlorobenzidine				
Hexachlorobutidiene			*		Benzo(a)anthracene				
4-Chloro-3-methylphenol			*		bis(2-Ethylhexyl)phthalate				
2-Methylnaphthalene					Chrysene				
Hexachlorocyclopentadiene		#			Di-n-octylphthalate			*	
2,4,6-Trichlorophenol			*		Benzo(b)fluoranthene				
2,4,5-Trichlorophenol					Benzo(k)fluoranthene				
2-Fluorobiphenyl					Benzo(a)pyrene			*	
2-Chloronaphthalene					Indeno(1,2,3-cd)pyrene				
2-Nitroaniline					Dibenzo(a,h)anthracene				
Dimethylphthalate					Benzo(g,h,i)perylene				
Acenaphthylene									

Min. RRF for SPCC(#) = 0.050 Max %RSD for CCC(*) = 30.0%

CONTINUING CALIBRATION					Date performed:				
Date of initial Calib.:					Init Calib #:				
Instrument ID:									
Data Set #:	Calc. Chk'	RT Chk'	RRF50	% Diff		Calc. Chk'	RT Chk'	RRF50	% Diff
2-Fluorophenol					3-Nitroaniline				
Phenol-d6					Acenaphthene			#	*
Phenol				*	2,4-Dinitrophenol			#	
bis(2-Chloroethyl)ether					4-Nitrophenol			#	
2-Chlorophenol					Dibenzofuran				
1,3-Dichlorobenzene					2,4-Dinitrotoluene				
1,4-Dichlorobenzene				*	2,6-Dinitrotoluene				
Benzyl Alcohol					Diethylphthalate				
1,2-Dichlorobenzene					4-Chlorophenyl-phenylether				
2-Methylphenol					Fluorene				
bis(2-Chloroisopropyl)ether					4-Nitroaniline				
4-Methylphenol					*2,4,6-Tribromophenol*				
N-Nitroso-di-n-propylamine			#		4,6-Dinitro-2-methylphenol				
Hexachloroethane					N-Nitrosodiphenylamine				*
Nitrobenzene-d5					4-Bromophenyl-phenylether				
Nitrobenzene					Hexachlorobenzene				
Isophorone					Pentachlorophenol				*
2-Nitrophenol				*	Phenanthrene				
2,4-Dimethylphenol					Anthracene				
Benzoic Acid					Di-n-butylphthalate				
bis(2-Chloroethoxy)methane					Fluoranthene				*
2,4-Dichlorophenol				*	Pyrene				
1,2,4-Trichlorobenzene					*Terphenyl-d14*				
Naphthalene					Butylbenzylphthalate				
4-Chloroaniline					3,3'-Dichlorobenzidine				
Hexachlorobutidiene				*	Benzo(a)anthracene				
4-Chloro-3-methylphenol				*	bis(2-Ethylhexyl)phthalate				
2-Methylnaphthalene					Chrysene				
Hexachlorocyclopentadiene			#		Di-n-octylphthalate				*
2,4,6-Trichlorophenol				*	Benzo(b)fluoranthene				
2,4,5-Trichlorophenol					Benzo(k)fluoranthene				
2-Fluorobiphenyl					Benzo(a)pyrene				*
2-Chloronaphthalene					Indeno(1,2,3-cd)pyrene				
2-Nitroaniline					Dibenzo(a,h)anthracene				
Dimethylphthalate					Benzo(g,h,i)perylene				
Acenaphthylene									

Min. RRF50 for SPCC(#) = 0.050 Max %Diff for CCC(*) = 25.0%

SURROGATE RECOVERIES

Dataset #:			Sample matrix:				
SEQ. #	S1 (NBZ) #	S2 (FBP) #	S3 (TPH) #	S4 (PHL) #	S5 (2FP) #	S6 (TBP) #	Tot Out
1.							
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	CLP QC Limits	
	Water	Soil
S1 (NBZ) = Nitrobenzene-d5	(35-114)	(23-120)
S2 (FBP) = 2-Fluorobiphenyl	(43-116)	(30-115)
S3 (TPH) = Terphenyl-d14	(33-141)	(18-137)
S4 (PHL) = Phenol-d6	(10-94)	(24-113)
S5 (2FP) = 2-Fluorophenol	(21-100)	(25-121)
S6 (TBP) = 2,4,6-Tribromophenol	(10-123)	(19-122)

COMMENTS:

INTERNAL STANDARD AREA SUMMARY

Data Set #	IS1 (DCB)	RT	IS2 (NPT)	RT	IS3 (ANT)	RT	IS4 (PHN)	RT	IS5 (CRY)	RT	IS6 (PRY)	RT
12 Hour Std												
Upper lmt.												
Lower lmt.												
SEQ.#.												
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IS1 (DCB) = 1,4-Dichlorobenzene-d4
IS2 (NPT) = Naphthalene-d8
IS3 (ANT) = Acenaphthene-d10
Upper lmt. = +100% of IS area

IS4 (PHN) = Phenanthrene-d10
IS5 (CRY) = Chrysene-d12
IS6 (PRY) = Perylene-d12
Lower lmt. = - 50% of IS area

METHOD BLANK SUMMARY

		Seq. #:
Data Set #:	Analysis Date:	FRN:
	Extraction Date:	Lab Lot #:

Compound	Conc. (ugl or ugkg)	Compound	Conc. (ugl or ugkg)
2-Fluorophenol		3-Nitroaniline	
Phenol-d6		Acenaphthene	
Phenol		2,4-Dinitrophenol	
bis(2-Chloroethyl)ether		4-Nitrophenol	
2-Chlorophenol		Dibenzofuran	
1,3-Dichlorobenzene		2,4-Dinitrotoluene	
1,4-Dichlorobenzene		2,6-Dinitrotoluene	
Benzyl Alcohol		Diethylphthalate	
1,2-Dichlorobenzene		4-Chlorophenyl-phenylether	
2-Methylphenol		Fluorene	
bis(2-Chloroisopropyl)ether		4-Nitroaniline	
4-Methylphenol		*2,4,6-Tribromophenol*	
N-Nitroso-di-n-propylamine		4,6_Dinitro-2-methylphenol	
Hexachloroethane		N-Nitrosodiphenylamine	
Nitrobenzene-d5		4-Bromophenyl-phenylether	
Nitrobenzene		Hexachlorobenzene	
Isophorone		Pentachlorophenol	
2-Nitrophenol		Phenanthrene	
2,4-Dimethylphenol		Anthracene	
Benzoic Acid		Di-n-butylphthalate	
bis(2-Chloroethoxy)methane		Fluoranthene	
2,4-Dichlorophenol		Pyrene	
1,2,4-Trichlorobenzene		*Terphenyl-d14*	
Naphthalene		Butylbenzylphthalate	
4-Chloroaniline		3,3'-Dichlorobenzidine	
Hexachlorobutidiene		Benzo(a)anthracene	
4-Chloro-3-methylphenol		bis(2-Ethylhexyl)phthalate	
2-Methylnaphthalene		Chrysene	
Hexachlorocyclopentadiene		Di-n-octylphthalate	
2,4,6-Trichlorophenol		Benzo(b)fluoranthene	
2,4,5-Trichlorophenol		Benzo(k)fluoranthene	
2-Fluorobiphenyl		Benzo(a)pyrene	
2-Chloronaphthalene		Indeno(1,2,3-cd)pyrene	
2-Nitroaniline		Dibenzo(a,h)anthracene	
Dimethylphthalate		Benzo(g,h,i)perylene	
Acenaphthylene		# of TIC's (list below)	

TIC	RT	Conc.	TIC	RT	Conc.
1.			11.		
2.			12.		
3.			13.		
4.			14.		
5.			15.		
6.			16.		
7.			17.		
8.			18.		
9.			19.		
10.			20.		

SEMI-VOLATILES BY GCMS - CHECKLIST PAGE [ ] OF [ ]

WSSRAP ID:	Dataset #:	Seq. No.:
Lab No.:	Lab File No.:	
Level: L/M	GPC'd?: Y/N	% Moisture:
Dilution Factor:		Sample Volume (g or ml):

	Primary Ion	Secondary Ion(s)	Ion Chk	Calc Chk	Ret. Time	Conc. ugl or ugkg	Conc. in DB
2-Fluorophenol	112	64					
Phenol-d6	99	42,71					
Phenol	94	65,66					
bis(2-Chloroethyl)ether	93	63,95					
2-Chlorophenol	128	64,130					
1,3-Dichlorobenzene	146	148,113					
1,4-Dichlorobenzene	146	148.113					
Benzyl Alcohol	108	79,77					
1,2-Dichlorobenzene	146	148,113					
2-Methylphenol	108	107					
bis(2-Chloroisopropyl)ether	45	77,79					
4-Methylphenol	108	107					
N-Nitroso-di-n-propylamine	70	42,101,130					
Hexachloroethane	117	201,199					
Nitrobenzene-d5	82	128,54					
Nitrobenzene	77	123,65					
Isophorone	82	95,138					
2-Nitrophenol	139	65,109					
2,4-Dimethylphenol	107	121,122					
Benzoic Acid	122	105,77					
bis(2-Chloroethoxy)methane	93	95,123					
2,4-Dichlorophenol	162	164,98					
1,2,4-Trichlorobenzene	180	182,145					
Naphthalene	128	129,127					
4-Chloroaniline	127	129					
Hexachlorobutidiene	225	223,227					
4-Chloro-3-methylphenol	107	144,142					
2-Methylnaphthalene	142	141					
Hexachlorocyclopentadiene	237	235,272					
2,4,6-Trichlorophenol	196	198,200					
2,4,5-Trichlorophenol	196	198,200					
2-Fluorobiphenyl	172	171					
2-Chloronaphthalene	162	164,127					
2-Nitroaniline	65	92,138					
Dimethylphthalate	163	194,164					
Acenaphthylene	152	151,153					

SEMI-VOLATILES BY GCMS - CHECKLIST PAGE [ ] OF [ ]

WSSRAP ID:	Dataset #:	Seq. No.:
Lab No.:	Lab File No.:	
Level: L/M	GPC'd?: Y/N	% Moisture:
Dilution Factor:		Sample Volume (g or ml):

	Primary Ion	Secondary Ion(s)	Ion Chk	Calc Chk	Ret. Time	Conc. ugl or ugkg	Conc. in DB
3-Nitroaniline	138	108,92					
Acenaphthene	153	152,154					
2,4-Dinitrophenol	184	63,154					
4-Nitrophenol	109	139,65					
Dibenzofuran	168	139					
2,4-Dinitrotoluene	165	63,182					
2,6-Dinitrotoluene	165	89,121					
Diethylphthalate	149	177,150					
4-Chlorophenyl-phenylether	204	206,141					
Fluorene	166	165,167					
4-Nitroaniline	138	92,108					
2,4,6-Tribromophenol	330	332,141					
4,6-Dinitro-2-methylphenol	198	182,77					
N-Nitrosodiphenylamine	169	168,167					
4-Bromophenyl-phenylether	248	250,141					
Hexachlorobenzene	284	142,249					
Pentachlorophenol	266	264,268					
Phenanthrene	178	179,176					
Anthracene	178	179,176					
Di-n-butylphthalate	149	150,104					
Fluoranthene	202	101,100					
Pyrene	202	101,100					
Terphenyl-d14	244	122,212					
Butylbenzylphthalate	149	91,206					
3,3'-Dichlorobenzidine	252	254,126					
Benzo(a)anthracene	228	229,226					
bis(2-Ethylhexyl)phthalate	149	167,279					
Chrysene	228	226,229					
Di-n-octylphthalate	149	-					
Benzo(b)fluoranthene	252	253,125					
Benzo(k)fluoranthene	252	253,125					
Benzo(a)pyrene	252	253,125					
Indeno(1,2,3-cd)pyrene	276	138,227					
Dibenzo(a,h)anthracene	278	139,279					
Benzo(g,h,i)perylene	276	138,277					

SEMI-VOLATILES BY GCMS - CHECKLIST PAGE [ ] OF [ ]

WSSRAP ID:	Dataset #:	Seq. No.:
Lab No.:	Lab File No.:	
Level: L/M	GPC'd?: Y/N	% Moisture:
Dilution Factor:		Sample Volume (g or ml):

# of TICs: Compound name	Ret. Time	Quant. ion	Conc. ugl or ugkg	Conc. in DB
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ATTACHMENT B

MISSOURI DEPARTMENT OF CONSERVATION

1/2

MAILING ADDRESS
P.O. Box 180
Jefferson City, Missouri 65102-0180

STREET LOCATION
2901 West Truman Boulevard
Jefferson City, Missouri

Telephone: 314/751-4115
JERRY J. PRESLEY, Director

January 22, 1990

ADMINISTRATIVE RECORD (_____ ARFS)
FILE NUMBER: _____ SECTION: _____
DOCUMENT NUMBER: _____ DATE: _____
DOCUMENT TITLE:

AUTHOR: _____ RECIPIENT: _____
TYPE: _____ # OF PAGE: _____

Dr. David Bedan
Department of Natural Resources
Division of Environmental Quality
P. O. Box 176
Jefferson City, Missouri 65102

Dear Dr. Bedan:

In response to your November 22, 1989 memo, we have reviewed the Draft Remedial Investigation Report for the Weldon Spring Site Remedial Action Project prepared by the U. S. Department of Energy. As usual the document is well done. One question that prevailed as I reviewed the document was whether this was a document that decided action or one that simply laid out the situation. I found some indications of both.

Several questions related to our Busch and Weldon Spring Wildlife Areas came to light. They are:

1. Page 5-112 through 5-122. It appears that the Department of Conservation sites 1, 3, 4, 5, 7 and 9 require remediation while sites 2, 6, 8 and 10 apparently do not require remediation. Sites 1, 2 and 10 apparently have been cleared up. Site 6 is recommended to be remediated during quarry cleanup. Why not include site 8 in the remediation of quarry cleanup?

2. Page 5-123. We concur in the need for cleanup of Southeast Drainage.

3. Page 5-132. Sediment samples from Site SD-4001, Lake 36, SD-4007 and Lake 35 have mean uranium levels of 31 pCi/g, 30 pCi/g, 26 pCi/g and 23.6 pCi/g. The reference level for uranium indicated on page 5 of the Executive Summary is 15 pCi/g. Would it follow that remediation on these sites is warranted since they exceed the reference level?

4. Page 5-155 and 5-157. Data are puzzling to us. We have collected a set of fish flesh samples for lead analyses. We would hope that as more data become available a decision can

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JAN 24 1990
DEQ ADMIN

COMMISSION

JERRY P. COMBS, Kennett
ANDY DALTON, Springfield
JAY HENGES, St. Louis
JOHN POWELL, Rolla

be made on appropriate action to respond to elevated lead levels. With very high lead levels in Ash Pond and upstream of Lake 36, how will the Department of Energy interact with the Department of Army on cleanup activities?

We appreciate your patience in soliciting our comments. If you have questions or wish to discuss these comments, please call me.

Sincerely,

W. H. Dieffenbach

WILLIAM H. DIEFFENBACH
ASST. ENVIRONMENTAL ADMINISTRATOR

WHD:jct

(action) Ker
Steve
File

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII
726 MINNESOTA AVENUE
KANSAS CITY, KANSAS 66101

JAN 2 3 1990

Mr. Steve McCracken
Acting Project Manager
U.S. Department of Energy
Weldon Spring Site Remedial
Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

Dear Mr. McCracken:

We have completed our review of the draft Remedial Investigation Report for the Chemical Plant and Raffinate Pit Area dated September 1989. Overall, the report presents a good summarization and evaluation of the various data collection efforts. Our comments and suggested revisions are enclosed with this letter.

Please call if you have any questions.

Sincerely yours,

Robert L. Morby
Chief, Superfund Branch
Waste Management Division

Enclosure

cc: David Bedan, MDNR (w/encl.)

1/29/90

REVIEW COMMENTS ON THE DRAFT REMEDIAL
INVESTIGATION REPORT FOR THE WELDON SPRING SITE

January 1990

General Comments:

1. The scope of the remedial investigation needs to be more fully defined. It may not be clear to the reader that the report is only intended to examine the contamination from the uranium processing plant, and the contamination from explosives production which is inside the DOE property lines. The rationale for this definition needs to be presented, since property lines are generally not relevent to the definition of the extent of contamination. It remains EPA's position that the DOE's and the U.S. Army's respective responsibilities must be defined in a written agreement to ensure that all needed investigation will be completed in an efficient manner. The adequacy of the scope of the RI needs to be evaluated in the context of such an agreement.

2. The field sampling plans which were developed and implemented to form the basis of the RI report are described in the report; however, the reader is not clearly directed to the respective sampling investigation reports which presumably contain more focused and thorough analysis than the summaries contained in the RI report.

3. A useful summary of data gap analyses and general plans for additional data collection is not presented.

4. The data available for analysis of ecological impacts appears to be limited. The impacts of contamination on the wildlife is presented only in the context of the implications to human health. A complete baseline risk assessment must consider environmental effects as well as public health effects. Information on the numbers of species using the contaminated area, their reproductive success, and any evidence that the contamination is affecting the viability of local wildlife populations should be presented.

Detailed Comments:

1. The Table of Contents should be expanded to include a list of plates.

2. In the Executive Summary (page 1), there is a statement which refers to the percentage of land transferred to the U.S. Atomic Energy Commission (AEC) versus the amount of land originally used

for ordnance production. Ten percent is the amount quoted; whereas, the actual amount is closer to one percent as explained in Appendix H. The original site covered 17,232 acres compared to 205 acres transferred from the Department of Army (DA) to AEC.

3. In the third paragraph of the Executive Summary, there are statements which are contradictory. It is stated first that the Weldon Spring Raffinate Pit (WSRP) and the Weldon Spring Chemical Plant (WSCP) areas are on the National Priorities List. The next sentence states that they have been nominated to be on the list.

4. On page 8 in the third paragraph, the reference to Figure 7 should be to Figure 6.

5. The first sentence of the first paragraph on page 10 should be rewritten. It appears that nitroaromatics precipitate in the unsaturated zone before reaching the saturated zone.

6. Several conflicting statements were found. As an example, on page 10 in the Executive Summary, the following statement is made: "Nitroaromatic compounds quickly degrade upon exposure to sunlight and therefore are not transported in surface waters." It is noted on page 6-16, Vol. I that the nitroaromatics TNB and DNB are not subject to photolytic degradation. Also, on page 1-4, the Army Reserve is 1,843 acres, while on page 3-13, Vol. I, it is approximately 1,660 acres.

7. On page 1-5 in the second paragraph, the text states that the Weldon Spring Wildlife Area is located across Missouri Highway 94. Figure 1.2-2, which is referenced, shows the site and the wildlife area on the same side of the highway.

8. Numerous abbreviations labeling buildings, water towers, etc., are shown on Plate 1. A legend should be provided to identify the structures.

9. Table 3.7-1 should indicate what the numbers on the table represent such as the number of samples taken.

10. In Section 4.5.11, page 4-33, second paragraph, it is concluded that the observed net infiltration in the raffinate ponds is "closely related" to the measured hydraulic conductivities of the underlying material. In fact, those hydraulic conductivities span four orders of magnitude. The magnitude of the measured net infiltration lies in the middle of that range. While this is to be expected, it may be misleading to use the term "closely related" to characterize this agreement.

11. The discussion on stratigraphy is good; however, we suggest that the surface soils be addressed in terms of the Department of Agriculture's soil series and descriptions.

12. Page 4-1 references Figure 4.1-2 for site elevations, but it only shows elevations for the surrounding area.

13. The term "normal" is also used incorrectly. In meteorology, "normal" refers to averages of climatological data for the 30-year period from 1951 through 1980. In the context used in the report, either the term "average" or "mean" is more appropriate.

14. The legend on Figure 4.3-2 should include a description of the well, trench and borehole numbering system.

15. In the first paragraph on page 4-21, the last sentence indicates that the four raffinate pits do not contribute to direct runoff; however, Figure 4.4-2 seems to show flow out of pit number 4. Table 4.4-2 also indicates the raffinate pits are closed basins, but Figure 4.4-3 seems to show a stream gage that measures the outflow from pit 4.

16. The term "swallow holes" appears occasionally. Pages 4-26, 4-30 and 4-31 refer to "swallow holes" and Figures 4.4-4 and 4.4-11 refer to "shallow holes." Definitions should be provided since it is not clear what these holes are.

17. The method used for estimating surface runoff on page 4-24 is not a very reliable one. A better approach would have been to calibrate a model to the measured events, then use a historical sequence of precipitation events to determine average runoff conditions. An alternative approach would be to examine records from similar gaged watersheds in the area.

18. On page 4-31, the definition of the vadose zone is misleading. The vadose zone may be temporarily saturated due to surface ponding and may have perched water tables. Perched water tables are mentioned on page 6-4. A possible definition is the zone between the soil surface and the permanently saturated zone.

19. On page 4-33, there is a discussion about lysimeters and that they were installed to determine possible contaminant migration. More explanation is needed to explain how a lysimeter would show contaminant migration. The discussion on page 5-141 about lysimeters is even more confusing on just how the lysimeters are being used. On Table 5.4-1, lysimeter LYS3506 should be LYS3606.

How does the comparison of the two figures lead to the conclusion of a deep "trough"? The discussion which continues onto page 6-B appears to contradict this conclusion. This paragraph is confusing and needs clarification.

29. The discussion on the factors affecting the persistence and attenuation of organic compounds should be expanded. Sometimes degradation products are more toxic than the parents. Were the degradation products adequately sampled and analyzed?

30. On page 6-16 in the first sentence of Section 6.2.7.2, change "deleted" to "detected".

31. From January 1967 to February 1969, the Department of the Army prepared plans to design and construct a plant at the site to produce the herbicide "agent orange". This fact is mentioned in the appendix, but the appendix does not indicate that there was no actual production of the herbicide at the Weldon Spring site during that two-year period.

32. Important information appears missing from the appendices. Descriptions of the monitoring well construction and sampling techniques should have been included.

20. The second paragraph on page 4-35 refers to Figure 4.5-5 when it should really be 4.5-6.

21. On page 4-40 in the third paragraph, briefly explain why the Bouwer and Rice method is believed to be the more reliable method.

22. The loss by seepage from the raffinate pits should be reported as a volume per unit of time. The second paragraph on page 4-47 only specifies an apparent velocity.

23. In Chapter 5, many concentrations are discussed in various samples. Generally, these concentrations are not referenced with any standard to indicate if the concentration is significant in terms of human health or the environment. Page 5-16 has numerous examples of this. Page 5-22, last paragraph, provides the kind of comparison to an established standard that would be helpful throughout the document.

24. An inconsistency was noted in Section 5.1.2.3, page 5-14, second paragraph. The report indicates that the evaporation of all water from raffinate pits 1 and 2 has not happened since 1980; however, Table 5.1-16 indicates a dry surface in 1987. A clarification is needed.

25. Tables 5.1-6 and 5.1-7 have the same title. One of them should be changed to reflect the differences in the data presented.

26. Section 3 of the report describes the investigations conducted at the site. To keep the report consistent, we suggest that the radiological investigations be described in that section as well, rather than in Section 5.

27. On Tables 5.2-2 through 5.2-31, there does not appear to be any difference between the constituents labeled "Other contaminants at levels above two times their upper background limit" and those labeled "...above their upper background limit."

28. The last paragraph on page 6-7 uses a comparison of Figures 4.6-3 and 4.6-4 to indicate a deep ground water "trough" extending from the Weldon Spring site to the Burgermeister Spring. It is suggested that conduit flow velocities in this "trough" are on the order of two feet per minute. This velocity is several orders of magnitude greater than any other reported velocities in the area. Because of this and the potential for very rapid offsite migration of contaminants, there should be more discussion about this "trough." How were these velocities calculated?

JOHN ASHCROFT
Governor

G. TRACY MEHAN III
Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
MEMORANDUM

Division of Energy
Division of Environmental Quality
Division of Geology and Land Surve
Division of Management Services
Division of Parks, Recreation, and Historic Preservation

DATE: January 29, 1990

TO: David Bedan, DEQ Administration

FROM: Peter Price, Geologist, DGLS

SUBJECT: Comments on Draft Remedial Investigation Report for the Weldon Spring Site Remedial Action Project, Rev. B

General Comments

Please reference MDNR's First Annual Report on the Shallow Groundwater Investigations at Weldon Spring, Missouri as MDNR, 1989 rather than Hoffman, 1989. Citations occur on pages 4-24, 26, 46, 50 and 51, on Table 4.6-9, and perhaps elsewhere.

Figure 4.1-2 presents a topographic map of the Weldon Spring area but is not detailed with respect to the site. Nowhere else is there a topographic map of the site. We would suggest adding a topographic map of the site at the same general scale as many of the other site maps in the report. Drainage patterns and surface features would be much more obvious with such a map in combination with the text descriptions.

Specific Comments

Table 4.6-1 - footnote (d) is not explained

P. 3-22 MDNR Dye Tracing Studies - this section does not report MDNR-DGLS dye tracing experiments correctly. Only two borehole dye traces were attempted in 1983 (MW 2020, March 9; MW 3007, April 7) by Dean. The report only mentions one losing stream dye trace (from West Raffinate Pit Drainage, Feb. 1984) of three conducted. The other two were from the head of the Southeast Drainage (June 1984) and from Ash Pond Drainage (March 1985). The 1988 attempted borehole traces are adequately described. Fig. 3.4-4, Water Tracing Sample Locations, appears to be a modified version of a map produced by MDNR-DGLS (MDNR, 1989).

P. 3-29, Section 3.7.1.6 - This section mentions recent (1988-1989) exploration programs, to help describe site geology, conducted by the PMC. Some information from these programs is presented in tabular form (Table 4.3-1) but drilling logs are not presented in the RI Report. Are drilling logs from these recent programs presented in another document?

P. 4-9, Section 4.3.1.1 - The Bushberg Sandstone has been reported in the literature as a Devonian age formation (Kleeschulte and Emmett, 1987; Miller, et al, 1974; Koenig, 1961). However, more recently the Bushberg has been assigned to the Mississippian System (Thompson, 1986). The text and Figure 4.3-1 should reflect current understanding.

The term "unit" is not customarily capitalized since it is not part of the formal name of a formation. Unit is capitalized several places on this page.

The thickness figures given for the Warsaw and Salem formations do not agree with those given in Figure 4.3-1. The thickness figures in the text refer to the site area for most formations. The descriptions of the Warsaw and Salem do not, and may mislead the reader.

P. 4-10, paragraph 2 - Alluvium overlies units other than glacial drift and loess in the vicinity of the site. The last sentence of this paragraph is incorrect.

P. 4-10, Section 4.3.1.2 - This section presents several isopach and contour maps of the site presumably generated from the geologic database. A check of several data points against geologic logs, particularly on Figure 4.3-19, reveals several points in disagreement with plotted contours or isopachs. Many data points cannot be checked because geologic logs have not been presented in this document or elsewhere. Is there an explanation for these apparent conflicts?

P. 4-13 - The residuum unit is described as an individual stratigraphic unit in the text but is not represented as such in the Generalized Stratigraphic Column (Figure 4.3-1). There is a problem in assigning it an age but it should be represented, perhaps as "Quaternary or pre-Quaternary" may be most appropriate.

P. 4-14 - MDNR-DGLS does not consider a hydraulic conductivity of 5 x 10^{-8} cm/sec. to be representative of the residuum unit. Our experience indicates that it has a much higher permeability. We support further sampling and testing of this unit, as mentioned.

P. 4-28 - The descriptions of gaining and losing reaches, particularly in paragraphs 2 and 3, are not clear because mentioned landmarks are incorrectly named and not represented on the reference maps. Road DD is maintained by the State and might better be referred to as State Road DD. Road C and B are Busch Wildlife Area roads and are not shown on Figure 4.4-9.

P. 4-30 - The March 1985 injection of dye was detected only at Burgermeister and its wet weather springs (SP 6301 and SP 6302). Dye was not recovered at SP 6303 (Dean, 1985; MDNR, 1989).

P. 4-35 - Second paragraph refers to Figure 4.5-5 but should probably be 4.5-4.

P. 4-44 - Section 4.6.2.5 Are final pump test results available? If available, the results should be presented and their significance explained.

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JOHN ASHCROFT
Governor

G. TRACY MEHAN III
Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation, and Historic Preservation

DIVISION OF ENVIRONMENTAL QUALITY
P.O. Box 176
Jefferson City, MO 65102

February 21, 1990

Mr. Steve McCracken
U.S. Department of Energy
Weldon Spring Remedial
Action Project
Route 2, Highway 94 South
St. Charles, Missouri 63303

Dear Mr. McCracken:

The Missouri Department of Natural Resources (DNR) has reviewed the draft Remedial Investigation Report for the Weldon Spring Site Remedial Action Project (DOE/OR/21548, September 1989). In general, the report presents a good summary of the characterization data on the Weldon Spring site.

Attached are comments from DNR's Waste Management Program, DNR's Division of Geology and Land Survey, and the Missouri Department of Conservation. No comments were received from the Missouri Department of Health.

Some additional specific comments are:

VOLUME I: Page 3-23, Section 3.4.5, Domestic Well Sampling: This section references the private well information received from the St. Charles Countians Against Hazardous Waste and the U.S. Geological Survey. Figure 3.4-5 is a preliminary map of the private well locations. The report does not discuss the extensive sampling data on these and other wells obtained by the Missouri Department of Health (MDOH) from 1982 to 1989. Attached is the MDOH data on these wells.

I suggest that you summarize this data and discuss its significance in demonstrating the limits of the groundwater contamination. This information may also be relevant to the baseline risk assessment in that it shows that private wells are not being affected by the uranium processing that occurred at the site. To protect the privacy of individuals, well owner names should not be used in the RI report.

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JOHN ASHCROFT
Governor

G. TRACY MEHAN III
Director

STATE OF MISSOURI

DEPARTMENT OF NATURAL RESOURCES

MEMORANDUM

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation, and Historic Preservation

RECEIVED

FEB 01 1990

DEQ ADMIN

DATE: January 30, 1990

TO: Mr. Dave Bedan, Radioactive Waste Site Coordinator, DEQ Admin.

THROUGH: Mr. John Doyle, P.E., Chief, HWS, WMP

FROM: Mr. Dave Freise, P.E., EE, HWPU, HWS, WMP

SUBJECT: Comments on Draft RI (September 1989) for WSCP site

This RI primarily addresses the Weldon Spring Chemical Plant, however, the report, to a minor degree, discusses the Quarry Site. Presumably this is because it is planned for the Quarry Site wastes to be stored at the Chemical Plant Site. Appendix B of the report contains ARAR's which deal with both the Chemical Plant and Quarry wastes. The Appendix deals to a large degree with the Quarry wastes since there are potentially many more ARAR's for the Quarry wastes.

Since this is a first attempt, please don't spare the red pen if I'm to learn what's needed of me. If you have any questions, please contact me at 751-5942.

JDD:dfr

REVIEW COMMENTS ON DRAFT RI/FS AND ARARS FOR WSCP SITE

GENERAL COMMENTS

1. Although much of the TNT operations formerly located at the Chemical Plant were possibly taken care of at the "burn" sites, I would like to see some discussion of the leveling of the site to construct the Chemical Plant. From Plate #1 it appears TNT plants/lines 1 through 4 were located in areas extensively changed by construction of the chemical plant. It would seem logical that some TNT and DNT contaminated wastes were buried or disposed of on site or elsewhere during the construction of the chemical plant.

2. Some of the Interim Response Actions listed in Table 1.2-2 would appear to require a relatively long time to accomplish. ARAR's for these actions are not discussed. EPA policy has stated ARAR's would be followed at "removal actions" to the extent practicable.

3. The fish sampling for the biological contamination portion of the report did not include any bottom feeders. Since the contaminants could be in the sediments, bottom feeders would more likely be contaminated.

4. Were the soil samples analyzed by depth interval (relates to comment 1 above)? It was difficult to tell from the report.

5. Shouldn't Figure 7 of the report show the Twin Lakes development as a receptor?

6. Were the soils selected for background soil sampling of the same toxinomic units as those found at the WSCP site? In some instances the existing chemical plant surface soil may be a subsurface horizon due to the site grading which occurred.

7. Please keep in mind that those IRA's which call for off site disposal will probably require special solid waste permits.

8. Has there been any effort to explain the differences in concentrations between Table 5.1-11 (BNI samples) and Table 5.1-19 (PMC samples)? The BNI results are considerably higher on average.

9. Appendix F and other portions of the report make reference to evaporating the red and yellow waters. This appears unlikely given the flow rates of 40 to 50 mgd.

10. Appendix H makes at least 3 references to the disposal of red water sludges or TNT contaminated material. What efforts have been made to trace the ultimate fate of these materials? Can it definitely be stated they are not buried below the WSCP site or at the Quarry?

11. Has any effort been made to characterize the materials which were dumped into Pit Number 4 in December 1966?

RCRA ARAR - Comments (See Vol. III Appendix B)

1. General - The ARAR's tables did not address the chemically contaminated portions of the buildings, process equipment, or storage tanks. In certain instances portions of the WSCP buildings and equipment may be considered hazardous waste.

2. Table 3 - Has the EPA text; Permit Writers Guidance Manual for the Location of Hazardous Land Storage and Disposal Facilities: Phase I. Criteria for Location Acceptability and Existing Regulations for Evaluating Locations (Feb. 1985), been evaluated for "To be considered" ARAR's?

3. Table 4 - Airborne particulates from handling of RCRA waste must be controlled (264.251,.273,.301).

4. Table 5A, Removal Criteria, does not address RCRA materials which are radiologically contaminated. The treatment, storage, and disposal, of these materials will need to meet RCRA requirements.

5. Table 5B - Tank storage for some period of time in existing tanks appears to be a possibility. If so then 40 CFR 264.191 would be relevant and appropriate.

6. Table 5B, page 3 - Some sections of 40 CFR 264.193 and 194 may not be substantive [eg. (g), (h), (i)].

7. Table 5B, page 4 - Inspections of storage tanks should be relevant and appropriate (40 CFR 264.195).

8. Table 5B, page 8 - Inspection of containers would appear to be relevant and appropriate (40 CFR 264.174).

9. Table 5B, Page 11 and 12 - Although 40 CFR 264.341,.342, and .344 are directly related to permit requirements they would appear to be substantive since the incinerator efficiency or operating limits cannot be determined by the operator with out the required analysis.

10. Table 5B, page 12 - The monitoring requirements of 40 CFR 264.347 appear to be substantive to operate an incinerator.

11. Table 5B - Closure requirements of 40 CFR 264.351 appear to be substantive.

12. Table 5B, page 15 - It would appear that more of 40 CFR 265 subpart P would be relevant and appropriate since it is parallel to 40 CFR 264 subpart O.

13. Table 5C - Wouldn't 40 CFR 265.400 be a "to be considered"?

14. Table 5G - This table should include the Land Ban (40 CFR 268) since any land filled RCRA materials will have to be in compliance with the treatability standards.

15. Table 5G - Page 5, Section 315 of 40 CFR 264 would appear to be substantive.

16. The proposed rules of 40 CFR 269 would appear to be "to be considereds". Part of these rules were proposed on February 5, 1987 (52 FR 3748).

17. Subpart F of 40 CFR Part 264 would appear to be relevant and appropriate to the Quarry site itself.

STATE RCRA ARARS

1. Table 3 - MO. Hazardous Waste Regulations chapter 13 (PCB's) incorporate the chapter 7 (TSDF's) requirements. Locations of commercial facilities handling wastes which come under the PCB rules must comply with MO-RCRA location standards. This may be relevant and appropriate at the site.

2. Table 4, page 1 - Missouri PCB Treatment, Storage, Disposal facilities must meet the MO. Hazardous waste regulations chapter 13 and 7.

3. Tank systems should consider the location standards of 40 CFR 264 subpart N in accordance with 10 CSR 25-7.264(2)(J)4, pages 12 and 13.

4. Sampling methods for incineration should comply with 10 CSR 25-7.264(2)(0), page 24, where more restrictive than 40 CFR 264.343.

5. The requirements of 10 CSR 25-7.264(P) & (Q), pages 24 through 28, would be applicable to treatment or disposal facilities.

6. Leak detection and leachate collection systems must have a permeability of at least 0.01 cm/sec. [See 10 CSR 25-7.264(2)(N)2.A.(II), page 23].

7. The compliance monitoring point of 40 CFR 264.95 is modified by 10 CSR 25-7.264(2)(F)2, page 5. The establishment of this point is referenced in 40 CFR 264 subpart F (See Table 5G, page 5 and 6).

DF:rlh

SAMPLING & ANALYSIS DATA AND BORING LOGS

The records cited in entry numbers 1 through 4 may be reviewed, by appointment only, at the Weldon Spring Site Remedial Action Project, St. Charles, Missouri.

1. Chain of Custody Forms (1986 - Present)
2. Sampling Data (1940 - 1986)
3. Sampling Data (1986 - Present)
4. Boring Logs

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

June 14, 1990

Addressees

RESPONSIVENESS SUMMARY FOR THE RI REPORT

Enclosed are two copies of the Responsiveness Summary for the Weldon Spring Chemical Plant/Raffinate Pit Remedial Investigation (RI) Report (Rev. B). The Responsiveness Summary addresses RI Report review comments from the U. S. Environmental Protection Agency (EPA), the Missouri Department of Natural Resources (MDNR), and the Missouri Department of Conservation (MDOC).

The following responses were modified to reflect the comments discussed in the March 28, 1990 meeting.

- EPA RI Report Review Comments (Enclosure A)
  - General comments 1 and 4
  - Detailed comments 17 and 28
- MDOC RI Report Review Comments (Enclosure B)
  - No change to Responsiveness Summary
- MDNR RI Report Review Comments (Enclosure C)
  - Detailed comment 10
- MDNR RI Report Review Comments (Enclosure D)
  - General comments 5 and 12

The RI will be revised to reflect conclusions of the comment responses. However, a revision to the RI will not be available until September 1990, because some minor changes may be necessary in order to assure that the RI is compatible with other environmental documents.

If you have any comments on the responsiveness summary, please respond by July 20, 1990.

Sincerely,

Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosures:
As Stated

cc w/o enclosure:
Action Item Log

Mr. Dan Wall
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U. S. Environmental Protection Agency
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Missouri Department of Natural Resources
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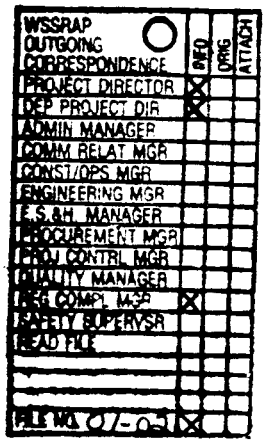

March 16, 1990

U. S. Department of Energy
Weldon Spring Site
Remedial Action Project
ATTN: Mr. S. H. McCracken
Project Manager
7295 Highway 94 South
St. Charles MO 63303

SUBJECT: Contract No. DE-AC05-86OR21548
DRAFT RESPONSIVENESS SUMMARY FOR THE RI REPORT

REFERENCE: Letter from S. H. McCracken to R. E. Hlavacek, EPA & MDNR Comments on the Draft Remedial Investigation (RI) Report for the Weldon Spring Chemical Plant/Raffinate Pit Area, March 1, 1990

Dear Mr. McCracken:

Attached please find twenty copies of the Responsiveness Summary for the Weldon Spring Chemical Plant/Raffinate Pit Remedial Investigation (RI) Report (Rev. B) for your review and comment. The Responsiveness Summary addresses RI Report review comments from the U. S. Environmental Protection Agency (EPA), the Missouri Department of Natural Resources (MDNR), and the Missouri Department of Conservation (MDOC).

As requested in your letter of March 1, 1990, the Responsiveness Summary was prepared for transmittal to EPA and MDNR/MDOC. This document was reviewed by ANL and members of the site DOE and PMC staff.

Please direct your comments to Mr. Doug Steffen of my staff.

Sincerely,

R. E. Hlavacek
Project Director

REH/mmw
Attachment

cc: Walker K. Love

LETTER5.LGO/TXTMMW

ATTACHMENT A

Comments of the U. S. Environmental Protection Agency

GENERAL COMMENTS

Comment 1:

The scope of the remedial investigation needs to be more fully defined. It may not be clear to the reader that the report is only intended to examine the contamination from the uranium processing plant, and the contamination from explosives production which is inside the DOE property lines. The rationale for this definition needs to be presented, since property lines are generally not relevent to the definition of the extent of contamination. It remains EPA's position that the DOE's and the U.S. Army's respective responsibilities must be defined in a written agreement to ensure that all needed investigation will be completed in an efficient manner. The adequacy of the scope of the RI needs to be evaluated in the context of such an agreement.

Response to Comment 1:

The scope of the Weldon Spring Site remedial investigation is presented in Section 1.1.1 where it is stated that the RI focused on both the on-site contamination associated with the chemical plant and raffinate pits, and the off-site areas also contaminated by these sources. Extensive efforts have been devoted to determining the extent of on-site and off-site contamination. DOE work has included characterization of various off-site media that may contain WSS contaminants. Data from this characterization work are presented either directly in the RI Report or in referenced documents.

DOE has assumed responsibility for investigation and remediation of all on-site soil contamination and any off-site soil contamination that is associated with a radiological source. DOE has also assumed responsibility for remediation, as required, of radiologically contaminated groundwater whether on- or off-site.

Comment 2:

The field sampling plans which were developed and implemented to form the basis of the RI Report are described in the report; however, the reader is not clearly directed to the respective sampling investigation reports which presumably contain more focused and thorough analyses than the summaries contained in the RI Report.

Response to Comment 2:

Agree. The field sampling plans are described in Section 2.2.1. The following specific references will be added to more clearly define the descriptions in Section 2.2.1:

Page 2-3, Paragraph 3, Line 1
Insert "(MKF and JEG, 1988j)"

Page 2-4, Paragraph 1, Line 2
Insert "(MKF and JEG, 1988t)"

Page 2-4, Paragraph 2, Line 1
Insert "(MKF and JEG, 1988i)"

Page 2-4, Paragraph 3, Line 2
Insert "(MKF and JEG, 1988n)"

Page 2-4, Paragraph 4, Line 1
Insert "(MKF and JEG, 1988o)"

Page 2-4, Paragraph 5, Line 3
Insert "(MKF and JEG, 1987l)"

Page 2-4, Paragraph 5, Line 3
Insert "(MKF and JEG, 1987b)"

The references discussed in Section 3, Weldon Springs Study Area Investigtions, are the investigation reports that form the basis for the RI Report. The reader will be directed to these reports by adding the following statement to Section 2.2, page 2-3, paragraph 1: "Results of these sampling programs are summarized in Section 3."

Comment 3:

A useful summary of data gap analyses and general plans for additional data collection is not presented.

Response to Comment 3:

Agree. The RI database is presently being evaluated relative to the alternative analysis for the feasibility study. Potential data gaps identified by this analysis will be summarized in the RI and general plans for additional data will be presented. DOE does anticipate collecting additional data in the following areas:

- o Soil contamination: Extent of soil contamination under the buildings, raffinate pits and Ash Pond.
- o Overburden physical characteristics: Field tests to verify hydraulic conductivity values in the vadose zone.
- o Contaminant transport and attenuation: Studies are currently being conducted by USGS/UMR to evaluate geochemical aspects of contaminant transport and attenuation.
- o Ecological studies: Studies are currently being planned to assess potential impacts to species using contaminated areas of the WSS. Data from these

studies will augment existing data from the MDOC (Busch Wildlife Area) and WSSRAP characterization programs.

Comment 4:

The data available for analysis of ecological impacts appears to be limited. The impacts of contamination on the wildlife is presented only in the context of the implications to human health. A complete baseline risk assessment must consider environmental effects as well as public health effects. Information on the numbers of species using the contaminated area, their reproductive success, and any evidence that the contamination is affecting the viability of local wildlife populations should be presented.

Response to Comment 4:

Agree. Although site-specific data are limited, extensive data exist on a regional scale related to the ecological character in the general site vicinity. The 217 acre WSS is adjacent to the 1,843 acre U.S. Army Reserve Training Area, the 6,919 acre Busch Wildlife Area, and the 7,200 acre Weldon Spring Wildlife Area. It has been our approach to utilize the local and regional data derived from these surrounding areas as the base for ecological information. This database may be augmented as a result of the data gap analyses. Planning for additional data collection both on- and off-site is currently underway.

DETAILED COMMENTS

Comment 1:

The Table of Contents should be expanded to include a list of plates.

Response to Comment 1:

Agree. This change will be made in the Table of Contents.

Comment 2:

In the Executive Summary (page 1), there is a statement which refers to the percentage of land transferred to the U.S. Atomic Energy Commission (AEC) versus the amount of land originally used for ordnance production. Ten percent is the amount quoted; whereas, the actual amount is closer to one percent as explained in Appendix H. The original site covered 17,232 acres compared to 205 acres transferred from the Department of Army (DA) to AEC.

Reponse to Comment 2:

Agree. Text in the Executive Summary (page 1, second paragraph, fifth sentence) will be changed to read: "The portion of the Weldon Spring Ordnance Works transferred to U.S. Atomic Energy Commission is about one percent..."

Comment 3:

In the third paragraph of the Executive Summary, there are statements which are contradictory. It is stated first that the Weldon Spring Raffinate Pit (WSRP) and the Weldon Spring Chemical Plant (WSCP) areas are on the National Priorities List. The next sentence states that they have been nominated to be on the List.

Response to Comment 3:

Agree. The Weldon Spring Raffinate Pit/Chemical Plant areas and the Weldon Spring Quarry area are all included on the National Priorities List. The text in the Executive Summary (page 1, third paragraph) will be changed by deleting the third sentence ("The remainder of the Weldon Spring Site, the Weldon Spring Chemical Plant and Raffinate Pit area, has been nominated to be included on the National Priorities List").

Comment 4:

On page 8 in the third paragraph, the reference to Figure 7 should be to Figure 6.

Response to Comment 4:

Agree. Figure reference in the Executive Summary (page 8, third paragraph, first sentence) will be changed to Figure 6.

Comment 5:

The first sentence of the first paragraph on page 10 should be rewritten. It appears that nitroaromatics precipitate in the unsaturated zone before reaching the saturated zone.

Response to Comment 5:

Agree. This sentence will be rewritten to read: "Nitroaromatic compounds in the groundwater are believed to enter the saturated zone by leaching from contaminated soils."

Comment 6:

Several conflicting statements were found. As an example, on page 10 in the Executive Summary, the following statement is made "Nitroaromatic compounds quickly degrade upon exposure to sunlight and therefore are not transported in surface waters." It is noted on page 6-16, Vol. I that the nitroaromatics TNB and DNB are not subject to photolytic degradation. Also, on page 1-4, the Army Reserve is 1,843 acres, while on page 3-13, Vol. I, it is approximately 1,660 acres.

Response to Comment 6:

Agree. Text will be revised by deleting the statement in the Executive Summary, page 10, that reads: "Nitroaromatic compounds quickly degrade upon exposure to sunlight and therefore are not transported in surface waters." This statement is too general in nature and is not correct as written.

Agree. Statement in Section 1.2.1, page 1-4, that presents the size of the Army Reserve property as 1,843 acres is incorrect. This figure will be changed to 1,660 acres as correctly shown in Section 3.2.3, page 3-13.

Comment 7:

On page 1-5 in the second paragraph, the text states that the Weldon Spring Wildlife Area is located across Missouri Highway 94. Figure 1.2-2, which is referenced, shows the site and the wildlife area on the same side of the highway.

Response to Comment 7:

Agree. Figure 1.2-2 is correct. The text describing the location of the Weldon Spring Wildlife Area (Section 1.2.1, page 1-5, second paragraph, first sentence) will be revised as follows: "The Weldon Spring Wildlife Area (Weldon Area) is located to the south of the WSS (Figure 1.2-2) and consists of approximately 2,900 ha (7,200 ac)."

Comment 8:

Numerous abbreviations labeling buildings, water towers, etc., are shown on Plate 1. A legend should be provided to identify the structures.

Response to Comment 8:

Agree. A legend will be provided on Plate 1 to identify these structures.

Comment 9:

Table 3.7-1 should indicate what the numbers on the table represent such as the number of samples taken.

Response to Comment 9:

Agree. The numbers in Table 3.7-1 indicate how many geotechnical tests of a given type were performed by each organization at WSSRAP. A heading "Number of Tests Performed", will be added within Table 3.7-1 to more clearly indicate the meaning of the data.

Comment 10:

In Section 4.5.1, page 4-33, second paragraph, it is concluded that the observed net infiltration in the raffinate ponds is "closely related" to the measured hydraulic conductivities of the underlying material. In fact, those hydraulic conductivities span four orders of magnitude. The magnitude of the measured net infiltration lies in the middle of that range. While this is to be expected, it may be misleading to use the term "closely related" to characterize this agreement.

Response to Comment 10:

Agree. Text on page 4-33, Section 4.5.1, second paragraph, last sentence, will be reworded to read: "The magnitude of the measured losses from the pits corresponds to a soil permeability of approximately 1.0×10^{-6} cm/sec which is an order of magnitude greater than the median laboratory value for saturated hyraulic conductivities at the site. Laboratory values for saturated overburden hydraulic conductivity range from 1.6×10^{-9} to 2.0×10^{-5} cm/sec (4.5×10^{-6} ft/day to 5.7×10^{-2} ft/day) (BNI, 1986a)."

Comment 11:

The discussion on stratigraphy is good; however, we suggest that the surface soils be addressed in terms of the Department of Agriculture's soil series and descriptions.

Response to Comment 11:

Field logging and laboratory classification was based on the Unified Soil Classification System which is more commonly used in performing engineering studies. Use of the USDA classification system will be considered for future studies.

Comment 12:

Page 4-1 references Figure 4.1-2 for site elevations, but it only shows elevations for the surrounding area.

Response to Comment 12:

Agree. A new Figure 4.1-3 will be drafted which will show site elevations. The reference in Section 4.1, page 4-1, paragraph 3, first sentence will be changed to Figure 4.1-3.

Comment 13:

The term "normal" is also used incorrectly. In meteorology, "normal" refers to averages of climatological data for the 30-year period from 1951 through 1980. In the context used in the report, either the term "average" or "mean" is more appropriate.

Response to Comment 13:

Agree. The text will be revised to strike the term "normal" and use "average" instead (Section 4.2, page 4-3, paragraph 4, second sentence).

Comment 14:

The legend on Figure 4.3-2 should include a description of the well, trench and borehole numbering system.

Response to Comment 14:

Agree. However, this information is too bulky to include in a figure. A new Table 4.3-1 will be added and titled "Well, Trench, and Borehole Numbering System Description", to indicate the various numbering conventions which have been employed at the Weldon Spring Site.

A sentence will be added to the last paragraph on page 4-10 (Section 4.3.1.2) following "...in a given borehole." that will read: "Table 4.3-1 lists the borehole and trench numbering conventions."

The first sentence at the top of page 4-11 (Section 4.3.1.2) that currently begins "Table 4.3-1 presents a list..." will be changed to read: "Table 4.3-2 presents a list...".

Comment 15:

In the first paragraph on page 4-21, the last sentence indicates that the four raffinate pits do not contribute to direct runoff; however, Figure 4.4-2 seems to show flow out of pit number 4. Table 4.4-2 also indicates the raffinate pits are closed basins, but Figure 4.4-3 seems to show a stream gage that measures the outflow from pit 4.

Response to Comment 15:

Agree. Figure 4.4-2 does appear to indicate outflow. This is misleading as Pit 4 does not discharge surface runoff. Figure 4.4-2 will be corrected by moving the arrow west of Pit 4.

Agree that Figure 4.4-3 is similarly misleading. As correctly indicated in Table 4.4-2, the raffinate pits are closed basins. The stream gage NP-004 shown in Figure 4.4-3 does not measure outflow from Pit 4, as there is none. Figure 4.4-3 will be corrected by moving the arrow west of Pit 4.

Comment 16:

The term "swallow holes" appears occasionally. Pages 4-26, 4-30 and 4-31 refer to "swallow holes" and Figures 4.4-4 and 4.4-11 refer to "shallow holes." Definitions should be provided since it is not clear what these holes are.

Response to Comment 16:

Agree. Text will be revised by adding a short definition on page 4-26 which will generically describe a swallow hole. On page 4-26, Section 4.4.4.1, second paragraph, after the second sentence and before "The 5000 series...", the following sentence will be added: "A swallow hole is a point in a stream bed where a sinking stream loses its discharge to the subsurface (White, 1988)."

The term "shallow hole" on Figure 4.4-4 is a typographical error and will be changed to "swallow hole". Figure 4.4-11 is correct as labeled.

Comment 17:

The method used for estimating surface runoff on page 4-24 is not a very reliable one. A better approach would have been to calibrate a model to the measured events, then use a historical sequence of precipitation events to determine average runoff conditions. An alterntive approach would be examine records from similar gaged watersheds in the area.

Response to Comment 17:

The USGS has recently completed a water budget study on a 4.6 square mile area which includes two Mississippi River subdrainages immediately northwest of the WSCP/WSRP site. Preparation of a data report is in progress and an interpretive report is expected about May, 1990 (M.J. Kleeschulte, personal communication, 1990).

Results of this study will be incorporated into estimates of average discharge volumes at Weldon Spring Site NPDES discharge points.

Comment 18:

On page 4-31, the definition of the vadose zone is misleading. The vadose zone may be temporarily saturated due to surface ponding and may have perched water tables. Perched water tables are mentioned on page 6-4. A possible definition is the zone between the soil surface and the permanently saturated zone.

Response to Comment 18:

Agree. Text will be changed by striking the first sentence of Section 4.5, page 4-31, and inserting the following in its place: "The geological profile extending from the ground surface to the phreatic surface is called the vadose zone. The term "vadose zone" is preferable to the term "unsaturated zone" because saturated conditions may be locally present in the form of perched groundwater and unsaturated flow due to infiltration, seepage, or percolation."

Comment 19:

On page 4-33, there is a discussion about lysimeters and that they were installed to determine possible contaminant migration. More explanation is needed to explain how a lysimeter would show contaminant migration. The discussion on page 5-141 about lysimeters is even more confusing on just how the lysimeters are being used. On Table 5.4-1, lysimeter LYS3506 should be LYS3606.

Response to Comment 19:

Agree. Text on page 4-33, Section 4.5.1, third paragraph, second sentence, will be changed to read: "Lysimeters, sometimes called soil-moisture samplers, are commonly used to sample soil-pore liquids in unsaturated media. The ten

lysimeters were installed by UNC Geotech in July 1987 as part of a preliminary assessment of contaminant transport by unsaturated flow in the vicinity of the raffinate pits. The lysimeters were installed in locations where seepage from the raffinate pits was expected to be encountered in the form of unsaturated flow in the vadose zone."

Sentence 3 of paragraph 1, Page 5-141, Section 5.4.1, will be changed to read: "Wells MW-3013 and MW-3018 also monitor the quality of perched and mounded water within the overburden."

On Table 5.4-1, the heading "LYS3506" will be changed to "LYS3606."

Comment 20:

The second paragraph on page 4-35 refers to Figure 4.5-5 when it should really be 4.5-6.

Response to Comment 20:

Agree. The reference on page 4-35 (Section 4.5.1, second paragraph, fourth line) will be changed from Figure 4.5-5 to Figure 4.5-4; this is the correct reference.

Comment 21:

On page 4-40 in the third paragraph, briefly explain why the Bouwer and Rice method is believed to be the more reliable method.

Response to Comment 21:

Agree. Text changes will be made to include an explanation. The fifth sentence of the third paragraph on page 4-40, Section 4.6.2.1, will be deleted and replaced with the following:

"The Bouwer and Rice method is believed to be more reliable for calculating in situ hydraulic conductivities than the Hvorslev method due to the difference in methodologies used to determine the effective radius of influence for a test occurrence (i.e. the radius over which head loss or gain is dissipated). Bouwer and Rice (1976) pointed out that the Hvorslev method, in most cases, assumes that the effective radius of influence is equal to the distance from the bottom of the well to the potentiometric surface. However, in reality, the effective radius of influence is considerably less than the distance from the bottom of the well to the potentiometric surface. Bower and Rice used an electrical resistance network analog to determine the effective radius of influence for different slug test geometries. An empirical equation was then developed to relate the effective radius of influence to the geometry of the well and the aquifer. This technique is applicable to determining the effective radius of influence for partially penetrating and fully penetrating wells in unconfined aquifers. It can also be used to estimate the hydraulic conductivity of confined aquifers that receive water from the upper confining layer through recharge or compression.

"With this in mind, the Bouwer and Rice method was used to analyze all data because it is considered to more closely simulate Weldon Spring Site conditions. The Hvorslev technique was used because its widespread industry use allows comparison of WSS data with other data analyzed by that method."

Comment 22:

The loss by seepage from the raffinate pits should be reported as a volume per unit of time. The second paragraph on page 4-47 only specifies an apparent velocity.

Response to Comment 22:

Agree. Text on page 4-47, Section 4.6.3.1, second paragraph, fourth sentence, will be changed to read: "The water balance study at the raffinate pits indicated average losses of 6.16m^3/d for Pit 2 to 50.13 m^3/d for Pit 3 due to seepage (BNI, 1987)."

Comment 23:

In Chapter 5, many concentrations are discussed in various samples. Generally, these concentrations are not referenced with any standard to indicate if the concentration is significant in terms of human health or the environment. Page 5-16 has numerous examples of this. Page 5-22, last paragraph, provides the kind of comparison to an established standard that would be helpful throughout the document.

Response to Comment 23:

Tables and figures are presented in Vol. II that compare background concentrations in soils and water quality standards to the analytical results for soils, sediments, surface water, and groundwater (see Figures. 5.2-1 through 5.2-30 and Tables 5.2-2 through 5.2-31, 5.3-1, and 5.4-2). Because of the extensive amount of information presented, it was determined that the most effective means of presenting these comparisons is in tabular form.

The presence of contamination in any medium does not by itself necessarily indicate risk to human health or the environment. The determination of risk is also dependent upon exposure to the contaminants. Exposure pathway analyses and dose calculations were made as part of the baseline risk assessment. Details of these calculations are provided in the Site Baseline Risk Assessment Report. A summary is also provided in chapter 7 of the Site Remedial Investigation Report. In addition, the Site FS-EIS will include a risk analysis.

Comment 24:

An inconsistency was noted in Section 5.1.2.3, page 5-14, second paragraph. The report indicates that the evaporation of all water from raffinate pits 1 and 2 has not happened since 1980; however, Table 5.1-16 indicates a dry surface in 1987. A clarification is needed.

Response to Comment 24:

Agree. The "Surface Water Volume" entries in Table 5.1-16 will be changed from "dry surface" to "<5,000 m^3".

Comment 25:

Tables 5.1-6 and 5.1-7 have the same title. One of them should be changed to reflect the differences in the data presented.

Response to Comment 25:

Agree. The title of Table 5.1-6 will be changed to "Compilation of Asbestos Data, Samples with Suspected Radiological Contamination". The title of Table 5.1-7 will be changed to "Compilation of Asbestos Data, Samples Not Suspected to be Radiologically Contaminated". Title notations in the table of contents for Volume I and Volume II will also be changed.

Comment 26:

Section 3 of the report describes the investigations conducted at the site. To keep the report consistent, we suggest that the radiological investigations be described in that section as well, rather than in Section 5.

Response to Comment 26:

Agree. Descriptions of radiological investigations will be moved from Section 5 to Section 3.

Comment 27:

On Tables 5.2-2 through 5.2-31, there does not appear to be any difference between the constituents labeled "Other contaminants at levels about two times their upper background limit" and those labeled "...above their upper background limit."

Response to Comment 27:

Agree. Tables 5.2-2 through 5.2-31 will be corrected.

Comment 28:

The last paragraph on page 6-7 uses a comparison of Figures 4.6-3 and 4.6-4 to indicate a deep ground water "trough" extending from the Weldon Spring site to the Burgermeister Spring. It is suggested that conduit flow velocities in this "trough" are on the order of two feet per minute. This velocity is several orders of magnitude greater than any other reported velocities in the area. Because of this and the

potential for very rapid offsite migration of contaminants, there should be more discussion about this "trough." How were these velocities calculated? How does the comparison of the two figures lead to the conclusion of a deep "trough"? The discussion which continues onto page 6-B appears to contradict this conclusion. This paragraph is confusing and needs clarification.

Response to Comment 28:

Agree. The groundwater flow velocities in the conduit system discussed in this paragraph are based on MDNR dye studies. Results of these studies are presented in Section 4.4.4.3, page 4-30. The dye was carried approximately 1,980 m (6,500 ft) in 40 to 72 hours. The velocity figures presented in Section 6.1.3.2, page 6-7, will be presented on page 4-30. The text in on page 4-30, Section 4.4.4.3, second paragraph, third sentence, will be revised to read: "The time of travel is estimated to be 48 to 72 hours, indicating flow velocities of 0.76 to 1.1 cm/sec (1.5 to 2.2 ft/min), depending on rainfall conditions (Dean, 1984a)."

The text in Section 6.1.3.2 will be revised as follows: The paragraph beginning at the bottom of page 6-7 and continuing onto page 6-8 will be deleted and replaced with this paragraph:

Figure 4.6-3 illustrates the potentiometric surface of the water table aquifer in the vicinity of the WSCP. The prominent feature of the potentiometric surface is a linear depression which extends from the area west of the WSCP northward toward Burgermeister Spring and Lake 34. Figure 4.6-5 is a potentiometric map of the water table aquifer in the WSCP/WSRP areas. The steep potentiometric gradient near MW-4002 and the linear depression in Figure 4.6-3 are inferred to be a function of both surface relief and conduit flow. The axis of the linear depression closely follows the surface drainage pattern. The MDNR conducted ground water dye tracing tests which confirmed the presence of conduit flow within the area of the linear depression. Figure 6.1-1 illustrates the locations where the dye traces were conducted and the places to which the conduits flowed. The potentiometric linear depression is present because water normally in storage within the pore spaces of the water table aquifer is being drained by conduit flow. Conduit flow by its nature is orders of magnitude greater than the predominant Darcian laminar flow in the nonhomogeneous, antisotropic porous medium limestone aquifer.

Comment 29:

The discussion on the factors affecting the persistence and attenuation of organic compounds should be expanded. Sometimes degradation products are more toxic than the parents. Were the degradation products adequately sampled and analyzed?

Response to Comment 29:

The section describing contaminant persistence and attenuation for nitroaromatic compounds (Section 6.2.7) in the RI Report will be rewritten to include more detailed information on factors affecting the environmental fate of TNT, DNT, NB, TNB and DNB. The environmental fate for some of these compounds is also discussed in Appendix A of Vol. III. In a chemical characterization survey of the

quarry conducted by BNI from October to December 1984 and May 1985, soil and sediment samples were analyzed for 2,6- diamino - 4 - nitrotoluene and 2,4-diamino - 6 - nitrotoluene, known biotransformation products from TNT. Results of this survey indicated the presence of these potential biotransformation products in several samples. No other efforts have been made to test for the presence of biotransformation products.

The rewritten section 6.2.7 is as follows:

6.2.7.1 2,4,6-TNT

2,4,6 TNT is almost insoluble in water, sparingly soluble in alcohol, and readily soluble in benzene, toluene and acetone. Upon exposure to sunlight or ultraviolet light, decomposition of TNT in water occurs by a process known as photolysis. The rate of photolysis is accelerated by the products formed during the photolytic process as well as the presence of other natural substances. Humic substances in natural water are also subject to photolysis, yielding hydrogen ions and hydroxyl radicals that can reduce organic compounds. Nitrate ions in water can also promote photochemical oxidation of trace organic compounds through production of hydroxyl radicals. The half-life of TNT in natural surface waters due to photolysis is estimated to be between 3 and 22 hours (Spanggord et al., 1980).

The primary photodegradation product of 2,4,6 TNT is 1,3,5-trinitrobenzene; other by-products include 2,4,6-trinitrobenzonitrite and 1,3,5-trinitrobenzaldehyde (U.S. Army, 1986a). These photoproducts will readily volatilize from sediments and water (Cullahan, 1979). However, based on the relatively low Henry's Law constant for 2,4,6-TNT, (0.18 torr M^{-1}), volatilization is not an expected pathway for attenuation of 2,4,6-TNT (Spanggord et al., 1980).

The tendency for 2,4,6-TNT to adsorb to soils is primarily dependent upon the organic content of the soil (U.S. Army, 1986b). Due to the extremely low organic content of the Ferrelview and clay till formations, adsorption is not expected to be an important retardation factor in WSS soils. Minimal adsorption is expected on carbonate minerals and chert in the limestones, so dispersion and dilution are the most likely mechanisms by which TNT concentrations will decrease in the bedrock aquifer.

The biotransformation of 2,4,6-TNT in natural waters is very slow, even in the presence of organic nutrients (Spanggord et al., 1980). The half-life for biotransformation of 2,4,6-TNT in surface waters is estimated to be 8-25 days, which is far longer than for photolysis (Burlison, 1980). Hence the fate of TNT in surface water will primarily be controlled through photolysis.

The biotransformation process for 2,4,6-TNT involves reduction of the nitrogroups through the nitroso and hydroxyl amino to either amines or azoxy dimers. Transformation of TNT in soil is known to occur under both aerobic and anaerobic conditions by bacteria and fungi. Biotransformation products can include the following:

4-amino - 2,6-dinitrotoluene
2-amino - 4,6-dintrotoluene
2,6-diamino - 4-nitrotoluene
2,4-diamino - 6-nitrotoluene
4-hydroxylamino - 2,4-dinitrotoluene
2,2', 6,6'-tetranitro - 4,4' azoxytoluene
4,4', 6,6'-tetranitro - 2,2' azoxytoluene
2,4,6-trinitrotoluene (McCormick, 1976; Won, 1974)

Many of these compounds are more hazardous and soluble than the parent compound 2,4,6-TNT. Accumulation of the biotransformation products can be inhibitory to soil microorganisms, hence reducing the rate of transformation.

The environmental factors shown to affect the rate of TNT transformation include initial TNT concentration, soil moisture, the presence of microorganisms, temperature, and oxygen levels. Of these factors, the initial concentration of TNT has the greatest overall effect on the rates of biotransformation; the greatest biotransformation rates occur at very low concentrations of TNT (0.1%), with progressively slower transformation rates occuring at 1% and 10% concentration of TNT (Kaplan et al., 1985).

After TNT concentration, the presence or absence of microorganisms and temperature has the greatest effect. Moisture level is less important, and organic matter and oxygen levels are insignificant in affecting the rate of biotransformation. However, the presence or absence of oxygen does alter the biotransformation products. Under anaerobic conditions, increased production of triamines occurs over aerobic conditions. Aerobic conditions lead to the formation of diamines and monoamines.

6.2.7.2 1,3,5 TNB and 1,3 DNB

TNB detected at the WSS is probably the product of oxidation of the methyl group of TNT by photolysis. It is essentially insoluble in water, sparingly soluble in hot alcohol, and readily soluble in acetone, ether, and benzene. It is a very stable compound; it is resistant to hydrolysis and is not photolytically or biochemically degraded or transformed as readily as TNT.

TNB is more volatile than TNT (See Table 6.2-1) by nearly one order of magnitude (half-life is approximately 130 days) hence, volatilization from surface waters is expected to be a major fate process. The estimated value of K_{OC}, the sorption partition coefficient based on organic carbon content, is 520, suggesting that adsorption on sediments and soils with a sufficient organic fraction may be a significant environmental fate. However, due to the very limited organic content of the WSS soils, adsorption is probably not a major factor in retarding migration of TNB. Volatilization from soils is also not considered a significant factor affecting the persistence of TNB in soil.

1,3 DNB is sparingly soluble in water and slightly less volatile than TNB (Table 6.2-1). Volatilization from surface waters is considered an important fate process. Although studies have shown that DNB is subject to photolysis, the rate of volatilization is much higher; hence photolysis is not considered to be a significant environmental fate.

The sorption partition coefficient, K_{OC}, is estimated to be 64, which indicates soil sorption is not expected to be an important fate for 1,3-DNB.

It has been reported that 1,3-DNB is resistant to attack by soil microorganisms (Alexander and Lustigman, 1966), but is nearly completely degraded in a two-stage model waste water treatment system (Bringman and Kuehn, 1971). Laboratory studies performed by McCormick (1978) using an enzyme preparation of V. alalescenes demonstrated that 1,3-DNB and 1,3,5 TNB were reduced by hydrogen.

6.2.7.3 2,4 and 2,6 DNT

2,4-DNT and 2,6-DNT are formed as impurities and intermediates during the production of TNT. They are sparingly soluble in water, alcohol, and ether, but readily soluble in acetone and benzene. Based on calculated soil adsorption coefficients (Spanggord et al., 1980) these compounds are expected to have only a slight tendancy to sorb to soils, sediments and suspended solids. Some biotransformation in soil may occur in both the aerobic and anaerobic zones. In natural water systems, large amounts of supplemental carbon are needed for biotransformation to occur. Photolysis in water systems is rapid and is probably the most important removal process for DNT in surface waters. Volatilization may be a significant factor for 2,6-DNT in surface water but not for 2,4-DNT; neither compound is expected to volatilize from soils.

The biotransformation products of DNT are the aromatic amines and aminonitrotoluenes, and include the following:

2-nitroso - 4-nitrotoluene
2-amino - 4-nitrotoluene
4-amino - 2-nitrotoluene
4-nitroso - 2-nitrotoluene
2,2'-dinitro - 4,4' azoxytoluene
4,4'-dinitro - 2,2'-azoxytoluene
4-acetamino - 2-nitrotoluene
4-methyl - 3-nitroaniline
2-methyl - 5-nitroamine (McCormick et al., 1978)

Many of the biotransformation products are toxic and inhibit the biotransformation process. With sufficient supplemental carbon, the anaerobic biotransformation process proceeds much faster than the aerobic process, and tends to favor production of the amine 2-methyl - 5-nitroamine.

Both isomers of DNT rapidly photolyze in ultraviolet light or sunlight. Photolysis of 2,4-DNT results in production of the following compounds (Burlinson and Glover, 1977):

2,4-dinitrobenzaldehyde
2-amino - 4-nitrobenzaldehyde
2,2'-carboxaldehyde - 5,5'-dinitroazoxybenzene
2,4-dinitrobenzoic acid
2-amino - 4-nitrobenzoic acid
2,2'-carboxy - 5,5' dinitroazoxybenzene

The nitrobenzoic acids may be further broken down into other products such as 1,3-dinitrobenzene. The final products of reaction are carbon dioxide, water, and nitric acid.

The photolysis half-life in sunlight for 2,4-DNT is estimated to be between 2 to 10 hours, depending upon the amount of humic substances present and concentration of activated transformation products. These factors can accelerate the rate of photolysis by 1.3 - 2.5 times (Simmons and Zepp, 1986).

The photolysis half-life for 2,6-DNT is 12 minutes by indirect photoreaction. The rate is affected by the presence of humic materials in natural waters, which can accelerate photodecomposition 11-17 times (Mill and Mabey, 1985; Simmons and Zepp, 1986)

The half-life of 2,4-DNT in water by volatilization is estimated to be 410 days (Spanggord et al., 1980); hence, volatilization is not considered a significant environmental fate for 2,4-DNT. On the other hand, the volatilization half-life of 2,6-DNT is 140 days (Spanggord et al., 1980) which indicates this process is an important fate process for 2,6 DNT.

6.2.7.4 Nitrobenzene

Nitrobenzene is moderately soluble in water, and has a moderate tendency to sorb on soils and sediments. Greater adsorption is associated with soils and sediments which have high organic fractions. Nitrobenzene can be expected to leach into the ground from a release on land and degrade within a few months as biodegradation in both aerobic and anaerobic environments can be significant. Reduction of the NO_2 group of the NB ring may be an important degradation process in groundwater under the reducing conditions occurring in the groundwater beneath the site. NB in surface waters is also subject to photolysis; the main photoproducts are azobenzene and anailine (Barltrop and Bunce 1968). The photolysis half-life of NB is estimated to be 133 days. The half-life can be accelerated by 1-3 times due to the presence of humic substances and nitrate ions (Simmons and Zepp, 1986).

Alexander, M. and B.D. Lustigman, 1966. Effect of Chemical Structure on Microbial Degradation of Substituted Benzenes. J. Agr. Food Chem. 14(4):410-13.

Barltrop J.A. and N.J. Bunce, 1968. Journal Chem Soc Section C. pp. 1467-74.

Bringman, G., and R. Kuehn, 1971. Biological Decomposition of Nitrotoluenes and Nitrobenzenes by Azotobacter Agilis. Gesundh.-Ing. 92(9):273-6. (Ger.).

Burlinson, N.E. and D.J. Glover, 1977. Photochemistry of TNT and Related Nitrobodies. Quarterly Progress Report No. 12, for 1 April to 30 June 1977. Explosive Chemistry Branch, Naval Surface Weapons Center, Silver Spring, MD.

Cullahan, Michael A. et al., 1979. Water-Related Environmental Fate of 129 Priority Pollutants. Washington D.C.: U.S. Environmental Protection Agency. EPA 440/4-79-029.

Kaplan, D.L. et al., 1985. Effects of Environmental Factors on the Transformation of 2,4,6-Trinitrotoluene in Soils. U.S. Army Natick Research and Development Center. Technical Report Natick/TR-85/052, January.

McCormick, N.G., J.H. Cornell, and A.M. Kaplan, 1978. Identification of Biotransformation Products From 2,4-dinitrotoluene. Appl. Environ. Microbiol. 35(5):945-948.

Mill, T.and W. Mabey, 1985. Environmental Toxicology Chemistry 1:175-216.

Simmons, M.S. and R.G. Zepp, 1986. Water Resources 20:899-904.

Spangoord R.J., T. Mill, T.W. Chou, W.R. Mabey, J.H. Smith, and S. Lee, 1980. Environmental Fate Studies on Certain Munition Waste Water Constituents. Final Report, Phase II - Laboratory Studies. SRI International, Menlo Park, CA. DAMD 17-78-C-8081.

U.S. Army Toxic and Hazardous Materials Agency, 1986a. Summary Remedial Investigation/Feasbility Study. Aberdene Proving Ground, MD. Final Report. Cornhusker Army Ammunition Plant.

U.S. Army Toxic and Hazardous Materials Agency, 1986b. West Virginia Ordnance Works: Endangerment Assessment for Sewer Lines, the TNT Manufacturing Area, and the Burning Grounds. Prepared by Environmental Science and Engineering, Inc. Florida. Aberdeen Proving Ground, MD. Final Report.

Comment 30:

On page 6-16 in the first sentence of Section 6.2.7.2, change "deleted" to detected".

Response to Comment 30:

Agree. Text in Section 6.2.7.2, page 6-16, first paragraph, line 1, will be changed to read: "TNB detected at the WSS is probably the product of oxidation of the methyl group of TNT by photolysis."

Comment 31:

From January 1967 to February 1969, the Department of the Army prepared plans to design and construct a plant at the site to produce the herbicide "agent orange". This fact is mentioned in the appendix, but the appendix does not indicate that there was no actual production of the herbicide at the Weldon Spring site during that two-year period.

Response to Comment 31:

Agree. Text on page H-5 of Appendix H will be revised by inserting the following sentence between the second and third sentences in entry Feb. 1969: "No herbicide production occurred."

Comment 32:

Important information appears missing from the appendices. Descriptions of the monitoring well construction and sampling techniques should have been included.

Response to Comment 32:

Agree. Monitoring well completion diagrams should be published along with the borehole logs for the wells. However, these diagrams and logs have not been included in the RI Report because of the excessive bulk they would add. At this time, no plans exist to publish these logs. However, the logs are to be compiled in a compendium of geologic data which will be available for review at the Weldon Spring Site.

Sampling techniques are described in the Hydrogeologic Investigations Sampling Plan. This document is indirectly referenced on page 2-4, Section 2.2.1 of the RI Report. The reference to this and other sampling plans will be more clearly defined by revising the text in Section 2.2.1 as indicated in the response to General Comment 2 of this attachment.

ATTACHMENT B

Comments of the Missouri Department of Conservation

GENERAL COMMENTS

Comment 1:

Page 5-112 through 5-122. It appears that the Department of Conservation sites 1, 3, 4, 5, 7 and 9 require remediation while sites 2, 6, 8 and 10 apparently do not require remediation. Sites 1, 2 and 10 apparently have been cleaned up. Site 6 is recommended to be remediated during quarry cleanup. Why not include site 8 in the remediation of quarry cleanup?

Response to Comment 1:

Site 8 will be remediated during bulk waste removal to a level that assures proper worker protection in the quarry support area. The final verification of remediation will be performed as a part of the follow-on quarry cleanup after bulk waste removal to a level consistant with unrestricted use in that area.

Comment 2:

Page 5-123. We concur in the need for cleanup of Southeast Drainage.

Response to Comment 2:

Comment is noted. As stated in the report text, the Southeast Drainage will be characterized after major site remedial actions are completed and may be remediated as part of the final soil and pit cleanup. However, before a decision to remediate the Southeast Drainage is made, the potential environmental damage to the area will be weighed against the risks posed if the area is not remediated.

Comment 3:

Page 5-132. Sediment samples from site SD-4001, Lake 36, SD-4007 and Lake 35 have mean uranium levels of 31 pCi/g, 30 pCi/g, 26 pCi/g and 23.6 pCi/g. The reference level for uranium indicated on page 5 of the Executive Summary is 15 pCi/g. Would it follow that remediation on these sites is warranted since they exceed the reference level?

Response to Comment 3:

The decision on remediation of the sites in question will be made after final cleanup criteria are established. Page 5 of the Executive Summary does not adequately

explain the purpose of reference levels as used in the RI. The following explanation will be included as a new paragraph in the Executive Summary, page 5, and will become the fourth paragraph in Contaminant Sources:

"It is important to understand that the radionuclide reference levels presented here are not intended to guide site remediation. The reference levels were used because site-specific cleanup guidelines have not yet been developed for the WSS. The RI presents reference levels only for the purpose of estimating area and volumes of soil containing radionuclide concentrations. Once final cleanup guidelines have been established, the estimated areas and volumes will be revised. Pages 5-45 and 5-46 of the RI provide further detail as to the purpose and justification of reference levels."

Comment 4:

Page 5-155 and 5-157. Data are puzzling to us. We have collected a set of fish flesh samples for lead analyses. We would hope that as more data become available a decision can be made on appropriate action to respond to elevated lead levels. With very high lead levels in Ash Pond and upstream of Lake 36, how will the Department of Energy interact with the Department of Army on cleanup activities?

Response to Comment 4:

DOE is very interested in the results of the MDOC fish analyses for lead. DOE will continue to coordinate its work in the Busch Wildlife Area with the MDOC in order to establish the nature and extent of lead contamination or other constitutents that may originate at the Weldon Spring Site. As part of the ongoing effort to determine the extent of WSS contamination, DOE is continuing its plans to perform media and biological characterization in conjunction with MDOC sampling in the Busch Wildlife Area. Routine monitoring activities at the Weldon Spring Site are also ongoing in order to provide a better definition of contaminant discharges. Although isolated soil locations with high lead concentrations exist at the WSS, samples collected from surface water monitoring locations during 1987 and 1988 indicate that no lead is being discharged from the site. Samples collected during lake and stream sediment characterization (MKF and JEG, 1989h) showed little difference in lead concentrations between Lakes 34, 35, 36 and 37 (background lake). It should be noted that Lake 37 is in a drainage basin that does not carry runoff from the Weldon Spring Site.

ATTACHMENT C

Comments of the Missouri Department of Natural Resources

GENERAL COMMENTS

Comment 1:

Please reference MDNR's First Annual Report on the Shallow Groundwater Investigations at Weldon Spring, Missouri as MDNR, 1989 rather than Hoffman, 1989. Citations occur on pages 4-24, 26, 46, 50 and 51, on Table 4.6-9, and perhaps elsewhere.

Response to Comment 1:

Agree. References to this report will be changed throughout Section 4.0 from "Hoffman, 1989" to "MDNR, 1989" on pages:

4-24, paragraph 3, last line.
4-26, paragraph 4, line 3.
4-46, paragraph 1, last line.
4-50, paragraph 3, last line.
4-51, paragraph 2, last line.
Table 4.6-9 footnote "d".

A search will also be conducted for this reference in the other report sections.

Entry 3 on page 4 of the Reference Section in Volume I will be changed from "Hoffman, 1989" to "MDNR, 1989. First Annual Report on Shallow Groundwater Investigations at Weldon Spring, Missouri."

Comment 2:

Figure 4.1-2 presents a topographic map of the Weldon Spring area but is not detailed with respect to the site. Nowhere else is there a topographic map of the site. We would suggest adding a topographic map of the site at the same general scale as many of the other site maps in the report. Drainage patterns and surface features would be much more obvious with such a map in combination with the text descriptions.

Response to Comment 2:

Agree. A new Figure 4.1-3 will be drafted which will consist of a site topographic map at approximately the same scale as the other site maps. The present Figure 4.1-3 will be renumbered to become Figure 4.1-4.

DETAILED COMMENTS

Comment 1:

Table 4.6-1 - footnote (f) is not explained.

Response to Comment 1:

Agree. This is a typographical error, "(f)" will be replaced with "(d)" in last footnote.

Comment 2:

Page 3-22 - MDNR Dye Tracing Studies - this section does not report MDNR-DGLS dye tracing experiments correctly. Only two borehole dye traces were attempted in 1983 (MW-2020, March 9; MW-3007, April 7) by Dean. The report only mentions one losing stream dye trace (from West Raffinate Pit Drainage, Feb. 1984) of three conducted. The other two were from the head of the Southeast Drainage (June 1984) and from Ash Pond Drainage (March 1985). The 1985 attempted borehole traces are adequately described. Fig. 3.4-4, Water Tracing Sample Locations, appears to be a modified version of a map produced by MDNR-DGLS (MDNR, 1989).

Response to Comment 2:

Agree. Section 3.4.4, paragraph 1, sentence 2, will be revised to read: "...dyes were injected into two boreholes (MW-2020 and MW-3007)..."

Agree. Section 3.4.4, paragraph 2, will be revised to read: "Dye was placed in a surface drainage west of Raffinate Pit 4 in February 1984 and west of Ash Pond in March 1985. These drainages are unnamed tributaries to the Schote Creek drainage to Lake 35. In November 1984, MDNR-DGLS also released dye at the sewer outfall at the head of the Southeast Drainage. The summary of the dye trace results can be found in the MDNR-DGLS, 1989, Shallow Groundwater Investigation Phase I Report. (MDNR, 1989)."

Figure 3.4-4 will be modified to indicate "MDNR, 1989" rather than "MKF & JEG, 1988" as the source.

Comment 3:

Page 3-29, Section 3.7.1.6 - This section mentions recent (1988-1989) exploration programs, to help describe site geology, conducted by the PMC. Some information from these programs is presented in tabular form (Table 4.3-1) but drilling logs are not presented in the RI Report. Are drilling logs from these recent programs presented in another document?

Response to Comment 3:

These logs were not included as an RI Report appendix because of the bulk they would add. Although there are currently no plans to publish these logs in document form, the logs are to be compiled in a compendium of geologic data which will be available for public review at the Weldon Spring Site.

Comment 4:

Page 4-9, Section 4.3.1.1 - The Bushberg Sandstone has been reported in the literature as a Devonian age formation (Kleeschulte and Emmett, 1987; Miller, et al, 1974; Koenig, 1961). However, more recently the Bushberg has been assigned to the Mississippian System (Thompson, 1986). The text and Figure 4.3-1 should reflect current understanding.

Response to Comment 4:

Agree. Text on page 4-9, Section 4.3.1.1, second paragraph, first sentence, will be changed to read: "The sequence from the Bushberg Sandstone unit of the Lower Mississippian system to the Burlington and Keokuk Limestones form the shallow bedrock aquifer."

The fifth sentence will also be changed to read: "The Chouteau Limestone unconformably overlies the Bushberg Sandstone."

Figure 4.3-1 will be altered to indicate that the Bushberg Sandstone is Mississippian rather than Devonian in age.

Comment 5:

The term "unit" is not customarily capitalized since it is not part of the formal name of a formation. Unit is capitalized several places on this page.

Response to Comment 5:

Agree. The term "unit" will be changed from upper to lower case in the following text of Section 4.3.1.1, on page 4-9: paragraph 2, line 1 to line 7; paragraph 3, line 1; and paragraph 4, line 2. Other report sections will also be searched and this terminology change made as required.

Comment 6:

The thickness figures given for the Warsaw and Salem formations do not agree with those given in Figure 4.3-1. The thickness figures in the text refer to the site area for most formations. The descriptions of the Warsaw and Salem do not, and may mislead the reader.

Response to Comment 6:

Agree. The last sentence of paragraph 5, page 4-9, Section 4.3.1.1, will be changed to read: "In the vicinity of the Weldon Spring Site, the Warsaw Formation ranges in thickness from 18.3 - 24.4m (60-80 ft) (Whitfield et al., 1989)."

Paragraph 6 of page 4-9, Section 4.3.1.1, will be revised to read: "In the vicinity of the Weldon Spring Site, the Salem Formation ranges in thickness to 4.5m (15 ft) (Whitfield et al., 1989). The Salem Formation is a light gray...".

Comment 7:

Page 4-10, paragraph 2 - Alluvium overlies units other than glacial drift and loess in the vicinity of the site. The last sentence of this paragraph is incorrect.

Response to Comment 7:

Agree. The last sentence of paragraph 2, page 4-10, Section 4.3.1.1, will be replaced with the following: "In some upland valleys, alluvium of the Holocene Series overlies the glacial drift and loess, or it lies directly upon the Paleozoic bedrock."

Comment 8:

Page 4-10, Section 4.3.1.2 - This section presents several isopach and contour maps of the site presumably generated from the geologic database. A check of several data points against geologic logs, particularly on Figure 4.3-19, reveals several points in disagreement with plotted contours or isopachs. Many data points cannot be checked because geologic logs have not been presented in this document or elsewhere. Is there an explanation for these apparent conflicts?

Response to Comment 8:

The contouring package (CPS-1) used in generating Figure 4.3-19 and the other maps in Section 4.3.1.2, is an industry standard. A rectangular grid is superimposed on the control points (data) and the grid nodes are assigned values based on all of the control points within the search limit of that node. The grid nodes, rather than the control points, are contoured. Consequently, the control points which do not coincide with grid nodes may not be precisely honored in the contour map. The continuous surface is, however, best represented in this fashion.

The geologic logs that were used to develop Figure 4.3-19 and the other maps in Section 4.3.1.2 were not included in the RI because of the bulk they would add to the report. These logs are being compiled in a compendium of geologic data and will be available for review at the Weldon Spring Site.

Comment 9:

Page 4-13 - The residuum unit is described as an individual stratigraphic unit in the text but is not represented as such in the Generalized Stratigraphic Column (Figure

4.3-1). There is a problem in assigning it an age but it should be represented, perhaps as "Quaternary or pre-Quaternary" may be most appropriate.

Response to Comment 9:

Recent mapping of the area by Whitfield et al., in 1989 does not mention the residuum as being stratigraphically distinct. Figure 4.3-1 is intended to provide a more regional stratigraphic perspective rather than focusing on site-specific units. The residuum is mentioned in Figure 4.3-1 as being subjacent to various units of Pleistocene age.

Comment 10:

Page 4-14 - MDNR-DGLS does not consider a hydraulic conductivity of 5×10^{-8} cm/sec. to be representative of the residuum unit. Our experience indicates that it has a much higher permeability. We support further sampling and testing of this unit, as mentioned.

Response to Comment 10:

Agree. This sample should not be construed to be representative of the entire residuum unit. However, it does represent the lower end of the range of values possible in this heterogeneous unit.

Four additional samples were sent to the laboratory for permeability testing. Three consisted of noncohesive gravels which could not be tested. The other sample was gravelly, but cohesive. Preliminary test results for that sample indicate a hydraulic conductivity of 3.0×10^{-8} cm/sec.

Text will be changed to indicate heterogeneity of the residuum. The first two sentences of paragraph 4, page 4-14, will be replaced with the following:

"In terms of hydraulic conductivity, the residuum is extremely heterogeneous. Laboratory testing of a sample from near the top of the unit yielded a value of 5.0×10^{-8} cm/sec (1.4×10^{-4} ft/day). Four additional samples have been sent out for testing. Three of these consisted of noncohesive gravels which could not be tested. The other sample was gravelly, but cohesive. Preliminary test results for that sample indicate a hydraulic conductivity of 3.0×10^{-8} cm/sec. As indicated in the previous section, the interstitial clay within the residuum is generally quite plastic and, where sufficient clay is present, forms a tight matrix within the gravel fraction."

Comment 11:

Page 4-28 - The descriptions of gaining and losing reaches, particulary in paragraphs 2 and 3, are not clear because mentioned landmarks are incorrectly named and not represented on the reference maps. Road DD is maintained by the State and might better be referred to as State Road DD. Road C and B are Busch Wildlife Area roads and are not shown on Figure 4.4-9.

Response to Comment 11:

Agree. The figures and discussion presented in Section 4.4.4.2 will be revised as suggested in Comment 11. In addition, work performed by the MDNR to supplement that of the USGS will be acknowledged and Figure 4.4-9 will be modified to be consistent with Plate 7 of MDNR, 1989.

Text revisions will include: Section 4.4.4.2, page 4-27, paragraph 3 - after the first sentence, insert the following: "The information provided by the USGS was supplemented and slightly modified by the MDNR (MDNR, 1989)."

At the end of the same paragraph, add the following: "Figures 4.4-6 through 4.4-8 show the USGS discharge measurement locations and the estimated discharge values for subdrainages near the site. Results of the MDNR and USGS studies are presented in Figure 4.4-9."

Section 4.4.4.2, page 4-28, paragraph 2, sentence 2: change "St. Charles County Road DD" to "State Road DD."

Section 4.4.4.2, page 4-28, paragraph 3, sentence 2: change "St. Charles County Road C" to "Busch Wildlife Area Road C." In sentence 4, change "St. Charles County Road B" to "Busch Wildlife Area Road B."

Section 4.4.4.2, page 4-29, first paragraph, sentence 2: change "County Road D" to "State Road D."

Figure 4.4-9 will be modified by changing "County Road" references to "State Road" and by adding Busch Wildlife Area Roads C and B. An additional change will be made to indicate that a short segment of the Burgermeister Spring branch (drainage 6300) and the segment of Crooked Creek from State Road D to Highway 40 (drainage 6100) are losing streams.

Comment 12:

Page 4-30 - The March 1985 injection of dye was detected only at Burgermeister and its wet weather springs (SP-6301 and SP-6302). Dye was not recovered at SP-6303 (Dean, 1965; MDNR, 1989).

Response to Comment 12:

Agree. Text on page 4-30, Section 4.4.4.3, first sentence, will be revised to read "...dye were detected in those from Burgermeister Spring (SP-6301) and Overflow Spring (SP-6302) (Dean, 1985)."

Comment 13:

Page 4-35 - Second paragraph refers to Figure 4.5-5 but should probably be 4.5-4.

Response to Comment 13:

Agree. Reference was incorrect and will be changed to Figure 4.5-4 (page 4-35, Section 4.5.1, second paragraph, third sentence).

Comment 14:

Page 4-44 - Section 4.6.2.5 - Are final pump test results available? If available, the results should be presented and their significance explained.

Response to Comment 14:

The pumping tests have been performed and the resulting data prelimarily reduced. The results will be available in the Aquifer Characterization Data Report which is currently under development. It is anticipated that this report will be issued in mid-1990.

ATTACHMENT D

Comments of the Missouri Department of Natural Resources

GENERAL COMMENTS

Comment 1:

Although much of the TNT operations formerly located at the Chemical Plant were possibly taken care of at the "burn" sites, I would like to see some discussion of the leveling of the site to construct the Chemical Plant. From Plate #1 it appears TNT plants/lines 1 through 4 were located in areas extensively changed by construction of the chemical plant. It would seem logical that some TNT and DNT contaminated wastes were buried or disposed of on site or elsewhere during the construction of the chemical plant.

Response to Comment 1:

Historical records were reviewed to determine the sequence and extent of Weldon Spring Site operations and construction activities. Activities involved with TNT production and disposal, and chemical plant construction were particularly scrutinized in developing site sampling plans.

Because of the size of the site and the diversity of activities that occured, two sampling approaches - biased and unbiased - were used to provide comprehensive soil contamination characterization. The biased sampling locations were selected on the basis of historical documentation of WSOW and WSUFMP operations and the results of the more recent site investigations. Topographic modifications from cut and fill activities were also taken into account in the selection of sampling locations. Unbiased sampling was conducted across the site to provide a statistically valid database for soils characterization and to document uncontaminated areas (MKF and JEG, 1988j).

In the Phase II sampling effort, chemical soil samples were collected from 245 locations within the WSCP and WSRP areas. Soil sampling locations were surveyed to establish horizontal and vertical control prior to sampling. Soil samples were collected using continuous sampling equipment driven through conventional hollow-stem augers. This sampling method provided a relatively undisturbed sample for chemical analysis and lithologic logging (MKF and JEG, 1989a).

Areas sampled for nitroaromatic compounds included WSOW process areas, drainageways, and the burning area and rubble areas. Nitroaromatic compounds were detected at the 15 locations shown in Figure 5.2-1. The depth intervals and contaminant concentrations are presented in Table 5.2-2. The locations where nitroaromatic compounds were detected by the WSOW biased sampling program generally confirm previous results from the Phase I and IRA studies which indicated that the Ash Pond area is the area most extensively contaminated with low levels of nitroaromatic compounds. Based on review of the historical records describing site operations, a process line for TNT production near Frog Pond was identified. This

process line may have been a source of nitroaromatic contamination in the vicinity of Frog Pond. The contaminated areas are associated with primary TNT production or waste water management.

Location PH2-OWB-001 (C-1) is in the wash house area of TNT Production Line 1. Gross contamination has been identified in similar settings on the adjoining Army Reserve training area (locations PH1-27, 28, 29 and 30). The contamination probably originated as waste water spilled on the soil from the wash house. Most gross contamination in this area was apparently removed during decontamination efforts prior to construction of the WSUFMP facilities in about 1954. The depth to contamination (1.8 to 3.7 m or 6 to 12 ft) is consistent with cut and fill mapping which indicates the presence of 1.2 to 1.8 m (4 to 6 ft) of fill overlying WSOW topography. Construction and subsequent removal of building foundations would have disturbed soil, allowing contaminant migration to the depths which sampling has indicated are contaminated.

Comment 2:

Some of the Interim Response Actions listed in Table 1.2-2 would appear to require a relatively long time to accomplish. ARAR's for these actions are not discussed. EPA policy has stated ARAR's would be followed at "removal actions" to the extent practicable.

Response to Comment 2:

It is the policy of the DOE to comply with all applicable or relevant and appropriate regulations in performing the IRAs. A detailed discussion of ARARs and how compliance will be achieved for each IRA is presented in the engineering evaluation and cost analysis (EE/CA) reports. A detailed analysis of ARARs will be included in the site FS-EIS report.

Comment 3:

The fish sampling for the biological contamination portion of the report did not include any bottom feeders. Since the contaminants could be in the sediments, bottom feeders would more likely be contaminated.

Response to Comment 3:

Agree. The Biouptake Study Sampling Plan (MKF and JEG, 1987b) identified the need and plan for obtaining samples of bottom feeding and other representative fish species from water bodies receiving drainage from the WSS. Fish sampling at the Busch and Weldon Spring wildlife areas was conducted by MDOC and PMC personnel using electrofishing equipment. A few catfish, generally considered to be bottom feeders, were collected from Lakes 35 and 36 and analyzed for radionuclides. No catfish were successfully collected from the other locations at that time. Carp and largemouth buffalo, two predominantly bottom feeders, were collected from the Femme Osage Slough.

Additional sampling was conducted by MDOC in the fall of 1989 to assess lead levels in fish from Lakes 36 and 37. The PMC also collected fish at that time to be analyzed for uranium at lower detection levels. These samples also included catfish. No data are yet available for these samples. Results are anticipated in early April, 1990. These data will be finalized and included in the Biouptake Report scheduled for issue in mid-1990.

Plans for additional characterization work include fish tissue sampling in Lakes 34 and 35. Results of this work will also be available in mid-1990.

Comment 4:

Were the soil samples analyzed by depth interval (relates to comment 1 above)? It was difficult to tell from the report.

Response to Comment 4:

Yes. Sampling depths were established by evaluating cut and fill activities. For example, ordnance works sampling completely penetrated filled areas and sampled original ordnance works topography. The depth intervals and contaminant concentrations are presented in Table 5.2-2.

Text revisions will be made in Section 3.2.1.3, page 3-10, second paragraph. The third sentence in this paragraph (Topographic modifications...") will be deleted and replaced with the following: "Cut and fill activities were also evaluated in determining sampling locations and depths."

Comment 5:

Shouldn't Figure 7 of the report show the Twin Lakes development as a receptor?

Response to Comment 5:

Nitroaromatic contamination has been detected at the Twin Island Lake development. The Army is currently supplying bottled water to residents of the development. Plans are underway to connect the development to a public water system.

DOE recognizes the concern reflected by Comment 5, however, for the present, Figure 7 should remain unchanged since the Twin Island Lake development has not been established as a receptor of groundwater contaminated by substances from the WSS.

Comment 6:

Were the soils selected for background soil sampling of the same toxinomic units as those found at the WSCP site? In some instances the existing chemical plant surface soil may be a subsurface horizon due to the site grading which occurred.

Response to Comment 6:

Yes. The soil samples collected for background determinations were from the same units as those present on site. The following sentence will be added to Section 5.2.1 between sentences 3 and 4 in the third paragraph on page 5-26: "The studies focused on the same soil units at off- and on-site locations in order to compare background concentrations."

Comment 7:

Please keep in mind that those IRA's which call for off site disposal will probably require special solid waste permits.

Response to Comment 7:

The DOE is aware of this requirement for off-site disposal of waste.

Comment 8:

Has there been any effort to explain the differences in concentrations between Table 5.1-11 (BNI samples) and Table 5.1-19 (PMC samples)? The BNI results are considerably higher on average.

Response to Comment 8:

It is not known why the BNI sample results are higher (on average) than the PMC sample results. An evaluation performed to explain the difference in radionuclide concentrations reported in the BNI and PMC data sets is discussed in Section 2.4.4 of Waste Assessment Radiological Characterization of the Weldon Spring Site Raffinate Pits, Rev. 0, DOE/OR/21548-062, August 1989. This report concluded that "there exists a statistically significant difference between the mean values of the two data sets. However, there was no discernible overall pattern of bias between the data sets with regard to concentration value, concentration heterogeneity, or radionuclides".

The PMC followed documented sampling procedures during sample collection and analyses at the raffinate pits. The PMC has also performed data validation on some raffinate pit sample results. Data validation information relating to the BNI data set was not provided in the Bechtel characterization report. Attempts were made by the PMC to obtain this information from Eberline, Bechtel's technical subcontractor, but these attempts were unsuccessful. On the basis of this information, the DOE is of the opinion that the PMC's data more accurately represent the true radiological chacteristics of the raffinate.

Comment 9:

Appendix F and other portions of the report make reference to evaporating the red and yellow waters. This appears unlikely given the flow rates of 40 to 50 mgd.

Response to Comment 9:

Agree. According to Fishel and Williams, 1944, a primary purpose in the design and construction of the waste water treatment plants was evaporation of the red and yellow waste waters. However, no information is provided as to the efficiency or effectiveness of the process once the waste water treatment plants were built.

The following revision will be made to the text in Appendix F, page F-5, paragraph 5. Strike the last sentence ("The lines discharged...") and replace with the following paragraph:

"Due to the state of emergency and apparent low priority placed on wastewater treatment, details on wastewater management practices are sketchy. Early in the operation of the WSOW, wastewaters were discharged directly from production lines or pumped into lagoons. The direct discharge and leakage from the lagoons caused contamination of area streams and springs. After stream and spring contamination was noted, wastewaters were pumped directly to the Missouri River (Fishel and Williams, 1944). At some point, wastewater evaporation and incineration plants were constructed and placed in operation (Greely and Hansen, 1942), however, it is not clear that this treatment practice ever totally replaced disposal in the Missouri River."

Comment 10:

Appendix H makes at least 3 references to the disposal of red water sludges or TNT contaminated material. What efforts have been made to trace the ultimate fate of these materials? Can it definitely be stated they are not buried below the WSCP site or at the Quarry?

Response to Comment 10:

Based on a comprehensive historical review, it was discovered that during decontamination in 1944, residues from nitroaromatic-contaminated material burning areas of unknown locations were scraped into piles and attempts were made to reburn these piles. The burning process was not very successful, so the residues were dumped, presumably in the Weldon Spring Quarry (Hannon, 1944). Figure 3.1-3 indicates the location of a demolition storage area for nitroaromatic-contaminated rubble and a burning ground for nitroaromatic-contaminated material. Figure F-4 also indicates the location of the burning ground.

As described in Sections 3.2.1 and 5.2.1, four soil sampling programs have been carried out at the WSCP/WSRP areas by the PMC. Nitroaromatic contamination was detected in 15 samples ranging in concentration from 0.48 to 307 ug/g. The final phase of samplings included biases for known locations of ordnance works activities, uranium feed materials activities, and a random sampling program. No

nitroaromatic compounds were detected in the uranium feed materials-biased and random samples. With the exception of the abandoned waste pond northeast of Frog Pond, no gross contamination was discovered in the soils sampling program.

The information described above will be added to the text in Appendix F, page F-6, following paragraph 1.

Comment 11:

Has any effort been made to characterize the materials which were dumped into Pit Number 4 in December 1966?

Response to Comment 11:

The DOE is not aware of any effort to specifically characterize the materials dumped into Raffinate Pit 4 in December 1966. However, Raffinate Pit 4 characterization has been addressed in other sampling programs performed at the Weldon Spring Site, including work described in these reports: Draft: Waste Assessment Radiological Characterization of the Weldon Spring Site Raffinate Pits. Revision A. DOE/OR/21548-062. April 1989. (MKF and JEG, 1989e) and Draft Report, Waste Assessment and Chemical Characterization of the WSS Raffinate Pits. January 1989. (MKF and JEG, 1989c).

Comment 12:

VOLUME I: Page 3-23, Section 3.4.5, Domestic Well Sampling: This section references the private well information received from the St. Charles Countians Against Hazardous Waste and the U.S. Geological Survey. Figure 3.4-5 is a preliminary map of the private well locations. The report does not discuss the extensive sampling data on these and other wells obtained by the Missouri Department of Health (MDOH) from 1982 to 1989. Attached is the MDOH data on these wells.

I suggest that you summarize this data and discuss its significance in demonstrating the limits of the groundwater contamination. This information may also be relevant to the baseline risk assessment in that it shows that private wells are not being affected by the uranium processing that occurred at the site. To protect the privacy of individuals, well owner names should not be used in the RI Report.

Response to Comment 12:

Comment is noted. Text will be revised by deleting the last sentence in Section 3.4.5 (page 3-23) that reads: "Future WSSRAP efforts..." The following paragraph will be added at the end of Section 3.4.5:

"Extensive sampling of private wells in the vicinity of the Weldon Spring Site has been performed by the MDOH since 1982. Preliminary data received from the MDOH for the period 1982-1989 indicate that private wells in the vicinity are not being affected by the uranium processing that occurred at the Weldon Spring Site. Evaluation of MDOH private well data is continuing in conjunction with

interpretation of the site monitoring well data. The results of the interpretations will be used in assessing risks associated with the Weldon Spring Site."

Comment 13:

VOLUME III: APPENDIX H, Chronology of Events at the Weldon Spring Site: This chronology is very helpful. However, the information on 1986-89 is very limited. I suggest that you provide a more detailed chronology for these last three years.

Response to Comment 13:

Agree. The chronology in Appendix H will be expanded to present a more detailed discussion of activities during 1986-1989.

RCRA ARAR - COMMENTS (SEE VOL. III APPENDIX B)

General Response to ARAR Comments:

Please note that due to the current status of WSSRAP and potential ARARs, the following response pertains to RCRA ARAR comments 1-16 and State RCRA ARAR comments 1-7.

The identification and discussion of potential ARARs (Appendix B, Vol. III) is very preliminary and not intended to be all inclusive. Identification of ARARs is an integral part of the baseline risk assessment, remedial investigation, and feasibility study. Hence, ARAR determinations are expected to change as new information becomes available and as the remedial action alternatives are developed and evaluated. At this stage of the RI/FS process, it is possible to define with some assurance both the contaminant-specific and location-specific ARARs for the Chemical Plant and Raffinate Pit areas. However, the identification of potential action-specific ARARs is completely dependent upon the particular remedial alternatives being considered. This evaluation will be performed as part of the FS effort. However, it was considered prudent to identify those ARARs that may constrain or define a particular alternative as early as possible in order to highlight problems and expedite the FS process. It should be emphasized that the list of action-specific ARARs, which includes Federal and State RCRA provisions, is not intended to be complete or to presume results of the FS; rather it is an attempt to take an initial look at the ARARs associated with those alternatives which are considered likely to pass preliminary screening and/or which are perceived as being especially problematic.

A more detailed, and comprehensive assessment of action-specific ARARs will be made during the development and evaluation of the remedial action alternatives. In addition, during the detailed design phase, efforts will be made to ensure that the technical specifications will attain ARARs. The comments received on the Federal and State ARARs are both timely and helpful, as ARARs for the proposed remedial action alternatives are presently being identified. All comments pertaining to RCRA ARARs are being assessed for applicability to the various options under consideration.

Comment 1:

General - The ARAR's tables did not address the chemically contaminated portions of the buildings, process equipment, or storage tanks. In certain instances portions of the WSCP buildings and equipment may be considered hazardous waste.

Comment 2:

Table 3 - Has the EPA text; Permit Writers' Guidance Manual for the Location of Hazardous Land Storage and Disposal Facilities: Phase I. Criteria for Location Acceptability and Existing Regulations for Evaluating Locations (Feb. 1985), been evaluated for "To be considered" ARAR's?

Comment 3:

Table 4 - Airborne particulates from handling of RCRA waste must be controlled (264.251, .273, .301).

Comment 4:

Table 5A, Removal Criteria, does not address RCRA materials which are radiologically contaminated. The treatment, storage, and disposal, of these materials will need to meet RCRA requirements.

Comment 5:

Table 5B - Tank storage for some period of time in existing tanks appears to be a possibility. If so then 40 CFR 264.191 would be relevant and appropriate.

Comment 6:

Table 5B, page 3 - Some sectins of 40 CFR 264.193 and 194 may not be substantive (eg. (g), (h), (I)).

Comment 7:

Table 5B, page 4 - Inspections of storage tanks should be relevant and appropriate (40 CFR 264.195).

Comment 8:

Table 5B, page 8 - Inspection of containers would appear to be relevant and appropriate (40 CFR 264.174).

Comment 9:

Table 5B, pages 11 and 12 - Although 40 CFR 264.341, .342, and .344 are directly related to permit requirements they would appear to be substantive since the incinerator efficiency or operating limits cannot be determined by the operator without the required analysis.

Comment 10:

Table 5B, page 12 - The monitoring requirements of 40 CFR 264.347 appear to be substantive to operate an incinerator.

Comment 11:

Table 5B - Closure requirements of 40 CFR 264.351 appear to be substantive.

Comment 12:

Table 5B, page 15 - It would appear that more of 40 CFR 265 subpart P would be relevant and appropriate since it is parallel to 40 CFR 264 subpart O.

Comment 13:

Table 5C - Wouldn't 40 CFR 265.400 be a "to be considered"?

Comment 14:

Table 5G - This table should include the Land Ban (40 CFR 268) since any land filled RCRA materials will have to be in compliance with the treatability standards.

Comment 15:

Table 5G - page 5, Section 315 of 40 CFR 264 would appear to be substantive.

Comment 16:

The proposed rules of 40 CFR 269 would appear to be "to be considereds". Part of these rules were proposed on February 5, 1987 (52 FR 3748).

Comment 17:

Subpart F of 40 CFR Part 264 would appear to be relevant and appropriate to the Quarry site itself.

Response to Comment 17:

The quarry site is being managed as a separate operable unit and ARAR analysis is a part of that effort. Twenty-eight groundwater monitoring wells serve as an integral component of the routine environmental monitoring system in the quarry area.

STATE RCRA ARAS

General Response to ARAR Comments:

Please note that due to the current status of WSSRAP and potential ARARs, the response under **"RCRA ARAR - COMMENTS (SEE VOL. III APPENDIX B)"**, above, pertains to RCRA ARAR comments 1-16 and State RCRA ARARs 1-7.

Comment 1:

Table 3 - MO. hazardous waste regulations chapter 13 (PCB's) incorporate the chapter 7 (TSDF's) requirements. Locations of commercial facilities handling wastes which come under the PCB rules must comply with MO-RCRA location standards. This may be relevant and appropriate at the site.

Comment 2:

Table 4, page 1 - Missouri PCB Treatment, Storage, Disposal facilities must meet the MO. hazardous waste regulations chapter 13 and 7.

Comment 3:

Tank systems should consider the location standards of 40 CFR 264 subpart N in accordance with 10 CSR 25-7.264(2)(J)4, pages 12 and 13.

Comment 4:

Sampling methods for incineration should comply with 10 CSR 25-7.264(2)(0), page 24, where more restrictive than 40 CFR 264.343.

Comment 5:

The requirements of 10 CSR 25-7.264(P) & (Q), pages 24 through 28, would be applicable to treatment or disposal facilities.

Comment 6:

Leak detection and leachate collection systems must have a permeability of at least 0.01 cm/sec. (See 10 CSR 25-7.264(2)(N)2.a.(II), page 23).

Comment 7:

The compliance monitoring point of 40 CFR 264.95 is modified by 10 CSR 25-7.264(2)(F)2, page 5. The establishment of this point is referenced in 40 CFR 264 subpart F (See Table 5G, page 5 and 6).

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
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June 14, 1990

ADDRESSEES

PLAN FOR MONITORING RADIONUCLIDE EMISSIONS OTHER THAN RADON AT WELDON SPRING SITE CRITICAL RECEPTORS - REV. 0, MAY 1990

Enclosed for your information is Rev. 0 of the Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors - Rev. 0, May 1990.

The Plan contains the DOE monitoring activities to be undertaken at the Weldon Spring Site for compliance with 40 CFR 61. USEPA has concurred in the plan concept, quality assurance and reporting procedures. The Plan will be fully implemented for calendar year 1990.

Sincerely,

Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

cc w/o enclosure:
R. E. Hlavacek, PMC

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DOE/OR/21548-127
(CONTRACT NO. DE-AC05-86OR21548)

SUPERCEDED

PLAN FOR MONITORING RADIONUCLIDE EMISSIONS OTHER THAN RADON AT WELDON SPRING SITE CRITICAL RECEPTORS

For the
Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

Prepared by MK-Ferguson Company and Jacobs Engineering Group

MAY 1990 REV. 0

U.S. Department Of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

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Weldon Spring Site Remedial Action Project

Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors

May 1990

Revision 0

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Prepared for

U.S. DEPARTMENT OF ENERGY
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Under Contract DE-AC05-86OR21548

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ABSTRACT

During the course of the Weldon Spring Site Remedial Action Project (WSSRAP) radionuclides may be emitted to the air. Emissions of radionuclides are regulated by the U.S. Environmental Protection Agency in 40 CFR 61. It is clear in 40 CFR 61 that, for sites being remediated according to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), no monitoring or reporting of radon emissions is required prior to completion of temporary or permanent disposal sites, other than that already required under CERCLA. For radionuclides other than radon, however, it is not clear whether 40 CFR 61 requires sites being remediated according to CERCLA to implement additional monitoring and reporting prior to completion of disposal facilities. Because the U.S. Department of Energy is committed to protection of the public and environment, a plan has been formulated which defines how the WSSRAP will implement a monitoring program for radionuclides other than radon. This plan adheres to the specifications contained in 40 CFR 61.

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1 INTRODUCTION

1.1 SITE HISTORY

The Weldon Spring Site is located in St. Charles County, Missouri, about 30 miles west of St. Louis on land formerly used by the Department of Army (DA) as a trinitrotoluene (TNT) and dinitrotoluene (DNT) ordnance works. The site consists of a 9-acre former limestone quarry; a 51-acre raffinate disposal area; and a 166-acre uranium feed materials plant. The feed materials plant was built in 1955-1957 by the Atomic Energy Commission (AEC), the predecessor to the U.S. Department of Energy (DOE), and operated by Mallinckrodt Chemical Works for the AEC from 1957 through 1966. The plant processed uranium ore concentrates and recycled scrap to pure uranium trioxide, uranium tetrafluoride, and uranium metal. Thorium ore concentrates were also processed. The raffinate residues from this processing were disposed of in four large open pits. During the plant's operational period, the buildings, the equipment, the immediate terrain, the process sewer system, and the drainage easement to the Missouri River became contaminated with uranium, thorium, and their decay products.

During the period 1943-1957, the DA disposed of rubble and soils contaminated with TNT and DNT in a former limestone quarry about 4 miles from the ordnance works. Later, from 1959 through 1966, the AEC disposed of building rubble and soils contaminated with thorium and uranium and their decay products in the same quarry. The quarry now contains about 95,000 cubic yards of contaminated materials, including quarry materials contaminated by this radioactive waste.

In 1967, the feed materials plant site was selected to be converted to a herbicide production facility. Except for the materials stored in the raffinate pits, the site was transferred

back to the DA and renamed the Weldon Spring Chemical Plant (WSCP). The DA began a major effort to decontaminate three process buildings for herbicide production. The cleanup was not totally successful, and in 1969, reduced requirements for the herbicide and increased cleanup costs resulted in cancellation of the project. The 51 acres encompassing the Weldon Spring Raffinate Pits (WSRP) were transferred back to the AEC in 1971.

On November 27, 1984, the DOE was directed by the Office of Management and Budget to assume responsibility for the decontamination of the WSCP and to integrate work with other DOE remedial actions proposed for the Weldon Spring Quarry (WSQ), and the WSRP. In 1987 the WSQ was placed on the National Priorities List (NPL). The WSCP/WSRP were placed on the NPL in 1989. These NPL sites are being remediated according to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Environmental Policy Act (NEPA).

During cleanup of the Weldon Spring Site (WSS) a temporary storage area (TSA) for wastes from the WSQ is proposed. In addition, the DOE-preferred alternative for all wastes at the WSQ and WSCP/WSRP is to build a permanent disposal site at the WSCP/WSRP.

1.2 REGULATIONS PERTAINING TO RADIOACTIVE EMISSIONS

Because of the radioactive materials present at the WSCP/WSRP and WSQ, radon is emitted to the atmosphere as are other radionuclides from the U-238, U-235, and Th-232 natural decay series. Atmospheric emissions of radon and radionuclides other than radon are regulated by the U.S. Environmental Protection Agency (EPA). The regulations are contained in 40 CFR 61 which was updated and became effective on December 15, 1989. It is clear in Section G of 40 CFR 61 that, for DOE

facilities being remediated according to CERCLA, radon monitoring or reporting programs required through the CERCLA program are sufficient to protect the public health until temporary or permanent storage facilities for Ra-226-containing byproduct material are completed. Once all wastes have been placed and completely covered at the TSA, radon flux monitoring will be performed at the TSA. If a permanent disposal site is constructed at the WSCP/WSRP, radon flux monitoring will be performed after construction of the disposal site is completed. Radon flux monitoring will be performed according to 40 CFR 61, Appendix B, Method 115.

However, it is not clear in those sections of 40 CFR 61 that pertain to radionuclide emissions other than radon whether DOE sites being remediated according to CERCLA are required to monitor and report emissions prior to completion of temporary or permanent storage facilities.

1.3 MONITORING RADIONUCLIDE EMISSIONS OTHER THAN RADON

The DOE is currently determining through discussions with EPA whether the monitoring and reporting requirements for radionuclide emissions other than radon contained in 40 CFR 61, Subpart H apply to CERCLA sites prior to completion of permanent or temporary storage facilities. Regardless of whether 40 CFR 61, Subpart H applies to the WSS during remediation, the DOE is committed to protection of the public and environment. Therefore, a monitoring and quality assurance program sensitive enough to detect concentrations of radionuclides other than radon at levels specified in 40 CFR 61 will be initiated at the WSS.

Results of the monitoring will be reported in annual site environmental reports. These reports are intended to allow EPA

oversight of radionuclide emissions during remediation according to CERCLA/NEPA. The monitoring, reporting, and quality assurance program is discussed below.

2 METHODS OF EMISSION EVALUATION

The national emission standard for radionuclides other than radon is set so that no member of the general public receives an effective dose equivalent greater than 0.10 mSv (10 mrem) per year. 40 CFR 61 Subpart H requires that radionuclide emissions other than radon be measured and effective dose equivalents estimated by computer models. If the emission monitoring and modeling specified in Subpart H is impractical, alternate procedures may be acceptable. As an alternate to modeling dose equivalents, air concentrations can be monitored at critical receptors.

After evaluating the methods of assessing effective dose equivalents from radionuclides other than radon, it was determined that monitoring air concentrations at critical receptors was the most accurate means of assessing effective dose equivalents to maximally exposed individuals. This plan describes how the Weldon Spring Site Remedial Action Project will use monitoring results to estimate effective dose equivalents to members of the public resulting from emissions of radionuclides other than radon.

3 SCOPE

This plan discusses the monitoring, reporting, and quality assurance program requirements that will be used to estimate and document the effective dose equivalent from airborne emissions of radionuclides other than radon at locations of highest potential offsite exposure. The monitoring plan, including rationale for the monitoring program as well as sampler location, description, analytical methods, and frequency is discussed in Section 4. This monitoring program meets the specifications in 40 CFR 61, Subpart H. Also contained in Section 4 is a description of the annual reporting system.

Section 5 contains the quality assurance plan. This plan meets the requirements of 40 CFR 61, Appendix B.

4 PLAN

The Weldon Spring Site (WSS) is currently being remediated according to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Environmental Policy Act (NEPA). It no longer operates as a uranium and thorium processing plant and has been in mothball status since about 1966. Therefore, radionuclides are no longer emitted from the types of sources (i.e. stacks, vents, or pipes) described in 40 CFR 61, Subpart H.

Airborne emissions of radionuclides at the WSS result from wind dispersal of surface soils or dust and dirt within deteriorating buildings and from fugitive dust generated during remedial actions. Monitoring these types of emission sources is not practical because of the inability to adequately characterize the emission inventory. The amount of entrainment can be estimated from fugitive dust emission factors developed by the U.S. Environmental Protection Agency (EPA) for various materials handling activities, but it is generally recognized that those estimates contain gross uncertainties. Measurement of the entrainment and emissions inventory is also extremely difficult and results are uncertain at best, because the emissions are highly variable both over time and location. Accurate measurements of area or volumetric fugitive emissions can only be made with complete knowledge of the micro-meteorology in and around the source and the use of many (usually greater than 10) concentration or measurement locations. Therefore, modeling of downwind dispersion and subsequent dose calculations using either assumed or measured emission rates leads to extremely uncertain results. The most accurate method of dose calculation at nearby receptor points is through the use of actual concentration measurements at these locations.

An assessment of the effective dose equivalents at critical receptors will be documented by environmental measurements of radionuclide air concentrations. Critical receptors are defined as those locations at which individuals abide or reside where the highest potential offsite concentrations of radionuclides other than radon are likely to occur during remediation of the Weldon Spring Site (WSS). The proposed monitoring and sample analysis plan is presented in Section 4.1. Section 4.2 describes how the monitoring meets the specifications in 40 CFR 61.

4.1 MONITORING PLAN

This section describes sampler locations, discusses rationale for selecting critical receptor locations, establishes occupancy times at critical receptor locations, describes the samplers, presents sampling frequency, and presents sample analytical techniques. Also included in Section 4.1.4 is a discussion of how the monitoring results will be reported.

4.1.1 Sampler Locations

The WSS includes the Weldon Spring Raffinate Pits (WSRP), the Weldon Spring Chemical Plant (WSCP), and the Weldon Spring Quarry (WSQ). Eleven air particulate samplers are in use at the WSS. Five samplers are located on the WSCP/WSRP perimeter. Four are located offsite, one of which measures background air. Two are at the WSQ perimeter. Sampler locations with respect to the WSCP/WSRP and WSQ are shown on Figures 4-1 through 4-3.

Sampler location AP-4007 at the Busch Wildlife Area office measures background concentrations for the WSS. This station is located 1.1 km (0.7 mile) from the WSCP perimeter. The forested and gently rolling terrain between the WSCP and this sampling

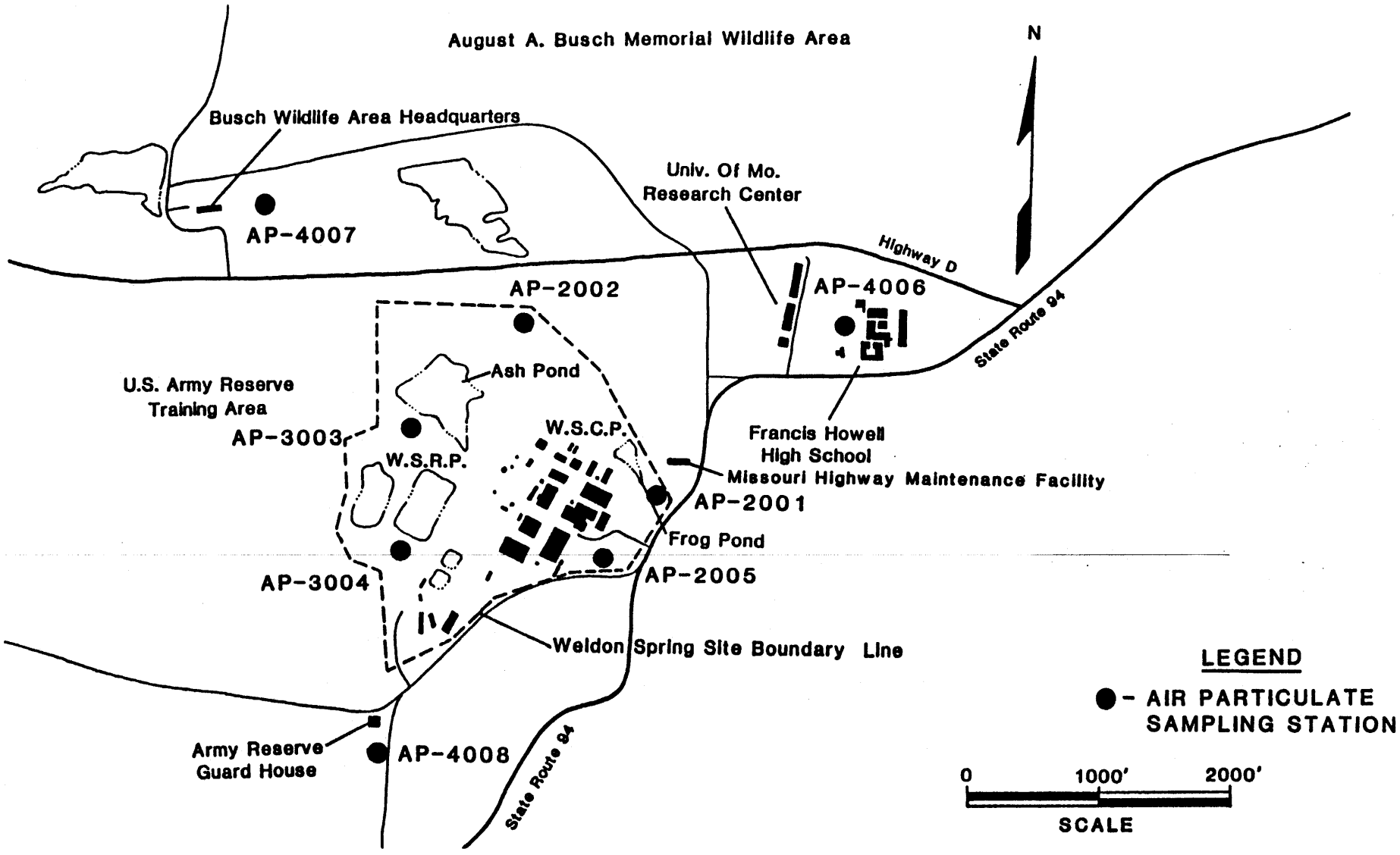


FIGURE 4-1

AIR SAMPLER LOCATIONS SURROUNDING THE WSCP/WSRP

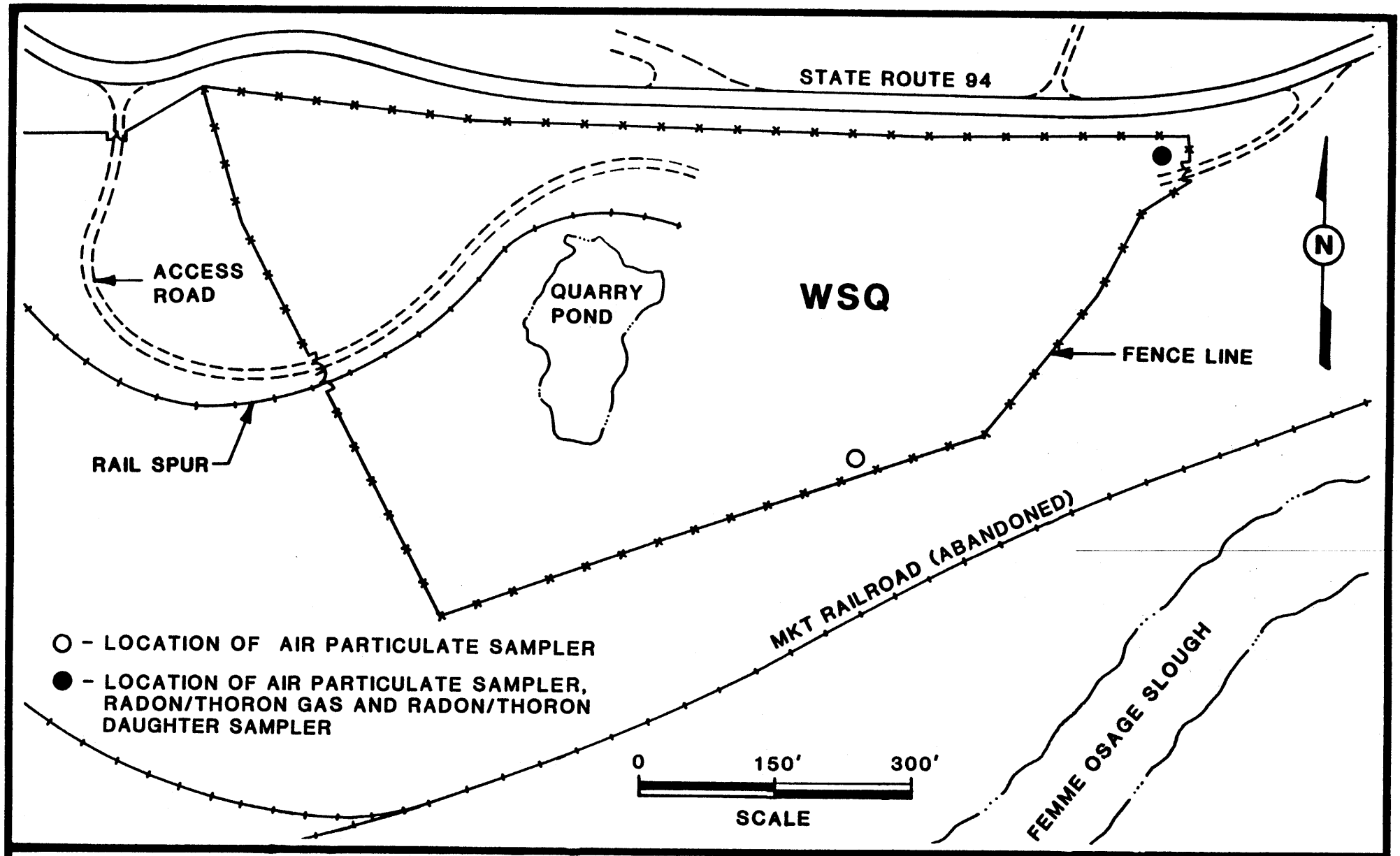
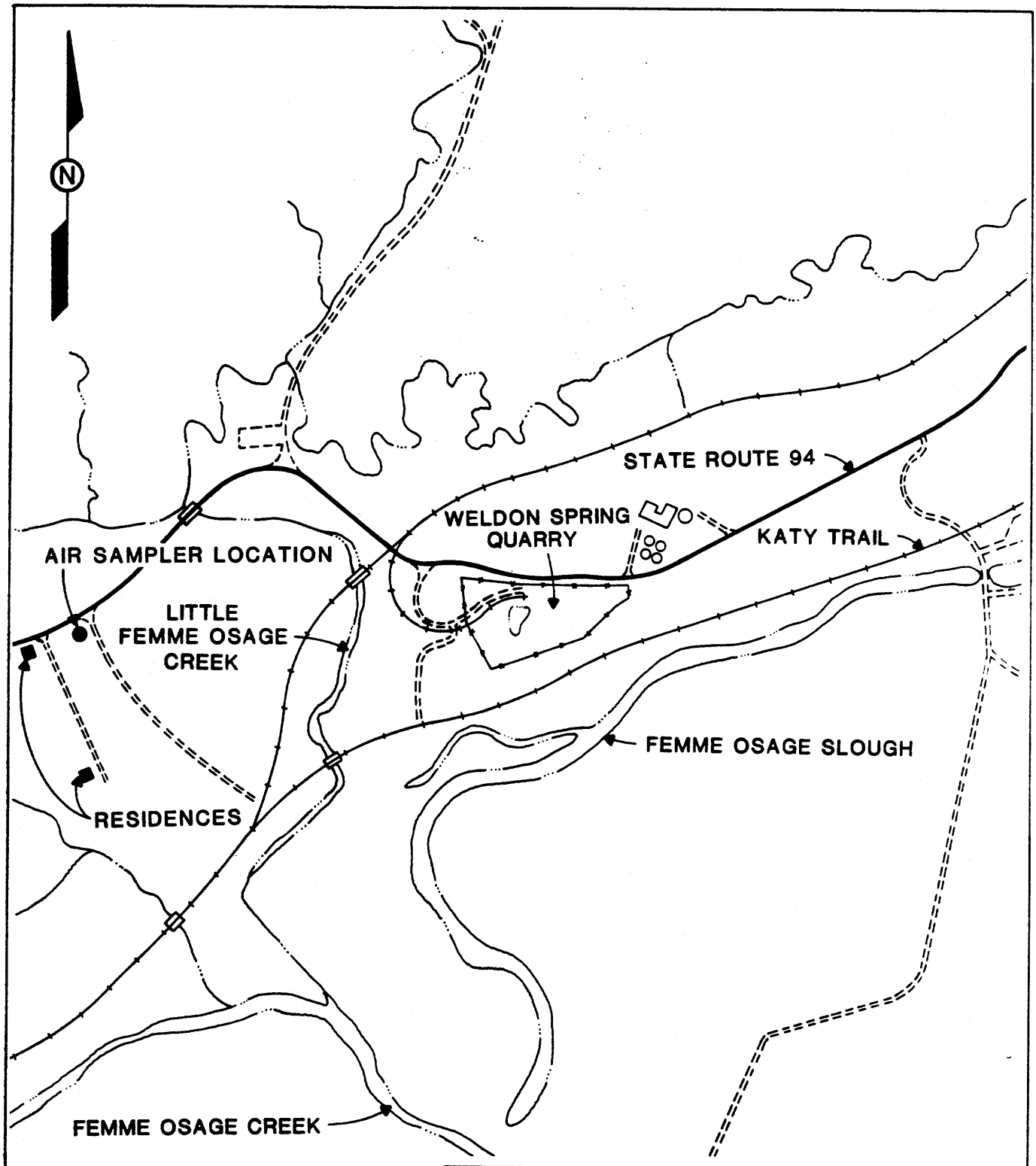


FIGURE 4-2

WSQ AIR MONITORING LOCATIONS



SCALE

FEET

0 800 1600

0 243.8 487.7

METERS

QUARRY MONITORING STATION

FIGURE 4-3

REPORT NO. DOE/OR/21548-127	DRAWING NO.: A/VP/012/0590	
ORIGINATOR: SG	DRAWN BY: GLN	DATE: 5/90

station provides a significant physical barrier to airborne particulates originating from the site.

As shown in Figure 4-1, sampler stations AP-2001, AP-4006, AP-4008, and AP-2005 are strategically located to measure radioactive air particulate concentrations around the WSCP/WSRP at the point where a maximally exposed individual resides or abides. Station AP-2001 is at the common boundary of the WSCP and Missouri Highway Maintenance Facility. Station AP-4006 is located at the Francis Howell High School. Station AP-4008 is on the Weldon Spring Army Reserve Training Area. Station AP-2005 is located between the WSCP and the Weldon Spring Site Remedial Action Project (WSSRAP) Administration Building.

Located 0.8 km (0.5 mi) west of the quarry is a residence. This residence is within 150 meters (0.1 mi) and directly in line with the quarry monitoring station (Figure 4-3).

These sites were selected as critical receptor locations because they are located within 1.0 km (0.62 mile) of the WSS where members of the public may spend at least eight hours per day for a significant fraction of a year. Other facilities (for example the St. Charles County Water Treatment Plant and the Weldon Spring Heights Subdivision) are located near the WSS; however, no other facility is closer than 2.5 km (1.6 mile) from the WSS. Because of this greater distance these facilities were not considered critical receptors.

At the one critical receptor that is a residence, occupancy will be assumed to be continuous. The number of individuals at the other receptors and typical occupancy patterns are discussed below.

There are nine workers at the highway maintenance facility. A typical worker is at the facility less than 40 hours per week, 50 weeks per year.

There are approximately 1,800 students, faculty and staff members at the high school. Faculty and staff generally spend more time at the school than do students. A typical employee spends 45 hours per week, 50 weeks per year at the school. One janitor lives on the school grounds. Occupancy for this person will be assumed to be continuous.

A remedial investigation is being conducted at the Army Reserve Training area. Subcontract workers perform site characterization tasks intermittently. One employee of the Department of the Army works at most 40 hours a week, 50 weeks per year at the office on the Army Reserve property.

Currently there are approximately 110 workers at the WSSRAP Administration Building. Workers typically spend less than 50 hours per week, for 50 weeks per year, at the facility.

4.1.2 Sampler Description and Sampling Frequency

Air particulate samplers are low volume, self adjusting carbon-vaned, oil-less air pumps at the three quarry locations, and low volume, self-adjusting, twin diaphragm, oil-less air pumps at the five WSCP/WSRP site perimeter locations and at the other three offsite locations. Each sampler is mounted in a weather-protective housing with a 110-volt outlet and a thermostat-controlled fan for cooling. Each sampler will have a timer to document the operational periods. Samplers also have a flow meter and vacuum gages to automatically maintain constant flow.

Air filters are mounted approximately 1 meter (3 feet) above ground surface. The sampling head is on the side of the protective housing opposite the cooling fan exhaust. This prevents the cooling fan exhaust from disturbing the air being drawn through the filter.

All air samplers will run continuously at a flow rate of approximately 40 liters per minute. Samples are collected on 47 millimeter diameter 0.8 micron pore size mixed ester cellulose filter paper. Filters are exchanged weekly.

4.1.3 Sample Analysis

Air samples obtained at the common perimeter of the WSCP and the highway department, the high school, the Army training area, near the WSSRAP Administration Building, by the nearest WSQ resident, and at the Busch Wildlife Area Headquarters will be used to assess effective dose equivalents to a maximally exposed individual. Other sampling locations do not represent potential locations for maximum public exposure because public occupancy times at these locations is negligible.

Each filter, representative of approximately 403,200 liters of air (40 liters per minute times 10,080 minutes per week) will be analyzed for gross alpha concentration. Following gross alpha analysis filters will be cut into three equal sections, with each section placed in an individual envelope. The filters will be cut in thirds for quality assurance. This will allow an evaluation of analytical precision. Three pieces are used because, if an error caused a difference in analytical results between two filter portions, the third portion will allow a determination of which result was erroneous.

In January of each year the three sections of 52 weekly filters will form three composite samples for each of the five

critical receptor locations and the Busch Wildlife Area background station. The 18 composite samples (filter thirds from six sampler locations) will be analyzed for isotopic thorium, isotopic uranium, Ra-228, and Ra-226. Analysis for this suite of radionuclides allows a determination of the concentration of all radionuclides at the Weldon Spring Site which could contribute more than 10 percent of the total effective dose equivalent. Radon and daughters are not included because they are not regulated by 40 CFR 61, Subpart H.

Yearly analyses of the filters is considered acceptable because it meets the intent of 40 CFR 61. The primary method given in 40 CFR 61 of determining effective dose equivalents is through computer modeling. The computer modeling exercise is to be performed and reported annually. Monitoring of airborne concentrations is also allowable. Therefore, a yearly determination of the airborne concentrations and associated effective dose equivalent at critical receptors meets the specifications of 40 CFR 61.

4.1.4 Reports

Reports of environmental monitoring for radionuclide emissions other than radon have been made for calendar years 1986 through 1988 in Annual Environmental Monitoring Reports (DOE, 1986; DOE, 1987a; DOE, 1988). These monitoring reports were transmitted to EPA Region VII. Although the monitoring at critical receptor locations was not sensitive enough to distinguish an annual effective dose equivalent of 0.10 mSv (10 mrem) above natural background, results for years 1986 through 1988 detected no significant difference at the 95 percent confidence level between gross alpha concentrations at critical receptors and the background monitoring station. This was as expected because no significant activities occurred at

the WSS during these years that generated airborne radionuclide emissions.

Beginning with air samples collected during calendar year 1990, results of the monitoring performed as specified in Section 4.1 of this plan and an assessment of the effective dose equivalent at critical receptor locations will be reported in the 1990 Annual Site Environmental Report. These annual reports meet the requirements of 40 CFR 61 because the WSS is being remediated according to CERCLA. This allows EPA oversight which is sufficient to protect the public health by providing EPA Regional Office VII with all the information it needs to assess potential impacts on public health as a result of remediating the WSS.

4.2 COMPARISON TO 40 CFR 61 SPECIFICATIONS

In order to satisfy the sensitivity requirements of 40 CFR 61 through environmental monitoring the following must be met:

1. The air at the point of measurement must be continuously sampled for collection of radionuclides.

2. Those radionuclides released from the facility that are major contributors to the effective dose equivalent must be collected and measured as part of the environmental measurement program.

3. Radionuclide concentrations which would cause an effective dose equivalent of 10% of the standard must be readily detectable and distinguishable from background.

4. Net measured radionuclide concentrations must be compared to the concentration levels in Table 2,

Appendix E of 40 CFR 61. In the case of multiple radionuclides being released from a facility, it must be demonstrated that the value for all radionuclides is less than the concentration level in Table 2, and the sum of the fractions that result when each measured concentration value is divided by the value in Table 2 for each radionuclide is less than 1.

5. A quality assurance program must be conducted that meets the performance requirements described in Appendix B, Method 114 of 40 CFR 61.

This subsection describes how the monitoring program at the WSS will satisfy items 1 through 4. Item 5 is addressed in Section 5.

Items 1 and 2 have been addressed previously. Samplers will run continuously and all major contributors to effective dose equivalent will be collected and measured.

Regarding Item 3, the sampling protocol at the critical receptor locations will be followed at the background monitoring station. Assuming typical Th-232 soil concentrations of 40 Bq/kg (1 pCi/g) and a typical rural airborne dust loading of 16 $\mu g/m^3$ (EPA, 1980), airborne Th-232 concentrations in background air would be 6×10^{-13} MBq/m^3 (2×10^{-17} Ci/m^3). (Th-232 was chosen for this example because it is the greatest contributor to effective dose equivalent.) Assuming continuous inhalation at 20 m^3/day (Cember, 1983) for 365 days/year and using a committed effective dose equivalent conversion factor of 4.43×10^{-4} Sv/Bq (EPA, 1988), a committed effective dose equivalent of 2×10^{-3} mSv (0.2 mrem) is predicted. Since the committed effective dose equivalent for Th-232 is received over a 50-year period the effective dose equivalent received in any single year would be at least a factor of ten lower. For these

TABLE 4-1 Sensitivity Analysis

Radionuclide	Required Sensitivity MBq/m³	(Ci/m³)	Ratio
U-238	3.1E-10	(8.3E-15)	0.018
U-234	2.9E-10	(7.7E-15)	0.020
Th-230	1.3E-10	(3.4E-15)	0.044
Ra-226	1.2E-10	(3.3E-15)	0.045
Th-232	2.3E-11	(6.2E-16)	0.242
Th-228	1.2E-10	(3.1E-15)	0.048
Ra-228	2.2E-10	(5.9E-15)	0.025
		SUM	0.442

reasons the annual effective dose equivalents for each radionuclide in background air is much less than 1×10^{-2} mSv (1 mrem). Monitoring results which attain the sensitivity requirements of Item 4 would, therefore, be readily detectable and distinguishable above background.

The sensitivity of the monitoring method meets the criteria in Item 4. A radiochemical detection limit for each radionuclide of 40 mBq (1 pCi) can be attained (Horton, 1990). By dividing this detection level by the 700 m³ drawn through the filter thirds in each composite sample, an airborne concentration of 5.28×10^{-12} MBq/m³ (1.5×10^{-16} Ci/m³) can be detected. Listed in Table 4-1 are the radionuclides for which monitoring will be performed, the analytical sensitivity specified in Table 2, Appendix E of 40 CFR 61, and the ratio of achievable sensitivity to the required sensitivity. Since the

ratio of the sensitivities for each radionuclide is less than 1.0 and the sum of the ratios is less than 1.0, the proposed analytical method meets the requirements of 40 CFR 61.

5 QUALITY ASSURANCE

This section discusses the quality assurance program that will be conducted to ensure that emission measurements are representative and are of known precision and accuracy. Also included are administrative controls to assure prompt response when measurements indicate unexpectedly large emissions. In addition to complying with all requirements contained in this section, this monitoring program will also comply with the Weldon Spring Site Quality Assurance Program Plan (QAPP) (DOE, 1987b).

5.1 ORGANIZATIONAL STRUCTURE

The responsibility for implementing the emission monitoring program lies within the Environmental, Safety and Health (ES&H) Department. As such, the ES&H Manager has overall responsibility. Actual sampling protocol will be carried out within the Radiation Protection Group under the guidance of the Radiation Protection Manager. Audits will be conducted by the Quality Assurance Department which reports directly to the MK-Ferguson Company Quality Assurance Director. Any corrective actions which require modifications in the way remedial actions are performed at the Weldon Spring Site (WSS) are the responsibility of the Operations Department Manager. The lines of responsibility are shown in Figure 5-1.

5.2 SAMPLE COLLECTION AND ANALYSIS PROCEDURES

Project procedures exist for all phases of sample collection and analysis except for the method of dividing individual filters in thirds and the means of compositing samples. This procedure is currently being drafted and will be forwarded upon completion.

FIGURE 5-1 Lines of Authority

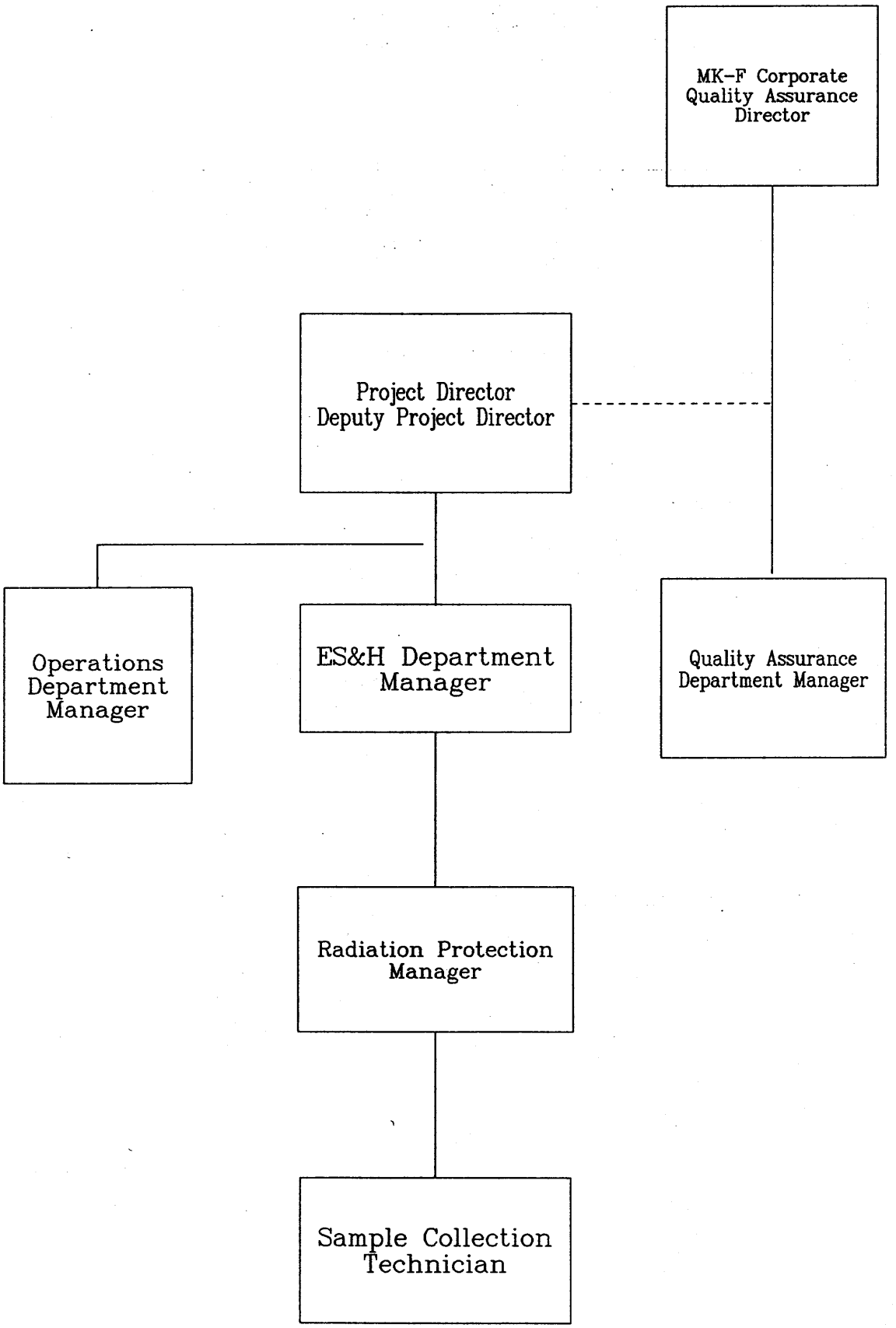


Table 5-1 presents a list of procedures and aspects of the sampling program which they govern. Each procedure is attached to this plan for reference.

Actual radioanalytical procedures are not performed at the site but at a subcontractor laboratory. The radioanalytical procedures used are specified in Table 5-2.

TABLE 5-1 Sampling Procedures

Procedure Number	Title	Sampling Program Aspects
ES&H 2.6.4	Ludlum Model 2000 Scaler and Model 43-10 Detector: Gross Alpha Measurement Operator and Calibration	Gross alpha analysis of air filters. Detector calibration, operational check, and usage.
ES&H 4.1.2	Chain-of-Custody	Chain-of-Custody for samples sent for radiochemical analysis
ES&H 4.6.4	Constant Flow Air Sampler Operation	Air filter change outs, filter handling, air sampler calibration and operation.

TABLE 5-2 Radioanalytical Procedures

Nuclide	Method
U-238	EPA-908
U-234	EPA-908
Th-232	EERF[(a)]-06
Th-230	EERF-06
Th-228	EERF-06
Ra-228	EPA-903.1
Ra-226	EPA-904

(a) Eastern Environmental Radiation Facility

5.3 ADMINISTRATIVE CONTROLS

Assurance that increased radionuclide emissions due to unplanned or unforeseen circumstances can be detected and controlled is achieved through weekly gross alpha analyses of each filter. Isotopes of thorium are the alpha-emitters at the WSS that have the highest potential to cause radiation dose at critical receptor locations. Isotopes of thorium are most prevalent in the quarry and in the raffinate pits. For other site areas such as Weldon Spring Chemical Plant (WSCP) buildings, uranium is the primary contaminant. At the quarry, Th-230 comprises, on average, 33 percent of the total alpha activity contributed by those radionuclides that will be measured at critical receptor locations. At the raffinate pits, Th-230 comprises, on average, 87 percent of the total alpha activity contributed by those radionuclides that will be

measured at critical receptor locations. Clearly, Th-230 has the highest potential to cause a radiation dose at critical receptor locations.

If the potential for a person to receive a yearly effective dose in excess of 0.10 mSv (10 mrem) can be detected on a weekly basis, sufficient control over radionuclide emissions can be attained. This is achieved if a dose equivalent rate of 0.002 mSv (0.2 mrem) per week can be detected. Given a typical weekly occupancy time of five 8-hour days for persons closest to the site where the highest potential airborne concentrations are expected to occur, a quantity of air inhaled during eight hours at work of 10 m^3 (Cember, 1983), and a Th-230 committed effective dose equivalent conversion factor of 8.8×10^{-5} Sv/Bq (EPA, 1989), a dose equivalent of 0.002 mSv/week (0.2 mrem/week) corresponds to an airborne concentration of 4.4×10^{-10} MBq/m^3 (1.2×10^{-14} Ci/m^3).

A natural background gross alpha concentration of $2 \times 10^{-10} \pm 1.2 \times 10^{-10}$ MBq/m^3 at two standard deviations ($5 \times 10^{-15} \pm 3.26 \times 10^{-15}$ Ci/m^3) has been documented at the site (DOE, 1988). It can be seen that a committed effective dose equivalent rate due entirely to Th-230 of 0.002 mSv/week (0.2 mrem/week) can be resolved above natural background gross alpha concentrations. In fact, an effective dose equivalent rate much lower than 0.002 mSv/week (0.2 mrem/week) can be resolved above natural background gross alpha concentrations.

The wastes at the WSS contain a mixture of alpha emitters. Although some of the detected alpha activity will be due to Th-232 and Th-228, which have a higher potential to cause internal dose, a larger percentage of alpha emitters with lower internal dose delivery potential will also be present. This is based on measured radionuclide concentrations in waste

materials. In addition, a Th-230 concentration of 4.4×10^{-10} MBq/m^3 (1.2×10^{-14} Ci/m^3) would result in a committed effective dose equivalent of 0.002 mSv/week (0.2 mrem/week). The effective dose equivalent would be much less because the dose equivalent from inhalation of Th-230 in any given year is spread out over a period of more than 10 years.

To ensure that remedial actions do not result in unplanned or unforeseen airborne radionuclide concentrations at critical receptor locations, a "sliding weekly average" gross alpha concentration will be computed for each critical receptor monitoring station. The sliding weekly average gross alpha concentration will be computed by summing all weekly gross alpha concentrations and dividing by the number of weeks of sampling during a calendar year. As successive weekly samples are analyzed, the results will be used to recompute the sliding weekly average concentration. If a sliding weekly average gross alpha concentration at critical receptor locations in excess of natural background is detected with 95 percent confidence, site operations which may have caused the elevated concentration will be evaluated to determine whether all reasonably achievable dust control measures have been implemented.

A weekly sampling frequency is adequate to control radiation exposures because the 0.10 mSv (10 mrem) level specified in 40 CFR 61 is a long-term standard (i.e. yearly). A response time of one week to control unplanned or unforeseen emissions will be adequate to maintain control over emissions.

5.4 QUALITY CONTROL

The quality control program will include spikes, duplicates, blanks, and control charts. This program is designed to meet the requirements of 40 CFR 61, Appendix B.

With each group of filters sent for radiochemical analysis, two filters will be spiked with known activities of Th-230 and two filters will be spiked with known activities of natural uranium (U-238, U-235, and U-234 in natural activity ratios).

Since each filter composite collected at critical receptor locations is cut into thirds, these filter thirds will serve as duplicates. Five percent of all gross alpha analyses are repeated to verify detector performance.

Field blanks are used each week when air filters are exchanged. These will be composited and analyzed radiochemically following analysis for gross alpha activity. In addition, each week an unused filter is analyzed for gross alpha activity. These filters will be composited and analyzed radiochemically.

Control charts are maintained to verify gross alpha detector performance. A control chart is generated to track daily detector background and daily certified standard source checks. Daily background and source counts must fall within three standard deviations of values posted when the detectors undergo semiannual calibration (MKF and JEG, 1989).

In addition to the system of spikes, duplicates, blanks, and control charts the radioanalytical analyses will be evaluated for internal consistency. At the WSS, U-238 and U-234 are in secular equilibrium. Uranium concentrations on air filters should also be in equilibrium. When radioanalytical results are provided, the degree of equilibrium will be evaluated. In most cases, Th-228 and Ra-228 are also in equilibrium. Equality between these radionuclides will also be evaluated.

5.5 DATA QUALITY OBJECTIVES

Accuracy and precision of radiochemical analyses will be measured at the 85 percent confidence level. Accuracy, as determined with the results of spiked samples, will be considered acceptable if analytical results of spiked samples are within $\pm$50 percent of known values for 85 percent of all samples. Precision will be determined by averaging the results of the three duplicate analyses. Precision will be considered acceptable if the standard deviation of duplicate analyses is within $\pm$50 percent of the average for 85 percent of the duplicate data sets. Analytical precision will also be calculated for U-238/U-234 for each composite sample. Precision will be considered acceptable if the standard deviation of the U-238/U-234 results for each composite sample are within $\pm$ 50 percent of the average for 85 percent of all samples.

Accuracy and precision of gross alpha analyses will be measured at the 95 percent confidence level. Accuracy, as determined by the daily source counts, will be considered acceptable if 95 percent of all daily values fall within three standard deviations of the certified standard source. Precision, as determined by the results of duplicate analyses, will be considered acceptable if 95 percent of the duplicate counts are within three standard deviations of the original count.

5.6 AUDITS

Internal audits will be conducted yearly by the WSSRAP Quality Assurance Department in accordance with the WSSRAP QAPP. The primary purpose of the audits will be to assure that sample collection, sample compositing, gross alpha analyses, and sample chain of custody are performed according to standard operating procedures. The internal audits will also ensure

conformance with this overall "Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors."

External audits of the radioanalytical laboratory will also be performed annually by the WSSRAP Quality Assurance Department. These audits will ensure conformance of the radioanalytical laboratory to standard operating procedures.

5.7 CORRECTIVE ACTIONS

If data quality objectives are not met, the Radiation Protection Manager will provide a report evaluating the reasons for noncompliance and providing a statement of required corrective actions. The Environmental Safety and Health Manager will ensure the appropriateness of the recommended corrective actions and ensure that corrective actions are implemented in a timely manner.

If results of gross alpha analyses indicate detectable emissions of radioactive particulates at critical receptor locations the Radiation Protection Manager shall inform the Operations Department Manager. The Operations Department Manager will be responsible for ensuring that emissions are controlled to a level which is as low as reasonably achievable.

5.8 REPORTS

Emissions measurement program results including assessment of data quality, results of internal audits and corrective actions, if any, shall be prepared annually.

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CHEMICAL PLANT ADMINISTRATIVE RECORD FILE

ARFS FILE # C-201-4

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	C-200-201-1.12	SMALL MAMMAL SAMPLING PLAN
	C-200-201-1.13	ENVIRONMENTAL MONITORING PLAN FOR THE CALENDAR YEAR 1992
	C-200-201-1.14	SAMPLING PLAN FOR DETERMINATION OF HYDRAULIC PROPERTIES OF UNDISTURBED SOILS IN THE WS DISPOSAL STUDY AREA

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

CHEMICAL PLANT
201-1.11

DOE/OR/21548-229

Weldon Spring Site Remedial Action Project

Agricultural Sampling Plan

Revision 0

September 1991

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

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1 INTRODUCTION

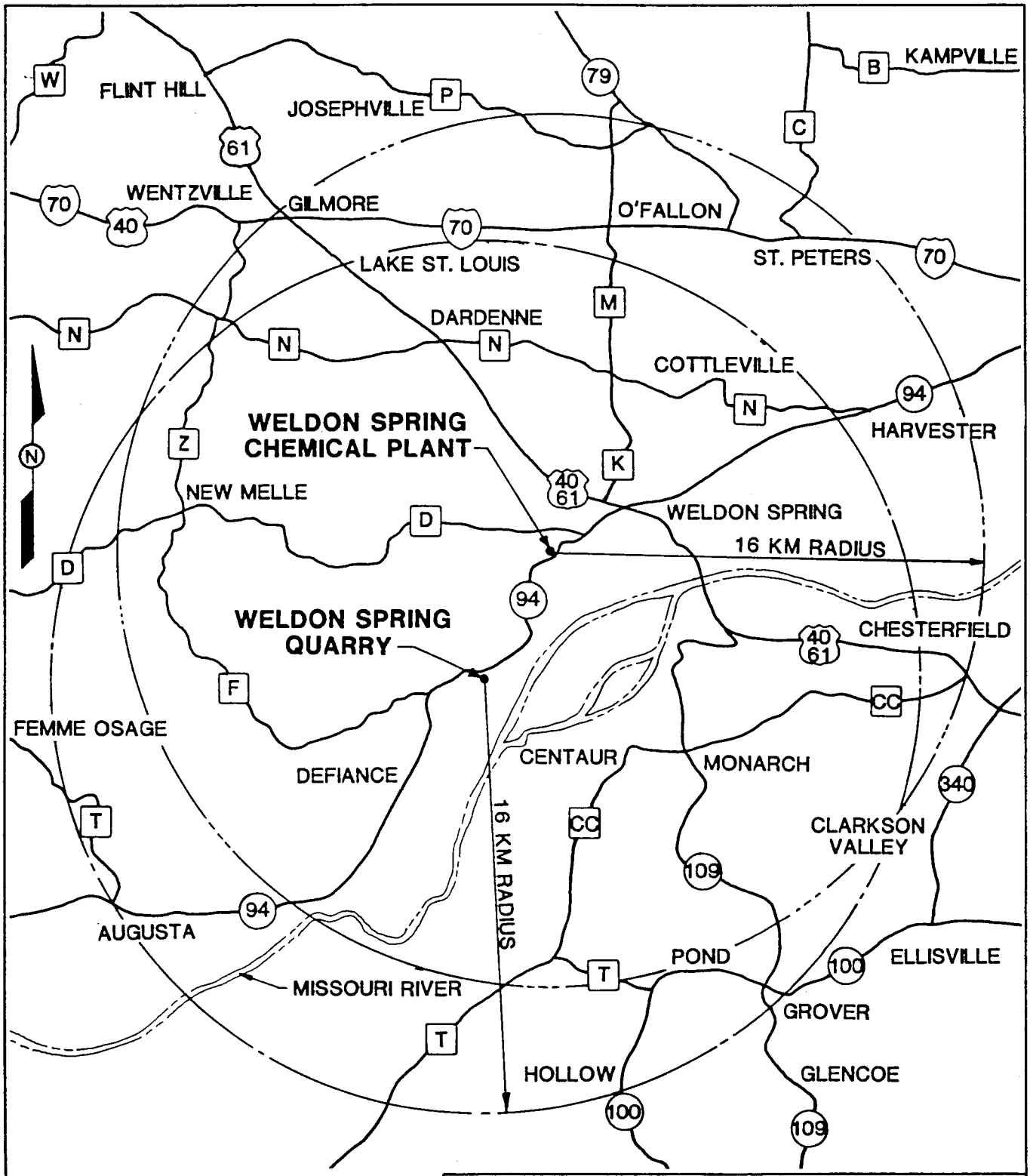
The following sampling plan is prepared in response to U.S. Department of Energy (DOE) requirements for analysis of "foodstuffs" in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (January 1991). In addition to these requirements, the plan responds to public concern about the potential for contamination of corn crops growing in the St. Charles County well field at the Weldon Spring Wildlife Area. The well field is located adjacent to the Femme Osage Slough near the Weldon Spring Quarry. Uranium concentrations in the slough have ranged from a low of ND to a high of 557 pCi/l, with an average around 54.8 pCi/l (MKF and JEG 1991).

The scope of this plan has been broadened to include agricultural grain products other than corn, such as soybeans, millet, and grain sorghum. Most of the land surrounding the Weldon Spring site and the Weldon Spring quarry consists of deciduous hardwood forest interspersed with old fields and croplands. Together, the Busch Wildlife Area, the Weldon Spring Wildlife Area, and Howell Island are comprised of approximately 64% forest, 17% cropland, and 15% old field (MDOC 1989). Portions of the Busch Wildlife Area and the Weldon Spring Wildlife Area are leased to sharecroppers for farming. In return, the farmers leave a portion of their crop for wildlife consumption. Along with surrounding Missouri Department of Conservation (MDOC) farmlands, there are numerous local farms in the vicinity of the Weldon Spring Chemical Plant and quarry.

1.1 Purpose

The purpose of this sampling plan is to characterize concentrations of radionuclides in agricultural products and to determine types of crops grown in the Weldon Spring area. This sampling plan describes the requirements for agricultural sampling to determine what environmental monitoring activities may be required in the future at the Weldon Spring Site Remedial Action Project (WSSRAP). By using this tiered approach, sampling can focus on food stuffs and feed products to determine the need for second tier sampling of milk, eggs, poultry, etc.

The areas to be sampled are within 16 km of either the Weldon Spring site boundary and the Weldon Spring quarry boundary (Figure 1-1) as designated by the guidance in Environmental Regulatory Guide (DOE 1991). The site and the quarry are approximately



SITE SURVEY RANGE

FIGURE 1-1

0 5 MI
0 8.05 KM
SCALE

REPORT NO.:		EXHIBIT NO.: A/VP/097/0791	
ORIGINATOR: MGT	DRAWN BY: GLN	DATE: 7/91	

6.4 km apart. Since the sample areas overlap, samples will be taken in both the overlap and non-overlap areas. Background locations will be outside the 16 km radius of both areas.

1.2 Scope of Work

This sampling plan defines field methods for obtaining agricultural samples, sample selection, analytical requirements and methods, and quality control measures.

Sampling of agricultural products will take place just before harvesting commences. This will require close communication between the Project Management Contractor (PMC), the Missouri Department of Conservation, and farmers.

Surveying local farms will require contact with Agricultural Stabilization and Conservation Service (ASCS) to determine what crops have been planted in St. Charles County including portions of Franklin and St. Louis counties and the percentage of each. Also, local farmers will be contacted, if necessary, on the basis of sample selection.

1.3 Objectives

Sampling will be conducted to achieve the following objectives:

- Characterize background radiological levels in agricultural (foodstuffs) products.
- Determine the concentration of radionuclides in agricultural products near the site.
- Determine whether crops grown within the study area (Figure 1-1) contain significantly higher levels of radionuclides in excess of background.
- Make recommendations on environmental surveillance for agricultural products.
- Summarize agricultural practices surrounding the WSS.

1.4 Sample Collection

Sample collection will be based upon farming practices in the areas of concern. Information on farming practices is provided by the County Soil Conservation Service. There will be 20 samples taken in the overlap area, 10 samples in each nonoverlap area, and 20 samples outside the radius for a total of 50 samples, plus the quality assurance samples. Samples will be taken with consideration given to the distance from the contamination source. These locations will be representative of crop areas around the Weldon Spring Chemical Plant (WSCP), crop areas around the quarry, crops in the overlap area between the WSCP and the quarry[1], and background crops.

For agricultural products, approximately 1 kg will be sent for each sample. Only grain portions of the agricultural products gathered will be sent to the laboratory for analysis. The exception to this will be corn samples which along with grain will also include samples of (1) an entire corn stalk, excluding roots, (2) leaves only, and (3) cobs. Any soil will be removed from the samples prior to shipping. Samples will be collected and documented using the Biological Sample Collection Form (Figure A-1).

Soil samples will be collected at each location in accordance with ES&H SOP 4.4.5s, *Soil/Sediment Sampling*. These samples will be subject to the same quality control sampling as the agricultural samples. All sampling equipment will be decontaminated after each sample as specified in ES&H SOP 4.1.3s, *Sampling Equipment Decontamination*. A soil sampling form will be completed for each sample, see Figure B-1.

In addition to crop sampling, informal garden surveys will be conducted within the 16 km radii. This survey will be used to gather general information and to plan future argricultural sample plans deemed necessary from the 1992 study. Information collected will include, but not be limited to, garden size, variety of species, and final destination of the product. If livestock are present, this will be noted in the logbook as specified in Environmental, Safety and Health (ES&H) Standard Operating Procedures (SOPs) 1.1.4s, *Logbook Procedure*.

---

[1] Sampling will be concentrated in locations nearest to, and downwind of, the WSCP and the quarry.

1.5 Sample Location and Identification

Exact sample locations will be chosen in the field and will be mapped and described on the field sheet. Sample locations will be at least a quarter of a mile apart.

Samples will be labelled in the format, BG-XXXX-MMDDYY, which will identify the samples by biological matrix (BG), agricultural products, and date sampled. The 3rd and 4th spaces will designate sample location. The 5th and 6th spaces will distinguish what type of agricultural product is being sampled. The last six digits will represent the date sampled. Sample identification and location will be reported on field sheets.

1.6 Background Samples

Background samples will be taken from areas outside of the 16 km radius and include crops found in the study area. Background samples will equal the total number of study samples taken. All background samples will be collected, identified, and recorded in the same manner as the study samples.

1.7 Analytical Requirements

Crop and soil samples will be analyzed for total uranium, Ra-226, Ra-228, and isotopic thorium. All samples will be field screened for radioactive contamination prior to shipment to off-site analytical laboratories. Laboratories performing radiological analyses for the WSSRAP are required to have an approved quality assurance laboratory plan and procedures. This QAPP details specific measures which the laboratory will implement to ensure data quality.

Data Quality Requirements (DQRs) are quantitative statements of selection, accuracy, and precision which specify the quality of data needed to support specified data uses. DQRs for this effort will be consistent with those established for routine environmental monitoring which are documented in the Environmental Data Administration Plan (EDAP) (MKF and JEG 1990).

Table 1-1 Requirements for Agricultural and Soil Samples

	Methods	Lower Limit of Detection	Sample Amount
Agricultural Samples:			
Total Uranium	EPA 908.1	1.0 pCi/g	500 grams
Radium-226	EPA 900.1	1.0 pCi/g	500 grams
Radium-228	EPA 904	1.0 pCi/g	500 grams
Isotopic Thorium	EPA 907	1.0 pCi/g	500 grams
Soil Samples:			
Total Uranium	EPA 908	1.0 pCi/g	500 grams
Radium-226	EPA 900.1	1.0 pCi/g	500 grams
Radium-228	EPA 904	1.0 pCi/g	500 grams
Isotopic Thorium	EPA 907	1.0 pCi/g	500 grams

1.8 Quality Assurance Samples

Quality control samples will be obtained for every 20 samples to assess laboratory performance and analytical precision. These samples will include duplicates, matrix spikes, matrix spike duplicates, and field blanks.

The labeling of QA samples will follow the same format as other samples collected with the addition of a two-character modifier at the end of the ID number.

Duplicate	XX-XXXX-XXXXXX-DU
Matrix Spike	XX-XXXX-XXXXXX-MS
Matrix Spike Duplicate	XX-XXXX-XXXXXX-MD
Field Blank	XX-XXXX-XXXXXX-FB

1.9 Sample Shipment and Chain of Custody

Samples will be shipped to off-site analytical laboratories for analysis. Sample chain of custody will comply with WSSRAP SOP ES&H 4.1.2. Shipment and packaging samples will follow Regulatory Compliance Procedures RC-11, RC-17, RC-19s, and RC-22s.

2 DATA REPORTING

Data collected during background sampling will be reported and interpretation and determinations will be made on minimum background levels of uranium, Ra-226, Ra-228, and isotopic thorium for agricultural products. These background samples will represent normal radionuclide levels in noncontaminated areas.

Data collected from study areas and from background samples will be interpreted and tested under various statistical methods. The statistical tests will determine whether concentrations found in agricultural crops within the 16 km vicinity of the Weldon Spring site (WSS) have significantly higher level of radiological concentrations than those outside the 16 km radius at a 90% confidence level.

One of two statistical tests will be used to make the determination; the Student's T-test or the Mann-Whitney U-test. The determination of which statistical test to use is based upon whether the distribution of data populations can be assumed to be normal, and whether the variances among sample populations (background and vegetative debris) are equal. Preliminary tests of variance and normality will be determined by using the W-test and F-test. For the W-test data reported as non-detects or less than the detection limit (DL) will be quantified as DL/2 per EPA guidance (EPA 1991).

Information gathered from agricultural sampling will also be compared to data results of soils taken from sample locations and the distance from source (either Weldon Spring Chemical Plant (WSCP) or Weldon Spring quarry (WSQ)). Correlation tests will be used to determine if any relationship can be drawn between soils, distance, and agricultural concentrations of radionuclides.

All data will be presented in a report prepared following the Format Guide for Formal Reports, Rev. 2 February 1991.

3 DATA ADMINISTRATION

Data will be reviewed and quality control samples compared following standard operating procedures (ES&H 4.9.1a, RC-31a) and the *Environmental Data Administration Plan* (MKF and JEG 1990).

Quality Assurance procedures will follow the guidelines established in the *Environmental Quality Assurance Program Plan* (MKF and JEG 1991).

4 REFERENCES

Missouri Department of Conservation, 1989. *Area Management Plan For the August A. Busch Complex*. Jefferson City, MO.

MK-Ferguson Company and Jacobs Engineering Group, 1991. *Environmental Quality Assurance Program Plan*. Rev. 0. DOE/OR/21548-238. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. In press.

MK-Ferguson Company and Jacobs Engineering Group, 1990. *Environmental Data Administration Plan*. Rev. 0. DOE/OR/21548-119. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. May.

MK-Ferguson Company and Jacobs Engineering Group, 1991. *Annual Site Environmental Report for Calendar Year 1990*. Rev. 1. DOE/OR/21548-193. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. August.

U.S. Department of Energy, 1991. *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*. DOE/EH-0173T. Washington, D.C. January.

WSSRAP Procedures

ES&H 1.1.4s - *Logbook Procedures*
ES&H 4.1.1/1 - *Numbering System For Environmental Samples and Sampling Locations*
ES&H 4.4.5s/1 - *Soil/Sediment Sampling*
ES&H 4.1.3 - *Sampling Equipment Decontamination*
ES&H 4.1.2 - *Chain of Custody*
ES&H 4.9.1a/1 - *Environmental Monitoring Data Verification*
RC-11 - *Transporation and Tracking of Material*
RC-17s/2 - *Packaging, Shipping and Receiving of Radioactive Materials*
RC-19s/1 - *Packaging, Shipping and Receiving of Non-Radioactive Hazardous Material*

RC-22s/0 - *Management of Samples Returned to WSS*
RC-31a/0 - *Environmental Monitoring Data Validation*

APPENDIX A

Sample Collection Forms

100791

WELDON SPRING SITE REMEDIAL ACTION PROJECT
7295 Highway 94 South
St. Charles, Missouri 63304
(314) 441-8086

BIOLOGICAL SAMPLE COLLECTION FORM

SAMPLE ID: _____ Date: _____

LOCATION: _____ TIME: _____

PERSONNEL: _____

_____

LOCATION TYPE: LAKE STREAM SPRING RIFFLE POOL TERRESTRIAL

SAMPLE TYPE: BENTHOS PLANKTON FISH MAMMAL VEGETATION

SAMPLE PURPOSE: CHEMICAL RADIOLOGICAL ECOLOGICAL

VOUCHER SPECIMEN BIOMASS OTHER: _____

SAMPLING METHOD/EQUIPMENT: _____

SAMPLE SIZE/VOLUME: _____

DIAGRAM/COMMENTS: _____

_____

_____

_____

PARAMETERS TAKEN: _____

_____

_____

PRESERVATIONS: Packed in Ice (4°C) _____

Other _____

DUPLICATES TAKEN: _____

_____

Signature: _____ Date: _____

APPENDIX B

Soil/Sediment Sampling Form

100791

WELDON SPRING SITE REMEDIAL ACTION PROJECT
7295 Highway 94 South
St. Charles, Missouri 63304
(314) 441-8086

SOIL/SEDIMENT SAMPLING FORM

SAMPLE NUMBER: _____ DATE: _____

LOCATION: _____

PERSONNEL: _____

_____

SAMPLE COLLECTION METHOD: _____

SAMPLE TYPE: DEPTH COMPOSITE GRAB OTHER _____

SAMPLING EQUIPMENT DECONTAMINATION METHODS: _____

SAMPLE DESCRIPTION:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Signature _____ Date: _____

CHEMICAL PLANT
201-1.12

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
7295 Highway 94 South
St. Charles, Missouri 63304

January 6, 1992

Distribution

SMALL MAMMAL SAMPLING PLAN

The subject sampling plan is enclosed for your review. The sampling plan is prepared in response to U. S. Environmental Protection Agency requirements for establishing baseline risk assessments for biota residing on or near the Weldon Spring Site Remedial Action Project (WSSRAP), as part of the Comprehensive Environmental Response, Compensation and Liability Act Remedial Investigation/Feasibility Study process.

This plan includes sampling small mammals such as rats, mice and shrew located on WSSRAP and surrounding areas to determine general population numbers, species presence, and any abnormalities which may be occurring within individuals of these species or communities of small mammals.

If you have any comments, please contact Alan D. Gibson.

Sincerely,

Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

cc w/o enclosure:
Jim Powers, PMC

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MK-Ferguson Company
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St. Charles, Missouri 63304

DOE/OR/21548-248
CONTRACT NO. DE-AC05-86OR21548

SMALL MAMMAL SAMPLING PLAN

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

DECEMBER 1991 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

DOE/OR/21548-248

Weldon Spring Site Remedial Action Project

Small Mammal Sampling Plan

Revision 0

December 1991

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
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PLAN TITLE: Small Mammal Sampling Plan	

APPROVALS

Steven Green — 12-20-91

Department Manager — Date

Phil D. Coate — 12/23/91

Quality Assurance Manager — Date

Rob Jenkins — 12-24-91

Deputy Project Director — Date

Rob Jenkins for JRP — 12-24-91

Project Director — Date

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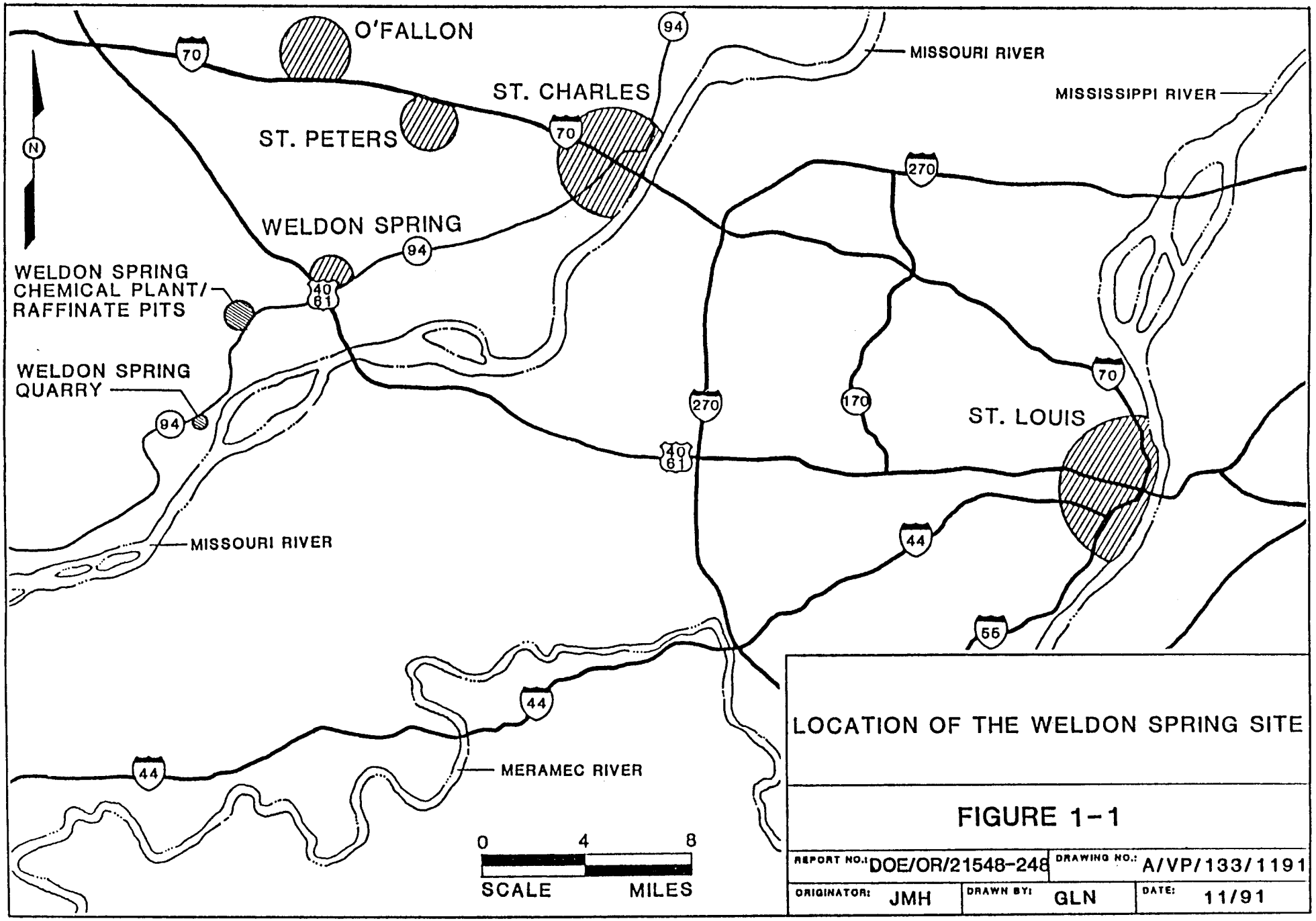
1 INTRODUCTION

The Weldon Spring Site Remedial Action Project (WSSRAP) is being conducted as a Major Systems Acquisition under the Surplus Facilities Management Program (SFMP) of the U.S. Department of Energy (DOE). The major goals of the SFMP are to eliminate potential hazards to the public and the environment that are associated with contamination at SFMP sites and to make surplus real property available for other uses to the extent possible. The WSSRAP consists of two main areas. The Weldon Spring Chemical Plant (WSCP) and the Weldon Spring Quarry (WSQ) (Figure 1-1).

The following sample plan is prepared in response to U.S. Environmental Protection Agency (EPA) requirements for establishing baseline risk assessments for biota residing on or near the Weldon Spring Site Remedial Action Project (WSSRAP), as part of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Remedial Investigation/Feasibility Study (RI/FS) process. This study comprises a portion of the comprehensive, year-round program to monitor the impact of the contaminants from the Weldon Spring site (WSS) on the surrounding region's groundwater, surface waters, and soil properties through multiple pathways, including monitoring for potential exposure to non-receptor human populations. The chemical plant area has largely been characterized as part of the WSCP RI/FS investigation. The WSCP is one of four separate operable units (SOUs) that have been created in order to facilitate the remedial decision making. The other SOUs are quarry bulk wastes, site groundwater, and quarry residuals area. A portion of this sampling plan is directed at the quarry residual areas and is part of the ecological characterization requirements for the residual RI/FS. The quarry residual area includes the quarry proper and surrounding vicinity properties including groundwater. The regulatory requirements are detailed in the *Weldon Spring Quarry Residual Work Plan* (MKF and JEG 1991a). The other areas included in this plan are being studied as part of the on-going environmental monitoring program.

This plan includes sampling small mammal populations located on the WSS and surrounding areas, to determine general population numbers, species presence, and any abnormalities which may be occurring within individuals of these species or communities of small mammals. Small mammals such as mice, rats, and shrew serve as prey species to indigenous and transient species, some of which may be federally or state endangered. Additionally, these small mammals utilize the same resources as larger species, such as deer, which are hunted within this region and are part of the human food chain.



LOCATION OF THE WELDON SPRING SITE

FIGURE 1-1

REPORT NO.:	DOE/OR/21548-248	DRAWING NO.:	A/VP/133/1191		
ORIGINATOR:	JMH	DRAWN BY:	GLN	DATE:	11/91

As indicated by Douglas (1989), rodents are recommended for use in ecological monitoring at the population level because they are small, easy to handle, and spend their entire life cycle within a relatively small area. Additionally, the majority of avian and terrestrial carnivores, to a greater or lesser degree, utilize a rodent prey base (Douglas 1989).

Small mammals are prey for birds, snakes, and other mammals. The American kestrel, red-tailed hawk, barred owl, eastern screech owl, and the great horned owl have been sighted in the study area (MKF and JEG 1991b). Small mammals make up no less than 70% of these species' diet (Toland 1985, Wilson 1984). Other birds that prey on small mammals that potentially occur in the study area are listed on the State and/or Federal list of threatened and/or endangered species (Table 1-1).

Snakes that are known to occur within the study areas and prey on small mammals include: the black rat snake, bull snake, kingsnake, red milk snake, eastern yellowbelly racer, copperhead, and the timber rattlesnake (Johnson 1980). Larger mammals include the coyote, red fox, gray fox, skunk, and bobcat. Of the mammals that may be encountered at any of the sites, only the long-tailed weasel is listed on the State list as "rare."

Biouptake studies are conducted to determine possible exposure pathways of radiological and chemical contamination to humans by ingestion of potentially contaminated fish and game. The Project Management Contractor (PMC) began biouptake studies at the WSS in 1987. These studies have included mammals (rabbits, squirrels, and deer), reptiles (snapping turtle),and fish (large mouth bass, crappie, catfish, and sunfish). These studies are typically planned sampling events, but opportunistic sampling is also incorporated into the program. No significant biological uptake of radiological contaminants has been detected in either the fish or small mammals. Fish were also sampled for metals and showed low concentrations of chromium, arsenic, lead, and other metals which were slightly above the detection limit. These concentrations of metals are not a product of the WSS, but have been shown to be attributable to normal bioaccumulation. Radionuclide bioaccumulation factors were low, and conservatively overestimated doses would still result in negligible exposures (MKF and JEG 1989a).

A variety of wastes are present at the WSSRAP, and have been largely identified at the chemical plant during past site investigations and history of use at the WSS. The groundwater, surface water, springs and soils from various locales on the WSSRAP exhibit various amounts of nitroaromatics, inorganic ions, and radiological contaminants. Detailed information can be

Table 1-1 List of Threatened or Endangered Birds of Prey Potentially Occuring in the Study Area

Common Name	Diet on Small Mammals	Abundance[1]	State Status[2]	Federal Status[3]
Bald Eagle	Not usually small mammals	r	E	E
Cooper's Hawk	60-80%	ca	R	-
Northern Harrier	15-25%	u	E	-
Sharp-shinned Hawk	2-6%	ca	R	-
Red-shouldered Hawk	40-60%	r	WL	-
Mississippi Kite	10%	-	R	-

Notes:

[1] Abundance (MDOC 1991a)

u = uncommon, fairly frequent reports, in small numbers
r = rare, sparingly recorded but generally every year
ca = casual, has been recorded but not every year

[2] State Status (MDOC 1991b)

E = Endangered
R = Rare. Rare indicates present in small numbers. If environment worsens, status in Missouri could deteriorate to Endangered
WL = Watch list. Not currently rare or endangered, but has a restricted distribution or has experienced sufficient decline to indicate it may soon become Rare or Endangered.

[3] Federal Status (MDOC 1991b)

E = Endangered throughout range.

obtained in the *Annual Site Environmental Report* (MKF and JEG 1991c) and the *Draft Remedial Investigation Report for the Weldon Spring Site* (MKF and JEG 1991d). As part of the quarry residuals RI/FS investigation, soil, surface water, and groundwater will also be characterized for contaminates. Details of this program are outlined in the *Weldon Spring Quarry Residual Work Plan* (MKF and JEG 1991a).

1.1 Purpose

The purpose of this sampling plan is to determine if contaminants, primarily radionuclides, may be effecting small mammal populations utilizing the Weldon Spring site and vicintiy properties.

Field monitoring of resident small mammal populations can play a major role in defining the extent and scope of environmental impact, because:

- Resident organisms are continuous monitors of environmental quality.
- Accurate qualitative field assessments of natural populations directly measure adverse effects of the environmental parameters.
- Data is amenable to statistical analysis for interpretation.

1.2 Scope of Work

This sampling plan defines field methods for: measuring small mammal populations, obtaining small mammal samples, sample selection, analytical requirement and methods, and quality control measures.

Sampling of small mammal populations will occur during two distinct sampling seasons: winter (February 1992) and spring (April - May 1992). Nineteen sampling sites have been selected as representative of both control and potentially contaminated areas.

Because this will be a very limited study, it will not be possible to detect differences in population densities or fluctuations, nor to accurately assess impact. However, the utilization of background areas selected for the close similarity to the possibly-impacted areas will provide a relative comparison. As noted in an U.S. Environmental Protection Agency (EPA) Risk Assessment Forum, estimation of animal numbers at any one point in time is difficult. Ideally, population surveys should be based on several years of correlative background data and be conducted over an extended time frame, but in most instances this is cost-prohibitive (EPA 1991). The goal is to determine the presence and useage of the area by small mammals and their potential effect on threatened and/or endangered species and game species.

1.3 Objectives

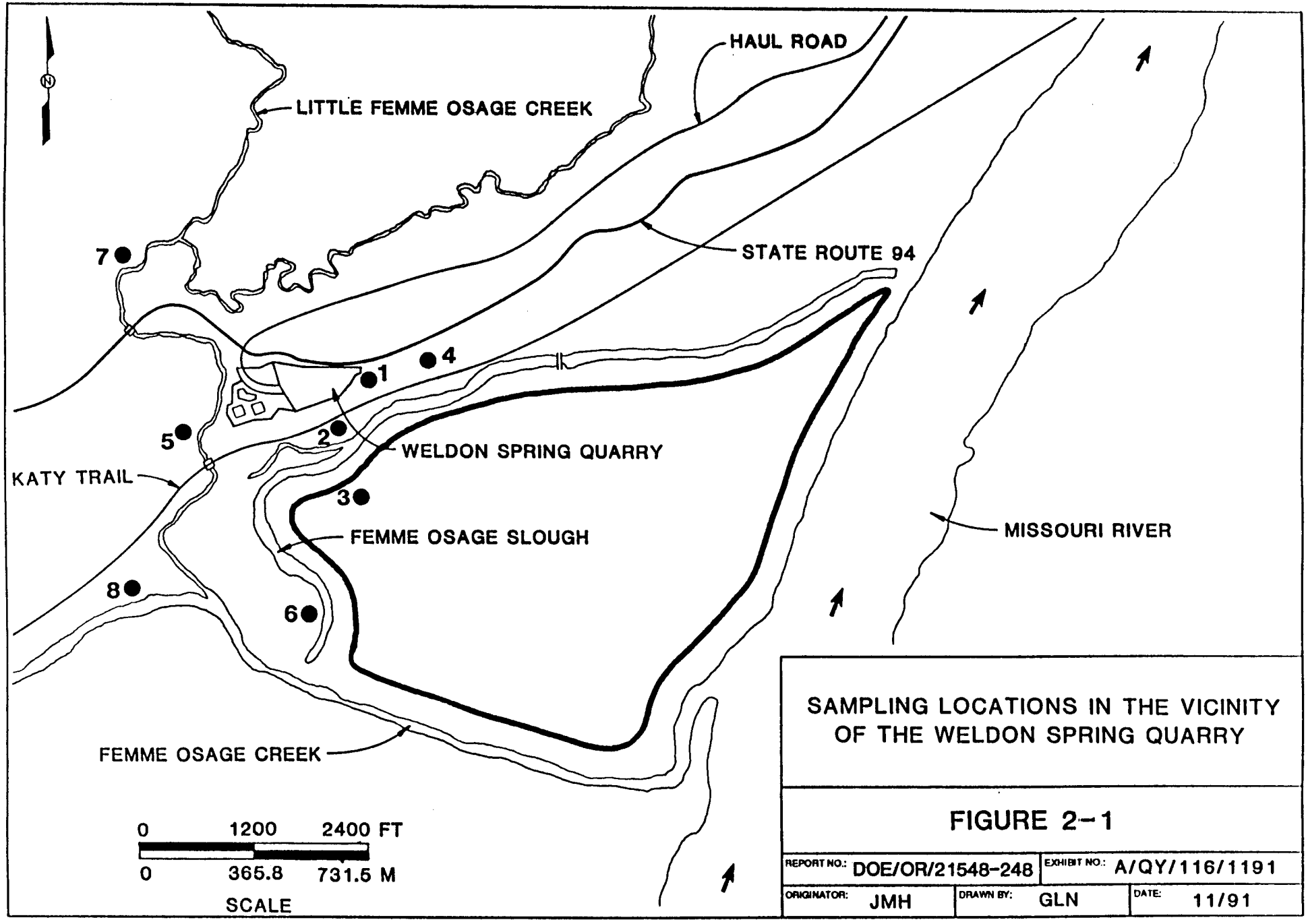
Sampling will be conducted to achieve the following objectives:

- Provide a representative sampling of the taxa of small mammals present on the WSS and the surrounding area to determine approximate population numbers and genera represented.
- Determine usage of study areas by small mammals.
- Characterize background radionuclide levels in resident small mammal populations.
- Continue monitoring of the Weldon Spring Chemical Plant.
- Determine the concentration of radiological residues in selected tissues of resident small mammals located on or near study sites.
- Determine whether tissue obtained from small mammals located within the study areas contain significantly higher levels of radionuclides in excess of background.

2 SAMPLE LOCATION AND IDENTIFICATION

Sites of collection transects are outlined on Figures 2-1, 2-2, 2-3, and 2-4, and include:

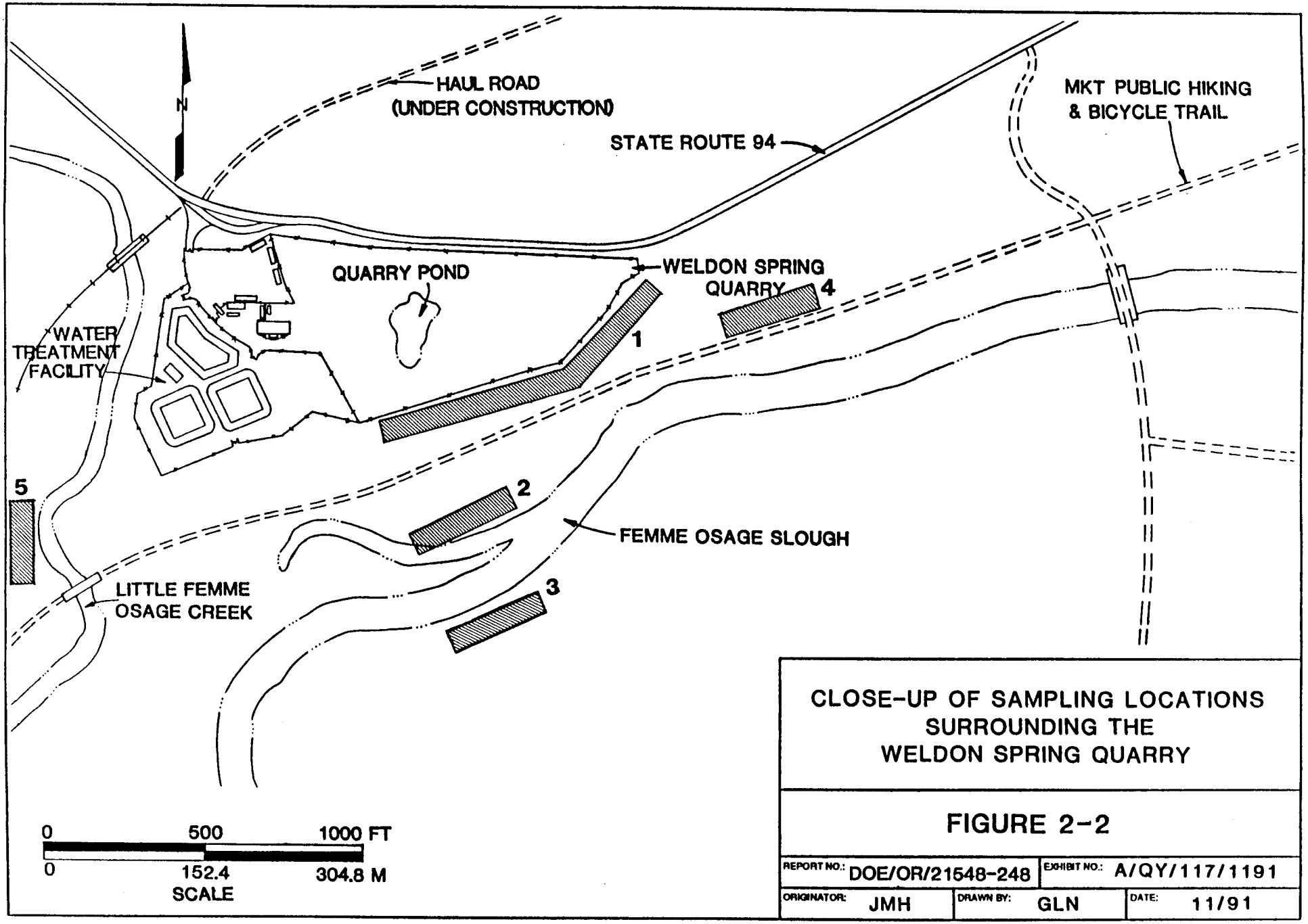
- Site No. 1, perimeter of Weldon Spring Quarry (WSQ) fence.
- Site No. 2, vicinity property No. 9.
- Site No. 3, Agricultural fields.
- Site No. 4, upper southeast drainage of WSQ toward vicinity property No. 9.
- Site No. 5, Little Femme Osage Creek drainage.
- Site No. 6, Bottomland Forest of the southern arm of the Femme Osage Slough.
- Site No. 7, background locality for Sites Nos. 4 and 7.
- Site No. 8, background locality for Site No. 2.
- Site No. 9, upper southeast drainage of Weldon Spring Chemical Plant (WSCP) toward Missouri River.
- Site No. 10, lower southeast drainage of WSCP toward Missouri River.
- Site No. 11, background for Sites Nos. 12 and 13.
- Site No. 12, bottomland palustrine forest near Ash Pond.
- Site No. 13, mixed deciduous (upland) forest, near North Dump
- Site No. 14, Frog Pond and drainage



SAMPLING LOCATIONS IN THE VICINITY OF THE WELDON SPRING QUARRY

FIGURE 2-1

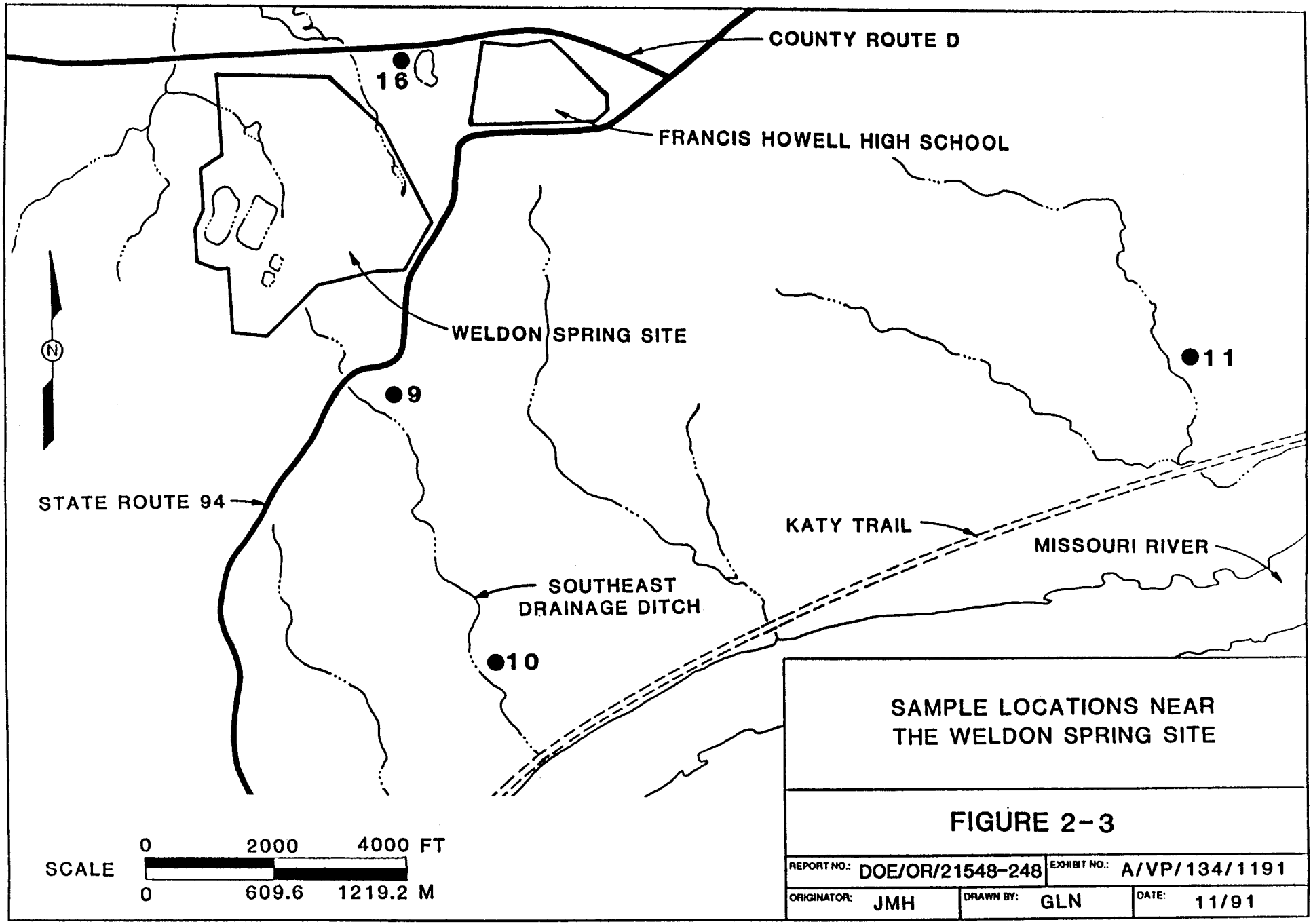
REPORT NO.: DOE/OR/21548-248		EXHIBIT NO.: A/QY/116/1191			
ORIGINATOR: JMH	DRAWN BY: GLN	DATE: 11/91			



CLOSE-UP OF SAMPLING LOCATIONS
SURROUNDING THE
WELDON SPRING QUARRY

FIGURE 2-2

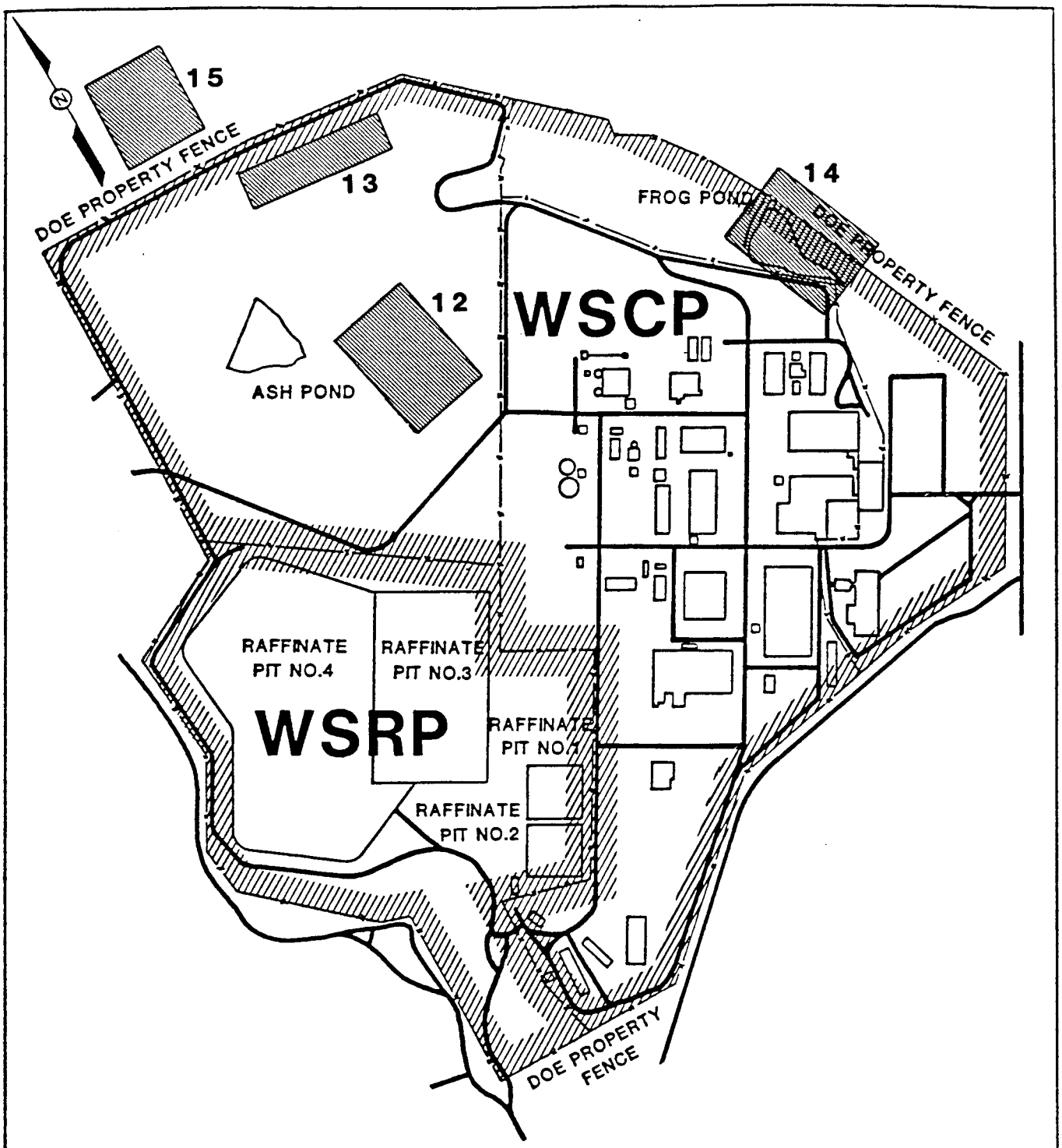
REPORT NO.:	DOE/OR/21548-248	EXHIBIT NO.:	A/QY/117/1191		
ORIGINATOR:	JMH	DRAWN BY:	GLN	DATE:	11/91



SAMPLE LOCATIONS NEAR
THE WELDON SPRING SITE

FIGURE 2-3

REPORT NO.:	DOE/OR/21548-248	EXHIBIT NO.:	A/VP/134/1191		
ORIGINATOR:	JMH	DRAWN BY:	GLN	DATE:	11/91



SCALE 0 500 1000 FT
0 152.4 304.8 M

SAMPLING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT

FIGURE 2-4

REPORT NO.	DOE/OR/21548-248	EXHIBIT NO.	A/CP/165/1191		
ORIGINATOR	JMH	DRAWN BY	GLN	DATE	11/91

- Site No. 15, Ash Pond drainage
- Site No. 16, Lake No. 10, background for Site No. 3

All samples will be collected, identified, and recorded in the same manner.

3 SAMPLE DESIGN AND METHODS

For this study, Sherman live traps are specified, for they are inexpensive, easily transported and set, and can be thoroughly cleaned following recovery from contaminated sites. Trap placement will be along a 100 m transect and the majority of captured small mammals will be returned alive to the field. For purposes of indicating that an animal has been captured, sequentially numbered humane ear tags will be used.

Each sampling period will consist of two trapping days, a two weeks, intervals followed by two more trapping days, for a total of 4 trapping days per period. Live trapping will occur 4 days during February 1992 (1420 trap nights) and 4 days during April - May 1992 (1420 trap nights) for a total of 2840 trap nights. On Day 1 of a given sampling period, the captured animals will have the appropriate data recorded, be ear tagged with sequentially numbered tags, and released. On Day 2, captured animals will again have the appropriate data recorded and released. The last trapping day of each sampling period, 10 snap traps per transect will be set for obtaining samples. The number of snap traps may be increased or decreased by the subcontractor depending upon the densities encountered the pervious trapping days. If possible, four animals (preferably two male, two female) per genera will be selected at random for biouptake of radionuclides. During dissection, reproductive status, litter size, and any abnormalities will be recorded (for each individual) in the logbook. Whole small mammals and organs will be stored at 4°C and sent to an analytical laboratory to be analyzed for total uranium, Thorium 228/230/232 and Radium 226/228. If visible dirt remains, whole specimens will be rinsed off with deionized water. The decision to composite samples will be made by the Contractor at the time of dissection when the amount of samples collected can be assessed. Samples will be placed in plastic bags and labeled. Labels will include the sample date, sample identification number, taxonomic identification, and sample location.

There are 19 sampling areas, each with a 100 m transect. Each transect will have 20 alternating sized traps. Two sizes of Sherman live traps will be used: approximately 8.0 cm x 8.0 cm x 25.5 cm and 10.2 cm x 10.2 cm x 22.9 cm. Traps will be placed at 5 m intervals along each transect within the indicated areas on Figures 2-2 through 2-5. No transect will be established within 100 m of any other transect. Bait will be peanut butter balls or other appropriate bait. Modification of this pattern will be dictated by such site-specific constrains as slope, presence of water/sludge or extremely wet conditions, and will be determined by the contractor at time of trap deployment. Once in the field, two transects may be placed at a site

if deemed possible by the contractor. Transects must be at least 100m apart to ensure that the same population is not being sampled. If the number of transects is increased then the number of trap nights will be increased to a maximum of 5,680 trap nights.

During the February sampling period, traps will be established in the field transects in late afternoon and collected within two hours. Traps will be partially filled with cotton to provide nesting material to prevent loss of animal due to hypothermia. If an animal is found dead in a trap, it will be returned to the laboratory for dissection and included in data. During the April sampling period, traps will be established in the field transects on the afternoon previous to the morning retrieval of animal from the traps, if weather permits. If cold weather occurs, February sampling protocol will be observed. Traps will not remain in the field between sampling periods.

3.1 Small mammal field data

The following field data will be recorded on the small mammal survey form (Appendix A), and includes:

- Taxonomic identification of species.
- Sex.
- Age (juvenile, subadult, adult).
- Reproductive condition.
- Total body weight (g).
- Length of foot (mm).
- Length of tail (mm).
- Length of right ear (mm).
- For Day Two, notation if animal is recaptured from previous day.
- Trap number and size.

3.2 Soil Sampling

Soil samples will be taken at each transect after the last sampling period. Each transect will have four distinct samples. Four soil samples will be collected along each transect from trap Numbers 1-5, 6-10, 11-15, and 16-20. The sample will be taken from a depth of 0-6 in. using a bucket auger. Environmental Safety and Health (ES&H) Standard Operating Procedure

(SOP) 4.4.5s will be followed. The equipment must be decontaminated between each sample (ES&H 4.1.3s). All information will be recorded on a Soil/Sediment Sampling Form (Appendix B).

3.3 Quality Assurance Samples

Quality control samples will be obtained for every 20 samples to assess laboratory performance and analytical precision. These samples will include duplicates, matrix spike, and matrix spike duplicates.

3.3.1 Duplicate Samples

Both soil and tissue samples will have one duplicate sample taken for every 20 samples. The following two-character modifier will be added at the end of the ID number.

Biological tissue	BG-XXXX-XXXXXX-XXXX-DU
Soil	SO-XXXX-XXXXXX-DU

3.3.2 Matrix Spike/Matrix Spile Duplicate Samples

Only soil samples will be required to have matrix spike and matrix spike duplicates taken every 20 samples. The following ID number format will be used.

Matrix spike	SO-XXXX-XXXXXX-MS
Matrix spike duplicate	SO-XXXX-XXXXXX-MD

4 ANALYTICAL REQUIREMENTS

Small mammals used for biouptake samples will be field screened for radioactive contamination prior to shipment from the Weldon Spring Site Remedial Action Project (WSSRAP) for further analysis. Laboratories performing analyses for the WSSRAP are required to have an approved quality assurance laboratory plan and procedures.

Data Quality Requirements (DQRs) are quantitative statements of selection, accuracy, and precision which specify the quality of data needed to support specified data uses. DQRs for this effort will be consistent with those established for routine environmental monitoring which are documented in the *Environmental Data Administration Plan* (EDAP) (MKF and JEG 1990). Specific DQR's for this sampling plan are listed in Appendix B. Percision will be 90% and a detection limits of 1.0 pCi/l.

Based on the WSSRAP's consistent exercise of quality assurance measures, in the form of both quality control sample collection and standard operating procedures, this survey will report all routine monitoring data and results.

4.1 ANALYTICAL PARAMETERS

Small mammals:	Total Uranium
	Thorium 228/230/232
	Radium 226/228
Soil:	Isotopic Uranium
	Thorium 228/230/232
	Radium 226/228
	Nitroaromatics
	Arsenic
	Mercury
	Lead
	Cadmium
	Barium
	Selenium
	Silver
	Zinc

4.2 Collected Specimens, Laboratory Shipment, and Chain of Custody

Samples, both soils and small mammals, will be shipped by the contractor to a contract laboratory for analysis. Sample chain of custody will comply with WSSRAP SOP ES&H 4.1.2. Shipment and packaging samples will follow Regulatory Compliance Procedures RC-11. Laboratories will conform to standard quality assurance (QA) requirements.

Sample identification will conform to ES&H procedure 4.1.1, *Numbering System for Environmental Samples and Sampling Locations*. The sample numbering structure is BG-XXXX-XXXXXX-XXXX for biological samples and SO-XXXX-XXXXXX for soil samples. See appendix C for sample identification.

5 DATA REPORTING

From the data obtained in the field, species present and approximate population numbers will be calculated. The Hill's diversity index shall be used to calculate the diversity indices.

$$NA = \sum_{I=1}^{S} (pi)^{1/(1-A)}$$

Information gathered from analysis of small mammal populations will be compared with chemical and radionuclide sampling reports from WSSRAP and from other locales nearby. Data collected from study areas and from background samples will be interpreted and tested under various statistical methods. These methods will determine whether small mammals located on or near the Weldon Spring Site Remedial Action Project (WSSRAP) are being effected by chemical and/or radiological contaminants. One of two statistical tests will be used to make the determination: the Student's t-test, or the Mann-Whitney U-test. The basis of determination of which statistical test to use is whether the distribution of small mammal populations can be assumed to be normal, and whether the variances of all sample populations are equal. Preliminary testing of normality and variance will be made by W-test and F-test. W-test data reported as not detectible (ND), or below detection limits (DL), shall be quantified as DL/2 per EPA guidance (EPA 1991).

All data will be presented in a report prepared following the *Format Guide for Formal Reports*, Rev. 2. (MKF and JEG 1991e).

6 DATA ADMINISTRATION

Data will be reviewed and quality control samples compared following standard operating procedures (ES&H 4.9.1a, RC-31a) and the *Environmental Data Administration Plan* (MKF and JEG 1990).

Quality Assurance procedures will follow the guidelines established in the *Environmental Quality Assurance Program Plan* (MKF and JEG 1991f).

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WSSRAP Procedures

ES&H 1.1.4s - *Logbook Procedures*
ES&H 4.1.1 - *Numbering System for Environmental Samples and Sampling Locations*
ES&H 4.1.3s - *Sampling Equipment Decontamination*
ES&H 4.1.2s - *Chain of Custody*
ES&H 4.4.5s - *Soil/Sediment Sampling*
ES&H 4.9.1a - *Environmental Monitoring Data Verification*
RC-11 - *Transportation and Tracking of Material*

APPENDIX A
SMALL MAMMAL SURVEY FIELD SHEET

SMALL MAMMAL SURVEY FIELD SHEET

DATE:
LOCATION: #1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #11 #12 #13 #14 #15 #16 #17 #18 #19
COLLECTOR(S):_____
COMMENTS:

TRAP NO.	SPECIES	ID NO.	RECAP Y/N	SEX M/F	AGE A/SA/J	MASS REPROD		LENGTH (mm)				COMMENTS
						(G)	P/L/V/ST	TOTAL	TAIL	FOOT	EAR	

BLBR = Blarina brevicauda
CRPA = Cryptotis parva
SCAQ = Scalopus aquaticus
REME = Reithrodontomys megalotus
MUMU = Mus musculus

TAST = Tamias striatus
PELE = Peromyscus leucopus
PEMA = Peromyscus maniculatus
MIOC = Microtus ochrogaster
RANE = Rattus norvegicus

GEBU = Geomys bursarius

Data Entry: Date: _____ Initials: _____ File: _____

APPENDIX B
SOIL-SEDIMENT SAMPLING FORM

WELDON SPRING SITE REMEDIAL ACTION PROJECT
7295 Highway 94 South
St. Charles, Misosuri 63304
(314) 441-8086

SOLI/SEDIMENT SAMPLING FORM

SAMPLE NUMBER: _____ DATE: _____

LOCATION: _____

PERSONNEL: _____

_____

SAMPLE COLLECTION METHOD: _____

SAMPLE TYPE: DEPTH COMPOSITE GRAB OTHER _____

SAMPLING EQUIPMENT DECONTAMINATION METHODS: _____

SAMPLE DESCRIPTION:

_____

_____

_____

_____

_____

_____

_____

_____

_____

Signature _____ Date: _____

APPENDIX C
SAMPLE IDENTIFICATION NUMBER FORMAT

SAMPLE IDENTIFICATION NUMBER FORMAT (BG-XXXX-XXXXXX-XXXX)
(SO-XXXX-XXXXXX)

A. Sample type = 2 characters

BG = Biological
SO = Soil

B. Sample location = 4 characters

01_ = Site No. 1
02_ = Site No. 2
03_ = Site No. 3
04_ = Site No. 4
05_ = Site No. 5
06_ = Site No. 6
07_ = Site No. 7
08_ = Site No. 8
09_ = Site No. 9
10_ = Site No. 10
11_ = Site No. 11
12_ = Site No. 12
13_ = Site No. 13
14_ = Site No. 14
15_ = Site No. 15
16_ = Site No. 16

(Biological)

__BB = Blarina brevicauda
__CP = Cryptotis parva
__RM = Reithrodontomys megaiotus
__SA = Scalopus quaticus
__TS = Tamias striatus
__PL = Peromyscus lleucopus
__PM = Peromyscus maniculatus
__GB = Geomys bursarius
__MO = Microtus ochrogaster
__RN = Rattus norvegicus
__MM = Mus musculus

(Soil)

__1_ = Transect 1
__2_ = Transect 2
___A = Samples from area between traps 01-05
___B = Samples from area between traps 06-10
___C = Samples from area between traps 11-15
___D = Samples from area between traps 16-20

C. Data Code = 6 characters

XX____ = Month (01-12)
__XX__ = Day (01-31)
____XX = Year

D. Individual identification (ear tag number-biological)
= 4 characters (0001 thru 1000)

0001 = Individual number 1
0010 = Individual number 10
0100 = Individual number 100

E. Quality Assurance Samples = 2 character modifiers

Duplicate	= XX-XXXX-XXXXXX-DU
Matrix Spike	= XX-XXXX-XXXXXX-MS
Matrix Spike Duplicate	= XX-XXXX-XXXXXX-MD

CHEMICAL PLANT
201-1.13

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
7295 Highway 94 South
St. Charles, Missouri 63304

February 19, 1992

Addressees:

APPROVED 1992 ENVIRONMENTAL MONITORING PLAN, JANUARY 1992, REVISION 1

Enclosed is the approved 1992 WSSRAP Environmental Monitoring Plan (EMP), Revision 1. The EMP is prepared to ensure that the public's health and safety are protected and that all applicable legal and regulatory requirements are met. The scope of this plan includes the effluent monitoring and environmental surveillance activities that will be performed during 1992. These activities include the monitoring of surface water, groundwater, radon, gamma radiation, air particulate, sediment, biological and meteorological conditions.

Revision 1 updates the text regarding analytical accuracy and investigation and detection levels for environmental sample analysis. Please substitute this revision for the plan that you were provided on January 7, 1992.

If you have any questions or desire a meeting to review this plan, please contact Alan D. Gibson at (314)441-8978.

Sincerely,

Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

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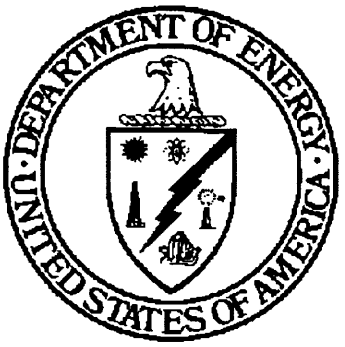
DOE/OR/21548-237
CONTRACT NO. DE-AC05-86OR21548

ENVIRONMENTAL MONITORING PLAN FOR CALENDAR YEAR 1992

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

JANUARY 1992 **REV. 1**



U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

MORRISON KNUDSEN CORPORATION

MK-FERGUSON GROUP

INTER-OFFICE CORRESPONDENCE

DATE: January 6, 1994

TO: File

FROM: Michelle French MF

SUBJECT: **CORRECTIONS TO WELDON SPRING ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1992**

Recent evaluation of the Weldon Spring Site Environmental Report for Calendar Year 1992 has revealed an error in the units given in two tables in Section 4.0. The units of "μCi/ml" in Tables 4-5 and 4-6 on Pages 75-82 should read "$\mu Ci/m^3$". This errata sheet will be included in further reproduction of the above mentioned document and be maintained in Document Control for reference.

MF/jn

Printed in the United States of America. Available from the National Technical Information Service, NTIS, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161

NTIS Price Codes - Printed copy: A07
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MK-FERGUSON A MORRISON KNUDSEN COMPANY	Issue Date:
Weldon Spring Site Remedial Action Project Contract No. DE-AC05-86OR21548	Rev. No. 1
PLAN TITLE: Environmental Monitoring Plan for Calendar Year 1992	

APPROVALS

Environmental Protection Manager — Date: 1/29/92

ES&H Manager — Date: 1/29/92

Quality Assurance Manager — Date: 01/29/92

Deputy Project Director — Date: 1/29/92

Project Director — Date: 1/29/92

DOE Project Manager — Date: 2/10/92

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DOE/OR/21548-237

Weldon Spring Site Remedial Action Project

Environmental Monitoring Plan for Calendar Year 1992

Revision 1

January 1992

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

ABSTRACT

Environmental monitoring plans have been formulated annually since the inception of the Weldon Spring Site Remedial Action Project (WSSRAP) to ensure that the public's health and safety are protected and that all applicable legal and regulatory requirements are met. These plans have evolved over the years as characterization activities have defined the extent and magnitude of contamination.

This 1992 Environmental Monitoring Plan satisfies requirements of the U.S. Department of Energy (DOE) Order 5400.1 requiring each DOE facility with the potential for contributing to environmental pollution to prepare an environmental monitoring plan for its program.

The scope of this plan includes the effluent monitoring and environmental surveillance activities that will be performed during the 1992 environmental monitoring year (calendar year). These activities include the monitoring of surface water, groundwater, radon, gamma radiation, air particulate, sediment, biological and meteorological conditions.

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1 INTRODUCTION

The Weldon Spring site (WSS) is located near Weldon Spring, Missouri, 30 mi west of St. Louis, Missouri. The WSS consists of an inactive uranium production facility including raffinate pits, a chemical plant, an abandoned limestone quarry, and associated vicinity properties. These areas contain chemically and radiologically contaminated materials originating from previous operations at the site.

Remediation of the Weldon Spring site was designated as a Major Project in May 1985. It has since been designated by the U.S. Department of Energy (DOE) as a Major System Acquisition. The program is known as the Weldon Spring Site Remedial Action Project (WSSRAP). The major goals of the WSSRAP are to eliminate potential hazards to the public and the environment, and to make surplus real property available for other uses to the extent possible. An environmental documentation approach has been developed that satisfies the requirements of both the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) and the National Environmental Policy Act (NEPA). The result of this process will be a Record of Decision regarding ultimate disposal of the WSS wastes.

DOE Order 5400.1, *General Environmental Protection Program* requires the preparation of an *Environmental Protection Program Implementation Plan* (EPPIP) at all DOE sites. The Weldon Spring site EPPIP (MKF and JEG 1991a) details the methods by which the WSSRAP will comply with this order. Because the WSSRAP is a remedial action project, the overall goal is different from the standard operating and/or production facilities for which DOE Order 5400.1 was developed. Therefore, the WSSRAP EPPIP meets the intent of DOE Order 5400.1, while being tailored to the unique aspects of a remedial action project. The WSSRAP has prepared this *Environmental Monitoring Plan* (EMP) to meet the requirements for DOE environmental monitoring programs as specified in DOE Orders 5400.1 and 5400.5 and the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE 1991), hereafter referred to as the *Regulatory Guide*.

1.1 Purpose

DOE Order 5400.1 requires the preparation of an *Environmental Monitoring Plan* to define the effluent monitoring and environmental surveillance required to demonstrate

compliance with applicable Federal, State and local environmental protection laws and regulations, Executive Orders, and internal DOE policies.

The purpose of this *Environmental Monitoring Plan* is to detail the environmental monitoring requirements at the WSS. Environmental monitoring is performed at the WSS to ensure that any potential public exposure is documented and quantified, to ensure that the public's health and safety and the environment are protected, and to demonstrate compliance with applicable legal and regulatory requirements. The monitoring program also confirms adherence to DOE environmental protection policies, and supports remedial planning.

1.2 Scope

This plan describes the effluent monitoring and environmental surveillance activities that will be performed at the WSS during calendar year 1992. These activities include monitoring of surface water, groundwater, radon, gamma exposure, air particulate, sediment, and meteorological conditions. The plan also describes applicable monitoring requirements, analytical methods used, and quality assurance measures. Details and rationale regarding sampling frequencies and analytic parameters are provided. Also presented are summaries of additional programs implemented to satisfy the requirements of DOE Order 5400.1, Order 5400.5, and the *Regulatory Guide*. An evaluation of compliance or non-compliance with each regulatory guide criteria statement was not included in the 1992 EMP. Where criteria statements were applicable to the WSSRAP, recognition of satisfying the criteria was included. The 1993 EMP will include a more detailed evaluation of the criteria statements.

1.3 Site History

In April 1941 the Department of the Army (DA) acquired 17,232 acres of land where, from November 1941 through January 1944, Atlas Powder Company operated a trinitrotoluene (TNT) and dinitrotoluene (DNT) explosives production facility known as the Weldon Spring Ordnance Works (WSOW). By 1949 all but approximately 2,000 acres had been transferred to the State of Missouri (August A. Busch Memorial Wildlife Area) and the University of Missouri (agricultural land). Except for several small parcels transferred to St. Charles County, the remaining property became the Weldon Spring U.S. Army Reserve and National Guard Training Area (WSTA).

Through a Memorandum of Understanding between the Secretary of the Army and the General Manager for the Atomic Energy Commission (AEC), 205 acres of the former WSOW were transferred in May 1955 to the AEC for construction and operation of the Weldon Spring Uranium Feed Material Plant (WSUFMP) to process uranium and thorium ore concentrates. Considerable explosives decontamination was performed by Atlas Powder and the DA prior to WSUFMP construction.

The WSUFMP was an integrated facility for converting processed uranium ore concentrates to pure uranium trioxide, intermediate compounds, and uranium metal. A relatively small amount of thorium was also processed. Wastes generated during these operations were stored in four raffinate pits.

In 1958 the AEC acquired title to the Weldon Spring Quarry (WSQ) from the DA. The WSQ had been used earlier by the DA for disposal of TNT-contaminated rubble during the operation of the WSOW. The AEC used the WSQ as a disposal area for a small amount of thorium residue, but most of the material disposed of there consisted of uranium and radium-contaminated building rubble and soils from the demolition of a uranium ore processing facility in St. Louis.

The WSUFMP was shut down in 1966, and in 1967 the AEC returned the facility to the DA for use as a defoliant production plant, to be known as the Weldon Spring Chemical Plant (WSCP). The Army started removing equipment and decontaminating several buildings in 1968.

The defoliant project was canceled in 1969 before any process equipment was installed. The DA retained the responsibility for the land and the facilities at the WSCP, but the 51-acre tract encompassing the Weldon Spring raffinate pits (WSRP) was transferred back to the AEC. The WSS was placed in caretaker status until 1986, when the Weldon Spring Site Remedial Action Project was initiated.

2 OBJECTIVES AND RATIONALE

The goal of the Weldon Spring Site Remedial Action Project (WSSRAP) is to protect and enhance the environment while ensuring the protection of the public. This will be accomplished by safely disposing of hazardous and radiological wastes that resulted from operation of the Weldon Spring Uranium Feed Materials Plant and the U.S. Army's ordnance operation. Within the overall project mission, the environmental protection program focuses on the operational activities of the project.

The WSSRAP objectives for the environmental protection program are as follows:

- To assess compliance with all applicable environmental quality standards and public exposure limits.
- To determine the background levels and site contributions of contaminants.
- To determine the effectiveness of effluent treatment and controls.
- To determine the validity and effectiveness of models.
- To determine the long term buildup and prediction of environmental trends from site-released contaminants.
- To accomplish the detection and quantification of unplanned releases.

It is the purpose of this EMP to describe the rationale and design criteria for the monitoring program; determine the extent and frequency of monitoring and measurements; outline the procedures for laboratory analyses, quality assurance requirements, program implementation procedures, and preparation and disposition of related reports.

The WSSRAP environmental protection program is separated into two distinct functions: (1) effluent monitoring, and (2) environmental surveillance. Effluent monitoring assesses the quantities of substances in a migration pathway from the site at the facility boundary, or in a pathway subject to compliance with applicable regulations (e.g., National Emissions Standards for Hazardous Air Pollutants [NESHAPs]) or permit levels and requirements (e.g., National

Pollution Discharge Elimination System [NPDES]). The environmental surveillance program generally reviews environmental media within or outside the facility boundary for the presence and concentration of site contaminants to detect and/or track the migration of those contaminants. Surveillance data are used to assess the presence and magnitude of any radiation or toxicological exposures by members of the public, or to assess the effects, if any, on the local environment.

The Weldon Spring site (WSS) has maintained a relatively stable configuration of its waste products since cessation of the plant operation and decontamination of some process buildings in the early 1970s. It is believed that this stability has allowed the site to achieve a rough equilibrium regarding the migration of contaminants from the site. Since the WSS is presently under active remediation, the nature of the waste units and their physical position and chemical state are subject to disturbance. The monitoring program for 1992 has been designed to address the pathways and constituents reflective of a changing waste setting.

The U.S. Department of Energy (DOE)has defined generic performance criteria that the DOE operations offices must use in developing their programs. The environmental protection program has incorporated these criteria into the WSSRAP monitoring program. The objective of the WSSRAP environmental monitoring program is to generate all data necessary to ensure regulatory compliance, and assess the public and environmental impact of site contaminants. Therefore, a program must be developed that assesses all viable environmental pathways. The program in this EMP defines a minimum scheme of data points to be collected to evaluate whether environmental conditions are changing and whether WSS-related contaminants or activities are impacting public health or the environment. Where additional data points or density is required to verify trends or more closely evaluate environmental conditions, additional samples may be collected that are not defined in the plan. Those samples will be collected to serve the objectives of the environmental/monitoring program at the Weldon Spring site and will be consistent with the guidelines of the DOE 5400 orders. The following section describes the pathway analysis performed by the WSSRAP to arrive at the monitoring program.

2.1 Pathway Analysis

To evaluate the potential impact on human or ecological receptors of activities at the WSS it is necessary to conduct a pathway analysis. Exposure pathways are identified considering the source, release mechanisms, type and location of contaminants at the site and the probable environmental fate (persistence, partitioning, transport and intermedia transfer) of these

contaminants; and the location and activities of potentially exposed receptors. See Table 2-1 for matrix of factors considered for the exposure pathway screening process. The primary objective of the pathway analysis is to identify those pathways that are, or may be "complete" under current conditions and given reasonable assumptions about future conditions. An exposure pathway is considered complete if a linkage can be shown between one or more contaminant sources, through one or more environmental transport processes, to an exposure point where human or ecological receptors are present.

Identification of potentially complete pathways is a qualitative judgement. Procedures used are intended to be conservative. The identification of a complete pathway does not necessarily indicate that adverse effects will occur; it indicates that the effort to monitor releases is worthwhile from the standpoint of protecting human health and the environment.

Separate pathway analyses were conducted for the WSQ and the WSCP. Results of these analyses are presented in Tables 2-2 and 2-3.

2.2 Monitoring Program Rationale

The critical pathway analysis (radionuclide and media) for the WSSRAP site was conducted for the Weldon Spring Quarry (WSQ) and the Weldon Spring Chemical Plant (WSCP). These analyses were based on data developed during various characterization studies (e.g., Phase I and II soils study, groundwater study, etc.), site specific criteria, site specific assumptions and the matrix of potential exposure routes (see Table 2-1).

Site specific criteria considered in this pathway analysis included physical, chemical, and biological characteristics of the radionuclides detected; spatial distribution; concentration; depth to groundwater; geology of the area; climatic conditions; area use by public and wildlife; and the proximity of contaminated sites to potential receptors.

Site specific assumptions for this analysis were as follows:

- Off-site residents have no access to the contaminant source areas.
- Access of large game animals to contaminant source areas is limited by perimeter fencing.

Table 2-1 Potential Exposure Route Matrix

Component of Exposure Assessment	Factors to be Considered
Affected Environmental Media	Air Groundwater Surface Water Sediment Surface Soil Subsurface Soil Aquatic Biota Terrestrial Biota
Release Mechanism of Medium	Air - Volatilization, fugitive dust. Groundwater - Groundwater flow, discharge to surface water. Surface Water - Surface runoff overland flow, groundwater seepage, partitioning with sediment, volatilization. Sediment - Surface runoff overland flow, groundwater seepage leaching, partitioning with surface water, release to biota surface disturbance. Surface soil - Fugitive dust transport/depository, surface runoff, overland flow leaching, surface disturbance. Subsurface soil - Leaching. Aquatic biota - direct contact, ingestion. Terrestrial biota - direct contact, ingestion.
Contaminant Transport Pathway	Airborne transport Groundwater migration Surface water flow Sediment Transport Fluid migration through subsurface soil Surface soil erosion Transport of aquatic biota Terrestrial biota migration

Table 2-1 Potential Exposure Route Matrix (Continued)

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Component of Exposure Assessment	Factors to be Considered
Contaminant Fate and Transport	Physical - Volatilization Sorption, surface complexation. Chemical - Photolysis oxidation/reduction Hydrolysis Dissolution/precipitation Ion exchange, chemical portioning Aqueous complexation Chemical degradation Hydration Biological - Bioaccumulation Biomagnification Biotransformation Biodegradation
Current and future receptors	Human - On-site workers Off-site residential, recreational, commercial, industrial. Ecological - On-site aquatic, terrestrial biota Off-site aquatic, terrestrial biota
Exposure routes by medium	Air - Indoor/outdoor vapor phase inhalation, immersion Indoor/outdoor particulate inhalation Groundwater - Ingestion Dermal contact Surface water - Ingestion Dermal contact Sediment - Ingestion Dermal contact Surface Soil - Ingestion Dermal contact Immersion Subsurface soil - Indoor/outdoor vapor phase inhalation. Biota - Ingestion Inhalation Dermal contact Immersion Cross Media transfers

Table 2-2 Weldon Spring Quarry Complete Exposure Pathway Selected for Evaluation

Population Potentially Exposed	Exposure Route, Medium, Exposure Point	Pathway Selected For Evaluation	Reason for Selection
Off-site Residents	Ingestion of groundwater from local wells downgradient from the site.	Yes	Use of groundwater as a source for drinking water by residents.
	Ingestion of game and fish inhabiting wildlife area.	Yes	Ingestion of game animals and fish by residents. Magnitude of exposure is low.
	Inhalation of particulates dispersed through wind erosion and remedial action.	Yes	Inhalation of wind dispersed particulates by nearby residents.
	Dermal contact with airborne and deposited particulates.	No	Dermal contact with radionuclides is not considered to be an important exposure route because off-site concentrations are extremely low or nonexistent.
	Ingestion of surface water and/or sediments.	Yes	Use of lakes on public land which show elevated uranium levels.
Wildlife Area Visitors	Inhalation of particulates dispersed through wind erosion and remedial action.	Yes	Inhalation of airborne particulates by visitors of wildlife area.
	Dermal contact with sediment in slough, creek.	No	Dermal contact with sediment in slough, creek while wading or swimming. Exposure potential is low since wading or swimming in these areas is prohibited.
	Ingestion of surface water while swimming.	No	Potential for ingestion of surface water (slough, creek) is low since this activity is prohibited in these areas.
Terrestrial Biota (on site)	Ingestion of surface waters and sediments.	Yes	Potential use of surface water as drinking water by biota and ingestion of sediment.
	Ingestion of vegetation and soils.	Yes	Use of vegetation as food source and incidental ingestion of soils. Inhalation route for biota is not considered to significantly contribute to overall dose.

Table 2-2 Weldon Spring Quarry Complete Exposure Pathway Selected for Evaluation (Continued)

Population Potentially Exposed	Exposure Route, Medium, Exposure Point	Pathway Selected For Evaluation	Reason for Selection
Terrestrial Biota (off site)	Ingestion of surface water and sediments.	Yes	Use by biota of area surface waters as drinking water and incidental ingestion of sediments.
	Inhalation of airborne particulates due to wind erosion and soil disturbance.	No	Inhalation route for biota is not considered to significantly contribute to overall dose due to extremely low or non-existent concentrations.
	Ingestion of vegetation and soils.	Yes	Use of vegetation as food source and incidental ingestion of soils.
Aquatic Biota (on site)	Uptake of surface water and contact with sediment.	Yes	Absorption through contact with surface water and sediment in the quarry.
	Ingestion of invertebrates and vegetation.	Yes	Ingestion of invertebrates and vegetation is an important uptake mechanism.

TABLE 2-3 Weldon Spring Chemical Plant Area Complete Exposure Pathways Selected for Evaluation

Population Potentially Exposed	Exposure Route, Medium, Exposure Point	Pathway Selected for Evaluation	Reason for Selection
Off-site Residents	Ingestion of game animals and fish inhabiting wildlife area.	Yes	Ingestion of game and fish by residents. Contribution to exposure considered low.
	Inhalation of particulates dispersed through wind erosion and remedial action.	Yes	Inhalation of airborne particulates by nearby residents.
	Dermal contact with airborne and deposited particulates	No	Dermal contact with radionuclides is not considered an important uptake mechanism.
	Ingestion of surface water and contact with sediment while swimming or wading.	No	Exposure potential for ingestion of surface water/contact with sediment is low since swimming or wading in Busch lakes is prohibited.
	Ingestion of food crops adjacent to area.	Yes	Potential use by local residents of food crops grown adjacent to site.
Wildlife Area Visitors	Inhalation of particulates dispersed through wind erosion and remedial action.	Yes	Inhalation of airborne particulates by wildlife area visitors.
	Ingestion of game and fish inhabiting wildlife area.	Yes	Ingestion of game and fish inhabiting wildlife area collected during hunting/fishing season.
	Ingestion of surface water and contact with sediments while swimming or wading.	No	Exposure potential through ingestion of surface water/contact with sediments in Busch Lakes for visitors is low since these activities are prohibited.
	Dermal contact with airborne and deposited particulates.	No	Dermal contact with radionuclides is not considered a significant uptake mechanism.
Terrestrial Biota (on site)	Ingestion of surface water and ingestion of sediments.	Yes	Ingestion of raffinate pits surface water and sediment by biota.
	Ingestion of vegetation and soils.	Yes	Use of vegetation as food source and incidental ingestion of soils.

TABLE 2-3 Weldon Spring Chemical Plant Area Complete Exposure Pathways Selected for Evaluation (Continued)

Population Potentially Exposed	Exposure Route, Medium, Exposure Point	Pathway Selected for Evaluation	Reason for Selection
	Inhalation of airborne particulates dispersed through wind erosion and remedial action.	No	Inhalation route for biota is not considered to significantly contribute to overall dose.
Terrestrial Biota (off site)	Ingestion of surface water and sediments.	Yes	Use of area surface water as a source for drinking water and incidental ingestion of soils.
	Ingestion of vegetation, crops, and soils.	Yes	Use of vegetation and crops as food source and incidental ingestion of soils by biota inhabiting the wildlife area.
	Inhalation of airborne particulates due to wind erosion and soil disturbance.	No	Inhalation route for biota is not considered to significantly contribute to overall dose.
Aquatic Biota (off site)	Uptake of surface water and contact with sediments.	Yes	Uptake by biota inhabiting surface water in wildlife area.
	Ingestion of invertebrates and vegetation.	Yes	Ingestion of invertebrates and vegetation is an important uptake mechanism.

- Prolonged or year round use of on-site water bodies by waterfowl is limited.
- Frequency and duration of wildlife area visits per individual is low (MDOC 1991).
- Consumption of game animals and fish per individual averaged over a year is low.

The monitoring programs described in the following subsections were designed with specific knowledge of the active pathways and the pathway analyses performed. Each media-specific monitoring and analysis program follows a general rationale.

2.2.1 Surface Water

Surface water is influenced by three general mechanisms; the monitoring program for 1992 will address each mechanism independently. Surface water is impacted by water that flows from the site and carries with it site-source contaminants and contaminants deposited in the sediments of the stream channels. Small quantities of water migrate from the site on a regular basis due to human influenced activities, such as the permitted, treated effluent from the on-site DOE administration building. Finally, surface water is impacted by the discharge of contaminated groundwater to surface water receptors at springs around the area of the site. Each feature receiving surface water is sampled and contaminant levels measured. The migrating surface waters are subsequently sampled along their course to track their behavior until the concentrations are diluted or otherwise rendered indiscernible from background levels.

2.2.2 Groundwater

The groundwater and hydrogeology beneath the site have been studied extensively. The present conceptual model of the hydrogeologic regime incorporates the activity of diffuse flow through the fractured limestone and the influence of discrete groundwater movement through solution enlarged fractures and conduits. The rationale for groundwater monitoring is to capture the influences of the on-site contaminant sources on the groundwater through the use of conventional monitoring wells around those sources and around the site perimeter. Converging conduits transport water, which transitions from diffuse flow to discrete flow, to springs previously mentioned. Proper monitoring of the resurging water at those springs satisfies the other mechanism of groundwater movement.

2.2.3 Air and Atmospheric Migration

Air pathway and atmospheric migration of contaminants and radiation constitute a broad set of exposure pathways. Characterization studies conducted over the past four years have determined that the only significant sources for airborne contamination from the WSS-related wastes lie within the boundaries of the WSCP/WSRP and the WSQ areas. As remedial activities begin to disturb source areas, the potential for increased airborne emissions will increase. More intensive work-area monitoring will maintain knowledge of real-time airborne emission levels.

Airborne particulates, radionuclides, and atmospheric radiation released from the WSS source areas must pass the facility boundaries before migrating to uncontrolled or public access areas. Site perimeter monitoring will be utilized to detect and monitor the migration of radioactivity detectable at the facility boundaries. Finally, specific locations around the WSS where there is concentrated human activity are considered "critical receptor" locations and receive focussed attention.

2.2.4 Soil and Sediment

Soils and sediments on and around the WSS have been, and in some locations continue to be, receiving contaminants from the WSS. The soil is generally in a stable condition and, although it might act as a long term source for groundwater contamination, soil in itself does not pose a dynamic contaminant front that would require routine monitoring. Soils and associated contamination that are disturbed during remedial activities may be mobilized by surface water runoff or dispersed in the air and migrate from the site. Therefore, the surface water monitoring program will monitor levels of suspended and settleable solids to assess the quantities of materials leaving the site; the air monitoring program, combined with air modeling when appropriate, will assess potential impact to off-site receptors.

For the purposes of this plan, sediments are those solid materials that are mobilized by fluid flow and accumulate to some discernable depth in and along the stream channels. Sediments have been characterized during the remedial investigations performed at the WSS and WSQ. That characterization, along with the determinations made during subsequent, routine biological and surface water sampling will meet the environmental monitoring data needs of the project for 1992.

2.2.5 Biological Media

Biological factors such as the animal and plant vectors in a biouptake chain will be sampled to assemble and maintain knowledge of the environmental and potential human impacts of the waste sources and to assess the effectiveness of the clean-up actions as they progress.

3 SURFACE WATER SURVEILLANCE PROGRAM

Surface water samples will be collected from locations known to be or potentially impacted by the Weldon Spring Chemical Plant/Weldon Spring raffinate pits (WSCP/WSRP) area and the Weldon Spring Quarry (WSQ). Because of the differing topography and hydrologic conditions at the WSCP/WSRP and WSQ, surface water sampling programs for each of the areas of the WSS are described separately. In previous environmental monitoring plans (EMP) for the Weldon Spring Site Remedial Action Project (WSSRAP) the monitoring of springs was included as part of the surface water monitoring program. The WSSRAP has changed this approach to incorporate spring monitoring under the groundwater monitoring program, consistent with the draft U.S. Environmental Protection Agency (EPA) guidance on groundwater monitoring in karst terrains. The data on contaminants in spring water will be more directly correlated to levels in the groundwater near the site as measured using conventional monitoring well techniques. Therefore, spring monitoring is no longer discussed in the surface water monitoring program section.

3.1 Surface Water Evaluation

Surface water bodies in and around the WSS and WSQ have been radiologically and chemically characterized through sampling and analyses. A surveillance program that includes monitoring potentially impacted surface water has been established to monitor radiological and chemical conditions. The extent of the surface water environmental surveillance program is based upon applicable regulations, hazard potential of effluents, quantities and concentrations of effluents, public interest, and the nature of potential or actual impacts on surface water. The environmental surveillance program for surface water will be conducted in accordance with the requirements of DOE Orders 5400.1, 5400.5 and the *Regulatory Guide*.

3.2 Surface Water Monitoring Program at the WSCP/WSRP

The WSCP/WSRP area is located on the Missouri-Mississippi River surface-drainage divide. The topography of the WSCP/WSRP is gently undulating and generally slopes northward to the Mississippi River. Streams do not cross the properties, but incipient drainageways convey surface water runoff to off-site streams. Most surface drainage from the WSCP area discharges either via an intermittent stream in the Army Reserve Training Area to the west or into Ash Pond on the WSCP property as shown in Figure 3-1. Discharges from the

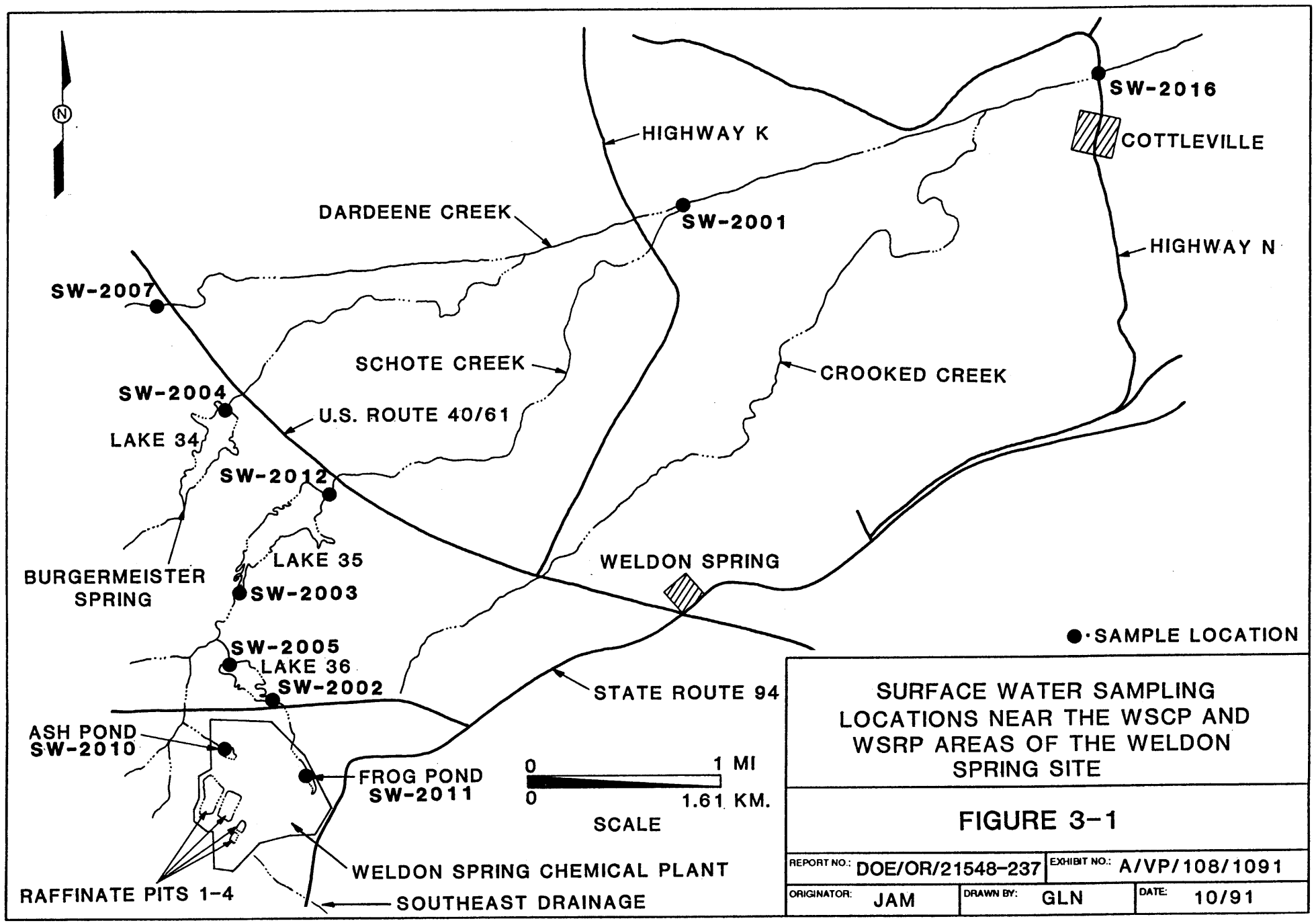
intermittent stream and Ash Pond combine near St. Charles County Road D and flow northward into Schote Creek, which in turn enters Dardenne Creek, which discharges into the Mississippi River. An additional surface drainage system ultimately reaching the Mississippi River drains the northeastern WSCP area through Frog Pond. A storm water sewer system that drains land surfaces from most of the plant area also discharges into Frog Pond. The Frog Pond drainage enters Lake 36 on the Busch Wildlife Area. Lake 36 in turn discharges into Lake 35 which ultimately discharges into Schote Creek.

Drainage from the southern portion of the WSCP property flows southeast to the Missouri River. Runoff originates from two sources. The first is the WSCP sanitary and process sewer system which merges prior to discharge from the WSCP. The sanitary sewer system was taken out of service in 1986, but receives some leakage from the storm water runoff system. The second source is surface runoff from the southern portion of the site.

Surface water which drains from the WSCP/RP area transports both dissolved and suspended element contaminants from waste materials distributed about the site. The locations chosen for monitoring of the surface water were chosen in order to provide the necessary data to track the fate and concentration of the contaminants to downgradient receiving streams and water features. The locations of the monitoring points and the rationale behind each location is described in detail in the following sections. The DOE has a firm understanding of the complex hydrogeologic system that influences the flow of surface water from the site to both the Missouri and Mississippi rivers. This understanding has come about through the cooperative efforts of the DOE with the Missouri and United States Geological Surveys.

3.2.1 Surface Water Monitoring Locations at the WSCP/WSRP

All surface water features monitored under the surface water surveillance program are situated on the north (Mississippi River) side of the drainage divide. Those waters requiring contaminant monitoring to the south of the surface divide are monitored under either the effluent monitoring or groundwater monitoring programs. The routine monitoring locations are numbered sequentially from SW-2001 through SW-2012 and SW-2016. Location numbers SW-2013, SW-2014 and SW-2015 were previously assigned to discrete temporary locations, which are not part of the 1992 routine monitoring program. Location SW-2016 is a new location added in this 1992 monitoring program and its function will be described in the following paragraphs in context with the entire sampling scheme.



SURFACE WATER SAMPLING LOCATIONS NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

FIGURE 3-1

REPORT NO.:	DOE/OR/21548-237	EXHIBIT NO.:	A/VP/108/1091		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	10/91

As shown on Figure 3-1, the sampling locations are distributed over surface water features at the down-gradient of the on-site contaminated water sources. Again, the program is designed to monitor the levels in the lakes and streams which pass through public and private lands in order to enable the DOE to assess the potential risk to down-gradient recipients. It also serves to document that the contaminant levels in the surface water diminish to background levels through dilution and other natural processes.

In previous monitoring years location SW-2001 at the confluence of Schote and Dardenne Creeks has been sampled as the furthest downstream location at which to measure the contaminant levels in Dardenne Creek after receiving the Schote Creek contribution. Location SW-2016 at the intersection of Dardenne Creek and County Highway N will now serve that function and was added because a report by the USGS noted that above background levels of uranium were measurable at that location.

Location SW-2007 is positioned on Dardenne Creek upstream of any tributaries that receive WSS contaminants in the runoff or groundwater discharge. This location serves as a background station for the determination of background contaminant levels prior to influence by the WSS discharge. Locations SW-2002 through SW-2006 and SW-2012 monitor the three lakes on the Busch Memorial Wildlife Area which lay within the receiving basin of WSS runoff. Location SW-2012 is positioned at the spillway of Lake 35. This lake leaks from its base and drains to Lake 34, among other places. Consequently, Lake 35 discharges only occasionally and monitoring of that discharge will be episodic with precipitation runoff.

The use of location SW-2006 (Busch Lake 10) has been discontinued since three years of data indicated no influence by the WSS and there is no visual or historical evidence of surface or subsurface impact. Locations SW-2008 and SW-2009 (Burgermeister Spring and Overflow Spring) continue to be monitored, but the location identifiers have been changed and monitoring is performed under the groundwater/spring monitoring program. Finally, locations SW-2010 and SW-2011 are at Ash Pond and Frog Pond within the boundary of the WSCP/RP area, and are monitored as the two major on-site surface water source features.

The raffinate pits located at the WSS are four solids-settling ponds utilized during plant operation to collect the waste products of the uranium purification and allow the decant water to discharge free of solids. The four pits vary in size; two are approximately 1 acre and contain approximately 12 ft of sludge material; Pit 3 is 9 acres in area and contains 12 ft to 14 ft of

sludge material; and Pit 4 is approximately 13 acres in area but contains only a minor amount of sludge along with some waste scrap steel and drummed wastes from the decommissioning of the plant. Although the overflow system of the pits has long been discontinued and no direct runoff from the pits is presently possible, the pits contain surface water on top of the sludge material. The WSSRAP monitors this water to maintain a database on its quality and documents notable changes. These locations are numbered SW-3001 through SW-3004 for Pits 1 through 4 respectively.

As was stated previously, other surface water locations requiring water quality monitoring, e.g., the surface water discharge points at the site boundary, are included in separate monitoring programs such as the effluent monitoring and groundwater monitoring program.

3.2.2 WSCP/WSRP Surface Water Monitoring Schedule

Surface water features at the WSCP/RP area will be monitored according to the schedule listed on Table 3-1. Samples will be collected for uranium on a quarterly basis and for metals, certain radioisotopes, and inorganic anions annually to maintain a database on these substances. Quality assurance samples will also be collected per Table 3-1 in accordance with WSSRAP QA sample policy.

3.3 Surface Water Monitoring Program for the WSQ

The 13 surface water monitoring locations within or near the WSQ have been chosen for routine monitoring to investigate and document whether surface waters near the quarry might pose a risk to human health or the environment.

The WSQ is located on the northern bluff of the Missouri River valley. Surface water within the quarry consists of the quarry pond which acts as a sump and intercepts groundwater. There is no direct surface water runoff from the quarry; however, the movement of contaminated groundwater from the quarry through the fine-grained alluvium to the Femme Osage Slough has resulted in elevated uranium levels in the slough water. The quarry pond and the slough are directly impacted by the contamination within the quarry, therefore, they are routinely monitored. Also, samples from the Missouri River, the Femme Osage Creek, and the Little Femme Osage Creek are collected routinely to provide control data for comparison with data from those locations directly impacted by contamination from the quarry.

TABLE 3-1 Monitoring Parameters for Surface Water at the WSCP/RP

					QA SAMPLES			
Location	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
SW-2001	U	I,U,M	R*	U				
SW-2002	U	I,U,M	R*	U	D			
SW-2003	U	I,U,M	R*	U				
SW-2004	U	I,U,M	R*	U		B	A	
SW-2005	U	I,U,M	R*	U				
SW-2007	U	I,U,M	R*	U		D		
SW-2010	U	I,U,M	R*	U	A			
SW-2011	U	I,U,M	R*	U				
SW-2016	U	I,U,M	R*	U				
SW-2012**	U	I,U,M	R*	U				
SW-3001		R*,I		U		D		
SW-3002		R*,I		U				A
SW-3003		R*,I		U				
SW-3004		R,I		U				
SW-5311	R	R	R	R				

* Isotopic analysis required
U Uranium
I Inorganic anions
R Radiological analysis including uranium radium and thorium
** When flow is available

M TCLP Metals plus Be, Tl, Sb.
D Primary laboratory duplicate
A Secondary radiation duplicate
B Secondary chemical duplicate
See Section 10 for discussion of QC data frequency

3.3.1 Monitoring Locations

Monitoring locations SW-1001 and SW-1002 (see Figure 4-3) monitor the Little Femme Osage Creek (which lies due west of the quarry) at points upstream and down stream of the WSQ. Six sampling locations--SW-1003 through SW-1005, SW-1007, SW-1009, and SW-1010--are distributed along the Femme Osage Slough west of, adjacent to, and east of the WSQ. These locations within the slough were chosen to provide the most representative data of potentially impacted areas from the quarry contamination. Location SW-1008, which monitors the ponded water within the WSQ, gives a rough determination of the concentrations of the various contaminants in the ponded surface water that may migrate to groundwater. Locations SW-1011, SW-1012, and SW-1013 (see Figure 3-2) were added to the monitoring program in 1989 to provide baseline water quality data from the Missouri River. SW-1011 is the Missouri River location furthest upstream above any potential influences from WSS contamination, while SW-1013 is furthest downstream below the outfall point of the southeast drainage easement. Location SW-1014, shown on Figure 3-2, was added to the monitoring program in 1991 to increase the coverage of water bodies potentially affected by the WSQ.

3.3.2 Monitoring Schedule

All surface water bodies near the WSQ that are used as baseline or are potentially affected by the WSQ, including the Femme Osage Slough, Femme Osage Creek, Little Femme Osage Creek, the Missouri River, and the quarry pond, will be sampled as shown in Table 3-2 at the locations shown in Figure 3-2.

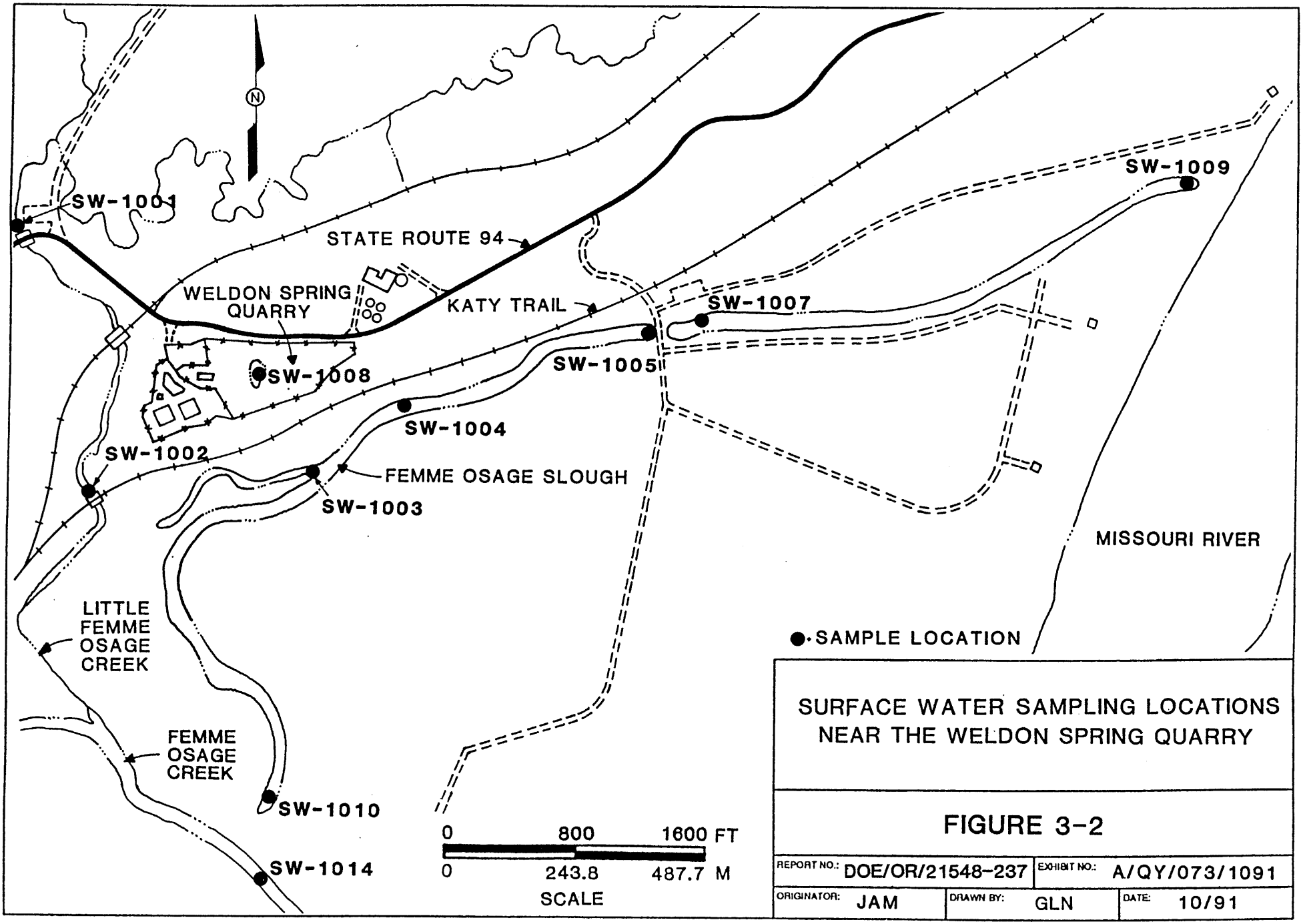
All locations will be monitored bimonthly, (once every two months), for uranium. This frequency will allow any trends to be identified in addition to maintaining a surveillance of uranium in surface water bodies near the WSQ. Additionally, all locations will be monitored at least annually for arsenic, barium, nitrate, sulfate, nitroaromatic compounds, and other radiological parameters, including Th-230, Th-232, Ra-226, Ra-228, gross alpha, and gross beta to provide baseline data and early detection of these parameters within surface water bodies near the WSQ. The quarry pond is monitored bimonthly for all parameters listed above, with the exception of arsenic and barium, to maintain surveillance of the contaminants within the quarry.

TABLE 3-2 WSQ Surface Water Monitoring Analytical Program for 1992

	1992 EMP						QA SAMPLES					
	JAN/ FEB	MAR/ APR	MAY/ JUNE	JULY/ AUG	SEPT/ OCT	NOV/ DEC	JAN/ FEB	MAR/ APR	MAY/ JUNE	JULY/ AUG	SEPT/ OCT	NOV/ DEC
WELDON SPRING QUARRY AREA												
SW-1001	U,M	R,N,I	U	U	U	U						
SW-1002	U,M	R,N,I	U	U	U	U			A		A	
SW-1003	U,M	R,N,I	U	U	U	U	D,B	A		A		
SW-1004	U,M	R,N,I	U	U	U	U						
SW-1005	U,M	R,N,I	U	U	U	U		D		D		
SW-1007	U,M	R,N,I	U	U	U	U						
SW-1008	R,I,N,M	R,N,I	R,N,I	R,N,I	R,N,I	R,N,I						
SW-1009	U,M	R,N,I	U	U	U	U		D,B				
SW-1010	U,M	R,N,I	U	U	U	U						
SW-1011	U,M	R,N,I	U	U	U	U		A		D		D
SW-1012	U,M	R,N,I	U	U	U	U						
SW-1013	U,M	R,N,I	U	U	U	U	A					
SW-1014	U,M	R,N,I	U	U	U	U			A,B		A,B	

R = Uranium, Ra-226, Ra-228, Th-230, Th-232, gross alpha and gross beta
U = Uranium
I = Nitrate, sulfate
N = Nitroaromatic compounds
M = Arsenic, barium

D = Primary laboratory duplicate
A = Secondary radiological laboratory duplicate
B = Secondary chemical laboratory duplicate
See Section 10 for discussion of QC data frequency



SURFACE WATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 3-2

REPORT NO.:	DOE/OR/21548-237	EXHIBIT NO.:	A/QY/073/1091		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	10/91

4 GROUNDWATER SURVEILLANCE PROGRAM

4.1 Groundwater Evaluation

Groundwater within and around the Weldon Spring Chemical Plant/raffinate pits (WSCP/RP) and Weldon Spring Quarry (WSQ) has been radiologically and chemically characterized through sampling and analyses. A surveillance program that includes monitoring potentially impacted groundwater has been established to monitor radiological and chemical conditions. The extent of the groundwater environmental surveillance program has been determined based upon applicable regulations, hazard potential of effluents, quantities and concentrations of effluents, public interest, and the potential or actual impacts on groundwater. The environmental surveillance program for ground water will be conducted in accordance with the requirements of the U.S. Department of Energy (DOE) Orders 5400.1, 5400.5 and the *Regulatory Guide*.

4.1.1 Groundwater Characterization

Groundwater within or near the WSCP/RP and the WSQ was sampled to determine potential exposure pathways. Chemical and radiological characterization of the groundwater within or near the WSCP/RP and WSQ was provided through the implementation of work plans, sampling plans, and other characterization plans. These plans, which were approved by the DOE and the EPA, include environmental monitoring, sampling locations, procedures, equipment, frequency and analysis required, minimum detection levels and quality assurance and quality control components. The evaluation of the characterization data and potential exposure pathways has provided the basis for the environmental surveillance program for groundwater as described in the Groundwater Monitoring Program Section of this *Environmental Monitoring Plan*.

4.1.2 Groundwater Estimated Release Quantities and Public Doses

It is the objective of the groundwater monitoring program at both the WSCP/RP and WSQ to collect sufficient data to estimate the approximate quantity of radionuclides released along that migration route. The radionuclide release information will be used to calculate the public dose to hypothetical groundwater users. At present, no wells are actively pumped as water supplies within a 1 mi radius of the WSCP/RP site. Wells outside that area have been

sampled in the past and have shown no evidence of radionuclide contamination from the Weldon Spring Site Remedial Action Project (WSSRAP). Those private wells will continued to be routinely sampled and analyzed by the Missouri Department of Health as part of an independent program by that agency. The results are also made available for review by WSSRAP staff.

The data collected from the WSQ and county wellfield region will allow a determination to be made on whether the WSQ presents an increased incremental risk to users of that water. No measurable increases in uranium levels above background at the wellfield have been seen to date.

4.2 Groundwater Monitoring Program for the WSQ

Forty-eight groundwater wells including 36 DOE monitoring wells, four St. Charles County monitoring wells, and eight municipal wells owned by St. Charles County have been chosen for routine monitoring to investigate and document the possibility that groundwater near the WSQ may pose a risk to human health or the environment.

4.2.1 Rationale

Chemical and radiological wastes at the quarry are of particular concern because of their proximity to the St. Charles County well field approximately 0.5 mi to the south. The issue of protection of the well field is one of great sensitivity to the public, the DOE, and other regulatory agencies. The DOE has issued a number of orders providing direction on the assessment of exposure to the public, including directions for protection from radiation and other chemical species where applicable. The monitoring strategy for and around the quarry has been developed to ensure the protection of public health and the environment.

Previous groundwater quality studies performed at the WSQ indicated several contaminants are present in or near the WSQ. Elevated uranium concentrations have been detected in the immediate WSQ area and in the alluvium north of the Femme Osage Slough. Elevated nitroaromatics, arsenic, barium, and inorganic anion concentrations have also been observed.

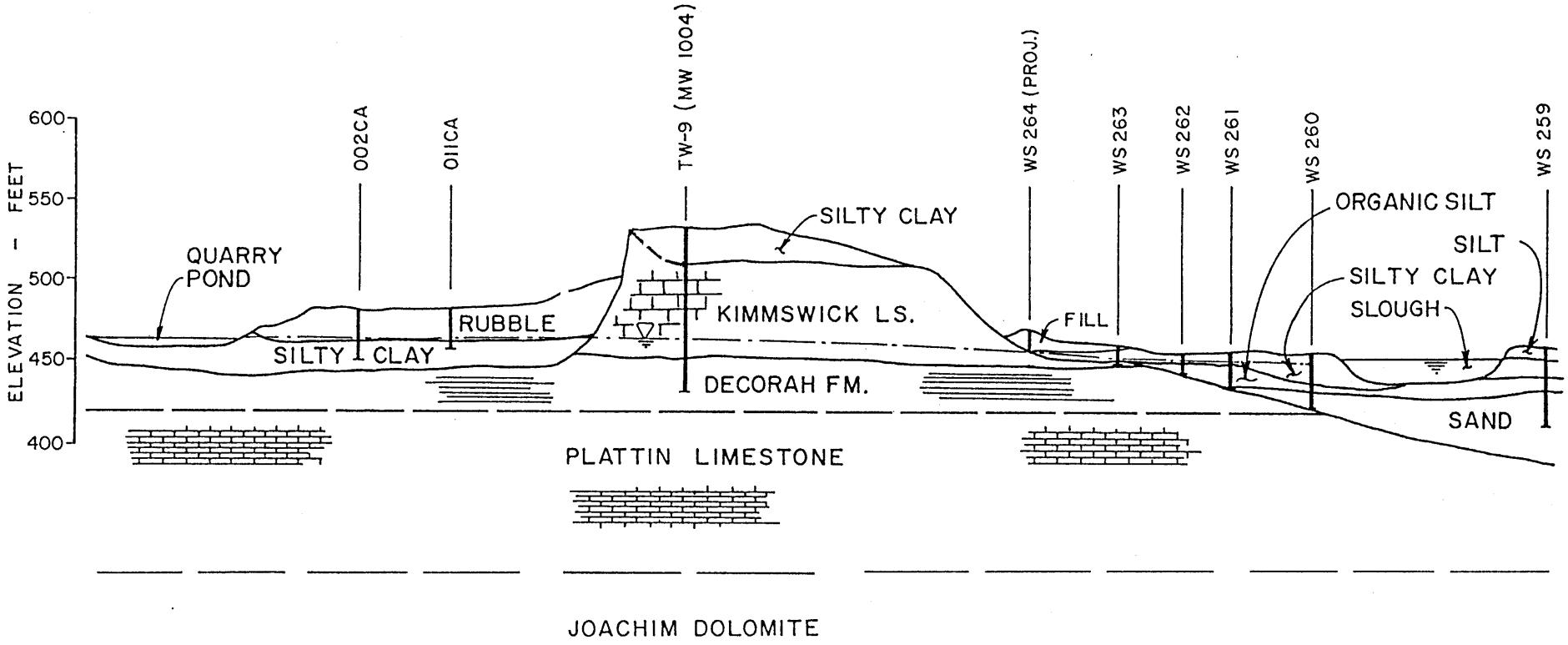
4.2.2 Monitoring Locations

The geology of the WSQ area is generally separated into upland overburden, Missouri River alluvium, and bedrock. The Missouri River alluvium and bedrock units produce groundwater and it is within these units that the groundwater is monitored. A general description of each unit follows and Figure 4-1 displays a generalized cross section of the quarry geology.

The unconsolidated upland material overlying bedrock consists of up to 30 ft of silty clay soil and loess deposits. A residual soil is present in some areas between the silty clay and the bedrock, however, the upland soils near the WSQ are generally not saturated and are not monitored.

The sediments comprising the alluvium along the Missouri River vary from clays, silts, and sands, to gravels, cobbles, and boulders. The maximum alluvium thickness near the WSQ is approximately 100 ft. The alluvium is truncated at the erosional contact with Paleozoic bedrock bluffs along the now-abandoned Missouri, Kansas, and Texas (MK&T) railroad bed. The alluvium thickness increases dramatically with distance from the bluff. Silts and clays with minor amounts of sand are the primary sediments between the bluff and the Femme Osage Slough. The thick, water-producing sands and gravels of the alluvial aquifer give way to fine-grained organically rich overbank deposits beneath the Femme Osage Slough. The potentiometric surface of the alluvial aquifer fluctuates in response to pumping of the St. Charles County production wells and the stage of the Missouri River. This indicates that the Missouri River is the primary recharge source for the alluvial aquifer.

Currently there are 33 wells including eight municipal production wells, four county-owned monitoring wells, and 21 DOE-owned monitoring wells which are screened within the alluvial material located between the quarry and the Missouri River. Five of the wells, MW-1035 through MW-1039 (see Figure 4-2), are located west of the quarry to monitor the immediate area surrounding the quarry water treatment plant equalization basin and effluent ponds. Six wells, MW-1006 through MW-1009, MW-1014, and M-1016 are located between the quarry and the slough to monitor contaminant migration south of the quarry within the alluvium. The monitoring wells MW-1010, MW-1011, and MW-1017 through MW-1024 are located south of the slough within the alluvium and are monitored to enable detection of contaminants south of the slough. County monitoring wells RMW-1 through RMW-4 are



NOTE:

SEE FIGURE FOR LOCATION OF CROSS-SECTION.

0 100 200
SCALE FEET

GEOLOGIC CROSS-SECTION ACROSS QUARRY AND WELL FIELD AREA

FIGURE 4-1

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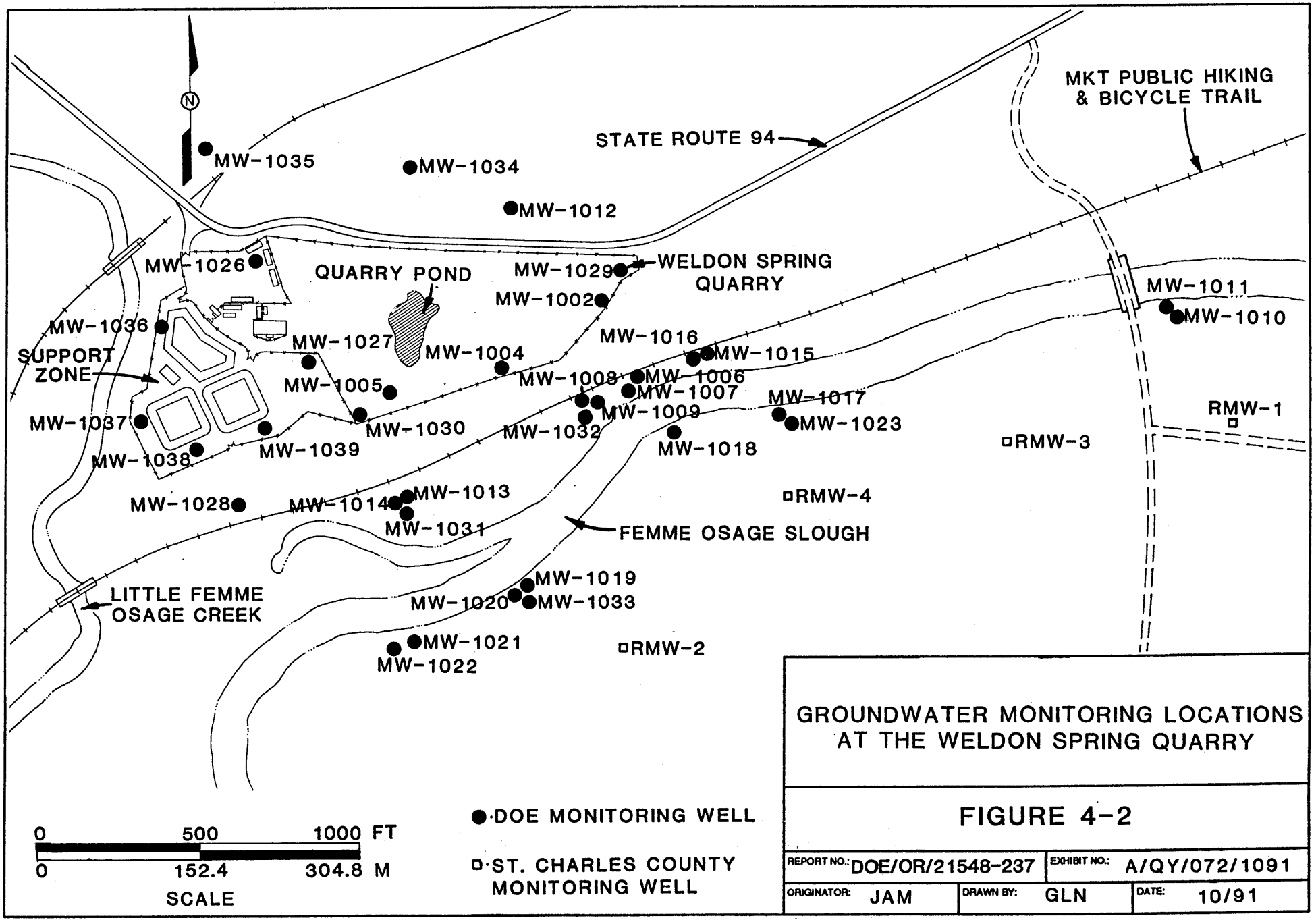
monitored to (1) ensure that the quarry contaminants are not migrating toward the municipal wellfield, and (2) enable an early warning of contaminant migration toward the county production wellfield if this should occur. The eight county municipal wells, PW-2 through PW-9, are also monitored to ensure that the quarry contaminants are not affecting the quality of the municipal wellfield water supply. See Figures 4-2 and 4-3 for monitoring and production wells near the WSQ.

Bedrock at the WSQ consists of three distinct Ordovician formations. In descending order, they are the Kimmswick Limestone, limestone and shale of the Decorah Group, and the Plattin Limestone. The Kimmswick Limestone is a coarsely crystalline limestone with numerous solution-enlarged joints. The Decorah Group consists of interbedded limestone and green shale; it is approximately 30 ft thick, and is horizontally fractured. The Plattin Limestone is a thinly bedded limestone about 100 ft to 125 ft thick. Currently, there are 15 DOE owned monitoring wells which are screened within either the Kimmswick-Decorah or Plattin Formations to monitor contaminants near the quarry within the bedrock. Monitoring wells MW-1002, MW-1004, MW-1005, MW-1012, MW-1013, MW-1015, MW-1026, MW-1027, MW-1029, MW-1030, MW-1032, and MW-1034 were installed to monitor contaminants within the Kimmswick-Decorah Formation surrounding the quarry. It should be noted that MW-1012 and MW-1034 are north and upgradient of the quarry and have been designated as background wells. Monitoring wells MW-1028, MW-1031, and MW-1033 are located south of the quarry within the Plattin Limestone to determine whether vertical contaminant migration has occurred.

4.2.3 Monitoring Schedule

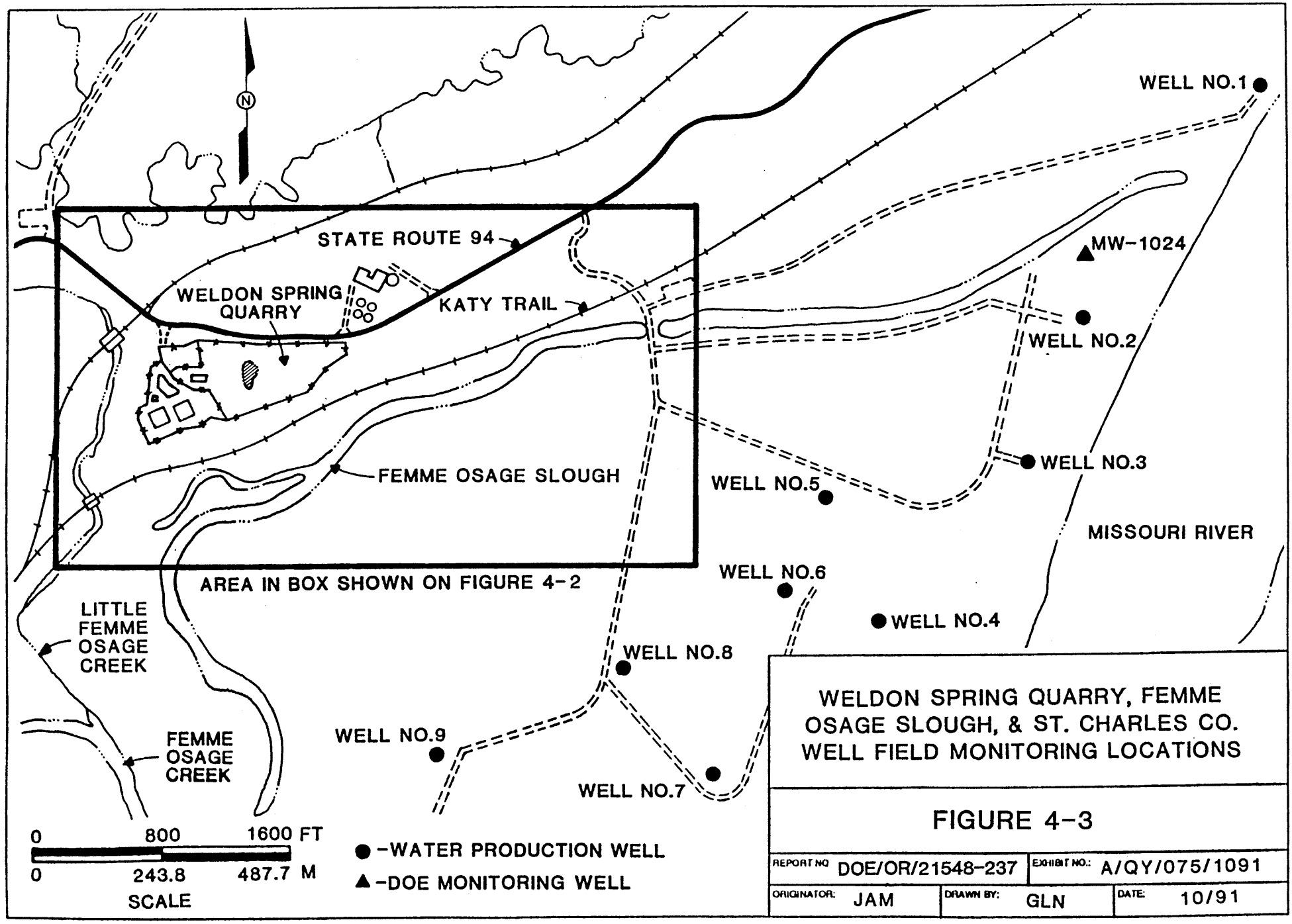
Two separate groundwater monitoring programs have been developed for the WSQ. The first program is a bimonthly sampling of all wells north of the Femme Osage Slough and also includes two wells, MW-1010 and MW-1011, south of the slough. These two wells were added to the bimonthly sampling because uranium levels above historical limits were detected for a short period during 1991 but returned to background levels by mid-year. This program is summarized in Table 4-1, and was developed to monitor contaminant migration and the effects of impoundment at the quarry water treatment plant scheduled to begin operation in the fall of 1991.



GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 4-2

REPORT NO.:	DOE/OR/21548-237	EXHIBIT NO.:	A/QY/072/1091		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	10/91



WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, & ST. CHARLES CO. WELL FIELD MONITORING LOCATIONS

FIGURE 4-3

REPORT NO	DOE/OR/21548-237	EXHIBIT NO.:	A/QY/075/1091		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	10/91

TABLE 4-1 WSQ Groundwater Monitoring Program Summary

1992 EMP AND QA SAMPLES						
	JAN/FEB	MAR/APR	MAY/JUNE	JULY/AUG	SEPT/OCT	NOV/DEC
MW-1002	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M
MW-1004	U,I,N,M	R,I,N,M	U,I,N,M-A,B	U,I,N,M	U,I,N,M	U,I,N,M
MW-1005	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M
MW-1006	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M-B	U,I,N,M
MW-1007	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M-A	U,I,N,M
MW-1008	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M
MW-1009	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M
MW-1010	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M
MW-1011	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M
MW-1012	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M
MW-1013	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M-D	U,I,N,M
MW-1014	U,I,N,M-B	R,I,N,M	U,I,N,M-D	U,I,N,M	U,I,N,M	U,I,N,M-D
MW-1015	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M
MW-1016	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M
MW-1026	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M-A,B
MW-1027	U,I,N,M-D	R,I,N,M-D,A,B	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M
MW-1028	U,I,N,M-A	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,M,N
MW-1029	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M-A	U,I,N,M
MW-1030	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M-B	U,I,N,M
MW-1031	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M-D	U,I,N,M	U,I,N,M
MW-1032	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M-A,B	U,I,N,M	U,I,N,M
MW-1034	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M-B
MW-1035	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M
MW-1036	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M
MW-1037	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M
MW-1038	U,I,N,M	R,I,N,M	U,I,N,M	U,I,N,M	U,I,N,M-B	U,I,N,M
MW-1039	U,I,N,M	R,I,N,M	U,I,N,M-D	U,I,N,M	U,I,N,M	U,I,N,M

R = Radiological - U, Th-230, Th-232, Ra-226, Ra-228, gross alpha and gross beta
M = Arsenic and barium
U = Uranium
I = Nitrate, sulfate
D = Primary laboratory duplicate
A = Secondary radiological laboratory duplicate
B = Secondary chemical laboratory duplicate
N = Nitroaromatic compounds
See Section 10 for discussion of QC data frequency

The second program monitors the area south of the Femme Osage Slough including the St. Charles County well field. Active production wells and select monitoring wells are sampled quarterly and annually. The raw and treated waters are also sampled. Table 4-2 presents the analytical parameters and sampling frequency of these wells. This portion of the WSQ groundwater monitoring program has been developed by representatives of the DOE, the Missouri Department of Natural Resources (MDNR), the Environmental Protection Agency (EPA), and St. Charles County.

The well field monitoring program includes sampling both untreated and treated water. Gross alpha analysis will be performed on the quarterly treated-water samples. This portion of the monitoring program satisfies the portion of the *Regulatory Guide* and DOE Order 5400.5 requiring the monitoring of affected or potentially affected public drinking water supplies as defined in 40 CFR Part 141.26. The quarterly gross alpha values will be averaged and presented in the *Annual Site Environmental Report.* All monitoring well locations are shown in Figures 4-2 and 4-3.

4.3 Groundwater Monitoring Programs for the Weldon Spring Chemical Plant/Raffinate Pit Area

The groundwater flow and contaminant transport mechanisms that make up the groundwater pathway are very different between the WSCP and the WSQ due to different geologic conditions. Groundwater monitoring at the chemical plant is conducted under two distinct monitoring programs. The first is the conventional application of monitoring wells at the site close to the contaminant source areas. The second is the monitoring of water from springs that represent the resurgence point for discrete flow paths receiving recharge in part from the site. The following sections describe the plans for both monitoring programs.

4.3.1 Geology and Hydrogeology

Geology at the WSCP and WSRP may be divided into two major units based on gross lithologic characterization: the unconsolidated glacial and residual soils, and the underlying bedrock.

The unconsolidated material consists of topsoil loess, glacially derived sediments, and residuum. Unconsolidated material to a depth of 20 ft to 50 ft is present at the WSCP/ WSRP.

TABLE 4-2 St. Charles County Well Field Sampling Program

MONITORING WELLS	ANNUAL SAMPLING PARAMETERS	QUARTERLY SAMPLING PARAMETERS
Well Number		
MW-1017	R	U,N,I,M
MW-1018	R	U,N,I,M
MW-1019	R	U,N,I,M
MW-1020	R	U,N,I,M
MW-1021	R	U,N,I,M
MW-1022	R	U,N,I,M
MW-1023	R	U,N,I,M
MW-1024	R,O,P	A,I,M,N,U
MW-1033	R	U,N,I,M,U
RMW-1	R,O,P	A,I,M,N,U
RMW-2	R,O,P	A,I,M,N,U
RMW-3	R,O,P	A,I,M,N,U
RMW-4	R,O,P	A,I,M,N,U
Pumping Wells		
PW-2	R,O,P,M1	A,N,U,M
PW-3	R,O,P,M1	A,N,U,M
PW-4	R,O,P,M1	A,N,U,M
PW-5	R,O,P,M1	A,N,U,M
PW-6	R,O,P,M1	A,N,U,M
PW-7	R,O,P,M1	A,N,U,M
PW-8	R,O,P,M1	A,N,U,M
PW-9	R,O,P,M1	A,N,U,M
RAW WATER	R,O,P,M1	A,N,U,M
TREATED WATER	R,O,P,M1	A,N,U,M

A = Gross alpha
I = Inorganic anions (nitrate, sulfate)
M = Metals - arsenic and barium
M1 = As, Ba, Hg, Pb, Cd, nitrate, sulfate
N = Nitroaromatic compounds
O = Organic, VOA and Semi-VOA
P = PCB, pesticides
R = Radiological - U, Th-230, Th-232, Ra-226, Ra-228, gross alpha and gross beta
U = Uranium, Natural
See Section 10 for discussion of QC data frequency

These glacial soils are generally silty clays with minor amounts of gravel. The unconsolidated materials are generally not saturated and therefore are not monitored.

Groundwater occurs in the bedrock underlying the WSCP/WSRP. The first bedrock unit encountered is the Burlington-Keokuk Limestone. The Burlington-Keokuk Limestone consists of two zones containing different lithologic characteristics: competent (unweathered), and weathered.

The shallow weathered Burlington-Keokuk Limestone is typically a grayish-orange to yellowish-gray, argillaceous limestone commonly containing as much as 60% chert nodules and interbeds. The weathered limestone is a low-yield, semi-confined, heterogeneous, anisotropic aquifer that is fractured and susceptible to natural solution processes. At the site, the aquifer generally exhibits diffuse flow properties overlain by discrete flow zones such as saturated highly weathered bedrock and saturated residuum in paleochannels.

The fracture flow, solution-effected discrete flow, and conduit flow are most effectively monitored by sampling springs at the resurgence points for that flow (Quinlan 1989).

The competent (unweathered) portion of the Burlington-Keokuk Limestone is thinly to massively bedded, gray to light gray, finely to coarsely crystalline, stylolitic, and fossiliferous. The fracture densities are significantly lower in the competent limestone than in the weathered limestone.

4.3.2 Groundwater Monitoring Program for the WSCP/WSRP

Groundwater monitoring is required by DOE 5400.1 to determine and document the effects of DOE operations on groundwater quality and quantity, and to demonstrate compliance with applicable Federal and State laws and regulations. Groundwater monitoring has been conducted at the WSCP/WSRP since the first quarter of 1987. The program has been adjusted yearly according to changes in laws and regulations, specific project needs, and Comprehensive Environmental Response, Compensation and Liability Act-National Environmental Policy Act (CERCLA-NEPA) requirements.

4.3.3 Rationale

Groundwater monitoring in the immature karst present at the WSCP/WSRP requires a two-pronged approach of monitoring wells and spring sampling. This stems from the fact that immature karst terrains have not developed a system of convergent conduit-dominated flow, but reflect components of both discrete and diffuse Darcian flow.

The groundwater monitoring program at the WSRP/WSCP has been modified from the 1991 Environmental Monitoring Plan (EMP) in order to provide the data necessary to:

- Ensure protection of public health and the environment.
- Develop a baseline for studying long term and short term effects of source removal to be conducted as part of CERCLA-NEPA activities slated for 1993-1994. At least one year of baseline data taken quarterly will be necessary in 1992 to provide adequate information for future comparisons.
- Develop a baseline for studying the effects of the settling ponds associated with the wastewater treatment plant.
- Perform spatial and temporal trend analyses.
- Provide information to support the groundwater separate operable unit (GWSOU) activity planning slated to begin in fiscal 1993.

The 4000 series wells will be monitored more frequently in 1992 than in 1991 to monitor contamination migrating off site. The density of the yearly data needs to be increased to determine trends and effectively monitor the surrounding environment.

Specific on-site wells will also be monitored more frequently than in 1991. Historical data has indicated increasing concentrations in these wells over time. More frequent sampling will provide information to analyze temporal and seasonal trends associated with these wells.

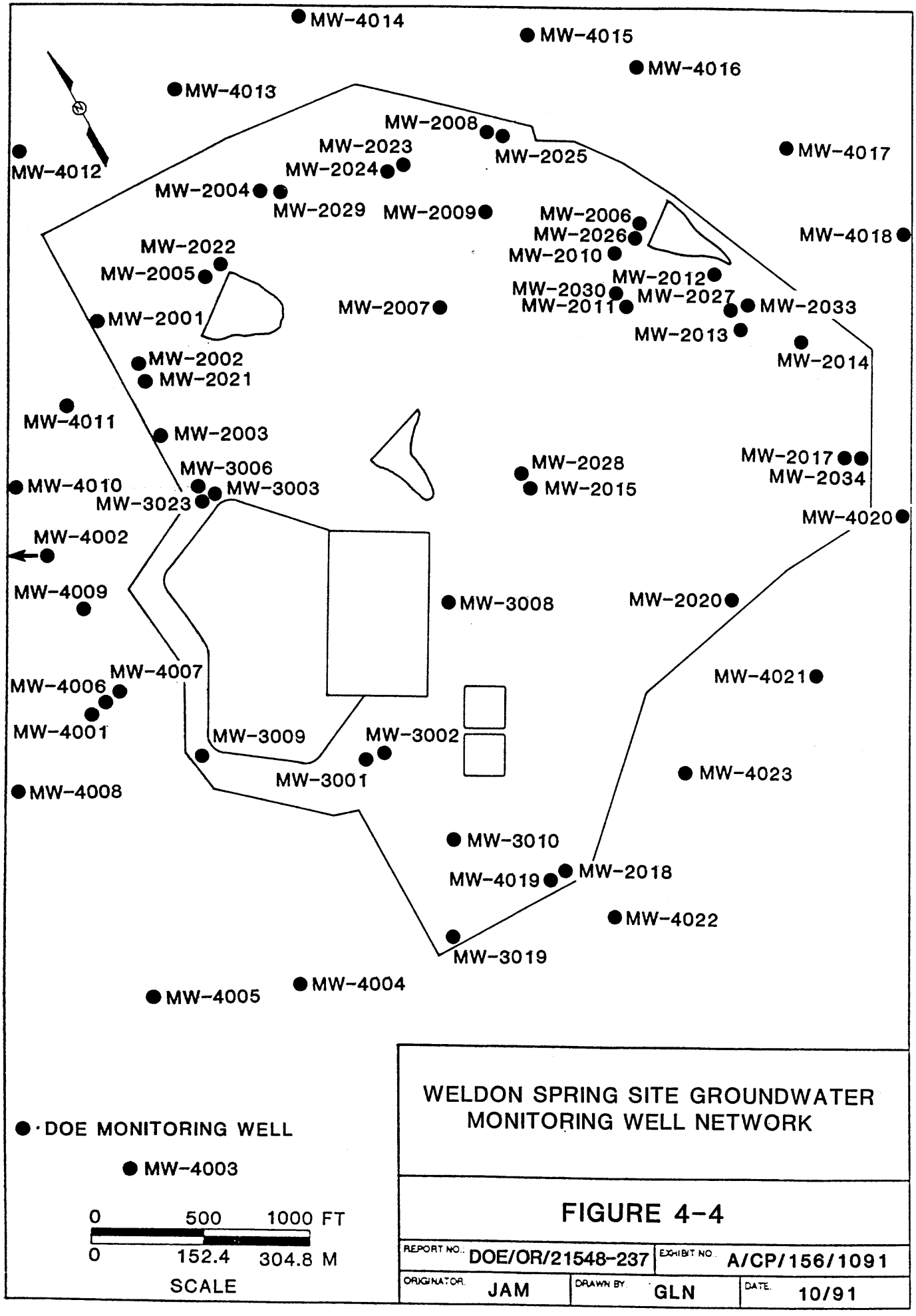
Frequent monitoring of a larger constituent list is necessary at specific wells to perform accurate spatial and temporal statistical comparisons. Greater frequency of data points is necessary to perform meaningful statistical analyses.

4.3.4 WSCP/RP Groundwater Monitoring Location

The number of monitoring wells in the 1992 sampling program will increase at the WSCP/WSRP. Additional monitoring wells will be installed in 1992 to obtain additional baseline information before contaminant source removal begins. Water quality of new and existing wells surrounding the source location will be monitored closely to analyze the short and long term effects of source removal. New wells will also be installed in 1992 according to Resource Conservation Recovery Act (RCRA) regulations to monitor the new water treatment plant. Monitoring well locations are shown in Figure 4-4. All monitoring wells are completed in the Burlington-Keokuk Limestone and are constructed of stainless steel or polyvinyl chloride (PVC). Monitoring wells are installed and developed in accordance with accepted procedure as discussed in the U.S. Environmental Protection Agency Resource Conservation and Recovery Act (RCRA), *Technical Enforcement Guidance Document* (EPA 1986) and Missouri State regulations, *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells* (EPA 1989) and the *Groundwater Protection Program Management Plan* (GWPPMP) (MKF and JEG 1991b). Fifty-eight of these wells monitor the upper portion of the formation. Eight wells monitor deeper portions of the bedrock aquifer, especially near potential source areas and in areas of known groundwater contamination. By monitoring these locations and depths, changes in the horizontal and vertical components of contaminant migration can be detected.

4.3.5 Monitoring Schedule

Quarterly sampling will be conducted at the perimeter 4000 series wells and key interior wells. The remaining interior wells will be sampled on a semiannual basis. The quarterly and semiannual samples will be analyzed for the same constituents that have historically been detected in the groundwater. In addition, for precautionary reasons, each well on site will be sampled and analyzed once per year for a suite of radionuclides that are present in the raffinate pit sludge. Analyses for volatile and semivolatile organic compounds, PCBs, and pesticides



WELDON SPRING SITE GROUNDWATER MONITORING WELL NETWORK

FIGURE 4-4

REPORT NO.	DOE/OR/21548-237	EXHIBIT NO.	A/CP/156/1091		
ORIGINATOR	JAM	DRAWN BY	GLN	DATE	10/91

were performed once and not detected in the groundwater (MKF and JEG 1988c). These data, along with historical records, indicates there is no need to continue monitoring those parameters.

The specific wells, analytical constituents, and schedule for the quarterly and semi-annual sampling events are listed in Tables 4-3 and 4-4 respectively. Each well is identified and is followed by the coded summaries of the analyses to be completed during 1992. The coded summaries also identify the quality assurance duplicate samples that will be taken. The code letters for each sample are explained at the bottom of the table.

Using monitoring well 2013 (MW-2013) in Table 4-3 as an example, the letters U, I, N, and R in the First Half column indicate that the full set of analyses will be performed during that sampling event. The letter U indicates that the sample will be analyzed for uranium; the letter I indicates that the samples will be analyzed for nitrate, and sulfate (inorganic anions); and the letter N indicates that the sample will be analyzed for nitroaromatic compounds; and the letter R indicate that the sample will be analyzed for radium, thorium, and uranium isotopes. The remaining letters indicate the laboratories where duplicate samples will be sent. The letter D indicates that a set of duplicate samples will be collected and sent to the primary analytical laboratory.

Additional quality control samples will be collected to assess sample quality. These samples will include field blanks, distilled water blanks, and equipment blanks. The frequency of these samples will vary, depending upon the type of sampling equipment used. These samples will be collected to ensure that no contamination is introduced as a result of cross-contamination, field procedures, or shipping. Collection methods and utility are discussed in Section 10 - Quality Assurance.

4.3.6 Groundwater Monitoring at Springs

Due to the complex nature of the groundwater flow system beneath the WSS, involving both diffuse flow and discrete flow components, an adequate and complete groundwater monitoring program must involve both the use of conventional groundwater monitoring wells near the contaminant sources, and monitoring at springs to detect the transition of diffuse flow migration to the discrete (conduit) pathway. Springs in the vicinity of the site have been monitored since 1987 beginning with the DOE/Project Management Contractor (PMC) broad-based Phase I Spring and Seep characterization wherein some 30 springs and seep features were

TABLE 4-3 WSCP/WSRP Semi-Annual Groundwater Monitoring Analytical Program

	1992 EMP AND QA SAMPLES	
	FIRST HALF	SECOND HALF
MW-2004	U,I,N,R	U,I,N
MW-2005	U,I,N,R	U,I,N
MW-2006	U,I,N,R-D	U,I,N
MW-2007	U,I,N,R	U,I,N
MW-2008	U,I,N,R-B	U,I,N
MW-2009	U,I,N,R	U,I,N-A,B
MW-2010	U,I,N,R	U,I,N
MW-2011	U,I,N,R	U,I,N
MW-2012	U,I,N,R	U,I,N
MW-2013	U,I,N,R-D	U,I,N
MW-2014	U,I,N,R	U,I,N
MW-2015	U,I,N,R	U,I,N-D
MW-2017	U,I,N,R	U,I,N
MW-2018	U,I,N,R	U,I,N
MW-2019	U,I,N,R-A,B	U,I,N
MW-2020	U,I,N,R	U,I,N-A
MW-2021	U,I,N,R	U,I,N
MW-2022	U,I,N,R	U,I,N
MW-2023	U,I,N,R	U,I,N
MW-2024	U,I,N,R	U,I,N
MW-2025	U,I,N,R	U,I,N
MW-2026	U,I,N,R	U,I,N
MW-2027	U,I,N,R	U,I,N
MW-2028	U,I,N,R	U,I,N
MW-2029	U,I,N,R	U,I,N
MW-2034	U,I,N,R	U,I,N
MW-3019	U,I,N,R	U,I,N

U = Natural Uranium, Total
I = Nitrate, Sulfate
N = Nitroaromatic Compounds
D = Primary Laboratory Duplicate
A = Secondary Radiological Laboratory Duplicate
B = Secondary Chemical Laboratory Duplicate
R = Radiological Parameters = Th-230, Ra-226, Pb-210, Po-210, Ac-227, Th-232, Ra-228, Th-228
See Section 10 for discussion of QC data frequency

TABLE 4-4 WSCP/WSRP Quarterly Groundwater Monitoring Analytical Program

	1992 EMP and QA Samples			
	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
MW-2001	U,R,I,N,G-A,B	U,N,I,G	U,I,N,G	U,I,N,G
MW-2002	U,R,I,N,G	U,N,I,G	U,I,N,G	U,I,N,G
MW-2003	U,R,I,N,G	U,N,I,G	U,I,N,G	U,I,N,G
MW-2030	U,R,I,N,G	U,N,I,G	U,I,N,G	U,I,N,G
MW-2031	U,R,I,N,G	U,N,I,G	U,I,N,G	U,I,N,G
MW-2032	U,R,I,N,G	U,N,I,G	U,I,N,G	U,I,N,G
MW-2033	U,R,I,N,G	U,N,I,G	U,I,N,G	U,I,N,G
MW-3003	U,R,I,N,G-D	U,N,I,G	U,I,N,G	U,I,N,G
MW-3006	U,R,I,N,G	U,N,I,G	U,I,N,G-D,A,B	U,I,N,G
MW-3008	U,R,I,N,G	U,N,I,G	U,I,N,G	U,I,N,G
MW-3009	U,R,I,N,G	U,N,I,G	U,I,N,G	U,I,N,G
MW-3023	U,R,I,N,G	U,N,I,G	U,I,N,G	U,I,N,G
MW-4012	U,R,I,N,G	U,N,I,G	U,I,N,G	U,I,N,G
MW-4013	U,R,I,N,G,G	U,N,I,G	U,I,N,G	U,I,N,G
MW-4001	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G
MW-4002	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G
MW-4003	U,R,I,N,G	U,I,N,G-B	U,I,N,G	U,I,N,G
MW-4004	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G
MW-4005	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G
MW-4006	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G
MW-4007	U,R,I,N,G-B	U,I,N,G	U,I,N,G	U,I,N,G
MW-4008	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G
MW-4009	U,R,I,N,G	U,I,N,G-A	U,I,N,G	U,I,N,G
MW-4010	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G
MW-4011	U,R,I,N,G	U,I,N,G-B	U,I,N,G	U,I,N,G
MW-4014	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G
MW-4015	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G
MW-4016	U,R,I,N,G	U,I,N,G-D	U,I,N,G	U,I,N,G
MW-4017	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G
MW-4018	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G
MW-4019	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G
MW-4020	U,R,I,N,G-D	U,I,N,G	U,I,N,G	U,I,N,G
MW-4021	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G
MW-4022	U,R,I,N,G-A	U,I,N,G	U,I,N,G	U,I,N,G
MW-4023	U,R,I,N,G	U,I,N,G	U,I,N,G	U,I,N,G

G = Geochemical Parameters = Nitrite, Chloride, Bromide, Fe, Mn, Ca, Mg, Na, K, Li, P, Ni, Ar, Ba, Sr, Cr, Si, Al, Pb, Ag Alkalinity and Dissolved Oxygen will be performed in the field.
U = Natural Uranium, Total
I = Nitrate, Sulfate
N = Nitroaromatic Compounds
D = Primary Laboratory Duplicate
A = Secondary Radiological Laboratory Duplicate
B = Secondary Chemical Laboratory Duplicate
R = Radiological Parameters = Th-230, Ra-226, Pb-210, Po-210, Ac-227, Th-232, Ra-228, Th-228
See Section 10 for discussion of QC data frequency

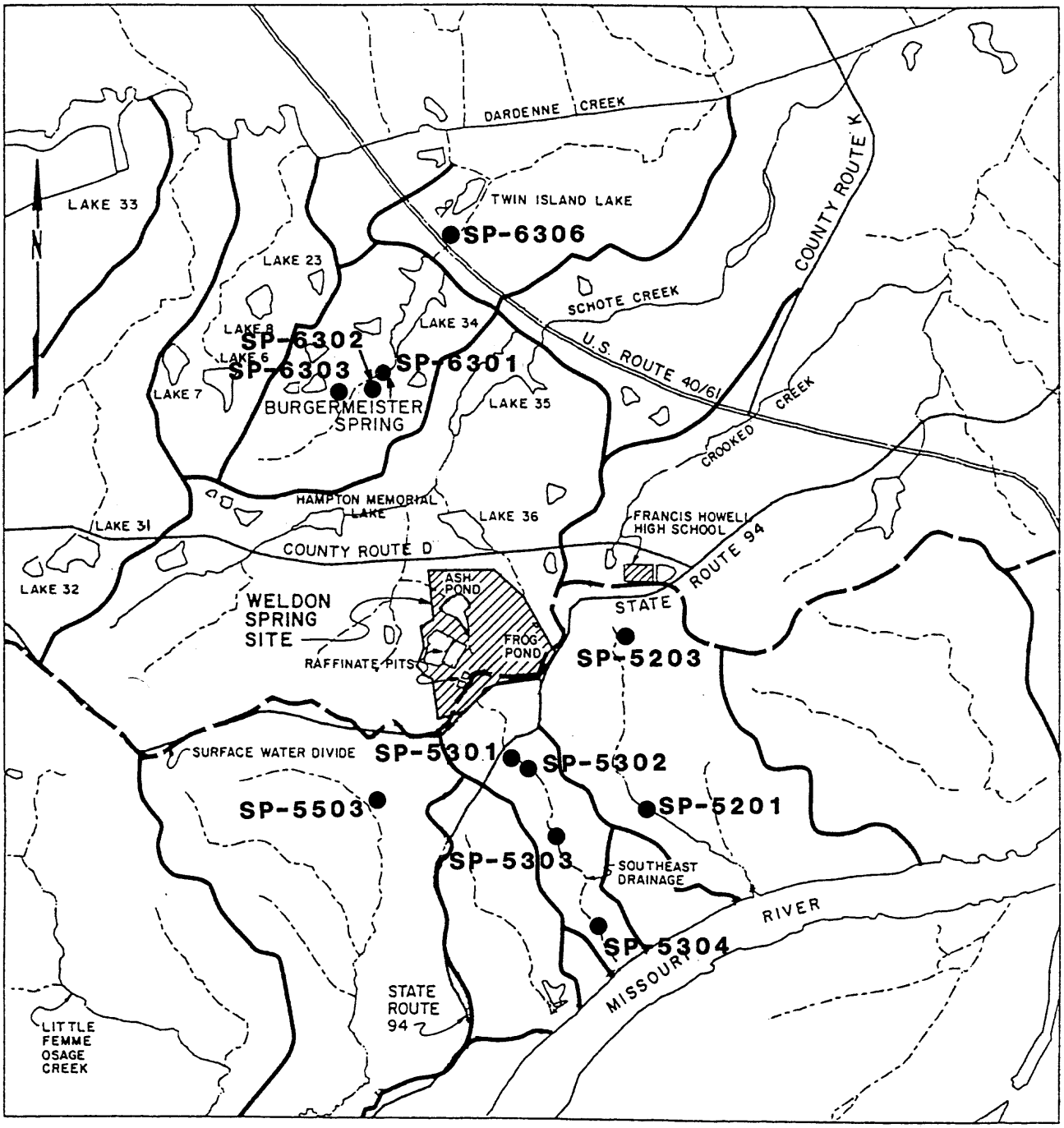
located within a 2-mi radius of the site. The springs were inventoried and sampled at varying flow rates. The set of springs impacted by the site was determined and a program of regular monitoring established around those springs. Through that program, and the additional studies conducted by the DOE, PMC, and State and U.S. Geological Surveys, the flow characteristics of the springs and their recharge basins were determined.

Phase I determined that a total of 11 springs, (nine perennial and two wet weather) were impacted or potentially impacted by site related contaminants. Each of these springs has been observed over time and their flow characteristics studied and recorded. Each spring has a unique recharge influence and response to varying recharge conditions. For this reason, the spring monitoring program described below will be of lesser or greater intensity than others in the program.

Following are the characteristics of the discrete flow mechanisms in action around the WSCP area. The rationale for monitoring and the particular structure of the individual monitoring programs are derived from these characteristics.

Regionally, the WSS resides on both groundwater and surface water divides. Waters that migrate from the site move toward the Mississippi River to the north of the divides and toward the Missouri River on the south side of the divides. This characteristic has allowed the WSSRAP to segregate the springs according to their respective geographic position within these basins. Although many springs were inventoried by both the DOE/PMC and the MDNR/DGLS, it was determined that springs located in only two major surface drainages were receiving contributions from contaminated water sources. Figure 4-5, shows the springs that have been routinely monitored for site-related contaminants.

Those drainages include Valley 5300 (southeast drainage), and Valley 6300 (Burgermeister Spring branch). The two source scenarios are quite different. The southeast drainage was used during operation of the Weldon Spring Uranium Feed Materials Plant as a discharge route for contaminated decant water from the sludge settling ponds. As a result of the imposition of contaminated water to the drainageway, the sediments have become contaminated by various substances including radionuclides. The natural springs along that drainage now discharge water containing uranium. Whether contamination at the Valley 5300 springs represents discharge of contaminated groundwater along conduit flow from an upstream source or the contamination comes from the sediments in the drainage itself, is not yet known.



● SPRING

0 3200 6400 FT

0 975.4 1950.7 M

SCALE

SPRINGS IN THE VICINITY OF THE WSS

FIGURE 4-5

REPORT NO.: DOE/OR/21548-237			EXHIBIT NO.: A/VP/109/1091		
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 10/91			

In the Burgermeister Spring branch, four springs receive site contaminants. The most prominent of the four, Spring 6301 (called Burgermeister Spring), is a perennial spring which receives both contaminated surface water runoff from the site and discharges contaminated groundwater at base flow conditions. Spring 6302 is an estuella or overflow point which discharges when the conduit capacity of the Burgermeister Spring is exceeded. Previous data indicate that the Burgermeister Spring and the overflow spring are effectively the same water discharging at two different points. Spring 6303 is a small perennial spring up-valley of the 6301/6302 set. Although too low and sporadic to draw final conclusions, the concentrations indicate at least occasional communication with uranium contaminated groundwater. The evidence thus far suggests that continued monitoring is warranted to (1) provide the data necessary to ensure environmental protection, and (2) provide additional information regarding the behavior of the conduit flow system.

Finally, Spring 6306, located below Busch Lake 34, is downstream of the previously described springs and evidence suggests it is derived in part from waters leaking from Lake 34. The presence of uranium in the waters at that spring may be due in part or entirely from the contaminated source waters of the lake. Other evidence suggests that a connection of leakage from Busch Lake 35 to that spring provides a second mechanism and source for the contaminated water at the spring.

4.3.6.1 Monitoring Program. Based upon what is known about the flow characteristics of the springs, the following program will be implemented to monitor the variations in contaminant levels in the site-effected springs. The monitoring program for 1992 will emphasize the flow rate from the springs at the time of sampling as a critical sampling component. Low flow is defined and intended hereafter to mean seasonal baseflow, or the stage of spring discharge when not influenced by active surface water runoff from the local land surfaces. Conversely, high flow is induced by precipitation events. The spring monitoring program will be implemented so as to sample spring waters at periods when they best represent the undiluted groundwater component of flow. To meet this criteria, springs will be sampled no sooner than a minimum of one week following the end of a precipitation event of sufficient intensity to cause surface runoff to occur. Planning and an extra level of scheduling flexibility will be required to implement this selective water sampling program.

Springs SP-5303 and SP-5304 will be monitored at low flow only, since the contributions from surface discharge to spring flow during high flow periods yield unrepresentative samples.

Spring 6301 (Burgermeister Spring) may accurately be described as the most critical point of contaminated groundwater resurgence associated with the WSS. Its discharge reflects the quality of both groundwater and surface water as they migrate from the areas impacted by WSS wastes. It follows that its quality, if characterized and monitored correctly throughout the site cleanup, should also reflect the improvements in environmental conditions. This "correct" monitoring will entail a close correlation of measured contaminant levels with the rate of discharge at the spring as well as the type of discharge event (baseflow, high groundwater level, or precipitation runoff) in progress at the time of sampling (Quinlan 1989).

Sampling of Spring 6302 (overflow spring) will be discontinued during 1992, since the historical data collected to date suggests that the waters which emanate at that spring when it flows are effectively the same as at Spring 6301. The continued collection of data from that location will no longer benefit the project.

The monitoring of Spring 6303 has shown that the spring is minimally impacted by WSS related contaminants. Continued monitoring of that spring provides data of limited usefulness since the cumulative impacts of contamination from that spring, and others in that drainage, are measured in the samples collected at Lake 34. Therefore, monitoring of Spring 6303 will also be discontinued for the 1992 monitoring year.

Spring 6306 has the potential to receive water from multiple sources including Busch Lakes 34 and 35. Although it is not believed that contaminant data from that spring will provide the DOE with any long term insight into the status of groundwater contamination or remedial effectiveness, the location of this spring, and the levels historically measured, warrant continued monitoring on a regular basis. This data will allow the DOE to make current, knowledgeable statements regarding its contamination status.

The data collected at wet-weather Spring 5503 suggest no impact by the WSS and it is appropriate at this time to discontinue monitoring that location.

Table 4-5 details the 1992 spring sampling program and schedule. In summary, springs that have historically been shown to receive contamination from the WSS, and whose measured contaminant levels continue to provide the DOE valuable environmental health and safety data,

Table 4-5 Groundwater Monitoring at Springs

	SCHEDULE			
LOCATION	Q1*	Q2**	Q3*	Q4*
SP-6301	L	H,L	L	H,L
SP-6306	L	H,L	L	H,L
SP-5303	L	L	L	L
SP-5304	L	L	L	L
SP-5201	L	L	L	L

* All samples analyzed for uranium, nitrate, and sulfate.

** Samples analyzed for full radiation (U, Th and Ra isotopes), nitrate, sulfate, and nitroaromatics.

L Low flow as defined in Section 4.3.6.1, para. 1

H High flow as defined in Section 4.3.6.1, para. 1

will be monitored more intensely. Those springs which have been shown to be minimally impacted or whose contaminant levels can be measured at other routine sampling locations will be discontinued for 1992.

5 BIOLOGICAL MONITORING PROGRAM

U.S. Department of Energy (DOE) Orders 5400.1 and 5400.5 and the *Regulatory Guide* require the development of surveillance programs for ecological systems to protect the health of the public and the environment. Specifically, these orders designate that samples of air, water, soil, foodstuffs, biota, and other media be collected for assessment. Ecological risk assessments are also an integral part of the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) process for the remediation of hazardous waste sites. U.S. Environmental Protection Agency (EPA) and DOE guidance require ecological surveillance to summarize site impacts and to the assess the effectiveness of proposed remedial actions. Other Federal and State laws covered by DOE orders include the *Threatened and Endangered Species Act*, the *Clean Water Act* and the *Wetlands Protection Act*. Primarily, the goal of the biological monitoring program is to support CERCLA ecological risk assessments conducted as part of the Remedial Investigation/Feasibility Study (RI/FS) process and to comply with the National Environmental Policy Act (NEPA) requirements. Identifying the ecosystem around the Weldon Spring site (WSS), the fauna and/or flora potentially at risk, and the levels and extent of contaminates with the ecosystem is the basis of the ecological Environmental Monitoring Plan (EMP) program.

A comprehensive biological surveillance program (Table 5-1) consisting of aquatic and terrestrial studies will be conducted at the Weldon Spring site (WSS) in order to meet these requirements. The focus of studies will include both qualitative and quantitative assessments of the ecosystems. The studies will collect data to determine evidence of biotic contamination, and identify receptor populations and the effects on biotic migration pathways as presented in Section 2.0. Various sites will be surveyed to examine community structure and population dynamics and to provide information on flora and fauna of the area.

Previous characterization studies at the WSS have defined the source areas of contamination and the potential pathways of contaminant migration. A lake and stream investigation was conducted in 1988 and sediment and water samples were analyzed for metals, nitroaromatics, polychlorinated biphenyls (PCBs), volatiles, semi-volatiles and radiological compounds. Elevated levels of radionuclides were detected (MKF and JEG 1989); however, no other compounds were detected. Biotic investigation conducted from 1987 to 1990 have included sampling of fish and small mammals (MKF and JEG 1988; 1989). No PCBs were

TABLE 5-1 1992 Biological Surveillance Plan

LOCATIONS	AQUATIC MONITORING				TERRESTRIAL MONITORING					
	FISH	BENTHIC INVERTEBRATES	ZOOPLANKTON	VEGETATION	HERPTOFAUNA	WATERFOWL	MAMMALS	AGRICULTURAL	VEGETATION	AVIFAUNA
Raffinate Pits 1-4				A*, S	S	S				S
Ash Pond					S	S	A		S	S
Frog Pond		A	A	A	S	S	A		S	S
SE Drainage		A			S		A		S	S
Busch Lake 34	A	A	A							
Busch Lake 35	A	A	A							
Busch Lake 36	A	A	A							
Burgermeister Spring		A	A		S		A		S	S
Quarry Pond/Forest							A		S	S
Femme Osage Slough	A	A	A	A	S	S			S	S
Little Femme Osage Creek		A								
Missouri River				A					A	
WSCP North Dump							A		S	S
WSCP Old Field							A		S	S
Katy Trail							A		S	S
Schote Creek		A								
Busch Agricultural								A		

TABLE 5-1 1992 Biological Surveillance Plan (Continued) 012292

LOCATIONS	AQUATIC MONITORING				TERRESTRIAL MONITORING					
	FISH	BENTHIC INVERTEBRATES	ZOOPLANKTON	VEGETATION	HERPTOFAUNA	WATERFOWL	MAMMALS	AGRICULTURAL	VEGETATION	AVIFAUNA
Weldon Spring Agricultural								A		
BACKGROUND LOCATIONS										
Lake 33	A									
Lake 37	A									
Lake 26		A	S	A	S		A			
Little Femme Osage Creek Upstream		A	S				A			
Geoke Spring SP-5001		A	S				A			
WSWA yellow Trial							A		S	S
WSWA Field 1 & 5							A		S	S
Augusta Farm								A		
Marals Temp Clair					S			A		
Prairie Lake - WSWA					S	S	A			S

A = Analytical Sampling (see text in Section 5)
S = Environmental Survey
* = Raffinate Pit 4 only
See Section 10 for discussion of QC data frequency

detected in fish samples. Arsenic, iron, lead, and chromium were detected in these samples, but were not attributed to site contaminants due to their equal presence in fish samples in control lakes (MKF and JEG 1988). No radionuclides were detected in small mammal samples. The Aquatic Biological Screening Investigation (ABSI) conducted in 1991 sampled benthic invertebrate, zooplankton, sediment and surface water. Elevated levels of uranium in surface water and sediment were found. Zooplankton diversities were higher in the contaminated lakes which may be the result of fish stocking practices. A report summarizing this study is in draft. Waterfowl were sampled from Raffinate Pit 4 during 1990. Results showed detectable levels of radionuclides in organ and bone samples. No control samples or documentation of use of the pits by waterfowl were taken. These needs are addressed in the 1992 EMP.

The biological surveillance program for 1992 will investigate the uptake and effects of radionuclides in select populations of biota. Other chemical contaminants will be studied as detailed below, based upon results as documented by previous soil, sediment, and surface water studies. Community structure and diversity will also be examined to determine any ecological effects of site contaminants. The 1992 EMP program is comprehensive in that an overall evaluation of ecological systems at the WSSRAP has not been previously performed. Based upon results in 1992, the ecological EMP will be re-evaluated to include only those areas considered at risk, requiring additional study, or of specific concern. Data gathered under the EMP will be used to monitor and assess the migration of contaminants from the site, the risks and effects to biota, and will also be used to guide future remedial action alternatives.

5.1 Aquatic Monitoring

Twelve locations will be included in the aquatic habitat studies of the biological surveillance program. Six locations will be monitored at the Weldon Spring Chemical Plant (WSCP), including the four raffinate pits, Ash Pond and its drainage to the northwest, and Frog Pond and its drainage to the north. At the Weldon Spring Quarry (WSQ), the Femme Osage Slough located south of the quarry will be routinely monitored.

Other aquatic sampling locations in the surrounding area include: the southern fork of the Little Femme Osage Creek, the Missouri River near the WSQ water treatment plant outfall, Lakes 34, 35, 36, and Burgermeister Spring at the Busch Wildlife Area; Schote Creek and the southeast drainage upper and lower springs; and SP-5301 and SP-5304 as designated in

Section 4. In addition, various lakes and creeks will be monitored as part of the background sampling program.

Past characterization studies conducted for the site have shown that the primary concerns to aquatic resources are the sediments and surface waters of ponds, lakes, and drainages. Chemical and radiological contaminants of concern include uranium, thorium, radium, nitrate, sulfate, fluoride, metals, and nitroaromatics. The aquatic monitoring program is designed with consideration to presence, concentration, chemical and radiological behavior, and the potential of human and ecological risk associated with the contaminants.

5.1.1 Fish Sampling

In conjunction with the Missouri Department of Conservation (MDOC) fisheries programs, fish samples will be taken annually from Lake 34, 35, 36, and the Femme Osage Slough. Background samples will be taken from Busch Lakes 33 and 37 because these lakes demonstrated no surface or subsurface connection to the WSS along water flow paths, and they resemble the study lakes in size and dynamics. Adult and juvenile fish will be collected using the electrofishing technique in which fish are stunned with a low electrical current, dip-netted from the water, and placed in holding tanks prior to data collection. All fish collected during the study will be identified, measured (total length), and counted. In addition, a gross examination of each fish will be made to determine the incidence of external disease, parasites, or physical abnormalities.

Specific game species, i.e., bass, sunfish, crappie, and catfish will be collected for radiological analysis. Edible portion, whole fish, and organ samples will be analyzed for isotopic uranium. Previous investigations of lake water and sediments and analysis of metals, nitroaromatics, PCBs, semivolatiles and volatile organics, and radiological compounds have shown uranium to be the only radiological contaminant of concern. The slightly elevated levels of arsenic, lead, mercury, and chromium found in fish samples were not attributed to WSS contaminants.

Results from radiological analyses will be used to calculate the effective dose equivalent to humans based upon consumption of fish. Bioaccumulation factors will also be calculated to determine whether fish from contaminated lakes result in factors above normal background levels of radiation (NCRP 1985, Gilbert 1985).

5.1.2 Invertebrates

Benthic invertebrates and zooplankton are routinely used as indicators of water quality. In 1991 a characterization program called the Aquatic Biological Surveillance Investigation (ABSI) was initiated. Fourteen locations were sampled and included lakes, streams, and springs. All but one designated location in the ABSI will be sampled in 1992. Schote Creek will be sampled instead of the original location at the confluence of Dardenne and Schote creeks.

Lakes and ponds will be sampled for benthic invertebrates and zooplankton; creeks and drainages will be sampled for benthic invertebrates. Benthic samples have been taken twice annually during April and July. For each lake, four locations have been selected based upon depth and sediment type. A composite sample will be collected for each location from three separate grabs using a dredge type sampler. Zooplankton samples will be collected weekly from April to June using a plankton net. Vertical tows will be taken, starting at the deepest end of the lake, and an estimate of water flow made using a flow meter connected to the plankton net.

Streams and drainages will be sampled at three sites: the riffle zone, the immediate upstream pool, and the immediate downstream pool. Riffle samples will be taken and will be composited from three Surber samples. Each pool sample will consist of three dredge grabs. A qualitative sample will be taken at each stream and drainage location in order to collect a representative community of benthic invertebrates. All invertebrates collected will be identified by species and enumerated to determine population densities and species diversities.

Biomass samples of benthic invertebrates will also be collected and retained for analysis of total uranium. Three grab samples taken from each lake and stream area will be separated into sub-samples by family or genus or composited based on total mass of sample collected.

A variety of hydrological data will be collected to assist in the interpretation of the biological data. Temperature, dissolved oxygen, conductivity, pH, water clarity (Secchi disc), total suspended solids, total phosphorus and alkalinity will be measured. A measure of the productivity of the lakes and streams will be taken by analyzing water samples for chlorophyll. Sediment and water samples will be analyzed for total uranium and toxicity metals (As, Hg, Pb, Cd, Cr, Ba, Se, Ag, Zn).

Total density and diversity will be calculated for benthic invertebrates and zooplankton. Comparisons will be made to uncontaminated lakes to determine if contaminants are effecting the invertebrate community in the lakes, springs, and streams. Water and sediment data will also be correlated to population densities and diversities to determine what factors or contaminants directly influence populations.

5.1.3 Aquatic Vegetation

The aquatic habitats found in the WSCP area and the Femme Osage Slough are all man-made impoundments, but have been classified as wetlands on the National Wetlands Inventory Map (U.S. Fish and Wildlife Service 1984). Even though these ponds are chemically and radiologically contaminated, they are utilized by fauna for foraging, breeding, and resting. A primary mechanism of contaminant entry is root uptake of radionuclides by aquatic vegetation.

A vegetation survey will be conducted of wetland areas to document the species, density, and seasonal occurrence of plants growing in the ponds. A reconaissance survey was conducted in August of 1991, and a wetland survey will be conducted in May and August of 1992, to make the necessary quantative field measurements during dry and wet conditions. This information will be used to assess wetland status of the aquatic habitats under Federal wetland guidance (FICWD 1989).

Four areas will be sampled for bioaccumulation of radionuclides in aquatic vegetation. The basin of Frog Pond and Raffinate Pit 4 is densely populated with various rooted aquatic vegetation. The Femme Osage Slough contains various species such as cattails and arrowheads. Whole samples (stems, roots, and leaves) will be taken in the late summer from these locations and analyzed for total uranium. In addition, aquatic and terrestrial vegetation along the Missouri River will be analyzed for total uranium concentrations under the preoperational monitoring of the National Pollution Discharge Elimination System (NPDES) program (Section 8).

Concentrations of radionuclides in vegetation will be measured and compared to background locations. These results, along with water and sediment data, will be used to determine if toxic effects could be occurring. Primarily, vegetation in aquatic habitats will be analyzed to determine whether fauna feeding on this vegetation are potentially exposed to radionuclides above background levels.

5.1.4 Waterfowl

Aquatic habitats at the WSS attract waterfowl and shorebirds throughout the year including mallard, spotted sandpiper, Canada goose, and herons. Many species utilize the waters for foraging, shelter, rest, and nesting.

In 1991, a summer resident census was conducted to determine waterfowl use of the aquatic resources at the WSCP and Femme Osage Slough. The results of this survey are not currently available, but based upon documentation of extended residency, samples of waterfowl game species will be collected. Samples will be analyzed for uranium, thorium, and radium concentrations in bones, flesh, and internal organs.

This characterization program may require that additional samples be taken in 1992. If so, a summer census will be conducted and additional games species will be sampled to determine bio-uptake of radionuclides. In addition, samples will be solicited from local hunters to be used as study and background data.

A winter migratory census will be taken, starting in September of 1991, and will continue one week per month through April 1992, and again from September to December of 1992.

5.1.5 Other Aquatic Studies

The Blanding's turtle is a semi-aquatic species considered endangered in Missouri. Two recent sightings were recorded for the turtle in the Busch Wildlife Area immediately north of the WSS. In order to determine if this endangered species occupies the aquatic habitats within the chemical plant or quarry area, a herpetofauna survey will be conducted. In addition to the Blanding's turtle, other species of frogs and toads will be surveyed. NEPA also requires a threatened and endangered species prior to any construction of, or modification to, facilities due to remedial actions.

Herptofauna occurring in the area will be determined by habitat searches and roadside and wetland observations. Surveys will include overturning logs, debris, and rocks during vegetation surveys. Incidental sightings during other ecological programs will be documented as well. Individuals will be identified either visually at a distance, or captured using a dip net, then identified and released. Specific sampling locations will include the Femme Osage Slough,

Raffinate pits 1 through 4, Ash Pond and Frog Pond and their drainages, and Burgermeister Spring and the southeast drainage. Sampling will be conducted in March for breeding frogs and toads, and in the early summer for the Blanding's turtle.

5.2 Terrestrial Habitats

The terrestrial community of the WSS area is diverse. The WSCP and WSQ are primarily old field or maintained grass habitats with remnant upland and slope forests. Much of the land immediately surrounding and adjacent to the WSS is state-owned wildlife area (ANL 1990). Habitats within these areas include old field, cultivated farmlands, upland slope, and bottomland forests.

The terrestrial community supports a wide variety of fauna including avian and mammal species. White-tailed deer, gray squirrels, and cottontail rabbits have been sighted within the chemical plant boundaries. Opossum, fox, and coyote roam within the Weldon Spring and Busch Wildlife areas. Many birds are summer residents in the area and many spring and fall migratory species utilize the field and forest habitats. Eastern screech and barred owls have been sighted along deciduous forests south of the chemical plant.

Specific terrestrial habitats will be surveyed and routinely monitored as part of the biological surveillance program. At the WSCP, these areas include the north dump area, the upland and riparian forests surrounding Ash Pond and Frog Pond and their drainages, and the old field habitat surrounding the raffinate pits. At the WSQ, these areas include the quarry floor, Femme Osage Slough, and the upland and bottomland forests, north and south of the Katy Trail. The riparian and upland areas along the southeast drainage, and forest along Burgermeister Spring will be also be included in the terrestrial survey programs.

Past characterization studies conducted for the site have shown that the primary concerns to terrestrial resources are the soils and vegetation in contaminated zones. Radiological contaminants of concern include uranium, thorium, and radium.

5.2.1 Vegetation

Terrestrial ecosystems are generally categorized according to the vegetation that dominates the plant community (EPA 1989). As a basis for terrestrial studies, a vegetation and

habitat map will be developed that delineates terrestrial ecosystems. Aerial photographs will be used to construct maps that will detail drainages, plant associations, historic and current land use, and ecosystem patterns.

Vegetation surveys will be conducted in each study location to document the community structure. Descriptions and inventories of plant species occurring at each location will be conducted during spring and summer. Vegetation communities will be quantified using the stratified random sampling methods. Species presence, percent vegetative cover, and percent canopy cover will be obtained. Qualitative notes on species abundance, growth factor, and terrain slope will be documented. Above-ground plant conditions will be visually examined for discolorations, parasitic galls, and leaf necroses. Specific efforts will be made in searching suitable habitats for species listed as threatened or endangered by the Missouri Department of Conservation.

Data collected from vegetation studies will primary be used to document vegetative habitats, identify effected areas and/or potentially effected environments. In addition, habitats that support or have the potential to support species of special concern (threatened or endangered) will be noted.

5.2.2 Birds

Avifauna surveys will be conducted using observational census methods. Binoculars, spotting scopes, and vocalizations will be used to document species occurrence. Surveys will be conducted bimonthly at each primary location. At each location, a 15-min observation period will be made and species will be recorded according to visual or audio identification. Data recorded will include habitat type, weather, sex, behavior, and species. Data collected will be used to estimate species diversity, density, and habitat use. In addition, all active nests found during surveys will be documented.

Particular attention will be paid to the surveying of threatened and endangered species including the bald eagle and Cooper's hawk based upon terrestrial habitat preferences. In addition, areas particularly favored by large bird populations and/or migrating birds will be noted in support of ecological assessments for the site and quarry.

5.2.3 Mammals

Large and small mammal surveys will be completed in order to determine the species, communities, and use of land within the boundaries of the WSS and within surrounding wildlife areas. Particular attention will be given to game species such as the white-tailed deer and eastern cottontail which are known to frequent the chemical plant area.

For large mammals, observational surveys will be conducted weekly within the chemical plant area. Site-specific locations, activities, and species will be documented. Observations will include visual sightings, detection of tracks, scats, and nests.

Opportunities will be taken to sample large mammals due to road-kill, accidental death, or donated samples; these samples will be analyzed for total uranium concentrations. Only mammals utilizing the chemical plant and quarry locations and those taken as background samples will be considered.

Small mammals will be biannually sampled during winter and spring. Live traps will be baited and placed along transects at the north dump area, south dump area, Frog Pond drainage, southeast drainage, and area surrounding the Femme Osage Slough. Small mammal densities and communities will be determine by the trap and recapture sampling method. Traps will be set for four nights and all captured mammals will be tagged and released. Species, age, sex, tail length, right hind-foot length, and previous capture data will be determined for each capture.

Small mammals will also be collected for radiological analysis. Primarily, rodents will be taken including deer mice, voles, and shrews. Each specimen will be identified by species and sex. The length and live weight will be determined and each species will be examined externally for the presence of lesions, tumors, or other abnormalities and reproductive condition. Whole-body specimens will be analyzed for uranium, thorium, and radium concentrations.

Small mammals are being surveyed to determine what populations are potentially at risk, what levels of contaminants are being accumulated, and the potential for larger mammals and birds that prey upon these mammals to biomagnify these contaminants.

5.2.4 Agricultural Products

Agricultural lands surrounding the WSS comprise approximately 20% of the terrestrial habitat. The Busch Wildlife and the Weldon Spring Wildlife areas contain approximately 2,200 acres and are leased to sharecroppers for farming (MKF and JEG 1991f). Besides state-owned property, many private farms are located within the immediate area. Agricultural products grown in the area include corn, soybeans, sunflowers, and sorghum. These products are grown primarily for cattle and wildlife feed and forage.

The wellfield located adjacent to the Femme Osage Slough south of the WSQ is also activity farmed. Uranium concentration in the slough has ranged from a low of $<$ 1pCi/l to a high of 557 pCi/l, with an average around 54.8 pCi/l. In addition to the U.S. Department of Energy (DOE) requirement for monitoring of "foodstuffs", the public has expressed concern over the potential for elevated levels of radionuclides in the agricultural products.

According to the requirements of the *Regulatory Guide*, an 8-mi radius of agricultural lands surrounding the site will be surveyed for farm and gardening practices. Samples will be selected and analyzed for uranium, thorium, and radium. Samples will be taken based upon farming practices within the study area as provided by the county Soil Conservation Service and the Missouri Department of Conservation.

The number of samples (for each crop type) will be equal to 1% of the total number of acres planted within the study area (example: 2,000 acres of corn planted = 20 samples for corn). A minimum of four samples will be collected. Samples will also be taken with consideration for the distance from a contamination source, such as the quarry pond. Soil samples will be collected from each location in addition to foodstuff samples. Samples will be analyzed for uranium, thorium, and radium concentrations. Determinations will be made on the significance of radiological concentrations found in agricultural samples taken within an 8-mi radius of the WSS and those collected from background locations.

5.3 Background Sampling

Sampling of similar ecological habitats and fauna as those found within the Weldon Spring site will be conducted. These background samples are necessary in order to establish baseline environmental conditions that occur within the surrounding area. Areas that have no

exposure pathway from the site, are in close proximity to the site, and that mirror ecological habitats in terms of water, chemistry, and topography. will be selected to serve as background sampling locations. Locations for aquatic studies include Busch Lakes 33, 37, and 26; the upstream branch of the Little Femme Osage Creek; Geoke Spring (SP-6501); and the upstream branch of Dardenne Creek. Locations for terrestrial studies include Marais Temps Clair Wildlife Area, Prairie Lake, Augusta Farm, Weldon Spring Wildlife Area (WSWA), Yellow Trail, and WSWA Agricultural Field 1 and 5.

Background sampling will be conducted for the 1992 *Environmental Monitoring Plan* (EMP) for all biouptake studies. These specifically include sampling for fish, benthic, invertebrates, zooplankton, agricultural products, aquatic vegetation, small mammals, and waterfowl.

5.4 Data Reporting

All information gathered from ecological survey and monitoring activities will be used to characterize the flora and fauna of the Weldon Spring site. Survey data will be summarized to indicate population densities, species presence, and species diversities. Estimates will be made on vegetative cover, faunal ranges, and usage patterns. A general overview of the ecological populations will be documented and used in determining significant receptor populations.

Data collected for biouptake studies will be used to determine exposures for human populations and for other animal populations. Dose calculations for humans based upon ingestion of contaminant biota will be performed as discussed in Section 9. Exposure indicators (bioaccumulation factors) and contaminate concentrations will be determined for biota. Behavioral indicators and habitat degradation or modification will be examined as part of the assessment. Contaminant concentrations will be compared to background concentration to determine evidence of biouptake. The statistical tests that will be used will determine whether selected biota utilizing contaminated resources have significantly higher levels of contaminant concentrations than background biota at a 90% confidence level. The student's T-test or the Mann-Whitney U-test will be used based upon whether the distribution of data populations can be assumed to be normal. Preliminary tests of variance and normality will be determined by using the W-test and F-test. For the W-test, data reported as non-detects or less than the detection limit (DL) will be quantified as DL/2 according to EPA guidance (1989).

5.5 Collection Permits

The taking of specific fauna for scientific study is authorized by permits from the Missouri Department of Conservation and the U.S. Fish and Wildlife Service. Applications for permits, as required by sampling plans and State and Federal regulations, will be submitted prior to sample collection. Compliance with all applicable State and local laws will also be followed in all ecological sampling programs designated here.

5.6 Natural Resource Trusteeship

The Project Management Contractor (PMC), under the authority of the DOE and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), acts as Natural Resource Trustees at the Weldon Spring Site Remedial Action Project (WSSRAP). Other agencies at the WSSRAP also act as Natural Resource Trustees. These include the U.S. Fish and Wildlife Service, the Missouri Department of Conservation and the Missouri Department of Natural Resources. The PMC coordinates with these agencies at the State and local level to notify them of releases of CERCLA hazardous substances. The biological monitoring program outlined here gathers the information necessary to provide an assessment of existing ecological conditions as required under the Natural Resource Trustee Act. In addition, the monitoring program provides a means to monitor unplanned releases and to assess the threat posed by a release. The results of annual monitoring as presented in the *Annual Site Environmental Report* are provided to these Federal agencies.

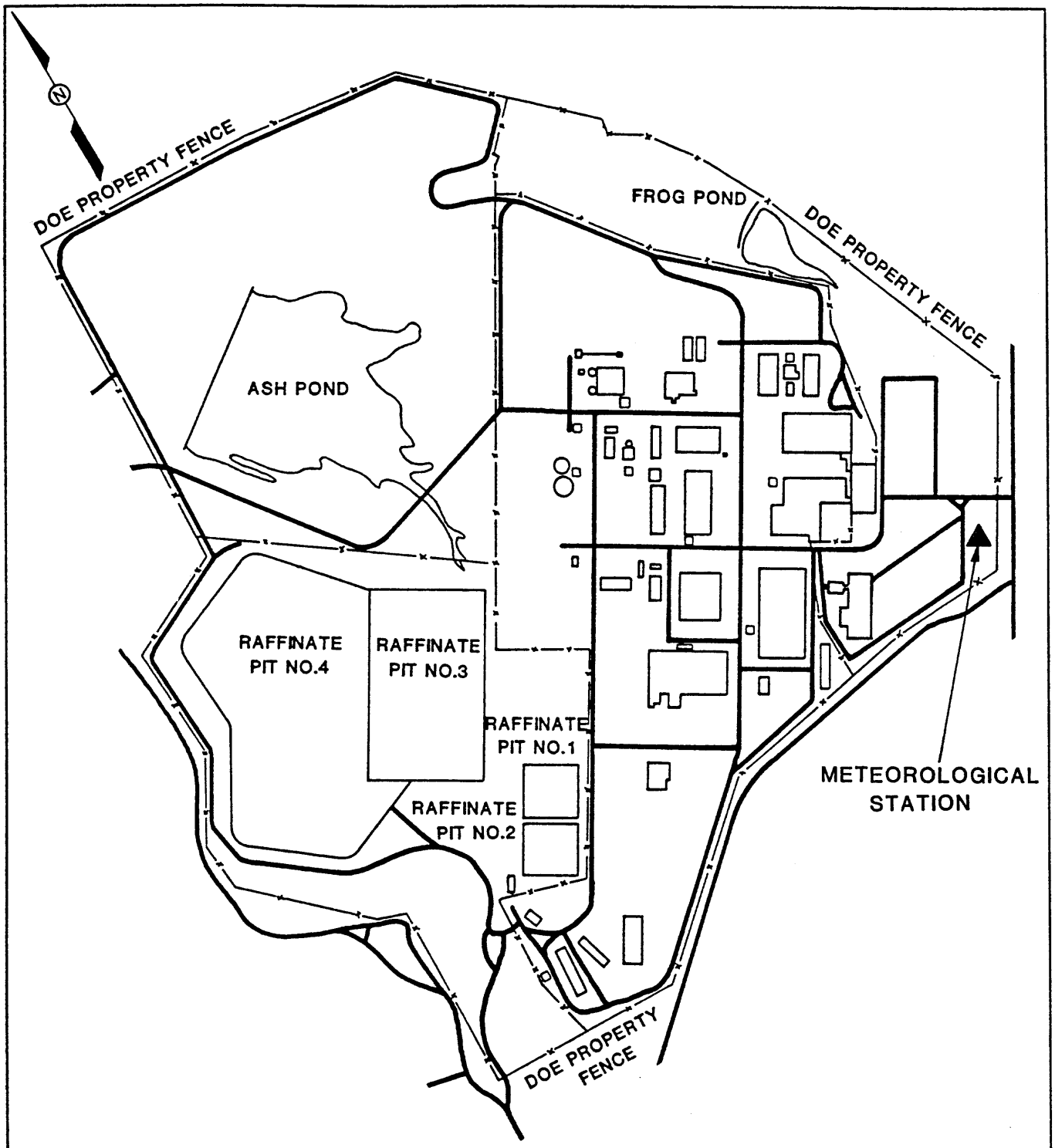
6 METEOROLOGICAL MONITORING PROGRAM

This section provides a description of the meteorological parameters measured, meteorological instrumentation, and computer programs and models that are utilized to support the environmental surveillance and emergency response activities at the Weldon Spring Site Remedial Action Project (WSSRAP). Radiological dose calculation to the general public is based upon measurements from critical receptor locations (Section 8.2.3). The use of actual concentration measurements at these locations yields more accurate dose calculations than those based upon modeling of downwind dispersion. The sources for off-site airborne releases that exist at the site are diffuse sources from waste areas and site remedial activities. No point source (stack-type) releases are in operation at the site.

The WSSRAP has two diffuse sources of airborne radiological emissions: the Weldon Spring Chemical Plant and Weldon Spring raffinate pits (WSCP/WSRP), and the Weldon Spring quarry (WSQ). An assessment of the two diffuse sources was conducted as required by the *Regulatory Guide*. The assessment included documenting the different radionuclides that could potentially be released from the sources and their concentrations.

The WSQ diffuse source is a 9-acre limestone quarry located approximately 2.4 mi south-southwest of the 217 acre WSCP/WSRP area. The WSQ is located 650 ft above sea level while the WSCP/WSRP is 500 ft above sea level. As determined by a certified meteorologist, the WSQ and the WSCP/WSRP meteorological conditions do not differ significantly and thus do not require separate meteorological monitoring stations. The location of the meteorological station is on the eastern edge of the WSCP/WSRP area more than 400 ft from the nearest building (Figure 6-1). Source term assessments are further discussed in Section 8.1.1 for the WSQ and in Section 8.1.2 for the WSCP/WSRP.

The meteorological station for the WSSRAP is designed to sample and record meteorological variables: wind speed, wind direction, horizontal wind fluctuation, ambient air temperature, barometric pressure, and precipitation intensity and accumulation. The station performs computations on the sampled signals and the data are stored electronically. Provision is also made to record the signals on a back up chart recorder located at the tower site. Data collected by the monitoring station will enable dispersion and diffusion modeling to supplement critical receptor monitoring in the event of an airborne release.



SCALE 0 500 1000 FT
0 152.4 304.8 M

LOCATION OF THE WELDON SPRING SITE METEOROLOGICAL STATION

FIGURE 6-1

REPORT NO.:	DOE/OR/21548-193	EXHIBIT NO.:	A/CP/162/1191		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	11/91

The meteorological station consists of a 10 m retractable, tilt-down tower with wind speed and direction sensors located at the 10 m level. Sensors at greater heights are not necessary since potential releases of airborne emissions are at or near ground level. The wind-aspirated temperature sensor is located on a post at the 2 m level and the precipitation gauge is located at ground level. The barometric pressure sensor is located inside an electronic enclosure situated adjacent to the tower. The horizontal wind fluctuation is computed by the station electronic circuitry. The aforementioned meteorological parameters are collected and stored as digital signals every 60 sec. Every hour, the one min recordings are averaged and stored as hourly data. This hourly data is then downloaded once per day to a remotely-located computer. The hourly data are then reviewed on a daily basis and archived onto floppy and hard drives.

These data are used to support the WSSRAP environmental surveillance program. Precipitation measurements will be correlated to aquifer water level fluctuations in the Femme Osage Slough and the WSQ. Water level fluctuations will be studied to aid in the determination of the cause of fluctuating uranium concentrations at the aforementioned locations. Wind direction results will be analyzed to determine if studies on foliar absorption by vegetation are needed. Radon and radon-daughter real time data will be coordinated with meteorological data at some future date.

Furthermore, the real-time data read out of meteorological variables aids site personnel in observing and analyzing the dispersion of potentially released airborne materials during and after an incident.

The computer program METDSPL is a qualitative atmospheric dispersion program designed to provide a schematic view of dispersion at the WSSRAP. This will aid the emergency response team in the event of a release. The plume depicted by METDSPL is based on an eulerian formulation. It simulates the path of a series of hypothetical gas particles released from a point source. The tracks of these particles are then plotted to scale on the computerized map of the site. METDSPL continuously polls the remote station for wind speed and wind direction values that are then updated on the screen, and a sector plot drawn. At the end of a segment time step, the vector averages over that interval are used to plot the distance and direction each segment moved during the period. The new paths and the background map are then redrawn.

Inspection and maintenance of the meteorological station, daily review of meteorological data, and semiannual calibration of the meteorological station are documented in Environmental Safety and Health procedures.

7 EXTERNAL RADIATION EXPOSURE ENVIRONMENTAL SURVEILLANCE MONITORING

The external radiation exposure environmental surveillance program at the Weldon Spring site (WSS) was designed to monitor potential external exposure points at the Weldon Spring Chemical Plant/Weldon Spring raffinate pits (WSCP/WSRP) and Weldon Spring Quarry (WSQ) perimeters, vicinity properties, and at off-site locations where the highest potential for an exposure to a member of the general public to gamma radiation exists. Gamma radiation is emitted by nearly all the radionuclides of the U-238 and Th-232 decay series. These radionuclides are found in above-background concentrations on the WSS, and as a result gamma radiation is monitored.

In addition, the environment contains naturally occurring radioactive substances which emit gamma radiation. Terrestrial radiation sources are natural radioactive elements in the environment (soil, water). Cosmic radiation is high-energy radiation that originates in outer space and filters through the atmosphere reaching the Earth's surface. Together, these two sources account for natural background gamma radiation. Terrestrial and cosmic radiation fluctuates depending on the soil composition and elevation above sea level.

The spherical environmental thermoluminescent dosimeters (TLD), which will be employed to monitor gamma radiation, are composed of five lithium fluoride chips in a durable spherical polyethylene holder. The TLDs will be collected and analyzed on a quarterly basis.

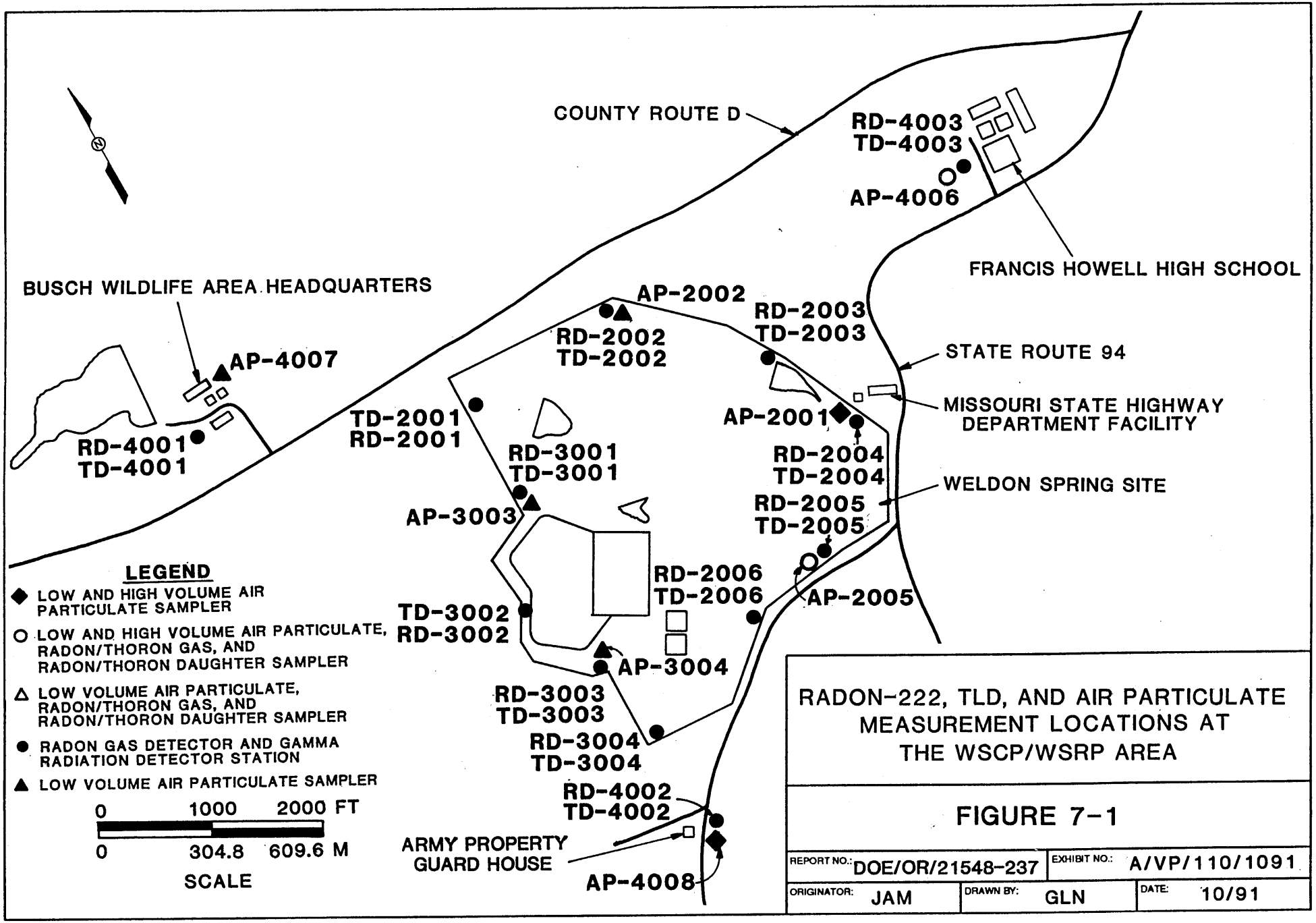
The locations chosen as external monitoring stations were based on the characteristics of the WSS. The potential for external gamma exposures to a member of the public as a result of fugitive dust emissions from the WSS is an unrealistic exposure pathway. Any airborne emission from the WSS will be intermittent, have low concentrations of radionuclides, and would have a low probability of drifting toward a location where a member of the public would frequent. Thus, this pathway would not result in a measurable external exposure to a member of the general public. In addition, there are no high energy accelerators, industrial x-ray, or large isotopic radiation sources present at the WSS. The only potential for external exposure to a member of the general public results from contaminated soils located at the WSCP/WSRP, WSQ, and vicinity properties.

Exposure from gamma radiation at the WSS will be monitored at 30 monitoring stations using environmental TLDs. Ten monitoring stations are located around the perimeter fence of the WSCP/WSRP (Figure 7-1). Five will be located around the perimeter of the temporary storage area (TSA) (Figure 7-2) located within the WSCP/WSRP. The TSA is one of the waste control facilities to be utilized in 1992 for the storage of bulk radioactive and chemical wastes from the WSQ. Eight monitoring stations will be located along the WSQ perimeter fence (Figure 7-3) spaced at intervals of 80 ft to 350 ft.

The 10 monitoring stations at the WSCP/WSRP are spaced at intervals ranging from 700 ft to 2,000 ft around the site perimeter. The five TSA monitoring stations will be located around the perimeter at intervals of 420 ft to 780 ft. The six monitoring stations at the WSQ will be spaced at intervals of 300 ft to 840 ft. The monitors at the perimeters of the WSCP/WSRP, TSA, and WSQ will be used to measure gamma exposure rates at the boundaries of those areas.

Spacing of the monitoring stations around the perimeters of the WSCP/WSRP, TSA, and WSQ is based on the relative potential for external exposures. The perimeter of the WSQ, which has the shortest distances between monitoring stations, is the most accessible to a member of the general public. In addition, the contaminated materials within the WSQ at some points are less than 150 ft from the perimeter. The intervals between monitoring stations at the TSA are similar to those at the WSQ. Material presently at the WSQ will begin to be moved to the TSA during 1992. In some places the TSA perimeter is less than 100 ft from the WSCP/WSRP perimeter. The intervals between monitoring stations at the WSCP/WSRP perimeter are larger because the potential for external exposure to a member of the general public at the WSCP/WSRP perimeter is less significant.

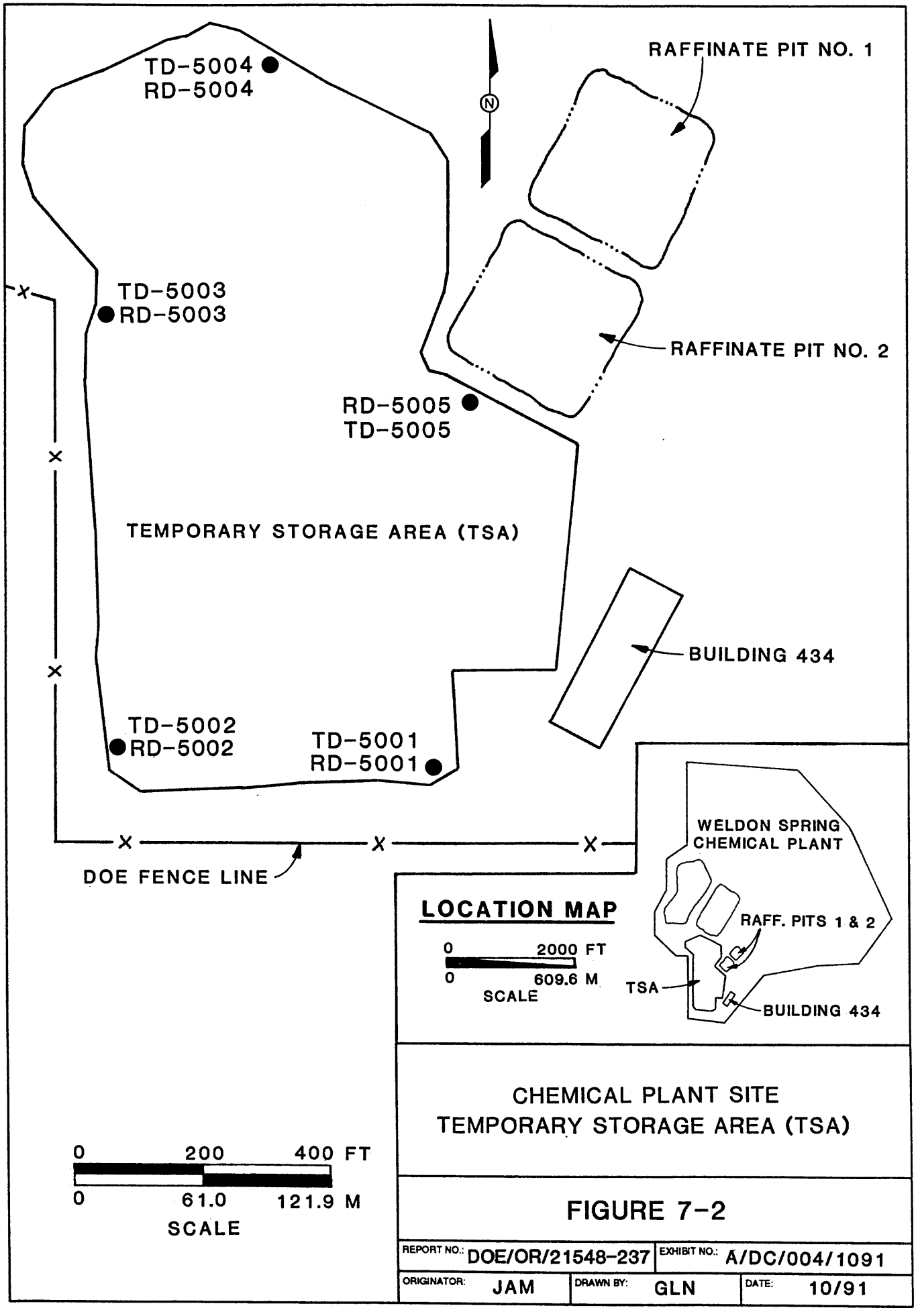
Five off-site monitoring stations (Figure 7-1), as well as two of the perimeter monitoring stations, will be used to assess gamma radiation exposure rates at locations near the WSCP/WSRP where members of the general public abide or reside. The monitoring stations at the Francis Howell High School and the Busch Wildlife headquarters were chosen because they have the largest populations near the WSCP/WSRP. The State of Missouri Highway Department, TD-2004; the Army Reserve guard house, TD-4002; and the WSSRAP administration building, TD-2005; are the closest locations to the WSCP/WSRP where a member of the general public abides or resides.

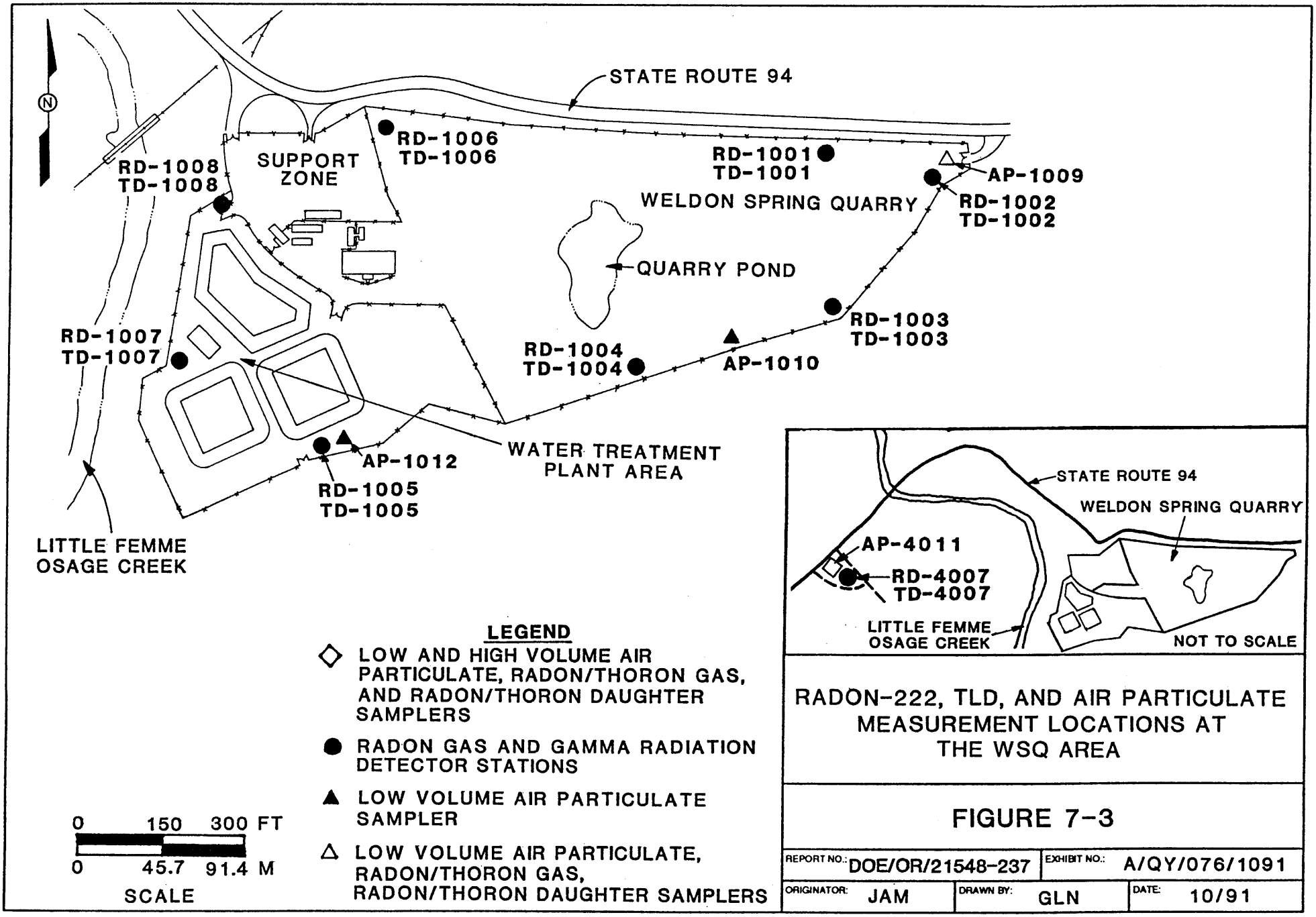


RADON-222, TLD, AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 7-1

REPORT NO.: DOE/OR/21548-237	EXHIBIT NO.: A/VP/110/1091	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 10/91

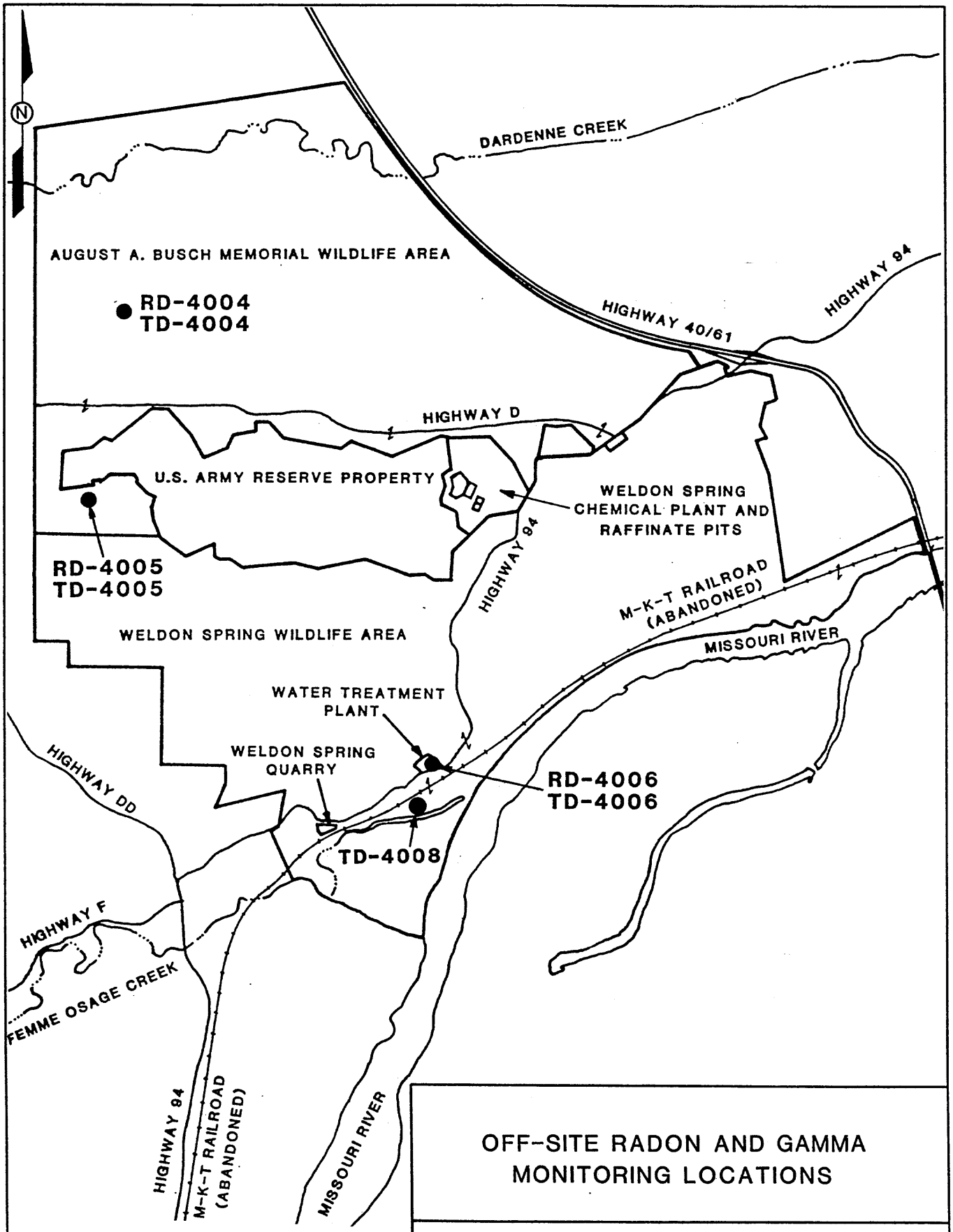

TD-5004
RD-5004
RAFFINATE PIT NO. 1
TD-5003
RD-5003
RAFFINATE PIT NO. 2
RD-5005
TD-5005
TEMPORARY STORAGE AREA (TSA)
BUILDING 434
TD-5002
RD-5002
TD-5001
RD-5001
DOE FENCE LINE
LOCATION MAP
0 2000 FT
0 609.6 M
SCALE
WELDON SPRING CHEMICAL PLANT
RAFF. PITS 1 & 2
TSA
BUILDING 434
0 200 400 FT
0 61.0 121.9 M
SCALE
CHEMICAL PLANT SITE
TEMPORARY STORAGE AREA (TSA)
FIGURE 7-2
REPORT NO.: DOE/OR/21548-237
EXHIBIT NO.: A/DC/004/1091
ORIGINATOR: JAM
DRAWN BY: GLN
DATE: 10/91



RADON-222, TLD, AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSQ AREA

FIGURE 7-3

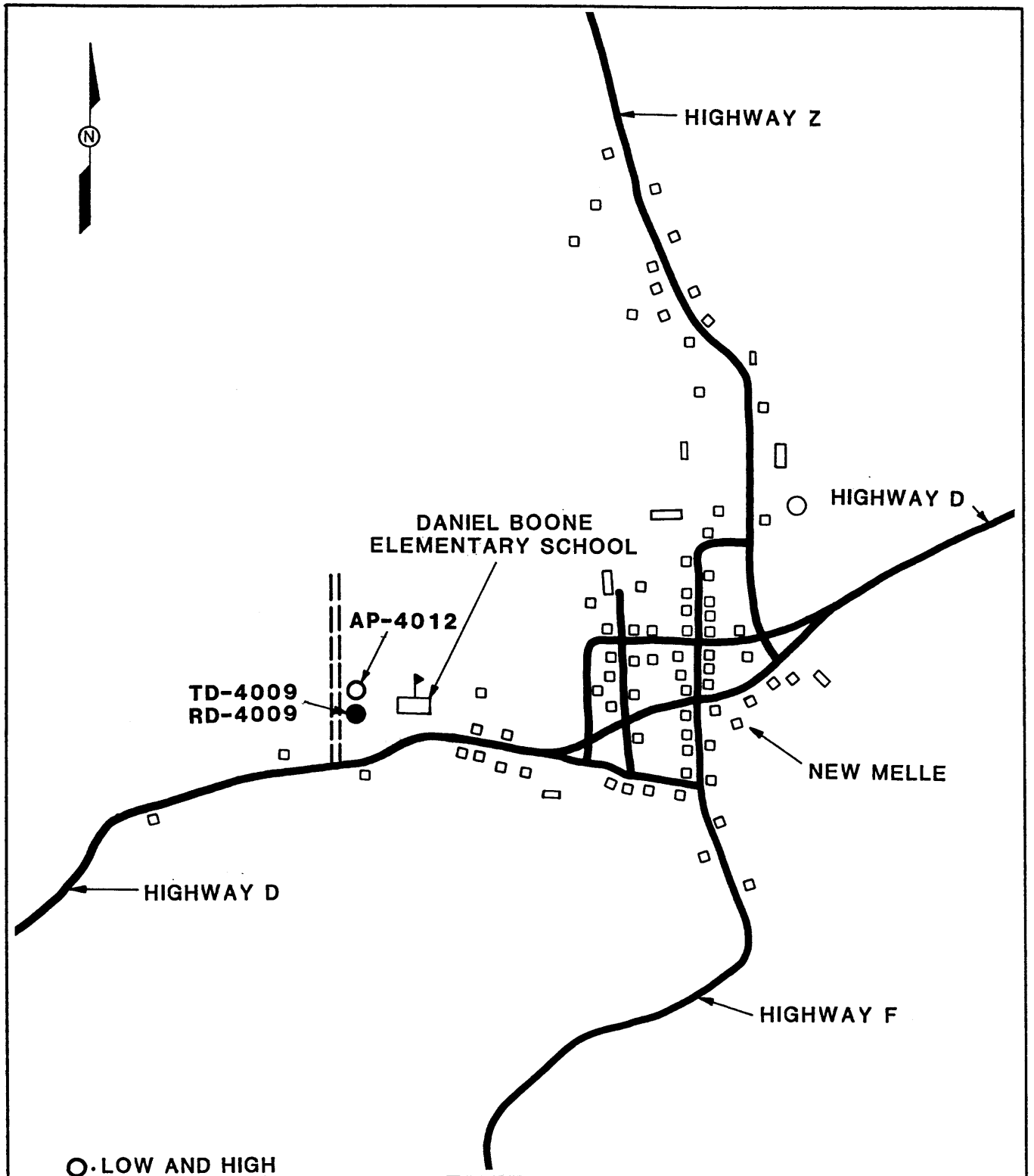
REPORT NO.:	DOE/OR/21548-237	EXHIBIT NO.:	A/QY/076/1091		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	10/91



OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

FIGURE 7-4

REPORT NO.:	DOE/OR/21548-237	EXHIBIT NO.:	A/VP/111/1091		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	10/91



BACKGROUND AIR MONITORING STATION

FIGURE 7-5

REPORT NO.: DOE/OR/21548-237			EXHIBIT NO.: A/VP/112/1091		
ORIGINATOR: JAM		DRAWN BY: GLN		DATE: 10/91	

The monitoring station near the residence, TD-4007 (Figure 7-3), was chosen because the individuals who reside there have an assumed continuous exposure time, the longest of any of the WSS nearby receptors. The location at the Femme Osage Slough vicinity property, TD-4008, was chosen because it has the greatest potential of the WSS vicinity properties to cause an external dose to a member of the general public. The Femme Osage Slough vicinity property is located near the Katy Trail, which has the largest population group that visits the WSS vicinity, and is used by individuals who fish from the Femme Osage Slough.

Five monitoring stations are used to measure background gamma radiation exposure rates (Figures 7-1, 7-4 and 7-5). The monitoring locations are TD-4001, TD-4004, TD-4005, TD-4006, and TD-4009. In 1989, background gamma radiation exposure rates were measured in each of the three distinct geological regions in the vicinity of the WSS. The three distinct regions are the dissected glacial till deposits, the alluvial deposition of the Missouri River, and the Salem Plateau. Statistical analysis of the data from the background measurements indicated that at the 95% confidence level there was no reason to suspect a difference in the gamma exposure rates between the three geological regions. Since there was no reason to suspect a difference between the gamma exposure rates in the three geological regions, an average of the results of the five background locations will give a better approximation of the background gamma radiation exposure rate.

Four of the background monitoring stations are within 4 mi of the WSCP/WSRP or WSQ. The fifth background station, TD-4009, is approximately 8 mi from the WSCP/WSRP and 7 mi from the WSQ. The *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE 1991) suggests that background stations should be located at a minimum of 6 mi to 9 mi from a site. Although three of the background stations are not located at the distances suggested in the *Regulatory Guide*, they are at appropriate distances with respect to the WSS. As mentioned, the WSS will not render external radiation exposures as a result of any airborne emissions. There are no high energy accelerators, industrial X-ray, or large isotopic radiation sources at the WSS, thus the distances that the four background stations are from the WSCP/WSRP or vicinity properties are more than sufficient to attenuate the gamma radiation from on-site contaminated soils.

Measurements with a pressurized ion chamber (PIC) as suggested in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE 1991) will not be made at monitoring stations used in previous years. Because the TLDs

integrate gamma exposure for 13 wk, the TLDs actually provide a better assessment to determine if any natural occurring anomalies are present at the location than would a short term PIC measurement. Results of previous TLD measurements are consistent with yearly background gamma exposures made by the Project Management Contractor (PMC) and other DOE contractors around the WSS. Results have ranged from 60 mR/year to 104 mR/year (BNI 1984; BNI 1985a; BNI 1985b, and MKF and JEG 1989a), with the exception of some of the monitoring stations at the WSQ. The monitoring stations at the WSQ, located in the controlled area, are positioned near contaminated soils and material. The above background results are due to the proximity of the monitoring stations to the contaminated soils. Because previous TLD measurements are consistent with background exposure rates performed by the PMC and others and are within the expected range for this altitude, it is concluded that there are no naturally occurring anomalies present. Thus, pressurized ionization chamber (PIC) measurements are not necessary.

New monitoring locations in 1992 include: background monitoring station TD-4009, monitoring station TD-4008 at the Femme Osage Slough, monitoring station TD-4007 near the residence west of the WSQ, WSQ perimeter stations TD-1005, TD-1007, and TD-1008, and WSCP/WSRP perimeter stations TD-2004 and TD-2005. The WSQ perimeter station TD-1005 and the WSCP/WSRP perimeter station TD-2004 and TD-2005 are previously existing stations which have been moved to new locations in order to obtain more useful monitoring data. Prior to installation of the new monitoring stations, a survey of the locations will be conducted as suggested in the *Regulatory Guide* to determine the absence of possible naturally occurring anomalies that could affect later measurements. The survey will be conducted with a PIC.

The five monitoring stations at the TSA, TD-5001, TD-5002, TD-5003, TD-5004, and TD-5005 will also be new stations in 1992. Because these stations are located in the controlled area where contaminated soils will be stored, PIC measurements are not necessary prior to installation of the stations. Measurements would be expected to be greater than background due to the contaminated soils in the area. However, baseline measurements will be taken with TLDs prior to arrival of bulk waste material from the WSQ to the TSA. The TLDs will be placed at the TSA for 13 weeks (calendar quarter) and from that data any increase in the external gamma radiation exposure rate as a result of TSA activities can be assessed.

The quality control measures that will be implemented for environmental TLDs include duplicates, chain-of-custody forms, field sheets, and review of vendor data. At least two

duplicate TLDs will be deployed, one at the WSQ and one at the WSCP/WSRP. When the TLDs are exchanged and retrieved, field sheets will be used to document placement and any unusual occurrences. Chain-of-custody forms will also be filled out as specified in the appropriate WSSRAP standard operating procedures (SOP). The data that is received from the vendor will be reviewed and any anomalies identified and investigated. In addition, performance testing and deployment and storage of TLDs will be done according to ANSI-N545-1975 and Nuclear Regulatory Commission (NRC) Regulatory Guide 4.13.

8 EFFLUENT MONITORING

The Weldon Spring Site Remedial Action Project (WSSRAP)has established two distinct monitoring programs which it characterizes as "effluent monitoring." These include airborne and waterborne effluents which might exceed the site perimeters. These programs are described in detail in the following sections.

8.1 National Pollution Discharge Elimination System (NPDES) Program

As a Federal facility, the WSSRAP is subject to, and complies with, Executive Order 12088, which requires all Federal facilities to comply with applicable pollution control standards. Further, U.S. Department of Energy (DOE) Order 5400.1 states that the DOE is to "conduct operations in compliance with the letter and spirit of applicable environmental ... regulations and standards." In this light, and since the WSSRAP contains point sources for waterborne pollutants, the project operates in compliance with Clean Water Act requirements.

8.1.1 Goal

To minimize the discharge of waterborne contaminants from the site, WSSRAP policy dictates that all surface water be closely monitored and controlled with treatment as necessary. Table 8-1 presents the known sources of water on the site. Erosion is to be minimized and sediment removed to a level commensurate with "best available technology." Contaminated water on the site is to be treated where appropriate, to ensure that water discharges meet Federal and State requirements.

The objective of the effluent monitoring program is to establish a base of information regarding water treatment requirements, and to verify compliance with State and Federal regulations. The remedial action goal is to clean up the site with no increase in contaminant discharge or degradation of the off-site streams. The elements of the program consist of source identification, periodic sampling and analysis to determine treatment requirements, transport, and treatment as required.

The program consists of studies and reports to identify, analyze, and evaluate appropriate measures to accomplish effective control of runoff, erosion, sediment, and contamination

TABLE 8-1 Existing or Potential Water Sources

SOURCE	CATEGORY*	QUANTITY
Raffinate Pits No. 1	RAD	1.3×10^6 gal
2	RAD	1.3×10^6 gal
3	RAD	7.7×10^6 gal
4	RAD	32.9×10^6 gal
Frog Pond	STR	500,000 gal
Ash Pond	STR	1,800,000 gal
Decontamination Pad	RAD	8.3 gpm
TSA (10 ac)	RAD	9,800,000 gpy
MSA (9 ac)	STR	8,800,000 gpy
Office Toilets	SAN	4,000 gpd
Laundry	SAN	2,500 gpd
Access Control Toilets	SAN	---
Laboratory	TBD	---
Sumps and Tanks	TBD	---
Stormwater Discharges (200 ac)	STR	195,000,000 gpy
Worker Toilets	SAN	---
Worker Showers	SAN	1.7 gpm
Decontamination Facilities	RAD	---
Ash Pond Diversion Pond	STR	---
Retention Basins	STR	---
Sewerage System	TBD	---
QUARRY		
Quarry Sump	RAD	3,000,000 gal
Quarry Stormwater (9 ac)	RAD	8,800,000 gpy
Quarry Washdown	RAD	2.5 gpm
Decontamination Pad	RAD	2.0 gpm
Worker Toilets	SAN	---
Worker Showers	SAN	0.6 gpm

TABLE 8-1 Site Water Sources (Continued) 012492

SOURCE	CATEGORY*	QUANTITY
VICINITY PROPERTIES		
Femme Osage Slough	STR	---
Busch Lake No. 34	STR	---
Busch Lake No. 35	STR	---
Busch Lake No. 36	STR	---

* Category is based on the primary treatment method required and existing natural uranium concentration.

SAN Biological Treatment; Uranium - background to 30 pCi/l
STR Sediment Treatment; Uranium - less than DCG, 600 pCi/l
RAD Complex Treatment; Uranium - greater than DCG, 600 pCi/l
TBD To Be Determined

sources. Also, procedures are required to ensure that appropriate measures are designed and built into projects, and to ensure appropriate maintenance measures are practiced.

8.1.2 Effluent Evaluation

Effluent monitoring at the Weldon Spring site (WSS) includes five surface water outfalls, one treated sanitary sewer discharge from the administration building, and one treated water discharge from the site treatment facility designed to treat the various contaminated waters that exist on the property. The wastewater treatment facility at the Weldon Spring Quarry (WSQ) will operate one permitted outfall. The treatment plant will treat contaminated water from several sources: (1) WSQ pond, (2) stormwater, and (3) waste water resulting from the equipment decontamination facility. Also, at the quarry water treatment plant, there will be a discharge or discharges of uncontaminated water used to test the treatment plant, ponds, and associated equipment. A similar discharge is proposed for the site water treatment plant.

Preoperational monitoring of receiving waters associated with both water treatment plants will be continued into 1992 to develop baseline values prior to operation. All of these discharges are monitored in accordance with National Pollutant Discharge Elimination System (NPDES) permits issued to the WSS by the Missouri Department of Natural Resources (MDNR).

Existing or potential site water sources are listed in Table 8-1. An estimate of the quantity of the sources are described in rates or total volume depending on the source. The current treatment category is also provided for the source. Certain of the waters, however, are not clearly defined and the treatment category for these waters will also require monitoring on a case-by-case basis for final determination.

8.1.2.1 Permitted Outfalls. Three permits have been issued by the Missouri MDNR for discharges from the WSSRAP. Permit MO-0107701 for the chemical plant contains seven outfalls and MO-0108987 for the quarry contains one outfall. *Quarterly Discharge Monitoring Reports* (DMR's) are required as compliance deliverables for these outfalls. Permit MO-G340001 for the quarry water treatment plant contains one outfall that requires a discharge monitoring report (DMR) as a compliance deliverable within 30 days of each discharge event. A similar outfall is proposed for the site water treatment plant. The *Annual Site Environmental Report* (ASER) (MKF and JEG 1991) and the *Quarterly Environmental Data Summaries* (QEDSs) also summarize the data from these outfalls. Discharge data is also reported to EG&G Idaho Nuclear Engineering Laboratories (INEL) and to DOE's Oak Ridge - Environmental Protection Division (OR-EPD) as detailed in the *Effluent Information System* (EIS) and *Onsite Discharge Information System (ODIS) Users Manual* (EG&G 1977).

NPDES permit MO-0107701 was issued to the DOE on July 29, 1988, for the discharge of surface water runoff through five outfalls from the Weldon Spring Chemical Plant (WSCP). A sixth outfall was added on November 4, 1988, for discharge from the sewage treatment plant at the administration building. A seventh outfall was added on October 1, 1990, for the discharge of treated effluent from the WSCP water treatment plant which will be used to treat contaminated water during remedial activities at the WSCP. Operation of the treatment facility associated with outfall NP-0007 will include storage of treated effluent (for additional treatment if necessary) until testing confirms all effluent standards have been met. Figure 8-1 shows the location of the permitted outfalls from the site.

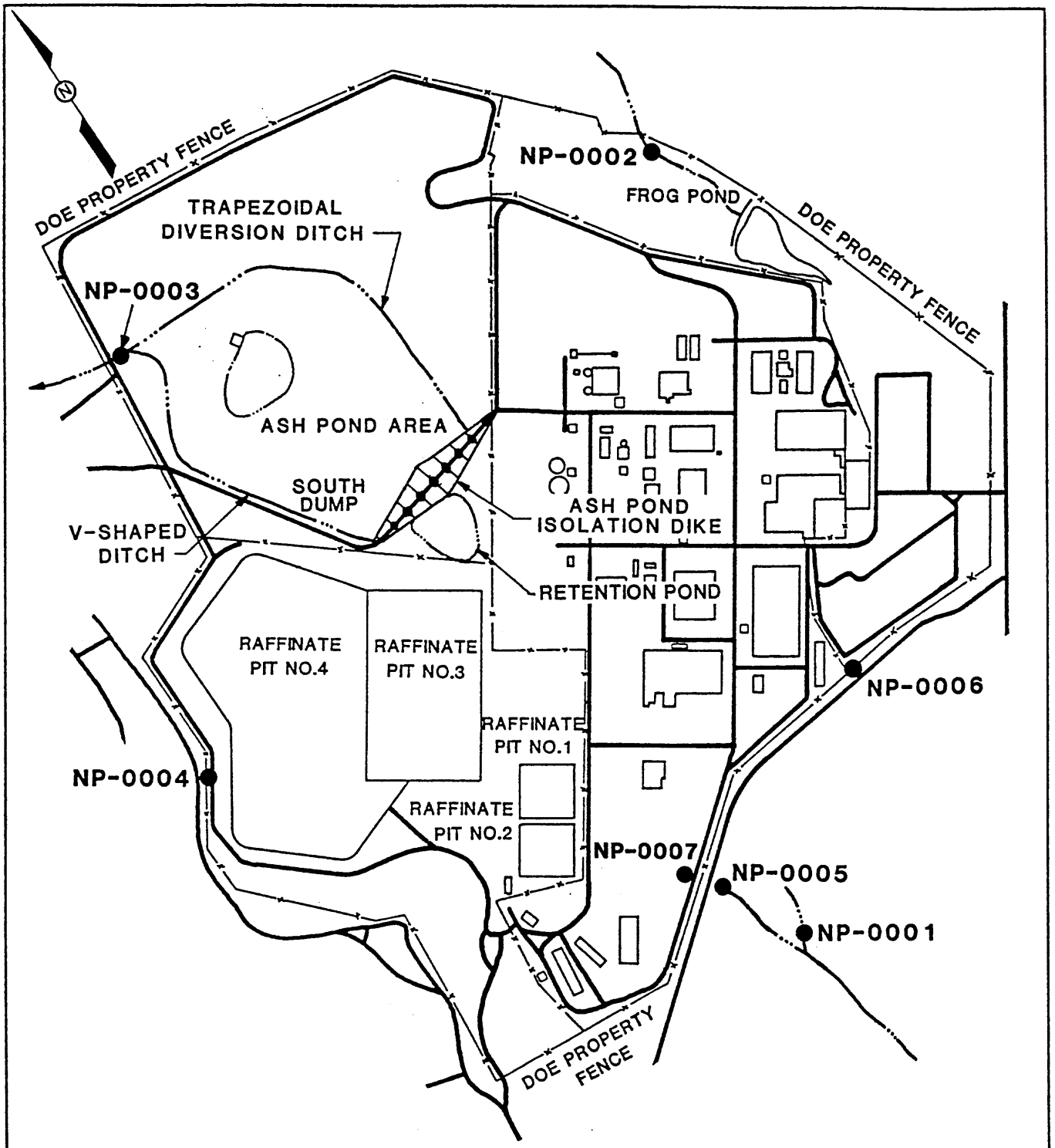
NPDES permit MO-0108987 was issued to the DOE on May 5, 1989, for the discharge of treated effluent from the WSQ water treatment plant which will be used to treat contaminated water during remedial activities at the WSQ. Operation of this treatment plant will include storage of treated effluent (for additional treatment if necessary) until testing confirms all effluent standards have been met. Figure 8-2 shows the permitted outfall for the quarry.

NPDES permit MO-G340001 was issued to the DOE on December 19, 1991, for the discharge of contaminated water used to conduct tests on the quarry water treatment plant, basins, and associated equipment. The water will be pumped from the basins to Little Femme Osage Creek.

8.1.2.2 Permitted Parameters. Monitoring parameters for the stormwater outfalls NP-0001 through NP-0005 include: flow, settleable solids, total suspended solids (TSS), nitrate-N, uranium, lithium, gross alpha, and pH. The parameters for the discharge for the administration building sanitary treatment system (NP-0006) include: flow, total suspended solids (TSS), pH, biological oxygen demand (BOD), and fecal coliform (Table 8-2). Monitoring parameters for outfall NP–0007 at the chemical plant and NP-1001 at the WSQ water treatment plant are similar and are shown on Table 8-3. These parameters are to be monitored before a batch of treated effluent is discharged to the Missouri River. The parameters for the chemical plant will be monitored at two locations; in the effluent basins prior to discharge to the Southeast Drainageway (NP-0007), and in the drainageway prior to discharge to the river to assess reintroduction of contaminants from the drainageway.

In addition to the batch parameters, other parameters are periodically monitored. Monitoring for 110 priority pollutants (Table 8-4) is required for these discharges once per year. These priority pollutants are organic compounds that are included in the following major categories: volatile organic compounds, semi-volatile organic compounds, pesticides, and polychlorinated biphenyls (PCBs). During the public comment period, xylene and trinitrotoluene (TNT) were added to the list of 110 priority pollutants. Priority pollutants for the chemical plant will be monitored at the same two locations as the other parameters.

Additional monitoring associated with these discharges includes in-stream monitoring to be conducted during discharge of each batch of treated effluent into the Missouri River. Four in-stream monitoring locations in the Missouri River are to be monitored for the following radiological parameters (expressed as activity): gross alpha, gross beta, uranium, Ra-226, Ra-228, Th-230, and Th-232. These radiochemical species constitute the primary radiological concern to potential downstream receptors. If measured levels appear to show an influence by site discharge, gross gamma emitters will be analyzed to evaluate incremental contribution toward proposed gamma and photon maximum contaminant level (MCL).



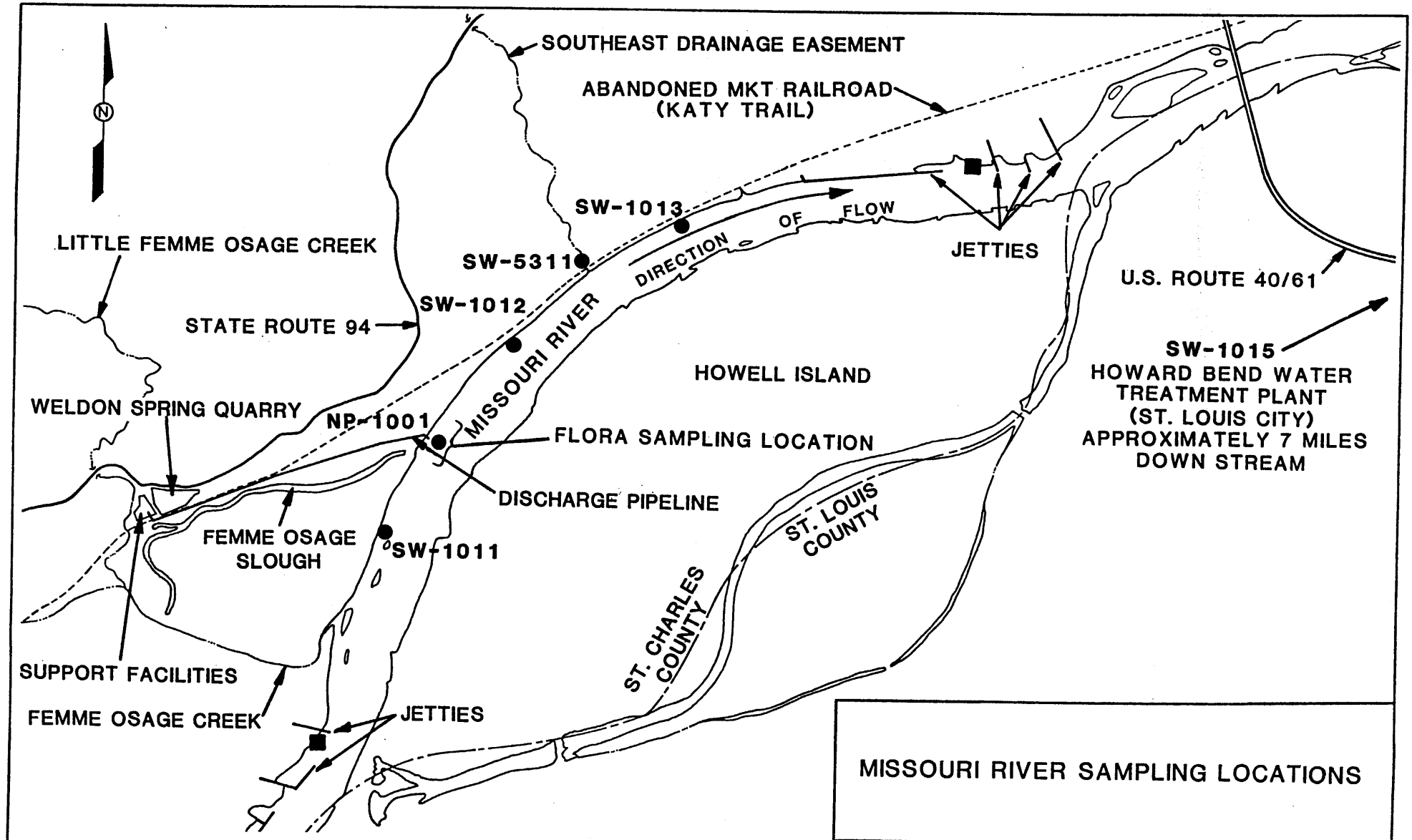
● -SAMPLE LOCATION

SCALE 0 500 1000 FT
0 152.4 304.8 M

NPDES SURFACE WATER SAMPLING LOCATIONS AT THE WSCP/RP

FIGURE 8-1

REPORT NO	DOE/OR/21548-237	EXHIBIT NO.:	A/CP/157/1091		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	10/91



MISSOURI RIVER SAMPLING LOCATIONS

FIGURE 8-2

REPORT NO.:	DOE/OR/21548-237	EXHIBIT NO.:	A/VP/113/1091		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	10/91

TABLE 8-2 NPDES Permit Monitoring Requirements - Sanitary and Stormwater Sources

PARAMETERS	UNITS	PERMITTED LIMIT	ANALYTICAL METHOD
SITE NP-001 thru NP-0005			
NP-0002, NP-0003, AND NP-0005 Monthly Monitoring of One Storm			
Flow	GPD	Monitor	V-notch weir
Settleable Solids	ml/l	(Monitor until ROD) 1	EPA 160.5
Total Suspended Solids (TSS)	mg/l	Monitor	EPA 160.2
Nitrate	mg/l	Monitor	EPA 352.1
Lithium	mg/l	Monitor	EPA 200.7
Uranium	mg/l	Monitor	EPA 900
Gross Alpha	pCi/l	Monitor	EPA 908.1
pH	SU	6-9	Beckman Ø11 Meter
NP-0001 and NP-0004 Quarterly Monitoring			
Flow	GPD	Monitor	Visual
Settleable Solids	ml/l	(Monitor with ROD) 1	EPA 160.5
Total Suspended Solids (TSS)	mg/l	Monitor	EPA 160.2
Nitrate	mg/l	Monitor	EPA 352.1
Lithium	mg/l	Monitor	EPA 200.7
Uranium	mg/l	Monitor	EPA 900
Gross Alpha	pCi/l	Monitor	EPA 908.1
pH	SU	6-9	Beckman Ø11 Meter
NP-0006 Monthly and Quarterly Monitoring			
Flow	GPD	Monitor	Pump Meters
Total Suspended Solids (TSS)	mg/l	15/20*	EPA 160.2
pH	SU	6-9	Meter
Biological Oxygen Demand (BOD)	mg/l	10/15*	EPA 405.1
Fecal Coliform	Colonies/100 ml	400/1,000*	STM 909A

* Monthly average/weekly average
** Monthly average/daily maximum

TABLE 8-3 NPDES Permit Monitoring Requirements - Complex Treatment

PARAMETER	PERMIT LIMIT	FREQUENCY	SAMPLE TYPE
Site NP-0007 and Quarry NP-1001			
Flow	Monitor, MGD	once/batch	24-hr total
Biochemical Oxygen Demand	Monitor, mg/l	once/batch	grab
Chemical Oxygen Demand	90/60 mg/l*	once/batch	grab
Total Suspended Solids	50/30 mg/l*	once/batch	grab
pH	6-9 standard units	once/batch	grab
Arsenic, Total	0.10 mg/l	once/batch	grab
Barium, Total	1.50 mg/l	once/batch	grab
Cadmium, Total	0.02 mg/l	once/batch	grab
Chromium, Total	0.10 mg/l	once/batch	grab
Copper, Total	1.0 mg/l	once/batch	grab
Iron, Total	0.6 mg/l	once/batch	grab
Lead, Total	0.1 mg/l	once/batch	grab
Manganese, Total	0.1 mg/l	once/batch	grab
Mercury, Total	0.004 mg/l	once/batch	grab
Selenium, Total	0.02 mg/l	once/batch	grab
Silver, Total	0.10 mg/l	once/batch	grab
Zinc, Total	5.0 mg/l	once/batch	grab
Cyanide, Total	0.0075 mg/l	once/batch	grab
Asbestos	Monitor fibers/l	once/batch	grab
2,4-DNT	0.22 μg/l	once/batch	grab
Fluoride, Total	4.0 mg/l	once/batch	grab
Nitrate as N: Site	20 mg/l	once/batch	grab
Quarry	Monitor mg/l	once/batch	grab
Sulfate as SO_4	500 mg/l	once/batch	grab
Chloride	Monitor mg/l	once/batch	grab
Gross Alpha	Monitor pCi/l	once/batch	grab
Gross Beta	Monitor pCi/l	once/batch	grab
Uranium, Total	Monitor pCi/l	once/batch	grab

TABLE 8-3 NPDES Permit Monitoring Requirements - Complex Treatment (Continued) 012392

PARAMETER	PERMIT LIMIT	FREQUENCY	SAMPLE TYPE
Ra-226, Total	Monitor pCi/l	once/batch	grab
Ra-228, Total	Monitor pCi/l	once/batch	grab
Th-230	Monitor pCi/l	once/batch	grab
Th-232	Monitor pCi/l	once/batch	grab

* Daily maximum/monthly average.

TABLE 8-4 NPDES Permit Monitoring Requirements Priority Pollutant List Quarry NP-1001 and Site NP-0007

Acenaphthene	4-chlorophenyl phenyl ether
Acrolein	4-bromophenyl phenyl ether
Acrylonitrile	Bis (2-chloroisopropyl) ether
Benzene	Bis (2-chloroithexy) methane
Benzidine	Methylene Chloride (dichloromethane)
Carbon Tetrachloride (tetrachloromethane)	Methyl Chloride (chloromethane)
Chlorobenzene	Methyl bromide (bromomethane)
1,2,4-trichlorobenzene	Bromoform (tribromomethane)
Hexachlorobenzene	Dichlorobromomethane
1,2-dichloroethane	Chlorodibromomethane
1,1,1-trichloroethane	Hexachlorobutadiene
Hexachloroethane	Hexachlorocyclopentadiene
1,1-dichloroethane	Isophorone
1,1,2-trichloroethane	Naphthalene
1,1,2,2-tetrachloroethane	Nitrobenzene
Chloroethane	2-nitrophenol
Bis (2-chloroethyl) ether	4-nitrophenol
2-chloroethyl vinyl ether	2,4-dinitrophenol
N-nitrosodi-n-propylamine	4,6-dinitro-o-cresol
Pentachlorophenol	N-nitrosodimethylamine
Phenol	N-nitrosodiphenylamine
Bis (2-ethylhexyl) phthalate	Phenanthrene
Butyl benzyl phthalate	1,2,5,6-dibenzanthracene (dibenzo(a,h)anthracene)
Di-n-butyl phthalate	Indeno (1,2,3-cd) pyrene (2,3-o-phenylene pyrene)
Di-n-octyl phthalate	Pyrene
Diethyl phthalate	Tetrachloroethylene
Dimethyl phthalate	Toluene
1,2-benzanthracene (benzo(a)anthracene)	Trichloroethylene
Benzo(a)pyrene (3,4-benzopyrene)	Vinyl Chloride (chloroethylene)

TABLE 8-4 NPDES Permit Monitoring Requirements Priority Pollutant List Quarry NP-1001 and Site NP-0007 (Continued)

3,4-benzofluoranthene (benzo(b)fluoranthene)	Aldrin
11,12-benzofluoranthene (benzo(k)fluoranthene)	Dieldrin
Chrysene	Chlordane (technical mixture and metabolites)
Anthracene	4,4-DDT
1,12-benzoperylene (benzo(ghi)perylene)	4,4-DDE (p,p-DDX)
Fluorene	4,4-DDD (p,p-TDE)
2-chloronaphthalene	Alpha-endosulfan
2,4,6-trichlorophenol	Beta-endosulfan
Parachlorometa cresol	Endosulfan sulfate
Chloroform (trichloromethane)	Endrin
2-chlorophenol	Endrin aldehyde
1,2-dichlorobenzene	Heptachlor
1,3-dichlorobenzene	Heptachlor epoxide (BHC hexachlorocyclohexane)
1,4-dichorobenzene	Alpha-BHC
3,3-dichlorobenzidine	Beta-BHC
1,1-dichloroethylene	Gamma-BHC
1,2-trans-dichloroethylene	Delta-BHC (PCB polychlorinated biphenyls)
2,4-dichlorophenol	PCB-1242 (Arochlor 1242)
1,2-dichloropropane (1,3-dichloropropane)	PCB-1254 (Arochlor 1254)
2,4-dimethylphenol	PCB-1221 (Arochlor 1221)
2,4-dinitrotoluene	PCB 1232 (Arochlor 1232)
2,6-dinitrotoluene	PCB-1248 (Arochlor 1248)
1,2-diphenylhydrazine	PCB-1260 (Arochlor 1260)
Ethylbenzene	PCB-1016 (Arochlor 1016)
Fluoranthene	Toxaphene
Xylene*	2,4,6-trinitrotoluene*

* QY NP-1001 only

Table 8-5 NPDES Permit MO-G340001, Monitoring Requirement - Quarry Water Treatment Plant Equipment Testing

Parameter	Permit Limit	Frequency	Sample Type
Flow	Monitor-Total Gal.	Once/event	24-hr total
Oil and grease	15 mg/l	once/event	grab
Total suspended solids	50 mg/l	once/event	grab

Additional periodic monitoring is required for other parameters such as whole effluent toxicity (WET) screens, supplemental monitoring of additional radionuclides, analysis of river sediment for uranium, and uranium analysis of terrestrial and aquatic flora. In order to encourage good erosion control practices, both NPDES permits place limitations on total suspended solids and pH for runoff from material storage or construction areas.

The parameters required for the water treatment plant equipment and basin testing, permit MO-G340001, include flow, oil, and grease and total suspended soilds (Table 8-5).

8.1.3 Preoperational Needs

DOE Order 5400.1 requires preoperational monitoring of processes which have the potential for environmental impact. Preoperational monitoring will be performed in or near the Missouri River since this is the receiving stream for discharge from both of the water treatment plants.

8.1.3.1 Sampling and Analysis. This monitoring includes surface water, sediment, and vegetation (aquatic and terrestrial) and will include all of the parameters that are regulated by the permits. Preoperational monitoring for uranium in surface water began in 1989 at locations SW-1011, SW-1012, and SW-1013 shown on Figure 8-2. In 1991, the parameters listed in Table 8-2 were added at these locations in addition to SW-1015 and SW-5311 also shown on Figure 8-2. These sample locations are positioned such that analytical data for these four locations may be used as preoperational data for discharges associated with both the WSQ and WSCP treatment plants. Monitoring will continue into 1992 for the above, as well as for total uranium on sediments and flora (terrestrial and aquatic).

8.1.3.2 Additional River Data. In addition to the sampling and analysis of the Missouri River for preoperational parameters, existing data reported by others will be obtained to expand the available data base. A major source of information is the river monitoring by Union Electric relative to the Callaway Power Generation facility. Raw water data from the Howard Bend Water Treatment Plant and its neighbor, the Hog Hollow Water Treatment Plant will also be retrieved. These represent the nearest downstream public water supply intakes from the Missouri River.

8.1.4 Additional Monitoring

8.1.4.1 Outfall Upsystem Sources. The source of runoff through the stormwater outfalls is from a variety of storm control systems including storm sewers, drainage channels, and retention basins. Monitoring these upsystem facilities is not part of the permit requirements, but they are sources for contamination of the outfalls. Monitoring is often needed to fully understand the waste characteristics at the permitted outfall. With this in mind, additional samples will be taken in these upstream facilities and may be taken in other areas on a case-by-case basis. Since explanations of exceedance are required by the MDNR when the sampling results vary significantly from the norm, upsystem data are often needed for these explanations.

8.1.4.2 New Stormwater Regulations. On November 16, 1990, the U.S. Environmental Protection Agency (EPA) issued the long awaited rule defining the entities which must apply for NPDES permits to discharge stormwater. These regulations implement Section 405 of the Water Quality Act of 1987, and require selected industries and municipalities to obtain NPDES stormwater permits from all storm drains exiting to public waterways. Initial attempts to regulate stormwater began in 1973. The deadline for individual industrial permits has been established as October 1, 1992.

The WSSRAP is subject to these rules because: (1) it currently processes five permitted outfalls which are considered stormwater; (2) it is classed in our permits as SIC 1629-heavy construction, dredging and surface cleanup; (3) it was historically involved in the mineral industry, coal handling, and hazardous materials; and (4) it is a future construction site of landfill, treatment works, decontamination, and recycle facilities.

Although additional monitoring requirements may not be needed in 1992, the rule will require that monitoring data be developed prior to reissuing of the permits. This data will be associated with two types of permit requirements.

- One application deals with the runoff from sites potentially contaminated from operating facilities and stored materials. This requirement applies to the WSSRAP, although facilities such as the WSSRAP operating under previously issued permits will not have to meet new quantification application requirements for existing permitted outfalls until they apply for renewal. Application requirements may apply for unpermitted outfalls.

- The other application deals with erosion and sediment control for construction activities of over 5 acres. The construction application requirements are much less stringent and stress best management practice.

8.1.5 Description of Effluent Monitoring Program

The monitoring system is best shown in tabular form. Tables 8-2 through 8-5 summarize the permit requirements for both permits and all nine outfalls.

8.1.5.1 Routine Monitoring Requirements. As the tables indicate, the outfalls are sampled at various frequencies. The continuous discharge outfalls are sampled on a monthly or quarterly basis as they discharge. The batch discharge outfalls from the site and quarry water treatment plants are to be sampled and the effluent held until compliance with the permit standards is determined.

Several parameters in the tables show monitoring only, and no effluent standard is applied. The site has established goals for these parameters, especially those associated with the radiological parameters. These goals are based on current NPDES permits and grouped into three general classes.

The administration building sewage treatment plant outfall, NP-0006, involves treatment of a sanitary waste with little or no radioactive contamination. The permit requirements are typical of a domestic treatment facility with discharge to an intermittent stream. The requirements are considered a high level of treatment: BOD 10 mg/l, and TSS 15 mg/l. Other nonradioactive sanitary wastewater generated on the site would be expected to meet these requirements. Non-radioactive is defined in the table as water containing less than the proposed drinking water standard for uranium of 30 pCi/l.

The stormwater outfall permit requirements have been established to monitor the rain-induced discharges and ensure the MDNR that the waters are rain-induced, and not seepage from one of the more contaminated sources. The site areas are being evaluated for future stormwater permit application requirements. The contamination levels in stormwater are highly variable, but considered as below the correction level because the annual average is historically less than the DOEs derived concentration guideline (DCG) for natural uranium of 600 pCi/l. The waters have contacted contaminated soil or material, but have not become contaminated enough to

warrant in-plant treatment. The primary contaminant encountered in the surface water is sediment derived from erosion occurring during overland or channel flow. This process has been occurring for years but has been minimized by natural vegetation. The only imposed standard deals with controlling erosion and sediment during remedial activities: settleable solids 1 ml/l/hr after the Record of Decision, total suspended solids (if no erosion control) 50 mg/l, and monitoring for other parameters including uranium. Stormwater discharge levels for uranium have been monitored over a significant time and vary considerably. The established goal for rain-induced discharges is that they discharge no water that exceeds historic levels. New or additional contaminant controls must also meet the DCG of 600 pCi/l natural uranium established by DOE Order 5400.5.

The contaminated water in the quarry sump, raffinate pits, and potentially in other miscellaneous waters requires treatment to the high levels shown in Table 8-3. The high levels of treatment imposed by the permit are due to the desire by the State to meet standards associated with potential contamination of groundwater. Although the DOE goal for uranium is to discharge less than the DCG, the treatment required to remove the non-radioactive contamination allows for a significantly lower goal for these discharges. The lower level is based on the as-low-as-reasonably-achievable (ALARA) concept that showed by calculation that since a high level of treatment is required for levels above 600 pCi/l, treatment to a goal of 30 pCi/l and not to exceed 100 pCi/l is cost effective. This 30 pCi/l level has recently been proposed by the EPA as the drinking water standard for uranium.

8.1.5.2 Intermittent Monitoring Requirements. The DOE has agreed to additional monitoring associated with the site and quarry water treatment plants in response to regulatory and public concerns. Concern over a negative effect on the Missouri River led to additional water monitoring that will be conducted in the river during discharge of each batch of treated effluent. In-stream monitoring locations are shown on Figure 8-2 and include a location upstream of the quarry outfall (SW-1011); between the quarry outfall and the southeast drainage (SW-1012); downstream of both outfalls (SW-1013); and at the water intake for the Howard Bend WTP-St. Louis City-River Mile 37 (SW-1015). Radiological parameters (expressed as activity per liter) are required for in-stream monitoring and include: gross alpha, gross beta, uranium, Ra-226, Ra-228, Th-230, and Th-232.

The southeast drainageway, which receives the site effluent at its upper end, is a vicinity property and contains some areas of contaminated sediment. To gain knowledge of the

contamination that is resuspended by the effluent flow down the drainageway, the outfall parameters for the site water treatment plant will also be analyzed just prior to entry to the river (SW-5311).

River sediment will be collected semiannually from the two locations shown on Figure 8-2, and analyzed for total uranium. Terrestrial and aquatic flora will be sampled from the river and levee areas upstream and downstream of the discharge point and analyzed for total uranium.

WET screens are required for the treatment plant effluent on a quarterly basis. Representative samples will be obtained from effluent ponds and used to perform the toxicity analysis on fish (pimephales), as described in the special conditions of the NPDES permit.

Po-210, Ac-227, and radon will be monitored semiannually for the quarry water treatment plant effluent. Preoperational monitoring for these parameters will be performed on the quarry sump water.

8.1.5.3 Upsystem Source Identification Needs. Sources of contamination occur upsystem of the three main stormwater discharges. These main discharges are the Frog Pond weir, NP-0002, Ash Pond weir, NP-0003 and the southeast drainage weir, NP-0005. Drainage facilities above each of these outfalls have an influence on the character of the discharges that is not fully understood. The variability of these discharges can best be determined by a concerted effort to monitor the upsystem facilities. This understanding will be more important as the new regulations are implemented and as more construction takes place on the site.

Additional sites that require investigation are not fully developed at this time. A full development will be presented in the *WSSRAPs Surface Water Protection Program Management Plan* that will be completed in early 1992. Certain locations are being considered for monthly monitoring; these include: Frog Pond, Ash Pond, Ash Pond diversion pond and outfall, the material staging area (MSA) pond, and the siltation basin (SB) pond. Other candidate locations may include periodic monitoring of the nonpermitted outfalls and some of the water entering the site.

The parameters needed to understand the contaminant sources do not include the full list of parameters needed for permit requirements. Flow estimates, uranium, and nitrate

concentrations will provide the necessary information for preliminary evaluations. Periodic scans using an expanded list of parameters may be of value for baseline information as remediation progresses.

8.1.6 Stormwater Requirements and Needs

8.1.6.1 Current Erosion and Sediment Control Requirements. Permits for both the site and quarry place limitations on total suspended solids and pH levels for runoff from material storage or construction areas. If this runoff is not treated in a facility designed, constructed, and operated to treat the volume of water associated with a 10-yr, 24-hr rainfall event, the total suspended solids must not exceed 50 mg/l and the pH must remain in the range of 6.0 to 9.0 standard units at the outfalls.

In order to evaluate the effectiveness of erosion control measures, the DOE/Project Management Contractor (PMC) will periodically collect surface water samples adjacent to construction or material storage areas for analysis of pH and total suspended solids. Total suspended solids and pH measurements from the permitted outfalls are reported to MDNR in the regular discharge monitoring report.

8.1.6.2 Future Characterization Data. The new regulations require stormwater characterization data be obtained in a prescribed manner. Specific methods are:

- Grab samples are required for pH, temperature, cyanide, total phenols, residual chlorine, oil and grease, fecal coliform, and fecal streptococcus.

- All samples from stormwater discharges shall be taken from the discharge resulting from a precipitation event of 0.1 in. and at least 72 hr from the previously measurable event.

- A flow weighted composite shall be taken for either the total discharge or the first 3 hr of discharge. The weighted sample should be taken with a continuous sampler or based on three grabbed aliquots per hour separated by a minimum of 15 min.

- Only one analysis is required for the composite. The grabbed aliquot taken in the first 30 min of the discharge shall be analyzed separately.

- A minimum of one grab sample may be taken in impoundments with retention greater than 24 hr.

- All samples shall be analyzed by methods approved under 40 CFR part 136 where applicable.

8.1.6.3 Reapplication Data

The collection of characterization data is needed for the reapplication and approval of current permits using the new sampling and quantification procedures. These activities will begin immediately to ensure adequate data for reapplication. The program needed to accomplish the activity includes three documents.

Surface Water Protection Program Management Plan -- The plan will describe the regulations, orders, and procedures governing the management of the site surface water. Transport, storage, treatment, and discharge of surface water will all be covered by the plan.

Site Hydrology Report -- The report will delineate the site watershed units, present the precipitation and flow data, and coordinate these data to develop runoff coefficients and predict surface water movement.

Stormwater Characterization Report -- The first part of this report will provide chemical data for the stormwater discharge using discrete samplers combined with flow information. The data will be used to develop sampling procedures to best describe the character of the discharges. These procedures will then be used to chemically characterize the discharges using the parameters required for the application.

Additional sampling of tributaries upstream of the regulated outfalls will also be needed to fully understand the discharge character. The characterization of the discharge may require a minimum of three storm events at each of the regulated points. The chemical characterization of the stormwater may also require sampling of a minimum of three events at each point. Additional details will be provided in a sampling plan.

8.1.6.4 Construction Application Data. Documentation to satisfy the application requirements for permits must be obtained because of the construction on the site. Most of the required data is currently being developed as part of other activities of the site and no sampling is needed to satisfy these requirements. Current studies will develop and detail the design requirements for controlling surface water for the site during and after the construction. A *Surface Water and Erosion Control Report* will propose the best combination of facilities that will constitute the best management practice (BMP) for the site. The presentation of this material to the MDNR will satisfy the relevant and appropriate requirements for the application. A formal application is not anticipated because of Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) regulations, however the spirit of the regulations is evident through the use of best management practices.

8.2 Airborne Effluent and Environmental Surveillance Program

This section documents the rationale and requirements of the programs that will be implemented to monitor airborne emissions from the WSSRAP and to evaluate the impacts of those emissions on the public and the environment. The WSSRAP has two diffuse sources of airborne radiological emissions; the WSCP/WSRP, and the WSQ. Emissions from these sources and the estimated exposures are predicted to be low. The emissions monitoring program is tailored to be commensurate with the low potential for exposure.

8.2.1 Source Assessment

As required by DOE guidance, an assessment of the two diffuse sources was conducted. The assessment included documenting the different radionuclides that could potentially be released from the sources and their concentrations. In addition, the assessment addressed the factors that could potentially contribute to the suspension of contaminants. The assessment provided a basis for the airborne emissions monitoring program and ensured that the design would provide timely, representative, and adequately sensitive monitoring results.

8.2.1.1 Weldon Spring Quarry Source Assessment. The WSQ diffuse source is a 9-acre limestone quarry located approximately 4 mi south-southwest of the WSCP/WSRP area. The WSQ is essentially in a closed basin; surface water within the rim flows to the quarry floor and into a pond which covers approximately 0.5 acre. The WSQ was used as a disposal area for dinitrotoluene (DNT), trinitrotoluene (TNT) process waste, uranium, radium and

thorium residues and the associated daughter products from on-site and off-site processing of uranium, and building rubble and soils from the demolition of a uranium processing facility in St. Louis. Airborne emissions from the quarry result from the wind blown resuspension of radioactive particulates from quarry soils and resuspension of radioactive particulates from activities at the WSQ such as the operation of heavy equipment and the excavation of soils. In addition, there are also airborne releases from the WSQ due to the decay of Ra-224 and Ra-226, daughters of Th-232 and U-238, into Rn-220 (thoron gas) and Rn-222 (radon gas).

Characterization of the WSQ soils has been completed in support of the WSQ Remedial Investigation/Feasibility Study (RI/FS). The radiological contaminants in the WSQ are uranium and thorium and their respective daughters. Concentrations range from 3.0 pCi/g to 1600 pCi/g U-238, <1.0 pCi/g to 2780 pCi/g Ra-226, 0.7 pCi/g to 36 pCi/g Th-232, <1.0 pCi/g to 2200 pCi/g Ra-228, and <1.0 pCi/g to 6800 pCi/g Th-230. A study is being conducted to determine the lung solubility class of WSQ bulk waste. Until the lung solubility classes have been determined, the most restrictive solubility classes will be assumed for uranium and thorium in the bulk waste.

Statistical evaluation of the results from effluent monitoring at the WSQ during 1990 indicated the results from one of the air particulate monitors and four of the radon track etch detectors were greater than background. The calculated effective dose equivalent to a hypothetical maximally exposed individual from the airborne emissions from the WSQ was 3.3 mrem (MKF and JEG 1991d). The 3.3 mrem dose calculated for the hypothetical individual from the airborne inhalation pathway was almost exclusively due to radon emissions. The assumptions that were used to calculate the dose were conservative. It was assumed that the daughter equilibrium ratio at Highway 94, where the individual walked twice daily, was 50% and that the concentration of radon at Highway 94 was the same as the concentration measured within the WSQ controlled area. These conservative assumptions resulted in a higher calculated dose to the hypothetical individual than would have otherwise been calculated using a less conservative daughter equilibrium ratio and a computer model to estimate the concentration at Highway 94.

Excavation of soils and placement of contaminated materials from remediation of the WSQ water treatment plant area are believed to be responsible for the above background air particulate monitoring results. These activities are similar to the activities that will occur during 1992. However, beginning in August of 1992, soils and bulk waste will be excavated within

the WSQ that have significantly higher concentrations of radiological contaminants. Engineering controls will be used during bulk waste removal to restrict the release of airborne particulates from the WSQ during excavation of soils and bulk waste removal. In the *Feasibility Study for Management of the Bulk Waste at the Weldon Spring Quarry* (ANL 1990a) the dose estimate from airborne radioactive particulates for a hypothetical individual who walked along Highway 94 twice a day, during the 1.25 years that will be required to remove the bulk waste, was 1.3 mrem. The dose estimate calculated for a nearby resident with a assumed 100% occupancy time during the 1.25 years was 0.18 mrem.

In order to remove the bulk waste from the WSQ, the sump will have to be dewatered. The water that will be removed from the sump will be treated and released from a water treatment plant that is adjacent to the WSQ. Although the potential for airborne emission from the water treatment plant is small, there is some potential for the release of radioactive airborne emissions at one stage during operation of a filter press. The filter press will be housed in a small building. The filter press will also have a metal shroud to minimize emission within the building. Finally, the building will be ventilated with a high efficiency particulate air (HEPA) filter system to minimize releases to the environment. No above background radioactive emissions are expected from the operation of the WSQ water treatment plant.

Radon concentrations measured at the WSQ have historically been above background because the radium concentrations in WSQ wastes are typically higher than other areas and because the WSQ is a large depression in the terrain with side walls ranging from 10 ft to 50 ft high. In conjunction with stable meteorological conditions, this tends to trap emanating radon within the quarry and raises the concentrations at the WSQ. During 1992 the bulk waste will begin to be removed from the WSQ. Evaluation of the potential emissions of radon during the excavation of the bulk waste was also done in the feasibility study. The results of the study indicate that a dose of 1.0 mrem would be received by the hypothetical individual who walked along Highway 94 twice a day for 1.25 years. Although the dose estimate in the feasibility study is lower than the calculated dose to the hypothetical maximally exposed individual from airborne emissions during 1990, it is based on more realistic assumptions. A daughter equilibrium ratio of 10% was assumed based on measured radon and radon daughter concentrations taken during 1989 (Haroun et al 1990), and the concentration at Highway 94 was calculated using the computer model MILDOSE (Strenge and Bander 1981) which was modified to more accurately assess airborne concentrations resulting from releases from large areas (Yuan et al. 1989). The dose calculated for a nearby resident in the feasibility study was 2.3 mrem.

8.2.1.2 WSCP/WSRP Source Assessment. The WSCP/WSRP diffuse source encompasses 217 acres on which 33 buildings and four raffinate pits are located. Airborne emissions from the WSCP/WSRP result from the windblown resuspension of radioactive particulates from site soils and chemical plant buildings, and resuspension of radioactive particulates from site operations such as building demolition, and soil excavation. In addition, there are airborne emissions from the WSCP/WSRP due to the transformation of Ra-224, Ra-226 daughters of Th-232 and U-238, into Rn-220 (thoron gas) and Rn-222 (radon gas). Because the site is not an operating facility there are no point sources.

Characterization of the WSCP/WSRP buildings and soils have been completed in support of the site RI/FS. Radiological contaminants in the WSCP buildings are uranium, thorium, and the respective daughters. Concentrations in bulk samples collected from the WSCP buildings range from background levels to 1000 pCi/g U-238, 17 pCi/g Ra-226, 2682 pCi/g Ra-228, and 250 pCi/g Th-230. As at the WSQ, a lung solubility study is being conducted using materials from the WSCP/WSRP. Bulk samples from process buildings and the raffinate pits have been collected. Until the lung solubility classes have been determined, the most restrictive solubility classes will be assumed for thorium and uranium.

The site soils characterization also indicates that the contaminants in the soils are uranium and thorium and their associated daughters. Most of the 217 acres of the WSCP/WSRP have above background concentrations of uranium (>1 pCi/g). Concentrations range from 0.3 pCi/g to 2,259 pCi/g U-238, 0.6 pCi/g to 452 pCi/g Ra-228, and 0.3 pCi/g to 123 pCi/g Th-230.

In the past several years statistical evaluation of the results from effluent monitoring and environmental surveillance monitoring at the WSCP/WSRP has indicated that there is no reason to suspect at the 95% confidence level that the results were greater than background (i.e., no above background exposure to the public from WSCP/WSRP operations has occurred). Activities that will be performed during 1992 are similar to those that were performed in previous years, such as excavation of low level radiologically contaminated soils and building demolition. Although building demolition during 1992 includes buildings that have significantly higher concentrations of contaminants than those that have been demolished previously, additional engineering controls will be used to control emissions. These engineering controls include cleaning or removing loose contamination (i.e., dust or dirt) from the internal and external surfaces of the building and equipment prior to the start of demolition. In addition, water will be used during demolition to control dust emissions.

As mentioned in the WSQ source assessment, the bulk waste from the WSQ is expected to begin being placed at the temporary storage area (TSA) during August of 1992. Engineering controls such as the use of water to control airborne particulate emissions will also be used at the TSA. Radon gas emissions due to the higher radium concentrations in the bulk waste will be minimized through the use of an attenuating cover material. In the *Feasibility Study for Management of the Bulk Waste at the Weldon Spring Quarry* (ANL 1990a) a dose estimate for airborne emissions from the bulk waste at the TSA was calculated. In the study a dose estimate was calculated for a worker in an on-site office building and a student at Francis Howell High School. The calculated dose to the office worker was 0.08 mrem from radon, and 0.84 mrem from radioactive particulates for a total of 0.92 mrem. The calculated dose for the student was 0.05 mrem from radon, and 0.05 mrem from radioactive airborne particulates for a total of 0.1 mrem.

8.2.2 Airborne Monitoring Programs

To effectively monitor the two WSSRAP diffuse sources that have been described, three air monitoring programs will be utilized; site specific monitoring, perimeter monitoring, and critical receptor monitoring. These three programs are designed to meet the requirements for airborne effluent monitoring and environmental surveillance as specified in the *Environmental Regulatory Guide for Radioactive Effluent Monitoring and Environmental Surveillance* (DOE 1990) and DOE Orders 5400.1 and 5400.5.

The location, equipment, sampling time, minimum detection levels, accuracy, and investigation levels will be discussed in the site specific, site perimeter, and critical receptor monitoring program sections. In addition, sample heights, proximity to obstructions, and linear flow rate will also be discussed in the individual monitoring program sections.

8.2.2.1 Site Specific Monitoring Program. As mentioned in the WSCP/WSRP source assessment, the large WSCP/WSRP diffuse source is made up of a number of smaller diffuse sources that include wind blown resuspension of radioactive particulates from contaminated soils and buildings, and resuspension of radioactive particulates due to site remediation activities such as building demolition and excavation of soils. Although there is some potential for resuspension of radioactive particulates due to natural meteorological occurrences, it is small compared to the potential for site remediation activities to resuspend radioactive air particulates. In order to assess the contribution of site remediation activities to

the total airborne emissions from the WSCP/WSRP, site specific monitoring will be utilized. Site specific monitoring will also be used at the WSQ to supplement data from the WSQ perimeter monitors. Site specific monitoring will use mobile air particulate samplers placed upwind and downwind from smaller diffuse sources.

Site specific monitoring, in addition to providing data concerning the contribution of specific activities to the total airborne inventory, will provide faster feed back concerning the effectiveness of engineering controls and data concerning dispersion patterns. Filters from site-specific monitors will be collected on a daily basis as compared to weekly for the perimeter samplers, which means data can be obtained as much as six days sooner. In addition, by varying the distances and configurations of the samplers, valuable information concerning dispersion patterns can be obtained for the WSSRAP.

During demolition of a building within the WSCP/WSRP area, for example, mobile air particulate samplers would be used to monitor airborne emissions from the specific activity. At least four monitors would be used, one upwind and three downwind from the activities. Placement of the samplers would be based on current meteorological conditions provided by the site meteorological station and experience gained from previous placement of samplers. During 1991, site specific monitoring was initiated during the demolition of four non-process buildings. The samplers were placed at various distances and configurations with respect to the source. The experience and data gained in 1991, and as 1992 progresses, will be used to assess the best placement for the samplers.

The air samplers will be placed in areas, when possible, that are free from obstructions or conditions that could effect the air sampling results. When possible, the air samplers are two times the distance from one obstruction or structure as the obstruction or structure is high (i.e., an air sampler would be placed 10 ft from a 5 ft tall tree). In addition, the samplers will be placed if possible, in areas that do not have turbulent air conditions, such as near busy roads, or active equipment.

Site specific monitoring will be utilized during remediation activities at the WSQ. Monitors will be placed just outside the work areas based on the current meteorological conditions. Site specific monitoring will be used to assess airborne emissions from specific activities and areas within the WSQ.

Equipment that will be used for site specific monitoring includes a portable air particulate sampler with a filter holder and a vacuum pump, a mass flow meter, filter, portable power supply, and air sampler stand.

There are two types of portable air samplers that will be used for site specific air monitoring; high volume self-adjusting brush motor air blower, and low volume carbon vaned oil-less vacuum pumps. The high volume samplers are generally operated at approximately 400 l/min, and the low volume pumps at approximately 40 l/min. The linear flow rates for the high and low volume air samplers, volume sampled per unit time, divided by the filter area, is 48 m/min and 23 m/min, respectively.

A mass flow meter which is calibrated in a NIST traceable wind tunnel will be used to set the flow rates of the portable air monitors at the beginning of each sampling period. The mass flow meter electronically compensates for temperature and pressure to read in standard liters per minute (sl/min, a liter of air at 0°C and barometric pressure of 76 cm Hg). The mass flow meter will also be used to check flow rates at the end of the sampling period.

The filters that will be used for low-volume samplers are a mixed cellulose esters membrane. These filters have a pore size of 0.8 μm and are 47 mm in diameter. The manufacturer states that the filter media retains 99.98% of dioclylphalate particles with an aerodynamic mean diameter of 0.3 μm at 32 l/min across a 100 cm^2 surface area. Filters for the high volume samplers are 102 mm in diameter glass fiber filters which retain 99.98% of dioclglphate particles with an aerodynamic mean diameter of 0.3 μm. The samplers will be placed on portable stands at a height of approximately 1 m off the ground. The air samplers will be placed at 1 m rather than 2 m as specified by the EPA due to the weight of the pumps and the safety problems that would be brought about by placing the pumps at 2 m off the ground. The 2 m height would require personnel to lift the pumps, which are relatively heavy and will be moved frequently, above their heads. In addition, the stands would have a high center of gravity, making the stands susceptible to tipping in strong winds.

Because there is presently no electrical service in the controlled area of the WSCP/WSRP where the portable air samplers will generally be used, portable generators will be used to power the air samplers.

The minimum detectable concentration (MDC) that will typically be achieved during site specific monitoring is approximately 5.0E-14 μCi/ml. Because work activities may not always have a duration long enough to collect a large sample volume, a sample MDC may be higher than the typical MDC of 5.0E-14 μCi/ml. In addition, the high-volume, site-specific samplers, due to the higher flow rates, can collect a large enough sample volume so that a sample MDC could be significantly lower than the typical MDC. Whenever possible a large sample volume will be collected in order to reduce the MDC.

The total typical accuracy or uncertainity associated with a site perimeter air particulate sample, at a concentration of 1E-15 μCi/ml, is 1.0×10^{-16} μCi/ml. The total sample accuracy or uncertainty is dependent on the uncertainty associated with a number of sources which include the volume sampled, detector calibration, uncertainties with efficiency and background count rate, and sample count rate.

After samples are collected, the filters will be stored for a minimum of 72 hr before they are counted to allow for decay of the short lived radon and thoron decay products. The activity of the samples will then be counted on an alpha-scintillation detector or a gas-flow proportional counter. Counting times for the alpha scintillation detector and the gas flow proportional counter will generally be 60 min. Counting times may be longer in order to achieve a lower MDC.

The investigation level which will be implemented for the site specific monitoring will be a downwind measured concentration of two times the up-wind concentration. The investigation will attempt to determine the source of the airborne contamination.

The Quality Control (QC) procedures that will be implemented as part of the site- specific monitoring program include the calibration of instruments, source and background counts, recounts of samples, and review of documentation. The QC procedures are intended to ensure the accuracy and validity of the data.

Calibration will be required for the alpha-scintillation and gas-flow proportional detectors, and the mass flow meter. The alpha-scintillation detector will be calibrated a minimum of every six months using NIST traceable radioactive sources. The gas-flow proportional counter will be calibrated when repairs are made to the detector. The mass flow meter will be calibrated on an annual basis by the manufacturer in a NIST traceable wind tunnel. In addition, the portable

airborne particulate samplers will be leak tested on an annual basis to ensure that the measured volume of air is passing through the sample collection filter.

Daily source and background counts will be made on the alpha-scintillation and gas- flow proportional detectors. The daily source and background count results are compared to the calibration results. If daily checks are within three standard deviations when compared to results obtained during calibration, instruments will be put into service. Instruments failing the daily background check will be taken out of service as described in the applicable WSSRAP standard operating procedure (SOP).

At least one in 20 samples will be recounted and the results compared to the initial count results. The precision between the two sample counts will be determined and the results kept on file.

A review of the sample documentation and calculations by an individual other than the sampler will be required as part of the QC procedure. The reviewer will be responsible for ensuring that the documentation is complete and the calculations correct.

8.2.2.2 Site Perimeter Monitoring. In order to monitor the airborne emissions from the two large diffuse sources, the WSCP/WSRP and the WSQ, which encompass large areas of soils having above background radionuclide concentrations, a perimeter monitoring program will be utilized. The program will require the use of eight air particulate monitors and radon track etch detectors at permanent locations. The monitors will be used in conjunction with site specific monitoring to estimate the total airborne emissions that leave the two diffuse sources. The use of air monitors at the WSCP/WSRP and WSQ perimeter, in conjunction with site specific monitoring, is the most effective way to monitor airborne emissions from the WSS. The sources described in the WSCP/WSRP and WSQ source assessment are essentially ground sources. Sources such as stacks or vents that release radioactive material at a significant distance from the ground have the highest measured concentrations at ground level some distance from the source. This occurs because it takes time for the material to reach the ground, and as the material falls, it is driven from the source by the wind. Ground sources however, have the highest concentration measured at the ground level at points closest to the source. As a result, the highest concentrations that leave the WSCP/WSRP and WSQ are at the perimeters.

There will be five perimeter radioactive air particulate monitoring stations at the WSCP/WSRP (Figure 7-1). The WSCP/WSRP perimeter monitors are generally equally spaced along the perimeter fence with distances ranging from approximately 2,079 ft to 2,970 ft. Because the potential for airborne emissions from the WSCP/WSRP is low, any airborne emissions that do occur will be intermittent and have low concentrations. The use of five perimeter monitors is commensurate with the potential for an exposure to a member of the general public.

There will be three perimeter radioactive particulate monitoring stations at the WSQ (Figure 7-3). The WSQ perimeter radioactive air particulate monitoring stations are located on the southeastern end of the WSQ and at the southern edge of water treatment plant area adjacent to the WSQ. The two sampling locations at the southeast end of the WSQ and the sampling location at the southern end of the water treatment plant facility represent areas that have the highest potential for airborne emissions. The prevailing winds in the vicinity of the WSQ are from the south and southwest during summer and fall, and from the north, northwest, and west during spring and winter. The WSQ is surrounded by steep cliffs on the north, east, and south and is accessible by relatively flat land only from the west. The third monitor will be used to monitor any potential emissions from the flat entrance area at the west end of the WSQ during remediation activities.

There will be 10 radon monitoring stations at the WSCP/WSRP perimeter (Figure 7-1) placed approximately 2,310 ft to 6,600 ft from one another. Due to the characteristics of the WSCP/WSRP diffuse radon source, the density of radon monitoring stations around the perimeter will be commensurate with the potential for causing an exposure from radon to a member of the general public. Remediation of the WSCP/WSRP is not expected to increase radon emissions, but some increase may occur during the transfer of bulk waste from the WSQ to the TSA which is located within this area. The TSA will be monitored for radon at the TSA perimeter. Five monitoring stations will be used at the TSA perimeter (Figure 7-2). The stations will be placed at intervals of 420 ft to 780 ft from one another. Because the waste that will be transferred from the WSQ to the TSA has higher concentrations than the WSCP/WSRP soils, there is higher potential for radon emissions from the TSA than from WSCP/WSRP. As a result, the distances between radon monitoring stations at the TSA will be less than WSCP/WSRP station separation.

An effective dose equivalent of 0.08 mrem was calculated at the nearest WSCP/WSRP critical receptor with the highest potential for an exposure to a member of the general public as a result of radon emission. Therefore the 10 radon monitoring stations at the WSCP/WSRP perimeter will be sufficient to monitor potential radon emissions.

There will be eight radon monitoring stations on the WSQ perimeter (Figure 7-3). The radon monitoring stations at the WSQ are approximately 264 ft to 825 ft apart. The distance between monitoring stations at the WSQ is less than at the WSCP/WSRP because of the higher radium concentration at the WSQ and because the WSQ is a large depression in the terrain with side walls ranging from 10 ft to 50 ft high. This, in conjunction with stable meteorological conditions, tends to trap emanating radon within the WSQ and raises the concentrations along the WSQ perimeter. As a result there is higher potential for radon emissions from the WSQ than from the WSCP/WSRP, and thus the distance between stations at the WSQ is smaller.

The number of radioactive air particulate and radon monitoring stations at the WSCP/WSRP and WSQ is in proportion to the potential for emissions from the sources. In addition, the use of site specific monitoring will allow monitors to be placed such that the density of monitors will be increased in the direction dictated by the current meteorological conditions.

Equipment for the site perimeter monitoring program includes low volume air particulate samplers, continuous radon-gas and radon-daughter monitors, a mass flow meter, scintillation detectors, a gas-flow proportional detector, filters, and radon track etch detectors.

The low volume air particulate samplers at the five WSCP/WSRP site perimeter locations are self-adjusting, twin-diaphragm, oil-less air pumps. At the two WSQ perimeter monitoring locations self adjusting, carbon vaned, oil-less air pumps are utilized. Each sampler will be mounted in a weather-protective housing with a 110-volt outlet and a thermostat-controlled fan for cooling. Each sampler will have an hour meter to document the operational periods. Samplers will also have a flow meter, vacuum gauges, and be equipped with a regulator to maintain a constant flow rate.

The continuous radon gas and radon daughter monitors (Figures 7-1 and 7-3) are portable, fully automated instruments capable of continuously monitoring for radon, and radon and thoron daughters. The radon detectors contain a 5 in. diameter tube that is optically coupled

to a 3 liter Lucas Cell coated with silver activated zinc sulphide to detect radon gas. The working level monitor uses a ruggedized silicon barrier diode detector which is used to detect radon and thoron daughters deposited on a membrane filter with a 0.45 μm pore size. The continuous radon and working level monitors have internal data storage capabilities. The data will be retrieved from the sampler locations by downloading the data from the samplers to a portable computer. The sensitivities of the continuous radon and radon daughter monitors are 1.0 pCi/l and 1.0 mWL. The manufacture stated accuracy for the continuous radon and radon daughter monitors is within $\pm$10% of the measured concentration.

A mass flow meter is used to set and measure the flow rate of the low volume air particulate samplers. The low volume air particulate samplers will be run continuously at a flow rate of approximately 40 l/min (1.4 cu ft/min) with weekly filter replacement. Prior to changing the filter each week, the flow rate is measured with the mass flow meter which electronically corrects for pressure and temperature to read in standard liters per minute. After the filter is changed the flow rate will be adjusted on an as-needed basis to 40 l/min. The starting flow rate of 40 l/min is then averaged with the ending flow rate, and the average flow rate used to calculate the total volume of air sampled. If the flow rate changes by more than 20% during the sampling period, the monitor will be evaluated to determine if service is required. The data will be flagged and used for qualitative purposes only. The linear flow rate for the perimeter low volume air particulate samplers is 23 m/min at 40 l/min. The site perimeter airborne particulate and continuous radon and radon daughter monitors will be leak tested on an annual basis. Leak testing will be done to ensure that the measured volume of air passed through the filters or detection system.

The filters used to monitor the site perimeter are the same mixed cellulose ester filters used for site-specific monitoring. The filters are 47 mm in diameter, have a pore size of 0.8 μm and retain 99.98% of dioclyphalate particles with an aerodynamic mean diameter of 0.3 μm.

The perimeter air particulate samplers will be placed at approximately 2 m above the ground. The radon track etch detectors and the continuous radon and radon daughter monitors will be placed approximately 1 m above the ground, respectively. The locations where samplers, detectors, and monitors will be placed are free from unusual localized effects or other conditions (e.g., in proximity to a large building, vehicular traffic, or trees) that could result in artificially high or low concentrations with the exceptions of the WSQ perimeter monitors. Several of the WSQ perimeter monitoring stations are in proximity to trees. Because the trees

serve as a natural barrier to airborne emissions, the trees will not be removed from the areas near the monitoring locations. In addition, due to the limited space available along the ridge at the southeastern perimeter of the WSQ, the stations cannot be moved to monitor the area and not be in proximity to the trees.

The radon detectors that will be deployed are track etch detectors that have a minimum sensitivity of 0.2 pCi/l. The vendor stated accuracy for the radon tract etch detectors is $\pm 25\%$ of the measured concentration. Data from 1990 indicated the average accuracy was $\pm 17\%$ with an average concentration of approximately 4.5 pCi/l which includes background. The detectors will be placed in pairs at each of the locations, and will be exchanged on a quarterly basis.

The air particulate filters will be counted to determine the gross alpha concentrations using an alpha scintillation detector or a gas flow proportional detector. The counting times for samples will in general be 60 min for the alpha scintillation detector and 5 min for the gas-flow proportional detector. The difference in count times between the alpha scintillation detectors and the gas-flow proportional detectors is due to differences in the background count rates and efficiencies of the instruments.

Each sample will be collected for a period long enough to ensure that a minimum detectable gross alpha concentration (MDC) of 1E-15 μCi/ml can be obtained. Because naturally occurring Po-210 and Pb-210 exist in the atmosphere at concentrations on the order of 2.5E-15 μCi/ml, obtaining a MDC less than 1E-15 μCi/ml is of little value due to the interference from Po-210 and Pb-210. An MDC of 1E-15 μCi/ml is sufficient to detect concentrations less than the derived concentration guides (DCGs) for radionuclides that are present at the WSS. The MDC is dependent on sample valume (sample time multiplied by the flow rate), the efficiency and background count rate of the instrument used to measure the activity on the filter, and the sample an dbackground count times.

The total typical accuracy or uncertainty associated with a site perimeter air particulate sample at a gross alpha concentration of 1E-15 μCi/ml is 1E-16 μCi/ml. The total sample accuracy or uncertainty is dependent on the uncertainty associated with the volume sampled, detector calibration uncertainties with the determination of detector efficiency, and detector background count rate, as well as the uncertainty associated with the sample count rate. Because difference detectors are used and because of variations in the other sources of uncertainty, the

accuracy may vary, but 1E-16 μCi/ml represents a typical accuracy which would be achieved of a sample with a gross alpha concentration of 1E-15 μCi/ml.

The investigation levels that will be established for the perimeter air monitoring program are measured concentrations greater than the concentrations measured at the background station. The low volume air particulate sampler and the continuous radon and radon daughter monitor results will be compared to the background station results on a weekly basis. The radon track etch detectors will be compared to the background stations results on an annual basis.

The low volume air particulate samplers and continuous radon and radon daughter cumulative measured concentrations will be compared to the background station cumulative measured concentrations. The perimeter stations will be compared to the background station using a statistical test to identify locations that have weekly measured concentrations greater than background. If it is determined that the measured concentrations at a location are greater than the background station's measured concentrations, an investigation will be conducted in order to attempt to identify the source of above background concentrations.

Because the radon track etch detectors are collected on a quarterly basis, and as a result there are only four data points per year per location, the radon track etch detectors are compared to the background stations results only on an annual basis. Each location's monitoring results are compared to results from the background stations. If the results from a location are found to be statistically greater than the results from the background stations, an investigation will be conducted to determine the source of the above background concentrations, with the exception of the quarry monitoring stations which are historically greater than background because of the radiologically contaminated material that was placed in the quarry.

The QA/QC procedures for the low volume air particulate samplers are the same as those described for site specific monitoring.

The QA/QC procedures that will be implemented for the continuous radon gas and radon daughter monitors include calibration and source checks. The continuous radon gas and radon daughter monitor will be calibrated annually at the Technical Measurement Center at Grand Junction, Colorado.

The QA/QC procedures that will be employed for the perimeter radon track etch detectors include duplicates, spikes, chain-of-custody and laboratory authorization forms, field sheets, and review of vendor data. The pair of radon track etch detectors placed at each location will serve as duplicates. Three spikes, track etch detectors exposed to a known source, will be returned to the vendor for analysis on an annual basis. In addition, field sheets will be used during deployment and recovery of the radon track etch detectors to document detector locations and any unusual occurrences. Chain-of-custody and laboratory authorization forms will be filled out in accordance with the applicable SOP in order to track the radon track etch detectors. Finally, the data received from the vendor will be reviewed for any anomalies.

8.2.2.3 Critical Receptor Monitoring. The most accurate method of dose calculation at nearby receptor points is through the use of actual concentration measurements at these locations. Measurements from nearby receptor points or critical receptors will be an important element in determining the emissions from the WSCP/WSRP and the WSQ when used in connection with site-specific monitoring data and the perimeter air monitoring data. Critical receptors are defined as those locations at which individuals abide or reside where the highest potential off-site concentrations of radionuclides other than radon are likely to occur during remediation of the Weldon Spring site (WSS). The sites that were selected as critical receptors are located within 0.62 mi of the WSS where members of the public may spend at least 8 hr/d for a significant fraction of the year.

Critical receptor locations AP-2001, AP-4006, AP-4008, and AP-2005 (Figure 7-1) are strategically located to measure radioactive airborne emissions for the WSCP/WSRP at points where maximally exposed individuals reside or abide. Station AP-2001 is at the common boundary of the WSCP and Missouri Highway Maintenance Facility. Station AP-4008 is located at the Weldon Spring Army Reserve Training Area. Station AP-2005 is located between the WSCP and the WSSRAP administration building. Station AP-4011 (Figure 7-3) is located 165 ft from the nearest residence 0.12 mi west of the WSQ.

Other facilities (i.e., the St. Charles County Water Treatment Plant and the Weldon Spring Height subdivision) are located near the WSS; however, because of the greater distance and previous monitoring data from closer critical receptor locations indicating that there has been no reason to suspect above-background radioactive airborne concentrations with 95% confidence, these facilities are not considered critical receptors.

The critical receptor monitoring program will utilize high volume air samplers, low volume air samplers, and radon track etch detectors at all locations; and continuous radon and radon-daughter monitors at critical receptor locations AP-2005 and AP-4006, and the background station AP-4012. The high volume samplers have heavy duty, turbine-type blowers and feature an electronic controller that automatically adjusts the speed of the sampler to correct for variations in line voltage, temperature, pressure and filter loading. The low volume air samplers are the same samplers described in site perimeter air sampling. They have dual diaphragm air pumps at all locations with the exception of the critical receptor nearest the WSQ (Figure 7-3) that utilizes the carbon vaned air pump. The continuous radon and radon daughter monitors are the radon track etch detectors as described in the site perimeter air monitoring program.

Mass flow meters will be used as described in the perimeter monitoring program for the low volume air samplers. A mass flow meter will also be used to measure and set the flow rates of the high-volume air samplers. The low volume and high volume air particulate samplers will be run continuously at 40 l/min and 950 l/min respectively. The linear flow rates for the low volume and high volume air particulate samplers are 48 m/min and 23 m/min respectively. The low volume air samplers, and the high volume air samplers flow rate will be checked at the end of each week and then readjusted to the desired flow rate after the new filter is installed. The start and finish flow rates will be averaged, and the average flow rate used to calculate the total volume sampled. If the flow rate changes by more than 20% during the sampling period, the monitor will be evaluated to determine if service is required. The data will be flagged and used for qualitative purposes only.

The critical receptor high volume and low volume air particulate samplers will be leak tested on a annual basis. The leak testing will be used to ensure that the measured volume of air is passing through the sample collection filter.

The filters used for the low volume air samplers are the same filters used for site specific monitoring, and are 99.98% efficient in retaining 0.3 μm DOP particulates at a flow rate of 32 l/min across 100 cm^2. The high volume air samplers use 203 mm x 254 mm glass fiber filters that have a mean DOP efficiency of 99.99% for particulate diameters of 0.3 to 0.4 μm.

The low volume air particulate samplers and continuous radon and radon daughter monitors will be placed at the same height specified in the perimeter monitoring section. The high volume air particulate samplers have a sample height of approximately 2 m. In addition,

the monitoring receptor stations will be located in proximity to unusual localized effects or other conditions (e.g., in proximity to a large building, vehicular traffic or trees) that could result in artificially high or low concentrations.

On a quarterly basis, each of the 13 weekly filters from high volume air particulate samplers at critical receptors and at the background station will be composited by location. The composite sample will then be dissolved and divided into three aliquots. The 18 composite samples (three aliquot from six sampler locations) will be analyzed for isotopic thorium, isotopic uranium, Ra-228, and Ra-226.

The filters from the low-volume air samplers will be collected on a weekly basis and analyzed for gross alpha concentrations using the same procedure described in the perimeter air monitoring program. The data stored in the continuous radon-gas and radon-daughter monitors will be collected weekly as described in the perimeter air monitoring program.

The investigation level for the critical receptor monitoring locations will be concentrations greater than background concentrations. The monitoring results from each location will be compared to the background stations location using a statistical test. If a station is found to be statistically different than background, an investigation to attempt to determine the source of the above background airborne radioactive material will be conducted.

The quality control procedures for the low volume air samplers and the continuous radon-gas and radon-daughter monitors will be the same as those described in the perimeter air monitoring program. The quality control program for the high volume air samplers will include spikes, duplicates, and blanks.

With each group of high volume sampler filters sent for radiochemical analysis, two filters will be spiked with known activities of Th-230, and two filters will be spiked with known activities of natural uranium (U-238, U-235 and U-234 in natural activity ratios). Since each filter composite collected at critical receptor locations is split into thirds, these thirds will serve as duplicates.

Field blanks will be collected each week when filters are exchanged. A field blank is an unused filter that is taken with the technician in the field. In addition, an unused filter will be collected directly from the filter package. The two sets of blanks will also be composited and

analyzed radiochemically. Results from the blank composite will be used to identify field or laboratory contamination of filters.

In addition to the system of spikes, duplicates, and blanks, the radioanalytical analyses will be evaluated for internal consistency. At the WSS, U-238 and U-234 are in secular equilibrium. Uranium concentrations on air filters should also be in equilibrium. When radioanalytical results are provided, the degree of equilibrium will be evaluated. In most cases, Th-228 and Ra-228 are also in equilibrium. Equality between these radionuclides will also be evaluated.

8.3 Asbestos Monitoring

During 1992, site perimeter air monitoring for asbestos will be routinely performed only when asbestos removal is taking place. Perimeter asbestos monitoring locations at the WSCP/WSRP and at the WSQ are the same as those used for radioactive air particulate monitoring (Figures 7-1 and 7-3). At least two perimeter asbestos monitoring stations at the WSQ and WSCP/WSRP will be used: one upwind and the other downwind from the asbestos removal activities. A determination of which monitoring stations to use will be based on current meteorological condition when asbestos removal begins. During asbestos removal activities at the WSCP/WSRP, an asbestos monitor will be placed at the Francis Howell High School in the same location as the radioactive air particulate monitoring station. Finally, asbestos monitoring will be performed inside and adjacent to asbestos removal work areas.

When asbestos removal activities are being performed at the WSS, daily asbestos monitoring will be performed in the immediate work area. Samples from the perimeter asbestos monitoring stations will be collected on a weekly basis. Samples from the Francis Howell High School monitoring station and from monitoring stations inside and adjacent to asbestos removal work areas will be collected on a daily basis.

9 ENVIRONMENTAL MONITORING PROGRAM ADMINISTRATION

This section describes the activities that will constitute much of the structure and substance of the environmental monitoring program at the site. Aspects of data management and presentation are discussed along with regulatory compliance and the performance of dose assessments. In addition, the performance of special studies that are outside the scope of this document, emergency preparedness, and changes in the scope of investigations are also addressed.

9.1 Data Analysis and Statistical Treatment

Proper data analysis and statistical treatment practices are essential to produce quality results from the effluent monitoring and environmental surveillance programs required by DOE 5400.1 and DOE 5400.5 and the *Regulatory Guide*. Therefore, it is necessary to develop a plan for implementing the following action items:

- Determining contaminant concentrations at each sampling location for each sampling period, and evaluating the accuracy and precision of those concentrations.

- Comparing the contaminant concentrations at each sampling location to previous concentration estimates at that point and to identify changes or inconsistencies in contaminant levels.

- Comparing the contaminant concentrations at each sampling location to the established limits for those contaminants.

- Comparing contaminant concentrations at single sampling locations or groups of locations to those at control (i.e., background) or other points and evaluating the reliability of those comparisons.

In order to ensure that environmental data are reviewed in a consistent manner and that appropriate and timely action is initiated when and if criteria are exceeded, the Weldon Spring Site Remedial Action Project (WSSRAP) has taken steps to establish investigation levels. The criteria applied by WSSRAP for defining the investigation levels for all environmental monitoring data (except asbestos) are described in several ES&H procedures. The procedures

have been written to direct the WSSRAP staff in the evaluation of the monitoring data. These evaluations will determine whether data collected over the course of routine environmental monitoring programs exceed specific action levels and refer to an administrative procedure (still in draft form) which will define the general actions to be taken for eceedence of any criteria. These procedures include:

ES&H 4.6.4 - *Constant Flow Low Volume Air Sampler Operation and Air Sample Filter Handling*

ES&H 4.6.6 - *Constant Flow High Volume Air Sampler Operation and Air Sample Filter Handling*

ES&H 4.6.7 - *RGA-40 Radon Gas Monitor: Operation and Data Handling*

ES&H 4.9.3 - *Surface Water and Groundwater Data Review Procedure*

These procedures are intended to effectively address the U.S. Department of Energy (DOE) guidance criteria for determining investigation levels for environmental monitoring programs.

The statistical techniques used to evaluate and analyze the data will be designed with consideration for the characteristics of effluent and environmental data. These characteristics may include skewed distributions of time series data, high variability analytical results, large amounts of missing data, and data that are below analytical detection limits.

9.1.1 Summary of Data Analysis and Statistical Treatment Requirements

The following sections summarize the methods of data analysis and statistical treatment of the effluent and environmental data. Immediately upon receipt from the laboratory, all new data will be evaluated against the corresponding historical statistics and entered into the WSSRAP environmental database. Apparent outliers will only be excluded from use after investigation confirms that an error has been made in the sample collection, preparation, measurement, or data analysis process.

Data will be summarized using a range, variance, standard deviation, standard error, median, mean, and confidence interval about the mean. The confidence level of the data will be estimated by using blank and spike samples, and comparing the results of these analyses to the known concentrations. The precision of the data will be estimated by comparison to replicate samples.

9.1.2 Variability of Effluent and Environmental Data

The variability of the effluent data will determine the degree of precision and accuracy that can be achieved with the results. Careful design and execution of the monitoring program can substantially improve the quality of the effluent monitoring and environmental surveillance results.

9.1.2.1 Sources of Variability. Variability of data may arise from six sources; sampling errors, analytical errors, statistical counting variations, data recording errors, and temporal, and spatial variability between environmental samples. Variability due to sampling and recording errors can be controlled. However, variability due to the environment cannot be controlled and must be checked through statistical summaries.

9.1.2.2 Estimating Accuracy and Precision. The validation process will assess the accuracy and precision of each data set according to WSSRAP data validation procedure (RC-31a) using replicate samples. The *Annual Site Environmental Report* (ASER) will present the results of specific validated data points (10 percent of all environmental data collected) and will report the average and standard deviationof the accuracy and precision by data set, including parameter and media specific data points.

9.1.3 Summarization of Data and Testing For Outliers

In order to adequately analyze the environmental data, it must be summarized. Testing for outliers in new data sets also requires that historical data be statistically summarized. The following subsections describe statistical methods used to summarize the historical data.

9.1.3.1 Distribution Analysis. Most common statistical tests rely on the assumption that the data being tested follows a normal distribution. However, this is not the case for most environmental data which generally follows a log-normal distribution. Therefore,

all data sets containing 10 or more samples will be tested for distribution type and, if necessary, the appropriate transformation will be made prior to calculation of summary statistics. Alternatively, nonparametric hypothesis testing will be used.

9.1.3.2 Measures of Central Tendency. For normally distributed data with only a small number of extreme or less-than-detectable values, the arithmetic mean is the appropriate estimator of central tendency. When the data set contains large numbers of extreme values or concentrations below the analytical detection limits, the median, which is less sensitive to extreme values than the mean, will be used to summarize the data. Trimmed means or minimum variance unbiased estimators may also be used in these cases.

9.1.3.3 Measures of Dispersion. Dispersion in normally distributed data, without large numbers of outliers and less-than-detectable values, will be represented as a variance, standard deviation, standard error, or confidence interval. If a large number of extreme values are contained within a data set, the interquartile range and the median absolute deviation will be reported.

9.1.3.4 Less-Than-Detectable Values. An effort will be made to obtain uncensored radionuclide data. If nondetects (NDs) are reported, different techniques may be used depending on the percentage of NDs in the data set. For analyzing data sets with a small percentage of NDs, the special techniques described by Gilbert and Kinnison (1981) will be used. For data sets with a larger percentage of NDs, rank dependent or proportion type hypothesis testing will be used.

9.1.3.5 Testing for Outliers. Rosner's (1975) test for detecting outliers will be used when the data is normally distributed. If the data is log normally distributed, the test will be conducted on the log transformed data.

9.1.3.6 Elements of Good Practice. Procedures will be used to aid in the interpretation of the effluent monitoring data and improve the quality of the results from the program by helping to detect erroneous measurements. Comments on the quality of the samples taken will be entered into the data base with the sample contaminant concentration measurements. In addition to the data collected during the regular sampling program, field logs describing events that might affect contaminant concentrations will be reviewed and incorporated as appropriate.

9.1.4 Treatment of Significant Figures

Any calculations performed using the analytical data will follow the accepted rules for significant figures. Results of any calculations will not contain more significant figures than that of the least precise value used in the calculation.

9.1.5 Parent-Decay Product Relationships

The delays associated with sample collection to sample analysis are insignificant compared to the half-lives of the radionuclide present and routinely monitored at the WSS. Therefore, it is not necessary to take into account decay times when calculating parent-decay product relationships.

9.1.6 Comparisons to Regulatory or Administrative Control Standards and Control Data

One reason for obtaining reliable estimates of contaminant concentrations at the monitoring stations is to compare the values to regulatory or administrative control standards or values at control stations to determine whether action must be taken to reduce the contaminant levels in the effluents.

9.1.6.1 Single Concentration Measurements. Statistical tests are not appropriate for comparisons of single values, such as when a single radionuclide concentration measurement is compared to its regulatory limit. Single values can have a large associated uncertainty, and they are not necessarily an accurate representation of how well the facility is complying with the limit. Statistical summaries of groups of related samples will be used when possible. If single concentration measurements cannot be grouped, statistical tolerance limits will be used.

9.1.6.2 Groups of Measurements. Concentration estimates from groups of sampling locations will be compared using standard analysis of variance techniques when the data meet the underlying assumptions of those tests. Standard nonparametric statistical comparison techniques will be used when the assumptions of the parametric tests are not met by the data. Caution will be used when comparing groups of readings from single points over time, because of the likely strong autocorrelation in the time series of data.

9.2 Dose Calculations

This section is intended to provide a description of models, computer programs, input data, and data sources that will be used to assess accurate and realistic radiation doses to the population and to a hypothetical maximally exposed individual that could result from remediation activities at the WSSRAP. Environmental monitoring data will be used either as direct input data in dose calculations or, where appropriate, will serve as data input in exposure and dose models.

The results of the dose calculations will be reported in the *Annual Site Environmental Report* (ASER). The methodology used to calculate the exposure point concentration and estimate dose will also be documented in the ASER.

9.2.1 Surface Water and Groundwater Dose Calculations

The radiological dose assessment from groundwater and surface water will be accomplished by using data gathered from groundwater and surface water effluents monitoring and environmental surveillance monitoring programs. Site-specific monitoring data representing surface water and groundwater radionuclide concentrations will be used as input in the dose assessment calculation. This data will allow a more accurate assessment of doses to a maximally exposed individual and the population surrounding the WSS.

The exposure and dose assessment estimate will be conducted for both the general off-site population and a maximally exposed receptor. Intake variables for a given pathway will be selected to reflect a reasonable, realistic exposure mode.

The results from the surface water and groundwater effluent monitoring and environmental surveillance programs will be evaluated in the ASER for the potential to contribute a radiological dose to a member of the general public. If measured concentrations in surface water and groundwater effluent from the WSS exceed natural background concentrations with 95% confidence, an exposure scenario will be developed to assess the dose. Realistic ingestion rates and times will be assigned for a maximally exposed individual. A standard dose conversion factor will be assumed and referenced for the calculations.

9.2.2 Airborne Radiological Dose Calculations

The radiological dose assessment from airborne emissions will be conducted using environmental data as well as computer models. Exposures for critical receptors and hypothetical maximally exposed individuals will be determined through monitoring data. For sources where perimeter monitors indicate exceedance of background with 95% confidence, population dose estimates will be made by computer modeling. This would constitute a change over previous monitoring years when computer modeling was not utilized. The new site specific monitoring program, in conjunction with existing perimeter monitoring data will be used to obtain a more reliable source term. This will allow computer modeling to be used if necessary.

The computer models that will be considered for use in this dose assessment include AIRDOS PC, LTSAMP, and COMPLY. COMPLY and LTSAMP are computer models that have the capability to assess radiological dose from airborne emissions at distances less than 300 m. COMPLY is a U.S. Environmental Protection Agency (EPA) computer model designed mainly to model emissions from stacks or vents rather than large diffuse sources. LTSAMP is a computer model developed at the Uranium Mill Tailings Remedial Action (UMTRA) project to calculate doses from large diffuse sources.

Because of the diverse nature of the sources at the WSSRAP, any one of these programs or all three may be used to assess doses due to airborne emissions from the two WSSRAP sources. The use of LTSAMP would also be dependent on gaining approval from the U.S. Department of Energy (DOE) headquarters.

Those pathways that are complete and could realistically contribute to the dose to a member of the general public will be assessed and documented in the ASER. Justification for elimination of any pathways will also be provided in the ASER. Scenarios that reflect realistic but conservative assumptions will be developed for those pathways that could contribute to the dose to a member of the general public. Realistic occupancy times will be assumed for potentially exposed individuals. Standard breathing rates and dose conversion factors from the Federal Guidance Report No. 11 (Eckerman et al. 1988) will be used in the calculations.

9.3 Records and Reports

The WSSRAP recognizes numerous DOE orders, notices, and directives in addition to Federal, State, and local regulations. Since the WSS is a remedial action project, rather than an operating facility, the distinction between applicable and nonapplicable guidelines must be determined when interpreting these regulations. The project must comply with appropriate regulations, and ensure that reports are written and distributed in a timely manner and records are properly maintained.

9.3.1 Reports and Reporting

The following DOE Orders: Order 5000.3A, Order 5400.1, Order 5400.5, Order 5284.1B and Order 5484.1 govern activities at the WSS. These orders are described below in the following paragraphs.

DOE Order 5000.3A, *Occurrence Reporting and Processing of Operations Information*, is a system of reporting those occurrences listed in 5400.1, 5400.5, and 5484.1. Occurrences are categorized into nine groups such as environmental, personnel radiation protection, and divided into three categories in order of decreasing severity: emergencies, unusual occurrences, and off-normal occurrences.

DOE Order 5400.1, *General Environmental Protection Program*, requires that all DOE facilities comply with those Federal, State, and local environmental protection laws that are applicable. Both environmental occurrences and routine monitoring reporting are covered. WSSRAP has prepared an *Environmental Protection Program Implementation Plan* (EPPIP) (MKF and JEG 1991a) to meet the specific requirements of DOE Order 5400.1. Environmental occurrences will be reported as stated in DOE 5484.1 and DOE 5000.3 in accordance with WSSRAP procedures. Reports prepared by the WSSRAP include the *Environmental Monitoring Plan, Annual Site Environmental Report, Groundwater Protection Program Management Plan, Groundwater Monitoring Plan, Radioactive Effluent Information System and On-site Discharge Data Reports*, the *Quarterly Environmental Data Summary* and the *Environmental Protection Program Implementation Plan* (EPPIP).

The *Environmental Monitoring Plan* (EMP) details environmental and effluent sampling. The EMP is reviewed annually, as needed, and reissued at least every three years. The *Annual*

Site Environmental Report (ASER) presents data results and interprets these results, highlighting any unusual data. The ASER is produced annually (see Section 9.3.1.1). The *Groundwater Protection Program Management Plan* structures the groundwater program into a consistent program which facilitates periodic review. This plan is reviewed and updated annually. The *Groundwater Monitoring Plan* is taken directly from the EMP, with the focus on the groundwater monitoring program. The *Radiation Effluent Information System and On-site Discharge Data Report* is an annual report which consist of a letter and DOE form F 5821.1 which covers any releases from the site. The *Environmental Protection Program Implementation Plan* (EPPIP) as mentioned above outlines DOE Order 5400.1 as it applies to WSSRAP. This plan is updated annually and should be referred to for a complete and thorough listing of applicable regulations.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, states that Department of Energy facilities will adopt specific standards and requirements that will not allow undue risk from radiation to effect the public or the environment. The WSSRAP has formulated its environmental protection program to meet the requirements of this order and the regulatory guide.

DOE Order 5482.1B, *Environment, Safety, and Health Appraisal Program*, establishes a review and appraisal program for the Environmental, Safety and Health (ES&H) programs at WSSRAP. There are six levels of appraisals and audits: management appraisals, technical safety appraisals, functional appraisals, internal appraisals, environmental surveys, and environmental audits. Each appraisal and audit requires a quarterly status report or a report as otherwise directed, to report on corrective actions.

DOE Order 5484.1, *Environmental Protection, Safety, and Health Protection Information Reporting Requirements*, outlines requirements and procedures for investigating occurrences which may impact environmental protection, safety, and health. Occurrences are categorized into three levels - A, B, and C. In addition, the Annual Radiation Exposure Information Reporting System (REIRS) requires an annual report of any exposures obtained by DOE or Project Management Contractor (PMC) employees, nonemployee radiation workers, and visitors.

9.3.1.1 Annual Site Environmental Report Description. The WSSRAP *Annual Site Environmental Report* (ASER) presents the findings of the environmental monitoring program conducted at the Weldon Spring site (WSS) in each monitoring year. The report

presents summary environmental data, discusses compliance with environmental standards, and highlights significant programs and efforts undertaken at the WSS. Annual environmental monitoring reports have been prepared for this site (or portions thereof) since 1981.

This DOE Order also requires a listing of environmental permits. Existing permits and compliance with those permits is discussed in the report.

The ASER is the DOE's vehicle for documenting the results of its extensive monitoring program at the WSSRAP. The report provides the public and concerned regulatory agencies with summary level discussions regarding the routine environmental monitoring program. It explains how the WSSRAP effluent monitoring program meets the requirements of the National Pollution Discharge Elimination System (NPDES) program and compares the measured contaminant levels to applicable standards. Further, the report indicates whether changes are occurring in contaminant distribution or contaminant source conditions on and around the site--changes which might equate to variations in potential exposure scenarios to the public or environmental receptors.

Environmental monitoring is the WSSRAP's most effective means by which to assess the impacts from the site. The data and evaluations contained in the report provide the summary of that monitoring for each monitoring year. The ASER reports results of the contaminant level measurements and compares the environmental levels of radioactivity and chemical contaminants released from the site with applicable standards.

In addition to the routine environmental monitoring conducted in each monitoring year, a number of related activities and special studies are performed. These activities and studies are directly applicable to the assessment of the overall impact of site operations on the environment. Therefore, these activities are described and the results are discussed in the ASER. These include Oak Ridge National Laboratories (ORNL) research on site, Federal Facility Agreement driven activities, and activities not scoped in this EMP.

The report contains trend analyses and figures for groundwater wells, definitions of selected terms used in the report, a discussion of the environmental guidelines that apply to the monitoring program, and presents dose assessment calculations.

Though not required by a DOE Order, the *Quarterly Environmental Data Summaries* (QEDS), are produced to aid in communicating site environmental data to the public and participating regulatory agencies. The QEDS summarizes environmental data, highlights any significant findings, and offers tentative interpretations. The QEDS allow preliminary data to be reviewed by interested individuals and organizations on a more frequent basis.

Permits issued under the National Pollutant Discharge Elimination System (NPDES), provisions of the *Clean Water Act*, also require recordkeeping and reporting. Recordkeeping requirements are stated in the NPDES permits issued by Missouri Department of Natural Resources (MDNR). Discharge Monitoring Reports (DMRs) are issued on a quarterly basis to MDNR and include information on sample collection, flow, and laboratory results. If there is a noncompliance event, MDNR must receive an oral response within 24 hours followed by a written response within five days. Written reports may also need to be filed with the DMRs.

The DOE Performance Indicator Program (PI) is a requirement of SEN-29-91, that calls for the production of a quarterly report. This program allows trending and analyzing operational data which will improve the DOE and contractor line management control of operations. The report contains a management summary, a PI summary, trends and analysis, and quantitative data.

Under the Federal Facilities Agreement, DOE must submit status reports of activities and technical documents to EPA for their review and approval. These include, but are not limited to, the ASER, EMP, QEDS, sampling plans, and unplanned sampling activity notifications. Each of these reports have their own reporting requirements and time constraints which are detailed in the *Federal Facility Agreement Implementation Plan* (MKF and JEG 1991g).

Other reports covering environmental issues are produced by the Environmental Compliance Department. The *Quarterly Compliance Report* is required by SEN-7-89. This report covers issues of non-compliance for the quarter with corrective actions. Also, the *Annual Report on Environmental Permits* is issued annually to the DOE. this report is required by DOE Order 5400.2 and covers all environmental permits issued to the site.

9.3.2 Records

DOE Order 5400.1 requires that all environmental surveillance and effluent monitoring records, computer programs, raw data, and procedures be maintained. These records must be protected against damage or loss. The WSSRAP maintains an *Environmental Data Administration Plan* (EDAP) (MKF and JEG 1991h) which governs sampling plan preparation, data verification and validation, database administration, and data archiving.

The EDAP provides a tracking system for sampling activities. Field log books and field data forms are filled out at sample collection. A chain-of-custody (COC) form is completed and accompanies the sample until it is properly disposed of or returned to WSSRAP. A laboratory authorization form is sent along with the sample, COC, and the shipping order form to authorize testing by an off-site laboratory. The sample information, such as identification number, date, and parameters is then entered into the Environmental Sample Tracking (EST) System. EST tracks the samples, calculates costs, invoice payments, and budget reports. Upon receipt of data from a laboratory, it is reviewed through verification and validation processes. The verification process reviews data delivery, sample preservation and identification, chain of custody, holding times, and data review to ensure compliance with DQO and standard operating procedures, validation reviews and evaluates laboratory data.

Data is accessed by the DOE and the PMC using a computerized data management program developed on site, the Generic Universal Report Utility (GURU). The database allows data to be selected and sorted based on identification number and parameter. Records are protected from alteration by the user.

Other computer programs used are: the Safety, Health, And Radiation Protection (SHARP) program, the Site Wide Audit Tracking System (SWATS), and the Waste Inventory Tracking System (WITS).

All environmental data and documentation from sampling, analysis, and quality review programs are maintained in hard copy records; i.e., documents and data in written, typed, or printed forms; and electronic records, i.e., computerized records of environmental data. Original documents are transferred to Quality Assurance and stored in the WSSRAP quality control area in a fireproof safe. Copies are kept in the ES&H files. Work data files and

electronic data records are maintained by the Data Administration sections and archived annually.

For a more detailed description, refer to the *Environmental Data Administration Plan* (MKF and JEG 1991h).

9.4 Environmental Activities Varying from EMP Scope

When additional characterization and monitoring activities are conducted that are not defined within the scope of the EMP, a judgement will be made by the Environmental Protection Group Manager as to the relevance of each of those activities to the overall environmental reporting requirements. An example of an activity which might be reported in the ASER is a soil or water characterization effort that exceeds the scope of those previously performed in the area. Conversely, an example of activities that may not warrant ASER reporting are what are termed "engineering characterization" efforts performed in support of various construction activities at the site. Those data would not contribute significantly to the overall understanding of the environmental conditions at the site.

During the 1992 monitoring year, it may be determined necessary to alter the scope of the monitoring program. In such case, the changes in monitoring schedule, frequency, and/or location will be authorized by the Environmental Protection Group Manager with notification given to the ES&H Department Manager. All variances from the program scope will be documented with a memorandum to project management and reported in the ASER.

9.5 Emergency Preparedness

The WSSRAP maintains on site the management and staffing structure necessary to respond to environmental and medical emergencies. Plans and procedures are in place that detail the response and reporting program, implementation criteria, and routine environmental response and safety drills. The specific plans which address these measures include: the *Emergency Response Manual* (MKF and JEG 1991j) and the *Emergency Preparedness Plan* (MKF and JEG 1991k). These plans encompass environmental emergencies, spills, fire, medical and natural disasters.

9.6 Laboratory Programs

Laboratories that are performing analysis for the *Environmental Monitoring Plan* are mainly using Contract Laboratory Program (CLP) methodologies. For certain analyses (such as radiochemical) the laboratories are using EPA 600 (drinking water), EPA 900 (radiochemical analysis of drinking water) or a method that is reviewed and approved by the PMC prior to analysis of a sample. Contracted laboratories have all submitted a site-specific *Quality Assurance Project Plan* (QAPjP) to the WSSRAP and have sent controlled copies of their standard operating procedures (SOP). The QAPjP and SOPs are reviewed and approved by the PMC prior to sample shipment to a laboratory. All of the current laboratories being used by WSSRAP have had a preliminary assessment of their facilities to make sure that they have the capability and facilities to perform work according to the specifications in their contract.

Site-specific QAPjP from laboratories consist of standard practices that ensure that the laboratory is performing high quality work. Each QAPjP prepared for WSSRAP is in accordance with the current *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans* (EPA 1980). The laboratories also demonstrate compliance with additional QA/QC as specified in their contracts which includes: sample preparation and analytical methods; calibration of instrumentation; periodic inspection, maintenance and servicing; statistical procedures to control precision and accuracy; corrective action programs; participation in external EPA Performance Audit Program; maintenance and storage of WSSRAP records; hardcopy and electronic formatting; notification of nonconforming issues; and WSSRAP internal QC samples.

Accuracy of all chemical and radiological analyses of water media samples is monitored by the routine use of control samples. This is a requirement of many published protocols (i.e., EPA) and is good laboratory practice. At the WSSRAP, 10% of all data are routinely validated (according to the WSSRAP Data Validation procedure) including all associated control samples. Also, approximately 8% of the existing database has been validated and its overall accuracy has been determined. These accuracy values have been extrapolated to represent the accuracy of the database as a whole.

Further, for radiological analyses which use counting methods, the counting accuracy is also assessed and reported with each such data point from the laboratory. These values are presented in the database under the "percent error" field.

Specific analytical methods used by the laboratories are specified in their contracts and documented by the PMC receiving controlled copies of the SOP used by the laboratory. Any changes to the standard analytical methods are documented in the controlled SOP copies.

The details of the WSSRAP data collection and management program are included in several documents including the *WSSRAP Environmental Data Administration Plan* (EDAP) (MKF and JEG 1991h) and various ES&H department procedures. The EDAP presents the minimum detection levels for environmental sample analysis by media and parameter. The levels represent the contract required detection limits (CRDLs) under the EPA Contract Laboratory Program (CLP) and represent the levels to which the laboratories are required to perform. Often times the laboratory instruments can achieve lower levels based upon the calibration, operational efficiency, and sample media and concentrations. In such cases, this instrument detection limit (IDL) is requested to be reported. Analyses for nitroaromatic compounds are performed according to USATHAMA-approved methods, which generally achieve lower detection levels than EPA Method 609. For water analyses, all samples are analyzed first by gas chromatography, with all positive detection confirmed with high performance liquid chromatography (HPLC). Radiological analyses are conducted by either EPA Method 520/5-84-006 or EPA Method 600/4-80-032. Again, these minimum detection levels are reported in the Appendix of the WSSRAP *Environmental Data Administration Plan.*

10 QUALITY ASSURANCE

Quality assurance (QA) for environmental monitoring activities at the Weldon Spring site (WSS) is divided into two separate categories. The first, programmatic or overall project QA, relates to the incorporation and documentation of the quality of all site activities. This approach is discussed in section 10.1. The second category is specific to the environmental monitoring activities presented in this plan and is discussed in Section 10.2.

10.1 Programmatic Quality Assurance

The Weldon Spring Site Remedial Action Project (WSSRAP) is obligated to comply with the requirements of American National Standards Institute (ANSI) and American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance Program-1 (NQA-1-1986) as outlined in DOE Order 5700.6B. These requirements were developed to assure that work performed at facilities handling, processing, or utilizing radioactive materials is of documented quality. To satisfy this obligation, Morrison Knudsen Corporation has prepared a corporate *Quality Assurance Manual* (MKC 1991) which addresses's the requirements of NQA-1. This corporate plan is consistent with the 18-element format of NQA-1. In addition to this corporate plan, the Project Management Contractor (PMC) has prepared a project specific quality assurance program plan (QAPP) which details how the various aspects of NQA-1 and MK-Ferguson's quality assurance program, as described in the corporate QA manual will be implemented at the Weldon Spring site. This QAPP has been reviewed and approved by project management, the project's Quality Assurance Manager, and the U.S. Department of Energy (DOE) Project Manager.

The QAPP details numerous ANSI/ASME NQA-1 requirements which support, control, or guide the environmental monitoring program. These requirements include: documented project organization, a documented quality assurance program, a document control system, the identification and control of items, inspections, the control of measuring and test equipment, handling, storage, and shipping of quality-affecting items, a program for implementing and verifying corrective action, a program for maintaining quality assurance records, and a routine audit program. QA procedures detail implementation of these requirements. Specific procedures include: QAPP-8, *Nonconformance and Corrective Action*, QAPP-9, *Quality Assurance Records*, QAPP-10, *Audits*, SQP-1, *Site Wide Audit Tracking System* and SQP-2, *Quality Assurance Surveillance*.

The WSSRAP also has prepared an environmental QAPP (EQAPP) to meet the intent of EPA QAMS 005/80. This document supports the project QAPP and is specific to environmental monitoring and characterization. Effective February 1992, the QAPP and EQAPP will be revised to meet the requirements of DOE Order 5700.6C. Root cause analysis and lessions learned will be addressed by a WSSRAP specific document which is presently being drafted and will be completed in 1992.

10.2 Environmental Monitoring Program Quality Assurance

The quality of the environmental monitoring program is maintained and documented through a number of measures described in the following subsections. The measures include: the use of standard operating procedures, the collection, analysis, and evaluation of quality control samples, performance audit samples, the use of standardized analytical methods, data management activities (data verification), data quality evaluation (data validation), maintaining quality assurance records, performing self assessments, supporting project quality assurance personnel in auditing and evaluating analytical laboratories, and audits by quality assurance personnel. Each of these items will be discussed in the following subsections.

10.2.1 Standard Operating Procedures

Standard operating procedures (SOPs) have been developed for routine activities associated with environmental monitoring at the Weldon Spring site. These procedures have been developed from U.S. Environmental Protection Agency (EPA) and DOE guidance and from standard industry practices and are specific to the WSS. Procedures at the WSS are prepared, reviewed, and approved by cognizant department managers, the Quality Assurance Manager, and project management. Controlled copies of procedures are maintained in accordance with the document control requirements of ANSI/ASME NQA-1. Procedures are reviewed at least annually and revised as appropriate.

Personnel undergo training specific to their responsibilities varying from procedure review through classroom training and "hands on" training under the supervision of a qualified individual. This training is tracked through the use of a training matrix. Each manager prepares for each individual a unique subset of procedures from all site procedures. Training records are maintained by the Productivity Improvement Coordinator. As procedures are revised, the matrices are updated and personnel are retrained.

TABLE 10-1 Procedures Applicable to Environmental Monitoring Activities

Procedure Number	Procedure Title
ES&H 4.1.1	Environmental Numbering System
ES&H 4.1.2	Chain of Custody
ES&H 4.1.3	Sampling Equipment Decontamination
ES&H 4.1.4	Packaging and Shipping Requirements for Non-regulated Samples
ES&H 4.3.1	Surface Water Sampling
ES&H 4.4.1	Groundwater Sampling
ES&H 4.4.2	Groundwater Level Monitoring and Well Integrity Inspections
ES&H 4.4.5	Soil/Sediment Sampling
ES&H 4.5.1	Ph and Temperature Measurements in Water
ES&H 4.5.2	Specific Conductance Measurement in Water
ES&H 4.5.7	Measurement of Settleable Solids
ES&H 4.5.8	Water Sampling Filtering
ES&H 4.6.1	Area TLD Deployment for Environmental Sampling
ES&H 4.6.2	Radon Concentrations Measurement in Ambient Air
ES&H 4.6.4	Constant Flow Air Sampler Operation and Sample Filter Handling
ES&H 4.6.6	Constant Flow High Volume Air Sampler Operation and Sample Filter Handling
ES&H 4.9.1	Environmental Monitoring Data Verification
CM&O-15	Task-specific Safety Assessments
RC-30	Monitoring Well Waste Management
RC-31	Environmental Monitoring Data Validation

Procedures applicable to environmental monitoring activities are listed in Table 10-1. These procedures cover all activities from groundwater sampling through chain-of-custody samples and provide detailed instructions to monitoring personnel.

10.2.2 Quality Control Samples

Numerous QC samples are collected in support of environmental monitoring activities. These include: duplicate samples, replicate samples, blank samples, and rinsate samples. Samples are also provided to the laboratory to perform internal laboratory quality control evaluations specific to sample media (matrix spikes and matrix spike duplicate samples). Table 10-2 presents a summary of the various quality control samples that will be collected to support environmental monitoring activities. Duplicate samples will be collected on a frequency of one per 20 samples collected or one per every 14 day period during which samples are collected if the sampling, by matrix, yields fewer than 20 samples during that period (EPA 1989). The WSSRAP will also participate in the DOEs laboratory cross-check program for radiological and chemical sample analyses. Performance audit samples prepared by an off-site laboratory will be submitted to WSSRAP-contracted laboratories for an evaluation of analytical performance.

10.2.3 Analytical Methods

Standardized analytical methods will be used to perform analyses related to environmental monitoring. This, combined with duplicate and replicate samples, will ensure that environmental monitoring results are comparable. The analyses to be performed and the analytical methods that will be used are discussed in Section 6 of this plan.

Each laboratory is required to prepared a project-specific *Quality Assurance Project Plan* (QAPjP). These QAPjPs are reviewed and approved by the WSS Project Quality Manager prior to performing analyses for the WSS.

10.2.4 Data Management Activities

Overall environmental data management activities for the Weldon Spring site are detailed in the *Environmental Data Administration Plan* (EDAP) (MKF and JEG 1991h). The EDAP provides guidance for the development of sampling plans, describes data management activities, and details general data quality requirements. These general data quality goals have been

Table 10-2 Field Quality Control Sample Summary

QC Sample Type	Frequency	Purpose
Duplicate	*1 per 20 or 1 per 14 days	Assess intralaboratory variability
Replicate	*1 per 20 or 1 per 14 days	Assess interlaboratory variability
Equipment Blank	1 per 20	Assess effectiveness of decontamination
Distilled Water Blank	1 per quarter	Assess quality of distilled water
Trip Blank	1 per day when analyzing for VOAs	Assess potential cross-contamination during shipping
Field Blank	1 per 20	Assess impact of ambient conditions on samples

* Whichever is of higher frequency

adopted for this monitoring program. The primary activities associated with this environmental monitoring program include data verification, database management, and data validation. These programs document the quality of data generated by on-site and off-site analyses of samples.

Data verification is the WSSRAP's process of reviewing the sampling documentation and analytical data to ensure that adequate documentation is maintained and that all results are reported in compliance with established reporting requirements. All data generated by analytical laboratories are verified.

The verification process consists of: reviewing accounting aspects, reviewing sampling documentation and chain-of-custody documentation, comparing actual holding times to method specified holding times, and a review of the data for comparability with historical results. All of these activities are documented according to Environmental, Safety and Health (ES&H) Procedure 4.9.1.

Following completion of data verification, data are merged into the site database and are available for general use. All databases are backed up regularly. Access to edit the data base is restricted to maintain the integrity the computer files.

Data validation is an independent (of the analytical laboratory) formal review of laboratory records performed to assess the quality of the reported data. Actual laboratory records are reviewed by data validation personnel to determine whether the analytical instruments were within calibration and to ensure that adequate documentation is available to support the validity of the data. Data validation is performed on approximately 10% of the all data generated. Approximately 5% of these data are randomly selected by the laboratory coordinator. An additional 5% is selected for validation based on the data review. Validation activities provide the WSSRAP with qualified data. All validated data receive a qualifier that provides information for data users to evaluate the useability of the data. These activities are performed and documented in accordance with procedure RC-31a/1.

10.2.5 Quality Assurance Records

Records generated as a result of environmental monitoring are maintained as quality assurance records. Field sampling forms, analytical data, equipment calibration records, and verification and validation documentation records are all considered quality assurance records and are maintained by the Quality Assurance Department in accordance with the requirements of QAPP-9. This provides both security and protection to critical records.

10.2.6 Self Assessments

Consistent with Department of Energy Order 5482.16, the WSSRAP has developed a formal self assessment program. This program is detailed in WSSRAP procedure MGT-1. Implementation of this procedure requires that all departments perform a self assessment at least annually. Self assessments are scheduled and tracked by the Quality Assurance Department and are performed by a team led by the manager of the department being assessed. A report which summarizes the areas evaluated and the assessment results is prepared following each self assessment. Findings and proposed corrective actions are tracked according to the Site Wide Audit Tracking System (SWATS).

10.2.7 Audits

Three aspects of the WSSRAP are audited to evaluate the quality-related activities of the environmental monitoring program. These include analytical laboratories, sample collection activities and programmatic procedures.

Analytical laboratories performing analyses for the WSS are audited annually. These audits are directed by a lead auditor from the Quality Assurance Department, with support provided by a select team of site personnel who have with knowledge of analytical methods and procedures. These audits focus on compliance with the project-specific *Quality Assurance Project Plan* (QAPjP) prepared by the laboratories prior to performing sample analysis and with laboratory-specific procedures and policies. An audit report is generated and corrective actions tracked by the QA Department.

The WSS QA Department routinely audits site operations, including environmental monitoring activities. These audits evaluate compliance with project-specific procedures. As with all other audits, an audit report is generated and corrective actions are tracked by the QA Department.

The Weldon Spring site is also routinely audited by numerous external entities including DOE - Headquarters and DOE - Oak Ridge. These audits assess compliance with applicable regulations, DOE orders guidance, site plans, and procedures. Formal reports and corrective actions are tracked using the SWATS.

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DOE ORDERS

5400.1	General Environmental Protection Program
5400.5	Radiation Protection of the Public and the Environment
5400.3A	Occurrence Reporting and Processing of Operations Information
5482.1B	Environment, Safety, and Health Appraisal Program
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements

PROCEDURES

ES&H 4.1.1	Environmental Numbering System
ES&H 4.1.2	Chain of Custody
ES&H 4.1.3	Sampling Equipment Decontamination
ES&H 4.1.4	Packaging and Shipping Requirements for Non-regulated Samples
ES&H 4.3.1	Surface Water Sampling
ES&H 4.4.1	Groundwater Sampling
ES&H 4.4.2	Groundwater Level Monitoring and Well Integrity Inspections
ES&H 4.4.5	Soil/Sediment Sampling
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ES&H 4.6.4	Constant Flow Air Sampler Operation and Sample Filter Handling
ES&H 4.6.6	Constant Flow High Volume Air Sampler Operation and Sample Filter Handling
ES&H 4.9.1	Environmental Monitoring Data Verification
CM&O-15	Task-specific Safety Assessments
RC-30	Monitoring Well Waste Management
RC-31	Environmental Monitoring Data Validation

CHEMICAL PLANT
201-1.14

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
7295 Highway 94 South
St. Charles, Missouri 63304

November 18, 1992

Mr. Dan Wall
Remedial Project Manager
U.S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Dear Mr. Wall:

SAMPLING PLAN FOR DETERMINATION OF HYDRAULIC PROPERTIES OF UNDISTURBED SOILS IN THE WELDON SPRING DISPOSAL FACILITY STUDY AREA

Enclosed are 2 copies of the above sampling plan. Principal elements of this plan include two-stage borehole field permeability tests and triaxial permeability tests using synthesized leachate. These tests are being undertaken in response to MDNR comments on site suitability issues. Additional testing activities are proposed to obtain information to be used to resolve remedial design and performance assessment issues. Portions of this plan have been made available, in draft form, to MDNR-DGLS staff in order to facilitate the timely acquisition of this data.

If you have any questions, please feel free to contact me.

Sincerely,

Jerry S. Van Fossen

Jerry S. Van Fossen
Deputy Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

cc w/enclosure:
Dave Bedan, MDNR (5 copies)
Mary Gilbert, PMC

DOE/OR/21548-164
CONTRACT NO. DE-AC05-86OR21548

SAMPLING PLAN FOR DETERMINATION OF HYDRAULIC PROPERTIES OF UNDISTURBED SOILS IN THE WELDON SPRING DISPOSAL FACILITY STUDY AREA

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

OCTOBER 1992 **REV. 1**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

MK-FERGUSON A MORRISON KNUDSEN COMPANY	Issue Date:
Weldon Spring Site Remedial Action Project Contract No. DE-AC05-86OR21548	Rev. No. 1
PLAN TITLE: Sampling Plan for Determination of Hydraulic Properties of Undisturbed Soils in the Weldon Spring Disposal Study Area	

APPROVALS

Environmental Documentation & Conceptual Design Manager — Date: 10-14-92

Quality Assurance Manager — Date: 10/15/92

ES&H Manager — Date: 10/15/92

Engineering Manager — Date: 10-14-92

Deputy Project Director — Date: 10/19/92

Project Director — Date: 10/19/92

DOE/OR/21548-164

Weldon Spring Site Remedial Action Project

Sampling Plan for Determination of Hydraulic Properties of Undisturbed Soils in the Weldon Spring Disposal Facility Study Area

Revision 1

October 1992

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

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ABSTRACT

Sampling and testing is proposed to obtain information on the hydrologic properties of site soils within the disposal facility study area (DFSA). Sampling and testing will focus on assessing the effects of naturally occurring fractures and synthesized leachate on soil permeability. Proposed activities will also help satisfy location standards defined by the Missouri Code of State Regulations for proposed landfills. Proposed activities include testing, exploratory trenches and laboratory chemical and physical analyses.

Six geotechnical boreholes are proposed to obtain soil samples for determination of saturated and unsaturated hydraulic conductivity and associated properties.

Sixteen two-stage borehole tests at six locations and five largey diameter sealed-double ring infiltrometer tests at four locations are planned to obtain information on in situ permeability of unsaturated site soils.

Three exploratory trenches are planned to obtain information on perched water conditions within the DFSA.

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1 INTRODUCTION

This sampling plan has been developed to provide the U.S. Department of Energy (DOE) and the Missouri Department of Natural Resources (MDNR) with reliable and reproducible data on the hydraulic properties of unsaturated soils at the Weldon Spring site (WSS) in the area of the proposed disposal facility (DF). Sampling and testing will focus on assessing the effects of naturally occurring fractures and synthesized leachate on soil permeability. This plan supercedes proposed actions outlined in the *Disposal Facility Siting Demonstration Proposal* (MKF and JEG 1991a).

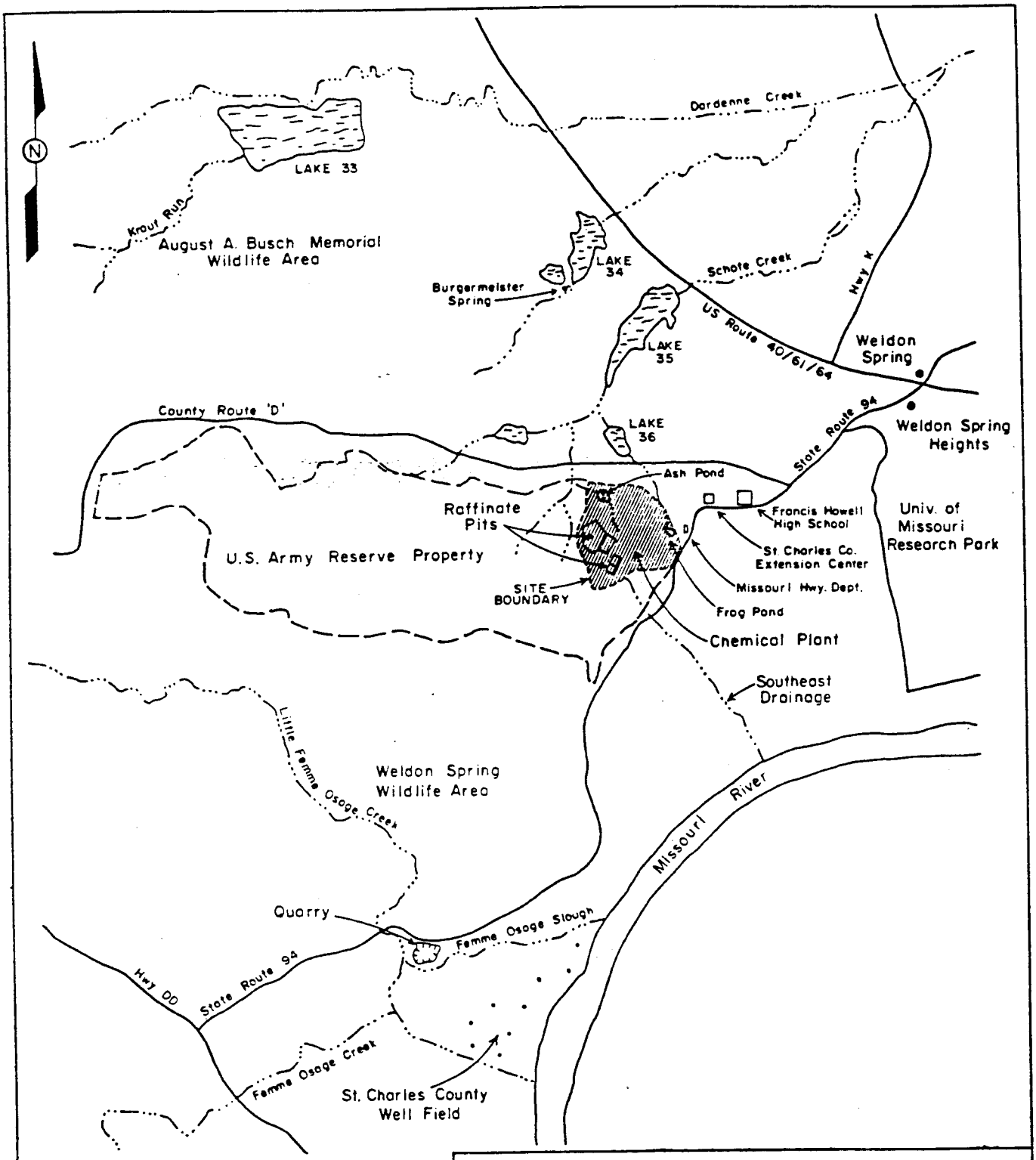
The WSS is a DOE surplus facility located in St. Charles County, Missouri (Figure 1-1). The site has been contaminated by trinitrotoluene (TNT) and dinitrotoluene (DNT) from past ordnance production activities and more recently by radionuclides and metals from the processing of uranium ore (MKF and JEG 1992a).

1.1 Purpose

The primary purpose of this investigation is to obtain representative soil samples of principal soil units beneath the proposed DF (Figure 1-2) and through laboratory analysis, determine their saturated and unsaturated hydraulic conductivity, the effect of leachate on soil permeability, and other hydraulic parameters. Fractures observed in the exposed glacial and post-glacial soils beneath the WSS are a concern to the State of Missouri and the DOE because of the effect these features might have on the hydraulic conductivity of the soils and the subsequent transport of leachate born contaminants.

This sampling program will also help satisfy design criteria for the cell foundation that are consistent with the Missouri Code of State Regulations 10 CSR 25-7.264(2)(N)1.A,B.

Zones within the overburden soils at the Weldon Spring Chemical Plant (WSCP) are considered to potentially contain perched groundwater. The remedial investigation report for the WSCP/Weldon Spring raffinate pits (WSCP/RP) areas summarizes the occurrence of perched water conditions known to exist at the site (MKF and JEG 1992a). Known areas of perched water are generally associated with seepage emanating from the raffinate pits. However, the site has been extensively reconfigured and differs from the topography that existed prior to development for the Weldon Spring Ordnance Works (WSOW). Therefore, it is reasonable to



WELDON SPRING SITE AND VICINITY

FIGURE 1-1

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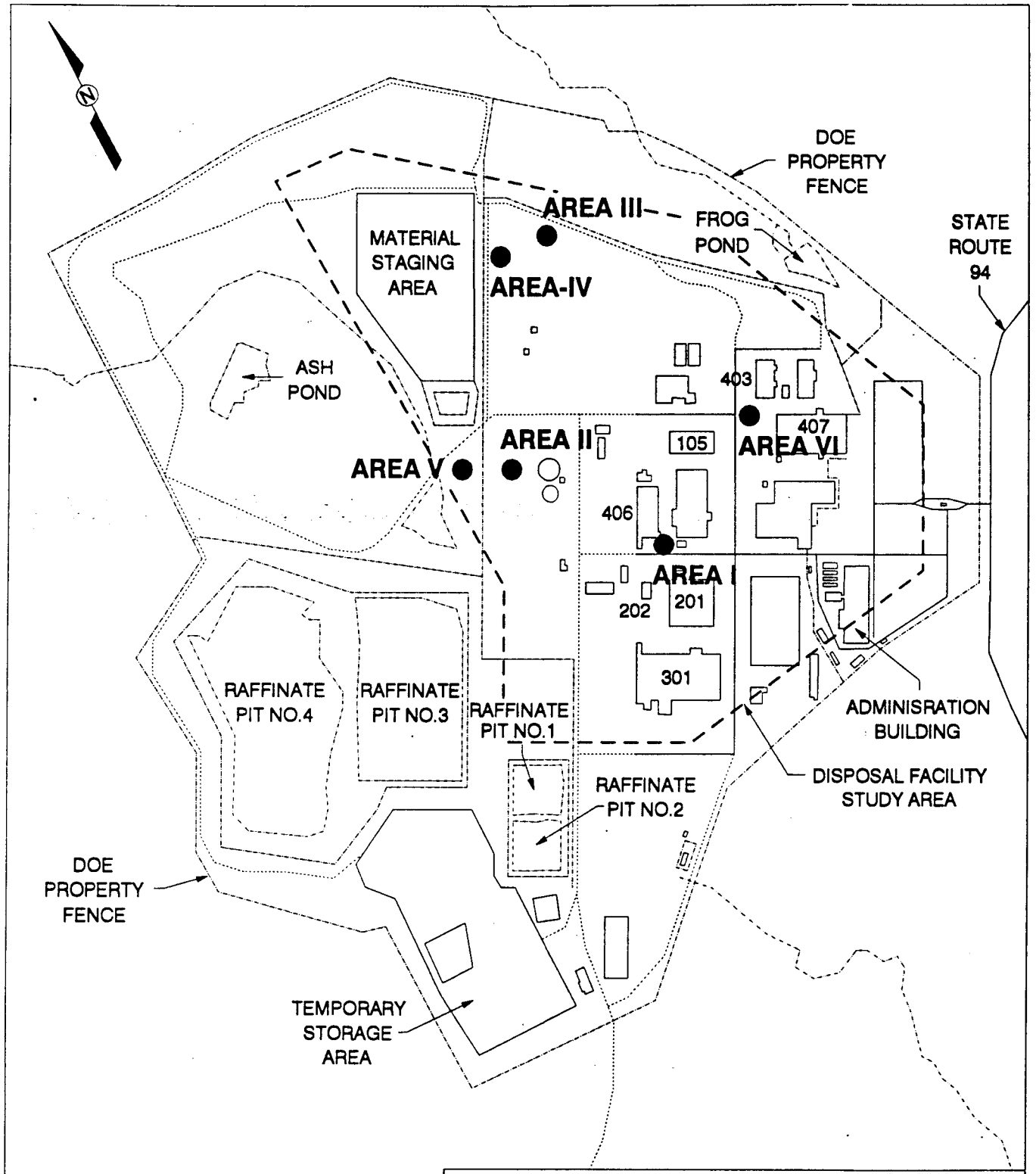

MAP OF THE WELDON SPRING CHEMICAL PLANT AREA SHOWING HYDRAULIC PROPERTIES SAMPLING LOCATIONS

FIGURE 1-2

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expect that pre-WSOW and pre-WSCP drainages actively transmit unsaturated flow at the fill and undisturbed soil interface. Organic soils may also be associated with perched water conditions. In order to facilitate the development a disposal cell foundation excavation plan, trenches will be excavated in locations specified as part of this plan to determine whether perched water or unsuitable soils are present. Figure 1-3 shows three trenches within the proposed DF footprint at locations of suspected seepages or perched water.

1.2 Scope

To determine the effects of fractures and other structures on soil permeabilities, field sealed double ring infiltrometer (SDRI) and two stage borehole (TSB) permeability tests (Boutwell 1992) of representative soil structures will be conducted in the proposed DF footprint. The permeability values obtained will be compared to those determined from laboratory techniques. Samples will be collected and tested as follows:

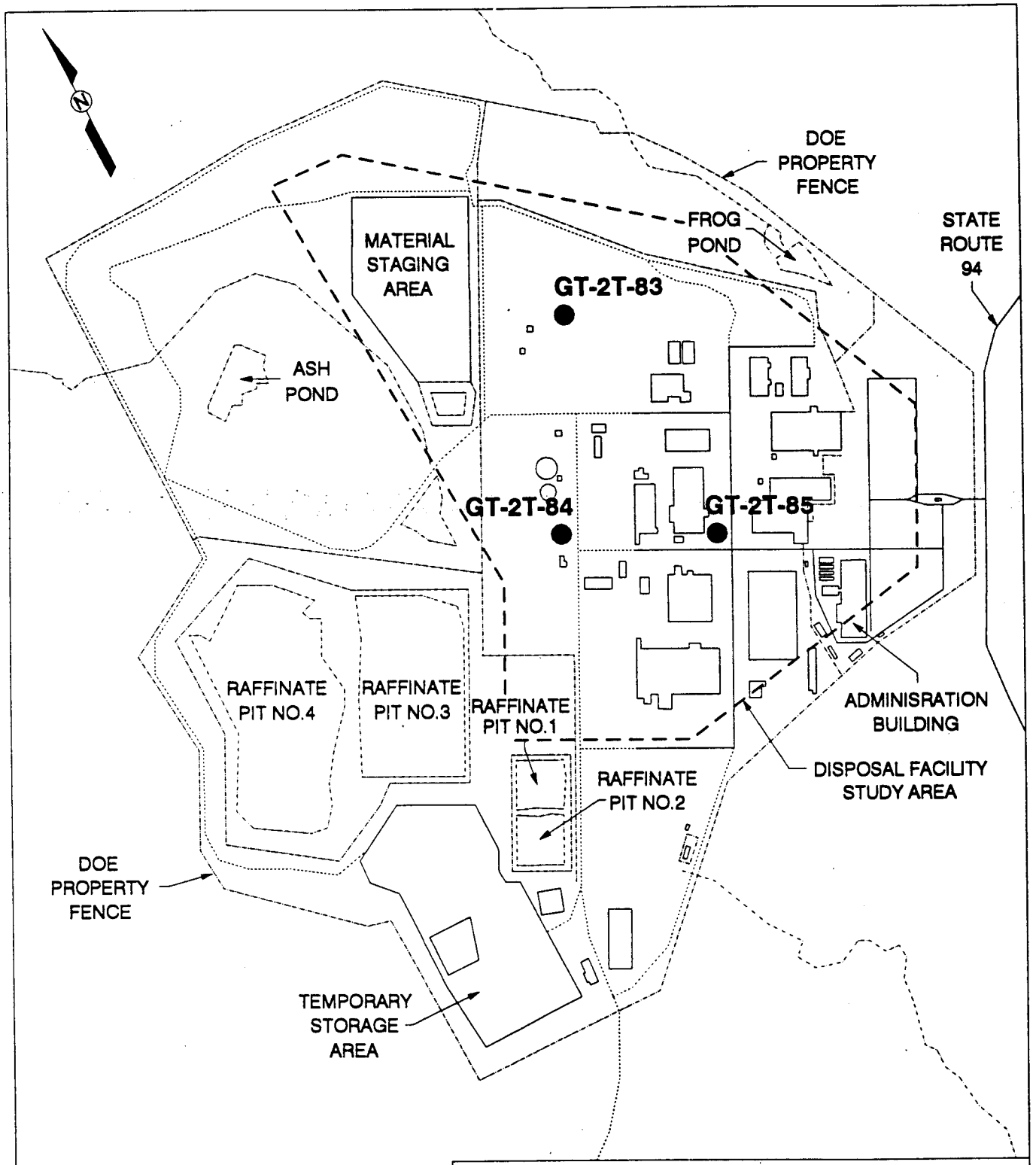
- Standard undisturbed samples (3-in. Shelby Tube type) will be collected for permeability test runs with both water and with a formulated leachate. Undisturbed and remolded samples from each unit of interest will be tested.

- Submersible pressure outflow cell (SPOC) tests will be run on standard-sized undisturbed samples to develop soil moisture retention curves. These curves will document the capillary retention properties of different units at varying temperatures. The saturated hydraulic conductivity will be determined directly from the tests; the unsaturated hydraulic conductivity will be calculated.

- General mechanical soil properties such as grain size distributions, Atterberg limits and specific gravities will also be determined from the standard size samples.

- Two stage borehole permeability (TSB) tests will be performed in the same locations and depths as the Ferrelview and clay till standard size samples.

- SDRI field tests will also be performed at the same locations and depths as noted above for laboratory testing and TSB tests.



LOCATION OF TRENCHES FOR PERCHED WATER INVESTIGATION

FIGURE 1-3

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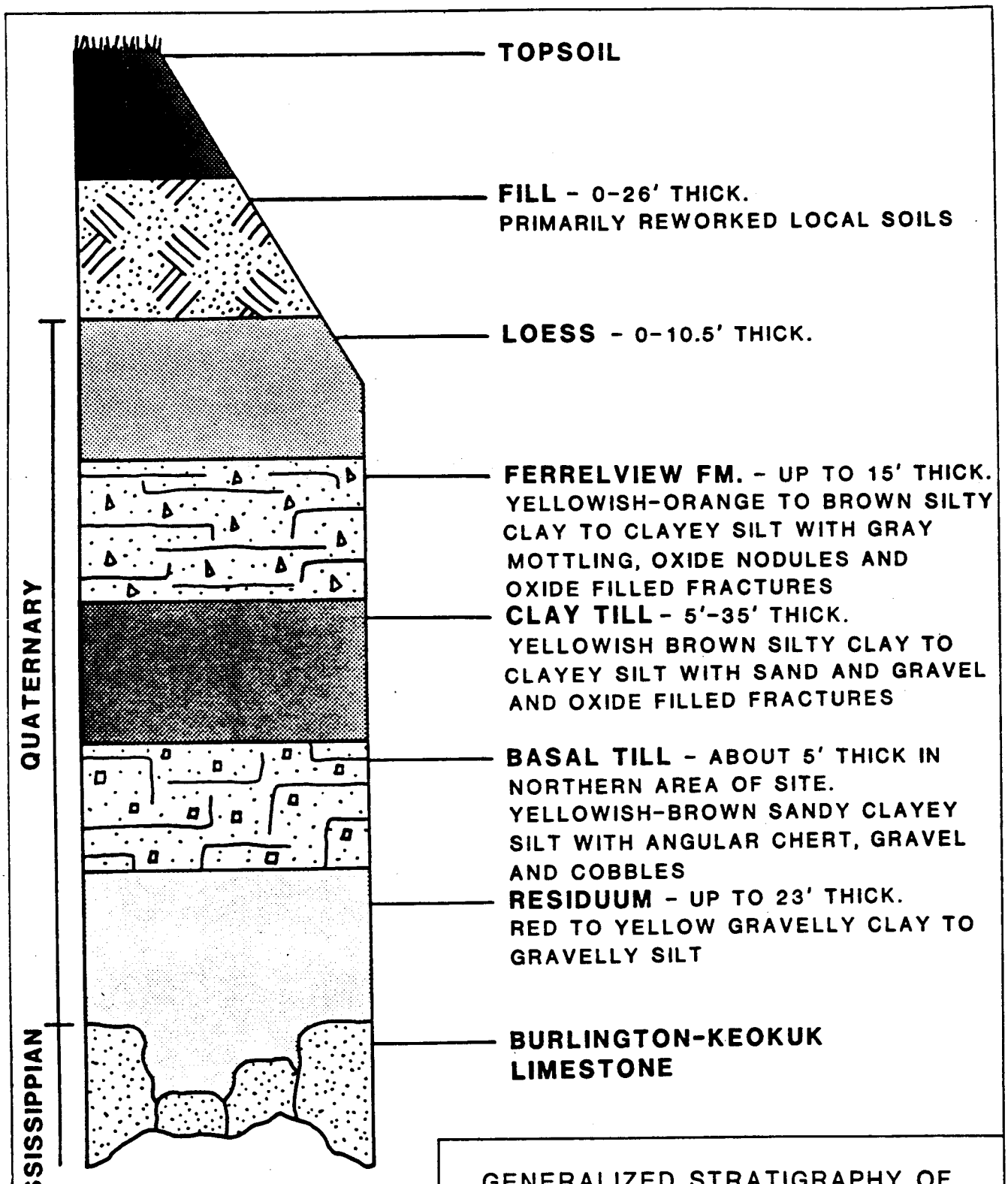
- Trenching will be performed to delineate and geotechnically characterize suspected seepages along backfilled former drainages at the WSS in the areas shown on Figure 1-3. Seepages occur at the contact of the old drainage surfaces and overlying fill.

1.3 Background

Past drilling and trenching programs at the WSS have delineated six principal soil units above the first bedrock unit. The Burlington-Keokuk Limestone is the first bedrock unit underlying the unconsolidated overburden (MKF and JEG 1992a). Figure 1-4 shows the generalized stratigraphy of the unconsolidated materials beneath the WSS (MKF and JEG 1990). The thickness of the unconsolidated material ranges from 15 ft to 40 ft beneath the WSS and is controlled by site development construction, surface erosional features, and bedrock topography. The unconsolidated material is generally thickest in the north-central portion of the site and becomes thinner toward the east.

In descending order, the six principal soil units are; the topsoil/fill unit, the loess unit, the Ferrelview Formation, the clay till unit, the basal till unit, and the residuum unit. The soil units of interest for the purposes of this investigation are the loess, Ferrelview Formation, and clay till units. The topsoil fill unit will be removed as part of the disposal facility foundation preparation. The basal till unit is thin and sporadically distributed under the site, and consequently this unit is not considered a good barrier to contaminant migration and will not be sampled. The residuum overlying the Burlington-Keokuk Limestone bedrock is highly heterogenous with significant percentages of coarse grained materials. It is not expected to retard contaminant migration to any significant extent. This unit will not be sampled or tested.

The upper Pleistocene loess unit underlies the topsoil/fill unit but is found mostly on hilltops (unless disturbed or removed by site construction activities). This unit is a windblown silt. It was affected by the topography at the time of its deposition and eroded from lower drainages by post-depositional stream action (MKF and JEG 1992a). The thickness of the loess varies from 0 ft to 10.5 ft across the site. The unit consists primarily of a silt to clayey silt with small amounts of sand. It has a low plasticity. The unit is the uppermost unit of interest with regard to permeability and other hydraulic properties.



NOT TO SCALE

GENERALIZED STRATIGRAPHY OF UNCONSOLIDATED MATERIALS AT THE WELDON SPRING SITE

FIGURE 1-4

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The Ferrelview Formation, another unit of interest for this investigation, is an interglacial deposit of mid-Pleistocene age, believed to have been deposited as a till plain sediment (Howe and Heim 1968). The transmissivity of these fractures and joints will be tested with samples obtained by this plan. Iron oxide nodules and conchoidal fracturing with slickensides are characteristic of this unit. Earlier particle size distribution laboratory testing of this unit has determined that it is primarily a silt to clay with small amounts of sand and fine gravel. Most particle sizes are less than 0.063 mm (0.002 in). The unit ranges from 0 ft to 22 ft in thickness across the site. A dark yellowish-orange to brown silty clay to clayey silt with gray mottling, this unit has joints or fractures, some of which contain secondary minerals such as pyrolusite.

The clay till unit underlies the Ferrelview Formation and is the most areally extensive overburden unit on the site. The clay till ranges in thickness from 0 ft to 30 ft and is found in almost all boreholes and trenches on site. This unit is a lower Pleistocene glacial till composed of yellowish brown silty clay and clayey silt. Pyrolusite as fracture coatings and nodules of iron oxide (limonite) are common. The unit is very stiff and moderately to highly plastic (MKF and JEG 1992a). The unit is characterized by pebbles of igneous and metamorphic origin. This soil unit is considered to have good potential as a barrier to leachate transport and will be sampled and tested in this investigation.

The basal till unit is the lowest member of the Pleistocene glacial sediments found on site. It underlies the clay till, reaching a maximum thickness of 5 ft in the area of Ash Pond and the western portion of the WSS. It is absent beneath the main portion of the WSS. It consists typically of yellowish-brown sandy, clayey silt with angular chert gravel and cobbles. The basal till will not be sampled in this investigation as it is too heterogenous, sporadic in distribution across the site, and too thin to rely on as a principal barrier unit with respect to leachate transport.

Modification of site topography for the Weldon Spring Ordnance Works, and later, the Weldon Spring Uranium Feed Materials Plant site development resulted in the placement of fill in natural surface drainages on the site. Infiltration and seepage from impoundments and leaky utilities on site has resulted in localized areas of saturated fill and topsoil within filled drainages. In some areas these conditions have resulted in a zone of perched water, while at other locations conditions may simply be characterized by porous fill or organic soil of a high moisture content. Section 2.4.2 of this sampling plan details plans to excavate trenches in locations suspected of containing perched water, or conducting seepage, within the Disposal Facility Study Area (Figure 1-3).

2 SAMPLE COLLECTION AND TESTING

2.1 Objective

The objective of this sampling plan is to provide representative undisturbed samples and field permeability test data necessary to determine the overburden permeabilities and hydraulic properties. Results of field and laboratory tests and field observations obtained from the implementation of this plan will be used in conjunction with the properties of engineered backfill to be placed as part of the cell foundation to achieve design criteria based on the state landfill location standards as defined under 10 CSR 25-7.264(2)(N)1.A,B.

2.2 Geotechnical Testing Requirements

The proposed laboratory testing program will follow American Society of Testing and Materials (ASTM), U.S. Army Corps of Engineers (COE), and U.S. Environmental Protection Agency (EPA SW-846) standards. Representative samples will be tested for general physical soil characteristics and engineering and hydrologic properties in order to characterize the ability of each overburden unit. General mechanical soil properties of interest include specific gravity, size gradation, soil classification, natural moisture, and dry density. Engineering properties include unconsolidated undrained triaxial compression and consolidated undrained triaxial compression tests.

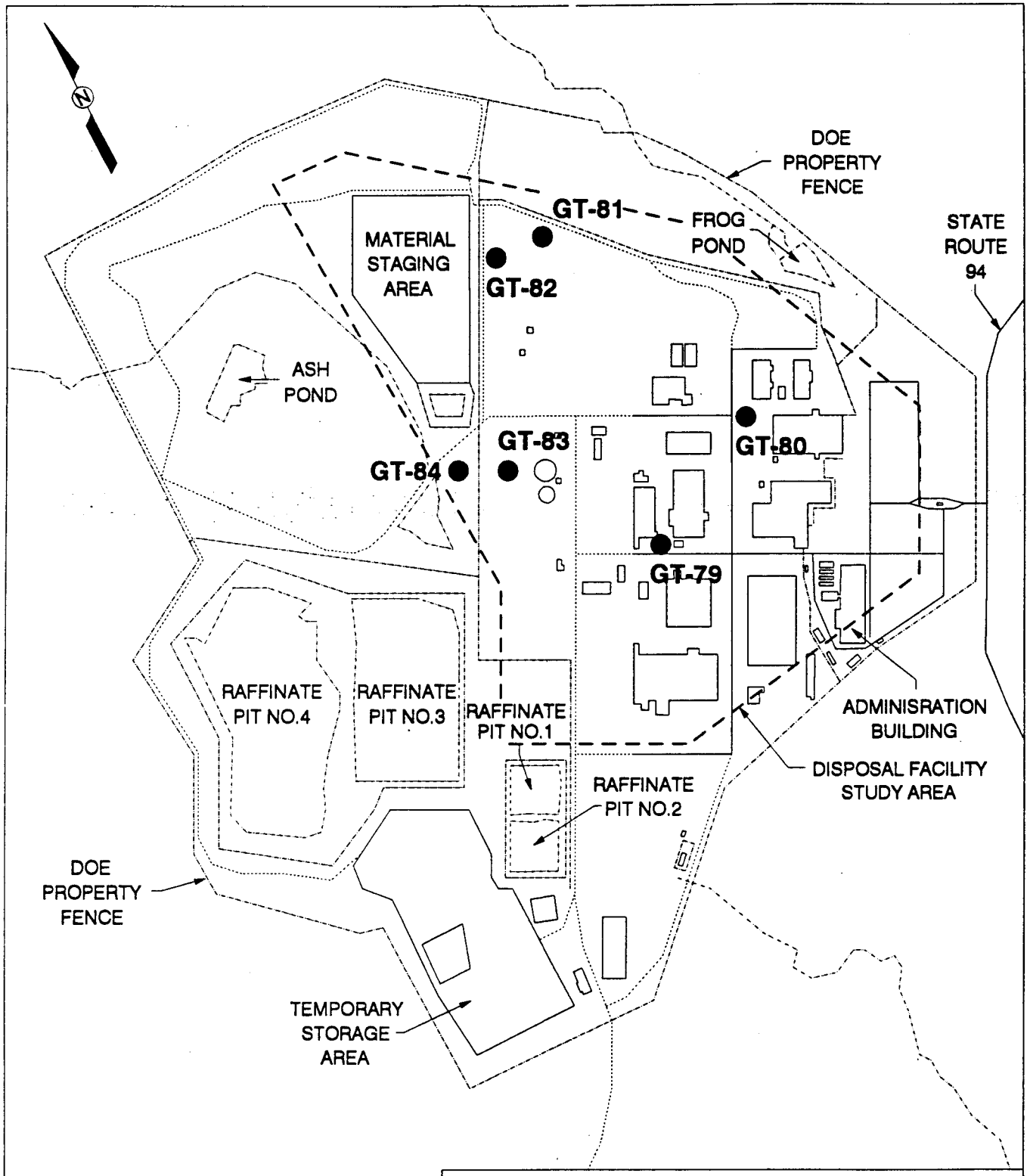
Table 2-1 lists the test methods, hydraulic properties of interest, and the sample type to be submitted for each test (ASTM standards were used unless a COE or EPA standard was preferred). Tests for which a standard has not been developed will be described in detail in the specifications for that phase of the study. Undisturbed and recompacted samples will be obtained by hollow stem augering and pushing Shelby (thin-walled) sample tubes. Leachate developed on site from cement stabilized/solidified material and soil will be used to test leachate constituent effects on the permeability of these samples.

Figure 2-1 shows the locations of, and numbering system for, the hydraulic properties samples (locations correspond to the areas of Figure 1-2). These samples will be taken prior to carrying out the sealed double ring infiltrometer (SDRI) and the two stage borehole (TSB) test programs. The boreholes will be used to further define the units prior to locating the in situ tests.

TABLE 2-1 List of Laboratory Hydraulic Tests

Soil Property (Test Method) Soil Unit	Sample Type		
	SDRI/TSB Support Undisturbed	Undisturbed	Recompacted
Moisture content (ASTM D2216) or Bush & Jenkins (1970) method:			
Loess Soil	-	3	-
Ferrelview Formation	4	9	-
Clay Till	3	9	-
Specific gravity and porosity (ASTM D854) or calculated from SPOC test:			
Loess Soil	-	3	-
Ferrelview Formation	4	9	-
Clay Till	3	9	-
Bulk soil density (ASTM D2937 or D1587-83) soil classification (ASTM D2487-90) and Atterbergs (ASTM D4318-84) (Includes tests for 12 TSBs):			
Loess Soil	-	3	-
Ferrelview Formation	4	15	-
Clay Till	3	15	-
Saturated hydraulic conductivity with water and leachate (EPA SW-846 Method 9100, or EM 1110-2-1906, Appendix VII, COE 1970):			
Loess Soil	-	1	1
Ferrelview Formation	-	6	1
Clay Till	-	6	1
Saturated hydraulic conductivity with water using Triaxial Cell Flexible Wall Permeameter (ASTM D5084):			
Loess Soil	-	2	-
Ferrelview Formation	4	6	-
Clay Till	3	6	-
Triaxial shear strength (ASTM D4767 or EM-1906, Appendix X, COE 1970):			
Loess Soil	-		
Ferrelview Formation	-	3CU, 3UU	1CU, 1UU
Clay Till	-	3CU, 3UU	---, ---
Soil water retention characteristics (SPOC Test Constanz and Herkelrath 1984):			
Loess Soil	-	3	
Ferrelview Formation	4	9	
Clay Till	3	9	
Saturated hydraulic conductivity with water, (EM 1110-2-1906, Appendix VII, COE 1970):			
Loess Soil	-	-	-
Ferrelview Formation	4	-	-
Clay Till	3	-	-

CU Confined undrained
UU Unconfined Undrained
- Not tested



SMALL DIAMETER GEOTECHNICAL BOREHOLES LOCATION MAP

FIGURE 2-1

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The current disposal facility construction plan does not use the loess soils for any structural load bearing fill. However, it is possible that some of this unit may unavoidably be incorporated into the facility's subgrade. Therefore, the hydraulic properties of the loess in both disturbed (recompacted-remolded) and undisturbed samples should be tested (MKF and JEG 1991a). On the other hand, the small volumes of loess soils relative to the Ferrelview Formation and clay till require only the minimum number of triaxial shear strength tests on this unit (Table 2-1). Field testing of the loess unit by either the TSB or the SDRI methods will not be necessary as these tests are for undisturbed, in situ conditions. During disposal facility (DF) construction, any suitable loess material present in the cell footprint will be excavated, mixed with other low permeability soil types, and recompacted.

The Ferrelview Formation and the underlying clay till all have a significant impact on the DF as leachate transport barrier units. These units will be tested for the effect of leachate on their permeabilities and shear strengths as undisturbed soil units (Table 2-1). The current construction plan for the DF will not disturb significant volumes of the underlying clay till unit, so this unit will not be tested for either remolded (disturbed) triaxial shear strength or remolded hydraulic conductivity parameters.

Table 2-2 lists the laboratory tests in support of the SDRI program. Individual SDRIs will be installed at four of the six areas. Areas I and II will not have any SDRIs installed. They will, however, have two each of the two stage borehole (TSB) permeameters installed. At each site, one TSB will be installed in the Ferrelview and one in the clay till. One Shelby Tube sample will be obtained for general engineering soil classification parameters from each TSB site.

The SDRIs will be constructed and maintained according to test plans and specifications specifically developed for the WSSRAP by D.B. Stephens & Associates (DBS&A) (1991). Figures 2-2 and 2-3 list locations and designations of the SDRI and TSB installations, respectively. Site Areas III and IV will be the locations for SDRI installations FP-01 and FP-02 (Figure 2-2), both installed in the clay till unit (Table 2-2).

Area V will have a duplicate set of SDRIs installed, one in the upper Ferrelview Formation (FP-03) and one in the lower Ferrelview (FP-04). A TSB will be installed near each SDRI to the same approximate depth. The purpose of these duplicate field permeameter installations is to determine to what degree the Ferrelview varies in permeability with depth.

TABLE 2-2 List of Field Tests and Supporting Samples

Test Area	SDRI No.	Soil Unit	TSB No.	Pre-Test[a] SDRI Samples for Soil Hydr. Prop.	SDRI Post-Test Soil Samples for Moisture and Bt	
I		Ferrelview	TSB 1	---	---	---
		Clay Till	TSB 2	---	---	---
II		Ferrelview	TSB 3	---	---	---
		Clay Till	TSB 4	---	---	---
III	FP-01	Clay Till	TSB 5	2[b]	12[c]	12
		Ferrelview	TSB 6			
IV	FP-02	Clay Till	TSB 7	1	12	12
		Ferrelview	TSB 8			
V	FP-03[d]	Ferrelview	TSB 9	1	12	12
	FP-04[e]	Ferrelview	TSB 10	2[b]	12	12
		Clay Till	TSB 11			
VI	FP-05	Ferrelview	TSB 12	1	12	12
		Clay Till	TSB 13			
Totals	5		13	7	60	60

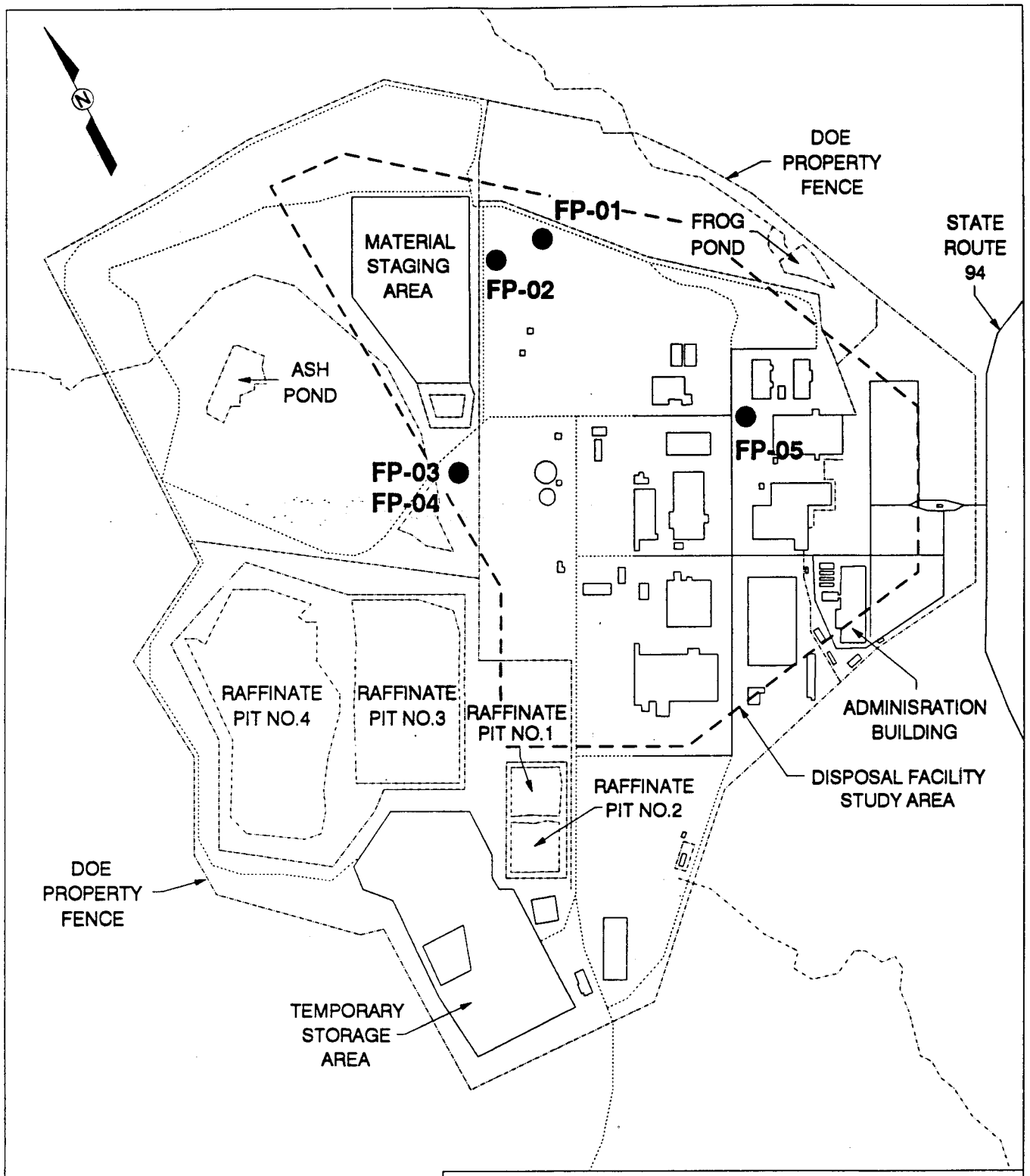
(a) Prior to running SDRIs, soil hydraulic property tests are those listed in Table 2-3.

(b) Duplicate soil samples for laboratory testing of hydraulic parameters at these locations.

(c) Estimated for 6 in. long samples taken continuously to bottom of wetting front (6 foot maximum depth).

(d) FP-03 will be constructed in the shallow portion of the Ferrelview Formation.

(e) FP-04 will be constructed in the deeper Ferrelview Formation.



SEALED DOUBLE RING INFILTROMETER (SDRI) TEST PADS LOCATION MAP

FIGURE 2-2

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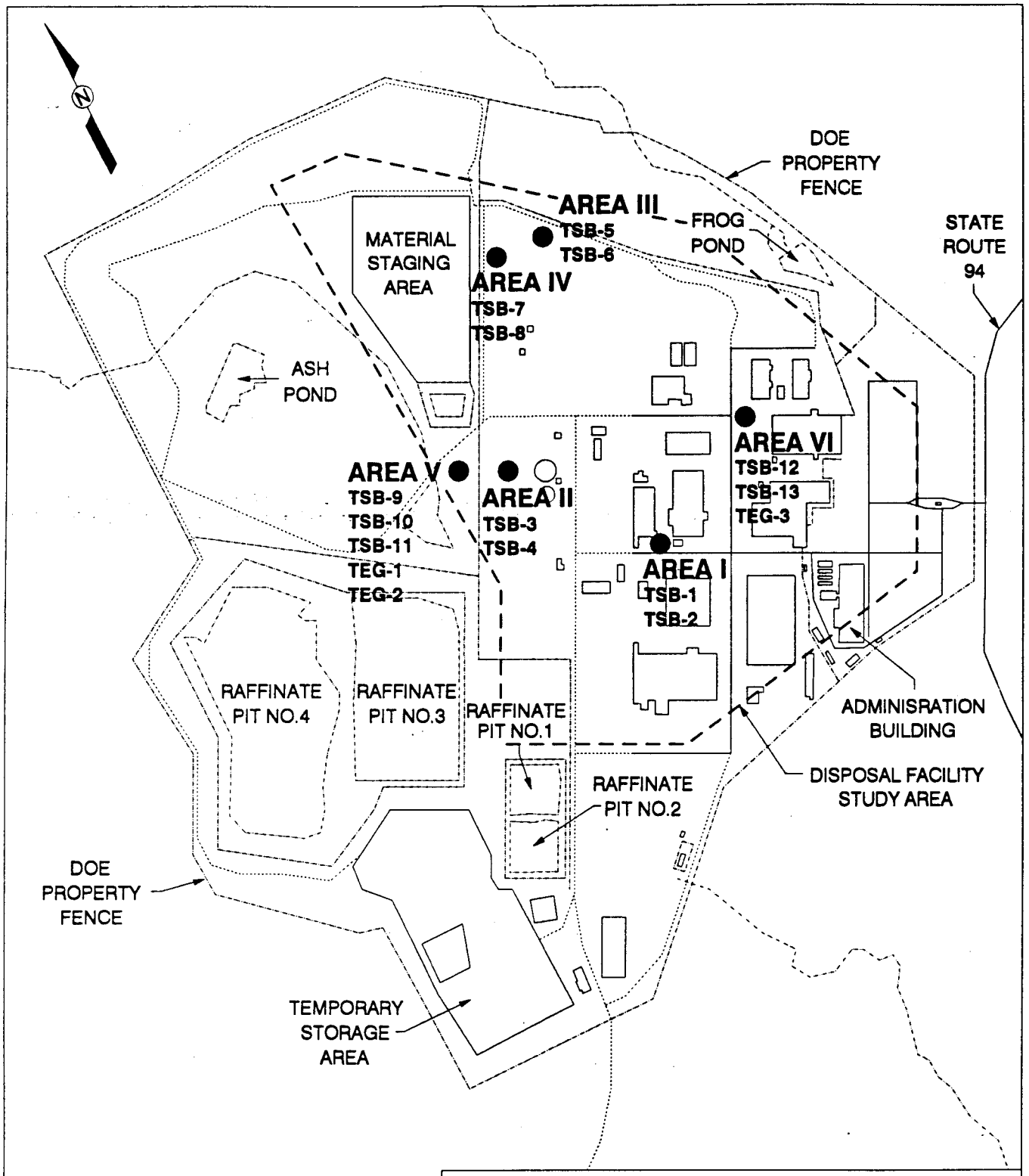


TWO-STAGE BOREHOLE (TSB) PERMEABILITY TESTS LOCATION MAP

FIGURE 2-3

REPORT NO.:		EXHIBIT NO.: A/CP/089/0892	
ORIGINATOR: SDG	DRAWN BY: GLN	DATE: 8/92	

Area VI will have one SDRI, FP-05 and two TSBs (Figures 2-2 and 2-3). One of the TSBs and the SDRI will be installed to test Ferrelview Formation. The remaining TSB will be installed to test the clay till at this location.

Each SDRI installation requires that initial, pre-test soil samples be taken (Table 2-2) for laboratory measurement of hydraulic soil properties. Table 2-3, as modified from DBS&A (1991), lists the specific test methods that should be followed in testing these pre-SDRI test samples. The number of tests required are included in the totals of Table 2-1. One sample for each soil type and location should be obtained. As shown on Table 2-2, two sets of duplicate soil samples will be obtained and tested for the complete set of hydraulic parameters as listed on Table 2-3. One set of duplicate soil samples will be for the Ferrelview Formation (potentially obtained from SDRI installation site FP-04, refer to Figure 2-2 for locations). The other set of duplicate soil samples will be for the clay till (potentially obtained from SDRI installation FP-01).

Post-test wetting front determination for the SDRI test is obtained by taking continuous thin wall tube samples from trenches excavated through the dismantled SDRI sites. The procedure for excavating the trenches, pushing the thin-walled samples, and ultimate wetting-front depth determination is detailed in DBS&A (1991) Sections 3.7, 3.8, and 3.9.

2.3 Sampling/Testing Locations and Identification

Sampling/testing locations are shown on Figure 1-2 as Areas I through VI. These locations were selected based on the following criteria.

- Minimum potential for future disturbance due to excavation of building foundations, underground utilities, or fill.
- Availability of the Ferrelview Formation and clay till unit.
- Easy access for sampling and testing equipment such as drilling rigs, backhoes, and infiltrometers.

The use of these criteria resulted in multiple sampling/testing locations in the northern portion of the disposal facility study area (DFSA) and a lack of locations in the southern portion

TABLE 2-3 Summary of Recommended Methods for Laboratory Hydraulic Parameter Testing of Soils at SDRI Sites

Hydraulic Parameter To Be Measured		Recommended Method	
1.	Soil-Moisture Retention Characteristics[a]	1.	SPOC Test
2.	Saturated Hydraulic Conductivity Using Flexible Membrane or Triaxial Cells	2.	ASTM D 5084-91
3.	Saturated Hydraulic Conductivity in Thin-Walled Sample Tubes	3.	Engineer Manual, 1980, Laboratory Testing of Soils, U.S. Dept. of Army, Office of Chief Engineer, Washington, D.C., Publication No. 1110-2-1906, Appendix VII, pp. 16-17.
4.	Unsaturated Hydraulic Conductivity (Calculated)	4.	van Genuchten, M., 1980, A Closed Form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils, Soil Sci. Soc. Am. J., v. 44, pp. 892-898.
5.	Volumetric Water Content[b]	5.	Bush, D.C., and R.E. Jenkins, 1970 (July), Proper Hydration of Clays for Rock Property Determinations, Journal of Petroleum Technology, pp. 900-904.
6.	Bulk Density	6.	Blake, G.R., and K.H. Hartge, 1986, Bulk Density, *In* Methods of Soil Analysis, Part I, Klute (ed.), American Soc. of Agronomy, Madison, WI, Chapter 13, pp. 363-367.
7.	Porosity (Calculated)	7.	Danielson, R.E. and P.L. Sutherland, 1986, Porosity *In* Methods of Soil Analysis, Part I, Klute (ed.), American Soc. of Agronomy, Madison, WI, Chapter 18, pp. 444-445.

Table is modified from D.B. Stephens & Associates, Inc. 1991.

[a] The Submerged pressure outflow cell (SPOC) method of Constantz and Herkelrath (1984) yields saturated and unsaturated hydraulic conductivity of soil specimens in the same apparatus. It is used here in lieu of ASTM moisture retention characteristics test methods D2325-68 and D3152-72.

[b] As recommended by D.B. Stephens & Associates 1991.

of the DFSA. This is because the units of interest are not easily accessible in the south and site remediation activities involving building demolition, foundation removal, fill removal, and contaminated soil removal will result in intense modification of surficial soils in the southern portion of the DFSA.

2.3.1 Area I

Sample Area I is in an open, grassy area, between chemical plant (CP) Building 202 and the main east-west site access road (Figure 1-2). The area is located on the south side of the road, across from CP Building 406, on a corner formed by the east-west access road and a deadend driveway that leads south to Buildings 201 and 301. The area is easily accessed by both these roadways. This location is near the center of the proposed DF's southern portion.

As shown on the logs of the three closest geotechnical boreholes (Appendix B, Figures B-2, B-3, and B-4), sporadic loess deposits of 0 ft to 3 ft in thickness may be encountered upon drilling in this area. The loess overlies between 7.5 ft to 17 ft of Ferrelview Formation (between 3 ft and 17.5 ft in depth). The Ferrelview overlies 10 ft to 20 ft of clay till, encountered at depths of between 15 ft to 20 ft. Appendix B, Figure B-1, summarizes symbols and designations used in geotechnical boring logs.

Area I will be the location for two TSB permeability tests. Table 2-2 lists the TSB and SDRI test sites, and the number and type of related soil samples. One TSB test will be conducted in the Ferrelview Formation and a second TSB test will be conducted in the clay till unit.

2.3.2 Area II

Area II is approximately 570 ft west and north of the first sample area, located just west of a large storage tank and the CP water tower. It also lies in an open area accessible from the east-west site access road. A source of subsurface control for this site includes test pit excavation GT-2T78 and geotechnical borehole log GT-53 (Appendix B, Figures B-5 and B-6). On the basis of this information, it is expected that 1 ft to 4 ft of topsoil, 1 ft to 2 ft of loess, 6 ft to 7 ft of Ferrelview Formation, 12 ft of clay till, and 1 ft to 2 ft of basal till will be encountered in this area. Two TSB permeability tests will be carried out at this site, one each in the Ferrelview and clay till soil units (Table 2-2).

2.3.3 Area III and IV

Areas III and IV are located 1,000 ft and 900 ft, respectively, to the north and west of Areas I and II (Figure 1-2). Area III is a at a lower elevation than the other areas, located just east of, and adjacent to, a drainage channel that flows north-northeast through the site. Area IV is just east of the material staging area (MSA) and adjacent to a roadway that runs north around the CP perimeter.

In Area III, the logs for G-7, T-6, GMW-9 (MW-2009), GT-42, and GT-69 (Appendix B, Figures B-7, B-8, B-9, B-10, and B-11) all indicate the presence of 0 ft to 2 ft of topsoil/fill overlying anywhere from 0 ft to 11 ft of Ferrelview Formation and loess soil (from 0.5 ft to 11.5 ft depth) in turn overlying 9 ft to 11 ft of clay till (from 1.5 ft to 20.5 ft in depth). The clay till increases in thickness to the west, in the direction of Area IV. One SDRI test and one TSB test will be conducted at the 8 ft depth in the clay till at this location. If a thickness of 5 ft or more the Ferrelview Formation is present, it will also be tested with the TSB method.

Area IV thicknesses are based on the logs of borings GMW-9 (Appendix B, Figure B-9), G-3 (Appendix B, Figure B-12) and GT-42 (also designated GT-2B42) (Appendix B, Figure B-10). The logs indicate a sequence of 0.5 ft to 4 ft of gravel fill overlying 6 ft to 11 ft of Ferrelview and 24 ft or more of clay till (beginning at 6 ft in depth and extending down to between 20.5 ft and 31 ft). Possible loess soil deposits could exist in this area within the upper 10 ft (see log GMW-9). This location will have a single SDRI installed in the clay till at approximately the 8 ft depth. Two TSB tests will be run at this location, one in the Ferrelview Formation, at an estimated depth of 5 ft, and one in the clay till unit at a depth of 8 ft (Table 2-2).

2.3.4 Area V

Area V is located just south of the MSA and east of the Ash Pond, near the intersection of two site roads, the Patrol Road that runs north-south and the Ash Pond Road (Figure 1-2). Geologic logs G-5, G-6, and GT-61 (Appendix B, Figures B-13, B-14, and B-15) indicate up to 14 ft of Ferrelview Formation, either exposed at the surface or overlain by 1 ft of fill; and 10 ft of clay till from approximately 14 ft to 24 ft in depth. Loess soil may on may not be present at this site as it appears from 2 ft to 5 ft in depth at GT-61, but is not reported on logs G-5 and G-6.

This area will be the site for two SDRI installations, one in the upper Ferrelview Formation approximately 2 ft in depth, and one in the lower Ferrelview at 10 ft in depth (Table 2-2). Three TSB tests will be run at this site. One TSB corresponding to each of the two SDRIs will be installed in the upper and lower Ferrelview. A single TSB test will be conducted within the clay till at this location (Table 2-2).

2.3.5 Area VI

Area VI is located at the northwest corner of the No. 407 Building Block, across the street from Building 105, to the west, and Building 403, to the north (Figure 1-2). Based on geologic logs G-8 and GT-55 (GT-2B55) (Appendix B, Figures B-16 and B-17), up to 6 ft of fill overlies 3 ft to 4 ft of loess (from 6 ft to 10 ft in depth). In turn, the loess overlies 6 ft to 10 ft of Ferrelview Formation (9 ft to 20 ft in depth) and 7 ft to 11 ft of clay till (from 15 ft to 27 ft in depth).

Area VI will be the location of a single SDRI test, constructed in the upper Ferrelview Formation at an estimated depth of 10 ft. Two TSBs will be run at this location; one at the same depth of Ferrelview as the SDRI, and a second one in the clay till unit at an estimated depth of 16 ft (Table 2-2).

2.3.6 Trench Locations

Figure 1-3 shows the locations of trenches proposed as part of this sampling plan. These trenches will be excavated to determine if filled drainages are presently acting to contain perched seepage or contain volumes of debris, organic material, or otherwise unsuitable soil which must be accounted for as part of the formulation of the disposal cell foundation excavation plan.

GT-2T-83

This trench location is in the coal pile area. The 1954 topographic map indicates the existence of a drainage and a surface drainage pipe in this location. The cut and fill map indicates the presence of 2 ft to 4 ft of fill. Adjacent areas contain up to 14 ft of fill based on information presented on the cut and fill map.

GT-2T-84

This trench location is about 85 ft northeast of Building 412. The map of 1954 topography indicates the presence of a drainage and surface drainage pipe in this area.

GT-2T-85

This trench location is about 80 ft north of the northernmost corner of Building 408. the 1954 topographic map indicates the presence of a drainage and closed depression in this area. Since this location is next to a site road, excavation will take place at the northwest corner of the road. Site development drawings indicate that this area is free of subsurface piping and utilities.

2.4 Sample Collection Methods

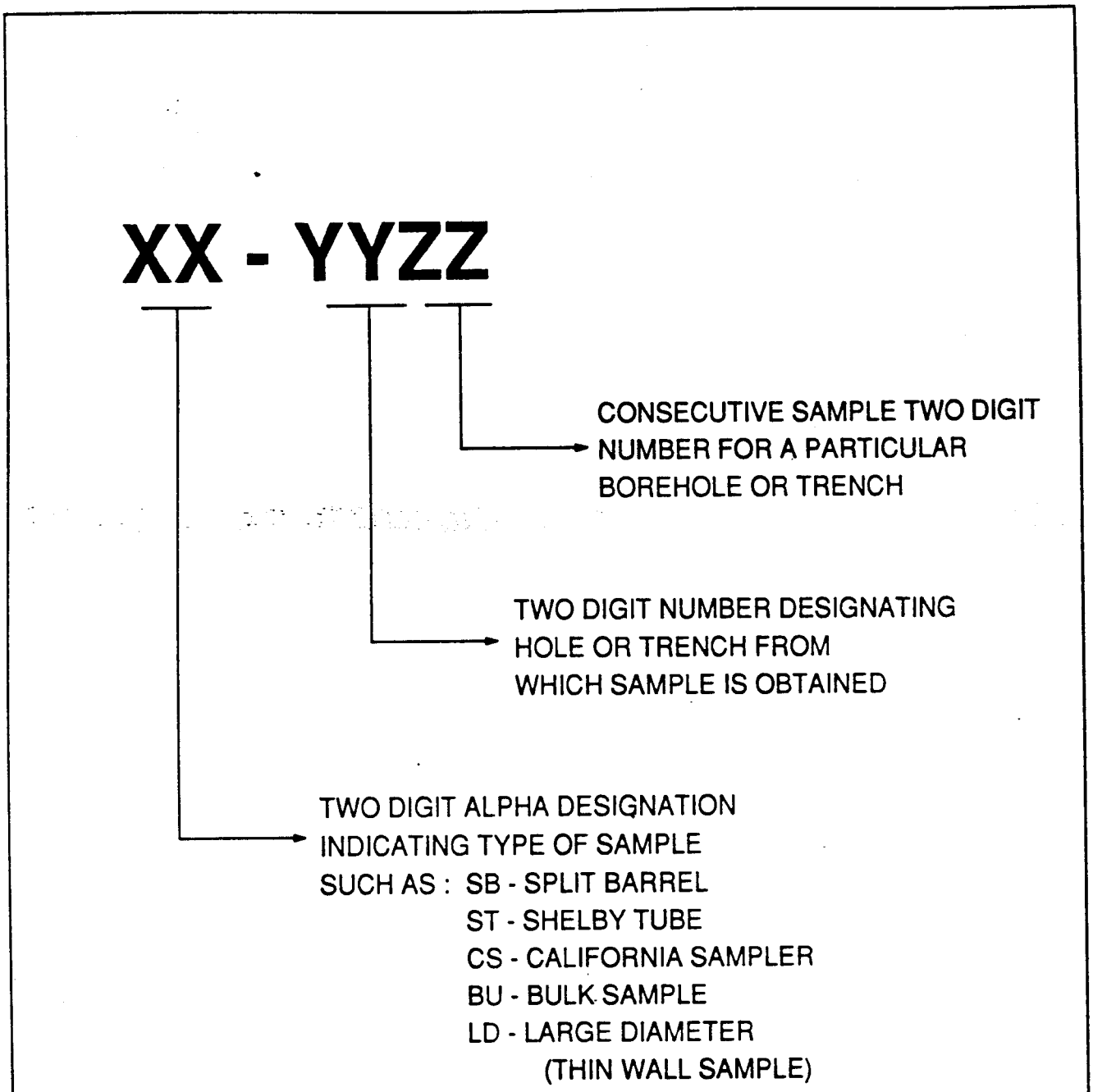
Figure 2-4 presents the alphanumeric designation that will be used for all sample identification.

2.4.1 Soil Hydraulics Sample Collection Methods

Sample collection methods will vary depending on the particular test method (see Table 2-1). Disturbed and undisturbed samples will be collected in a continuous manner at each sample area using a hollow-stem auger drilling rig. A minimum of one sample per unit from each of the test areas will be obtained. Sampling methods, sample preservation and shipping, and field descriptions of each unit sampled will be in accordance with ASTM, EPA and COE standards as they apply to each of the test methods being sampled for (ASTM D620, COE EM 1906, EPA SW-846). Undisturbed samples will be sealed with bees wax and packaged to retain moisture and avoid shifting during shipment in their original sample tubes.

2.4.2 Perched Water Investigation and Sampling

Trenches will be excavated to undisturbed soil or a maximum depth of 12 ft. Trench walls should be vertical or as close to vertical as practicable due to sloughing. Personnel shall not enter the trenches for any reason and shall not approach within 2 ft of the edge of the trench



EXPLANATION OF SAMPLE DESIGNATION SYSTEM

FIGURE 2-4

REPORT NO.: DOE/OR/21548-164		EXHIBIT NO.: A/PI/194/1091	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 10/91	

excavation. Excavated materials will be placed adjacent to the excavation for examination by the Project Management Contractor (PMC) field geologist or geotechnical engineer.

Excavated soils must be replaced in the same order as removed. Site restoration will be in accordance with Section 2.6 of this sampling plan.

Soil and seepage water encountered during trenching may be sampled for waste characteristics as deemed necessary by environmental safety and health (ES&H) personnel. Water samples will follow collection protocols for groundwater samples. Samples will be obtained from the backhoe bucket or by dipping from the ground surface using a ladle with an extension handle. Soil samples will be obtained from the backhoe bucket. All samples obtained from the backhoe bucket will be removed with minimal contact of the bucket walls. A total of four water samples and 10 soil samples, including duplicates, is planned. Soil and water samples will be analyzed for the constituents listed in Table 2-4.

2.5 Sample Shipment and Chain of Custody

Chain of custody and sample shipping will follow Weldon Spring Site Remedial Action Project (WSSRAP) standard operating procedures ES&H 4.1.2s, RC-17s, and RC-19s as applicable. All samples taken within the boundary of the WSS will be considered potentially contaminated and treated accordingly. Samples will be checked for radioactive contamination before being released to the laboratory. After the completion of the testing program, all contaminated samples will be returned to the Weldon Spring site (WSS).

2.6 Borehole, Excavation and Trench Abandonment

In order to avoid compromising soil integrity due to investigation disturbance, the following abandonment requirements will be followed for all boreholes, trenches, and excavations.

After sampling has been completed, all boreholes will be abandoned by tremie placing of a high solids bentonite based grout. Grout will be mixed and placed through a mud pump and tremied under positive pressure to the bottom of the hole. The ratio of clay grout to fresh potable water must achieve a weight of at least 9.4 lbs/gal as measured with an approved mud weight measuring device in the field (MKF and JEG 1991b).

TABLE 2-4 Water and Soil Sample Analytes

Media	Analytes
Water	HSL Metals PCBs PAHs Nitroaromatics[a] Uranium (total)
Soil	HSL Metals PCBs PAHs Nitroaromatics U-238 Ra-226 Th-230 Th-232

[a] 1,3,5-trinitrotoluene, 1,3-dinitrotoluene, nitrobenzene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, 2,3,6-trinitrotoluene.

Any borehole or trench not backfilled immediately after sampling will be either covered by the drill rig tools or barricaded with tape and traffic barricades.

Excavations will be backfilled with suitable low permeability excavated material and finally capped with the original topsoil material. Excavation backfill will be placed in 8 in. lifts and compacted to a minimum of 95% of maximum dry density as determined by ASTM D698 and a moisture content within 2% below to 4% above optimum moisture content. Narrow exploratory trenches in fill will be thoroughly compacted using a backhoe bucket. Shallow trenches excavated in upper portions of undisturbed soils will be backfilled and compacted to the same requirements as stated above for excavations.

2.7 Decontamination

Decontamination of sampling equipment will follow procedure ES&H 4.1.3s. Personal protective equipment (PPE) will be covered in the health and safety plan for each subcontract. All sampling equipment, augers, and other equipment that come into contact with contaminated soils will be decontaminated by high pressure water before each borehole is drilled. The entire drilling rig, or backhoe, will be decontaminated upon arrival on site and upon completion of drilling activities. Interior portions of equipment, such as pumps and hoses that are not accessible for cleaning with a pressure cleaner, will be thoroughly cleaned and flushed with potable water. Decontamination will be performed at the site decontamination pad. Split-spoon, Shelby Tube, or California samplers will be washed with a dispersant and water, rinsed with potable water, and reassembled after each sample is taken.

3 QUALITY ASSURANCE

The quality assurance (QA) plan for drilling, test pits, trenches, sampling, and testing includes all applicable Weldon Spring Site Remedial Action Project (WSSRAP) procedures established in the Weldon Spring *Environmental Quality Assurance Project Plan* (MKF and JEG 1992b) and in accordance with U.S. Environmental Protection Agency (EPA) guidelines. Work will be carried out in accordance with WSSRAP engineering procedures and standard operating procedures (SOPs). Forms required for geotechnical sampling include:

- Chain-of-Custody Form
- Sample seals and tapes
- Field data sheets
- Borehole logs
- Test pit logs
- Geotechnical laboratory testing reports

In addition, geotechnical laboratory testing of soil samples and analytical testing of soil and water samples will be performed in accordance with the subcontractors' quality assurance (QA) program, subject to Project Management Contractor (PMC) review and approval. Testing laboratories providing services under this plan must be approved by the PMC Project Quality Department.

QA during drilling, sampling, test pit excavation, and sampling operations will consist of surveillance and inspection of the drilling and excavating subcontractor. Drilling, excavating, and sample procedures will be established. All soil samples will be labeled immediately after removal from the sampler.

The correlation of sample identification to assigned laboratory tests will be verified at the laboratory upon receipt of each sample. Thorough sample tracking and documentation will be initiated and maintained throughout the testing program. Laboratory test results will be reviewed and approved by an individual other than the person who is performing the test before being submitted to the PMC.

4 HEALTH AND SAFETY

In accordance with CM&O-15a, safety concerns and mitigative measures related to sampling activities carried out under this plan will be identified and documented with task specific safety assessments (TaSSAs) which will be prepared, reviewed, approved, and filed with the Construction, Maintenance and Operations Department on a daily basis before work begins in the controlled area. Safety, industrial hygiene, and health physics personnel will also monitor health and safety conditions during sampling. Health physics personnel will monitor personnel and equipment working in areas of radiological contamination.

Personal protective equipment (PPE) will be worn as required at each sampling location. The requirements are outlined in the WSSRAP *Personnel Protective Equipment Requirements Manual* (MKF and JEG 1992c).

Subcontractors will submit a health and safety plan (HASP) prior to coming on site and their plan will be reviewed and approved by the site safety officer prior to commencing sampling work.

5 DATA DOCUMENTATION

Data documentation will follow Weldon Spring Site Remedial Action Project (WSSRAP) standard operating procedures and the *Project Management Contractor Quality Assurance Program*, Section 4 (MKF and JEG 1992d) relating to Documents and Records. During the course of the geohydrologic sampling, a qualified geological or geotechnical engineer will record the daily activities, following field logbook procedures (procedure ES&H 1.1.4) including:

- Date
- Weather conditions
- All personnel involved
- Chronological record of activities

Borehole and test pit logs will be kept on site and updated as the sampling progresses. These logs will be prepared by a qualified geologist, geological engineer or soils engineer (MKF and JEG 1991b). The following data will be included in each borehole or test pit log:

- Test pit or borehole identification.
- Test pit or borehole location.
- Drilling/sampling method and equipment.
- Drilling or excavating contractor.
- Date of commencement and completion.
- Total depth.
- Depth to water table and bedrock (if applicable).
- Hole diameter or test pit dimensions.
- Standard Penetration Test (SPT) number of blows per 6 in. of advancement.

- Lithologic description of materials and soil classification in accordance with ASTM D2488 (ASTM 1991).

- Munsell color chart number code.

- Sample numbers, depth of sample, and sample interval.

- Length of sample recovered (drilling only).

- Description of sampling method (i.e., number of blows for the standard penetration test - SPT.

- Description of completion operations (i.e., borehole or test pit abandonment operations).

- Borehole or test pit logs will be transmitted to the WSSRAP Project Quality Department in accordance with SQP-9a *Inventory, Valdiation, and Transfer of QA Records* for retention.

Daily logs maintained by the subcontractors will include the activities performed, personnel involved, locations, time, weather conditions, equipment used, and any problems encountered. A field report will be prepared after each geohydrologic investigation is completed. Geotechnical and hydraulic laboratory testing data will be evaluated by the Project Management Contractor (PMC) and transmitted to the Project Quality Deparmtent in accordance with SQP-9a for review and retention as a QA record.

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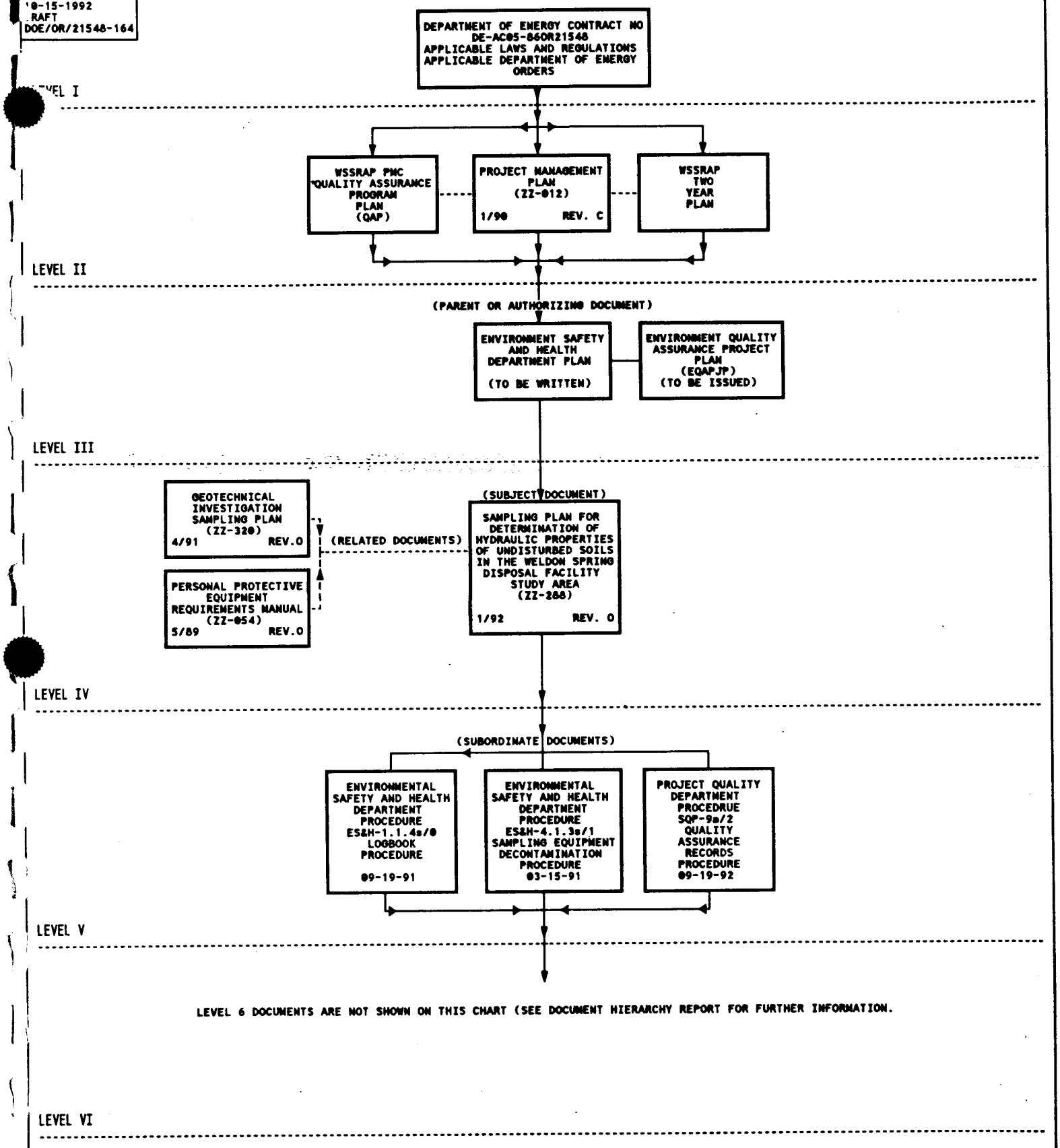
Code of Federal Regulations

10 CSR 25-7.264(2)(N)1.A and B. *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.*

Procedures

CM&O 15a *Task Specific Safety Assessment*
ES&H 1.1.4s *Logbook Procedure*
ES&H 4.1.2 *Chain of Custody*
ES&H 4.1.3s *Sampling Equipment Decontamination*
SQP 9a *Inventory, Validation, and Transfer of QA Records for Retention*
RC 17s *Packaging, Shipping and Receiving of Radioactive Materials*
RC 19s *Packaging, Shipping and Receiving of Nonradioactive Materials*

APPENDIX A
DOCUMENT HIERARCHY



SAMPLING PLAN FOR DETERMINATION OF HYDRAULIC PROPERTIES OF UNDISTURBED SOILS IN THE WELDON SPRING DISPOSAL FACILITY STUDY AREA

APPENDIX A

REPORT NO. DOE/OR/21548-164	EXHIBIT NO.
ORIGINATOR.	DRAWN BY.
DATE. 10-15-1992	

APPENDIX B
BOREHOLE AND TEST PIT LOGS

APPENDIX B - LIST OF FIGURES

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GEOTECHNICAL BORING LOG LEGEND

SYMBOLIC LOG

CLAY

SILT

SAND

GRAVEL

SILTY CLAY

CLAYEY SILT

GRAVELLY CLAY

CLAYEY GRAVEL

SANDY CLAY

TOPSOIL

SHALE

CHERTY LIMESTONE

SAMPLER DESIGNATIONS

SS = STANDARD PENETRATION SAMPLER (2.0" SPLIT SPOON)

SB = CALIFORNIA SAMPLER (3.0" SPLIT BARREL)
X
X = LINERS COLLECTED

ST = 3.0" SHELBY TUBE
P.P.= POCKET PENETROMETER ,UNCONFINED COMPRESSIVE STRENGTH (Tons/Sq.Ft.)

GROUNDWATER MEASUREMENTS

6.5'; 6/9 ▽ = DEPTH & DATE OF INITIAL WATER LEVEL MEASUREMENT

2.9'; 6/16 ▼ = DEPTH & DATE OF STABILIZED WATER LEVEL MEASUREMENT

COLORS

SOIL & ROCK COLORS FROM MUNSELL SOIL COLOR CHARTS

GEOTECHNICAL BORING LOG LEGEND

FIGURE B-1

REPORT NO. DOE/OR/21548-164	EXHIBIT NO. A/PI/179/1091	
ORIGINATOR JDC	DRAWN BY: SRS	DATE 10/91

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet 1 of 5

GEOTECHNICAL BORING LOG

Project Number: MKE 9423

Hole Number: GT - 47 (GT-2B47)

Project: WSSRAP - GT DRILLING	Location: SEISMIC LINE #6, STA. 1 + 35
Coordinates: (AEC) 100024.8N 50128.9W	Drilling Contractor: HANNIBAL TESTING LABORATORIES

Drill Make and Model	Depth Top of Rock	Depth Casing & Size	Hole Size
CME-55, CONT. FLT. HOLLOW STEM AUGER; CORE DRILLING: NQ WIRELINE	35.3 FEET	35.5FT 3½" I.D.	AUGER:7" CORE: 2.98"

Elevation	Angle from Vert. and Bearing	Depth Bottom of Hole
660.3 FT	VERTICAL	55.5 FEET

Water Level	Fluid & Additives	Date Start	Date Finish	Logger
	CLEAR WATER	9:20 7/13/88	1:35 7/15/88	A. BENFER P. PATCHIN

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION: Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		0 1.5	SS 01	7"	7.13.15 28		Silty Clay with angular gravel and fine to coarse sand, predominantly pale brown (10YR 6/3), dry, hard CL, contains roots FILL 1
		2.5 4.0	SS 02	7"	7.7.6 13		Clayey Silt, mottled, light yellow brown (10YR 6/4), moist, very stiff (2.25), ML LOESS
5		5.0 7.5	ST 03	27"			
		7.5 9.0	SS 04	10"	1.3.5 8		Silty Clay, mottled yellow brown (10YR 5/6), very silty and light gray (10YR 7/1) very plastic, moist, stiff (1.75), CL-CH -P.P.=2.0-2.75 - very stiff
10		10.0 12.5	ST 05	6"	Pushed 30"		-P.P.=2.75 - CH FERRELVIEW
		12.5 14.0	SS 06	17"	2.3.5 8		-P.P.=2.25, mostly light gray, trace fine gravel to coarse sand, CH
15		15.0 17.0	ST 07	0"	Pushed 24"		-P.P.=2.5 very stiff
		17.0 19.0	SB 08	12"	7.12.17 29		-P.P.=4.1, hard, 10% sand: grading
20		20.0 21.5	SB 09	12"	3.9.16 25		Silty Clay with 25% sand, fine to coarse, mottled light gray (10YR 7/1) and light yellow brown (10YR 6/4) moist, hard (4.0-4.2), CH with MnOx (black)
		22.5 24.0	SS 10	15"	4.7.11 18		-P.P.=4.5+, hard, trace fine gravel CLAY TILL
25							

AS INTERPRETED BY ALAN BENFER, 1991.

GEOTECHNICAL BORING LOG GT-47

FIGURE B-2A

REPORT NO.:	EXHIBIT NO.:
DOE/OR/21548-164	A/PI/145/0892

ORIGINATOR:	DRAWN BY:	DATE:
JDC	SRS	8/92

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet 2 of 5

Project Number: MKE 9423

Hole Number: GT - 47 (GT-2B47)

GEOTECHNICAL BORING LOG

Project: WSSRAP GT DRILLING

Location: SEISMIC LINE #6, STA. 1 + 35

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
		25.0	SB	18"	5.12.15		-P.P.=4.0-4.5, hard, increasing fine gravel (15%) subrounded
		26.5	11		27		
		27.5	SS	18"	4.5.9		-P.P.=4.2, hard, FeOx nodules, slickensides, fine gravel (angular chert)
		29.0	12		14		CLAY TILL
	30	30.0	SS	6"	3.11.20		Gravelly -P.P.=3.0-4.5 very stiff to hard with slickensides
		31.5	13		31		Clayey Gravel, mostly angular chert up to 1½", clay (30%) strong brown (7.5YR 5/6) CH, moist, medium dense, GC
		32.5	SS	15"	21.30.20		33.0-34.0 mostly angular limestone ½" to 1" white (7.5YR 8/)
		34.0	14		50		RESIDUUM?
7/13	35						35.5'
7/14		35.5	SB-15	0"	7.50		Drove 6" to refusal. Auger refusal @ 35.5'. GC as above with 3" chert gravel, sub-rounded with minor strong brown clay (7.5YR 5/6). Refusal at 6:30 a.m. 7/14/88.
							Hole continued with NQ core barrel.
	40						Cored from 35.5' to 55.5'. Core description on sheets 3 through 5.

GEOTECHNICAL BORING LOG GT-47

FIGURE B-2B

REPORT NO.:	EXHIBIT NO.:	
DOE/OR/21548-164	A/PI/146/0892	
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SOIL BORING LOG

Sheet 1 of 2
Project Number: 3840
Hole Number: GT - 71

Project: Weldon Springs Site Remedial Action Project	Location: 70'W of SW corner of Bldg. 201
Coordinates: (AEC) N99758.2, W50300.1	Drilling Contractor: Geotechnology Services, Inc.
Drill Make and Model: CME 750, ATV mounted	Depth Top of Rock: 34.5 / Depth Casing & Size: -- / Hole Size: 7 1/2" (Auger)
Elevation: 659.3	Angle from Vert. and Bearing: Vertical / Depth Bottom of Hole: 34.5
Water Level: Dry	Fluid & Additives: None / Date Start: 4/11/91 10:50 / Date Finish: 4/11/91 15:05 / Logger: E. Rennat

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION
							Silty Clay Mottled lt. to med. brown and gray, moist, plastic, stiff, occasional Fe and Mn staining. CL
		2.5-4	SS 7101	12"	4-6-8 (14)		
	5	5-7.5	ST 7102	21"			
		7.5-9	SS 7103	13"	1-5-8 (13)		
	10	10-12.5	ST 7104	27"			
		12.5-14	SS 7105	18"	2-6-8 (14)		FERRELVIEW
	15	15-17.5	ST 7106	26"			Clay Mottled lt. brown and gray, moist, plastic, stiff, 5% medium to coarse subrounded chert sand, occasional 1/4" chert clasts. CL - CH
		17.5-19	SS 7107	19"	3-6-8 (14)		
	20	20-22.5	ST 7108	27"			
		22.5-24	SS 7109	18"	4-7-7 (14)		CLAY TILL
	25						

SS = Split Spoon ST = Shelby Tube CS = California Sampler (3")

SOIL BORING LOG
GT-71

FIGURE B-3A

REPORT NO.: DOE/OR/21548-164	EXHIBIT NO.: A/PI/147/0892	
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92

MK-ENVIRONMENTAL SERVICES

Project Number: 3840	Boring Number: GT - 71	Sheet 2 of 2

SOIL BORING LOG

Project: Weldon Springs Site RAP Location:

Elevation: Drilling Contractor:

Drilling Method and Equipment:

Water Level and Date: Start: Finish: Logger:

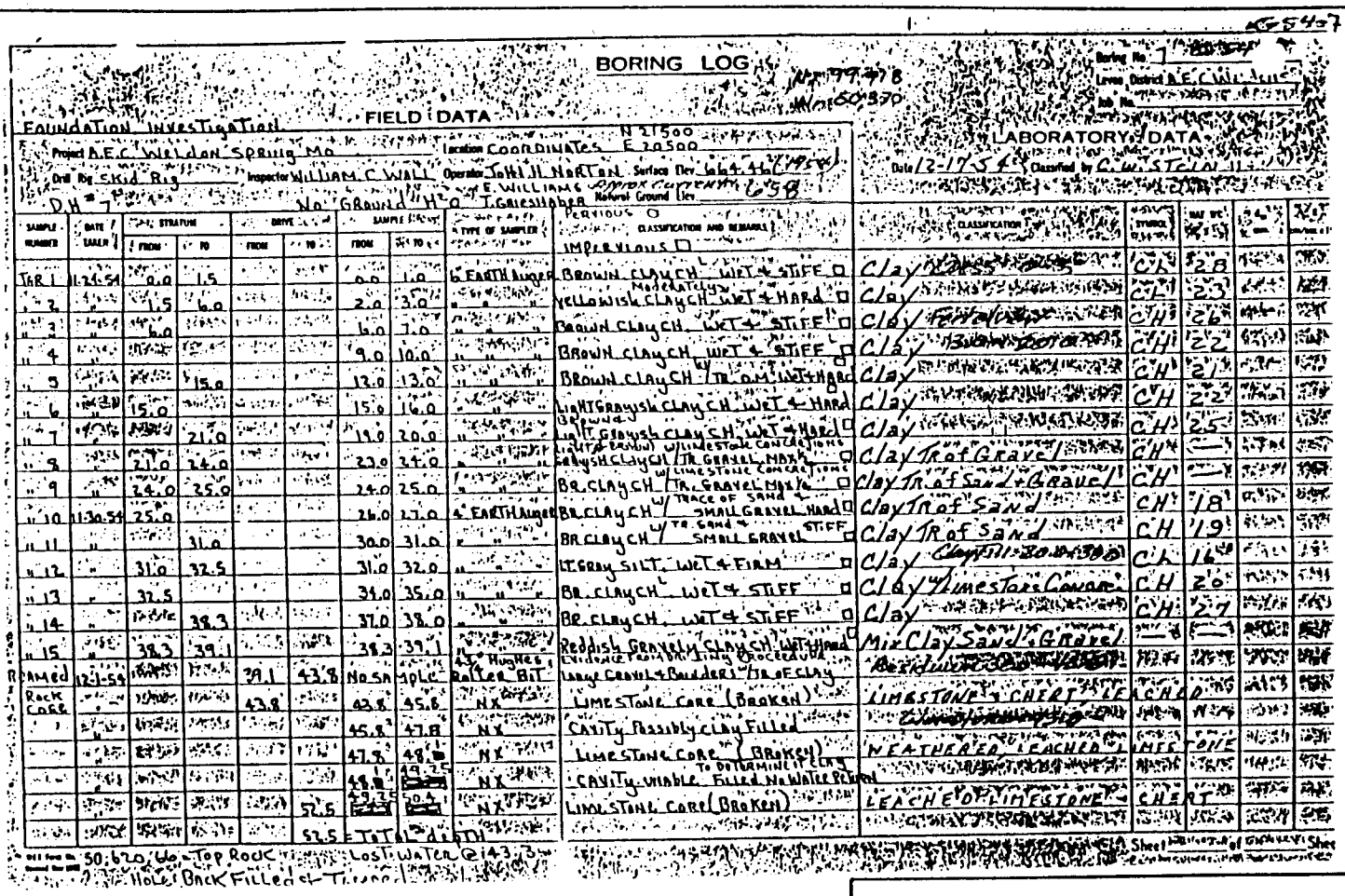
ELEVATION / DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION: Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
	25-27.5	ST 7110	27"			Sandy Clay Lt. brown, moist, plastic, stiff, occasional Fe and Mn staining, chert clasts CL
	27.5-29	SS 7111	19"	6-10-15 (25)		
						BASAL TILL
30	30-31.5	CS 7112	15"	(21-36-20)		Gravelly Clay Lt orange, moist, plastic, stiff, some Mn staining along fractures; angular chert clasts up to 1", up to 30% toward bottom CL
	32.5-34	SS 7113	11"	15-15-50/5		
						RESIDUUM
35						Auger Refusal at 34.5'
40						
45						
50						
55						

SS = Split Spoon ST = Shelby Tube CS = California Sampler (3")

SOIL BORING LOG
GT-71

FIGURE B-3B

REPORT NO.: DOE/OR/21548-164	EXHIBIT NO.: A/PI/148/0892	
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92



BORING LOG

FIELD DATA

FOUNDATION INVESTIGATION

Project A.E.C. Weldon Spring Mo — Location COORDINATES N 21500 E 20500

Drill Rig Skid Rig — Inspector WILLIAM C WALL — Operator JOHN H NORTON — Surface Elev 664.4 ft (MSL)

DH-7 — No GROUND H2O T. GRIESHABER — Natural Ground Elev 658

SAMPLE NUMBER	DATE TAKEN	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER	PERVIOUS ○ IMPERVIOUS □ CLASSIFICATION AND REMARKS
THR 1	11-24-54	0.0	1.5			0.0	1.0	6" EARTH Auger	BROWN CLAY CH WET & STIFF □
" 2	"	1.5	6.0			2.0	3.0	"	YELLOWISH CLAY CH Moderately WET & HARD □
" 3	"	6.0				6.0	7.0	"	BROWN CLAY CH WET & STIFF □
" 4	"					9.0	10.0	"	BROWN CLAY CH WET & STIFF □
" 5	"		15.0			13.0	13.0	"	BROWN CLAY CH w/ TR GRAVEL MAX WET & HARD □
" 6	"	15.0				15.0	16.0	"	LIGHT GRAYISH CLAY CH WET & HARD □
" 7	"		21.0			19.0	20.0	"	LIGHT GRAYISH CLAY CH WET & HARD □
" 8	"	21.0	24.0			23.0	24.0	"	LIGHT BROWN w/ LIMESTONE CONCRETIONS GRAYISH CLAY CH w/ TR GRAVEL MAX □
" 9	"	24.0	25.0			24.0	25.0	"	BR CLAY CH w/ TR GRAVEL MAX □
" 10	11-30-54	25.0				26.0	27.0	4" EARTH Auger	BR CLAY CH w/ TRACE OF SAND w/ SMALL GRAVEL HARD □
" 11	"		31.0			30.0	31.0	"	BR CLAY CH w/ TR SAND w/ SMALL GRAVEL STIFF □
" 12	"	31.0	32.5			31.0	32.0	"	LT GRAY SILT WET & FIRM □
" 13	"	32.5				34.0	35.0	"	BR CLAY CH WET & STIFF □
" 14	"		38.3			37.0	38.0	"	BR CLAY CH WET & STIFF □
" 15	"	38.3	39.1			38.3	39.1	"	REDDISH GRAY CLAY CH WET & HARD □
REAMED	12-1-54			39.1	43.8	NO SAMPLE		4" Hughes Roller Bit	Experimental Coring Procedure Using Drilling Procedure LARGE GRAVEL & BOULDERS IN BR CLAY
ROCK CORE 1	"			43.8		43.8	45.8	NX	LIMESTONE CORE (BROKEN)
" 2	"					45.8	47.8	NX	CAVITY, POSSIBLY CLAY FILLED
" 3	"					47.8	48.8	NX	LIMESTONE CORE (BROKEN)
" 4	"					48.8	49.25	NX	To Determine if Cavity Fillable Filled No Water Return CAVITY, FILLED
" 5	"					49.25	50.4	NX	LIMESTONE CORE (BROKEN)
					52.5	TOTAL DEPTH			

Drill Rate 50:60 Top Rock 60 Lost Water @ 43.3

Hole Back Filled at Time

LABORATORY DATA

Boring No. 7 — Lewis District A.E.C. Weldon — Job No. 60370

Date 12-17-54 — Classified by C. WISTON

CLASSIFICATION	SYMBOL	NAT. W.C. %	L.L. %	P.I. %
Clay Trace Sand	CH	28		
Clay	CH	23		
Clay	CH	26		
Clay	CH	22		
Clay	CH	21		
Clay	CH	22		
Clay	CH	25		
Clay Tr of Gravel	CH	—		
Clay Tr of Sand & Gravel	CH	—		
Clay Tr of Sand	CH	18		
Clay Tr of Sand	CH	19		
Clay	CH	16		
Clay Limestone Gravel	CH	20		
Clay	CH	27		
Mix Clay Sand & Gravel	—	—		
LIMESTONE & CHERT	LEACHED			
WEATHERED LEACHED LIMESTONE	CHERT			
LEACHED LIMESTONE	CHERT			

Sheet ___ of ___ Sheets

BORING LOG
G54-7

FIGURE B-4

REPORT NO.	EXHIBIT NO.
DOE/OR/21548-164	A/PI/144/0892
ORIGINATOR: JDC	DRAWN BY: SRS
	DATE: 8/92

MORRISON-KNUDSEN ENGINEERS, INC.

LOG OF TEST PIT GT-2T78

- Location: 50 feet plan west of northwest corner of fence around facility 428
- Type of excavator: Cat 416 extendable backhoe (new)
- Start excavation: 4:30 p.m. 07/13/88
- Finish excavation: 5:05 p.m.
- Finish backfilling: 8:05 a.m. 07/14/88
- Finish decontamination: 9:05 a.m.

Depth, Feet		Description
0-1.0	CL	Fill: Silty clay; dark yellowish-brown (10YR4/6); some gravel (1/2" to 2"); dry; medium plasticity; medium stiff.
1.0-4.0	CL	Silty Clay: Yellowish-brown (10YR6/8) and light brownish- gray (10YR6/2); dry; medium plasticity; very stiff.
4.0-6.5	CL	Silty Clay: As above but moist to wet and stiff (possible reworked loess).
6.5-12.0	CH	Silty Clay: Yellowish-brown (10YR5/8) mottled with light brownish-gray (10YR6/2) and brownish-yellow (10YR6/8); wet; high plasticity; very stiff.

Samples Collected

GT-2T78: BU-01A, 4.0'-6.5'
GT-2T78: BU-01B, 4.0'-6.5'

GT-2T78: BU-02A, 6.5'-12'0'
GT-2T78: BU-02B, 6.5'-12'0'

6306j/8

Logged By. W. A. Gale

LOG OF TEST PIT GT-2T78

FIGURE B-5

REPORT NO.	EXHIBIT NO.
DOE/OR/21548-164	A/PI/182/1091

ORIGINATOR	DRAWN BY.	DATE
JDC	SRS	10/91

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet 1 of 2

Project Number: MKE-9423

Hole Number: GT-53(GT-2B53)

GEOTECHNICAL BORING LOG

Project: WSSRAP GEOTECH Drilling	Location: Seismic Line #3 Sta. 2+88
Coordinates: (AEC) 100284N 50781W	Drilling Contractor: Hannibal Testing Laboratories
Drill Make and Model: CME-55 7" Hollow Stem Auger: Coring: NQ Wireline	Depth Top of Rock: 42.5'
Depth Casing & Size: 42.5', 3½' I.D.	Hole Size: Auger:7" Core: 2.98"
Elevation: 655.5 ft.	Angle from Vert. and Bearing: Vertical
Depth Bottom of Hole: 42.5'	
Water Level:	Fluid & Additives: None
Date Start: 12:30 8/12/88	Date Finish: 8:35 8/16/88
Logger: P. Patchin	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	0	0	SS	5"	4.3.2		Clayey Silt, dark grayish brown (10YR 5/2), with
		1.5	01		5		ang. gravel, roots to .3', very stiff (2.25) damp, ML
		2.5	ST	16"	Pushed		Silty Clay, light brnsh gry (2.5Y 6/2) with ang. L.S.
		4.6	02		25"		gravel to 2½", vry stiff (3.5), CL (Gravel at 4.6' for approx. .5')
							FILL
	5	5.0	SS	15"	3.3.5		Clay, yellowish brn (10YR 5/4) slightly silty, moist,
		6.5	03		8		plastic, very stiff (2.25), no gravel, minor MnOx strings and FeOx blebs. CL-CH
		7.5	ST	19"			Silty Clay, mottled light brnsh gray (2.5Y 6/2) and
		10.0	04				brnsh yellow (10YR 6/6), MnOx stringers and FeOx blebs abundant, moist, very stiff (2.25) CH
	10	10.0	SS	16"	3.4.6		-- P.P. = 2.25 CL-CH
		11.5	05		10		FERRELVIEW
		12.5	ST	22"			Clay, mottled lt gry (2.5Y 7/2) and strng brn
		15.0	06				(7.5YR 5/6), fine ang. grvl and sand (5%), plastic, moist, CH
12/88 15/88	15	15.0	SS	16"	6.9.10		-- Silty Clay, mottled lt gry (10YR 7/1) and brnsh
		16.5	07		19		yllw (10YR 6/6) slty (40%) very fine ang. grvl (3%) FeOx blebs and MnOx stringers, damp, CL-CH
		17.5	ST	21"			Gravelly Clay, brnsh yllw (10YR 6/8) damp with 10%
		20.0	08				sub-rnded to ang. grvl includ. igneous rx, minor
	20	20.0	SS	13"	5.10.12		lt gry sandy parts, vry stiff (4.0), CL
		21.5	09		22		-- P.P. 4.5 sandy (30%) fine, abund. MnOx, brnsh yllw (10YR 6/6)
		22.5	SB	12"	7.11.16		-- P.P. = 4.25 2" ang. chert and rounded mafic
		24.0	10		27		gravel, 20% fine sand
							CLAY TILL
	25						

GEOTECHNICAL BORING LOG
GT-53 (GT-2B53)

FIGURE B-6A

REPORT NO. DOE/OR/21548-164		EXHIBIT NO. A/PI/183/1091	
ORIGINATOR JDC	DRAWN BY SRS	DATE 10/91	

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet 2 of 2

Project Number MKE-9423

Hole Number GT-53(GT-2B53)

GEOTECHNICAL BORING LOG

Project: WSSRAP Geotech Drilling

Location: Seismic Line #3 Sta. 2+88

ELEVATION / DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
25.0	25.0 26.5	SS 11	14"	3.5.6 11		-- P.P. = 3.25 Sandy, CL CLAY TILL
	27.5 29.0	SB 12	12"	6.13.30		Silt, mottled light brnsh gry (10YR 6/2) and brnsh yllw (10YR 6/3) slightly clyey, no grvl, dry, stiff, (1.75) minor MnOx and FeOx blebs, ML
30	30.0 31.5	SS 13	13"	8.12.12 24		Silty Clay, mottled yllwsh red (5YR 5/6) and light yllwsh brn (10YR 6/4), 30% silt, 5% fine grvl, FeOx blebs and MnOx stringers (minor), damp, hard (4.5) ML
	33.3	SE 14	6"	25.50 for 4"		
35	35.0 36.5	SS 15	12"	9.12.12 24		32.5 - Clayey Gravel, grvl up to 2", chert, angular white, clay (30%) red (2.5YR 4/6) GC -- As above, clay is yllwsh brn (10YR 5/8) and red (2.5YR 4/6) silty, GC
	37.5 39.0	SE 16	12"	8.13.25		-- As above, approx. 50% clay, very stiff (3.0) moist, GC RESIDUUM
40	40.0 41.5	SS 17	14"	12.20.17 37		-- As above, 30% clay some angular limestone, chert is white (2.5Y 8/) T.D. 42.5'
						Auger Refusal at 42.5' @ 1:20 p.m. 8/15/88

GEOTECHNICAL BORING LOG
GT-53 (GT-2B53)

FIGURE B-6B

REPORT NO.	DOE/OR/21548-164	EXHIBIT NO.	A/PI/184/1091
ORIGINATOR	JDC	DRAWN BY	SRS
DATE	10/91		

X section B
X section A

GEOLOGIC DRILL LOG

PROJECT: FUSRAP - WELDON SPRING SITE					JOB NO. 14501-201	SHEET NO. 1 of 2	HOLE NO. G-7		
SITE: NORTH OF COAL PILE	COORDINATES: N101,200 W50,450					ANGLE FROM VERT. 90	BEARING -		
BEGUN 6/17/83	COMPLETED 6/18/84	DRILLER GEOTECHNOLOGY INC. KURT JAEGER/GEORGE MATTHEWS	DRILL MAKE AND MODEL CME-45/CME-750	HOLE SIZE 6-1/4"/3"	OVERBURDEN (FT.) 18.5	ROCK (FT.) 45.5	TOTAL DEPTH 64.0		
CORE RECOVERY (FT./%) 24.7/53	CORE BOXES 4	SAMPLES 3	EL. TOP OF CASING -	GROUND EL. 633.3	DEPTH/EL. GROUND WATER 34.20'/599.10		DEPTH/EL. TOP OF ROCK 18.5'/614.8		
SAMPLE HAMMER WEIGHT/FALL 140 LBS/30 IN	CASING LEFT IN HOLE DIA./LENGTH NONE	LOGGED BY: LAWRENCE YOUNG							

SAMPLE TYPE AND NUMBER	SAMPLE INTERVAL (DEPTH CORE RUN)	SAMPLE RECOVERY (CORE RECOVERY)	% RECOVERY (CORE RECOVERY)	WATER PRESSURE TESTS: LOSS IN GAL.	PRESSURE P.S.I.	TIME IN MINUTES	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	REMARKS ON WATER LEVELS, WATER RETURN, CONDUCT OF DRILLING, ETC.
							633.3	0			2' cut 0 TO 11.5 FT SILTY CLAY, MODERATE BROWN(5YR 4/4), MOIST, STIFF TO VERY STIFF, TRACE TO SOME SUBROUNDED TO ROUNDED FINE GRAVEL (PRIMARILY IGNEOUS AND METAMORPHIC ORIGIN), MOTTLED WITH LIGHT GRAY(N6) SILT LENSES, PYROLUSITE STRINGERS.	0-18.5 FT DRILLED WITH 6¼IN OD HOLLOW STEM AUGERS USING CENTER P.
SS 2"	18"	13"	13	3	5	8		5		1	Clay till	
SS 2"	18"	15"	20	5	8	12		10		2		0 TO 10.0 FT BOREHOLE WAS RADIOLOGICALLY LOGGED BY EBERLINE ANALYTICAL CORPORATION.
							621.8	11.5			11.5 11.5 TO 18.5 FT GRAVELLY CLAY, DARK YELLOWISH ORANGE(10YR 6/6), MOIST, HARD, WITH WEATHERED ANGULAR CHERT GRAVEL AND COBBLES.	
SS 2"	11"	9"	50+	32	50/5"			15		3	Basal till	18.5 TO 19.0 FT DRILLED WITH 2-7/8 INCH TRICONE ROLLER BIT AND FRESH WATER TO START COREHOLE.
							614.8	18.5			18.5 18.5 TO 37.0 FT LIMESTONE, DARK YELLOWISH ORANGE(10YR 6/6), MODERATELY HARD, SEVERELY WEATHERED, WITH SEAMS OF MODERATE REDDISH BROWN(10R 4/6) CLAY AND CHERT GRAVEL, SEMI-COMPETENT CHERT LAYERS OR NODULES. Reinforcement	19.0 TO 21.0 FT CORED WITH NQ3 WIRELINE DIAMOND IMPREGNATED BIT USING CLEAR WATER
NQ3	2.0'	1.9'	95	1.9L			200÷0	20		RUN #1		21.0 TO 27.0 FT DRILLED WITH TRICONE ROLLER BIT USING CLEAR MUD
							21.0					
								25			21.0 TO 26.0 FT CLAY FILLED CAVITY WITH COAL DUST OR FLY-ASH MIXED WITH CLAY, AND ANGULAR CHERT GRAVEL. 26.0'	27.0 TO 64.0 FT CORED WITH NQ3 WIRELINE DIAMOND IMPREGNATED BIT USING WATER AND CLEAR MUD.
NQ3 WIRELINE CORE	3.0'	1.1'	37	1.1 L				30		RUN #2	Limestone	
				10.6	5	5	200÷0					
				12.2	10	4						
NQ3 WIRELINE CORE	7.0'	1.3'	19							RUN #3		
							598.3	35				

RUN	AP (FT.)	LP (FT.)	RQD (FT.)
1	0.3	0.2	0
2	0.3	0.2	0
3	0.2	0.2	0

6/18/84

SAMPLE BROKEN STRENGTH TUBE, PROCEEDING PARTICULARLY NOTED

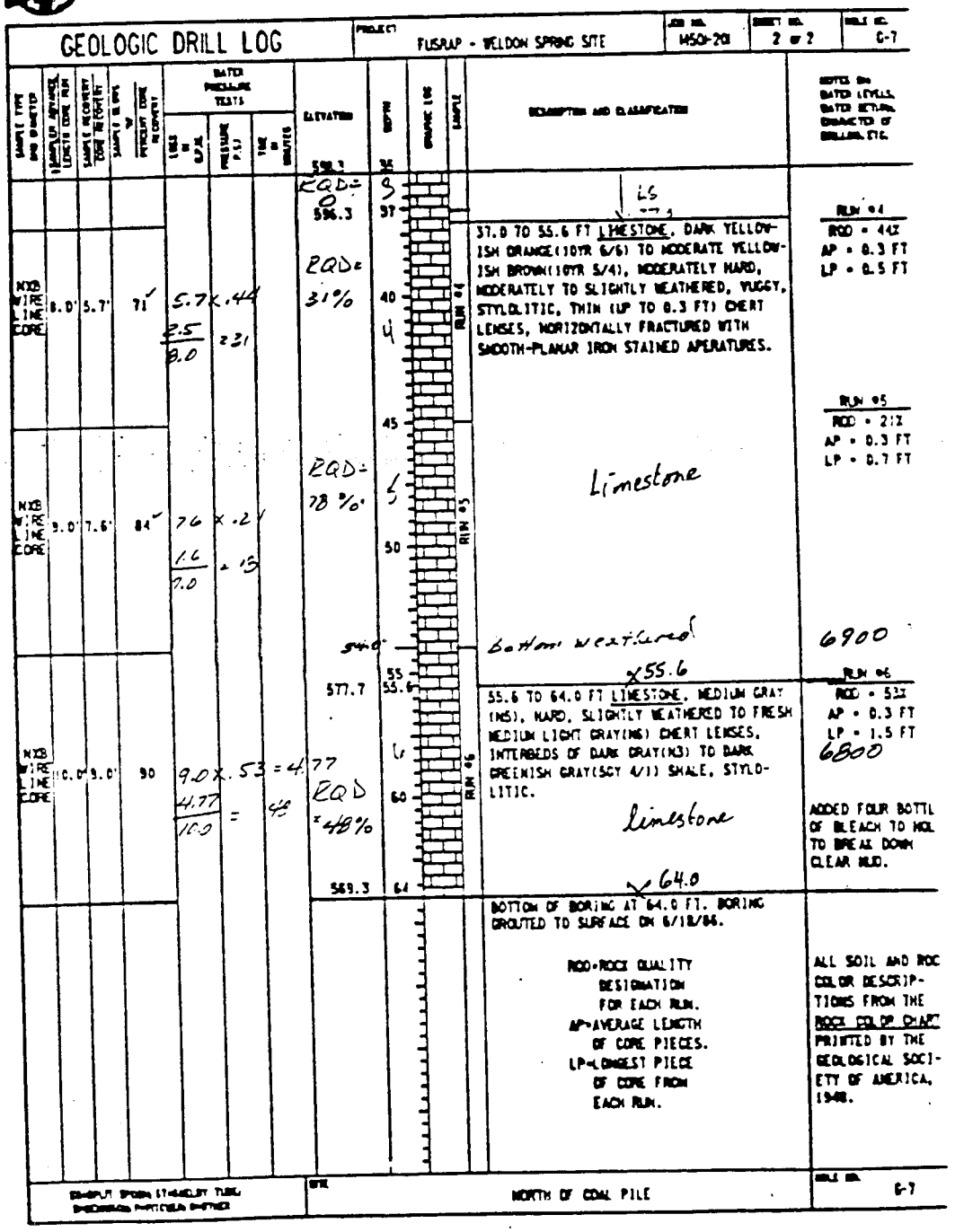
SITE: NORTH OF COAL PILE

HOLE NO. G-7

GEOLOGIC DRILL LOG
G-7

FIGURE B-7A

REPORT NO.	DOE/OR/21548-164	EXHIBIT NO.	A/PI/188/1091
ORIGINATOR	JDC	DRAWN BY	SRS
DATE	10/91		



GEOLOGIC DRILL LOG

PROJECT: FUSRAP - WELDON SPRING SITE | JOB NO. 1450-201 | SHEET NO. 2 of 2 | HOLE NO. G-7

SAMPLE TYPE AND NUMBER	SAMPLE ATTEMPTED, LENGTH OF CORE RUN	SAMPLE RECOVERY, CORE RECOVERED	SAMPLE RECOVERY % PERCENT OF CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN GAL.	WATER PRESSURE TESTS: PRESSURE P.S.I.	WATER PRESSURE TESTS: TIME IN MINUTES	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON WATER LEVELS, WATER RETURN, DRILLING ETC.
							596.3	35			RQD= 0	
NXB WIRE LINE CORE	8.0'	5.7'	71'	5.7 / 8.0	x .44 = .31		RQD= 31%	40		RUN #4	37.0 TO 55.6 FT LIMESTONE, DARK YELLOWISH ORANGE(10YR 6/6) TO MODERATE YELLOWISH BROWN(10YR 5/4), MODERATELY HARD, MODERATELY TO SLIGHTLY WEATHERED, VUGGY, STYLOLITIC, THIN (UP TO 0.3 FT) CHERT LENSES, HORIZONTALLY FRACTURED WITH SMOOTH-PLANAR IRON STAINED APERATURES.	RUN #4 RQD = 44% AP = 0.3 FT LP = 0.5 FT
NXB WIRE LINE CORE	9.0'	7.6'	84'	7.6 / 7.0	x .2 = .15		RQD= 78 %	45		RUN #5	Limestone	RUN #5 RQD = 21% AP = 0.3 FT LP = 0.7 FT
							540'	50			Bottom weathered x55.6	6900
NXB WIRE LINE CORE	10.0'	9.0'	90	9.0 / 10.0	x .53 = 4.77 = 48		577.7 RQD = 48%	55 / 55.6		RUN #6	55.6 TO 64.0 FT LIMESTONE, MEDIUM GRAY (N5), HARD, SLIGHTLY WEATHERED TO FRESH MEDIUM LIGHT GRAY(N6) CHERT LENSES, INTERBEDS OF DARK GRAY(N3) TO DARK GREENISH GRAY(5GY 4/1) SHALE, STYLOLITIC. Limestone x64.0	RUN #6 RQD = 53% AP = 0.3 FT LP = 1.5 FT 6800
							569.3	64			BOTTOM OF BORING AT 64.0 FT. BORING GROUTED TO SURFACE ON 6/18/86.	ADDED FOUR BOTTL OF BLEACH TO HOL TO BREAK DOWN CLEAR MUD.

RQD=ROCK QUALITY DESIGNATION FOR EACH RUN.
AP=AVERAGE LENGTH OF CORE PIECES.
LP=LONGEST PIECE OF CORE FROM EACH RUN.

ALL SOIL AND ROC COLOR DESCRIPTIONS FROM THE ROCK COLOR CHART PRINTED BY THE GEOLOGICAL SOCIETY OF AMERICA, 1948.

SITE: NORTH OF COAL PILE | HOLE NO. G-7

GEOLOGIC DRILL LOG
G-7

FIGURE B-7B

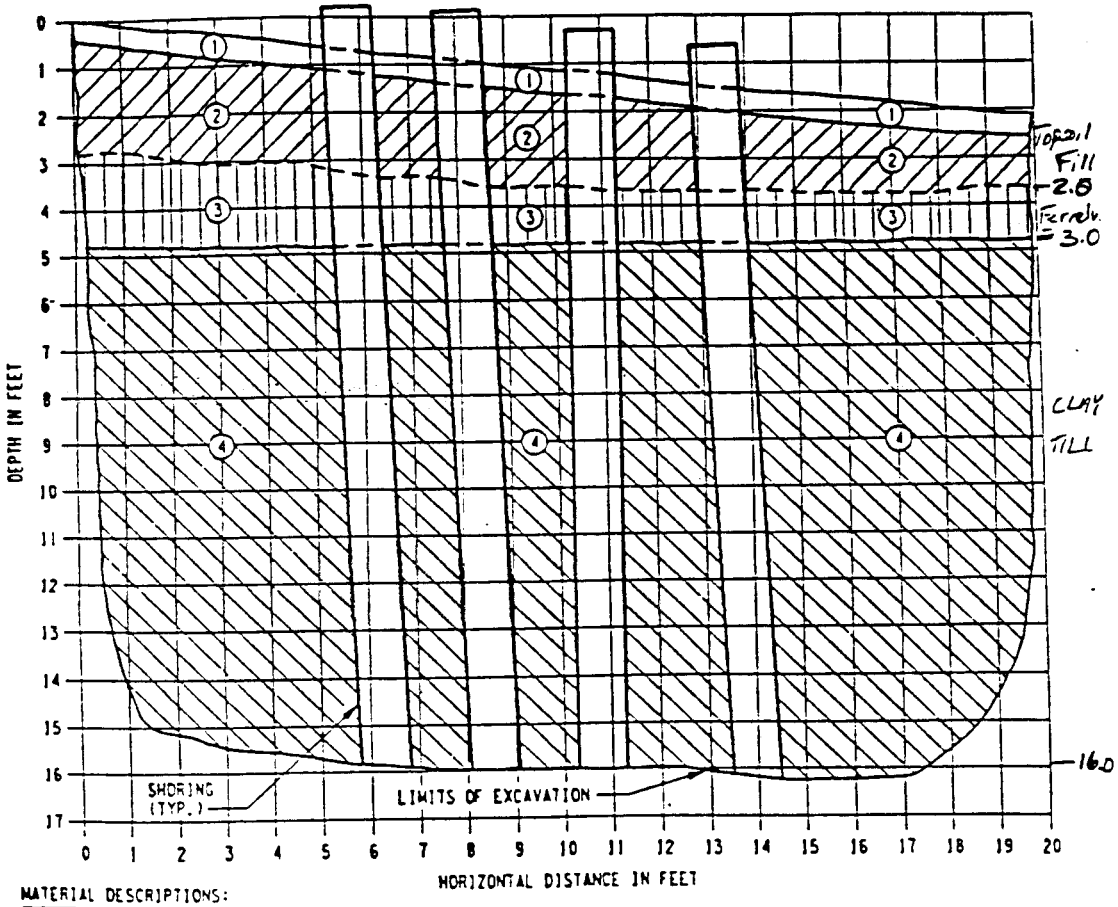
REPORT NO.	DOE/OR/21548-164	EXHIBIT NO.	A/PI/189/1091
ORIGINATOR	JDC	DRAWN BY	SRS	DATE	10/91

BECHTEL TRENCH LOG

EXCAVATION NO. T-6

PROJECT WELDON SPRING JOB NO. 14501-201 GROUND EL. 638 LOCATION N101,206.5 W50,411.0

DATE EXCAVATED 5-1-86 METHOD OF EXCAVATION BACKHOE DATE BACKFILLED 5-2-86



MATERIAL DESCRIPTIONS:

(1) TOPSOIL - BROWN, CLAYEY SILT, SLIGHTLY SANDY, SOME FINE TO MEDIUM GRAVEL. DRY.

(2) FILL - MOTTLED GRAY AND YELLOW-BROWN, SLIGHTLY SILTY TO SILTY CLAY, WITH SCATTERED FINE TO MEDIUM GRAVEL AND A FEW COBBLES. SLIGHTLY DAMP.

(3) CLAY (FERRELVIEW FORMATION) - MOTTLED GRAY AND YELLOW-BROWN, SILTY CLAY, FEW IRON NODULES AND RARE SAND GRAINS (QUARTZ AND CHERT). DAMP. MODERATELY PLASTIC.

(4) CLAY TILL - MOTTLED YELLOW-BROWN AND GRAY, VERY SILTY CLAY, SAND CONTENT UP TO 5%, SAND SUBROUND, MEDIUM GRAINED CHERT AND QUARTZ. DAMP TO SLIGHTLY DAMP, VERY LOW PLASTICITY. BLOCKY FRACTURE WITH FRACTURE SURFACES COATED WITH MANGANESE. GRAVEL, COBBLES, AND BOULDERS MAKE UP 10 - 15%. GRAVEL IS SUBANGULAR TO SUBROUNDED, FINE TO COARSE GRAINED. COBBLES AND BOULDERS ARE SUBROUNDED AND UP TO 1 1/2'Ø. GRAVEL IS CHERT AND LIMESTONE. COBBLES AND BOULDERS ARE VERY WEATHERED WHITE LIMESTONE AND GRAY CHERT WITH WHITE WEATHERED RIMS.

SIDE SOUTH BEARING N34W EXCAVATOR WEST END CONSTRUCTION CO., INC. GEOLOGIST E. BERGLUND

BECHTEL TRENCH LOG
T-6

FIGURE B-8

REPORT NO	DOE/OR/21548-164	EXHIBIT NO	A/PI/185/1091		
ORIGINATOR	JDC	DRAWN BY	SRS	DATE	10/91

GEOLOGIC DRILL LOG

PROJECT: FUSRAP - WELDON SPRING SITE	JOB NO. 14501-201	SHEET NO. 1 of 2	HOLE NO. GMW-9		
SITE: 300 FT NORTH OF COAL STORAGE AREA	COORDINATES: N101,350 W50,700	ANGLE FROM HORIZ. 90	BEARING -		
BEGUN 6/25/86	COMPLETED 7/16/86	DRILLER GEOTECHNOLOGY INC. KURT JAEGER	DRILL MAKE AND MODEL CME 45/CME 750	HOLE SIZE 6"/3"	OVERBURDEN (FT.) 20.5	ROCK (FT.) 33.5	TOTAL DEPTH 54.0'
CORE RECOVERY (FT./%) ~42/33	CORE BOXES 2	SAMPLES 5	EL. TOP OF CASING -	GROUND EL. 636.7	DEPTH/EL. GROUND WATER 39.0/597.7	DEPTH/EL. TOP OF ROCK 20.5 FT/616.2	
SAMPLE HAMMER WEIGHT/FALL 140 LBS/30 IN	CASING LEFT IN HOLE DIA./LENGTH 2"/61'	LOGGED BY: JE KAISER/E. BERGLUND					

SAMPLE TYPE AND DIAMETER	SAMPLER ADVANCE LENGTH (CORE RUN)	SAMPLE RECOVERY (CORE RECOVERY)	SAMPLE BLOWS / PERCENT CORE RECOVERY	WATER PRESSURE TESTS: TYPE IN 1ST 5' E.P.M.	PRESSURE P.S.I.	TIME IN MINUTES	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							636.7	0				
6" HSA							636.2	0.5			0 TO 0.5 FT SILTY CLAY (CL). BLACK (N1) LOW PLASTICITY. MOIST. ORGANICS.	0-20.5 FT DRILLED WITH 6 IN OD HOLLOW STEM AUGERS USING CENTER PLUG.
SS 2"	18"	11"	10	3	4	6		5		1	0.5 TO 11.5 FT SILTY CLAY: LIGHT BROWN (5YR 5/6) TO RED BROWN (10R 4/6) LOW PLASTICITY. SOFT. MOIST. MOTTLED. LOCALLY LIGHT GRAY (N7) SILTY CLAY LENSES OCCASIONAL LIMESTONE FRAGMENTS. SOME BLACK OXIDE (N1) STAINING. Ferrelview? Loess?	
6" HSA												
SS 2"	18"	16"	23	5	10	13		10		2	10.0 FT BECOMING MORE BROWN	0 TO 10.0 FT BOREHOLE WAS RADIOLOGICALLY LOGGED BY EBERLINE ANALYTICAL CORPORATION.
6" HSA												
ST 3"	24"	20"	83				625.2	15		ST1 3	11.5 TO 20.5 FT GRAVELLY CLAY(GC): LIGHT REDDISH BROWN(10R 4/6) REDDISH BROWN(10R 3/4). MEDIUM TO HIGH PLASTICITY. STIFF. LOCALLY, LIMESTONE AND CHERT FRAGMENTS (ANGULAR, GENERALLY 1/2" AVG.) MOTTLED. MOIST. 15 FT BECOMING REDDISH BROWN. CLAY TILL	11.5FT: SHELBY TUBE
SS 2"	18"	18"	39	6	17	22				3		
6" HSA												
SS 2"	5"	5"	50+	50/5"	-	-		20		4		20.5 FT AUGER REFUSAL. 20.5 FT PERFORMED INTERFACE PERMEABILITY TEST AT 5 GPM.
							616.2	20.5			20.5 TO 26.5 FT LIMESTONE, YELLOWISH ORANGE(10YR 6/6), DECOMPOSED, SOFT TO MODERATELY HARD, WITH LIGHT GRAY(N7) HARD CHERT INTERBEDS AND NODULES, YELLOWISH ORANGE(10YR 6/6) CLAY SEAMS WITH ANGULAR CHERT GRAVEL.	BURLINGTON/KEOKUK FM
NXCS 3"	9'	3.3'	37%					25		RUN #1		20.5 TO 54.0 FT CORED WITH NXCS WIRELINE DIAMOND IMPREGNATED CORE BIT USING WATER.
				15.4	10	5						
				18.6	20	5	610.2	26.5			26.5 TO 29.0 FT LIMESTONE, LIGHT GRAY (N6), MODERATELY WEATHERED, HORIZONTALLY FRACTURED, WITH FEW INTERBEDS OF LIGHT GRAY(N7), HARD CHERT, UP TO 3 INCHES THICK, SOME SOLUTION PITS <1/8 INCH DIAMETER. 29.4 TO 29.0 FT BOX CHERT IN CORE.	
				15.1	10	5	607.7	29				
NXCS 3"	10'	2.0'	20%					30		RUN #2	29.0 TO 54.0 FT LIMESTONE, YELLOWISH BROWN(10YR 6/4), WEATHERED TO LOCALLY DECOMPOSED, HORIZONTALLY FRACTURED, WITH LIGHT GRAY(N7), HARD CHERT INTERBEDS, FILLED VOIDS, AND NODULES. 29.0 TO 33.0 FT CORE IS BOX CHERT.	
							601.7	35				

SS=SPLIT SPOON, ST=SHELBY TUBE, RC=ROCK CORE, PT=DENSITY PARTICLE, OT=OTHER, HSA=HOLLOW STEM AUGER

SITE: 300 FT NORTH OF COAL STORAGE AREA — HOLE NO. GMW-9

GEOLOGIC DRILL LOG
GMW-9

FIGURE B-9A

REPORT NO.: DOE/OR/21548-164	EXHIBIT NO.: A/PI/149/0892	
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92

GEOLOGIC DRILL LOG

PROJECT: FUSRAP - WELDON SPRING SITE | JOB NO. 14501-201 | SHEET NO. 2 of 2 | HOLE NO. GMW-9

SAMPLE TYPE AND DIAMETER	SAMPLER ADVANCE / LENGTH CORE RUN	SAMPLE RECOVERY / CORE RECOVERY	SAMPLE BLOWS PER 6" / PERCENT CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M.	WATER PRESSURE TESTS: PRESSURE P.S.I.	WATER PRESSURE TESTS: TIME IN MINUTES	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							604.7	35			33.0 TO 43.7 FT DECOMPOSED LIMESTONE WITH CLAY SEAMS.	6/26/86
NXB 3"	10'	5.3'	53%					40		RUN #3	43.7 TO 44.7 FT HIGHLY WEATHERED LIMESTONE, CORE IS 70% CHERT 44.7 TO 46.5 FT LIGHT GRAY(N6), FRESH LIMESTONE. 45.7 TO 46.0 FT CORE IS 60% CHERT. 46.5 TO 49.0 FT MODERATELY WEATHERED, CORE IS 50% CHERT. 48.5 FT OPEN FRACTURE, ORIENTED 60 ° FROM HORIZONTAL, IRON STAINED.	RUN / AP (FT) / LP (FT) / RQD (%) 1 / 0.15 / 0.55 / 39 2 / 0.25 / 0.45 / 68 3 / 0.15 / 0.45 / 16 4 / <0.1 / 0.2 / 0
NXB 3"	6'	0.6'	10%					50		RUN #4	49.0 TO 54.0 FT RECOVERED ONLY PIECES OF CHERT.	
							582.7	54			BOTTOM OF BORING AT 54.0 FT. REAMED HOLE TO 8-1/2" AND INSTALLED 2 INCH 316L STAINLESS STEEL MONITORING WELL SCREENED FROM 47.6 TO 57.6 FT.	
											AP=AVERAGE LENGTH OF CORE PIECES FROM EACH RUN. LP=LONGEST PIECE OF CORE FROM EACH RUN. RQD=ROCK QUALITY DESIGNATION FOR EACH RUN.	ALL SOIL AND ROCK COLOR DESCRIPTIONS FROM THE ROCK COLOR CHART, PRINTED BY THE GEOLOGICAL SOCIETY OF AMERICA, 1948.

SS=SPLIT SPOON ST=SHELBY TUBE; D=DENNISON P=PITCHER O=OTHER

SITE: 300 FT. NORTH OF COAL STORAGE AREA

HOLE NO. GMW-9

GEOLOGIC DRILL LOG
GMW-9

FIGURE B-9B

REPORT NO.:	EXHIBIT NO.:
DOE/OR/21548-164	A/PI/150/0892

ORIGINATOR:	DRAWN BY:	DATE:
JDC	SRS	8/92

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet 1 of 5

Project Number: MKE 9423

Hole Number: GT - 42 (GT-2B42)

GEOTECHNICAL BORING LOG

Project: WSSRAP GT DRILLING	Location: INTERSECTION SEISMIC LINES 3 & 8
Coordinates: (AEC) 101206.0N 50804.6W	Drilling Contractor: HANNIBAL TESTING LABS
Drill Make and Model: CME-55, 7" HOLLOW STEM AUGER; CORE NO WIRELINE	Depth Top of Rock: 37.0
Depth Casing & Size: 7" AUGER 35.0	Hole Size: 7"/2.98"
Elevation: 648.0 ft.	Angle from Vert. and Bearing: VERTICAL
Depth Bottom of Hole: 57.0 FT.	
Water Level: NONE	Fluid & Additives: CLEAR WATER
Date Start: 8:20 6/21/88	Date Finish: 7:20 6/24/88
Logger: A. BENFER	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION: Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		.5 2.0	SS 01	1"	5.8.12 20		Silty Clay, pinkish gray (7.5YR 6/2) dry, hard (4.5+) CL contains roots Mottled brownish yellow (10YR 6/6) and light gray (10YR 7/1). P.P. = 4.5+
		2.0 3.5	SS 02	12"	8.10.13 23		
	5	4.5 6.0	SS 03	1"	5.8.7 15		FERRELVIEW Very silty Silty Clay, mottled yellow brown (10 YR 5/6) and light gray (10YR 7/1) moist, stiff (1.8) with trace of gravel (5%)
		7.0 8.5	SS 04	6"	4.5.6 11		CLAY TILL
	10	9.5 12.0	ST 05	28"			-P.P. = 4.5+ hard, with MnOx (black) and sandstone cobble
		12.0 13.5	SS 06	12"	3.6.11 17		-P.P. = 4.5+ with sand (10%) and fine gravel (15%)
	15	14.5 16.0	SS 07	10"	3.6.9 15		-P.P. = 3.7 very stiff
		17.0 18.5	SB 08	12"	10.23.25 37		-P.P. = 4.5+, hard
	20	19.5 21.0	SS 09	2"	5.15.23 38		-P.P. = 4.5+ Silty Clay, sandy (fine 20%), gravelly, weathered limestone (2.5Y 7/6) dry, hard.
		22.0 23.5	SS 10	13"	7.7.11 18		-P.P. = 4.0 very stiff, yellow brown (10YR 6/6) subrounded sand (20%) and fine gravel (5%) MnOx (black)
	25	24.5	SB		13.23.25		

GEOTECHNICAL BORING LOG
GT-42

FIGURE B-10A

REPORT NO DOE/OR/21548-164		EXHIBIT NO A/PV186/1091	
ORIGINATOR JDC	DRAWN BY SRS	DATE 10/91	

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet 2 of 5
Project Number: MKE 9423
Hole Number: GT - 42 (GT-2B42)

GEOTECHNICAL BORING LOG

Project: WSSRAP GT DRILLING
Location: INTERSECTION SEISMIC LINES 3 & 8

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
		26.0	11	12"	37		- P.P. = 4.0
		27.0 28.5	SS 12	20"	4.5.9 14		- P.P. = 2.5 - 3.5 with stringers of $CaCO_3$ (white), subrounded gravel
	30	29.5 31.0	SS 13	0	3.20.27 47		Silty Clay, Sandy & gravelly (20%) hard lt. yellow brown (2.5Y 6/4) CL
							Gravel (Chert), clayey (20%), red (10R 5/6), and light gray, (10YR 7/1), dry, dense. GC. RESIDUUM
							Chert - heavy gravel 33.5' softer at 34' - layered
							auger refusal at 35.0'. Switched to 3" roller bit with water. Chert, red clay and minor limestone
							Boring continued with NQ core, 37.0' to 57.0', pages 3-5.

GEOTECHNICAL BORING LOG
GT-42

FIGURE B-10B

REPORT NO.	DOE/OR/21548-164	EXHIBIT NO.	A/PI/187/1091
ORIGINATOR	JDC	DRAWN BY	SRS
DATE	10/91		

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SOIL BORING LOG

Sheet 1 of 2
Project Number: 3840
Hole Number: GT-69

Project: Weldon Springs Site Remedial Action Project	Location: 200' NW of Bldg. 109, at foot of slope
Coordinates: (AEC) N:01092.9, W50327.1	Drilling Contractor: Geotechnology Services, Inc.
Drill Make and Model: CME 750, ATV mounted	Depth Top of Rock: 31.5 / Depth Casing & Size: -- / Hole Size: 7 1/2" (Auger
Elevation: 647.1	Angle from Vert. and Bearing: Vertical / Depth Bottom of Hole: 31.5
Water Level: Dry	Fluid & Additives: None / Date Start: 4/08/91 15:00 / Date Finish: 4/11/91 9:00 / Logger: E. Rennat

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION
							Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
							Silty Clay Mottled lt. to med. brown and lt. gray, moist, medium stiff, plastic, occasional Fe and Mn staining; Dk brown organics near top CL
		2.5-4	SS 6901	14"	1-4-5 (9)		
	5	5-7.5	ST 6902	15"			
							FERRELVIEW
		7.5-9	SS 6903	18"	2-7-10 (17)		Clay Orange-brown, moist, stiff, plastic, Mn staining along irregular fractures, 10% quartz sand considerable whitish calcite below 12.5' CL - CH
	10	10-12.5	ST 6904	28"			
		12.5-14	SS 6905	18"	3-10-15 (25)		
	15	15-17.5	ST 6906	24"			- ST pushed only 24"
							CLAY TILL
		17.5-19	SS 6907	18"	6-14-20 (34)		Clayey Sand and Sandy Clay Mottled lt. gray and lt. brown, slightly moist, stiff low plasticity, Fe and Mn staining, some calcite SC - CL
	20	20-22.5	ST 6908	27"			
							BASAL TILL
		22.5-24	SS 6909	19"	6-11-29 (40)		Reddish, moist, stiff, plastic, Mn stainning along irregular fractures; angular chert gravel, increasing with depth Gravelly Clay and Clayey Gravel
	25						

SS = Split Spoon ST = Shelby Tube CS = California Sampler (3")

SOIL BORING LOG
GT-69

FIGURE B-11A

REPORT NO.:	EXHIBIT NO.:
DOE/OR/21548-164	A/PI/151/0892

ORIGINATOR:	DRAWN BY:	DATE:
JDC	SRS	8/92

MK-ENVIRONMENTAL SERVICES

Project Number: 3840	Boring Number: GT - 69	Sheet 2 of 2

SOIL BORING LOG

Project: Weldon Springs Site RAP Location:

Elevation: Drilling Contractor:

Drilling Method and Equipment:

Water Level and Date: Start: Finish: Logger:

ELEVATION / DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION: Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
	25-26.5	CS 6910	12"	(52-41-31)		(cont'd)
	27.5-29	SS 6911	17"	3-20-18 (38)		- orange-brown color, 50% chert gravel, occasional calcite encrustation GC - CL
30	30	CS --	.2"	(100/1")		RESIDUUM
						Auger Refusal at 31.5'
35						
40						
45						
50						
55						

SS = Split Spoon ST = Shelby Tube CS = California Sampler (3")

SOIL BORING LOG
GT-69

FIGURE B-11B

REPORT NO.: DOE/OR/21548-164	EXHIBIT NO.: A/PI/152/0892	
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92

GEOLOGIC DRILL LOG

PROJECT: FUSRAP - WELDON SPRING SITE	JOB NO.: 14501-201	SHEET NO.: 1 of 3	HOLE NO.: G-3	
SITE: NORTHWEST OF COAL STORAGE AREA	COORDINATES: N101,195.3 W50,948.6	ANGLE FROM HORIZ.: 90	BEARING: -	
BEGUN: 2/1/86	COMPLETED: 2/11/86	DRILLER: TONY CALTRY, BROTCKE ENGINEERING	DRILL MAKE AND MODEL: CME-55 ATV	HOLE SIZE: 6 1/4" 3
OVERBURDEN (FT.): 54.6	ROCK (FT.): 33.6	TOTAL DEPTH: 88.2 FT		
CORE RECOVERY (FT./%): 30.5/91	CORE BOXES: 4	SAMPLES: 11	EL. TOP OF CASING: -	GROUND EL.: 654.0
DEPTH/EL. GROUND WATER: 65.55 FT/588.45	DEPTH/EL. TOP OF ROCK: 54.6 FT/599.4			
SAMPLE HAMMER WEIGHT/FALL: 140 LBS/30 IN	CASING LEFT IN HOLE: DIA./LENGTH: NONE	LOGGED BY: LAWRENCE YOUNG		

SAMPLE TYPE AND DIAMETER	SAMPLER ADVANCE LENGTH CORE RUN	SAMPLE RECOVERY CORE RECOVERY	SAMPLE BLOWS "N" PERCENT CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M.	PRESSURE P.S.I.	TIME IN MINUTES	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
				1ST 6	2ND 6	3RD 6	654.0	0				
							653.5	0.5			0-0.5 FT GRAVEL, LIGHT GRAY (N7), LIMESTONE.	0-54.6 FT DRILLED WITH 6¼IN OD HOLLOW STEM AUGERS.
											0.5-4.0 FT CLAYEY SILT, BLACK (N1), SOFT, MOIST, ORGANIC DEBRIS. Fill	
							650.0	4				
SS 2"	18"	18"	17	4	6	11		5		1	4.0-42.0 FT CLAYEY SILT, MODERATE BROWN (5YR 4/4), MOIST, VERY STIFF, TRACE CHERT GRAVEL. Ferrelview ?	
SS 2"	18"	18"	16	4	7	9		10		2		
SS 2"	18"	18"	22	5	9	13		15		3		
SS 2"	18"	18"	26	7	10	16		20		4		
SS 2"	18"	18"	33	14	15	18		25		5		DRIVING COBBLE.
SS 2"	18"	18"	28	7	13	15		30		6		
							619.0	35				

SS=SPLIT SPOON; ST=SHELBY TUBE; D=DENNISON; P=PITCHER; O=OTHER

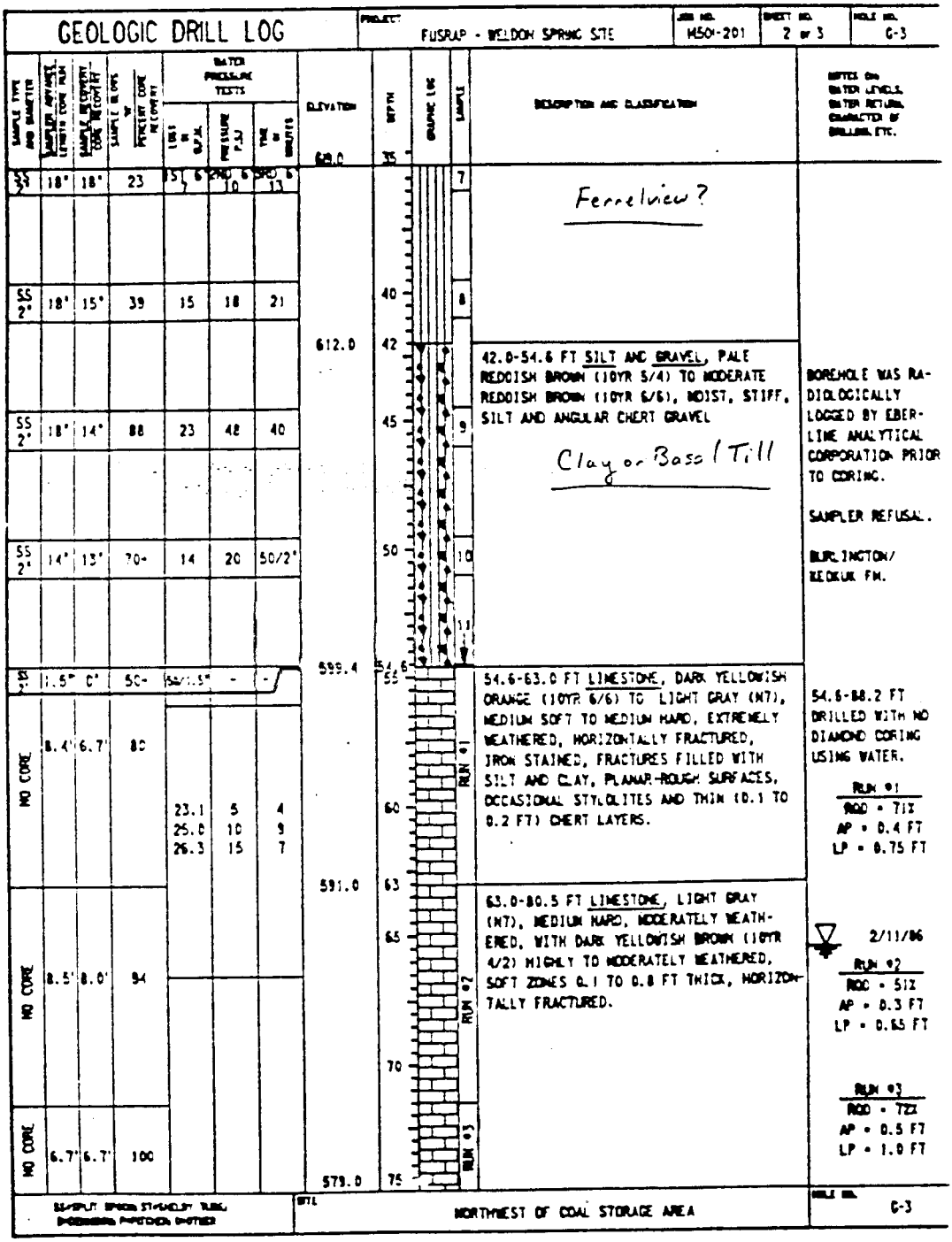
SITE: NORTHWEST OF COAL STORAGE AREA — HOLE NO.: G-3

UNITS INTERPRETED BY
D. E. CONOVER, JULY 1992.

GEOLOGIC DRILL LOG
G-3

FIGURE B-12A

REPORT NO.: DOE/OR/21548-164	EXHIBIT NO.: A/PI/153/0892	
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92

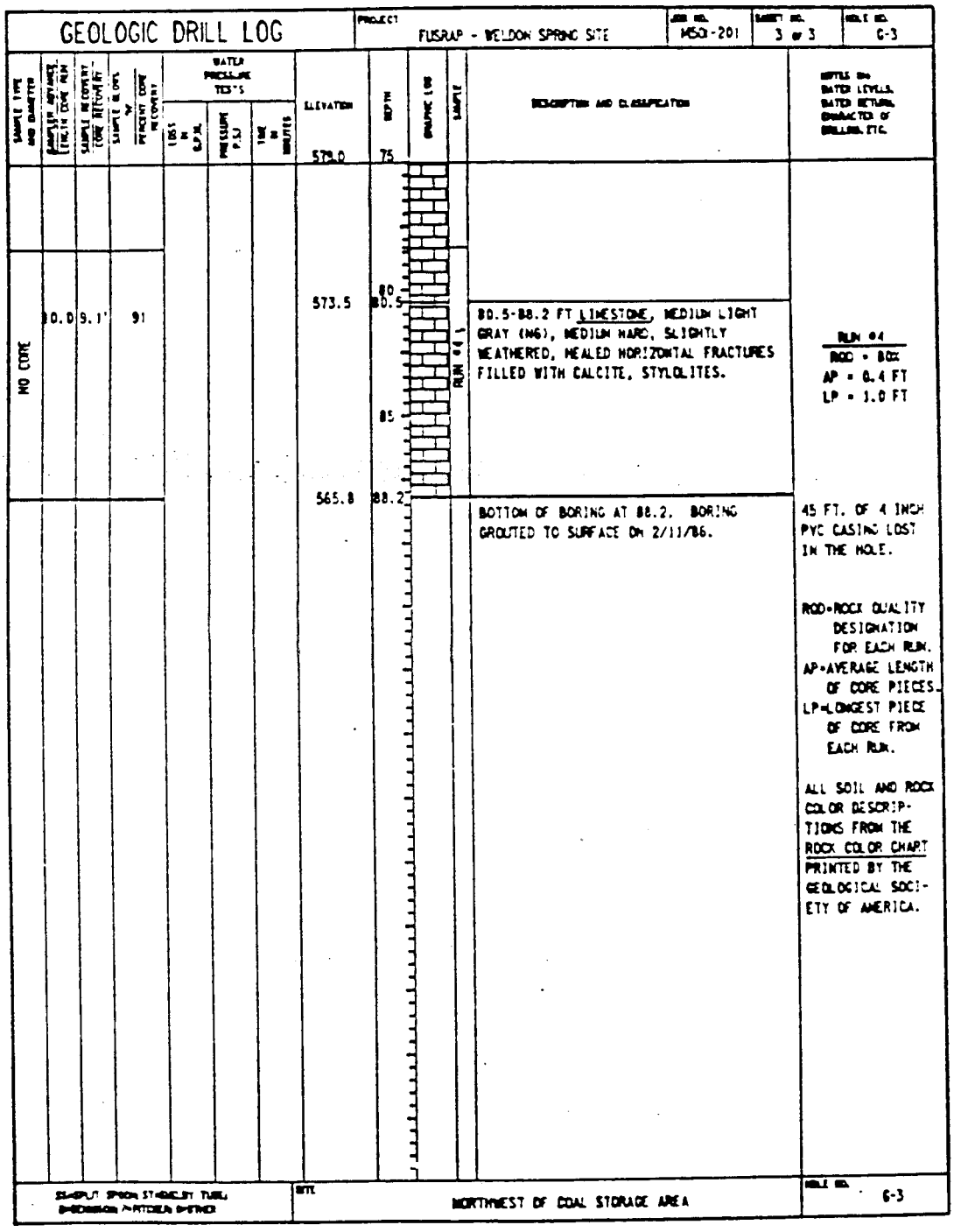


UNITS INTERPRETED BY
D. E. CONOVER, JULY 1992.

GEOLOGIC DRILL LOG
G-3

FIGURE B-12B

REPORT NO.: DOE/OR/21548-164	EXHIBIT NO.: A/PI/154/0892	
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92



GEOLOGIC DRILL LOG

PROJECT: FUSRAP - WELDON SPRING SITE | JOB NO. M50-201 | SHEET NO. 3 of 3 | HOLE NO. G-3

SAMPLE TYPE AND DIAMETER	SAMPLER ADVANCE (FEET IN CORE RUN)	SAMPLE RECOVERY (CORE RECOVERY)	SAMPLE RECOVERY % (PERCENT CORE RECOVERY)	WATER PRESSURE TESTS: LOSS IN G.P.M.	WATER PRESSURE TESTS: PRESSURE P.S.I.	WATER PRESSURE TESTS: TIME IN MINUTES	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING ETC.
							578.0	75				
NO CORE	10.0	9.1'	91				573.5	80 80.5		RUN #1	80.5-88.2 FT LIMESTONE, MEDIUM LIGHT GRAY (N6), MEDIUM HARD, SLIGHTLY WEATHERED, HEALED HORIZONTAL FRACTURES FILLED WITH CALCITE, STYLOLITES.	RUN #1 ROD = 80% AP = 0.4 FT LP = 1.0 FT
								85				
							565.8	88.2			BOTTOM OF BORING AT 88.2. BORING GROUTED TO SURFACE ON 2/11/86.	45 FT. OF 4 INCH PVC CASING LOST IN THE HOLE.

ROD=ROCK QUALITY DESIGNATION FOR EACH RUN.
AP=AVERAGE LENGTH OF CORE PIECES.
LP=LONGEST PIECE OF CORE FROM EACH RUN.

ALL SOIL AND ROCK COLOR DESCRIPTIONS FROM THE ROCK COLOR CHART PRINTED BY THE GEOLOGICAL SOCIETY OF AMERICA.

SS=SPLIT SPOON ST=SHELBY TUBE
SITE: NORTHWEST OF COAL STORAGE AREA
HOLE NO. G-3

GEOLOGIC DRILL LOG
G-3

FIGURE B-12C

REPORT NO.: DOE/OR/21548-164	EXHIBIT NO.: A/PI/155/0892	
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
FUSRAP - WELDON SPRING SITE	14501-201	1 of 2	G-5

SITE	COORDINATES	ANGLE FROM HORIZ.	BEARING
ADJACENT TO ASH DISCHARGE LINE	N100,650 W51,250	90	-

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	HOLE SIZE	OVERBURDEN (FT.)	ROCK (FT.)	TOTAL DEPTH
7/8/86	8/4/86	GEOTECHNOLOGY KURT JAEGER	CME-55	6"/3"	40.0	33.0	73.0'

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP OF CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
30.3/92	3	8	-	635.9	38.0/598.0	40.0'/595.9

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
140 LBS/30 IN	NONE	A. ATKINSON

SAMPLE TYPE AND DIAMETER	SAMPLER ADVANCE LENGTH CORE RUN	SAMPLE RECOVERY CORE RECOVERY	SAMPLE IN DBS % PERCENT CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M.	PRESSURE P.S.I.	TIME IN MINUTES	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							635.9	0				
6" HSA							634.9				0 TO 1.0 FT ORGANIC DEBRIS, GRASS, LEAVES, ROOTS, WOOD FRAGMENTS. Fill	0-38.0 FT DRILLED WITH 6IN OD HOLLOW STEM AUGERS USING CENTER PLUG.
SS 2"	18"	2.5	26	9	12	14		5		SS-1	1.0 TO 7.0 FT CLAY SILT/SILTY CLAY, MOTTLED ORANGE AND GRAY (10YR 5/4), VERY STIFF, MOIST, BLACK FRAGMENTS. Ferrelview	
6" HSA												
ST 3"	24"	22"					628.9	7		ST-1	7.0 TO 17.0 FT SILTY CLAY, YELLOWISH BROWN (10YR 5.5/5) TO ORANGE (10YR 5/5) AND GRAY (5Y 5/1), VERY STIFF, MOIST, TRACE SAND. Ferrelview	0 TO 10.0 FT. BOREHOLE WAS RADIOLOGICALLY LOGGED BY EBERLINE ANALYTICAL CORPORATION.
SS 2"	18"	0	27	10	14	13		10				
HSA												
SS 2"	18"	3.5"	23	9	10	13				SS-2		
6" HSA												
SS 2"	18"	18"	17	6	5	8		15		SS-3		
6" HSA							618.9	17			17.0 TO 22.0 FT CLAYEY SILT, GRAYISH ORANGE (10YR 6/3), WITH ORANGE AND BLACK MOTTLING, VERY STIFF, MOIST. Clay Till?	
SS 2"	18"	21"	23	7	13	10		20		SS-4		
6" HSA							613.9	22			22.0 TO 40.0 FT GRAVELLY CLAY, ORANGE (10YR5/4 TO 10YR 5/6) TO YELLOW (10YR 6/6) VERY STIFF TO HARD, MOIST, WITH ANGULAR WHITE (N9) TO DARK YELLOWISH ORANGE (10YR 6/6) CHERT. Basal Till	
SS 2"	18"	18"	50	18	23	27		25		SS-5		
6" HSA												
SS 2"	18"	16"	29	13	17	12		30		SS-6		
6" HSA												
SS 2"	8"	11"	50/2"	43	50/2"	-	600.9	35		T		

SS=SPLIT SPOON ST=SHELBY TUBE; D=DENISON PIPITCHER O=OTHER

SITE	HOLE NO.
ADJACENT TO ASH DISCHARGE LINE	G-5

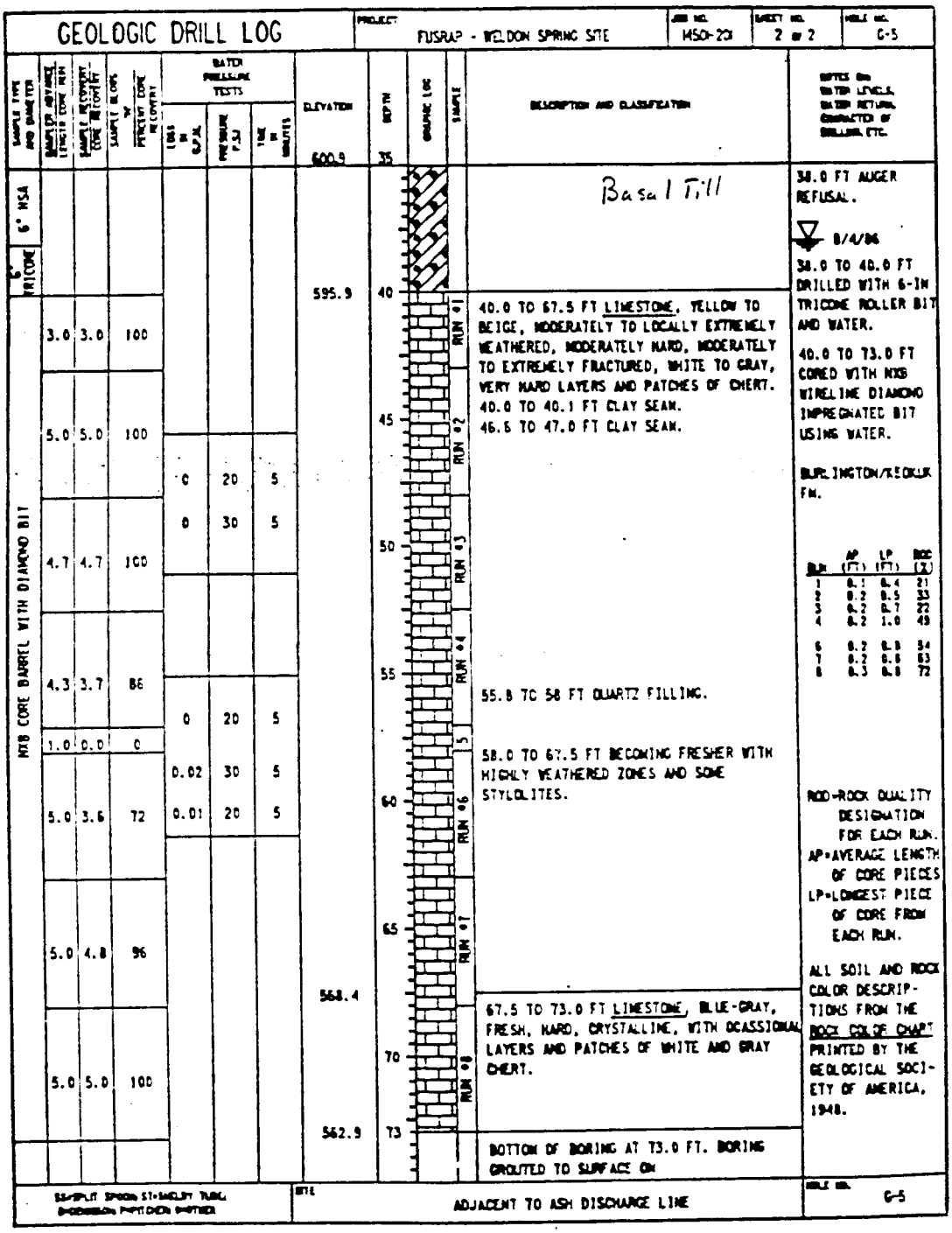
AS INTERPRETED BY
ALAN BENFER, JULY 1992.

GEOLOGIC DRILL LOG
G-5

FIGURE B-13A

REPORT NO.:	EXHIBIT NO.:
DOE/OR/21548-164	A/PI/156/0892

ORIGINATOR:	DRAWN BY:	DATE:
JDC	SRS	8/92



AS INTERPRETED BY ALAN BENFER, 1992.

GEOLOGIC DRILL LOG
G-5

FIGURE B-13B

REPORT NO.: DOE/OR/21548-164	EXHIBIT NO.: A/PI/157/0892	
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92

GEOLOGIC DRILL LOG

PROJECT: FUSRAP - WELDON SPRING SITE	JOB NO. 14501-201	SHEET NO. 1 OF 2	HOLE NO. G-6		
SITE: SOUTH OF ASH POND	COORDINATES: N100,450 W51,150	ANGLE FROM HORIZ. 90	BEARING -		
BEGUN 6/17/86	COMPLETED 6/20/86	DRILLER GEOTECHNOLOGY INC. KURT JAEGER/GEORGE MATTHEWS	DRILL MAKE AND MODEL CME-45/CME-750	HOLE SIZE 6-1/4"/3"	OVERBURDEN (FT.) 23.5
ROCK (FT.) 43.5	TOTAL DEPTH 67.0'	CORE RECOVERY (FT.)/% 29.0/71	CORE BOXES 4	SAMPLES 6	EL. TOP OF CASING -
GROUND EL. 639.7	DEPTH/EL. GROUND WATER 10.77/628.93	DEPTH/EL. TOP OF ROCK 23.5'/616.2			
SAMPLE HAMMER WEIGHT/FALL 140 LBS/30 IN	CASING LEFT IN HOLE: DIA./LENGTH NONE	LOGGED BY: LAWRENCE YOUNG			

SAMPLE TYPE AND NUMBER	SAMPLE OR RUN INTERVAL, LENGTH (IN.) OR RUN	SAMPLE RECOVERY (IN.) OR RUN RECOVERY	SAMPLE BLOWS PER 6" OR PERCENT CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M. PER FT.	WATER PRESSURE TESTS: PRESSURE P.S.I.	WATER PRESSURE TESTS: TIME IN MINUTES	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							639.7	0				0-23.5 FT DRILLED WITH 6¼IN OD HOLLOW STEM AUGERS USING CENTER PLUG.
SS 2"	18"	12"	14	4	7	7				1	0 TO 16.0 FT SILTY CLAY, MODERATE BROWN (5YR 4/4), MOTTLED WITH MEDIUM LIGHT GRAY(N6) SILT LENSES, MOIST, STIFF TO VERY STIFF, TRACE TO SOME FINE GRAVEL (PRIMARILY IGNEOUS AND METAMORHIC COMPOSITION), PYROLUSITE STRINGERS. Ferruginous	
								5				
SS 2"	18"	18"	18	3	8	10				2		0 TO 10.0 FT BORE-WAS RADIOLOGICALLY LOGGED BY EBERLINE ANALYTICAL CORPORATION.
								10				▽6/20/86 *
ST 3"	2'	2'	PUSHED	@ 700	PSI.					3		* MAY BE AFFECTED BY INCOMPLETE BREAKDOWN OF CLEAR MUD.
SS 2"	18"	18"	19	6	8	11				4		SHELBY TUBE STUCK IN HOLE. DROVE SPLIT SPOON SAMPLER INTO TUBE TO RECOVER.
								15				
							623.7	16			16.0 TO 23.5 FT GRAVELLY CLAY, DARK YELLOWISH ORANGE(10YR 6/6), MOIST, HARD WITH LIGHT GRAY(N7) ANGULAR CHERT GRAVEL. Clay Till	
ST 3"	2'	0'	PUSHED	@ 1000	PSI.					5		
SS 3"	3"	3"	50+	50/3"						6		23.5 FT AUGER REFUSAL 23.5 TO 25.0 FT USED TRICONE ROLLER BIT TO START CORE HOLE.
								20				
							616.2	23.5			23.5 TO 40.0 FT LIMESTONE, LIGHT BROWNISH GRAY (5YR 6/1), MEDIUM SOFT TO MEDIUM HARD, SEVERELY WEATHERED, WITH MODERATE BROWN(5YR 3/4)CLAY SEAMS, CHERT GRAVEL, SEAMS UP TO 1.5 FT IN THICKNESS, INTERBEDDED WITH SEMI-COMPETENT CHERT LENSES OR LAYERS. Basal Till / Residuum	25.0 TO 67.0 FT CORED WITH NQ3 WIRELINE DIAMOND IMPREGNATED BIT USING WATER AND CLEAR MUD.
NQ3	2.0'	2.0'	100					25		RUN #1		
NQ3 WIRE LINE CORE	3.0'	1.0'	33							RUN #2		RUN AP (FT.) LP (FT.) RMD (%): 1 — 0.7 34; 2 0.1 0.4 33
								30				
NQ3 WIRE LINE CORE	9.0'	1.3'	14							RUN #3		
							604.7	35				

SS=SPLIT SPOON ST=SHELBY TUBE; PERCOLATION PARTICULARS OMITTED

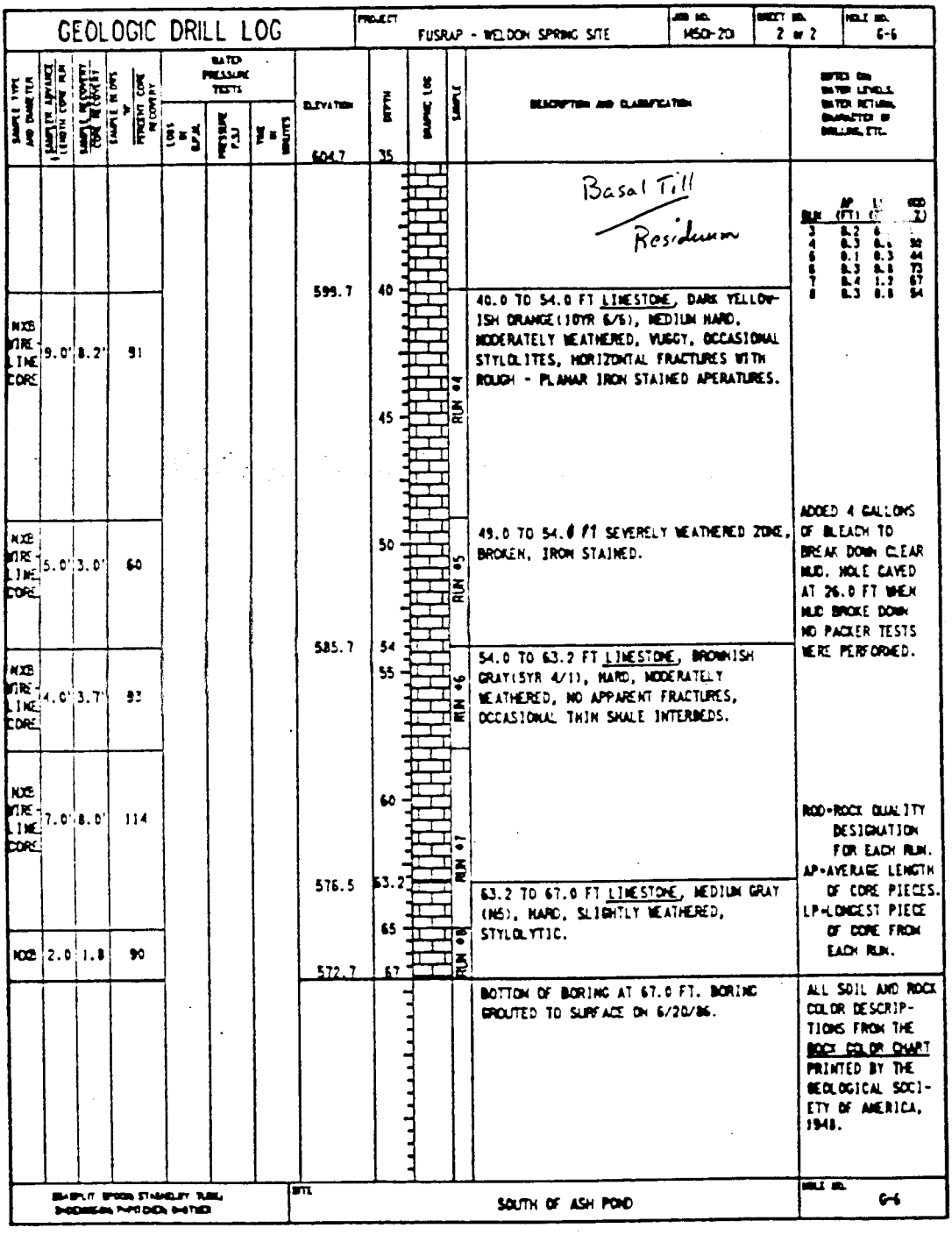
SITE: SOUTH OF ASH POND — HOLE NO. G-6

AS INTERPRETED BY
ALAN BENFER, JULY 1992.

GEOLOGIC DRILL LOG
G-6

FIGURE B-14A

REPORT NO.: DOE/OR/21548-164	EXHIBIT NO.: A/PI/158/0892	
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92



AS INTERPRETED BY
ALAN BENFER, JULY 1992.

GEOLOGIC DRILL LOG
G-6

FIGURE B-14B

REPORT NO.:	EXHIBIT NO.:
DOE/OR/21548-164	A/PI/159/0892

ORIGINATOR:	DRAWN BY:	DATE:
JDC	SRS	8/92

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 3

Project Number: WP-117

Hole Number: GT-61

Project: Geotechnical Investigation Phase II	Location: Chemical Plant Area, approximately 100' west of building 401
Coordinates: N.100609.25 W.50679.21 (AEC)	Drilling Contractor: Hannibal Testing Labs
Drill Make and Model: CME 55, 6 7/8" O.D. H.S. Auger, 3¼" I.D.	Depth Top of Rock: 59.5
Depth Casing & Size: 59.5 7" Auger	Hole Size: 7½"
Elevation: G.S. 658.13'	Angle from Vert. and Bearing: Vertical
Depth Bottom of Hole: 59.5	
Water Level: None	Fluid & Additives: None
Date Start: 6/20/89	Date Finish: 6/21/89
Logger: P. Patchin	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	0				Augered		0-2.0 Road base rockfill (limestone gravel) FILL 2.0
		2.5 4.0	SS 01	17"	3-3-4 7		CLAYEY SILT, nonplastic, mottled yellowish brown (10YR 5/4) and very dark grayish brown (10YR 3/2), damp, FeOx and MnOx blebs abundant, (20% clay), siltier at top, stiff (1.75), ML LOESS 5.0
	5	5.0 7.5	ST 02	17"			CLAY, highly plastic, mottled yellowish brown (10YR 5/4) and light gray (10YR 7/2), damp to moist, minor FeOx blebs, stiff (1.5), CH FERRELVIEW
		7.5 9.0	SS 03	18"	2-3-3 6		CLAY, as above, slightly siltier, pp=1.5, CH with whitish concretion (1cm), no HCl reaction 10.5
	10	10.0 12.5	ST 04	29"			CLAY, as above, increased light gray (10YR 7/2), MnOx stringers and FeOx blebs, pp=2.0, minor fractures, CH FERRELVIEW
		12.5 14.0	SS 05	18"	2-3-5 8		CLAY, as above, minor very fine gravel < 5% slickensides, increased yellowish brown color, pp=2.5, CH
	15	15.0 17.5	ST 06	29"			SILTY CLAY, slightly plastic, sandy(5%) very fine, mottled yellowish brown (10YR 5/8) and minor light gray (10YR 7/2)(sand), dry to damp, fine gravel(quartz and chert) subangular to subrounded, MnOx stringers abundant, FeOx blebs, hard (4.25), CL
		17.5 19.0	SS 07	18"	3-6-8 14		SILTY CLAY, as above with predominant yellowish brown (10YR 5/8); 10% gravel fine to 1 cm, dry, subrounded mafic gravel, hard (>4.5), 5 mm FeOx blebs, CL
	20	20.0 22.5	ST 08	26"			SILTY CLAY, as above, pp=4.5 CLAY TILL
		22.5 24.0	SS 09	18"	3-5-9 14		SILTY CLAY, as above, some vertical fractures with leaching, damp to dry, abundant MnOx, some mottling, pp=4.5
	25						Sample ST10 on next page

BOREHOLE LOG GT-61

FIGURE B-15A

REPORT NO.: DOE/OR/21548-164	EXHIBIT NO.: A/PI/160/0892		
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92	

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 2 of 3

Project Number: WP-117

Hole Number: GT-61

Project: Geotechnical Investigation Phase II

Location:

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	25	25.0	ST 10	30"			SILTY CLAY, as above, increased sand (very fine)(20%), minor gravel fine to very fine, dry, pp > 4.5, non-plastic, vertical fractures with leaching, CL
		27.5					
		27.5	SS 11	18"	4-8-11 19		SILTY CLAY, as above, very silty and sandy (40%), grading to CLAYEY SILT at bottom, vertical fractures leached to light olive gray (5Y 6/2), pp=4.5, dry CL-ML
		29.0					CLAY TILL 30.0
	30	30.0	ST 12	20"	20		SILTY SAND, very fine grained, brownish yellow (10YR 6/8) dry, hard(>4.5) MnOx streaks, no gravel, SM.
6/20		31.6					CLAY TILL?
		32.5	SS 13	16"	4-7-7 14		SILTY SANDY CLAY with 10% fine gravel, slightly plastic, damp to moist, yellowish brown(10YR 5/8), with abundant vertical fractures stained with MnOx and leached, very stiff(3.75) CL
		34.0					CLAY TILL
	35	35.0	SB 14	6"	36-50-45 50		GRAVELLY SAND fine grained, dry to damp, brownish yellow(10YR 6/8). Gravel is coarse grained($CaCO_3$ cemented SS(10%)), very dense, SW. CLAY TILL(BASAL TILL?)
		36.5					Interbedded CLAY, SILT and SAND, mottled yellowish brown(10YR 5/8) and light gray(5Y 7/1). 60% clay is dry to damp slightly plastic with abundant MnOx stringers, vertical fractures, sand is in pockets fine to medium grained(gray), only minor very fine gravel, FeOx nodules, CL
		37.5	SS 15	18"	4-6-7 17		
		39.0					
	40	40.0	SB 16	12"	7-10-18 28		As above, more clay(75%), abundant FeOx nodules, damp to dry, minor fine gravel, CL
		41.5					CLAY TILL 42.5
							CLAY TILL?
	45	45.0	SS 17	18"	8-10-11 21		CLAYEY SILT, mottled light gray(2.5Y 7/2)and yellowish brown(10YR 5/8) with 3cm microcrystalline, angular limestone gravel piece at 42.7'. Silt is nonplastic, damp, with abundant MnOx stringers and FeOx stain, very clayey at top, very stiff(2.5) CL
		46.5					BASAL TILL?
	50	50.0	SB 18	12"	3-36-40 50		GRAVELLY SILT, as above with 30% subangular chert gravel, silt is clayey, light gray(10YR 7/2) with FeOx mottling, damp to dry, dense ML
	*	51.5					RESIDUUM
							See next page for sample SS19 description.

BOREHOLE LOG
GT-61

FIGURE B-15B

REPORT NO.: DOE/OR/21548-164

EXHIBIT NO.: A/PI/161/0892

ORIGINATOR: JDC

DRAWN BY: SRS

DATE: 8/92

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 3 of 3

Project Number: WP-117

Hole Number: GT-61

Project: Geotechnical Investigation Phase II

Location:

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	55	55.0 56.5	SS 19	7"	6-7-8 15		CLAYEY GRAVEL, brownish yellow(10YR 6/8) with poorly sorted subangular chert gravel, fine to 4 cm with MnOx dendrites, some very coarse sand (fine gravel) and minor silt, damp to moist, GC RESIDUUM Auger refusal 59.5
	60						Top of bedrock at 12:55 p.m. 6/21/89 Borehole grouted to surface with Volclay bentonite grout. *Falling Head Test at 51.5', take = 48 oz/10 min After pulling drill pipe determined rock piece at end of pipe. Pipe may have not been seated properly.

BOREHOLE LOG
GT-61

FIGURE B-15C

REPORT NO.: DOE/OR/21548-164	EXHIBIT NO.: A/PI/162/0892	
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92

GEOLOGIC DRILL LOG

PROJECT: FUSRAP - WELDON SPRING SITE	JOB NO.: 14501-201	SHEET NO.: 1 OF 3	HOLE NO.: G-8		
SITE: EAST OF BLDG. 407	COORDINATES: N100,450 W49,900	ANGLE FROM HORIZ.: 90	BEARING: -		
BEGUN: 6/16/86	COMPLETED: 6/18/86	DRILLER: GEOTECHNOLOGY INC. KURT JAEGER/GEORGE MATTHEWS	DRILL MAKE AND MODEL: CME-45/CME-750	HOLE SIZE: 6-1/4"/3"	OVERBURDEN (FT.): 30.0
ROCK (FT.): 45.0	TOTAL DEPTH: 75.0'				
CORE RECOVERY (FT.): 43.3/92	CORE BOXES: 5	SAMPLES: 8	EL. TOP OF CASING: -	GROUND EL.: 655.3	DEPTH/EL. GROUND WATER: 52.0'/603.8
DEPTH/EL. TOP OF ROCK: 30.0'/625.3					
SAMPLE HAMMER WEIGHT/FALL: 140 LBS/30 IN	CASING LEFT IN HOLE DIA./LENGTH: NONE	LOGGED BY: LAWRENCE YOUNG			

SAMPLE TYPE AND DIAMETER	SAMPLER ADVANCE LENGTH CORE RUN	SAMPLE RECOVERY CORE RECOVERY	SAMPLE BLOWS / PERCENT CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M.	PRESSURE P.S.I.	TIME IN MINUTES	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	WATER ON WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							655.3	0			6' Fill	
							654.8	0.5			0 TO 0.5 FT GRAVEL, MEDIUM GRAY(N5), LIMESTONE, TRACE ORGANIC DEBRIS, ROADBED.	0-30.0 FT DRILLED WITH 6¼IN OD HOL LOW STEM AUGERS USING CENTER PLUG.
SS 2"	18"	5"	6	3	3	3	Ferrelview	1			0.5 TO 15.0 FT SILTY CLAY, DARK GREENISH GRAY(5GY 4/1) TO MODERATE YELLOWISH BROWN(10YR 5/4), MOIST, MEDIUM STIFF, TO STIFF, MOTTLED WITH MEDIUM GRAY(N5) SILT LENSES, OXIDIZED ZONES NEAR BOTTOM OF UNIT. FILL 6.0	Grading Plan
								5			3' Loess - 9.0	0 TO 10.0 FT BOREHOLE WAS RADIOLOGICALLY LOGGED BY EBERLINE ANALYTICAL CORPORATION.
											9.0 Loess	
SS 2"	18"	13"	13	2	5	8		2				
								10			Ferrelview	Picks from GT-5's
ST 3"	2.0'	2.0'	PUSHED @ 700 PSI				Ferrelview	3				
SS 2"	18"	19"	12	4	5	7		4			15.0	
							640.3	15			15.0 TO 26.0 FT SILTY CLAY, LIGHT BROWN (5YR 5/6), MOIST, VERY STIFF, SOME FINE GRAVEL, PYROLUSITE STRINGERS.	
SS 2"	18"	21"	17	4	6	11		5				
								20			Clay till	
ST 3"	2.0'	2.0'	PUSHED @ 700 PSI				Clay till	6				
SS 2"	18"	24"	18	6	7	11		7				
								25				
							629.3	26			26.0 TO 30.0 FT GRAVELLY CLAY, LIGHT BROWN(5YR 6/6) TO DARK YELLOWISH ORANGE (10YR 6/6), MOIST, HARD, VERY LIGHT GRAY (N8), MODERATELY WEATHERED, ANGULAR CHERT GRAVEL, TRACE TO SOME FINE-GRAINED SAND.	AUGER REFUSAL AT 30.0 FT. 30.0 TO 75.0 FT. DRILLED WITH NXB DIAMOND IMPREGNATED CORE BIT AND FRESH WATER.
SS 2"	11-1/2"	9"	50+	5	50/5-1/2"							
				12.1	5	9	625.3	30			30.0 TO 34.3 FT LIMESTONE, DARK YELLOWISH ORANGE(10YR 4/6), MODERATELY SOFT, SEVERELY WEATHERED, WITH MODERATE BROWN (5YR 3/4), CLAY SEAMS WITH CHERT GRAVEL AND SEMI-COMPETENT CHERT LAYERS.	RUN #1 ROD = 30% AP = 0.4 FT LP = 0.5 FT
NXB WIRE LINE CORE	10.0	9.0	90%	13.2	10	8	RQD = 27%	1	RUN #1			
		9.0	1.3	2.7				34.3				
			2.7/10 =	15.5	5	6	621.0 620.3	35				

SS=SPLIT SPOON ST=SHELBY TUBE; PHOTOGRAPH PHOTOCHECK; OTHER

SITE: EAST OF BLDG. 407 X-Section

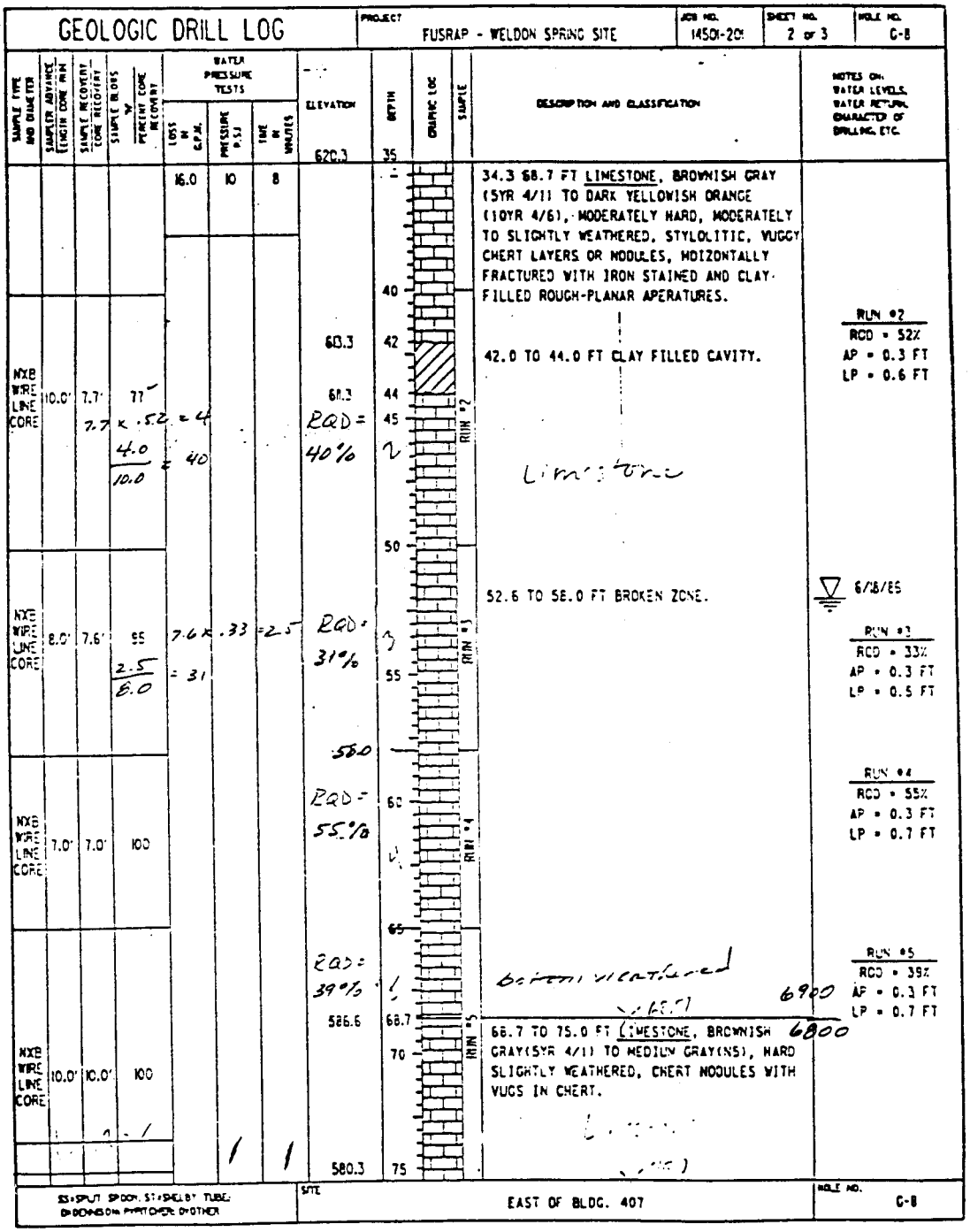
HOLE NO.: G-8

INTERPRETATION OF UNITS BY ALAN BENFER, 1989.

GEOLOGIC DRILL LOG
G-8

FIGURE B-16A

REPORT NO.: DOE/OR/21548-164	EXHIBIT NO.: A/PI/163/0892	
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92



GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
FUSRAP - WELDON SPRING SITE	14501-201	2 of 3	G-8

SAMPLE TYPE AND DIAMETER	SAMPLER ADVANCE / LENGTH CORE RUN	SAMPLE RECOVERY / CORE RECOVERY	SAMPLE BLOWS / PERCENT CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M.	PRESSURE P.S.I.	TIME IN MINUTES	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
				16.0	10	8	620.3	35			34.3 68.7 FT LIMESTONE, BROWNISH GRAY (5YR 4/1) TO DARK YELLOWISH ORANGE (10YR 4/6), MODERATELY HARD, MODERATELY TO SLIGHTLY WEATHERED, STYLOLITIC, VUGGY CHERT LAYERS OR NODULES, HOIZONTALLY FRACTURED WITH IRON STAINED AND CLAY-FILLED ROUGH-PLANAR APERATURES.	
NXB WIRE LINE CORE	10.0'	7.7'	77				613.3	40 / 42		RUN #2	42.0 TO 44.0 FT CLAY FILLED CAVITY.	RUN #2 RQD = 52% AP = 0.3 FT LP = 0.6 FT
			7.7 x .52 = 4 / 4.0 / 10.0 = 40				611.3 RQD = 40%	44 / 45			Limestone	
NXB WIRE LINE CORE	8.0'	7.6'	95	7.6 x .33 = 2.5			RQD = 31%	50 / 55		RUN #3	52.6 TO 58.0 FT BROKEN ZONE.	6/18/85 RUN #3 RQD = 33% AP = 0.3 FT LP = 0.5 FT
			2.5 / 8.0 = 31				58.0					
NXB WIRE LINE CORE	7.0'	7.0'	100				RQD = 55%	60		RUN #4		RUN #4 RQD = 55% AP = 0.3 FT LP = 0.7 FT
NXB WIRE LINE CORE	10.0'	10.0'	100				RQD = 39%	65		RUN #5	bottom weathered 6900	RUN #5 RQD = 39% AP = 0.3 FT LP = 0.7 FT
							586.6	68.7 / 70			68.7 TO 75.0 FT LIMESTONE, BROWNISH GRAY(5YR 4/1) TO MEDIUM GRAY(N5), HARD SLIGHTLY WEATHERED, CHERT NODULES WITH VUGS IN CHERT. 6800	
							580.3	75				

SS=SPLIT SPOON, ST=SHELBY TUBE, DENNISON=PYRITCHER, OTHER

SITE	HOLE NO.
EAST OF BLDG. 407	G-8

INTERPRETATION OF UNITS BY ALAN BENFER, 1989.

GEOLOGIC DRILL LOG G-8

FIGURE B-16B

REPORT NO.:	EXHIBIT NO.:
DOE/OR/21548-164	A/PI/164/0892

ORIGINATOR:	DRAWN BY:	DATE:
JDC	SRS	8/92

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
FUSRAP - WELDON SPRING SITE	14501-201	3 of 3	G-8

SAMPLE TYPE AND DIAMETER	SAMPLER ADVANCE LENGTH CORE RUN	SAMPLE RECOVERY CORE RECOVERY	SAMPLE BLOWS /ft PERCENT CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M.	WATER PRESSURE TESTS: PRESSURE P.S.I	WATER PRESSURE TESTS: TIME IN MINUTES	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							580.3	75			BOTTOM OF BORING AT 75.0 FT. BORING GROUTED TO SURFACE ON 6/18/86.	ROD=ROCK QUALITY DESIGNATION FOR EACH RUN. AP=AVERAGE LENGTH OF CORE PIECES LP=LONGEST PIECE OF CORE FROM EACH RUN. ALL SOIL AND ROCK COLOR DESCRIPTIONS FROM THE ROCK COLOR CHART PRINTED BY THE GEOLOGICAL SOCIETY OF AMERICA, 1948.

SS:SPLIT SPOON ST:SHELBY TUBE, D:DENNISON, P:PITCHER, O:OTHER

SITE: EAST OF BLDG. 407

HOLE NO. G-8

INTERPRETATION OF UNITS BY ALAN BENFER, 1989.

GEOLOGIC DRILL LOG
G-8

FIGURE B-16C

REPORT NO.:	EXHIBIT NO.:
DOE/OR/21548-164	A/PI/165/0892

ORIGINATOR:	DRAWN BY:	DATE:
JDC	SRS	8/92

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet 1 of 5

GEOTECHNICAL BORING LOG

Project Number: MKE 9423

Hole Number: GT-55 (GT-2B55)

Project: WSSRAP GEOTECH DRILLING	Location: Approx. 33' E. seismic line #2, Sta. 4+67
Coordinates: (AEC) 100490N 49937W	Drilling Contractor: Hannibal Testing Laboratories
Drill Make and Model: CME-55 7" Hollow Stem Auger; Core: NQ Wireline	Depth Top of Rock: 33.0
Depth Casing & Size: 3½" I.D.	Hole Size: 7" Auger 2.98" Core
Elevation: 655.6 ft. G.S.	Angle from Vert. and Bearing: Vertical
Depth Bottom of Hole: 53.0	
Water Level:	Fluid & Additives: Clear Water
Date Start: 08/19/88	Date Finish: 12:00 08/24/88
Logger: P. Patchin A. Benfer	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	0	0.0 1.5	SS 01	5"	3.7.11 18		Silt, very dark grayish brown, (10YR 3/2) with angular limestone gravel, roots 0.0-0.2'. Pale yellow (10YR 7/4)) at 1.4', dry. ML FILL
		2.5 5.0	ST 02	20"			Silt, brown (10YR 5/3), slightly clayey, mottled with gray (10YR 6/1), damp to dry, hard (4.5) ML
	5	5.0 6.5	SS 03	12"	1.3.3 6		Clayey silt, yellowish brn (10YR 5/6), stiff (1:5), damp, ML FILL 6.0
8/19 8/22		7.5 10.0	ST 04	19"			Silty clay, olive gray (5Y 5/2), moist, stiff (2.0) silt (40%) CL LOESS - P.P. = 2.0, less silt, CL-CH 10.0
	10	10.0 11.5	SS 05	12"	3.6.9 15		Silty Clay , mottled - P.P. = 3.0, very stiff, gray (5Y 6/1) and brnsh yellow (10YR 6/8), minor MnOx FERRELVIEW
		12.5 15.0	ST 06	25"			Clay, mottled light gray (10YR 7/1) and brownish yellow (10YR 6/6), moist - tip wet, very stiff (2.5), CL-CH FERRELVIEW
	15	15.0 16.5	SS 07	14"	2.4.5 9		- P.P. = 2.2, trace sand (< 5%), moist
		17.5 20.0	ST 08	20"			- P.P. = 2.75, mottled brownish yellow (10YR 6/6) and light gray (10YR 7/1) and black (MnOx). 20.0
	20	20.0 21.5	SS 09	18"	4.8.11 19		10% sand and fine gravel, CL Silty clay, sandy (20%) and fine gravel (5%), mottled brownish yellow (10YR 6/8), light gray (10YR 7/1, and black (MnOx), moist, hard (4.5+). CL-CH
		22.5 24.0	SB 10	12"	5.9.12 21		- P.P. = 3.0, very stiff, 20% sand CLAY TILL
	25						

GEOTECHNICAL BORING LOG GT-55

FIGURE B-17A

REPORT NO.:	EXHIBIT NO.:
DOE/OR/21548-164	A/PI/166/0892
ORIGINATOR: JDC	DRAWN BY: SRS
DATE: 8/92	

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A MORRISON KNUDSEN COMPANY

Sheet 2 of 5

Project Number: MKE 9423

Hole Number: GT-55 (GT-2B55)

GEOTECHNICAL BORING LOG

Project: WSSRAP GT Drilling

Location: Approx. 33' E. seismic line #2, Sta. 4+67

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	25.0	SS 11	18"	3.5.8 13			Silty Clay, sandy (15%), fine gravel 1/8-1/4" (15%), mottled brownish yellow (10YR 7/6), light gray (10YR 7/1) and black MnOx stringers, moist, very stiff (3.3). CH. FeOx nodules.
	26.5						27.0
	27.5	SB 12	12"	4.11.16 27			Clay, 15% fine gravel (1/8" chert), mottled, red (10R 5/6), light gray (10YR 7/1) and minor black, moist, very stiff (3.5). CH
	29.0						
30	30.0	SS 13	7"	4.31.30 61			- Gravel, (chert), clay matrix (25%) red brown (5YR 5/4), dense. GC. RESIDUUM
	31.5						
	32.5	SS 14	0"	Rods Bouncing			T.D. 33.0 auger refusal 1:40 8/22/88
35							Switched to NQ core at 33.0', to 53.0', pages 3-5
40							

GEOTECHNICAL BORING LOG GT-55

FIGURE B-17B

REPORT NO.: DOE/OR/21548-164	EXHIBIT NO.: A/PI/167/0892	
ORIGINATOR: JDC	DRAWN BY: SRS	DATE: 8/92

CHEMICAL PLANT ADMINISTRATIVE RECORD FILE

ARFS FILE # C-202-1

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SECTION	SECTION TITLE
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202	Sampling and Analysis Data - Chain of Custody Forms

DOCUMENT NUMBERS	DOCUMENT TITLE
C-200-202-1.01( )	PHASE I CHEMICAL SOIL INVESTIGATION DATA REPORT THE WSCP/WSRP
C-200-202-1.02(r)	RADIOLOGICAL AND CHEMICAL UPTAKE BY EDIBLE PORTIONS OF SELECTED BIOTA AT THE WSS
C-200-202-1.03(r)	AQUIFER CHARACTERISTICS DATA REPORT FOR THE WSCP/WSRP AND VP
C-200-202-1.04	WSSRAP ANNUAL SITE ENVIRONMENTAL REPORT 1989

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

CHEMICAL PLANT
202-1.01

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

3589-88-I-DOE-262

FERGUSON
RECEIVED
JUN 16 1988
WSSRAP CONTRACT 3589

June 15, 1988

ADDRESSEES

PHASE I CHEMICAL SOIL INVESTIGATION DATA REPORT FOR THE WELDON SPRING CHEMICAL PLANT/RAFFINATE PITS

Enclosed is a final copy(s) of the Phase I Chemical Soil Investigation Data Report for the Weldon Spring Chemical Plant/Raffinate Pits for your use. This investigation was designed to supply baseline soil information for the site.

Results from the sampling indicate the presence of elevated levels of nitrate, sulfate, and certain metals in the soils at the Chemical Plant and Raffinate Pit area. The data presented in the report will be used to develop the Chemical Soil Investigation Sampling Plan which will contain the overall soil characterization strategy for the site.

Sincerely,

R. R. Nelson

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

ADDRESSEES FOR LETTER DATED JUNE 15, 1988

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DOE/OR/21548-016

United States Department Of Energy

PHASE I CHEMICAL SOIL INVESTIGATION DATA REPORT FOR THE WELDON SPRING CHEMICAL PLANT / RAFFINATE PITS

JUNE, 1988

WELDON SPRING SITE REMEDIAL ACTION PROJECT

ED 234

PHASE I CHEMICAL SOIL INVESTIGATION

DATA REPORT

FOR

THE WELDON SPRING CHEMICAL PLANT/RAFFINATE PITS

PREPARED FOR:

U.S. DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

UNDER CONTRACT NO. DE-AC05-86OR21548

PREPARED BY:

MK-FERGUSON COMPANY

AND

JACOBS ENGINEERING GROUP

ROUTE 2, HIGHWAY 94 SOUTH

ST. CHARLES, MISSOURI 63303

JUNE, 1988

PHASE I CHEMICAL SOIL INVESTIGATION

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1.0 INTRODUCTION

This report presents the Phase I Chemical Soil Investigation data for the Weldon Spring Chemical Plant/Raffinate Pits (WSCP/WSRP). Sample collection methods, sampling equipment decontamination techniques, analytical procedures, and analytical results are also presented in this report, as well as limited interpretations of those results. This investigation was not intended to fully characterize chemical soil contamination at the WSCP/WSRP. The objective of this investigation was to supply baseline soil information for development of a detailed Chemical Soil Investigation Sampling Plan that will more fully define the extent and magnitude of chemical soil contamination at the WSCP/WSRP.

The WSCP/WSRP portions of the Weldon Spring Site (WSS) consist of 217 acres located approximately 2 miles southwest of Weldon Spring, Missouri. Uranium ore concentrate was processed at the WSCP from 1957 until 1966 when it was known as the Weldon Spring Uranium Feed Materials Plant (WSUFMP). Process wastes from uranium ore concentrate processing are contained in four raffinate pits located on the site. Prior to 1955, the WSCP/WSRP area was part of the Weldon Spring Ordnance Works (WSOW). The WSOW produced trinitrotoluene (TNT) and dinitrotoluene (DNT) during World War II. Three complete TNT batch plants and portions of a fourth plant existed within the confines of the present WSCP/WSRP 217-acre area.

Prior to this investigation, only limited amounts of chemical data were available for the soils at the WSCP/WSRP. In 1975-76 the Department of Army (DA) documented low levels (ug/Kg) of nitroaromatics in WSCP soils (DACDIR, 1975). This report provided the only documentation of chemical soil contaminants at the WSCP/WSRP. In the spring of 1987, United Nuclear Corporation (UNC) was contracted through the Department of Energy (DOE) to perform a radiological characterization of the WSCP/WSRP soils.

Soil samples were split from selected radiological sampling locations by on-site personnel for chemical analysis. Field work began in May and was completed by mid-July 1987. Analytical results were received in August 1987.

1.1 Purpose

This investigation was designed to provide baseline data regarding chemical soil contamination and to develop on-site background metals concentrations at the WSCP/WSRP. Sampling locations were selected to investigate potential chemical soil contamination source areas from TNT production and/or uranium processing and to provide areal coverage of the site. Samples were collected concurrently with the radiological soils characterization performed by UNC. The results of this investigation and previously collected data have been used to

develop a comprehensive chemical soil characterization sampling plan.

1.2 Scope

This sampling effort consisted of collecting 149 samples from 37 locations. Sampling locations were selected by evaluating WSOW and WSUFMP processes. Potential source areas were identified and targeted for sampling. Additional locations were added to provide areal coverage.

Analytical parameters were selected based on results of the Phase I Water Quality Assessment which detected elevated levels of nitroaromatics, nitrate, sulfate, fluoride and metals in the groundwater beneath the WSCP/WSRP. No organics (except nitroaromatics) were detected, so soil samples were not analyzed for organic compounds.

2.0 SAMPLING

2.1 Sample Collection

Soil samples were collected from 37 locations at or near the WSCP/WSRP. Figure 2-1 shows the sampling locations. Thirty-two locations were within the fenced WSCP/WSRP boundary. Four of the remaining five boreholes were drilled in WSOW Waste Lagoon

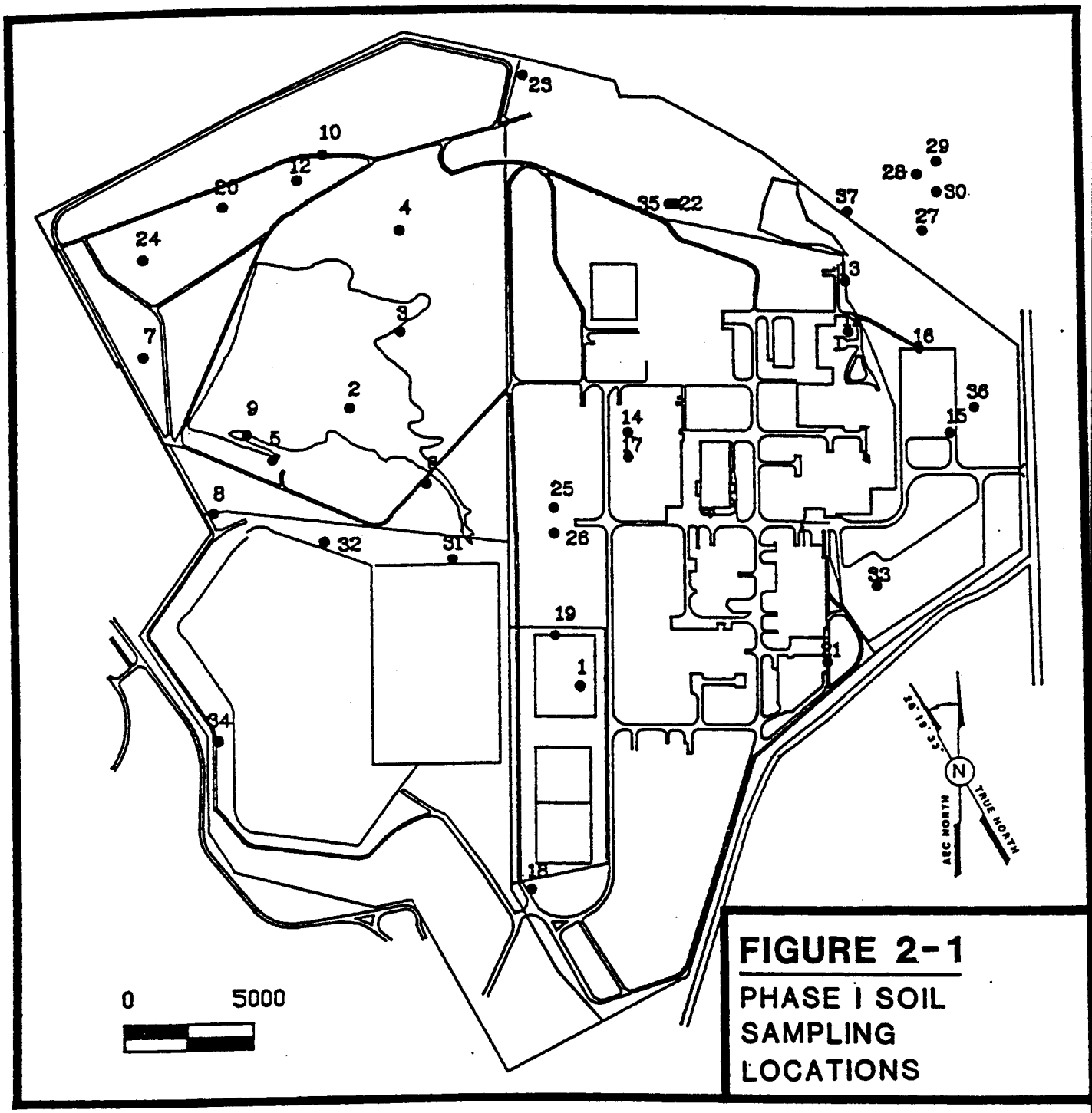

FIGURE 2-1
PHASE I SOIL SAMPLING LOCATIONS

No. 1, located just northeast of Frog Pond to, investigate this potential source area.

The final borehole was located between the WSCP and the WSOW waste lagoon. Table 2-1 details borehole coordinates, numbers, depths and date drilled.

Samples were collected using a truck-mounted CME-55 drill rig employing 6 5/8" outside diameter (O.D.) hollow stem augers for drilling and a 3" O.D. by 24 inch long split tube sampler. Samples were collected continuously by driving the split tube sampler with a 140 lb. drop weight.

After driving the sampler two feet, it was removed from the borehole and taken to a shaded area prior to opening, in order to prevent the photolysis of nitroaromatic residues in the soil. Samples were obtained using a stainless steel spatula to fill the sample containers. Samples were collected in the following increments at most locations:

0 to 6 inches
6 to 24 inches
24 to 48 inches
48 to 72 inches

If the borehole advanced beyond 6 feet, samples were composited over 4- to 10-foot intervals. The 0- to 6-inch interval was

Table 2-1

Boring Locations and Depths

Location No.	Location Coordinates West,North	Date Sampled	Depth of Borehole (ft.)
1	SO-50700,99400	05/29/87	12
2	SO-51600,100500	06/02/87	9
3	SO-51400,100800	06/02/87	6
4	SO-51400,101200	06/02/87	6
5	SO-51900,100300	06/02/87	10
6	SO-51300,100200	06/02/87	6
7	SO-52400,100715	06/02/87	6
8	SO-52131,100094	06/02/87	6
9	SO-52000,100400	06/02/87	15
10	SO-51700,101500	06/03/87	6
11	SO-49600,100800	06/03/87	24
12	SO-51800,101400	06/03/87	6
13	SO-49610,10100	06/03/87	14
14	SO-50500,100395	06/04/87	6
15	SO-49200,100400	06/04/87	6
16	SO-49320,100735	06/04/87	6
17	SO-50500,100300	06/04/87	6
18	SO-50900,98600	06/04/87	6
19	SO-50800,99600	06/04/87	
20	SO-52090,101300	06/09/87	6
21	SO-49700,99500	06/09/87	6
22	SO-50300,101300	06/09/87	6
23	SO-50910,101803	06/09/87	6
24	SO-52400,101100	06/09/87	6
25	SO-50800,100100	06/10/87	20
26	SO-50800,100000	06/10/87	6
27	SO-49300,101200	06/15/87	3
28	SO-49320,101420	06/15/87	4
29	SO-49240,101470	06/15/87	3
30	SO-49240,101350	06/15/87	13
31	SO-51200,99900	06/26/87	16
32	SO-51700,99975	06/29/87	16
33	SO-49500,99800	06/30/87	6
34	SO-52119,99200	06/30/87	16
35	SO-50325,101300	06/30/87	6
36	SO-49100,100500	07/02/87	6
37	SO-49600,101275	07/02/87	6

collected using a post hole digger since the split tube sample did not provide enough soil for both chemical and radiological analyses.

Sample collection information was recorded on field data forms. Sample chain-of-custody was maintained throughout the sample collection and shipping process according to approved WSSRAP procedures.

2.2 Equipment Decontamination

Soil sampling equipment was cleaned using a hybridized decontamination procedure designed to protect against cross-contamination by nitroaromatics and other chemical species. All augers, drill rods, and split tube samplers were washed using a hot water high-pressure washer. Augers and drill rods were cleaned between boreholes while split tube samplers were decontaminated between samples.

After washing with hot, high-pressure water, the split tube samplers were allowed to air dry. They were then rinsed with toluene, followed by acetone and hexane. The toluene rinse was used to dissolve any nitroaromatic residues. Acetone and hexane rinses were employed to remove toluene and other contaminants not removed by the hot water high-pressure wash. The split tube samplers were again allowed to air dry prior to being reassembled. All rinsing solvents were collected.

Stainless steel spatulas and pans and the post hole digger were washed with distilled water, followed by the same solvent rinse sequence as used on the split tube samplers. This procedure was performed before every sample.

Field personnel wore new disposable vinyl gloves when collecting soil samples. Gloves were changed after decontaminating sampling equipment.

2.3 Sample Preservation

After soil samples were collected, the filled sample containers were placed in a cooler with Blue Ice or similar reusable ice product. All samples were chilled to 4 degrees centigrade. This temperature was maintained throughout sample collection and shipment. No other preservation techniques were used.

2.4 Sample Analyses

Soil samples were analyzed by metaTRACE, Inc. of St. Louis, Missouri. Analytical parameters included nitroaromatics, metals, nitrate, sulfate, chloride, fluoride, and percent moisture. Selected surface samples were analyzed for asbestos. Precleaned sample containers were supplied by metaTRACE, Inc.

Analytical parameters were selected based on known or suspected contaminants from the WSOW and WSUFMP.

Nitroaromatic analyses were performed according to the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) High Pressure Liquid Chromatography (HPLC) methodology. Metals analyses were performed to U.S. EPA Contract Laboratory Program (CLP) standards. Nitrate, sulfate, chloride and fluoride analyses were performed according to EPA method 300.0.

3.0 RESULTS

Analytical results are presented in Appendix A of this report. Each group of analytical parameters is discussed in detail in the following sections. All interpretations made in this report are based on analytical results, field observations, past waste management practices, aerial photography, and the draft UNC report "Radiological Characterization of the Weldon Spring, Missouri Remedial Action Site", October 1987.

3.1 Nitroaromatics

All soil samples were analyzed for nitroaromatics using HPLC according to USATHAMA methodology. No detectable levels of nitroaromatics were present in any samples collected on-site. Detectable levels were measured in soil samples taken from the waste lagoon used in WSOW production located off-site, just north of the WSCP (Figure 2-1). Table 3-1 presents nitroaromatics results from soil samples collected in WSOW Waste Lagoon No. 1.

TABLE 3-1

Nitroaromatics Results for the WSOW Waste Lagoon No. 1

Soil Location Number	Coordinates	Depth Interval	Date Sampled	Concentration UG/G					
				2,4,6-TNT	2,4-DNT	2,6-DNT	Nitro-Benzene	1,3,5-Trinitro-Benzene	1,3-Dinitro-Benzene
27	SO-49300,101200	1.5,2.5	06/15/87	.93	<1.02	1.4	<1.96	<0.77	<1.23
	SO-49300,101200	2.5,3	06/15/87	1.1	2.3	<1.78	<1.82	<0.72	<1.14
28	SO-49320,101420	1,1.5	06/15/87	52.4	7.6	<1.82	<1.86	4.0	0.63
	SO-49320,101420	2,4	06/15/87	*	*	*	*	*	*
29	SO-49240,101470	1,2	06/15/87	17.2	3.0	<1.78	<1.82	2.2	<1.13
	SO-49240,101470	2,3	06/15/87	13.7	2.2	<1.76	<1.80	3.7	<1.12
30	SO-49240,101350	0,3	06/15/87	307	13.8	<1.77	2.3	2.8	0.67
	SO-49240,101350	3,5	06/15/87	<1.52	0.56	<1.79	<1.83	1.9	<1.14
	SO-49240,101350	5,8	06/15/87	<1.48	<0.92	<1.74	<1.77	1.2	<1.11
	SO-49240,101350	8,13	06/15/87	<1.55	<0.97	<1.82	<1.86	0.48	<1.16

Source: WSSRAP, 1987

Soil sampling locations were not chosen to confirm previous positive results for nitroaromatics as reported in the 1976 Department of Army Report "Assessment of Weldon Spring Chemical Plant in St. Charles Missouri--Final". The validity of this previously collected data and the need for additional sampling will be discussed in the Chemical Soil Investigation Sampling Plan.

3.2 Metals

All soil samples were analyzed for CLP metals and lithium. Lithium was used in pilot studies at the WSCP and is present in the WSRP and groundwater. Acid usage in both explosives production and uranium processing make metal contamination of the soil a distinct possibility. Metal contamination of the soil has been documented at other ordnance works such as the West Virginia Ordnance Works and Alabama Army Ammunition Plant (ESE, 1986).

3.2.1 Elevated Concentrations Detected

Several metals were detected in elevated concentrations in several soil samples. Lead, barium and zinc were present in concentrations above background and appear to be related to WSOW sources. Based on the sampling effort, there appears to be a relationship between elevated levels of lead and zinc.

Sample-specific analytical results are presented in Appendix A of this report.

The use of lead in explosive production equipment has been documented at other ordnance works (ESE, 1986) and is the primary non-nitroaromatic soil contaminant.

Lead was used in WSOW process buildings and as flooring to minimize static electricity. Acidic spills could have dissolved lead and other metals. Spill control probably consisted of neutralization with lime or soda ash and/or dilution followed by washing.

Lead concentrations in the soil at the WSCP ranged from <0.6 ug/Kg to 43,000 ug/Kg. The highest value was observed at Location No. 3 (Figure 2-1) north of Ash Pond in the 2- to 4-foot interval downslope from the final production area of TNT Line No. 2.

Elevated zinc levels were present with elevated lead levels in numerous samples. Zinc concentrations were much lower, however, only ranging up to 820 ug/Kg. The source of the zinc contamination is not known at this time.

Barium was also present in elevated concentrations in select samples. Up to 4,000 ug/Kg of barium were detected in soils

from the Ash Pond area. The source and/or reason for barium contamination is not known at this time.

3.2.2 Background Metals Determinations

Another purpose of this investigation was to establish background metals concentrations in on-site soils. On-site background concentrations were determined statistically. Concentrations for each metal were analyzed statistically to determine average background concentrations and ranges. Frequency histograms were plotted for each metal. These histograms were evaluated to detect concentrations outside of the normal distribution of the population. These elevated values were removed from the background data set prior to calculating the arithmetic mean, arithmetic standard deviation and the geometric mean. This data is presented on Table 3-2 with the background ranges.

Several metals appear to be present as low-level contamination throughout soils at the WSCP/WSRP. These metals include: aluminum, antimony, barium, iron, lead, magnesium, manganese, nickel, vanadium and zinc. Background samples will be collected from off-site locations during the overall soil characterization as described in the Chemical Soil Investigation Sampling Plan. These "on-site" background values will be compared to background

TABLE 3-2

Statistical Data for Background Metals
Concentrations in Soils at the WSCP/WSRP

Compound	Sample Size	Arithmetic Mean mg/Kg	Geometric Mean mg/Kg	Arithmetic Standard Deviation mg/Kg	Onsite Background Ranges	
					Low mg/Kg	High mg/Kg
Al	142	12,536	11,350	4,902	1250	27,700
Sb	98	29	25	8	2	40
As	114	6	6	4	2	15
Ba	140	161	145	70	25	390
Be	129	1	1	1	< DL	6
Cd	125	3	3	1	< DL	7
Ca	114	3,495	3,044	1,839	190	9,300
Cr	144	24	23	6	2	42
Co	144	16	14	7	6	40
Cu	143	15	14	6	3	34
Fe	139	18,636	17,914	5,306	8,500	35,400
Pb	127	29	25	16	7	84
Li	92	10	9	3	< DL	17
Mg	133	2,437	2,256	956	417	5,900
Mn	127	495	370	334	49	1,400
Hg	Background less than the detection limit of 0.1 mg/Kg					
Ni	138	19	18	7	7	43
K	145	757	698	311	255	1,701
Se	Background less than the detection limit of 0.5 mg/Kg					
Ag	96	3	2	2	1	13
Na	136	486	437	202	49	982
Tl	Background less than the detection limit of 1.0 mg/Kg					
V	141	35	34	7	6	54
Zn	141	45	39	29	6	220

< DL - Less than detection limit

Source: WSSRAP, 1987

samples collected as described in the Chemical Soil Investigation Sampling Plan.

3.3 Inorganic Anions

Soil samples collected during this investigation were also analyzed for nitrate, sulfate, fluoride and chloride. Elevated levels of nitrate and sulfate were observed at numerous locations, most commonly in surficial soil samples. This is to be expected since the nitrates probably originated from neutralized nitric acid. Nitric acid was used both at the WSOW and the WSUFMP. The highest concentration of nitrate (868 mg/Kg) was detected in a ditch carrying waste from a WSOW process building at Location 36. Elevated nitrates and sulfates were also observed in WSOW Waste Lagoon No. 1 north of the WSCP.

Elevated sulfate levels were occasionally associated with elevated nitrate levels, especially in the WSOW Waste Lagoon. This would be expected due to the use of mixed nitric and sulfuric acid in TNT production. Other areas of sulfate contamination are also probably related to WSOW production due to the use of sulfuric acid as a catalyst. Additional investigations are required to determine the source and extent of this contamination.

Some slightly elevated chloride and fluoride levels are present

Some slightly elevated chloride and fluoride levels are present in WSCP/WSRP soils. The source of these species is not known at this time.

Selected surface soil samples were analyzed for asbestos based on the usage of asbestos in WSOW process buildings. All submitted samples contained less than 1 percent asbestos and no elevated levels were observed.

4.0 CONCLUSIONS

This investigation was designed to supply baseline soil information and establish on-site background metal concentrations. This investigation indicates the presence of elevated levels of nitrate, sulfate and certain metals in the soils at the WSCP/WSRP. Limited conclusions regarding the extent and magnitude of contamination can be made based on the data collected. The data presented in this report will be used in developing the Chemical Soil Investigation Sampling Plan, which details the overall soil characterization strategy for the Weldon Spring Site.

Several preliminary conclusions can be made from the data presented in this report. These conclusions are:

1. Nitroaromatic compounds were not detected in the on-site soil samples collected in this investigation. Additional

sampling is required for WSOW sources, particluarly in production areas, surface drainages and the burning ground area.

2. Nitroaromatics bind tightly to soil particles at the WSCP/WSRP. This was evidenced by the soil samples collected from the WSOW wastewater lagoon located just north of the WSCP. Nitroaromatic concentrations decreased from percent levels (0.3%) to less than the detection limits through eight feet of soil. This information will be used when designing the overall chemical soil characterization sampling plan.

3. Areas of nitrate and sulfate contamination appear to be related to WSOW processes and sources.

4. There appears to be low-level contamination by several metals including aluminum, antimony, barium, iron, lead, magnesium, manganese, nickel, vanadium and zinc. Isolated undetected areas of higher concentration may exist for these metals. Additional investigations are required to determine true background conditions and assess contaminant extent.

5. There do not appear to be any elevated concentrations of beryllium, cadmium, mercury, selenium or thallium in soils at the WSCP/WSRP.

6. Elevated asbestos levels are not present in surficial soils as a result of WSOW building demolition. Elevated levels of asbestos may be present near overhead piping in the WSCP.

7. There do not appear to be any significant on-site soil contamination areas contributing to groundwater contamination.

These conclusions will be used to guide further soil investigations as detailed in the Chemical Soil Investigation Sampling Plan. The data in this report will be factored into the overall soil contamination assessment and used in the Remedial Investigation Report.

5.0 REFERENCES

Department of Army, 1976. Assessment of Weldon Spring Chemical Plant in St. Charles, Missouri - Final.

Environmental Science and Engineering (ESE), 1986. West Virginia Ordnance Works: Endangerment Assessment for Sewerlines, the TNT Manufacturing Area, and the Burning Grounds, Final Report. June, 1986.

MK-Ferguson, 1987. Phase I Water Quality Assessment. Prepared for Department of Energy - Oak Ridge Operation Office.

United Nuclear Corporation, 1987. Radiological Characterization of the Weldon Spring, Missouri Remedial Action Site. October, 1987.

APPENDIX A

APPENDIX A

Phase I Soil Metals Results

Location No.	Soil Sample Coordinates and Depths	Date Sampled	Concentration MG/KG																						
			Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
1	SO-50700,99400-0,4-0587	05/29/87	16000	U		113			3190	30	6	10	15400		U	2100	187	0.2	11	655	U		451	U	25	34
	SO-50700,99400-4,8-0587	05/29/87	2760	18		288	1.2		3900	41	30	20.4	26200	36	U	3500	3400	0.2	24	1300	U		408	U	48	60
	SO-50700,99400-8,12-0587	05/29/87	2100	U		252			3550	31	16	24	35400		U	3420	420	U	28	1020	U		516	U	40	84
2	SO-51600,100500-0,0.5-0687	06/02/87	4915	U	2.8	59	1.3	4.2	7520	17	8	27	14100	39	U	890	650N	U	22	725	U		335	U	29	220
	SO-51600,100500-0,5.2-0687	06/02/87	8400	9	11	78	2.6	3.9	6400	31	16	46	30000	23	9	1050	210N	U	36	860	U	1.3	460	1.8	48	178
	SO-51600,100500-2,4-0687	06/02/87	7900	U	U	99	0.7	1.3	1300	13	9	7	10100	8	U	850	442N	U	8	543	U	U	286	U	22	22
	SO-51600,100500-4,6-0687	06/02/87	11000	U	3	96	0.8	2.6	1015	16	16	8	18400	20	U	1250	560N	U	10	630	U	U	98	U	36	25
	SO-51600,100500-6,9-0687	06/02/87	8350	U	5.8	86	0.9	0.3	1220	37	14	8	32200	26	U	850	130N	U	14	292	U	U	128	U	63	20
3	SO-51400,100800-0,0.5-0687	06/02/87	3850	U	2.1	39	0.9	2	4240	12	7	22	14930	12	U	427	113	U	14	331	U	U	275	U	22	177
	SO-51400,100800-0.5,2-0687	06/02/87	6000	7	1.5	71	1	3.5	12800	17	10	30	20500	45	U	1700	280	U	22	530	U	1.1	415	U	28	12
	SO-51400,100800-2,4-0687	06/02/87	5900	20	4.2	99	U	10.5	9300	42	35	34	82500	43000	U	2900	457	U	20	1400	U	4.7	650	U	25	337
	SO-51400,100800-4,6-0687	06/02/87	11300	10	4.4	208	1.2	3.8	20600	24	14	19	20400	29	8	3900	1400	U	19	813	U	2.5	119	U	38	83
4	SO-51400,101200-0,0.5-0687	06/02/87	10120	9	4.6	111	0.7	2.3	37400	18	11	14	15900	28	7	2210	665	U	12	1076	U	2.3	233	U	37	45
	SO-51400,101200-0.5,2-0687	06/02/87	24100	11	7.3	172	0.9	3.4	3500	32	13	21	30800	15	14	3400	140	U	18	1600	U	1.1	96	U	59	49
	SO-51400,101200-2,4-0687	06/02/87	10900	6	2.5	215	0.7	2.4	2200	20	12	12	16900	11	10	2600	550	U	20	740	U	1.2U	437	U	31	35
	SO-51400,101200-4,6-0687	06/02/87	8150	7	U	270	0.8	2.3	1710	15	29	7	16300	21	U	1660	2550	U	16.4	317	U	1.2	425	U	35	20
5	SO-51900,100300-0,0.5-0687	06/02/87	11655	7.8	U	167	0.9	2.6	6600	20	11	17	18300	28	7	2300	500	U	20	1040	U	1.2	280	U	32	53
	SO-51900,100300-0.5,2-0687	06/02/87	18800	13	U	360	1.1	3.5	4700	29	11	21	22000	15	12	3500	280	U	28	1015	U	1.2	440	U	43	53
	SO-51900,100300-2,4-0687	06/02/87	16800	10	U	133	0.7	1.6	2700	22	7	6	9800	15	8	1950	60	U	10	1250	U	U	715	U	23	22
	SO-51900,100300-4,6-0687	06/02/87	18100	U	3	43	0.9	2.5	3050	22	12	9	16600	13.6	7	1800	53	U	11	506	U	U	780	U	40	19
	SO-51900,100300-6,9-0687	06/02/87	14500	U	2.5	68	0.6	2.5	3300	15	12	10	16500	9	U	1900	105	U	14	634	U	U	520	U	26	21
6	SO-51300,100200-0,0.5-0687	06/02/87	6700	6.7	2.4	73	0.8	2.2	34400	17	7	16	12000	16	U	2500	355	U	11	832	U	1.7	400	U	26	47
	SO-51300,100200-0.5,2-0687	06/02/87	12600	7	2.3	187	0.9	3.5	29000	21	19	16	21700	23	7	3920	1030	U	18	529	U	U	270	U	41	7
	SO-51300,100200-2,4-0687	06/02/87	10300	7	2.7	152	0.8	2.3	35000	18	13	21	16400	15	U	2350	750	U	15	520	U	U	280	U	35	32
	SO-51300,100200-4,6-0687	06/02/87	14500	U	2.4	204	0.7	2.4	34900	20	12	12	16600	14	8	2040	540	U	14	1090	U	U	312	U	36	36

APPENDIX A

Phase I Soil Metals Results

No.	Coordinates and Depths	Sampled	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
			Concentration MG/KG Location Soil Sample																							Date
7	SO-52400,100715-0,0.5-0687	06/02/87	11000	U	U	130	0.6	2.4	6100	19	11	48	17100	1100	71	1770	520	U	14	1110	U	U	250	U	31	54
	SO-52400,100715-0.5,2-0687	06/02/87	8120	U	4	207	0.9	2.3	7000	23	16	16	20500	590	9	2933	782	U	18	950	U	U	58	U	38	48
	SO-52400,100715-2,4-0687	06/02/87	15200	9	2.9	194	0.9	3.4	13300	27	19	14	20500	285	10	2350	1014	U	17	990	U	1.1	250	U	43	55
	SO-52400,100715-4,6-0687	06/02/87	8200	U	4	209	0.8	2.3	10500	20	17	10	15700	128	U	1800	880	U	15	481	3.8	1.2	49	U	30	30
8	SO-52131,100094-0,2-0687	06/02/87	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SO-52131,100094-2,4-0687	06/02/87	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SO-52131,100094-4,6-0687	06/02/87	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9	SO-52000,100400-0,0.5-0687	06/02/87	12000	7	1.1	4000	1	3.3	6200	31	13	17	21900	34	9	1900	285	U	25	1340	U	1.1	360	U	34	48
	SO-52000,100400-0.5,2-0687	06/02/87	21250	12	3.4	1560	1.1	3.6	2600	36	18	22	28600	17	16	3132	564	U	29	1650	U	1.2	433	U	54	48
	SO-52000,100400-2,4-0687	06/02/87	12000	U	2.5	179	0.8	2.4	2011	23	29	11	16800	17	7	1800	1780	U	18	466	U	U	720	U	35	23
	SO-52000,100400-4,6-0687	06/02/87	19440	7	1.6	120	0.7	2.4	2904	23	8	8	16000	10	7	2124	96	U	11	475	U	U	600	U	30	23
	SO-52000,100400-6,10-0687	06/02/87	20000	8	2.6	117	1.2	2.6	2720	23	12	13	23000	16	U	2400	65	U	16	728	U	U	663	U	42	26
	SO-52000,100400-13,15-0687	06/02/87	27700	12	U	286	3.9	3.9	5000	39	39	13	30700	16	33	3350	1008	U	83	990	U	1.3	554	U	46	100
10	SO-51700,101500-0,0.5-0687	06/03/87	10074	U	5.5	153	0.8	2.2	6406	18.4	10	13	16044	23	5.6	2046	475	U	16.2	880	U	1.0	341	U	28	44
	SO-51700,101500-0.5,2-0687	06/03/87	12364	3.5	6.5	233	0.9	3	5762	24	22	12	22361	32	6	1891	2014	U	16	723	U	2.1	399	1.2	40	38
	SO-51700,101500-2,4-0687	06/03/87	15023	16	8.8	222	1.2	3.8	1925	27	34	20	25437	42	11	2799	1557	U	24	856	U	4	428	U	45	57
	SO-51700,101500-4,6-0687	06/03/87	9278	13	4.2	178	1.0	2.7	1772	21	16	9.1	15912	28	9	1848	1045	U	19	333	U	3.4	579	U	35	26
11	SO-49600,100800-0,0.5-0687	06/03/87	4341	36	3.1	51	0.9	5.9	48240	28	12	15.0	862	57.1	7.3	194032	328	U	18.7	573	U	9.6	591	U	31	47
	SO-49600,100800-0.5,2-0687	06/03/87	9397	31	3.7	104	1.1	6.6	87084	28	16	15	13776	43	8	24354	631	U	25	705	U	8.2	567	U	37	60
	SO-49600,100800-2,4-0687	06/03/87	124230	13	6.0	149	1.1	2.4	3653	21	17	13	15904	29.8	7.3	2183	448	U	17.2	548	U	3.2	206	U	33	32
	SO-49600,100800-4,6-0687	06/03/87	11725	U	6.6	145	0.8	2.4	3750	19	10	12.5	16600	15.2	U	2206	387	U	14	472	U	1.5	172	U	30	27
	SO-49600,100800-6,10-0687	06/03/87	14987	6	5.3	163	0.8	4	6924	21	12	12	17177	28	8.4	2588	378	U	22	696	U	1.2	682	U	28	83
	SO-49600,100800-10,20-0687	06/03/87	14049	9.1	3.3	97.5	1.7	2.2	3921	20	11	17	13530	26	7	1864	52	U	23	738	U	2.3	387	U	25	55
	SO-49600,100800-20,24-0687	06/03/87	12649	13	5.7	117	1.8	2.8	3818	21	21	14	19740	38	U	1805	227	U	34	554	U	3.9	400	U	25	35

APPENDIX A

Phase I Soil Metals Results

No.	Coordinates and Depths	Sampled	Concentration MG/KG Location Soil Sample Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
12	SO-51800,101400-0,0.5-0687	06/03/87	8600	10	2.8	79	1.3	3.4	8400	22	13	19	22000	34	9	1300	252	U	23	940	U	2.4	502	U	101	9
	SO-51800,101400-0.5,2-0687	06/03/87	14000	16	9	529	0.9	4.9	36000	26	16	470	18250	1710	13	5900	682	U	20	480	U	3	405	U	43	575
	SO-51800,101400-2,4-0687	06/03/87	22000	13	9	162	1.4	4.8	2800	36	28	28	31500	34.8	15	4500	665	U	30	1150	U	4	314	U	52	66
	SO-51800,101400-4,6-0687	06/03/87	12700	13	6	111	1.1	3.8	2600	27	16	17	23700	29	15	3200	803	U	27	895	U	3.4	430	U	48	44
13	SO-49610,10100-0,0.5-0687	06/03/87	2350	19	4.6	145	0.8	3.6	21400	26	13	17	16600	60	11	5000	406	U	18	1300	U	4	430	U	34	490
	SO-49610,10100-0.5,2-0687	06/03/87	165000	6	5	188	1.0	2.9	6400	27	15	12	20500	18	9	2850	554	U	19	475	U	2	166	U	36	35
	SO-49610,10100-2,4-0687	06/03/87	147000	4	13	117	1.1	2.7	4350	24	14	13	21000	16	7	1820	740	U	20	700	U	1.7	174	U	36	42
	SO-49610,10100-4,6-0687	06/03/87	8800	6.3	4.5	143	0.9	2.0	2500	18	23	10	15400	25	U	11000	1550	U	14	440	U	1.5	407	U	30	21
	SO-49610,10100-6,10-0687	06/03/87	8300	11	10	125	3.1	6.4	2250	55	20	21	55000	44	U	9800	3750	U	34	255	U	3.2	240	U	89	40
	SO-49610,10100-10,14-0687	06/03/87	161500	11	8	430	2.5	4.5	6300	28	21	22	26500	31	8	2500	2600	U	80	760	U	3.4	435	U	34	80
14	SO-50500,100395-0,0.5-0687	06/04/87	6400	40	9	88	U	U	127000	74	10	25	12000	34	U	45300	285	U	23	1560	U	U	1620	U	35	65
	SO-50500,100395-0.5,2-0687	06/04/87	15500	18	U	83	U	U	5650	23	6	18	15500	U	U	3200	134	U	11	720	U	U	508	U	29	39
	SO-50500,100395-2,4-0687	06/04/87	15500	U	U	72	U	U	4400	11	U	11.5	14100	U	U	2664	139	U	5U	732	U	U	684	U	15	36
	SO-50500,100395-4,6-0687	06/04/87	15400	16	U	720	U	U	3780	24	388	13	16400	84	U	2400	6100	U	42	726	U	U	600	1.2	42	36
15	SO-49200,100400-0,0.5-0687	06/04/87	14000	24	U	162	U	U	15400	28	10	28	17700	48	U	4900	360	U	14	1400	U	U	420	U	36	66
	SO-49200,100400-0.5,2-0687	06/04/87	9400	28	U	52	U	U	188000	36	8	20	14300	U	U	16000	210	U	18	810	U	U	1620	U	50	48
	SO-49200,100400-2,4-0687	06/04/87	18900	7U	U	124	U	U	31000	21	11	9	11500	U	U	4300	124	U	8	825	U	U	750	U	19	31
	SO-49200,100400-4,6-0687	06/04/87	16080	7U	U	144	U	U	3500	20	6U	10	17000	U	U	2000	60	0	8.4	576	U	U	1350	U	29	32
16	SO-49320,100735-0,0.5-0687	06/04/87	4600	30	U	85	1.3	7	130000	29	9	18	11600	59	U	28000	460	U	21	1040	U	5	2000	U	35	61
	SO-49320,100735-0.5,2-0687	06/04/87	12500	U	U	180	U	U	6000	25	14	25	26000	U	U	4030	450	U	33	1100	U	1.20	800	U	37	820
	SO-49320,100735-2,4-0687	06/04/87	10100	25	U	138	U	6	128000	33	20	20	14500	U	U	25000	450	U	19	960	U	5	525	U	50	44
	SO-49320,100735-4,6-0687	06/04/87	15900	U	U	220	U	U	27000	29	14	21	22300	U	U	3000	806	U	19	1150	U	U	434	U	43	56

APPENDIX A

Phase I Soil Metals Results

No.	Coordinates and Depths	Sampled	Concentration MG/KG Location Soil Sample Date																						
			Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
17	SO-50500,100300-0,0.5-0687	06/04/87	11000	U	U	146	U	U	15600	26	9	13	13800	29	U	4500	415	U	12	1024	U	U	1460	U	29	59
	SO-50500,100300-0.5,2-0687	06/04/87	17500	18.6	U	188	1.1	U	6100	35	28	13	21000	29	U	2800	1300	U	23	684	U	3.4	310	U	45	51
	SO-50500,100300-2,4-0687	06/04/87	24600	22	U	124	1.3	U	4600	39	13	17	23200	33	U	3300	90	0.7	20	780	U	4	1150	U	39	46
	SO-50500,100300-4,6-0687	06/04/87	13900	17	U	220	1.2	U	2900	25	12	12	14200	23	U	2200	91	U	18	421	U	2.9	573	U	29	44
18	SO-50900,98600-0,0.5-0687	06/04/87	6500	28	U	72	U	U	180000	30	24	27	9550	42	U	5700	522	U	18	850	U	7	1400	U	37	84
	SO-50900,98600-0.5,2-0687	06/04/87	5900	30	U	70	1.2	U	185000	35	10	20	8500	38	U	2400	660	U	12	550	U	9	477	U	40	48
	SO-50900,98600-2,4-0687	06/04/87	14488	21	13.2	390	1	4	3339	28	14	22	21801	36	10	3388	705	U	42	896	U	4.7	517	U	34	70
	SO-50900,98600-4,6-0687	06/04/87	14149	18	15.1	229	0.9	3.6	3607	27	17	19	20404	39.6	8	3043	4546	U	22	699	U	5.4	718	U	33	68
19	SO-50800,99600-8,9-0687	06/04/87	13299	17	5.7	103	1.1	3.2	2121	29	16	11	20763	44.7	8	1398	4559	U	14	499	U	5.1	710	U	40	25
20	SO-52090,101300-0,0.5-0687	06/09/87	10116	20	10.6	138	0.9	3.2	14603	24	19	18	17578	55	8	1831	741	U	19	845	U	5.7	366	U	35	55
	SO-52090,101300-0.5,2-0687	06/09/87	13392	22	10.8	161	1.1	4.0	3087	29	29	14.0	24242	58	10	1843	1865	U	23	726	U	5.5	383	U	48	63
	SO-52090,101300-2,4-0687	06/09/87	15240	24	5.0	193	1.3	4.4	2686	31	23	24.0	25431	48	13	3798	810	U	31	1181	U	6.5	849	U	45	45
	SO-52090,101300-4,6-0687	06/09/87	9822	U	2.9	185	0.3	2	2335	18	11	11.5	16062	7.7	9.7	2419	464	U	20	608	U	U	700	U	29	39
21	SO-49700,99500-0,0.5-0687	06/09/87	5982	38	2.8	77	1.2	7.0	53586	41	15	27	11451	132	9	13014	291	U	50	853	U	13	525	U	37	139
	SO-49700,99500-0.5,2-0687	06/09/87	15470	118	9.7	140	5.5	2.9	2934	21	10	16.7	21462	13.1	7.7	2571	416	U	18	741	U	1.0	377	U	30	38
	SO-49700,99500-2,4-0687	06/09/87	14925	U	3.3	282	1.9	4.1	16812	27	27	18.5	21778	29.0	14.3	4085	2464	U	59	929	U	4.3	712	U	40	55
	SO-49700,99500-4,6-0687	06/09/87	13038	U	4.9	236	1.1	2.6	2472	2	15	9.1	16415	22.2	9	2002	862	U	11.0	300	U	2.0	617	1.2	34	26
22	SO-50300,101300-0,0.5-0687	06/09/87	8114	U	2.0	172	0.6	2.1	2996	16	14	8.0	11480	26.9	6.0	1349	1300	U	17.5	700	U	1.5	310	U	25	41
	SO-50300,101300-0.5,2-0687	06/09/87	14391	U	8.7	266	0.8	2.8	2426	20	12	7.9	16908	25	7.8	1859	385	U	9.0	348	U	2	235	U	34	19.2
	SO-50300,101300-2,4-0687	06/09/87	10382	U	7	76	0.6	2.2	3470	15	6	9.7	13658	14.7	U	1935	49	U	10.6	342	U	2.1	458	U	23	16
	SO-50300,101300-4,6-0687	06/09/87	7552	U	4.0	142	1.6	2.4	2423	18.4	15	16	15856	22	U	1627	175	U	26	509	U	2.8	308	U	25	35
23	SO-50910,101803-0,0.5-0687	06/09/87	7943	U	4.3	255	5.2	3.4	4914	20	15	13	12699	33	7	1549	1574	U	15	934	U	U	410	U	26	70
	SO-50910,101803-0.5,2-0687	06/09/87	19171	U	4.1	117	0.4	3.4	1369	22	11	21.1	26763	24.4	12.2	3136	253	U	21	1113	U	1.2	379	U	40	55
	SO-50910,101803-2,4-0687	06/09/87	13161	U	4	251	0.7	2.4	2218	22	9	16	19571	10	11	2823	322	U	20	774	U	U	363	U	31	40
	SO-50910,101803-4,6-0687	06/09/87	10755	U	3	217	.4	2.5	2487	17	20	9	18338	115	7	1876	767	U	10	390	U	U	440	U	35	23

APPENDIX A

Phase I Soil Metals Results

No.	Coordinates and Depths	Sampled	Concentration MG/KG Location Soil Sample Date																						
			Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
24	SO-52400,101100-0,0.5-0687	06/09/87	9057	U	4.1	278	0.5	2.4	3445	14	12	9	14270	31	7.7	1585	1763	U	15	982	U	U	344	U	28	58
	SO-52400,101100-0.5,2-0687	06/09/87	8552	U	5.7	244	0.7	2.6	5876	16	27	10	15878	31.0	6	1378	2936	U	16	788	U	1.4	302	U	33	29
	SO-52400,101100-2,4-0687	06/09/87	15264	U	7.6	151	0.8	2.7	1381	22.7	26.5	13.2	18985	29.5	11.7	2561	1232	U	23	940	U	2.3	383	U	36	39
	SO-52400,101100-4,6-0687	06/09/87	11615	U	4.4	162	0.8	1.9	1782	18	7	8	13095	13	7	1608	268	U	11	450	U	U	511	1.2	27	22
25	SO-50800,100100-0,0.5-0687	06/10/87	11376	2.6	21	145	1.0	2.5	9175	26	12	14	16796	39	6	2842	691	U	14	839	U	1.0	456	u	32	339
	SO-50800,100100-0.5,2-0687	06/10/87	12580	17	6.5	149	1.2	3.9	30511	30	16	17	18042	53	13	3522	471	0.1	17	650	U	11	525	U	42	38
	SO-50800,100100-2,4-0687	06/10/87	10811	14	21.2	116	0.9	2.7	3131	19	9	12	13313	41.3	8	1677	437	U	12	382	U	6	424	U	35	13
	SO-50800,100100-4,6-0687	06/10/87	17912	13	21	228	1.7	3.9	3057	32	106	16	22507	71	12	2021	1237	U	39	519	U	6.1	435	U	45	23
	SO-50800,100100-6,10-0687	06/10/87	7911	17	11	83	1.0	2.1	3102	15	10	8.5	9332	39	7	1433	68	U	13	325	U	5.4	344	U	23	12
	SO-50800,100100-10,20-0687	06/10/87	24321	11	5.8	224	2.8	4.1	5351	32	31	16	25043	53	17	3233	711	U	62	979	U	6	428	U	41	66
26	SO-50800,100000-0,0.5-0687	06/10/87	1250	18.7	2.5	117	0.9	3.2	17779	26	14	15	15300	57	14	3002	348	U	19	1682	U	6.2	542	U	34	56
	SO-50800,100000-0.5,2-0687	06/10/87	16019	11	7.2	267	1.0	2.6	7505	29	15	15	16309	50	14	2367	331	U	15	597	U	7.4	901	U	39	29
	SO-50800,100000-2,4-0687	06/10/87	11258	20	8.8	153	1.0	3.6	2511	26.3	29	13	19474	68	12	1603	1678	U	16	840	U	7	596	U	41	30
	SO-50800,100000-4,6-0687	06/10/87	1500	U	U	25	U	U	190	10	U	U	2130	U	U	190	139	U	U	U	U	U	240	U	U	6
27	SO-49300,101200-1.5,2.5-0687	06/15/87	12612	U	10	192	1.0	2.6	1313	24	16	10	20316	27	U	1680	1057	U	13	618	U	0.5	980	U	37	30
	SO-49300,101200-2.5,3-0687	06/15/87	22811	U	9.5	176	1.1	4.2	1768	34	18	23	2993	32	15	3456	526	U	23	1237	U	3.0	964	U	52	54
28	SO-49320,101420-1,1.5-0687	06/15/87	15933	U	9.7	189	0.8	3	1336	27	15	19	23316	53	12	2536	478	U	16	1245	U	2.7	1178	U	48	42
	SO-49320,101420-2,4-0687	06/15/87	11686	U	7	151	0.7	2.7	1992	22	15	14	16277	26	11	2761	441	U	20	878	U	2.5	823	U	29	34
29	SO-49240,101470-1.2-0687	06/15/87	21441	U	14	136	1	3	1038	28	15	20	26852	39	13	2630	375	U	21	975	U	3	967	U	45	49
	SO-49240,101470-2.3-0687	06/15/87	14275	U	10	144	0.8	3	1928	24	21	24	21287	43	9	2917	414	U	17	751	U	3.8	1410	U	29	51
30	SO-49240,101350-0,3-0687	06/15/87	13171	U	8	183	0.8	2.9	1469	22	14	15	19985	68	10	1934	418	U	14	813	U	4.3	982	U	41	34
	SO-49240,101350-3,5-0687	06/15/87	11528	4	5	310	0.8	3.4	2407	27	15	18	18915	43	14	3067	666	U	24	1063	U	6	1008	U	34	43
	SO-49240,101350-5,8-0687	06/15/87	9399	6	6	117	0.5	2.3	1617	21	15	7	11787	42	11	1487	321	U	11	1701	U	6	707	U	30	21
	SO-49240,101350-8,13-0687	06/15/87	16445	14	12	90	0.9	3	2906	30	15	13	176	66	14	1805	83	0.1	14	590	U	10	527	U	39	18

APPENDIX A

Phase I Soil Metals Results

			Concentration MG/KG Location Soil Sample																					Date
No.	Coordinates and Depths	Sampled	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
31	SO-51200,99900-0.5,2-0687	06/26/87	12020	9	8	242	1	2.8	2648	22	19	12	20850	27	6	1940	1250	0.4	18	645	U	0.9	560	U	39	39
	SO-51200,99900-2,4-0687	06/26/87	12621	5	5	259	0.8	2.3	2798	21	14	13	17035	22	6	2154	714	0.4	16	681	U	0.7	635	U	36	39
	SO-51200,99900-4,6-0687	06/26/87	13575	9	3	270	0.9	2.9	10198	23	16	15	21126	19	8	2722	1007	U	26	688	U	1.4	763	U	35	47
	SO-51200,99900-6,10-0687	06/26/87	18798	9	8	241	1.2	3.8	4081	27	18	22	28105	21	9	3170	1166	0.1	30	953	U	1.5	842	U	42	60
	SO-51200,99900-10,14-0687	06/26/87	6545	4	2	128	0.6	1.6	1145	13.5	8.6	7	12795	11	U	814	995	1.4	7.4	378	U	U	486	U	26	20
	SO-51200,99900-14.3,16-0687	06/26/87	13398	7	1.6	103	1.1	3.7	2026	21	31	8	324	16.3	U	1185	1098	1.4	27	507	U	1.0	573	U	33	29
32	SO-51700,99975-0.5,2-0687	06/29/87	19543	9	14	239	1.3	4	2337	26	40	24	27275	32	9.4	3134	1677	U	25	1026	U	1.0	549	U	40	57
	SO-51700,99975-2,4-0687	06/29/87	13993	8	13.1	242	1	3	2570	23	15	18	22085	17	9	2886	563	U	26	719	U	1.0	772	U	36	51
	SO-51700,99975-4,6-0687	06/29/87	12880	6	8.6	277	1	2	2598	25	11	9	17350	17	7	2044	388	U	14	367	U	U	739	U	36	30
	SO-51700,99975-6,8-0687	06/29/87	13898	6	8.5	230	1	2	2588	20	10	9	16421	11	10	2178	258	U	12	306	U	0.5	785	U	32	35
	SO-51700,99975-8,12-0687	06/29/87	15018	3.6	11.1	209	1.1	2.4	3757	24	12	12	18388	14	U	2176	117	U	22	444	U	0.5	616	U	34	25
	SO-51700,99975-12,16-0687	06/29/87	9179	8	3.6	484	2	4	3577	19	38	24	25820	31	U	2050	1907	U	82	474	U	1.2	404	U	43	55
33	SO-49500,99800-0.5,2-0687	06/30/87	10945	11	12.1	182	0.8	3.5	37006	20	12	17	14560	19	6	8796	246	U	19	670	U	2.1	542	U	33	46
	SO-49500,99800-2,4-0687	06/30/87	23501	6	13.7	289	0.7	4.1	3556	34	29	26	30363	20	12	3359	1018	U	25	924	U	0.8	722	U	45	59
	SO-49500,99800-4,6-0687	06/30/87	10486	4	5.5	146	0.6	2.1	3165	18	9	17.6	12694	9.6	8	2349	155	U	22	596	U	U	544	U	26	41
34	SO-52119,99200-5,6-0687	06/30/87	10168	12	4.1	140	0.9	3.6	36371	23	15	12.5	14725	19.2	U	8624	465	U	16	552	U	2.1	563	U	32	34
	SO-52119,99200-6,8-0687	06/30/87	9585	2.4	6.6	129	0.7	2	2160	17	19	8.7	15415	22.3	U	1194	792	U	11	424	U	U	455	U	31	44
	SO-52119,99200-8,10-0687	06/30/87	15587	5	5.5	130	0.9	2.7	1855	22	23	9.7	21688	30	8	1480	1216	U	13	663	U	U	552	U	40	30
	SO-52119,99200-10,12-0687	06/30/87	14044	U	9.4	151	0.6	3	3138	25	14	12.4	23720	15	U	1738	294	U	14	434	U	U	687	U	39	24
	SO-52119,99200-12,16-0687	06/30/87	11324	6	12.2	187	2.2	3.1	3405	29	14	20	24284	20	7	2244	499	U	43	526	U	0.6	641	U	35	54
35	SO-50325,101300-1,2-0687	06/30/87	8446	18	13.6	156	0.7	5	37139	22	14	11	13562	29	U	13741	712	U	19	591	U	3.2	569	U	31	79
	SO-50325,101300-2,4-0687	06/30/87	14275	2	12.0	55	0.7	2.0	3602	16	8	9.5	12687	8	U	2076	54	U	12	525	U	U	447	U	24	21
	SO-50325,101300-4,6-0687	06/30/87	16996	3.7	13.0	103	0.7	2.2	7070	19	12	10	14910	9.2	U	2824	123	U	12	552	U	U	463	U	27	22

APPENDIX A

Phase I Soil Metals Results

			Concentration MG/KG Location Soil Sample																					Date
No.	Coordinates and Depths	Sampled	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
36	SO-49100,100500-0,2-0787	07/02/87	12209	3.3	4.2	181	0.7	2.2	3102	20	10	11	15683	10	13.3	2442	370	U	17.8	665	U	U	449	U	33	38
	SO-49100,100500-2,4-0787	07/02/87	15396	7.2	9.2	99	0.7	2.5	2818	25	13	7	17314	34	8	2230	476	U	12	385	U	0.5	631	U	36	32
	SO-49100,100500-4,6-0787	07/02/87	18516	5	11.0	70	0.7	2.2	3585	20	8.7	10	17132	7	6	2282	62	U	10	520	U	U	495	U	32	24
37	SO-49600,101275-0,2-0787	07/02/87	13958	5.5	9.2	205	0.9	2.7	2505	22	11	14	18348	15	12	2511	410	U	21	676	U	0.8	440	U	35	44
	SO-49600,101275-2,4-0787	07/02/87	15120	3	4.7	271	1.3	2.9	2657	22	15	11	23012	17	8	1712	374	U	13	482	U	U	772	U	41	27
	SO-49600,101275-4,6-0787	07/02/87	13146	U	5.4	80	0.6	1.5	2220	19	6	6.3	10051	11.2	8	1373	80	U	13	421	U	U	710	U	19	21

APPENDIX B

DATA QUALITY

Throughout this sampling effort, analytical data quality was assessed through the use of duplicates and spikes. These additional analyses were performed for all analytical parameters.

All Quality Control Data is presented at the end of this appendix. Overall, no holding times were exceeded and the Quality Control Data is acceptable. Therefore, the analytical data presented in this report conforms to applicable standards of accuracy and precision and is representative of sample conditions at the time of collection.

All data presented in this report will be validated according to the procedures to be presented in the forthcoming Quality Assurance Project Plan (QAPP). This data will then be used to assess overall soil contamination.

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United States Department Of Energy

RADIOLOGICAL AND CHEMICAL UPTAKE BY EDIBLE PORTIONS OF SELECTED BIOTA AT THE WELDON SPRING SITE

NOVEMBER, 1988

WELDON SPRING SITE REMEDIAL ACTION PROJECT

Reading

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

December 7, 1988

Mr. Dave Parker
ATSDR, Superfund Branch
U.S. Environmental Protection Agency
726 Minnesota Avenue
Kansas City, Kansas 66101

Dear Mr. Parker:

RADIOLOGICAL AND CHEMICAL UPTAKE BY SELECTED BIOTA AT THE WELDON SPRING SITE

Enclosed is a draft copy of the above report. Please provide any comments by December 23, 1988.

If you have any questions call Ken Lawver at 314-441-8978.

Sincerely,

R. R. Nelson

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

RADIOLOGICAL AND CHEMICAL UPTAKE

BY EDIBLE PORTIONS OF SELECTED BIOTA

AT THE WELDON SPRING SITE

PREPARED BY:

MK-FERGUSON COMPANY

AND

JACOBS ENGINEERING GROUP

ROUTE 2, HIGHWAY 94 SOUTH

ST. CHARLES, MISSOURI 63303

PREPARED FOR:

U.S. DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS

WELDON SPRING SITE

REMEDIAL ACTION PROJECT OFFICE

ROUTE 2, HIGHWAY 94 SOUTH

ST. CHARLES, MISSOURI 63303

NOVEMBER 1988

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1.0 INTRODUCTION

This study was initiated to investigate the possible exposure pathways of chemical and radiologic contamination to humans by ingestion of potentially contaminated fish and game from the presence of the former Weldon Spring Uranium Feed Materials Plant. Since the Weldon Spring Site (WSS) is surrounded by prime hunting and fishing habitat, (i.e. August A. Busch and Weldon Spring Wildlife areas), questions concerning the consumption of potentially contaminated animal tissue have been raised. Game animals that migrate on and off site are exposed to contaminated soils and water on site and to contaminated water leaving the site by natural drainage channels. Fish in the lakes and streams which receive this water are also a potential source of exposure to the public.

The interest in a bio-uptake study was generated in response to concerns expressed at the Draft Environmental Impact Statement (DEIS) public hearings. As a result, a draft bio-uptake sampling plan was submitted by the Department of Energy (DOE) to the Environmental Protection Agency (EPA Region VII) and the Missouri Department of Natural Resources for review (DOE, 1987d). Suggested changes and additions to the proposed scope of work were incorporated into the sampling plan where feasible, and field work began in November 1987.

This document is a report of the data and a discussion of the results obtained. A discussion of other biological sampling efforts and bio-uptake studies which have been performed by others prior to the current effort is included also. This study is not a comprehensive evaluation of all levels of the food chain. It is a screening process to identify the ranges of the concentrations of some chemical and radiological constituents within the few fish and mammal species that are eaten by humans. The purpose of this study was limited to evaluating only those tissues that are routinely consumed for food. Human

exposure through ingestion pathways is being determined as part of a risk assessment for EPA Remedial Investigation/Feasibility Study (RI/FS) documentation for the WSS.

1.1 SITE HISTORY AND ENVIRONMENTAL SETTING

The Weldon Spring Site is a DOE surplus facility located approximately 30 miles west of St. Louis in St. Charles County, Missouri. From 1941 to 1944, the U.S. Department of the Army (DA) operated the Weldon Spring Ordnance Works for production of trinitrotoluene (TNT) and dinitrotoluene (DNT). During this operation, small areas of the 17,000-acre site were contaminated by TNT process materials. In 1954, 220 acres of the Ordnance Works property were transferred to the U.S. Atomic Energy Commission (AEC). From 1957 to 1966, the AEC operated a uranium processing facility on the site. During the operation of the Uranium Feed Materials Plant, the buildings, equipment, and some terrain of the plant site became contaminated with radionuclides in the uranium transformation series.

After closure by the AEC, the Feed Materials Plant was reacquired by the Army in 1967. The Army partially decontaminated the buildings, dismantled some of the equipment, and began to convert the facilities for the production of herbicides. In 1969, prior to the Weldon Spring Chemical Plant (WSCP) becoming operational, the herbicide project was cancelled. In 1985, the custody of the WSCP was transferred from the DA to the Department of Energy (DOE). In conjunction with this transfer, the Weldon Spring Site Remedial Action Project (WSSRAP) was created as DOE Major Project Number 182.

1.2 SOURCES OF CONTAMINATION

Radiologically contaminated soils at the WSCP are generally confined to the north and south dump areas, Frog Pond drainage, and to areas immediately surrounding the buildings. Uranium

concentrations range from background levels of about 1 pCi/g to several thousand pCi/g. The majority of radium-226 and thorium-232 concentrations are at mean background levels (UNC, 1988). Therefore, sampling of small mammals on site was focused on those areas where the potential for radionuclide uptake was greatest. Contaminated soils in these areas are also the major source areas contributing to surface water runoff contamination.

Surface water runoff from the north and west sides of the WSS flows to Ash Pond (Figure 1-1). A significant portion of this runoff flows through the south dump area and enters Ash Pond. Water from Ash Pond flows to Lake 35 in the August Busch Wildlife Area, to Schote Creek and Dardenne Creek, and eventually to the Mississippi River (Figure 1-2). Since plant operations ceased in 1967, the discharge from Ash Pond has become an intermittent stream.

Lake 35 is the closest lake to Ash Pond that receives effluent from Ash Pond. Lake 35 is commonly used by the public for recreational activities such as fishing and limited boating.

Water from Ash Pond also discharges via underground connections to Burgermeister Spring, to Lake 34, to Dardenne Creek, and eventually to the Mississippi River (Dean, 1985). At present, there is no recreational use of Burgermeister Spring, but Lake 34 is used for recreational purposes similar to those of Lake 35. Lakes 34 and 35 are not used as drinking water or as irrigation sources (Figure 1-2).

Surface water runoff from the northeast portion of the WSS drains into Frog Pond. An intermittent stream running out of Frog Pond flows north to Lake 36. The outfall of Lake 36 discharges into Lake 35, to Schote Creek, to Dardenne Creek, and eventually to the Mississippi River. Lake 36, located in the Busch Wildlife Area, is the closest lake in an unrestricted area receiving effluent from Frog Pond. Lake 36 is also used for

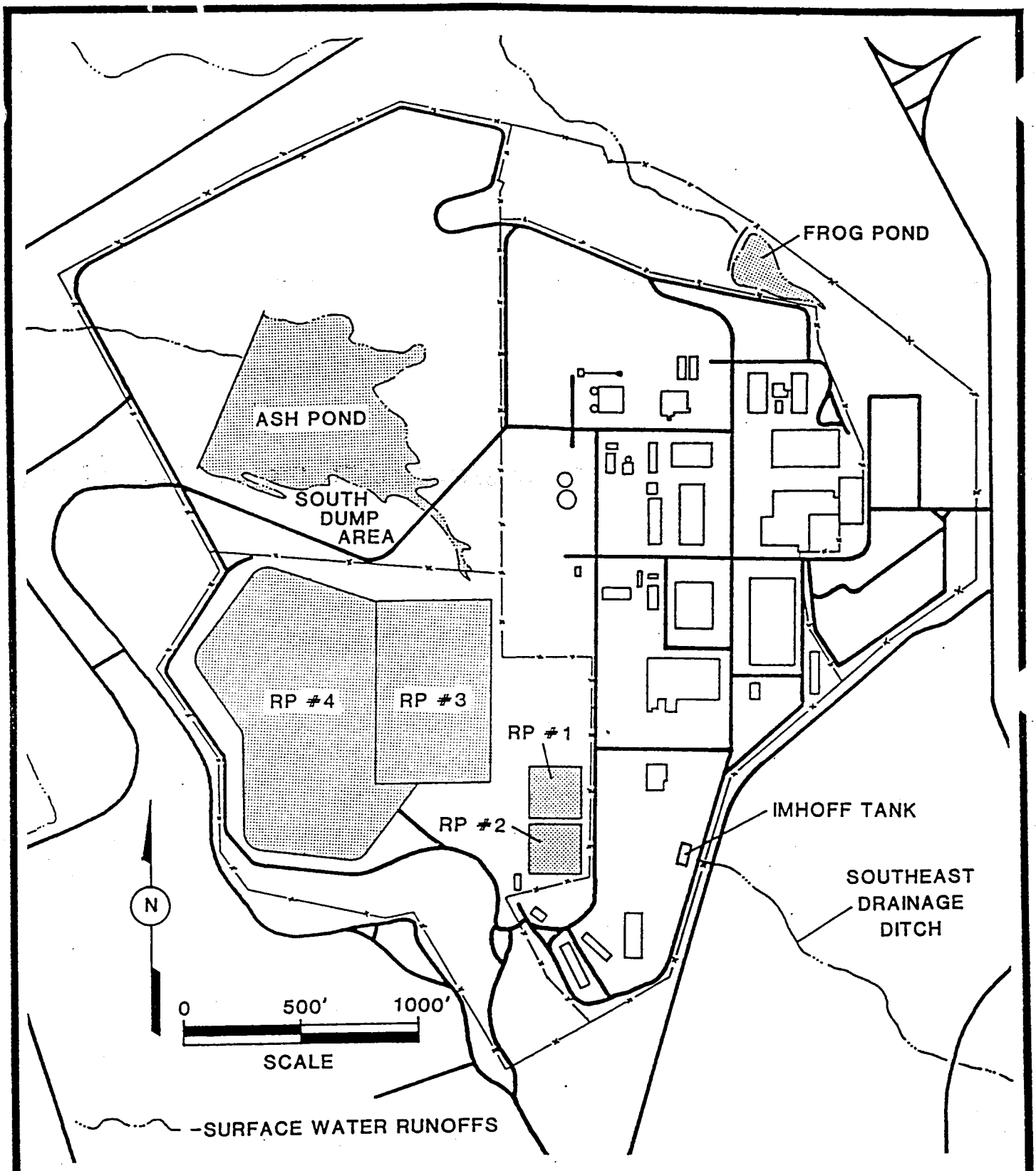


FIGURE 1-1

SITE MAP WITH ASH POND AND FROG POND DRAINAGES

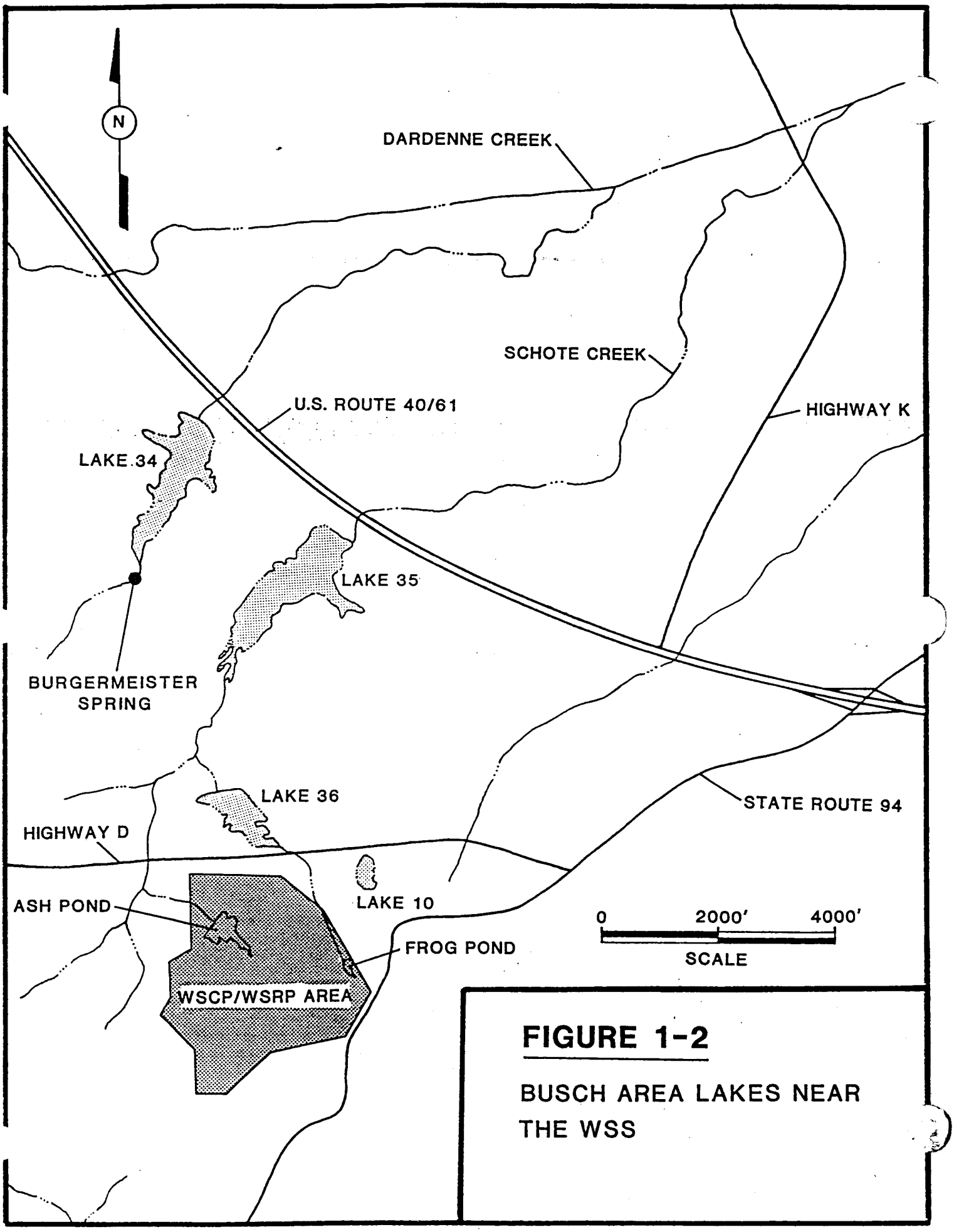


FIGURE 1-2

BUSCH AREA LAKES NEAR THE WSS

fishing and boating but not as a source of drinking water or as a source for irrigation.

On the southeast corner of the WSCP, the outfall from the Imhoff tank (the former WSCP sanitary sewage system) flows down a drainage ditch to the Missouri River. This drainage system contains areas of elevated radionuclide concentration. Currently, flow through the Imhoff tank results from the infiltration of storm water flowing into the sewer system. Sanitary wastes no longer enter the sewer system.

The Weldon Spring Quarry (WSQ) is approximately 4 miles south-southwest of the WSCP. Radioactive wastes were disposed of in the WSQ by the AEC from 1957 to 1966 (Figure 1-3) (U.S. DOE, 1987a). The DA also disposed of TNT process wastes into the WSQ. A large portion of the AEC radioactive wastes were from the Mallinckrodt Chemical Works' Destrehan Street Feed Plant in St. Louis. Materials from this plant were contaminated with radionuclides in the uranium transformation series.

The Femme Osage Slough is located in the Weldon Spring Wildlife Area, approximately 500 feet south-southeast of the WSQ (Figure 1-3). The slough is believed to be hydraulically connected to the quarry sump (U.S. DOE, 1987b). This slough is not used as a source of drinking water or for irrigation, but is used frequently for fishing.

Average radioactivity levels in surface water and runoff samples taken from in and around the WSS during 1987 are presented in Tables 1-1, 1-2 and 1-3. Figures 1-4, 1-5 and 1-6 illustrate the locations of these samples. Tables 1-1 and 1-2 present data from samples that were collected from surface water locations at quarterly intervals and averaged over the entire year. Table 1-3 presents data from surface water runoff samples collected monthly and averaged for the year. These runoff samples are collected monthly, following significant rainfall events, to

monitor contaminant concentrations leaving the WSSRAP as a result of surface runoff. These averaged values are also presented in the 1987 Environmental Monitoring Report (U.S. DOE, 1987c). The radiologic activity levels in surface water generally decrease with increased distance from the site, mainly due to dilution by lake and runoff water.

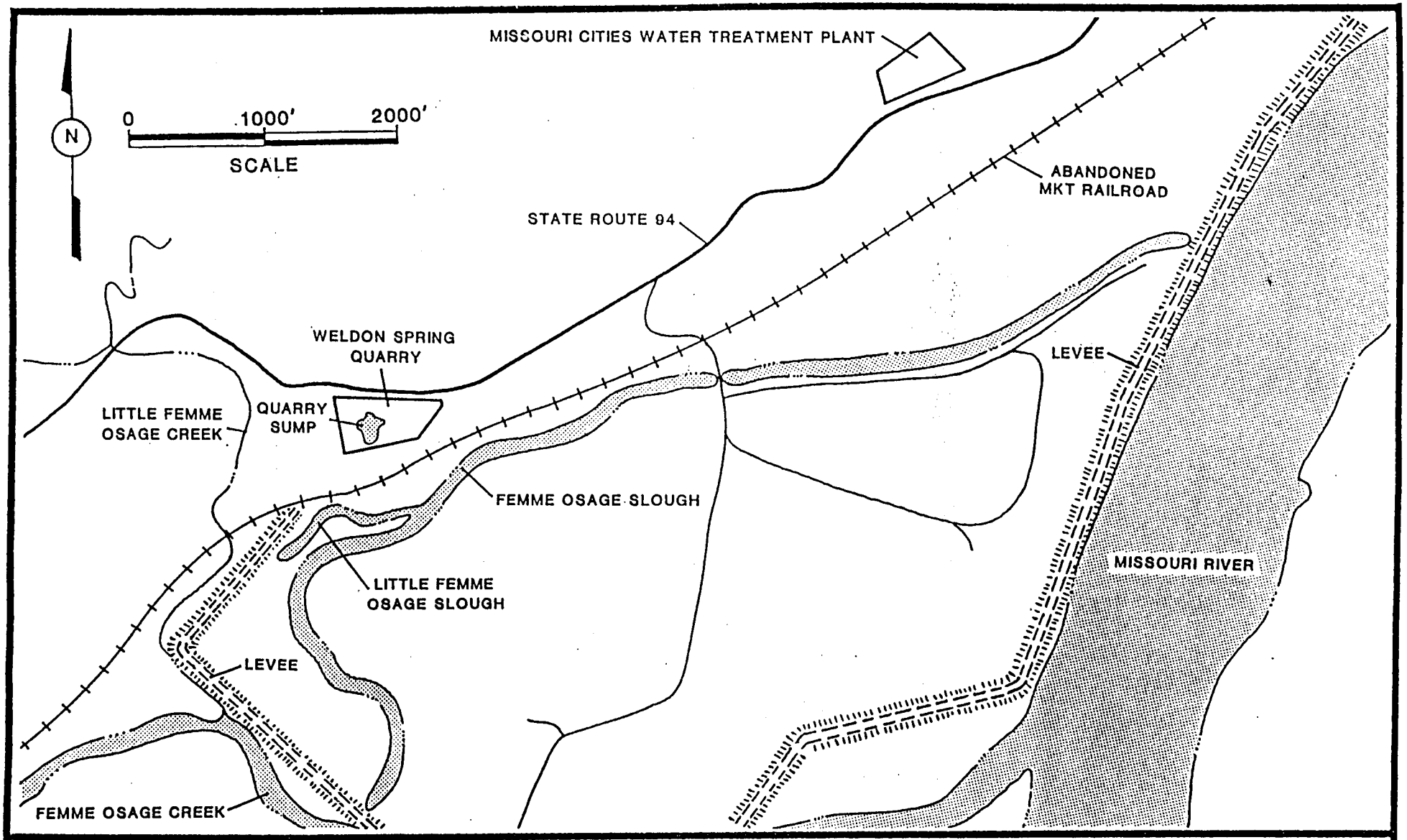


FIGURE 1-3

WSQ AND SLOUGH AREA

TABLE 1-1

ANNUAL AVERAGE RESULTS FROM SURFACE WATER SAMPLES COLLECTED FROM WSQ AREA*

LOCATION		GROSS ALPHA (pCi/L)	GROSS BETA (pCi/L)	NATURAL URANIUM (pCi/L)	Ra-226 (pCi/L)	TH-230 (pCi/L)	TH-232 (pCi/L)	NITRATE (ppm)	SULFATE (ppm)
WSQ AREA									
L. Femme Osage Ck.	SW-1001	<8	12	3	<2	<1	<1	1.4	55
L. Femme Osage Ck.	SW-1002	<4	<8	<1	<1	<1	<1	1.0	48
Femme Osage Slough	SW-1003	25	24	28	<1	<1	<1	<0.2	47
Femme Osage Slough	SW-1004	26	32	34	<1	<1	<1	<0.1	48
Femme Osage Slough	SW-1005	16	16	29	<1	<1	<1	<0.2	51
St. Charles Raw Water	SW-1006	<4	<10	<1	<1	<1	<1	<0.1	48

* Data from Environmental Monitoring Report (US DOE, 1987c)

TABLE 1-2

ANNUAL AVERAGE RESULTS FROM SURFACE WATER SAMPLES COLLECTED FROM WSCP/WSRP AREA**

LOCATION		GROSS ALPHA (pCi/L)	GROSS BETA (pCi/L)	NATURAL URANIUM (pCi/L)	Ra-226 (pCi/L)	TH-230 (pCi/L)	TH-232 (pCi/L)	NITRATE (ppm)	SULFATE (ppm)
WSCP/WSRP AREA									
Dardenne (Schote Ck.)	SW-2001	<3	<8	3	<1	<1	<1	*	52
Lake 36 (IN)	SW-2002	70	42	170	<1	<1	<1	0.8	63
Lake 35 (IN)	SW-2003	12	13	15	<1	<1	<1	1.1	18
Lake 34 (OUT)	SW-2004	19	18	25	<1	<1	<1	4.9	22
Lake 36 (OUT)	SW-2005	21	24	25	<1	<1	<1	0.3	36
Lake 10	SW-2006	<3	<7	2	<1	<1	<1	0.5	9
Dardenne Ck. (HWY 40)	SW-2007	4	9	<1	<1	<1	<1	*	50
Burgermeister Spring	SW-2008	57	39	92	<1	<1	<1	111	53

* Anomalous data presumed to be due to agricultural fertilizer application at these locations make calculation of annual average values suspect.

** Data from Environmental Monitoring Report (USDOE, 1987c).

TABLE 1-3

ANNUAL AVERAGE RESULTS OF NPDES SAMPLING SURROUNDING WSCP/WSRP

LOCATION	pH (SI)	FLOW (GPM)	TOTAL SETTLEABLE SOLIDS (ml/L)	TOTAL SUSPENDED SOLIDS (ml/L)	NATURAL URANIUM (pCi/L) +/- ERROR	GROSS ALPHA (pCi/L) +/- ERROR	NITRATE (mg/L)	TOTAL* NITROAROMATICS (mg/L)
South Ditch NP-001	7.7	40	<0.1	28	680 ± 30	500 ± 30	5.7	0.6<1.3
Frog Pond NP-002	7.9	50	<0.1	18	210 ± 10	110 ± 10	2.4	0.6<1.2
Ash Pond NP-003	7.5	200	<0.1	12	2240 ± 145	2030 ± 130	30	1.5<2.6
Pit 4 NP-004	7.4	25	<0.1	3	9.5 ± 1.0	36 ± 10	1.1	<1.1
South Ditch NP-005	7.7	40	<0.1	30	780 ± 75	560 ± 35	146	1.0<1.9

* First value indicates average, second value estimates upper bound to average including analyses which were below the lower detection limit.

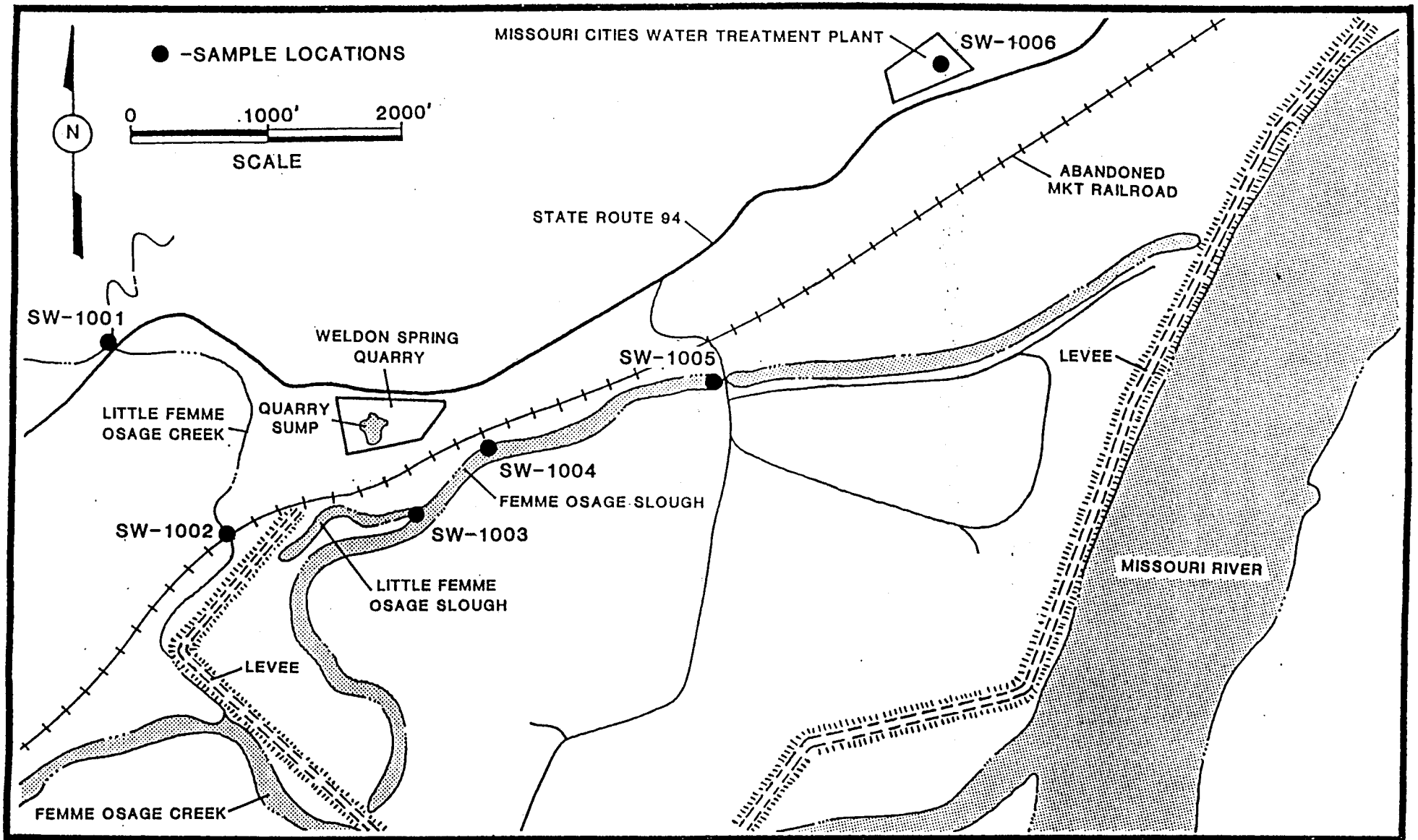


FIGURE 1-4

SURFACE WATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

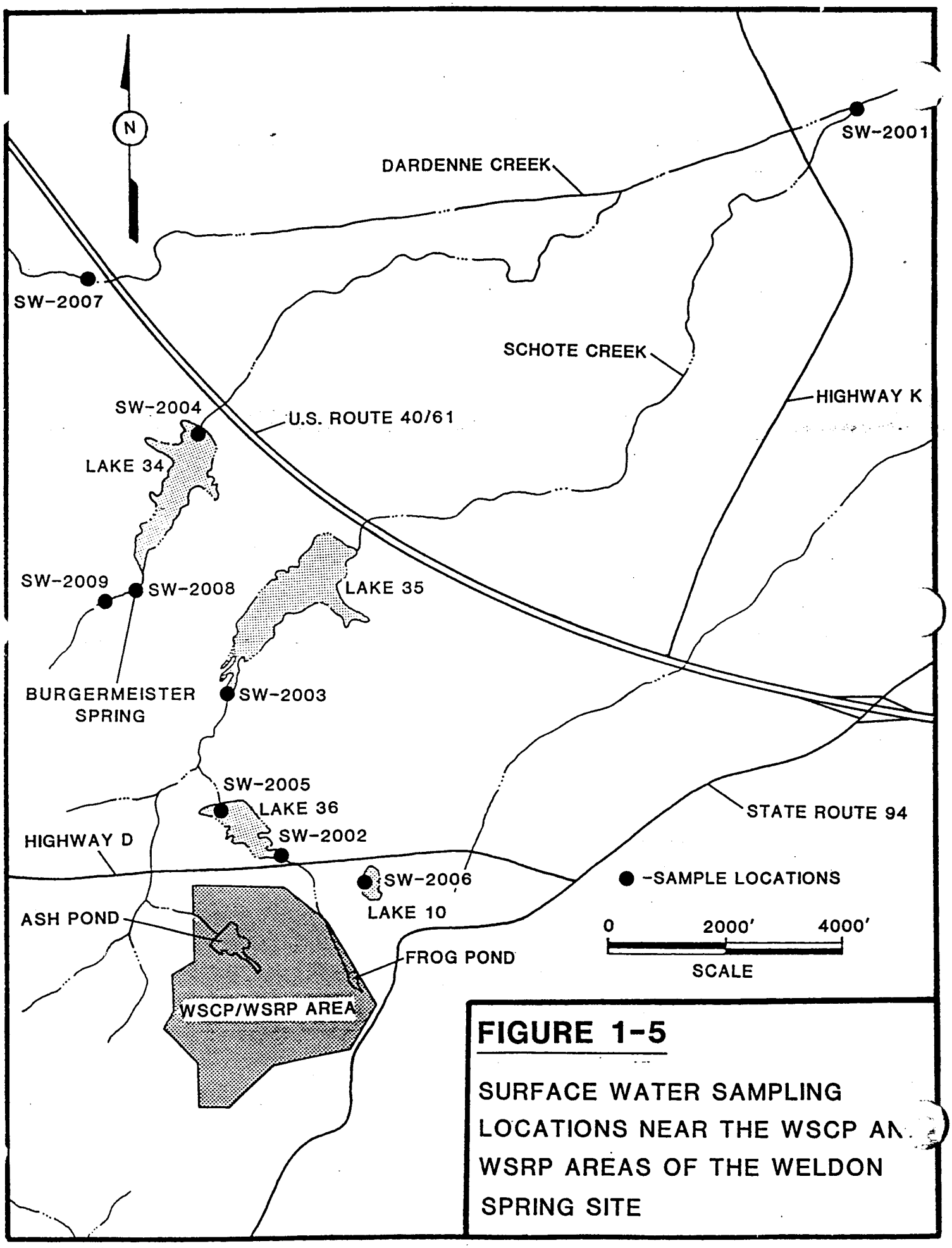


FIGURE 1-5

SURFACE WATER SAMPLING LOCATIONS NEAR THE WSCP AN WSRP AREAS OF THE WELDON SPRING SITE

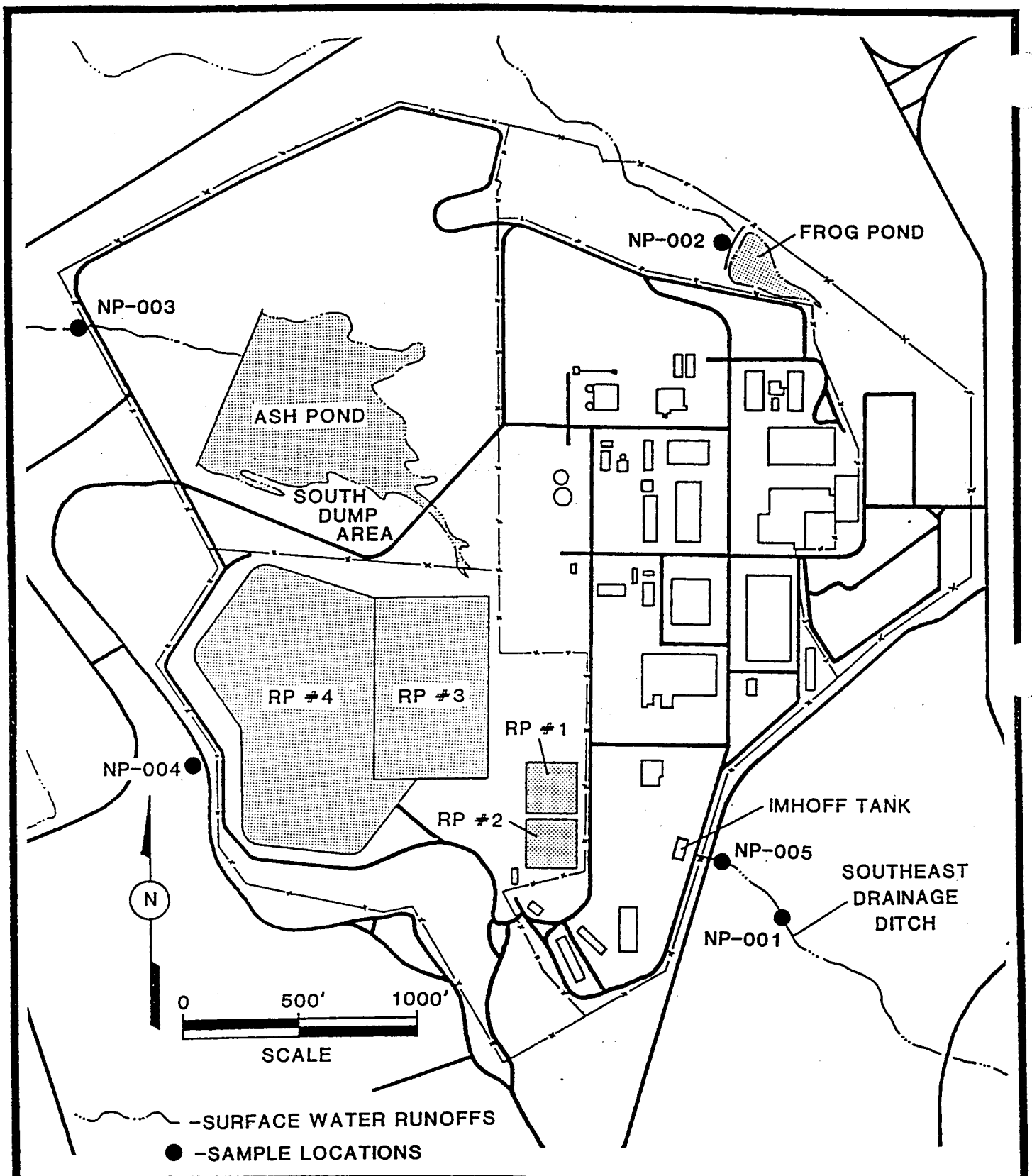


FIGURE 1-6

NPDES SURFACE WATER SAMPLING LOCATIONS

2.0 METHODS

Only terrestrial and aquatic animal specimens were included in the analyses for chemical and radiological uptake. Human consumption of plants from the contaminated areas is considered to be minimal. Although several sharecrop fields are operated by the Department of Conservation in the surrounding areas, they are used exclusively for wildlife forage. The nearest commercial farming areas or private gardens are several miles from the WSS. In addition, no indication of radiological contaminants has been found in any offsite areas used for plant production. Therefore, the present study has been focused on the animal tissue pathway.

2.1 FIELD METHODS

2.1.1 Aquatic Species

Aquatic sampling took place in October and November of 1987. Fish specimens were collected from surface waters impacted by contaminant releases from the WSS in order to determine the extent of radionuclide uptake by game fish. Specimens were collected using the electrofishing technique. Electrofishing utilizes a gas-powered generator to introduce an electric current into the water around the boat. Fish are temporarily stunned, then netted and placed in a water-filled tub in the boat. Fish samples were collected from Lakes 34, 35, 36, and 37 in the August A. Busch Wildlife Area and from the Femme Osage Slough on the Weldon Spring Wildlife Area. This work was accomplished with the cooperation of the Missouri Department of Conservation.

Fish specimens from Frog Pond were also collected by PMC personnel using the electrofishing technique. An attempt was made to collect samples from Raffinate Pits 3 and 4 and from the Quarry Sump. However, these bodies of water did not yield a

single specimen.

Lake 37 in the Busch Wildlife Area was chosen as a background location. Lake 37 is located at the western edge of the Busch Area in a small, isolated watershed which does not receive runoff from the WSS or the abandoned Army Ordnance Works.

According to the bio-uptake sampling plan (DOE, 1987d), five composite samples of fish were to be collected from each location. The five composites were to represent the following fish, prepared as specified:

1) sunfish, filleted
2) sunfish, cleaned (beheaded, scaled, and eviscerated)
3) bass, filleted
4) catfish, filleted
5) mixed species, filleted

The fish species chosen for sampling represented three different patterns of feeding and food preference. All three species are commonly consumed by the public as a result of recreational fishing at the Busch and Weldon Spring Wildlife Areas. Sunfish are omnivorous fish confined to shallow waters. Largemouth bass are predominantly piscivorous in the Busch Wildlife Area lakes. Catfish are predominantly omnivorous bottom feeders. Catfish were expected to be the species most likely to exhibit contaminant uptake due to their proximity to the potentially more contaminated lake sediments. The cleaned (beheaded, scaled, and eviscerated) sunfish composites represented fish commonly used to make "fish cakes", a common way of preparing this smaller fish.

Fish were cleaned and samples prepared either the same day they were collected or the morning following an evening collection. Each composite consisted of a minimum of three fish, totaling at least 800 grams. Samples were placed in plastic bags, weighed,

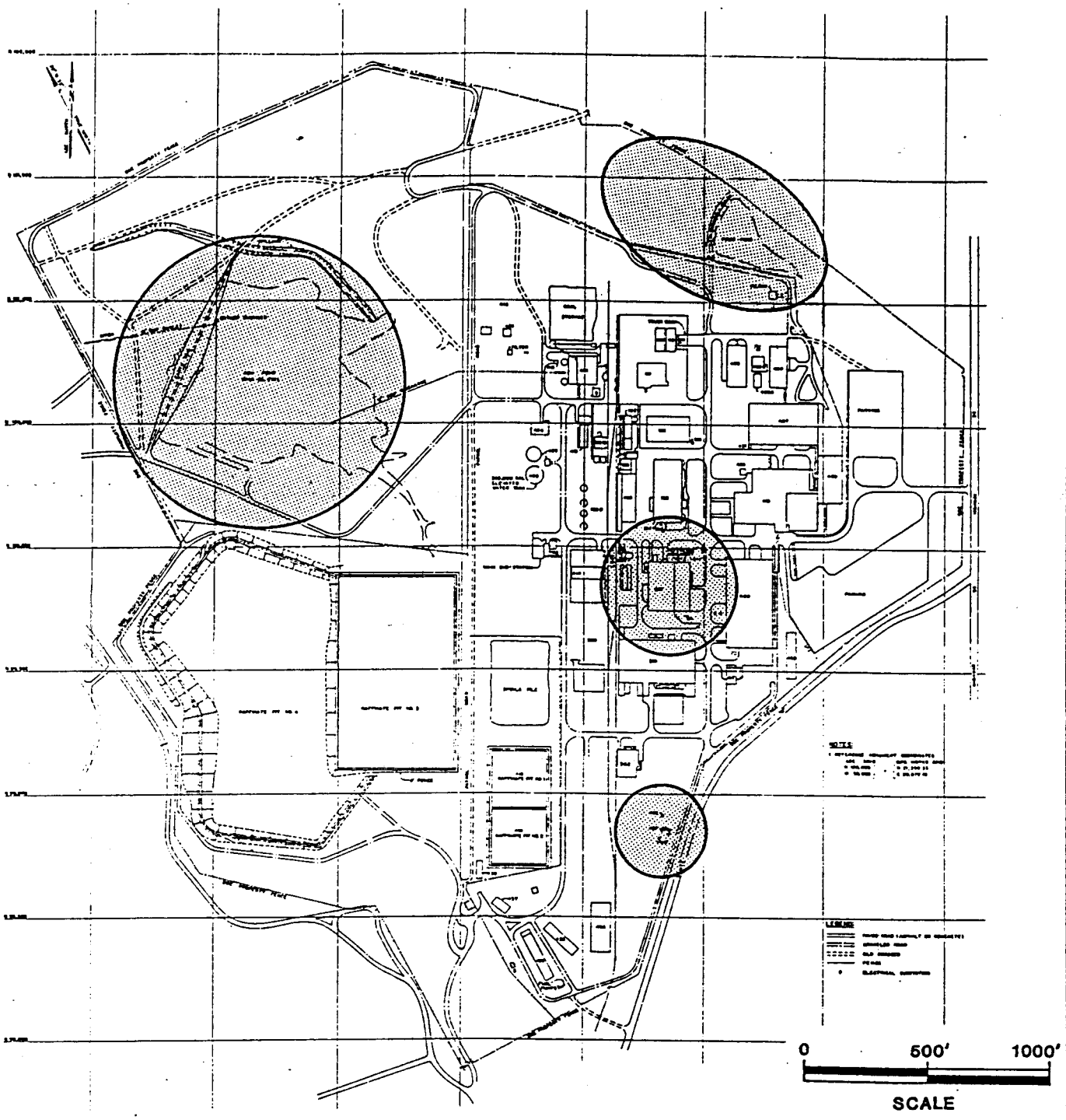
labeled, and immediately frozen. The frozen samples were sent for laboratory analyses within 48-72 hours of sample collection. The original sampling plan was followed whenever possible. However, at some locations substitutions were required due to species unavailability. For example, in Lake 35, crappie fillets were substituted for sunfish fillets. In the Femme Osage Slough, crappie replaced both sunfish composites; carp and largemouth buffalo were collected also because they were common within this body of water. At Frog Pond, sunfish were the only abundant fish and most of them were small in size. Therefore, only the cleaned sunfish composite could be collected.

The composite samples were sent to a subcontracted laboratory, metaTRACE, in Earth City, Missouri. The filleted composites were analyzed for natural uranium. The cleaned (scaled, beheaded, eviscerated) sunfish samples, representing fish that would be ground up to make fishcakes, were analyzed for thorium-230/232 and radium-226 as well as total uranium. The mixed fillet composites were analyzed for PCBs and CLP metals.

2.1.2 Terrestrial Species

Small game mammals (rabbits and squirrels) were collected from the Weldon Spring Chemical Plant (WSCP). Most of the samples were obtained by trapping with live traps using a variety of baits. However, this trapping was not as effective as anticipated, and samples were later obtained by hunting on site. A total of eight rabbits and three squirrels were collected from the WSS. Trapping was concentrated in two areas: the South Dump/Ash Pond area and the Frog Pond area. Hunting was utilized to obtain samples from areas around the chemical plant buildings. Figure 2-1 illustrates these areas.

Small mammal composite samples consisted of three individuals collected from each location. Specimens were cleaned on the day they were collected, placed in plastic bags, labeled, frozen,



SHADED AREAS INDICATE SAMPLING AREAS

FIGURE 2-1

SMALL MAMMAL SAMPLING AREAS AT WSS

and sent to the lab. At the lab, each composite was split into bone and tissue and analyzed separately for total uranium, thorium-230/232, and radium-226. The lab did not analyze for PCBs and metals since there were not enough individual specimens captured to provide the necessary volume of sample tissue.

Larger migratory game animals such as deer, turkey, geese, etc. were not sampled as part of the WSS bio-uptake study. Such animals readily migrate on and off site, spending an unknown proportion of their time on the WSS. An expansion of the bio-uptake study's scope to include larger migratory game animals was dependent upon the data obtained from the smaller terrestrial mammals. No small mammal samples were obtained from the quarry area since trapping in the WSQ area was unsuccessful.

2.2 ANALYTICAL PARAMETERS

The investigation focused primarily on the analysis for uranium in the biological specimens collected. In comparison with the other contaminants present in the WSS, uranium exists at the highest concentrations and quantities, and is one of the most water soluble. In addition, when introduced into the body, uranium is the most soluble of the radionuclides, incorporating into the soft tissues as well as into the bones. All samples were analyzed for total uranium except for the mixed fillet composites which were analyzed for PCBs and metals.

Surface waters at the WSS generally exhibit background concentrations of radium and thorium (DOE, 1987c). Radium and thorium are relatively insoluble and primarily incorporate into the bone. Therefore, only the cleaned sunfish composites which included bone were analyzed for these radionuclides. Small mammals were also analyzed for radium and thorium. Small mammal samples were split by the lab into tissue and bone subsamples and analyzed for all three radiological parameters.

The mixed species fish composites were analyzed for CLP metals and PCBs. Draft versions of the Biological Uptake Plan also included the analysis of biota samples for nitroaromatics, on the assumption that this analysis could be performed by the laboratory. Subsequent research indicated insufficient information concerning the uptake, biodegradation, and metabolism of nitroaromatic compounds by animals and humans, making it difficult to interpret analytical results. In addition, there are no accepted methodologies for the analysis of nitroaromatic compounds in biological tissue. Recovery of target compounds following extraction procedures was estimated to be extremely low. TNT and DNT degradation products in the samples would probably not be detected. The lower limits of detection would not be low enough to consistently detect the concentrations anticipated. Therefore, nitroaromatic analyses were not performed as part of this study.

Additional analyses of semi-volatile compounds were considered as part of the sampling plan, but were discounted because of the same factors discussed for nitroaromatics. Information concerning uptake, degradation and metabolism is considered inadequate, and acceptable analytical methodologies have not been developed.

2.3 ANALYTICAL METHODS

Laboratory analytical methods used for the bio-uptake study generally followed the same procedures as those used for water samples. The main differences were in the sample preparation procedures. Fish samples analyzed for radionuclides and CLP metals were first digested in concentrated hydrochloric acid and then diluted to one liter before analysis by the following methods: total uranium was analyzed according to EPA method 908.0, isotopic thorium by EPA 00/07, radium-226 by EPA 903.0, and metals by EPA CLP protocols. PCB (Aroclor) analyses also followed CLP methods but utilized fish tissue that was not

acid-digested.

Small mammal composite samples sent to the laboratory for analysis were split first into separate bone and soft tissue portions, and then prepared for analysis according to Eastern Environmental Radiation Facility procedures (USEPA, 1984). These procedures included ashing the samples at 550° C for 72 hours in a muffle furnace followed by treatment with various carriers, tracers, and acids prior to the actual analyses. Radionuclide analyses followed the same methods as listed above for the fish samples.

3.0 RESULTS

3.1 AQUATIC SAMPLES

Twenty-five (25) composite fish samples, representing a total of 184 fish, were sent to the laboratory for analysis. Results from the fish portion of the bio-uptake study are presented in Tables 3-1, 3-2, and 3-3. Table 3-1 presents the sample numbers, radiological results, and the number and type of fish collected from each location. All samples analyzed exhibited no radiological contaminants detected at the lower limits of detection indicated in Table 3-1. Values less than the detection limits for samples from Frog Pond are especially noteworthy in light of the water concentrations of nuclides shown in Table 1-1.

Table 3-2 presents the results of PCB analysis from the mixed species composites. No PCBs were detected in any of the four composite samples analyzed for these parameters with detection limits of 0.04 to 0.06 ug/g (ppm).

Table 3-3 presents the results of CLP metals analyses for the mixed species composites. Many metals naturally occur in biological tissues; therefore, careful comparison with the background location (Lake 37) is necessary in order to interpret these data. Most of the metals detected in the non-background samples occurred in concentrations similar to the background location. Only iron (Fe) concentrations were found to be higher in all samples when compared to Lake 37. Iron was detected in concentrations ranging from 11.7 to 50.7 ug/g compared to 4.89 ug/g at the background location. Elevated background iron levels are not unusual to this area, as evidenced by values for Dardenne Creek in the Phase I Water Quality Assessment Report (DOE, 1987b), (570 - 808 ug/l.)

Chromium was detected in one mixed species composite sample from

TABLE 3-1 FISH RADIOLOGICAL RESULTS

Sample #	Total Uranium	Thorium 230	Thorium 232	Radium 226	Comments
	CONCENTRATIONS pCi/g (wet weight)				
Lake 37:					
BG-3701-1087	ND (0.01)				11 Sunfish Filleted (800g)
BG-3702-1087	ND (0.01)	ND (0.2)	ND (0.3)	ND (0.2)	6 Sunfish Cleaned *(800g)
BG-3703-1087	ND (0.02)				4 LM Bass Filleted (800g)
Lake 36:					
BG-3601-1187	ND (0.01)				8 Sunfish Filleted (800g)
BG-3602-1187	ND (0.01)				10 Sunfish Cleaned *(800g)
BG-3603-1187	ND (0.01)				4 LM Bass Filleted (800g)
BG-3604-1187	ND (0.01)	ND (0.06)	ND (0.02)	ND (0.003)	7 Catfish Filleted (300g)
Lake 35:					
BG-3502-1087	ND (0.02)	ND (0.03)	ND (0.1)	ND (0.3)	9 Sunfish Cleaned *(800g)
BG-3503-1087	ND (0.01)				4 LM Bass Filleted (900g)
BG-3504-1087	ND (0.02)				5 Catfish Filleted (500g)
BG-3505-1087	ND (0.02)				12 Crappie Filleted (800g)
Lake 34:					
BG-3401-1087	ND (0.01)				7 Sunfish Filleted (800g)
BG-3402-1087	ND (0.01)	ND (0.2)	ND (0.05)	ND (0.01)	11 Sunfish Filleted (800g)
BG-3403-1087	ND (0.01)				3 1/2 LM Bass Filleted (800g)
BG-3405-1087	ND (0.01)				8 Crappie Filleted (800g)
Femme Osage Slough:					
BG-SL03-1087	ND (0.01)				3 LM Bass Filleted (800g)
BG-SL05-1087	ND (0.01)				5 Crappie Filleted (800g)
BG-SL07-1087	ND (0.01)				3 1/2 Carp Filleted (1200g)
BG-SL08-1087	ND (0.01)				2 LM Buffalo Filleted (800g)
BG-SL09-1087	ND (0.01)	ND (0.7)	ND (0.3)	ND (0.2)	4 Crappie Cleaned *(900g)
Frog Pond:					
BG-FP02-1187	ND (0.1)	ND (0.2)	ND (0.07)	ND (0.1)	24 Sunfish Cleaned *(800g)

ND = Not detected (detection limits in parentheses)
* = Scaled, beheaded, eviscerated to simulate fishcake preparation.

TABLE 3-2 BIO-UPTAKE PCB RESULTS

Sample #	CONCENTRATIONS (ppm) Aroclor 1016	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260	COMMENTS
Lake 37:								
BG-3706-1087	ND	ND	ND	ND	ND	ND	ND	4 bass, 5 sunfish (800g)
Lake 36:								
BG-3606-1187	ND	ND	ND	ND	ND	ND	ND	2 bass, 2 sunfish, 2 crappie (800g)
Lake 35:								
BG-3506-1087	ND	ND	ND	ND	ND	ND	ND	2 bass, 4 sunfish, 6 crappie (800g)
Lake 34:								
BG-3406-1087	ND	ND	ND	ND	ND	ND	ND	1 bass, 2 sunfish, 4 crappie (800g)
Det. Limits	0.04	0.06	0.04	0.05	0.04	0.04	0.04	

ND = Not detected

TABLE 3-3 BIO-UPTAKE CLP METALS RESULTS FOR MIXED SPECIES COMPOSITE SAMPLES*

	CONCENTRATION (ug/g)																						
Sample #	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
Lake 37																								
BG-3706-1087	ND	ND	13.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.23	ND	3423	ND	ND	--	9.1	ND	11.3
Lake 36																								
BG-3606-1187	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11.7	4.2	ND	ND	ND	0.16	ND	3530	ND	ND	510	ND	ND	9.5
Lake 35																								
BG-3506-1087	ND	ND	13.6	ND	ND	ND	ND	ND	ND	ND	50.7	ND	ND	ND	2.1	0.24	ND	2666	ND	ND	--	9.4	ND	9.44
Lake 34																								
BG-3406-1087	ND	ND	ND	ND	ND	ND	1050	2.98	ND	ND	24.2	4.0	ND	ND	ND	0.27	ND	3190	ND	ND	ND	ND	ND	12.3
Det. Limits	20	6	1	20	0.5	0.5	500	1	5	2.5	10	0.5	5	500	1.5	0.1	4	500	0.5	1	500	1	5	2

ND = Not Detected
-- = Analysis not performed
* See Table 3-2 for description of sample make-up

Lake 34 with a concentration above the detection limit.

The metals arsenic (As), mercury (Hg), potassium (K), thalium (Tl), and zinc (Zn) are also shown with concentrations above the limits of detection. Each of these chemical species is also detected in the samples from Lake 37 which is located outside of the drainage of the WSS. For this reason, these concentrations are considered to be natural levels for the metals in fish tissue in this setting.

The lead (Pb) concentrations in fish samples from Lake 36 and 34 are about a factor of eight higher than the detection limit. Lakes 36 and 34 have no point of commonality. They are part of separate drainage basins and have been shown not to be in hydraulic connection through subsurface flow conduits (Dean, 1985). Although lead was not used as part of the former Weldon Spring Uranium Feed Materials Plant, it was commonly used throughout the Army Ordnance Works as a spark-free metal. Lead was a minor component of the impurities contained within the yellowcake processed, and therefore is found at low levels in the raffinate pit sludges.

Reasons were examined to determine any significance and possible sources of the elevated lead levels in fish tissue. Importantly, Phase I Soils studies (DOE, 1988) indicated that no migration of lead has occurred beyond the raffinate pit containment. That same study also reported an average background level of lead naturally occurring in the soils surrounding the WSS of 29 ppm. It also demonstrated that elevated levels of lead in soils occurred onsite in highly localized deposits associated with the Ordnance Works sources.

Monitoring data from the Phase I Water Quality Assessment (DOE, 1987b) indicates that lead is below the level of detection of 5 ug/l in both surface and groundwater from and around the site. The only location where lead has been detected above detection

limits is in Dardenne Creek, downstream from the lakes in question and even further from the WSS.

The above information, combined with the apparent absence of lead in fish tissue from Lake 35 which is immediately downstream of Lake 36, imply that the source of the lead is probably localized and is not from the Weldon Spring Site. Several plausible mechanisms exist that individually or in concert provide explanation for the localized phenomenon of lead uptake into fish tissue. Lead shot has been known to be ingested by waterfowl. In routinely hunted areas, many waterfowl carry a large body burden of lead from hunting injury. Fish feeding on the contaminated carcasses of such fowl would evidence elevated concentrations of lead. Additionally, fish could ingest and digest individual lead pellets which in turn would be assimilated into the tissues and result in elevated lead concentrations. Use of lead materials in fishing equipment is widespread and common. Nationally, lead contamination of the environment is recognized as an issue of concern with lead coming from a wide variety of anthropogenic sources.

Another factor introducing variability into the lead concentration of different samples is based upon the nature of the composite samples themselves. Slightly elevated lead levels in fish tissues from Lakes 34 and 36 are presumed to be partly the effect of statistically variable samples of fish. In order to achieve the goal of the study, i.e., to examine the effect of species of concern to human diets, the metals analysis samples consisted of a composite of three different species of edible fish. Composite samples of 800 grams each were made from the catch that was obtained from each of the lakes. The guideline followed in determining the sample constituents was to incorporate as good a representative mix of these edible species as could be acquired from the catch at each lake. These composites consisted of the following proportions of fish:

- Lake 34
  - 1/2 of a bass
  - 4 crappie
  - 2 sunfish

- Lake 35
  - 2 bass
  - 4 sunfish
  - 6 crappie

- Lake 36
  - 2 ea 1/2 bass
  - 2 crappie
  - 2 sunfish

- Lake 37
  - 4 bass
  - 5 sunfish

Two important elements determined the mix of these samples. First, the samples were to be representative of species which humans eat, and second, the samples were to be representative of the catch obtained at each lake. While these samples represent the kind of variability that would reflect a human diet from the lakes, nevertheless they introduce some variability with respect to different species composition, as well as differences in age, sex, and possibly other factors.

The samplers tried to achieve as uniform a mix of fish as possible. One factor apparent between samples from Lake 34 and 36 is the small number of bass (larger fish had to be cut to achieve correct proportioning). Bass are on the top end of the fish food chain and, given the rule of thumb of 10 fold increase in bioaccumulation in each higher trophic level, these bass may have more lead than the other fish. Also, age is another factor in bioaccumulation. Since larger fish in a species group are

usually older fish, it appears older bass were caught in 34 and 36. For these reasons, it is believed that they may be contributing proportionally higher levels of lead.

Arsenic (As) levels about 14 times the lower detection limit were found in fish samples from Lakes 35 and 37. Arsenic is an element well known for its bioaccumulation capacities. It occurs naturally and also as a result of human activity. Naturally occurring arsenic concentrations on or around the WSS have an arithmetic mean of 6 mg/kg (DOE, 1988). Lake 37 is not influenced by the Weldon Spring Site and, therefore, accumulation of arsenic is clearly a result of other mechanisms. This finding is reinforced by a similar arsenic concentration in fish from Lake 35. This lake is downstream from Lake 36 where the fish did not show accumulations of arsenic above the levels of detection. The Phase I Water Quality Assessment reports all surface water and groundwater samples of the WSS had levels of arsenic below the detection limits (DOE, 1987b). Only water samples taken directly from the Raffinate Pits showed concentrations ranging from below the level of detection up to 38 ug/l, or part per billion concentrations. For these reasons, the arsenic accumulations in fish from Lakes 35 and 37 appear to be unrelated to the Weldon Springs facility.

Chromium (Cr) was detected only in the fish sampled from Lake 34 at slightly less than 3 times the detection limit. Chromium is a naturally occurring element in soils and waters of the area. Natural soil background concentrations at or around the WSS have an arithmetic mean of 24 mg/kg (DOE, 1988). It is found at detectable but low concentrations in all ground and surface waters with about 50 ug/l being a reasonable approximation of the background levels (DOE, 1987b). Chromium has been detected in fish tissues at or slightly above background concentrations in other studies (Wixson, 1982). With the ubiquitous nature of chromium, a single fish sample containing less than 3 times the

detection limit cannot be considered as significant nor can it be attributed to the WSS.

Concentrations of the metals calcium (Ca), potassium (K), and sodium (Na) were anticipated because these metals are essential constituents of living tissues. Their presence at varying levels as indicated in Table 3-3 was expected also.

3.2 TERRESTRIAL SAMPLES

A total of eight rabbits and three squirrels were collected from the Ash Pond area, three rabbits from among buildings at the WSCP, and two rabbits from around the Imhoff Tank drainage. Three squirrels were collected from the Frog Pond area. Table 3-4 presents the results of radiological analyses for these samples. No radiological contaminants were detected at the lower limits of detection as shown in Table 3-4.

No samples were collected off-site or from the quarry area. Trapping at the quarry was unsuccessful.

TABLE 3-4 SMALL MAMMAL RADIOLOGICAL RESULTS

Sample #	Matrix	CONCENTRATIONS (pCi/g) Total Uranium	Thorium 230	Thorium 232	Radium 226
ASH POND AREA					
BG-AP20-1287	Rabbit Tissue	ND (0.02)	ND (0.03)	ND (0.01)	ND (0.01)
	Rabbit Bone	ND (0.3)	ND (0.1)	ND (0.4)	ND (0.1)
WSCP AREA					
BG-IT20-021188	Rabbit Tissue	ND (0.4)	ND (1)	ND (1)	--
	Rabbit Bone	ND (0.08)	ND (1)	ND (1)	--
BG-CP20-021188	Rabbit Tissue	ND (0.04)	ND (1)	ND (1)	--
	Rabbit Bone	ND (0.05)	ND (1)	ND (1)	--
FROG POND AREA					
BG-FP21-1287	Squirrel Tissue	ND (0.09)	ND (0.05)	ND (0.01)	ND (0.01)
	Squirrel Bone	ND (0.03)	ND (0.07)	ND (0.05)	ND (0.07)

ND = Not Detected (detection limits in parentheses)

4.0 DATA INTERPRETATION

The principal objective of the biological sampling program was to establish the fate of the site contaminants in edible biota in the local environment so that their impact could be experimentally measured. The characterization design was based on the direct sampling of edible biota and the analysis of samples for contaminants. Assimilation of contaminants by biota is a complex phenomenon, especially in aquatic organisms that absorb contaminants directly from water as well as from food in their gastrointestinal tract. This section presents a determination of bioaccumulation factors of radionuclides for aquatic species so that a comparison with similar studies can be made. It does not present an analysis of the bioaccumulation for nonradiological chemical species.

The bioaccumulation factor of an organism or tissue is the ratio of a radionuclide in the whole organism or tissue to that in water. A variety of environmental factors can influence the assimilation of contaminants, and hence the bioaccumulation in organisms. For example, the calculation of a radiation dose to man from food chains usually requires that bioaccumulation factors be calculated only for the edible portion of the organism. Whole-body bioaccumulation factors may be quite different from those reported for muscle tissue. When a contaminant accumulates in the bone, its contribution to the whole body concentration is greater than its concentration in the muscle. Therefore, the actual radiation dose to man from the ingestion of the muscle may be much lower than the radiation dose calculated using the whole-body accumulation factor.

Several factors can significantly influence the organism bioaccumulation factors reported in the literature, including the method used to determine bioaccumulation factors, various environmental parameters, the chemical form of the contaminant, and characteristics of individual species. Because of the

uncertainties associated with bioaccumulation factors, there is a tendency to select values that are usually overestimates. It may be impractical to expect validation studies to show close agreement between many of the values found in literature and experimentally measured site-specific values. This conservatism needs to be noted when the data are interpreted.

4.1 PREVIOUS STUDIES

The National Council on Radiation Protection and Measurements (NCRP) has published a reference document on the application of radionuclide transport models from the point of discharge to the environment to the point of intake by man (NCRP Report No. 76, 1984). The report indicated that comprehensive studies of uranium, thorium, and radium in aquatic biota concerning their relative concentrations and their movement through aquatic food chains are not readily available. The report presented limited experimental data for the concentration of uranium and radium in freshwater biota (Table 4-1).

T.L. Gilbert (Argonne National Laboratory) et al. prepared a manual for the U.S. Department of Energy for implementing residual radioactivity guidelines (Gilbert et al., 1985). The manual included various food pathway factors used in deriving the environmental transport factors of residual materials. Table 4-2 lists these bioaccumulation factors for fish which are represented by the ratios of aquatic concentrations to the radionuclide concentration in fresh water.

Since models of aquatic dispersion of radionuclides released to water are very dependent on the exact local conditions of surface or underground flow and on absorptive capacities of prevalent biota, the NCRP and Gilbert documents were used as comparative references for the WSSRAP studies.

Two separate biological sampling studies have been performed at

TABLE 4-1 - RANGE OF BIOACCUMULATION FACTORS FOR URANIUM AND RADIUM IN FRESHWATER BIOTA

BIOTA	URANIUM			RADIUM			
	LAKE MICHIGAN[a] WAHLGREN et al. (1976)	LAKE ISSYK-KUL[a] USSR BONDIETTI et al. (1979)	ZIROVSKI MINING AREA[b] YUGOSLAVIA STEGNER AND KOBAL (1982)	JADUGUDA MINING AREA INDIA BONDIETTI et al. (1979)	AMIMAS RIVER[c] COLORADO-NEW MEXICO ANDERSON (1963)	ZIROVSKI[b] MINING AREA STEGNER AND KOBAL (1982)	PATHFINDER[d] MINING AREA ROPE AND WHICKER (1980)
Fish							
Piscivorous	0.5-0.7						
Planktivorous	0.3-0.6	8					
Omnivorous			0.7-38			42-137	0.3-3.3
Benthic omnivore				3-8	3-8		135
Zooplankton	16-44	80					
Phytoplankton	88-156			40-2600	400-1200		
Algae	51				200-2800		1100-3500
Invertebrates	2-8	40	1-35	1-2	500-1000	650	
Macrophytes	62-215	400			752-1200		960-6900

a Large deep oligotrophic lake.

b Small productive cold water river.

c Small (700 cfs) shallow river with high level of suspended solids.

d Small cold water settling pond, maximum depth 4 m.

Source: NCRP, 1985

TABLE 4-2
SELECTED BIOACCUMULATION FACTORS IN AQUATIC SPECIES
USED BY ARGONNE NATIONAL LABORATORY
(uCi/kg WET WEIGHT TO uCi/l IN WATER)

ELEMENT	FRESHWATER FISH[a]	SALTWATER FISH[a]	CRUSTACEAN[b]	MOLLUSCS[b]
Bi	15	15	1000	1000
Po	500	300	5000	5000
Ra	50	50	100	100
Ac	25	25	1000	1000
Th	30	10000	2000	2000
Pa	10	10	10	10
U	2	10	10	10

a Whole fish

b Soft parts only

Source: Gilbert, T.L. et al. 1985

the WSS prior to the data collection discussed in this report. Information gathered from these two studies has been used to estimate upper bounds for bioaccumulation factors for aquatic species. The previous studies are shown with values resulting from the current study in subsequent sections.

In 1977, a biological sampling program was initiated by a contractor for the Department of the Army at the WSCP. Ryckman/Edgerly/Tomlinson and Associates (RETA) performed the assessment (RETA, 1978). One hundred eighteen (118) terrestrial and 60 aquatic biological samples were collected from permanent bodies of water and contaminated land areas on-site, drainages, off-site bodies of water receiving drainage from the WSS, and background sites. Water and sediment samples were collected in coordination with biological samples to obtain correlative data on bioaccumulation.

The detailed analytical results of all biological samples taken by RETA are presented in the appendix to the Phase II report (RETA, 1977). The WSSRAP has been unable to locate this detailed data. A summary of that study is available in the Phase III report (RETA, 1978). The summary presents the general relationships between the contaminant levels in the food chain and the water bodies studied based on samples from the study. These relationships are roughly shown in Table 4-3. For comparative purposes, RETA listed numerical values indicating the ratio between the sample concentrations in a common unit, such as parts per million (ppm). As an arbitrary numeric value, an uranium concentration of 100 ppm in the sediment would suggest 1 ppm in water, 100 ppm in macrophyte roots, and 1 ppm in frogs. From these generalized relationships, it was evident during the sampling phase that there was no evidence of biomagnification of contaminants in these samples which are representative of the food-chain.

In 1983 and 1984, the Missouri Department of Conservation (MDOC)

TABLE 4-3

GENERALIZED FOOD-CHAIN RELATIONSHIPS OF CONTAMINANTS BASED ON RESULTS OF THE RETA STUDY

SAMPLE	URANIUM	THORIUM	RADIUM
SEDIMENT	100	100	100
WATER	1	1	1
ALGAE	10-100	10-100	1
INVERTEBRATES	1-10	2-100	1
MACROPHYTE ROOTS	100	10-50	10-50
SMARTWEED	100	- - -	10
FROGS	1	- - -	1
FROG SKELETONS	- - -	0.1	10-100
MUSKRATS	0.1 (EXTERNAL)	- - -	- - -
SKELETON	- - -	20-50	100
KIDNEY	- - -	- - -	- - -
STOMACH CONTENTS	- - -	20-50	100
RACCOONS			
SKELETON	1-10	- - -	1-10
KIDNEY	1-10	1	- - -
STOMACH CONTENTS	1-10	1	- - -

Source: Ryckman, Edgerly, Tomlinson, and Associates, 1978.

collected samples of water, fish, and sediments from various water bodies near the WSS (deRoss, C. 1984). These locations were Lakes 9, 10, 34, 35, and 36, the Femme Osage Slough, and the Big Femme Osage Creek. Approximately ten fish (edible portions only) were composited per sample. Table 4-4 lists the results from the MDOC sampling effort for Lakes 34, 35, and 36, the Femme Osage Slough, and a background lake located north of Jefferson City, Missouri. Natural uranium concentrations in fish ranged from 0.002 to 0.06 pCi/g.

In 1985, an assessment was performed by Argonne National Laboratory (ANL) using the data from MDOC. In addition to the analytical data from the fish, the radiation doses received during recreational activities and from consuming the fish were assessed. Bioaccumulation factors were calculated by the WSSRAP from MDOC samples and analyses of routine water samples. The results ranged from 0.08 to 7.0 (uCi/kg wet weight to uCi/l in water). Higher bioaccumulation factors were seen for samples that were not filleted and submitted with bones in the sample.

Based upon measured concentrations of uranium in the water and fish tissue by MDOC, the detection limit of 0.01-0.05 pCi/g of natural uranium, Ra-226, Th-230, or Th-232 was chosen as an analytical detection limit goal. Also, the dose received under given assumptions by ingesting edible tissue at these concentrations was considered when choosing the detection limit. The radiation dose received by ingesting edible tissue at these concentrations is much less than 1.0 mrem/yr.

TABLE 4-4
NATURAL URANIUM CONCENTRATIONS IN FISH AND WATER BODIES OF BUSCH WILDLIFE AREA

	nat-U IN WATER[b] (pCi/l)	FISH TYPE	nat-U IN FISH[a] (pCi/g)
Lake 34	18-33	Bluegill*	0.06
		Tiger Musky	0.008
		Channel Catfish	0.005
		Grass Carp	0.005
Lake 35	8-21	Largemouth Bass	0.005
		Channel Catfish	0.002
Lake 36	9-53	Largemouth Bass	0.005
		Channel Catfish	0.007
Femme Osage Slough	8-47	Bluegill*	0.02
		Carp	0.012
		Buffalo	0.009
Background (Little Dixie Lake)	--	Bluegill*	0.02
		Largemouth Bass	0.005
		Channel Catfish	0.009

* Bluegills were not filleted, they were decapitated, eviscerated and scaled

Source: (a) deRoss, C. 1984.
(b) DOE, 1987c

4.2 FACTORS INFLUENCING BIOACCUMULATION

The method used to determine bioaccumulation factors can have a significant influence on the calculated value. Although bioaccumulation factors are simple to calculate, compounded uncertainties can vary the results by several magnitudes.

Some of the factors responsible for this variation are:

- Physical state of the sample -- wet, dry or ash,
- Sampling variations,
- Analytical variations,
- Filtered vs unfiltered water,
- Tissue(s) being examined,
- Chemical state of the analyte,
- Habitat of the organism,
- Age and size of the organism, and
- Others.

Bioaccumulation factors are variously calculated using wet weight, dry weight, or ash weight of the biota. Conversion factors are available for converting dry weight to wet weight for most biota. Bioaccumulation factors based on dry weight are higher than those based on wet weight. The data based on samples collected for this study represent the wet weight of the biota.

Sampling and analytical errors can have significant influence in a sampling program. Laboratory error, number of samples, appropriate time scales for movement of biota, and acute releases of radionuclides into the environment are probably the greatest sources of error. The laboratory and sampling protocol used by the analyses herein are described in Section 3.

The use of filtered or unfiltered water samples in the analyses influences the bioaccumulation factor results. Since a

significant fraction of some elements in water may be in the suspended phase, bioaccumulation factors based on filtered samples may be much greater than those based on unfiltered samples. The water concentrations cited in this report represent unfiltered water samples.

The distribution of elements in tissues influences results. A reference to the specific tissue analyzed must be made because whole-body concentrations may be quite different than only muscle tissue concentrations. Tissues and organs have different metabolic requirements for certain elements. A description of samples submitted for analysis is presented in Section 3.

The chemical state of the radionuclide and the chemical composition of the water influence the bioaccumulation of the biota. Mineral content of the water, soluble forms, exchangeable sites, and stable states of the compound may influence the availabilities of contaminants to biota. Also, the location of water stratification and the nature of the habitat of the biota have effects. The feeding habits of an individual species may vary from ecosystem to ecosystem. Benthic feeding, changing food habits, age and size of biota, and seasonal variations of the habitat may have an impact on the data.

4.3 CALCULATED BIOACCUMULATION FACTORS

The bioaccumulation factor of an organism or tissue is the ratio of radionuclide concentration in the whole organism or tissue to that in water. The ratio of the equilibrium concentration of the assimilated nuclide in the organism or tissue to the average concentration of that nuclide in the water during the history of exposure is the theoretical bioaccumulation factor.

For the field study reported here, all analytical results for all radionuclides were less than the lower limit of detection.

Therefore, all calculated bioaccumulation factors represent a maximum which may be equal to or less than the numerical values indicated. A summary table (Table 4-5) presents the calculated maximum bioaccumulation factors for the WSS along with the model values (Gilbert, et al. 1985) and other values based on actual data (NCRP, 1984).

4.4 COMPARISON WITH STUDY RESULTS

The assimilation of an element by biota is calculated by using a single empirical relationship to represent the transfer of the element to an organism from consumption of contaminated foodstuffs and absorption of water. Calculated results from bioaccumulation factors published by the NCRP and Gilbert are compared with the experimental results from the current study. These results are listed in Table 4-6.

The current results, in general, indicate that maximum concentrations (i.e. at the lower limit of detection) are less than those calculated using the transfer factors provided by the Gilbert models. As indicated in the previous discussion, these models are conservative and are meant to be used as a guide for more complex calculational methodologies. Though no positive results were seen in the WSSRAP study, the limits of detection were well within the range of the values published by the NCRP and experimental values from the MDOC. Since the NCRP published complete data sets from biological studies, the current data seem to be more comparable to the values published by the NCRP than the model estimates.

TABLE 4-5

COMPARISON OF BIOACCUMULATION FACTORS (B.F.) FOR URANIUM

AREA	SPECIES[a]	GILBERT B.F.	NCRP B.F.	WSSRAP[b] B.F.
Lake 34	Crappie (f)	2.0	0.5-0.7	0.4
	LM Bass (f)	2.0	0.5-0.7	0.4
	Sunfish (f)	2.0	0.7-38	0.4
	Sunfish (c)	2.0	0.7-38	0.4
Lake 35	Crappie (f)	2.0	0.5-0.7	1.3
	Catfish (f)	2.0	---	1.3
	Sunfish (c)	2.0	0.7-38	1.3
	LM Bass (f)	2.0	0.5-0.7	0.7
Lake 36	LM Bass (f)	2.0	0.5-0.7	0.4
	Sunfish (f)	2.0	0.7-38	0.4
	Catfish (f)	2.0	---	0.4
	Sunfish (c)	2.0	0.7-38	0.4
Frog Pond	Sunfish (f)	2.0	0.7-38	0.5
Slough	LM Bass (f)	2.0	0.5-0.7	0.3
	Crappie (c)	2.0	0.5-0.7	0.3
	LM Buffalo (f)	2.0	0.7-38	0.3
	Crappie (f)	2.0	0.5-0.7	0.3
	Carp (f)	2.0	---	0.3

(a) Letter in () indicates fillets or cleaned

(b) B.F. are maximum values at the lower limit of detection

Adapted from Gilbert, et al. 1985 and NCRP, 1985.

TABLE 4-6
COMPARISON OF URANIUM CONCENTRATIONS FROM CURRENT AND PAST STUDIES TO CONCENTRATIONS IN WSSRAP AREA WATER BODIES

AREA	SPECIES[a]	SURFACE WATER CONCENTRATION NAT-U(pCi/l)	NATURAL URANIUM CONCENTRATIONS (pCi/g) (WET WEIGHT) EXPERIMENTAL WSSRAP	MDOC	CALCULATED GILBERT	NCRP[b]
Lake 34	Crappie (f)	25	<0.01	---	0.05	0.01-0.02
	LM Bass (f)	(18 - 33)	<0.01	---	0.05	0.01-0.02
	Sunfish (f)		<0.01	---	0.05	0.02-0.95
	Sunfish (c)		<0.01	---	0.05	0.02-0.95
Lake 35	Crappie (f)	15	<0.02	---	0.03	0.008--0.01
	Catfish (f)	(8 - 21)	<0.02	0.002	0.03	---
	Sunfish (c)		<0.02	---	0.03	0.01-0.6
	LM Bass (f)		<0.01	0.005	0.03	0.008-0.01
Lake 36	LM Bass (f)	25	<0.01	0.004	0.05	0.01-0.02
	Sunfish (f)	(9 - 53)	<0.01	---	0.05	0.02-0.95
	Catfish (f)		<0.01	0.007	0.05	---
	Sunfish (c)		<0.01	---	0.05	0.02-0.95
Frog Pond	Sunfish (f)	210	<0.1	---	0.42	0.15-8.0
Slough	LM Bass (f)	30	<0.01	---	0.24	0.15-0.02
	Crappie (c)	(8 - 47)	<0.01	0.009	0.24	0.15-0.02
	LM Buffalo (f)		<0.01	---	0.24	0.02-1.1
	Crappie (f)		<0.01	---	0.24	0.015-0.02
	Carp (f)		<0.01	0.007	0.24	---

(a) Letter in () indicates fillets or cleaned

(b) Compared to similar species

Adapted from Gilbert, et al. 1985, NCRP, 1985 and deRoss, 1984.

5.0 CONCLUSIONS

This study was undertaken to determine the potential for biological uptake of contaminants either from, or related to, the WSS that may occur in the human food chain. It does not describe all possible bio-uptake routes in the complex aquatic and terrestrial food chains on or around the WSS.

Previous studies on the uptake of radioactive materials at the WSS were reviewed in Section 4. The RETA study conducted in 1978 was primarily a screening process to determine whether or not uptake of radioactive materials was taking place in selected organisms at or around the site. To accomplish this, the study examined a wide range of organisms and the organs and tissues of some animals. The results of that study indicate that measurable but very low levels of contamination were present. Many of the organisms and target organs examined in that study, however, would never significantly impact human health. For example, the RETA study looked for contamination by uranium, thorium and radium in algae, cattail roots, and arrowhead roots. Terrestrial organisms were also examined and low levels of uranium were found in smartweed, goldenrod and animal parts such as raccoon stomach, intestine contents, bones and kidneys. Slightly elevated uranium concentrations were also found in muskrat stomach contents. All positive results were at very low levels and in organs or organisms not considered part of the human diet.

In 1983-84, an additional study was conducted by the MDOC. The only organisms examined in this study were fish. Because the fish samples were filleted, it appears (though not stated in the report) that an attempt was being made to examine the impact of the fish upon the human population. Here, too, it was found that even though concentrations of radioactivity were detectable, these concentrations were very low.

The results of the MDOC study were later analyzed by Argonne National Laboratories to determine the amount of radioactivity that one could receive from eating fish from the area of the MDOC study. Calculations determined that if an individual ate the national average annual per-capita consumption of fish from these sources, the individual would receive only 1/1000 of the background level of radiation generally received by Missouri residents.

It is not surprising to find that the previous reports reviewed in Section 4 described low levels of contamination in some organisms. Plants or animals in intimate contact with the water and/or sludges in the raffinate pits, ash pond or other sites of known contamination generally will have slightly elevated levels of radioactivity caused by either primary or secondary contamination. Fish in some of the slightly contaminated lakes off-site also will acquire slight levels of radioactivity.

The most recent data collected for this report offer an advantage over the previous studies. The new data were acquired in compliance with the latest guidance for sampling and analysis, were handled according to the latest chain of custody requirements and were analyzed according to procedures and instruments that are more accurate than those of the former studies completed five and ten years ago, respectively. For these reasons, it is probable that the most recent data are a more accurate representation of the actual effects upon human health than were the data of former studies.

The following conclusions can be made:

- No significant biological uptake of radiological contaminants was detected in fish collected from the WSS or August A. Busch Wildlife Area, or the Weldon Spring Wildlife Area.

- Two conclusions on the chemical data can be drawn. The amount of bioaccumulation of metals from these lakes is generally small, and even these small variations are probably localized incidents. Other studies (Wixson, 1982) have shown similar low concentrations of chromium, arsenic, lead, and other metals in fish tissue at or slightly above the detection limits. In any case, concentrations of metals in fish tissues from this study are not believed to be due to contamination from the Weldon Spring Site.

- Bioaccumulation factors calculated using data from this study are low compared to factors developed from other investigations. Use of these other factors would result in a conservatively overestimated dose. However, exposures would still be negligible.

- No significant biological uptake of radiological contaminants was detected in small mammals collected from WSS.

- No PCBs were detected in any of the offsite fish samples collected.

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APPENDIX A
QUALITY ASSURANCE

This study followed the same quality assurance (QA) guidelines set up for the Environmental Monitoring Program (US DOE, 1987c). However, no duplicate samples could be sent to the laboratory as a result of the small number of individual samples collected.

All samples were collected according to a site-specific sampling plan approved by EPA and DOE. These procedures were instituted to ensure consistency in sample collection. Samples sent to the laboratory were assigned unique identification numbers and documented by completion of chain-of-custody and laboratory authorization forms.

The laboratory receiving samples undergoes an EPA Laboratory Performance Evaluation and an internal laboratory evaluation annually. The laboratory also maintains an internal quality assurance program that involves routine instrument calibration, source and background counts, yield determinations, and replicate analyses to check precision.

APPENDIX B
LABORATORY DATA

metaTRACE, Inc. ■ 13715 Rider Trail North ■ Earth City, MO 63045 ■ (314) 298-8566

SITE ID: B6-3706-1087
metaTRACE ID: AA04839
DATE SAMPLED: 10/20/87
MATRIX: FISH

PCB's	CONCENTRATION (UG/G)
Aroclor 1016	< 0.04
Aroclor 1221	< 0.06
Aroclor 1232	< 0.04
Aroclor 1242	< 0.05
Aroclor 1248	< 0.04
Aroclor 1254	< 0.04
Aroclor 1260	< 0.04

CLP METALS	CONCENTRATION (MG/KG)
Aluminum	2.76
Antimony	< 4.1
senic	13.9
rium	5.63
ryllium	< 0.30
admium	< 0.50
Calcium	98.7
Chromium	< 0.30
Cobalt	< 0.70
Copper	0.22
Iron	4.89
Lead	< 3.6
Lithium	< 5
Manganese	0.50
Magnesium	295.4
Mercury	0.23
Nickel	< 1.4
Potassium	3423
Selenium	< 6.4
Silver	< 0.30
Thallium	9.1
Vanadium	< 0.40
Zinc	11.3

SITE ID: B6-3506-1087
metaTRACE ID: AA04840
DATE SAMPLED: 10/20/87
MATRIX: FISH

PCB's	CONCENTRATION (UG/G)
Aroclor 1016	< 0.04
Aroclor 1221	< 0.06
Aroclor 1232	< 0.04
Aroclor 1242	< 0.05
Aroclor 1248	< 0.04
Aroclor 1254	< 0.04
Aroclor 1260	< 0.04

CLP METALS	CONCENTRATION (MG/KG)
Aluminum	3.27
Antimony	< 4.1
Arsenic	13.6
Barium	5.0
Beryllium	< 0.30
Cadmium	< 0.50
Calcium	366.2
Chromium	< 0.30
Cobalt	< 0.70
Copper	0.50
Iron	50.7
Lead	< 3.6
Lithium	< 5
Manganese	2.1
Magnesium	294.8
Mercury	0.24
Nickel	< 1.4
Potassium	2666
Selenium	< 6.4
Silver	< 0.30
Thallium	9.4
Vanadium	< 0.40
Zinc	9.44

metaTRACE, Inc. ■ 13715 Rider Trail North ■ Earth City, MO 63045 ■ (314) 298-8566

SITE ID: BG-3701-1087
metaTRACE ID: AA04832
DATE SAMPLED: 10/20/87
MATRIX: FISH

Radiochemical	ACTIVITY +/- ERROR (pCi/GRAM)
Uranium, Total EPA 908/ASTM	< 0.01

SITE ID: BG-3702-1087
metaTRACE ID: AA04833
DATE SAMPLED: 10/20/87
MATRIX: FISH

Radiochemical	ACTIVITY +/- ERROR (pCi/GRAM)
Uranium, Total EPA 908/ASTM	< 0.01

metaTRACE, Inc. ■ 13715 Rider Trail North ■ Earth City, MO 63045 ■ (314) 298-8566

SITE ID: BG-3703-1087
metaTRACE ID: AA04834
DATE SAMPLED: 10/20/87
MATRIX: FISH

Radiochemical	ACTIVITY +/- ERROR (pCi/GRAM)
Uranium, Total EPA 908/ASTM	< 0.02

SITE ID: BG-3502-1087
metaTRACE ID: AA04835
DATE SAMPLED: 10/20/87
MATRIX: FISH

Radiochemical	ACTIVITY +/- ERROR (pCi/GRAM)
Uranium, Total EPA 908/ASTM	< 0.02

metaTRACE, Inc. ■ 13715 Rider Trail North ■ Earth City, MO 63045 ■ (314) 298-8566

SITE ID: BG-3503-1087
metaTRACE ID: AA04836
DATE SAMPLED: 10/20/87
MATRIX: FISH

Radiochemical	ACTIVITY +/- ERROR (pCi/GRAM)
Uranium, Total EPA 908/ASTM	< 0.01

SITE ID: BG-3504-1087
metaTRACE ID: AA04837
DATE SAMPLED: 10/20/87
MATRIX: FISH

Radiochemical	ACTIVITY +/- ERROR (pCi/GRAM)
Uranium, Total EPA 908/ASTM	< 0.02

metaTRACE, Inc. ■ 13715 Rider Trail North ■ Earth City, MO 63045 ■ (314) 298-8566

SITE ID: BG-3505-1087
metaTRACE ID: AA04838
DATE SAMPLED: 10/20/87
MATRIX: FISH

Radiochemical	ACTIVITY +/- ERROR (pCi/GRAM)
Uranium, Total EPA 908/ASTM	< 0.02

WSSRAP ID	LAB ID	DATE SAM	DATE EXT	DATE ANA	METHOD	MATRIX	PARAMETER	CONC	ERR	UNITS	DL	CATEGORY	COMMENTS
36-3702-1087	AA04833	10/20/87	NA	1/21/88	EPA 00/07	FISH	Thorium 230	ND		pCi/G	0.2	RADIOCHEMICAL	WET WEIGHT
36-3702-1087	AA04833	10/20/87	NA	1/21/88	EPA 00/07	FISH	Thorium 232	ND		pCi/G	0.3	RADIOCHEMICAL	WET WEIGHT
36-3702-1087	AA04833	10/20/87	NA	1/21/88	EPA 903.0	FISH	Radium 226	ND		pCi/G	0.2	RADIOCHEMICAL	WET WEIGHT
36-3502-1087	AA04835	10/20/87	NA	1/21/88	EPA 00/07	FISH	Thorium 230	ND		pCi/G	0.3	RADIOCHEMICAL	WET WEIGHT
36-3502-1087	AA04835	10/20/87	NA	1/21/88	EPA 00/07	FISH	Thorium 232	ND		pCi/G	0.1	RADIOCHEMICAL	WET WEIGHT
36-3502-1087	AA04835	10/20/87	NA	1/21/88	EPA 903.0	FISH	Radium 226	ND		pCi/G	0.3	RADIOCHEMICAL	WET WEIGHT
36-SL05-1187	AA05368	11/10/87	NA	12/09/87	EPA 908.0	FISH	Total Uranium	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-SL09-1187	AA05369	11/10/87	NA	12/09/87	EPA 908.0	FISH	Total Uranium	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-SL09-1187	AA05369	11/10/87	NA	1/22/88	EPA 00/07	FISH	Thorium 230	ND		pCi/G	0.7	RADIOCHEMICAL	WET WEIGHT
36-SL09-1187	AA05369	11/10/87	NA	1/22/88	EPA 00/07	FISH	Thorium 232	ND		pCi/G	0.3	RADIOCHEMICAL	WET WEIGHT
36-SL09-1187	AA05369	11/10/87	NA	1/17/88	EPA 903.0	FISH	Radium 226	ND		pCi/G	0.2	RADIOCHEMICAL	WET WEIGHT
36-SL03-1187	AA05370	11/10/87	NA	12/09/87	EPA 908.0	FISH	Total Uranium	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-SL08-1187	AA05371	11/10/87	NA	12/09/87	EPA 908.0	FISH	Total Uranium	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-SL07-1187	AA05372	11/10/87	NA	12/09/87	EPA 908.0	FISH	Total Uranium	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-3405-1187	AA05373	11/10/87	NA	12/09/87	EPA 908.0	FISH	Total Uranium	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-3403-1187	AA05374	11/10/87	NA	12/09/87	EPA 908.0	FISH	Total Uranium	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-3401-1187	AA05375	11/10/87	NA	12/09/87	EPA 908.0	FISH	Total Uranium	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-3402-1187	AA05376	11/10/87	NA	12/09/87	EPA 908.0	FISH	Total Uranium	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-3402-1187	AA05376	11/10/87	NA	1/22/88	EPA 00/07	FISH	Thorium 230	ND		pCi/G	0.2	RADIOCHEMICAL	WET WEIGHT
36-3402-1187	AA05376	11/10/87	NA	1/22/88	EPA 00/07	FISH	Thorium 232	ND		pCi/G	0.05	RADIOCHEMICAL	WET WEIGHT
36-3402-1187	AA05376	11/10/87	NA	1/17/88	EPA 903.0	FISH	Radium 226	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-3603-1187	AA05377	11/10/87	NA	12/09/87	EPA 908.0	FISH	Total Uranium	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-3601-1187	AA05378	11/10/87	NA	12/09/87	EPA 908.0	FISH	Total Uranium	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-3602-1187	AA05379	11/10/87	NA	12/09/87	EPA 908.0	FISH	Total Uranium	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-3604-1187	AA05380	11/10/87	NA	12/09/87	EPA 908.0	FISH	Total Uranium	ND		pCi/G	0.01	RADIOCHEMICAL	WET WEIGHT
36-3604-1187	AA05380	11/10/87	NA	1/22/88	EPA 00/07	FISH	Thorium 230	ND		pCi/G	0.06	RADIOCHEMICAL	WET WEIGHT
36-3604-1187	AA05380	11/10/87	NA	1/22/88	EPA 00/07	FISH	Thorium 232	ND		pCi/G	0.02	RADIOCHEMICAL	WET WEIGHT
36-3604-1187	AA05380	11/10/87	NA	1/17/88	EPA 903.0	FISH	Radium 226	ND		pCi/G	0.003	RADIOCHEMICAL	WET WEIGHT
36-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Aluminum	ND		UG/G	20	METALS	WET WEIGHT
36-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Antimony	ND		UG/G	6	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Arsenic	ND		UG/G	1	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Barium	ND		UG/G	20	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Beryllium	ND		UG/G	0.5	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Cadmium	ND		UG/G	0.5	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Calcium	ND		UG/G	500	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Chromium	ND		UG/G	1	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Cobalt	ND		UG/G	5	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Copper	ND		UG/G	2.5	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Iron	11.7		UG/G	10	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Lead	4.2		UG/G	0.5	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Lithium	ND		UG/G	5	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Magnesium	ND		UG/G	500	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/22/88	EPA CLP	FISH	Manganese	ND		UG/G	1.5	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/23/88	EPA CLP	FISH	Mercury	0.16		UG/G	0.1	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/20/88	EPA CLP	FISH	Nickel	ND		UG/G	4	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/20/88	EPA CLP	FISH	Potassium	3530		UG/G	500	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/20/88	EPA CLP	FISH	Selenium	ND		UG/G	0.5	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/20/88	EPA CLP	FISH	Silver	ND		UG/G	1	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/20/88	EPA CLP	FISH	Sodium	510		UG/G	500	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/20/88	EPA CLP	FISH	Thallium	ND		UG/G	1	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/20/88	EPA CLP	FISH	Vanadium	ND		UG/G	5	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	1/20/88	EPA CLP	FISH	Zinc	9.5		UG/G	2	METALS	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1016	ND		UG/G	0.4	PESTICIDE /PCB'	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1221	ND		UG/G	0.6	PESTICIDE /PCB'	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1232	ND		UG/G	0.4	PESTICIDE /PCB'	WET WEIGHT
6-3606-1187	AA05381	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1242	ND		UG/G	0.5	PESTICIDE /PCB'	WET WEIGHT
-3606-1187	AA05381	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1248	ND		UG/G	0.4	PESTICIDE /PCB'	WET WEIGHT
-3606-1187	AA05381	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1254	ND		UG/G	0.4	PESTICIDE /PCB'	WET WEIGHT
-3606-1187	AA05381	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1260	ND		UG/G	0.4	PESTICIDE /PCB'	WET WEIGHT

metaTRACE, Inc. ■ 13715 Rider Trail North ■ Earth City, MO 63045 ■ (314) 298-8566

ES-09-03-16-22

WSSRAP ID	LAB ID	DATE SAM	DATE EXT	DATE ANA	METHOD	MATRIX	PARAMETER	CONC	ERR	UNITS	DL	CATEGORY	COMMENTS
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Aluminum	ND		UG/G	20	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Antimony	ND		UG/G	6	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Arsenic	ND		UG/G	1	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Barium	ND		UG/G	20	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Beryllium	ND		UG/G	0.5	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Cadmium	ND		UG/G	0.5	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Calcium	1050		UG/G	500	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Chromium	2.98		UG/G	1	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Cobalt	ND		UG/G	5	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Copper	ND		UG/G	2.5	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Iron	24.2		UG/G	10	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Lead	4.0		UG/G	0.5	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Lithium	ND		UG/G	5	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Magnesium	ND		UG/G	500	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Manganese	ND		UG/G	1.5	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	12/23/87	EPA CLP	FISH	Mercury	0.27		UG/G	0.1	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Nickel	ND		UG/G	4	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Potassium	3190		UG/G	500	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Selenium	ND		UG/G	0.5	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Silver	ND		UG/G	1	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Sodium	ND		UG/G	500	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Thallium	ND		UG/G	1	METALS	WET WEIGHT
3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Vanadium	ND		UG/G	5	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	1/22/88	EPA CLP	FISH	Zinc	12.3		UG/G	2	METALS	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1016	ND		UG/G	0.04	PESTICIDE /PCB'	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1221	ND		UG/G	0.06	PESTICIDE /PCB'	WET WEIGHT
-3406-1187	AA05382	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1232	ND		UG/G	0.04	PESTICIDE /PCB'	WET WEIGHT
3406-1187	AA05382	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1242	ND		UG/G	0.05	PESTICIDE /PCB'	WET WEIGHT
3406-1187	AA05382	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1248	ND		UG/G	0.04	PESTICIDE /PCB'	WET WEIGHT
3406-1187	AA05382	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1254	ND		UG/G	0.04	PESTICIDE /PCB'	WET WEIGHT
3406-1187	AA05382	11/10/87	NA	11/17/87	EPA CLP	FISH	Aroclor-1260	ND		UG/G	0.04	PESTICIDE /PCB'	WET WEIGHT
FP02-1187	AA06394	12/04/87	NA	01/19/88	EPA 00/07	FISH	Thorium 230	ND		pCi/G	0.2	RADIOCHEMICAL	WET WEIGHT
FP02-1187	AA06394	12/04/87	NA	01/19/88	EPA 00/07	FISH	Thorium 232	ND		pCi/G	0.07	RADIOCHEMICAL	WET WEIGHT
FP02-1187	AA06394	12/04/87	NA	01/20/88	EPA 903.0	FISH	Radium 226	ND		pCi/G	0.1	RADIOCHEMICAL	WET WEIGHT
FP02-1187	AA06394	12/04/87	NA	12/29/87	EPA 908	FISH	Total Uranium	ND		pCi/G	0.1	RADIOCHEMICAL	WET WEIGHT

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WSSRAP ID	LAB ID	DATE SAM	DATE EXT	DATE ANA	METHOD	MATRIX	PARAMETER	CONC	ERR	UNITS	DL	CATEGORY	COMMENTS
-FP21-1287	AA07683	01/06/88	NA	2/1/88	EPA 00/07	SQRL TISSUE	Thorium 230	ND		pCi/G	0.05	RADIOCHEMICAL	
-FP21-1287	AA07683	01/06/88	NA	2/1/88	EPA 00/07	SQRL TISSUE	Thorium 232	ND		pCi/G	0.01	RADIOCHEMICAL	
-FP21-1287	AA07683	01/06/88	NA	1/29/88	EPA 903.0	SQRL TISSUE	Radium 226	ND		pCi/G	0.01	RADIOCHEMICAL	
-FP21-1287	AA07683	01/06/88	NA	2/1/88	EPA 908.0	SQRL TISSUE	Total Uranium	ND		pCi/G	0.09	RADIOCHEMICAL	

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ES-19-03-K-03

WSSRAP ID	LAB ID	DATE SAM	DATE EXT	DATE ANA	METHOD	MATRIX	PARAMETER	CONC	ERR	UNITS	DL	CATEGORY	COMMENTS
G-FP21-1287 (B)	AA07685	01/06/88	NA	1/30/88	EPA 00/07	SORL BONE	Thorium 230	ND		pCi/G	0.07	RADIOCHEMICAL	
G-FP21-1287 (B)	AA07685	01/06/88	NA	1/30/88	EPA 00/07	SORL BONE	Thorium 232	ND		pCi/G	0.05	RADIOCHEMICAL	
G-FP21-1287 (B)	AA07685	01/06/88	NA	1/29/88	EPA 903.0	SORL BONE	Radium 226	ND		pCi/G	0.07	RADIOCHEMICAL	
G-FP21-1287 (B)	AA07685	01/06/88	NA	2/1/88	EPA 908.0	SORL BONE	Total Uranium	ND		pCi/G	0.03	RADIOCHEMICAL	

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WSSRAP ID	LAB ID	DATE SAM	DATE EXT	DATE ANA	METHOD	MATRIX	PARAMETER	CONC	ERR	UNITS	DL	CATEGORY	COMMENTS
-AP20-1287	AA07684	01/06/88	NA	1/30/88	EPA 00/07	RABBT TISSUE	Thorium 230	ND		pCi/G	0.03	RADIOCHEMICAL	
-AP20-1287	AA07684	01/06/88	NA	1/30/88	EPA 00/07	RABBT TISSUE	Thorium 232	ND		pCi/G	0.01	RADIOCHEMICAL	
-AP20-1287	AA07684	01/06/88	NA	1/29/88	EPA 903.0	RABBT TISSUE	Radium 226	ND		pCi/G	0.01	RADIOCHEMICAL	
-AP20-1287	AA07684	01/06/88	NA	2/1/88	EPA 908.0	RABBT TISSUE	Total Uranium	ND		pCi/G	0.02	RADIOCHEMICAL	

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WSSRAP ID	LAB ID	DATE SAM	DATE EXT	DATE ANA	METHOD	MATRIX	PARAMETER	CONC	ERR	UNITS	DL	CATEGORY	COMMENTS
-AP20-1287 (B)	AA07686	01/06/88	NA	2/1/88	EPA 00/07	RABBT BONE	Thorium 230	ND		pCi/G	0.1	RADIOCHEMICAL	
-AP20-1287 (B)	AA07686	01/06/88	NA	2/1/88	EPA 00/07	RABBT BONE	Thorium 232	ND		pCi/G	0.4	RADIOCHEMICAL	
-AP20-1287 (B)	AA07686	01/06/88	NA	1/29/88	EPA 903.0	RABBT BONE	Radium 226	ND		pCi/G	0.1	RADIOCHEMICAL	
-AP20-1287 (B)	AA07686	01/06/88	NA	2/1/88	EPA 908.0	RABBT BONE	Total Uranium	ND		pCi/G	0.3	RADIOCHEMICAL	

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ES-19-03-16-03

WSSRAP ID	LAB ID	DATE SAM	DATE EIT	DATE ANA	METHOD	MATRIX	PARAMETER	CONC	ERR	UNITS	DL	CATEGORY	COMM
S-CP20-021188	AA09901	03/02/88	NA	03/19/88	EPA 00/07	RABBT TISSUE	Thorium 230	ND		pCi/G	1	RADIOCHEMICAL	
S-CP20-021188	AA09901	03/02/88	NA	03/19/88	EPA 00/07	RABBT TISSUE	Thorium 232	ND		pCi/G	1	RADIOCHEMICAL	
S-CP20-021188	AA09901	03/02/88	NA	03/14/88	EPA 908.0	RABBT TISSUE	Total Uranium	ND		pCi/G	.04	RADIOCHEMICAL	
S-CP20-021188	AA09902	03/02/88	NA	03/30/88	EPA 00/07	RABBT BONE	Thorium 230	ND		pCi/G	1	RADIOCHEMICAL	
S-CP20-021188	AA09902	03/02/88	NA	03/14/88	EPA 00/07	RABBT BONE	Thorium 232	ND		pCi/G	1	RADIOCHEMICAL	
S-CP20-021188	AA09902	03/02/88	NA	03/14/88	EPA 908.0	RABBT BONE	Total Uranium	ND		pCi/G	.05	RADIOCHEMICAL	
S-IT20-021188	AA09903	03/02/88	NA	03/21/88	EPA 00/07	RABBT TISSUE	Thorium 230	ND		pCi/G	1	RADIOCHEMICAL	
S-IT20-021188	AA09903	03/02/88	NA	03/14/88	EPA 00/07	RABBT TISSUE	Thorium 232	ND		pCi/G	1	RADIOCHEMICAL	
S-IT20-021188	AA09903	03/02/88	NA	03/14/88	EPA 908.0	RABBT TISSUE	Total Uranium	ND		pCi/G	.04	RADIOCHEMICAL	
S-IT20-021188	AA09904	03/02/88	NA	03/21/88	EPA 00/07	RABBT BONE	Thorium 230	ND		pCi/G	1	RADIOCHEMICAL	
S-IT20-021188	AA09904	03/02/88	NA	03/14/88	EPA 00/07	RABBT BONE	Thorium 232	ND		pCi/G	1	RADIOCHEMICAL	
S-IT20-021188	AA09904	03/02/88	NA	03/14/88	EPA 908.0	RABBT BONE	Total Uranium	ND		pCi/G	.08	RADIOCHEMICAL	

CHEMICAL PLANT
202-1.03

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

December 4, 1990

Addressees:

AQUIFER CHARACTERISTICS DATA REPORT

This Aquifer Characteristics Data Report (ACDR) presents the results of investigations designed to physically characterize the hydrogeologic regime of the uppermost bedrock formation beneath the Weldon Spring Site chemical plant, raffinate pits, and vicinity properties (WSCP/RP/VP). Specifically, this report presents the results of slug tests and pumping and tracer testing. Slug tests and pumping tests were conducted as elements of hydrogeologic investigations sampling (MKF and JEG 1988b). Tracer tests were performed to complement physical aquifer characterization with respect to effective porosity and dispersivity.

The ACDR constitutes a portion of the Weldon Spring Site Remedial Action Project (WSSRAP) characterization program designed to support the Remedial Investigation/Feasibility Study (RI/FS) under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

If you have any questions please call Ken Lawver at (314)441-8978.

Sincerely,

Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

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As stated

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CONTRACT NO. DE-AC05-86OR21548

AQUIFER CHARACTERISTICS DATA REPORT FOR THE WELDON SPRING SITE CHEMICAL PLANT/RAFFINATE PITS AND VICINITY PROPERTIES

For the
Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

Prepared by MK-Ferguson Company and Jacobs Engineering Group

NOVEMBER 1990 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

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Weldon Spring Site Remedial Action Project

Aquifer Characteristics Data Report for The Weldon Spring Site Chemical Plant/Raffinate Pits and Vicinity Properties

November 1990

Revision 0

Prepared by

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St. Charles, Missouri 63303

Prepared for

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

aquifer/jdn/jof

ABSTRACT

This report describes the procedures and methods used, and presents the results of physical testing performed, to characterize the hydraulic properties of the shallow Mississippian-Devonian aquifer beneath the Weldon Spring chemical plant, raffinate pits, and vicinity properties. The aquifer of concern is composed of saturated rocks of the Burlington-Keokuk Limestone which constitutes the upper portion of the Mississippian-Devonian aquifer. This aquifer is a heterogeneous anisotropic medium which can be described in terms of diffuse Darcian flow overlain by high porosity discrete flow zones and conduits. Average hydraulic conductivity for all wells tested is 9.6E-02 meters/day (3.1E-01 feet/day). High hydraulic conductivity values are representative of discrete flow in the fractured and weathered zones in the upper Burlington-Keokuk Limestone. They indicate heterogeneities within the Mississippian-Devonian aquifer. Aquifer heterogeneity in the horizontal plane is believed to be randomly distributed and is a function of fracture spacing, solution voids, and preglacial weathering phenomena. Relatively high hydraulic conductivities in deeper portions of the aquifer are thought to be due to the presence of widely spaced fractures.

Pumping tests conducted in the upper 12 meters (39 feet) of saturated bedrock provided values for transmissivity which ranged from 0.19 to 0.49 meters^2/day (15.5 to 39.9 gallons per day/foot). The average storativity determined from pumping tests is 4.9E-04. Results of pumping tests indicate a primary lateral anisotropy and poor hydraulic communication between pumped intervals and deeper portions of the Burlington-Keokuk Limestone. This suggests that appreciable upward leakage is unlikely from deeper portions of the aquifer to the test interval. Limited evidence of delayed yield may indicate double porosity effects.

Groundwater velocities average 1.1E-01 meters/day (3.6E-01 feet/day). Calculated groundwater velocities and travel times are consistent with observed contaminant distribution, although actual flowpaths are expected to exhibit nonlinear aspects resulting in significant variations in velocity.

Pumping and tracer tests did not intercept free flow zones, or conduits capable of supplying sustained pumpage in excess of 1.5 liters/minute (0.4 gallons/minute). However, slug testing indicates the existence of randomly distributed high porosity zones in the upper saturated portion of the formation. Additional pumping tests in these locations would provide information on discrete flow properties.

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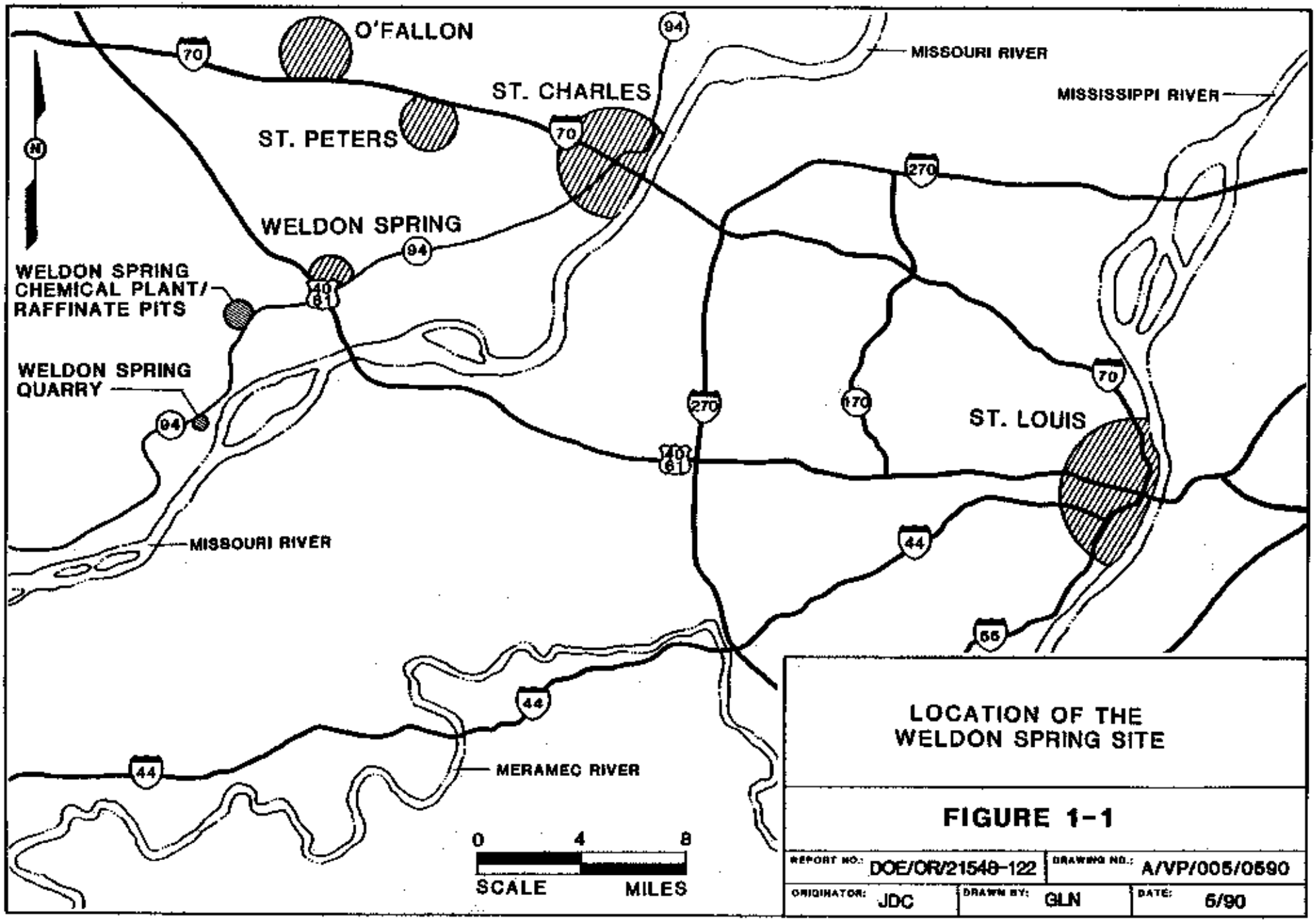
1 INTRODUCTION

This Aquifer Characteristics Data Report (ACDR) presents the results of investigations designed to physically characterize the hydrogeologic regime of the uppermost bedrock formation beneath the Weldon Spring Site chemical plant, raffinate pits, and vicinity properties (WSCP/RP/VP). Specifically, this report presents the results of slug tests and pumping and tracer testing. Slug tests and pumping tests were conducted as elements of hydrogeologic investigations sampling (MKF and JEG 1988b). Tracer tests were performed to complement physical aquifer characterization with respect to effective porosity and dispersivity.

The ACDR constitutes a portion of the Weldon Spring Site Remedial Action Project (WSSRAP) characterization program designed to support the Remedial Investigation/Feasibility Study (RI/FS) under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

1.1 Site Description

The chemical plant and raffinate pits are is located in St. Charles County, Missouri, approximately 48 km (30 mi) west of St. Louis and 23 km (14 mi) southwest of St. Charles as shown in Figure 1-1. The site is situated on Missouri State Highway 94 about 3 km (2 mi) southwest of the junction of Highway 94 with U.S. Routes 40 and 61. The site is surrounded by State and Federally owned lands. It is adjoined on the west by the Weldon Spring Training Area (WSTA) and on the east, north, and south by Missouri Department of Conservation (MDOC) lands.



LOCATION OF THE WELDON SPRING SITE

FIGURE 1-1

REPORT NO.: DOE/OR/21548-122	DRAWING NO.: A/VP/005/0590	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 5/90

The community of Weldon Spring, with a population of approximately 700, is located approximately 3 km (2 mi) north of the Weldon Spring site (WSS). The metropolitan area of St. Louis, with a population exceeding 2.5 million, is within 48 km (30 mi) of the site.

1.2 Site History

The site history, including previous decontamination efforts from 1941 to 1987, is summarized below. A more detailed history of WSS operations is included in the WSSRAP Remedial Investigation/Feasibility Study Work Plan (ORNL 1988).

The land encompassing the WSS was privately held until April 1941 when the Department of the Army (DA) acquired 6,974 ha (17,232 ac) of land. From November 1941 through January 1944, Atlas Powder Company operated a trinitrotoluene (TNT) and dinitrotoluene (DNT) explosives production facility known as the Weldon Spring Ordnance Works (WSOW). After another production operation during 1945 and 1946 the WSOW was closed in April 1946 and declared surplus to Army needs. By 1949, all but approximately 809 ha (2,000 ac) had been transferred back to the State of Missouri (August A. Busch Memorial Wildlife Area) and the University of Missouri (agricultural land). Except for several small parcels of land transferred to St. Charles County, the remaining property became the WSTA.

Through a Memorandum of Understanding between the Secretary of the Army and the Atomic Energy Commission (AEC) in May 1955, 83 ha (205 ac) of the former WSOW were transferred to the AEC for the construction and operation of the Weldon Spring Uranium Feed Materials Plant (WSUFMP) to process uranium and thorium ore

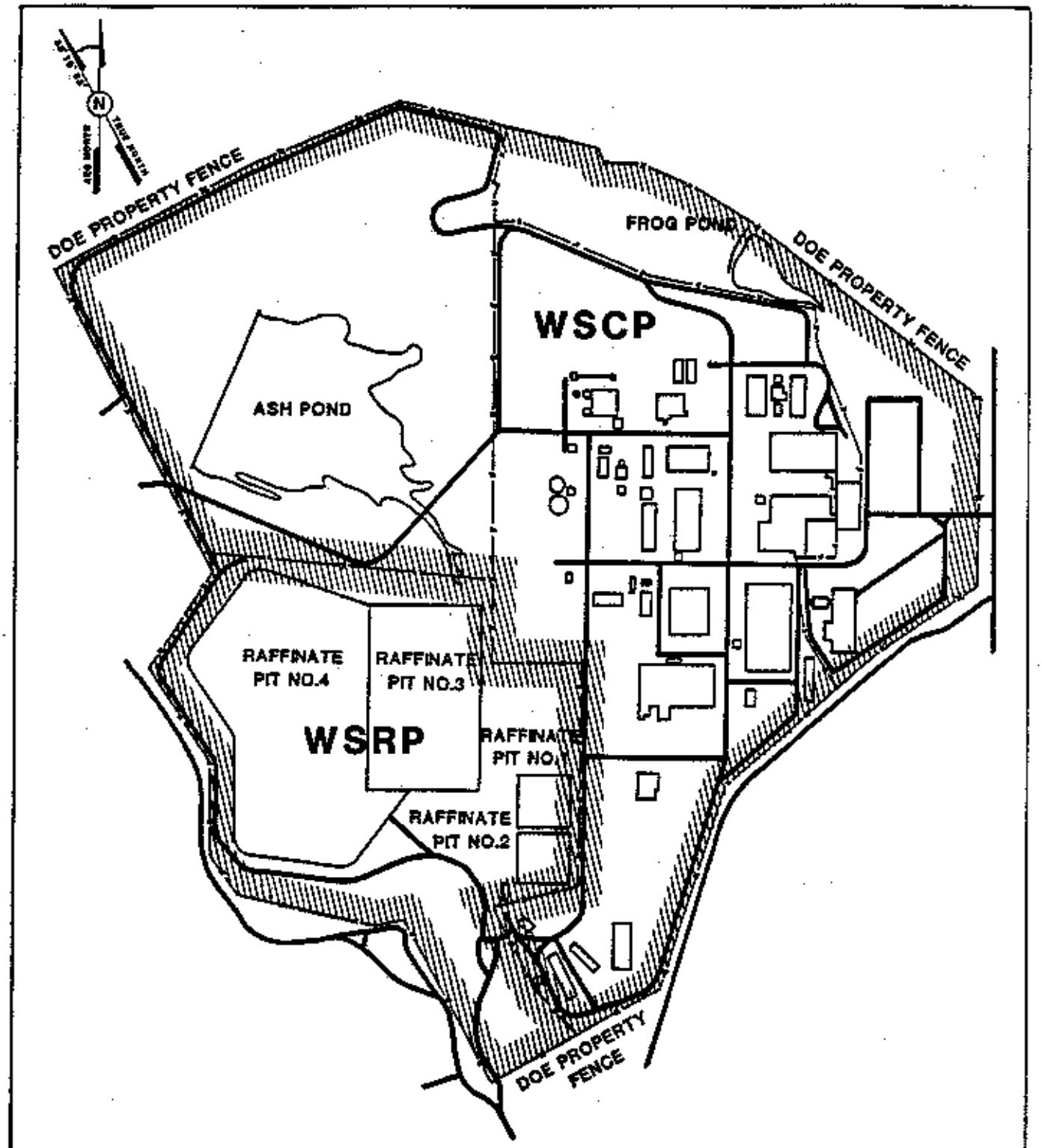
concentrates. The DA decontaminated a considerable portion of the WSOW before construction of the WSUFMP commenced (DA 1976).

The WSUFMP processed uranium and thorium ore concentrates from 1957 to 1966 with the Uranium Division of Mallinckrodt Chemical Works acting as the AEC operating contractor. This facility consisted of 13 major process buildings and approximately 30 support structures. The AEC closed the WSUFMP in December 1966.

On August 7, 1967, approximately 67 ha (166 ac) of the AEC facility were selected as the site for a herbicide production facility, later known as the Weldon Spring chemical plant (WSCP). The remaining 21-ha (51-ac) area, encompassing four process waste lagoons called the Weldon Spring raffinate pits (WSRP), remained under AEC control. Figure 1-2 is a site plan of the WSCP and WSRP. On December 31, 1967, 67 ha (166 ac) of property and improvements were transferred to the Kansas City District, U.S. Army Corps of Engineers, which was responsible for the design and construction of the herbicide facility.

Decontamination and dismantling operations were initiated in January 1968. Some progress was made in the decontamination of areas required for herbicide production equipment before the project was cancelled in February 1969. This cancellation was due in part to costs required to comply with the radiological contamination limits imposed on the facility and in part to a reduction of the DA's requirements for herbicide.

The herbicide project was cancelled before any production equipment was installed. However, the DA retained responsibility for the land and facilities at the WSCP.



MAP OF THE WSCP & WSRP

FIGURE 1-2

REPORT NO.: DOE/OR/21548-122	DRAWING NO.: A/CP/003/0590	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 5/90

The AEC contracted with National Lead Company of Ohio (NLO) to visit the WSRP periodically for environmental monitoring and to maintain the pit embankments and perform maintenance and surveillance tasks as necessary. Bechtel National, Inc. (BNI) assumed management responsibility for the WSRP from NLO in October 1981 under contract to the U.S. Department of Energy (DOE) which succeeded the AEC.

In November 1984, the U.S. Department of Energy (DOE) was directed by the Office of Management and Budget to assume custody and accountability for the WSCP from the DA. This transfer occurred on October 1, 1985.

In February 1985, the DOE proposed designating control and decontamination of the WSS as a major project. Designation was effected by DOE Order 4240.1E dated May 14, 1985. A Project Management Contractor (PMC) for the WSSRAP was selected in February 1986. In July 1986, a DOE Project Office was established on site. The PMC, MK-Ferguson Company, assumed control of the WSS on October 1, 1986.

2 GEOLOGIC SETTING

This section presents background information on the regional and local geology based on information available from published reports, results of previous investigations, and data derived from Project Management Contractor (PMC) investigations.

2.1 Regional Physiography and Geology

The site lies at the southern edge of the dissected till plains of the Central Lowlands Physiographic Province, which is characterized by gently rolling hills in upland areas (ORNL 1988). South of the site, the topography changes dramatically as the dissected till plains give way to narrow ridges and valleys which characterize the Ozark Plateau Physiographic Province. The surface drainage divide between the Mississippi River to the north and the Missouri River to the south bisects the site from southwest to northeast.

The stratigraphy in the Weldon Spring area is composed of approximately 610 to 915 m (2,000 to 3,000 ft) of Paleozoic Era marine limestone, dolomite, sandstone, and shale. A detailed description of regional stratigraphy is given by BNI (1987) and MKF and JEG (1989b). The bedrock in the Weldon Spring area exhibits a regional strike of N601°W and a regional dip of approximately 1° to the northeast. Due to vertical crustal movements during the Paleozoic Era, rocks of the Central Stable Region, of which Missouri is a part, were deformed into broad basins and arches (Eardley 1951). The closest of these features, the northwest trending House Springs-Eureka anticline, is located about 6 km (4 mi) southwest of the site. The rocks on the northeast limb of the fold strike approximately N60°W and dip approximately 0.5° to 1° to the northeast.

Geologic mapping of the Weldon Spring 7.5-minute quadrangle by the Missouri Department of Natural Resources Division of Geology and Land Survey (MDNR-DGLS) shows an east-west trending normal fault located approximately 1.6 km (1 mile) north of the site. The fault is reported to display approximately 18 m (60 ft) of vertical displacement with the north block down (Whitfield et al. 1989).

2.2 Geology of the Weldon Spring Chemical Plant, Raffinate Pits, and Vicinity Properties

The Weldon Spring Chemical Plant/Raffinate Pits/Vicinity Properties (WSCP/RP/VP) extend over several distinct geologic units that are pertinent to this study. There are several distinguishable overburden units and two units in the uppermost bedrock. The following subsections describe the principal geologic units based on information contained in the Geologic Report on Weldon Spring Raffinate Pits Site (BNI 1984), Hydrogeological Characterization Report for Weldon Spring Chemical Plant (BNI 1987), and the Draft Remedial Investigation Report (MK-F and JEG 1989b).

2.2.1 Geology of Unconsolidated Material

Unconsolidated surficial materials at the site are composed of fill material, loess, interglacial sediment, glacial tills, and residuum. The thickness of the surficial units ranges from 5 to 18 m (15 to 60 ft) and is controlled both by surface erosional features and bedrock topography. The unconsolidated units are generally thickest in the north central portion and thinnest in the eastern third of the site. The unconsolidated materials have been divided into six distinguishable units based on physical

characteristics observed during sampling and laboratory testing (MK-F and JEG 1989b).

2.2.1.1 Topsoil/Fill

The uppermost soil unit is composed of topsoil or fill material. This unit ranges up to 9 m (30 ft) in thickness. The topsoil fraction is widespread on site and ranges up to 1 m (3.5 ft) in thickness. It is generally a black, organically rich clayey-silt to silty-clay. The fill portion of the unit varies greatly in thickness because of its use as construction material for the raffinate pit dikes and Ash Pond dike, and recontouring of low areas prior to construction of buildings. The fill composition varies but is primarily clayey silt which is believed to have originated on or near the site.

2.2.1.2 Loess

Underlying the topsoil/fill unit is an upper Pleistocene loess unit that is distributed sporadically on the site due to pre-depositional topography, post-depositional erosion, and extensive reworking of site soils during site preparation and construction. Subsurface data indicate that the loess ranges up to 3 m (10 ft) in thickness. The unit is a low plasticity silt to clayey silt with very minor amounts of sand.

2.2.1.3 Ferrelview Formation

A mid-Pleistocene interglacial sediment interpreted as being the Ferrelview Formation underlies the loess and is present across most of the site. The Ferrelview is described in detail by Howe and Heim (1968). The unit ranges up to 6.5 m (22 ft) in thickness and consists of a mottled gray and dark yellowish-

orange silty-clay to clayey-silt. The unit is generally stiff and plastic. Iron oxide nodules and manganese oxide (pyrolusite) precipitates are common. The unit commonly displays slickensides as a result of post-depositional compaction and consolidation. Also, irregular blocky fractures are sometimes encountered which continue through the underlying clay till. Blocky fractures are described as tight dry features which are often coated with calcium or manganese minerals of a powdery or concretionary nature. Laboratory tests for particle size distribution indicate mostly silt- and clay-sized particles in this unit with minor sand and fine gravel (MK-F and JEG 1989b).

2.2.1.4 Clay Till

The clay till unit is a lower Pleistocene glacial till which underlies the Ferrelview Formation and is the most areally extensive overburden unit on the site. The clay till ranges in thickness to 9 m (30 ft) and is found in almost all boreholes and trenches on site. This unit is composed of yellowish-brown silty-clay and clayey-silt with some sand and rounded pebbles of chert and igneous and metamorphic detritus. Material in this unit is very stiff and moderately to highly plastic. Blocky fractures coated with pyrolusite are abundant.

2.2.1.5 Basal Till

The basal till unit is the lowest member of the Pleistocene glacial till sediments found on the site. It underlies the clay till and is found mainly on the western and north central portions of the site. Deposition of the basal till unit may have been influenced by bedrock topography since the unit is generally thin or absent in areas of higher bedrock elevations, and is thicker where bedrock elevations are lower. The basal till

ranges in thickness up to 3 m (10 ft) and can generally be described as a yellowish-brown sandy, clayey, silty-gravel with angular chert in a poorly bound matrix.

2.2.1.6 Residuum

The residuum unit is located beneath the basal till and clay till unit where the basal till is absent. The residuum forms the base of the unconsolidated material and is interpreted to be a pre-Pleistocene weathering product of the underlying cherty argillaceous limestone. The unit varies in thickness up to 8 m (26 ft) and is highly heterogeneous, ranging from a typically gravel dominated matrix to a gravelly-clay to gravelly-silt. The gravel fraction is generally weathered chert fragments but also consists of minor weathered limestone. Sample recovery in this unit is very difficult due to the large gravel fraction. As such, the unit is hard to characterize without using in situ methods.

2.2.2 Bedrock Geology

The uppermost bedrock unit at the Weldon Spring site (WSS) is the Burlington- Keokuk Limestone. This is a fine- to coarse-grained, thinly to massively bedded argillaceous to crystalline limestone containing abundant chert as nodules and beds. From borehole stratigraphic data, the formation has been divided into two units based primarily on weathering characteristics. The upper division is referred to as the weathered limestone portion, and the lower division is referred to as the competent limestone.

Roberts (1951) reported two major joint sets present within the exposed bedrock in the Weldon Spring area; one set trends between N30°W and N65°W and the other set trends N30°E to N72°E.

Subsequent regional and site-specific joint studies have generally confirmed these orientations (BGA 1984, MK-F and JEG 1987 and 1988b). Bedrock topography exhibits erosional features interpreted as paleochannels, which coincide with observed joint set orientations (MKF and JEG 1989b). Additionally, present-day drainages within the Missouri River watershed are incised into bedrock and exhibit strong linearity coincident with joint set trends. Drainage trends within the Mississippi River watershed are more sinuous than those in the Missouri River watershed and do not exhibit linearity due to the presence of overlying, unconsolidated sediments.

2.2.2.1 Weathered Limestone

The weathered limestone ranges in thickness from 3 to greater than 15 m (10 to greater than 50 ft), and is typically a grayish-orange to yellowish gray, argillaceous limestone, commonly containing as much as 60% chert as nodules and interbeds. Minor interbeds of fossiliferous, finely crystalline limestone occur near the top of the unit in some cores. The unit is moderately to highly fractured, slightly to severely weathered, with abundant iron oxide staining and manganese oxide in the rock matrix and along fractures. Solution features are quite common in this unit, ranging from pinpoint vugs to small cavities up to 1.5 m (5 ft) in diameter (BNI 1987). Many of the smaller vugs are lined with calcite and drusy to euhedral quartz. The larger cavities in many cases appear to be at least partially filled with clay or silt/clay/chert/gravel mixtures. These cavities are generally reported as core loss in the boring logs. In some locations, recognition of top of bedrock was hindered due to alternating rock and clay-rich zones at or near the bedrock surface. Rock quality designations (RQD) are generally poor to very poor indicating a high degree of fracturing and/or

weathering. Core samples from angled boreholes indicate that fracturing in the weathered limestone is predominantly horizontal and loosely spaced, typically occurring along shaley interbeds, bedding planes, or chert interbeds (MK-F and JEG 1990b). Mineralization and clay deposition along fractures is common.

2.2.2.2 Competent Limestone

Underlying the weathered portion of the Burlington-Keokuk Limestone is the competent limestone, which is thinly to massively bedded, gray to light gray, finely to coarsely crystalline, stylolitic, and fossiliferous. The rock is slightly weathered to fresh, containing 20% to 40% chert. Cored material shows very little iron oxide staining and exhibits unaltered pyrite on some fracture surfaces. Both horizontal and vertical fracture densities are significantly lower in the competent limestone than in the weathered limestone (MK-F and JEG 1990b).

3 HYDROGEOLOGIC SETTING

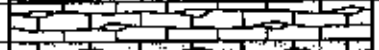
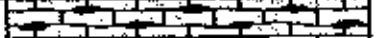
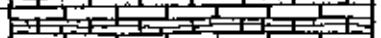
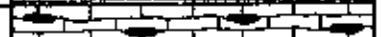
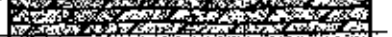
This section presents background information on regional and local hydrogeology based on information available from published reports, results of previous investigations, and Project Management Contractor (PMC) derived data.

3.1 REGIONAL HYDROGEOLOGY

Three principal aquifer systems have been identified in the Weldon Spring area. These are the alluvial aquifers, the shallow bedrock aquifer system, and the deep bedrock aquifer system. Additionally, a leaky confining unit is recognized (Kleeschulte and Emmett 1987).

The major alluvial aquifers in western St. Charles County consist of saturated sands, gravels, and silts which compose the alluvium of the Missouri River and Mississippi River floodplains (Kleeschulte and Emmett 1986). Yields to wells from these aquifers range up to 9,800 lpm (2,600 gpm) along the major rivers (BNI 1987). Recharge to the alluvial aquifers occurs from infiltration of precipitation, increases in bank storage due to flooding, and as underflow in the form of regional discharge from bedrock aquifers. Fluvial recharge may also be induced in some locations due to pumping of large-capacity wells near the Missouri River (Kleeschulte and Emmett 1986).

The shallow bedrock aquifer system is composed of saturated Mississippian and Devonian aged rocks which range from 76 to 197 m (250 to 650 ft) in thickness and compose the uppermost bedrock units in the area. These units correspond to the Mississippian-Devonian aquifer system as depicted in Figure 3-1.

SYSTEM	SERIES	STRATIGRAPHIC UNIT	TYPICAL THICKNESS (ft)	LITHOLOGY	HYDROSTRATIGRAPHIC UNIT
QUARTERNARY	HOLOCENE	ALLUVIUM	0.5-4		ALLUVIAL AQUIFER
	PLEISTOCENE	LOESS, GLACIAL TILL, INTERGLACIAL SEDIMENT AND RESIDUUM	15-55		(unsaturated) *
MISSISSIPPIAN	MERAMECIAN	SALEM FORMATION	0-15		(unsaturated) *
		WARSAW FORMATION	60-80		
	OSAGEAN	BURLINGTON-KEOKUK LIMESTONE	100-200		MISSISSIPPIAN-DEVONIAN AQUIFER SYSTEM
		FERN GLEN FORMATION	45-70		
	KINDERHOOKIAN	CHOUTEAU GROUP	20-50		
		BUSHBERG SANDSTONE	5-20		
DEVONIAN	UPPER	LOWER SULPHUR SPRINGS GROUP (UNDIF)	0-2		ORDOVICIAN LEAKY CONFINING UNIT
ORDOVICIAN	CINCINNATIAN	MAQUOKETA SHALE	10-30		
	CHAMPLAINIAN	KIMMSWICK LIMESTONE	70-100		
		DECORAH GROUP	30-60		
		PLATTIN LIMESTONE	100-130		
		JOACHIM DOLOMITE	80-105		
		ST. PETER SANDSTONE	120-150		ORDOVICIAN-CAMBRIAN AQUIFER SYSTEM
	CANADIAN	POWELL DOLOMITE	60-80		
		COTTER DOLOMITE	200-250		
		JEFFERSON CITY DOLOMITE	160-180		
		ROUBIDOUX FORMATION	150-170		
		GASCONADE DOLOMITE	250		
CAMBRIAN	UPPER	EMINENCE DOLOMITE	200		
		POTOSI DOLOMITE	100		

* THESE UNITS ARE BELIEVED TO BE UNSATURATED IN THE WSS VICINITY

MODIFIED FROM : MKF & JEG, 1989; WHITFIELD ET. AL. 1988; KLEESHULTE AND EMMETT, 1987

GENERAL STRATIGRAPHY AND HYDROSTRATIGRAPHY OF THE WELDON SPRING AREA

FIGURE 3-1

REPORT NO: DOE/OR/21548-122	EXHIBIT NO.: A/PI/075/1190		
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 11/90	

In the Weldon Spring area the Mississippian-Devonian aquifer system includes formations from the Burlington-Keokuk Limestone through the lower part of the Sulphur Springs Group. Reported yields to wells from this aquifer range from less than 4 lpm to 190 lpm (1 gpm to 50 gpm) (BNI 1987), but typically are from 19 lpm to 55 lpm (5 to 15 gpm). The higher yield wells are those that intercept zones of extensive secondary porosity such as joints and solution openings. The Mississippian-Devonian aquifer system is recharged by direct infiltration of precipitation along fractures and bedding planes in outcrop areas, unsaturated flow through unconsolidated overburden, and losing stretches of streams encounter bedrock joints. Discharge occurs as springs, seeps, evapotranspiration, underflow to the deeper portions of the bedrock under downward hydraulic gradient conditions, and as water supply wells are pumped (Kleeschulte and Emmett 1986).

Examination of potentiometric data from the Weldon Spring area by Kleeschulte and Emmett (1987) indicates that a groundwater divide runs beneath the trend of the ridge which divides surface water drainage between the Missouri and Mississippi watersheds.

A leaky confining layer is present below the Mississippian-Devonian aquifer from the top of the Maquoketa Shale down through the Joachim Dolomite. These units correspond to the Ordovician leaky confining unit as depicted in Figure 3-1. Individual units or zones within the leaky confining layer may yield low to moderate amounts, 40 to 190 lpm (10 to 50 gpm), of potable water on a local basis. The confining sequence is approximately 121 m (400 ft) thick (Kleeschulte and Emmett 1986).

The Ordovician-Cambrian aquifer system is approximately 305 m (1,000 ft) thick and consists of Ordovician and Upper Cambrian formations, which include the St. Peter Sandstone through the Potosi Dolomite (Kleeschulte and Emmett 1987). These units correspond to the Ordovician-Cambrian aquifer system as depicted in Figure 3-1. Yields from this aquifer range from 40 to 1900 lpm (10 to 500 gpm) (BNI 1987). Recharge to the Ordovician-Cambrian aquifer occurs primarily as direct infiltration of precipitation where the Ordovician units outcrop southwest of the Weldon Spring area. Additionally, recharge occurs where losing stretches of streams penetrate the aquifer near the outcrop area, and as underflow from superjacent aquifers under conditions of downward hydraulic gradient. Discharge from the Ordovician-Cambrian aquifer occurs principally as underflow to the alluvial and Mississippian-Devonian aquifers under upward hydraulic gradient conditions, and as evapotranspiration and seepage to springs and streams where the aquifer crops out.

3.2 Hydrogeology of the Weldon Spring Chemical Plant/Raffinate Pits/Vicinity Properties

The following subsections provide background information about the hydrogeologic regime at the Weldon Spring site (WSS) based on information available from previous investigations.

3.2.1 Surface Water/Groundwater Interaction

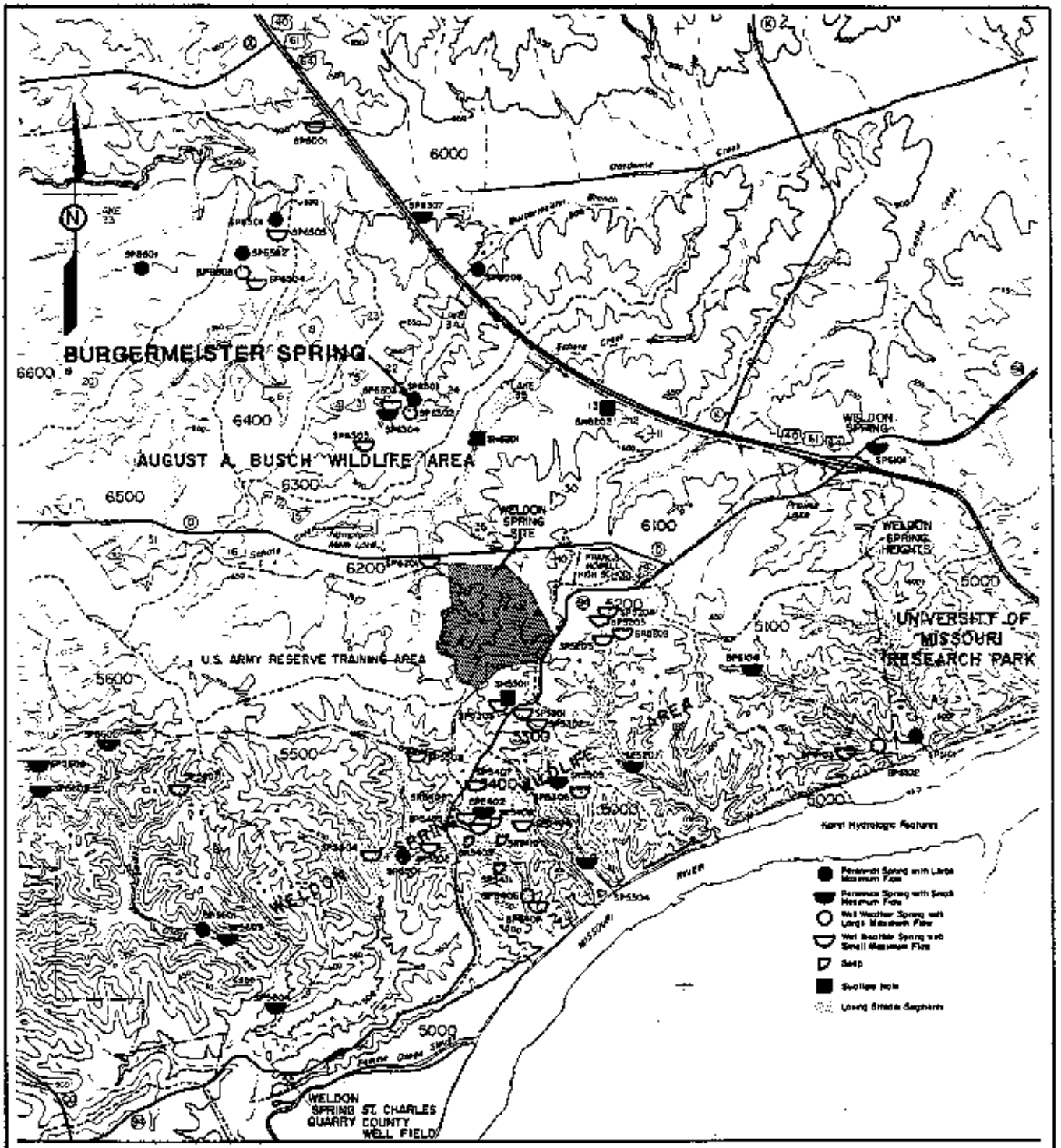
Spring and seep surveys, seepage runs, and dye trace and water trace studies have been conducted in the area around the WSS by the Missouri Department of Natural Resources (MDNR) and U.S. Geological Survey (USGS).

The locations of known springs and seeps within various tributary drainage basins are shown on Figure 3-2. Springs in the vicinity of the site vary from small seeps at bedrock and clay interfaces to solution enlarged bedrock conduits and fractures having flow rates of 750 lpm (200 gpm) or more during precipitation events. Some of the springs are wet weather springs, flowing only in response to significant rainfall events. Wet weather flow may be quite heavy, but is usually of short duration (MKF and JEG 1988b).

Several tributaries around the WSS have losing segments which have been identified by the MDNR (Dean 1983, 1984a, 1984b, and 1985) and the USGS (Kleeschulte and Emmett 1986; Kleeschulte et al. 1986). The results of dye trace studies conducted by the MDNR in the 6000-series drainages (Mississippi River Basin) indicate a probable subsurface connection between the unnamed tributary of Schote Creek that drains Ash Pond and the raffinate pit areas and the Burgermeister Spring area. Results of dye trace studies conducted by the MDNR in the 5000-series drainages (Missouri River Basin) indicate that a groundwater divide exists north of the area, and water lost to the streambed in the southeast drainage easement stays within the drainage boundary. Furthermore, at least some of the flow lost in the upper reaches of the southeast drainage easement re-emerges through springs in the lower reaches (MDNR 1989).

3.2.2 Unconsolidated Materials

The unconsolidated materials at the site are, for the most part, unsaturated. Unsaturated flow is present locally as a result of direct infiltration, leakage from on-site storm water, sewer and water lines, and leakage from the raffinate pits. Saturated conditions also exist due to mounded and perched



MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY
P.O. Box 250, Rolla, MO 65401

SPRINGS AND SEEPS IN THE WELDON SPRING AREA

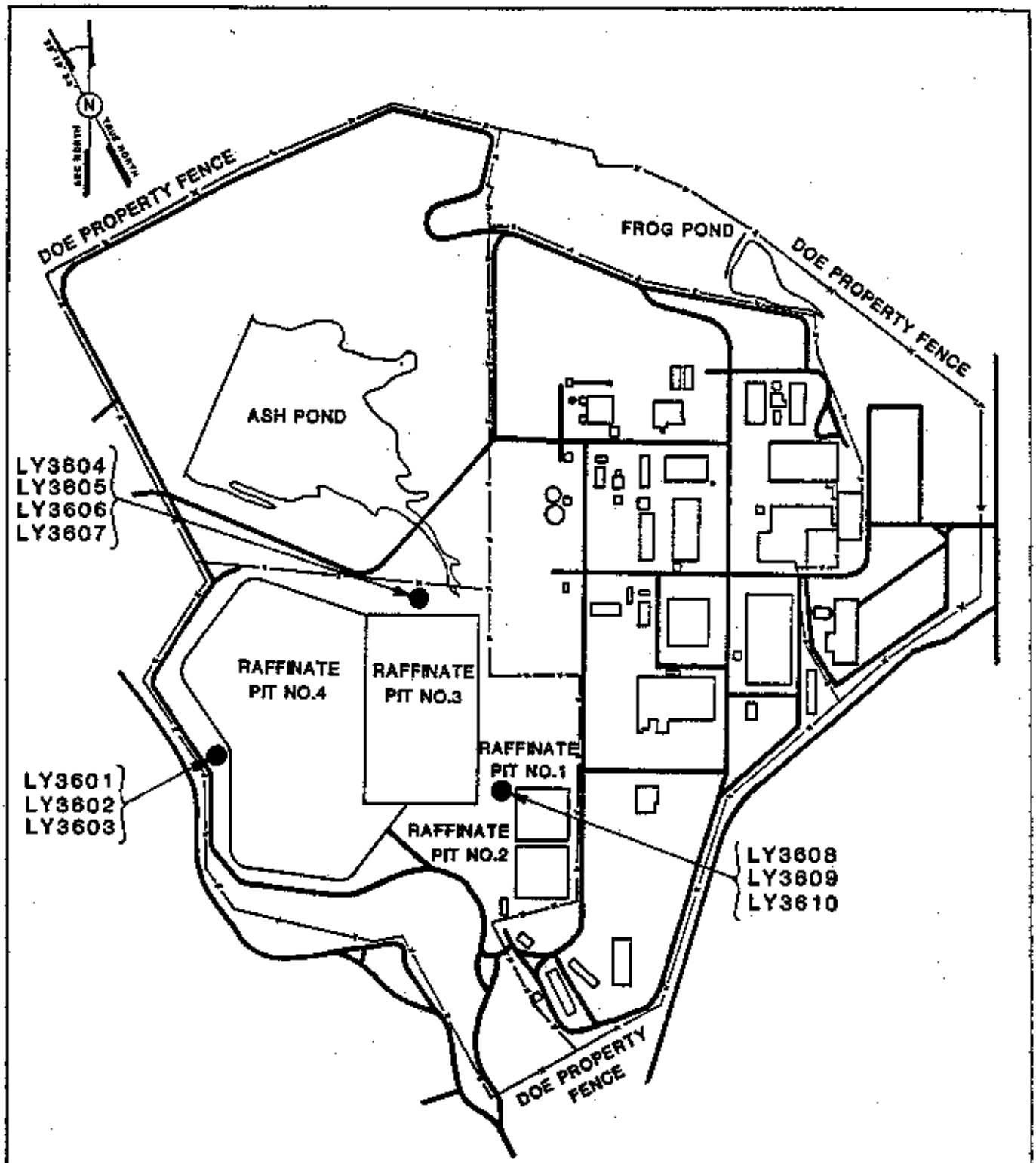
FIGURE 3-2

REPORT NO. DOE/OR/21548-122	EXHIBIT NO.: A/VP/053/1190	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 11/90

groundwater. Mounded conditions are apparent beneath the raffinate pits due to leakage. Perched conditions occur where leakage or infiltration accumulates over low permeability clay-rich horizons and in discrete permeable lenses.

Hydraulic conductivities and moisture content values of unconsolidated materials as determined by laboratory methods are presented in the site Remedial Investigation (RI) report (MKF and JEG 1989b). The saturated hydraulic conductivity values are generally quite low. Slug tests were performed by the PMC in March 1987 on wells that monitor seasonally saturated portions of the clay till unit in the vicinity of the raffinate pits. The results of these tests indicate an average saturated hydraulic conductivity of 1.0E-05 m/d (3.4E-05 ft/d) for the clay till unit (Allan 1987). This value agrees well with laboratory test results presented in the site RI report (MKF and JEG 1989b).

Ten lysimeters are currently in place at three locations around the perimeter of the raffinate pits. The locations of the lysimeters are indicated in Figure 3-3. Lysimeters LY-3604, LY-3605, LY-3606, and LY-3607, located north of Raffinate Pit 3, monitor silty zones over clay layers. Soil moisture from this location is considered to be leakage from Raffinate Pit 3 due to the elevated concentrations of nitrate, sulfate, and total uranium detected in samples from that location. Lysimeters LY-3608, LY-3609, and LY-3610 are located near the northwest corner of Raffinate Pit 1. Lysimeter LY-3609 and LY-3610 have not detected any moisture since installation, although they maintain a vacuum. A sample taken from LY-3608 indicates that near surface moisture (1.7 m (6 ft) below ground surface) is leakage from Raffinate Pit 1 due to the high concentration of nitrate. Lysimeters LY-3601, LY-3602, and LY-3603 are located at the base of the west berm of Raffinate Pit 4 near a small seep. Analysis



SCALE 0 500 1000 FT
0 152.4 304.8 M

LOCATIONS OF LYSIMETERS AT THE WELDON SPRING SITE

FIGURE 3-3

REPORT NO: DOE/OR/21548-122	DRAWING NO.: A/CP/096/1190	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 11/90

of the seep water and soil moisture suggest that this seep is a local discharge for infiltration which is captured by the riprap on the west flank of the west berm of Raffinate Pit 4.

Previous exploratory drilling investigations at the WSS indicated areas of anomalously high groundwater elevations or perched groundwater in the vicinity of the raffinate pits (BGA 1984; BNI 1984; and UNC Geotech 1988). Details regarding monitoring efforts designed to characterize saturated conditions in the surficial soils are given in the site RI report.

Seismic refraction surveys performed by Weston Geophysical Corporation (BNI 1984) detected velocity zones of 1,515 m/s (5,000 ft/s) in the vicinity of Raffinate Pit 3 which may be indicative of saturated conditions. The geophysical data indicate that the subsurface soil beneath Raffinate Pit 3 may be saturated and that saturated soil may also be present beneath unsaturated materials on the east, west, and south sides of Raffinate Pit 3. Subsequent borings in the vicinity of the raffinate pits have confirmed that localized saturated conditions are present (MKF and JEG 1989b).

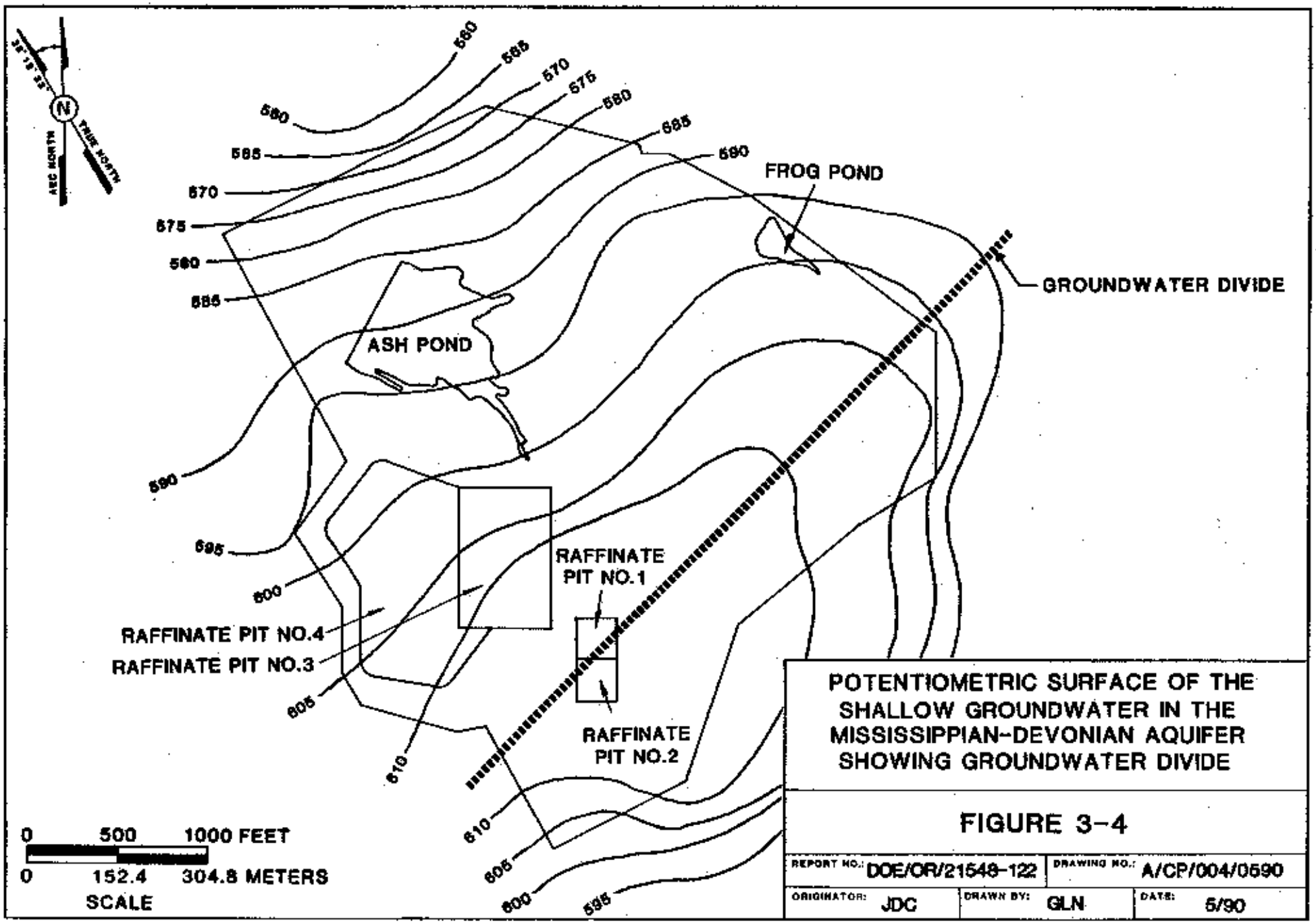
3.2.3 Mississippian-Devonian Aquifer System

The Mississippian-Devonian aquifer system is the uppermost aquifer present in the vicinity of the WSS. The upper portion of the aquifer consists of saturated rocks of the Burlington-Keokuk Limestone. As described in Section 3.1, this unit is subdivided on the basis of weathering in the vicinity of the site. At the WSS the lowermost unit in the Mississippian- Devonian aquifer system is the Bushberg Sandstone. Groundwater flow in the vicinity of the site is characterized by Darcian diffuse flow with conduit flow superimposed. The dynamics of groundwater flow

through the upper portion of the Mississippian-Devonian aquifer can best be described in terms of hydraulic head distribution. That is, groundwater flows from areas of high hydraulic head to areas of lower hydraulic head. Darcian principles may be applied to assess flow characteristics on a scale much larger than that of the spacing of individual fractures that have not been significantly enlarged by dissolution. Specific conduit flow pathways in the vicinity of the site have been defined from dye injection and water tracing performed by the MDNR (MDNR 1989).

Potentiometric data indicate the presence of a groundwater divide trending from the southwestern to northeastern portions of the site. Figure 3-4 is a potentiometric surface map based on data collected in December 1988 from shallow groundwater monitoring wells. Groundwater to the north of this divide flows northerly toward Dardenne Creek and groundwater to the south of the divide flows southerly toward the Missouri River.

Borehole packer testing of the saturated bedrock has revealed a general decrease in hydraulic conductivity with depth. Water quality data from the Weldon Spring chemical plant/ raffinate pits/vicinity properties (WSCP/RP/VP) monitoring well network indicate that although a downward hydraulic gradient exists between the shallower and deeper monitoring wells, the degree of communication is very limited (MKF and JEG 1989a). Contaminants detected in wells monitoring the shallower portion of the aquifer are generally present at lower concentrations or not at all in deeper monitoring wells. Vertical hydraulic conductivity is considered to be a function of vertical fracture spacing. Angle hole drilling indicates thatspacing of vertical fractures is sporadic, ranging from 0.75 m (2.5 ft) to 5.5 m (18 ft), and averages 3 m (10 ft). The ratio of horizontal to



POTENTIOMETRIC SURFACE OF THE SHALLOW GROUNDWATER IN THE MISSISSIPPIAN-DEVONIAN AQUIFER SHOWING GROUNDWATER DIVIDE

FIGURE 3-4

REPORT NO.:	DOE/OR/21548-122	DRAWING NO.:	A/CP/004/0590		
ORIGINATOR:	JDC	DRAWN BY:	GLN	DATE:	5/90

vertical fractures is approximately 20:1 or greater (MKF and JEG 1989b).

To provide insight into the degree of karst development and, consequently, the potential for conduit flow in the upper portion of the Mississippian-Devonian aquifer system, the following discussion of core recovery and drilling fluid loss is presented. Dissolution and weathering of the bedrock is indicated by poor core recovery in the upper 6 to 9 m (20 to 30 ft) of the bedrock in many locations; complete loss of circulation of drilling fluids during drilling of roughly half of the borings; dissolution features in cores; and low rock quality designation (RQD) values for the upper 3 to 15.25 m (10 to 50 ft) of bedrock cores (MKF and JEG 1990).

In general, core loss is concentrated in the top 6 to 9 m (20 to 30 ft) of bedrock with less than 1.5 m (5 ft) of core loss per boring. Notable exceptions include MW-4009 and MW-4010. MW-4009 experienced a total core loss of 7.6 m (24.9 ft) beginning at a depth of 17.1 m (56.2 ft) below ground surface and MW-4010 had 7.4 m (24.3 ft) of total core loss starting at a depth of 13.4-m (44 ft) below ground surface. These wells are located along the projection of the conduit traced from losing stream stretches that occur down-drainage from Ash Pond. A discussion of the effects of core loss and fluid loss during drilling is presented in the Report on Suitability of the Weldon Spring Site for Potential Location of a Disposal Facility (MKF and JEG 1990).

4 INVESTIGATION PROCEDURES

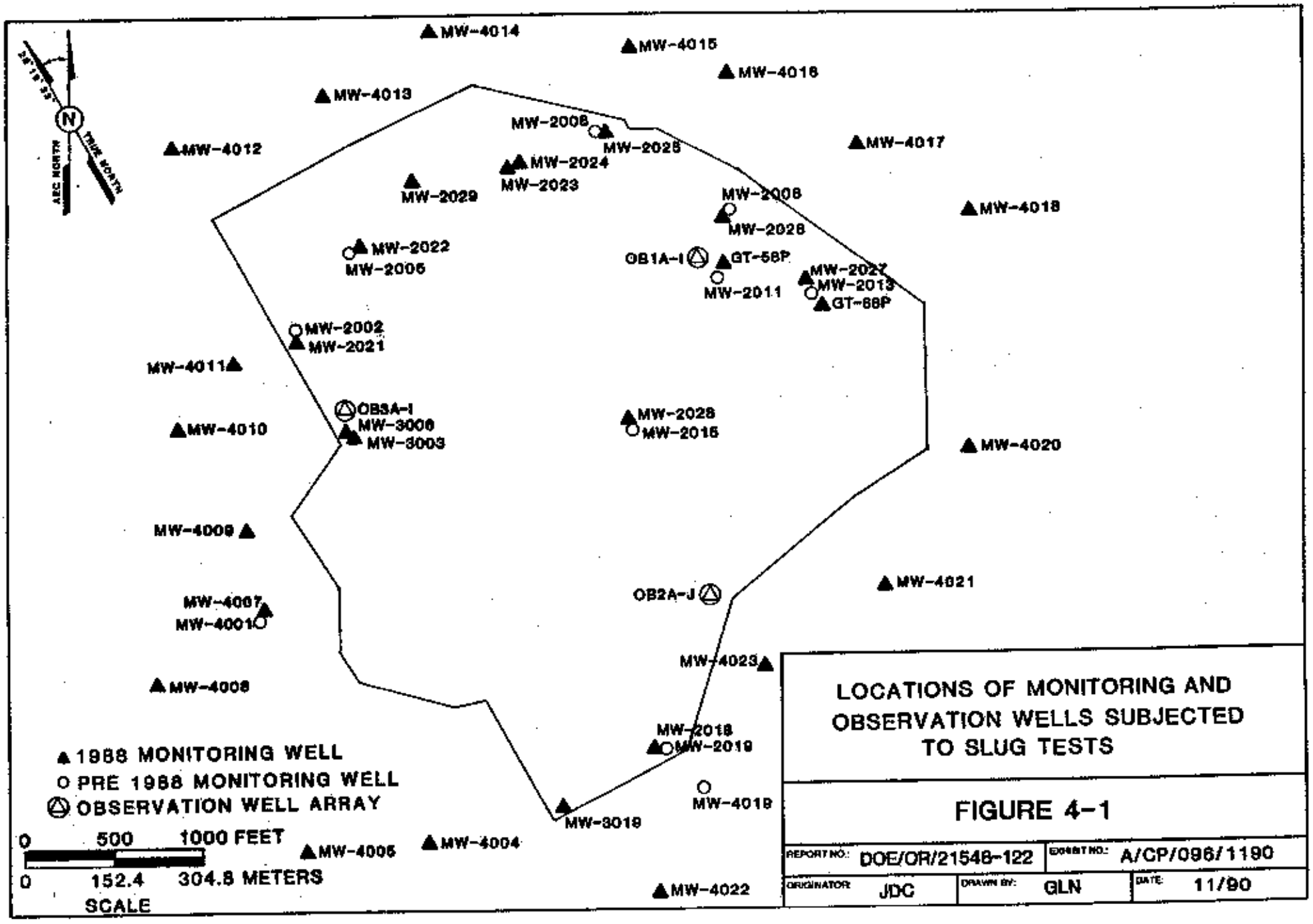
Three types of tests were performed to obtain the data included in this report: slug tests, pumping tests, and tracer tests. This section describes field procedures and the data management methods used for each type of test.

4.1 Slug Tests

Slug tests were performed on 39 monitoring wells, two geotechnical piezometers, and 28 observation wells between October 1988 and November 1989. The locations of wells and piezometers subjected to slug tests are presented in Figure 4-1. The testing was performed by Project Management Contractor (PMC) personnel in support of aquifer characterization efforts as detailed in the Hydrogeologic Investigations Sampling Plan (MKF and JEG 1988b). All of the wells selected for testing are screened within the Burlington-Keokuk Limestone which is the uppermost unit of the Mississippian-Devonian aquifer beneath the site. The results of these tests are expected to provide information on hydraulic conductivity and aquifer heterogeneity and anisotropy, and to complement pumping tests and water level and flow study data.

4.1.1 Field Procedures

Falling and rising head tests were conducted at each well using solid polyvinyl chloride (PVC) slugs attached to braided polypropylene rope. For 0.05 m (2 in.) inside diameter (ID) wells a 0.032 m (1.25 in.) diameter by 1.52 m (60 in.) long slug was used, and for 0.10 m (4 in.) ID wells a 0.076 m (3 in.) diameter by 1.52 m (60 in.) long slug was used. The 0.032 m



LOCATIONS OF MONITORING AND OBSERVATION WELLS SUBJECTED TO SLUG TESTS

FIGURE 4-1

REPORT NO.: DOE/OR/21548-122		EXHIBIT NO.: A/CP/096/1190	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 11/90	

(1.25 in.) diameter slug created a vertical head displacement of approximately 0.61 m (2 ft) and the 0.076 m (3 in.) diameter slug created a vertical displacement of approximately 1.52 m (5 ft). Head data were collected using an Enviro-Labs Model DL-120-MCP programmable data logger equipped with a 0-to-25-pound/sq in. (psi) pressure transducer.

Well numbers, depths to static water level, pressure transducer installation depths, initial transducer heads, test types (rising or falling), and test times were recorded in the field log book by field personnel. Variable interval sampling frequencies were also developed and recorded in the field.

In general, tests were conducted as follows:

1. The depth to static water level was determined and recorded.

2. The pressure transducer was placed in the well to a depth of approximately 2.5 m (8 ft) or more below the static water level.

3. A falling head test was performed by simultaneously starting data acquisition (using the data logger) and quickly lowering the PVC slug within the well to a depth below the previously determined static water level. Data acquisition proceeded until transducer head values closely approximated pretest conditions.

4. After transducer head values indicated a return to static or near static conditions, a rising head test was conducted by simultaneously starting data acquisition and withdrawing the PVC slug, thereby causing an instantaneous decrease in the transducer head value.

5. Data acquisition proceeded until head values returned to static or near static conditions whereupon testing was terminated.

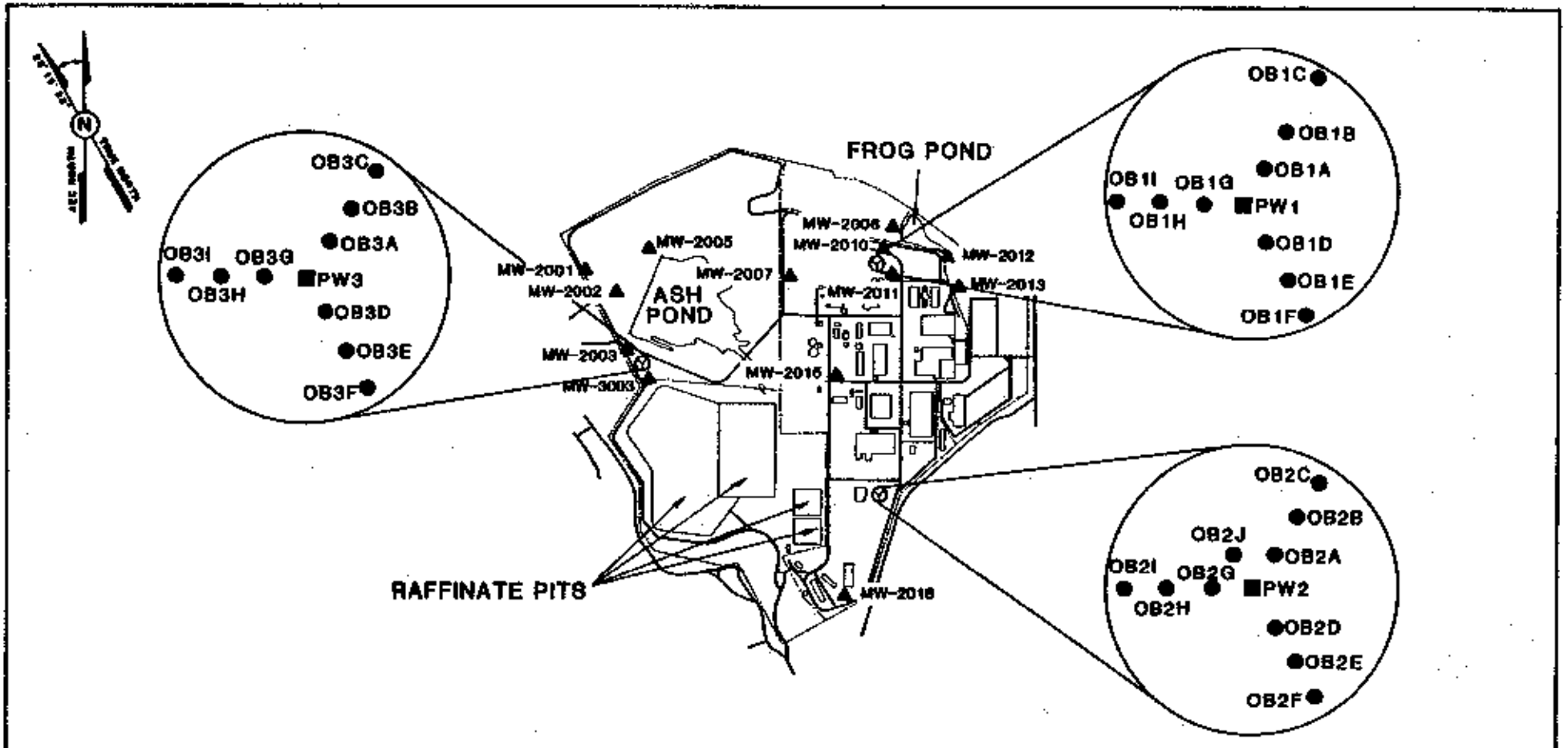
4.1.2 Data Management

All data were collected using the EL-120-MCP data logger and pressure transducer. Field data were periodically transferred to a portable computer for conversion to a LOTUS 1,2,3 compatible format using an Environ-Labs data conversion program. Individual test identification for data analysis was accomplished using HYCON, a LOTUS program developed at the Weldon Spring Site Remedial Action Project (WSSRAP) specifically for single well hydraulic conductivity data reduction and analysis.

4.2 Pumping Tests

The pumping tests were designed to provide data to be used in the calculation of the transmissivity, storativity, and areal anisotropy of the shallow bedrock aquifer beneath the Weldon Spring chemical plant and raffinate pits (WSCP/RP). Pumping tests began January 10, 1989 and continued through February 4, 1989. These tests were performed by Earth Scientists, Inc. of St. Louis, Missouri, on behalf of the PMC, at pumping and observation well networks installed specifically for performance of pumping tests. The locations of pumping and observation well networks are indicated in Figure 4-2.

The following subsections describe the rationale used to design testing, the procedures followed in the performance of the pumping tests, and the methods used to manage the data obtained during the testing.



■ PUMPING WELL
● OBSERVATION WELL
▲ MONITORING WELL

0 1000 2000 FEET
0 304.8 609.6 METERS
SCALE

LOCATIONS OF WELLS USED IN PUMPING TESTS

FIGURE 4-2

REPORT NO.: DOE/OR/21548-122		DRAWING NO.: A/CP/005/0590	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 5/90	

4.2.1 Testing Rationale

As the pumping and observation wells were developed, step-drawdown pumping tests were performed. The results of these tests showed that it was likely that the pumping tests could be run concurrently to shorten the period of test performance. To monitor for possible interference between pumping wells, a staggered starting schedule was developed. According to the schedule, the initial pumping test would be run for a minimum of 48 hours. During that time, static water levels were observed so that any effects at other test locations could be identified. Assuming negligible effects at other locations, a concurrent pumping test could begin and the process could be repeated until completion of all testing.

Preliminary calculations indicated that up to 240 hours of pumping would be necessary at each pumping location to monitor potential effects of delayed yield under steady state conditions. However, contingency plans were made to end the pumping before this time limit if pumping could not be sustained. Maximum sustainable pumping rates were determined based on the results of step-drawdown pumping tests performed during well development.

4.2.2 Field Procedures

Before the first test was started, static water levels were observed to determine background conditions of the aquifer. Potentiometric observation began on January 10, 1989. Water level measurements were taken at two-hour intervals at the three pumping/observation well networks and selected monitoring wells near the pumping wells (Table 4-1). These measurements continued for approximately 96 hours.

During and after the testing, water levels were monitored at time intervals based on three schedules. These schedules are shown in Table 4-2.

Upon termination of pumping, recovery measurements were taken until the water level had returned to within 10% of the original static water level.

Water levels were monitored by two methods. The water levels in the pumping wells were monitored using pressure transducers. The information was recorded using data loggers manufactured by In Situ, Inc., Laramie, Wyoming. The electronic data were verified by obtaining water levels with an electric tape at periodic intervals. Electric tapes were also used to obtain all water levels in the observation and monitoring wells.

The pumping test at Well No. PW-2 began at 8:36 am, Friday, January 13, 1989 at a pumping rate of 1.5 lpm (0.4 gpm). Water level measurements continued at and around the other pumping locations. Pumping continued until 6:30 pm, Friday, January 20, 1989 -- a total of 178 hours. Pumping was terminated after the water level in the pumping well began dropping rapidly to near the level of the pump intake. Water level recovery was then monitored until 8:39 am, January 22, 1989, when the test was terminated.

The pumping test at Well No. PW-3 began at 1:42 pm, Wednesday, January 18, 1989 at a pumping rate of 1.1 lpm (0.3 gpm). Pumping continued until 10:25 am, January 26, 1989 -- a total of 189 hours. Pumping was terminated after the water level in the pumping well began dropping rapidly to near the level of the pump intake, approximately 36 hours after the well

TABLE 4-1 Water Level Monitoring Locations Used During Pumping Tests

	Monitoring Locations	Well Depth (ft)	Screen Interval (ft)
PW-1	PW-1	90.3	49.5-89.5
	OB1A	89.5	48.0-89.0
	OB1B	91	50.5-90.5
	OB1C	88.5	48.0-88.0
	OB1D	90	49.5-89.5
	OB1E	94	54.0-94.0
	OB1F	93	52.5-92.5
	OB1G	90	49.5-89.5
	OB1H	93	53.0-93.0
	OB1I	90	49.5-89.5
	MW-2006	71	55.5-65.5
	MW-2007	99	83.0-93.0
	MW-2010	64	48.0-58.0
	MW-2011	79	62.8-72.8
	MW-2012	69.5	48.0-58.0
	MW-2013	75	58.0-68.0
PW-2	PW-2	89.8	45.0-85.0
	OB2A	85	44.5-84.5
	OB2B	85.5	45.0-85.0
	OB2C	85	44.5-84.5
	OB2D	85	44.5-84.5
	OB2E	86	45.5-85.5
	OB2F	84	43.5-83.5
	OB2G	85	44.5-84.5
	OB2H	85.5	45.0-85.0
	OB2I	86	45.5-85.5
	OB2J	143	130.0-140.0
	MW-2015	86	67.5-77.5
	MW-2018	69	53.0-63.0

TABLE 4-1 Water Level Monitoring Locations Used During Pumping Tests (Continued)

Test Locations	Monitoring Locations	Well Depth (ft)	Screen Interval (ft)
PW-3	PW-3	86	45.5-85.5
	OB3A	83	42.5-82.5
	OB3B	85.1	44.6-84.6
	OB3C	83	42.5-82.5
	OB3D	83	42.5-82.5
	OB3E	85	45.0-84.5
	OB3F	83	42.5-82.5
	OB3G	83	42.5-82.5
	OB3H	85	45.0-84.5
	OB3I	83	42.5-82.5
	MW-2001	64	48.0-58.0
	MW-2002	64	48.0-58.0
	MW-2003	64	48.0-58.0
	MW-2005	81	65.5-75.5
	MW-3003	89.5	79.2-89.2

TABLE 4-2 Time Intervals for Measuring Drawdown During Pumping Tests

Time Since Pumping Started/Stopped (Minutes)	Time Intervals Between Measurements
Pumping Tests	
0 - 1	1 sec.
1 - 5	10 sec.
5 - 10	30 sec.
10 - 15	1 min.
15 - 60	5 min.
60 - 240	30 min.
240 - 720	60 min. (1 hr.)
720 - 1440	120 min. (2 hr.)
1440 - termination of test	240 min. (4 hr.)
Observation Wells	
0 - 60	2 min.
60 - 120	5 min.
120 - 240	10 min.
240 - 360	30 min.
360 - 1440	60 min.
1440 - termination of test	480 min. (8 hr.)
Monitoring Wells	
0 - 12	1 min.
12 - 24	2 min.
24 - termination of test	4 min.

reached steady state. After pumping, water level recovery was monitored until 9:23 am, January 30, 1989.

The pumping test at PW-1 began at 12:55 pm, January 24, 1989 at a pumping rate of 1.1 lpm (0.3 gpm). Pumping continued for the planned 240-hour duration until 1:13 pm, February 3, 1989. Water level recovery was monitored until 1:08 pm, February 4, 1989.

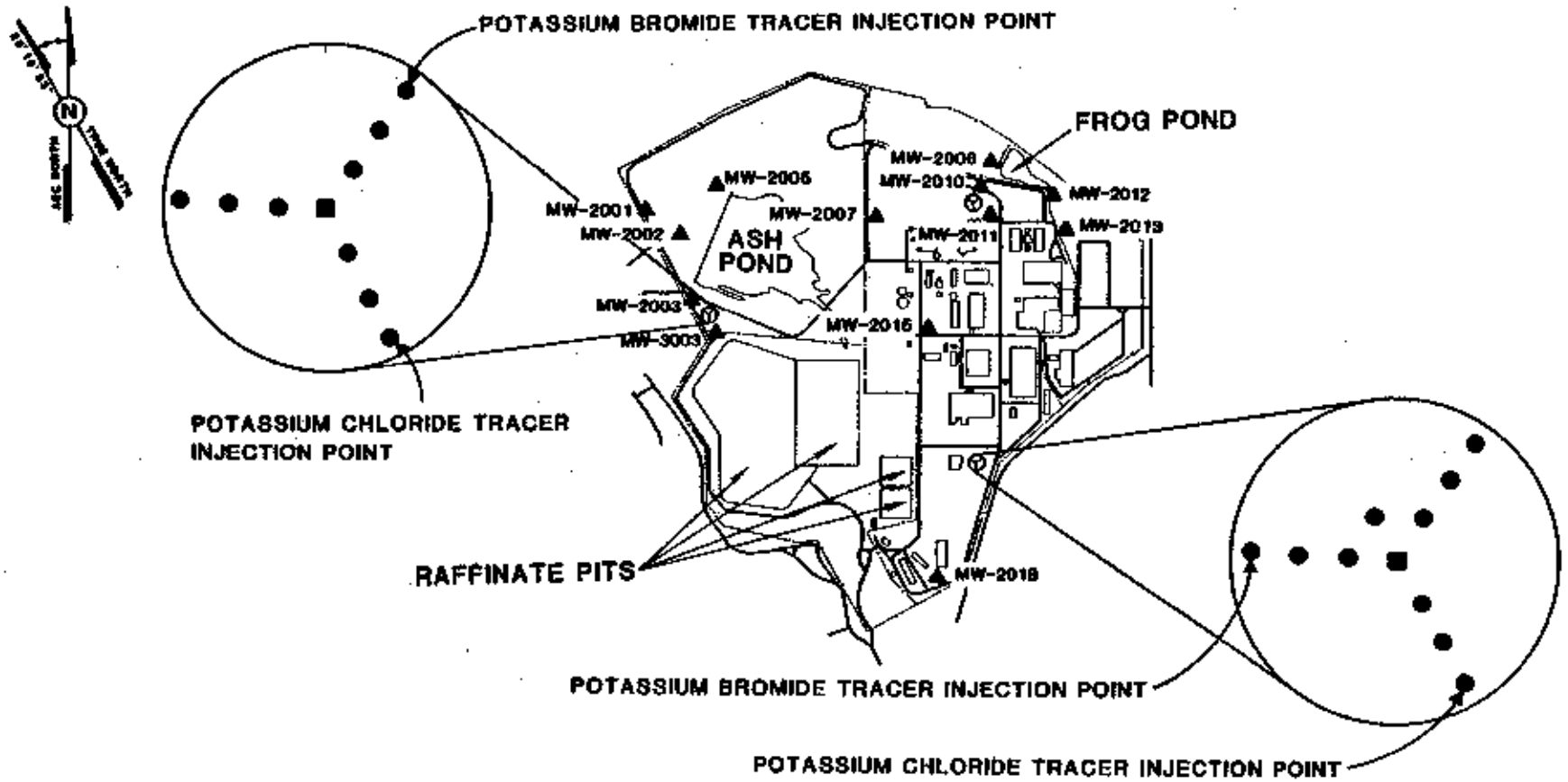
4.2.3 Data Management

Field measurements from the pumping tests included static water levels, pumping and recovery water levels, ambient air temperature, and barometric pressure. Barometric pressure and temperature were recorded from a mercury barometer and a thermometer at the pumping well.

All physical measurements collected by the subcontractor were recorded in field notebooks and were then transferred to LOTUS 123 spreadsheets. Calculations were made to convert the field elevations to elevations above mean sea level and to correct for changes in atmospheric pressure. The final data were then transmitted to the PMC in hardcopy and electronic form.

4.3 TRACER TESTS

The tracer tests were designed to aid in determining values of effective porosity and assessing dispersivity. The tracer tests were performed at the PW-2 and PW-3 networks. PW-1 was not considered suitable for tracer tests due to its susceptibility to freezing and proximity to known areas of nitroaromatic compound contamination. Figure 4-3 shows the location of the injection points at each test network. The following subsections describe



■ PUMPING WELL
● OBSERVATION WELL
▲ MONITORING WELL

0 1000 2000 FEET
0 304.8 609.6 METERS
SCALE

LOCATIONS OF OBSERVATION WELLS USED AS TRACER INJECTION POINTS

FIGURE 4-3

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the procedures followed in the performance of the tests and the methods used to manage the data as it was collected.

4.3.1 Field Procedures

A converging-flow technique was selected in which an aliquot of conservative ion tracer solution was injected into observation wells and samples were collected from the pump discharge at preset intervals. Chloride and bromide salts were selected as tracers because they are environmentally safe, readily available, and could be easily analyzed on site at parts-per-million levels using a specific ion electrode. Tracers were prepared by dissolving 5 kg (11 lb) of potassium bromide or potassium chloride in 8-liters (2.1 gallons) of deionized water. Two tracer tests were conducted at each location using different ion solutions to determine effects of anisotropy on travel time. Preliminary estimates indicated that 100 to 150 hours would be required for the tracers to travel from the injection well to the pumping well under the anticipated pumping rates.

Samples were collected in 250 ml Nalgene bottles according to the schedule shown in Table 4-3. New bottles were obtained specifically for the tracer testing but were reused as necessary. Prior to each use, the bottles were triple-rinsed with deionized water and immediately before a sample was taken were triple-rinsed with water from the pump discharge. At each sampling time, a total of four samples was taken from each well. This gave duplicate samples for each tracer analysis.

Pumping for the tracer tests at PW-3 began at 3:45 pm, March 21, 1989. A saturated potassium chloride solution was injected into observation well OB3C on March 22 between 3:15 pm and

TABLE 4-3 Sampling Intervals During Tracer Testing

Time Since Tracer Injection (hours)	Time Interval Between Samples (hours)
0 - 24	No Samples Taken
24 - 96	4
96 - termination of test	2

4:20 pm. A saturated potassium bromide solution was injected into observation well OB3F between 4:40 pm and 4:55 pm. After the tracers were injected at each location, each injection well was surged with a bailer to mix the tracer within the water column. Then a total of 275 liters (73 gallons) of aquifer water from the pump discharge was injected incrementally as a "chaser" to drive the tracer into the formation. Sample collection at the pumping well began at 4:00 pm, March 22 and continued until the test was terminated at 4:40 pm, April 12.

Pumping for the tracer tests at PW-2 began at 4:40 pm, March 22, 1989. A saturated potassium chloride solution was injected into observation well OB2I on March 24 between 9:30 am and 9:50 am, and a saturated potassium bromide solution was injected into observation well OB2E between 2:30 pm and 2:42 pm. Surging and injection of chaser water followed the tracer injections in the same manner as at the PW-3 location. Sample collection at the pumping well began at 12:30 am, March 25 and continued until the test was terminated at 4:50 pm, April 12.

4.3.2 Data Management

The measurements taken during the tracer tests were the same as those taken during the pumping tests with the addition of tracer concentrations. The tracer concentrations were determined by analyzing the water samples taken from the pumping wells using specific-ion electrodes attached to an Orion meter. Meter calibration curves were generated using standards of 1 part per million (ppm), 10 ppm, and 100 ppm for bromide and 10 ppm, 100 ppm, and 1,000 ppm for chloride. The calibration curves and slope intercept equation were used to convert millivolt readings to parts per million.

5 METHODS OF ANALYSIS

Monitoring wells, pumping wells, and observation wells were utilized for aquifer testing at the Weldon Spring chemical plant/ raffinate pits/vicinity properties (WSCP/RP/VP) in support of the environmental documentation process. The primary objectives of testing were to define the hydraulic characteristics of the aquifer. This information will be of use in predicting contaminant migration and in assessing groundwater remediation alternatives. Slug tests were performed to provide information on areal variations in hydraulic conductivity in the uppermost aquifer. Pumping tests were performed to accurately determine transmissivity and specific yield and to allow assessment of the effects of pumping on groundwater flow patterns and contaminant levels. Tracer tests were performed to assess the effective porosity and dispersive properties of the formation. The methods of analysis used to evaluate the slug tests, pumping tests, and tracer tests are discussed in this section.

5.1 SLUG TESTS

Test data were analyzed using two analytical methods. A method developed by Hvorslev (1951) was used to determine hydraulic conductivity. This method allowed comparisons because it is widely used. A method developed by Bouwer and Rice (1976) was also used to derive hydraulic conductivity values.

Slug test head recovery data revealed three types of data configurations that required examination and editing prior to analysis. These data configurations were:

Harmonic distortion - This occurs when a pressure wave is created during slug deployment. Since the transducer used to collect

data converts pressure to hydrostatic head in units of length, the force of slug deployment results in variations in pressure (head) at the transducer. These variations may be either greater than or less than actual head differences due to differences in aquifer hydraulic conductivity. The pressure wave created during slug deployment was generally observed to dissipate within the first 5 to 10 seconds of the test. Harmonic distortion was easily recognized during data inspection because head values within the distorted data segment usually exceeded the possible range of head values caused by slug deployment. Data segments exhibiting harmonic distortion were not included during data analysis. The omission of early time data did not impact the quality of data analysis since early time data segments reflected filterpack influences in most cases.

Level shifts - Data sets that exhibited instantaneous (vertical) shifts in head level that were not consistent with the established recovery rate were examined. It was found that the vertical shifts always occurred at programmed changes in collection frequency. Level shifts were not common. Retesting usually yielded acceptable data; however, in a few cases, the data were smoothed manually to reflect the pre-shift and post-shift recovery rates.

Filterpack influence - Most tests exhibited a dramatic decrease in the rate of head recovery within the first 5 to 30 seconds of data recovery. The fast early time recovery rate is attributed to the permeability of the filterpack material surrounding the screen. These portions of the data are easily recognized upon inspection and were not utilized for data analysis.

5.1.1 Hvorslev Method

The Hvorslev method is the simplest interpretation of piezometer recovery data under unconfined conditions. The analysis assumes a homogeneous, isotropic medium of infinite vertical extent, where the medium and fluid are incompressible and the change in volume of fluid within the borehole is instantaneous.

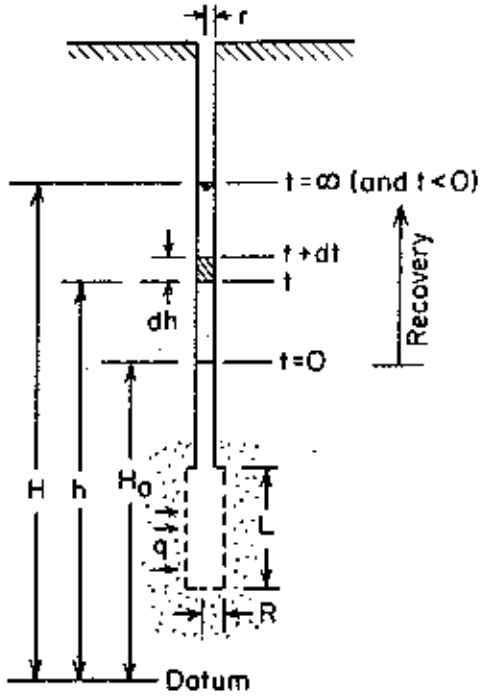
In the Hvorslev method, linear regression is used on a plot of the log of the ratio of the difference in head at any time during the test to the head difference at the beginning of the test (ln [H-h/H-H0]) versus time to determine the basic time lag, T_o. Hvorslev defines T_o as the time required for equalization of the active head while maintaining the original rate of flow. Hydraulic conductivity is then expressed as follows:

$$K = \frac{r^2 \ln(L/R)}{2LT_o} \qquad (1)$$

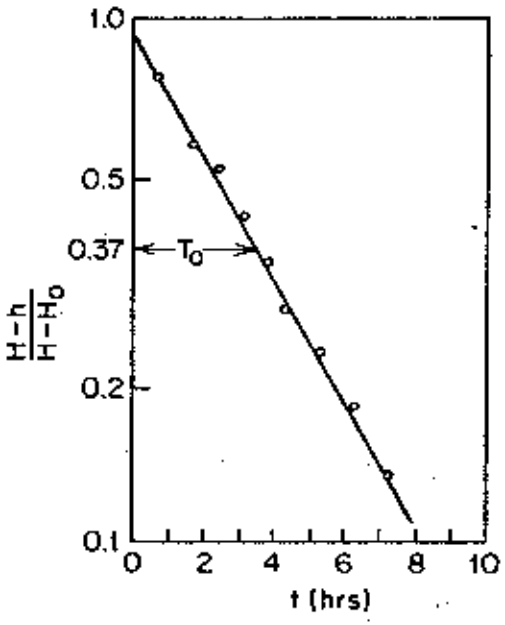
where:

r = radius of the casing
L = length of the intake
R = radius of the borehole at the intake
T_o = basic time lag

The basic geometry and graphical determination of T_o for the Hvorslev method are presented in Figure 5-1.



(a)



(b)

a) GEOMETRY

b) GRAPHICAL ANALYSIS

(SOURCE: FREEZE AND CHERRY, 1979)

SLUG TEST GEOMETRY: HVORSLEV METHOD

FIGURE 5-1

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5.1.2 Bouwer and Rice Method

The method developed by Bouwer and Rice is derived from a modification of the Thiem equation where:

$$Q = \frac{2\pi KLy}{\ln(R_e/r_w)} \qquad (2)$$

and the hydraulic conductivity is determined for an unconfined system by:

$$K = \frac{r_c^2 \ln(R_e/r_w) \ln(y_o/y_t)}{2Lt} \qquad (3)$$

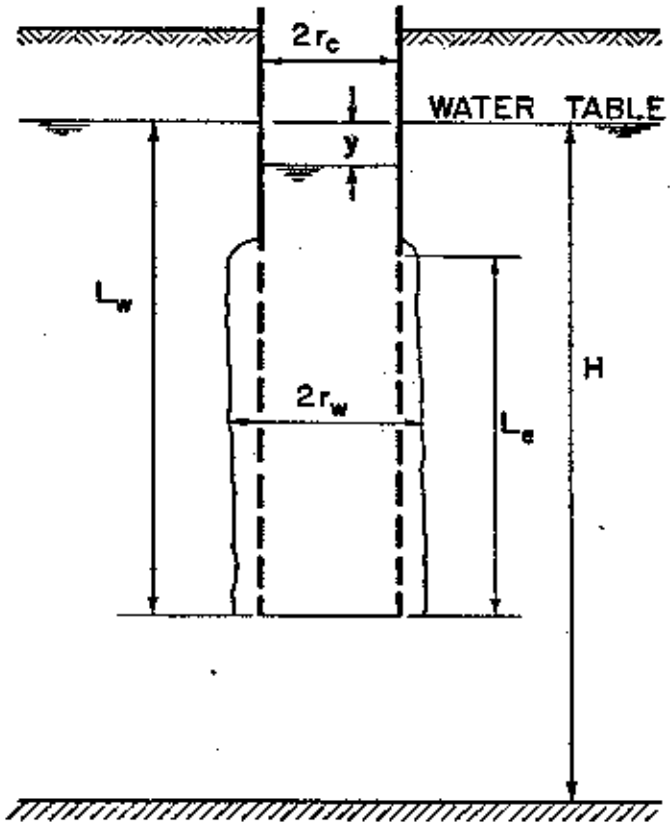
where:

- K = hydraulic conductivity
- r_c = radius of well casing
- r_w = radius of borehole at the intake
- L = length of intake
- t = time
- R_e = effective radius over which y is dissipated
- y = the vertical distance between the water in the well at time zero (y_o) or any time during the test (y_t) and the potentiometric surface at equilibrium

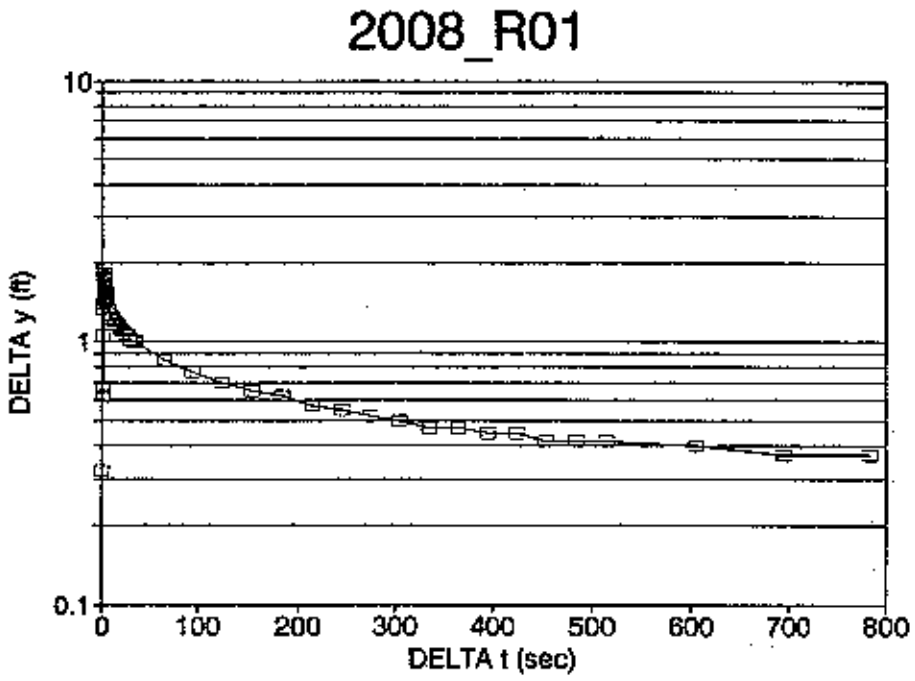
Test geometry for the Bouwer and Rice analysis is illustrated in Figure 5-2.

The change in head, y, was plotted versus time, t, (see Figure 5-2) to determine the appropriate straight line portion of the data for analysis. Most of the data exhibited a double straight line effect wherein data within the first 5 to 7 seconds exhibited a sharp decline in head difference, followed by a flattening of the time-versus-head relationship. In all cases the second straight line portion of the data was considered to reflect aquifer response. The terms 1/t and y_o/y_t were determined graphically as suggested by Bouwer (1989). Data plots are contained in controlled files maintained at the WSS project office. The data files are available for review on request. The straight line data portions used for analysis typically encompass later time data (up to 780 seconds) than that addressed by Bouwer (1989) in his update. However, it should be kept in mind that head-recovery curves for low permeability aquifers seldom resemble the example data plots used to illustrate principles of hydraulic phenomena.

Head recovery data were considered to reflect conditions closely approximating a fully penetrating situation where D is effectively equal to the distance between the potentiometric surface and the bottom of the test interval (screen). Fully penetrating conditions were assumed due to a conceptual model of anisotropy within the Burlington-Keokuk where hydraulic conductivity in the horizontal planes (K_x and K_y) are considered to be much greater than hydraulic conductivity in the vertical plane (K_z).



a)



b)

a) GEOMETRY
b) EXAMPLE DATA PLOT

SOURCE: FIGURE 5-2a FROM BOUWER, 1989

BOUWER AND RICE SLUG
TEST GEOMETRY

FIGURE 5-2

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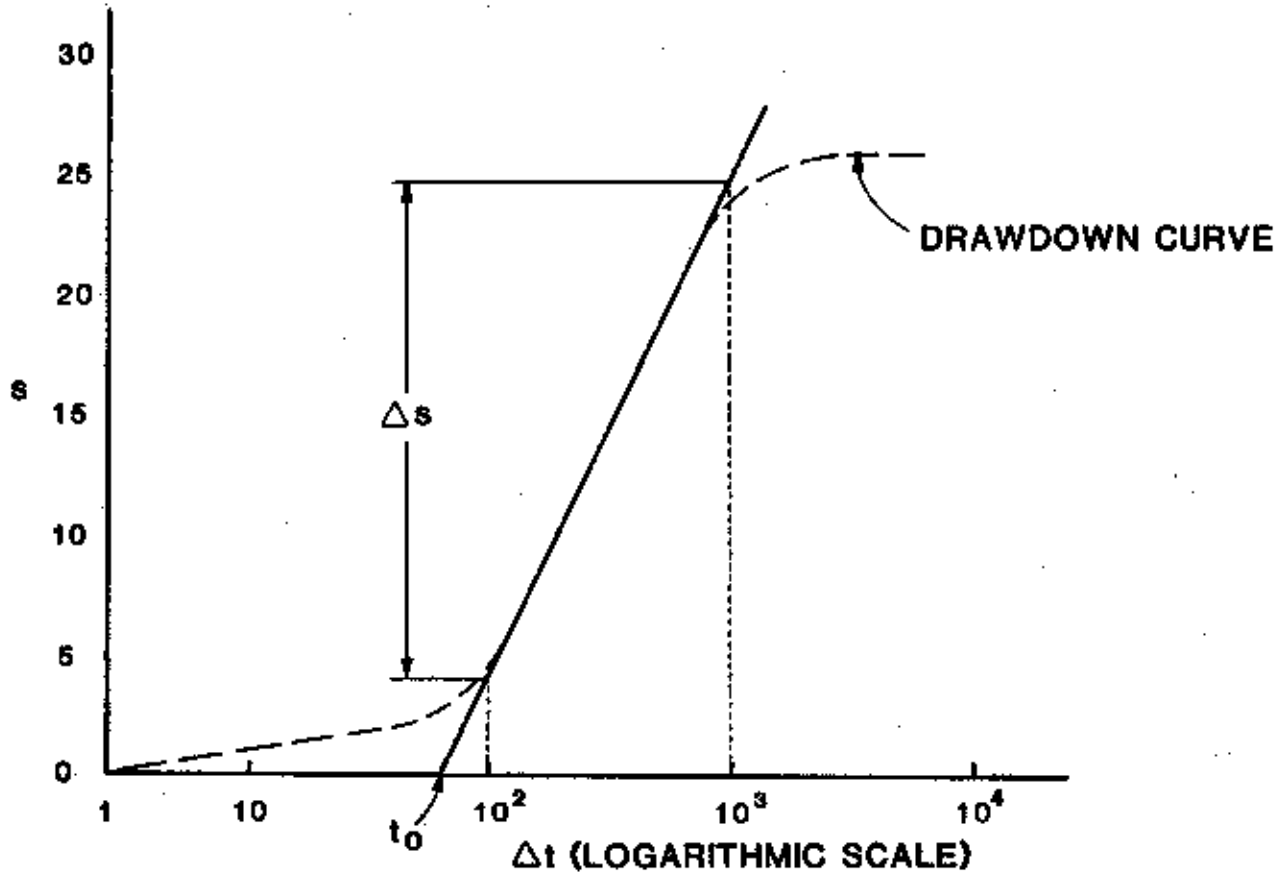
5.2 PUMPING TESTS

Pumping tests were designed to assess the reasonableness of the assumption that the shallow Mississippian-Devonian aquifer beneath the site can be modeled as an equivalent homogeneous porous medium exhibiting areal anisotropy in the horizontal plane.

Data obtained from the pumping tests were used to determine three properties of the upper portion of the Mississippian-Devonian aquifer beneath the WSCP/RP/VP: transmissivity, storativity, and lateral anisotropy. Values of transmissivity and storativity were obtained using the Cooper-Jacob (time-drawdown) semi-log method (Cooper and Jacob 1946). Anisotropy was determined using the Hantush method, which also yields values for transmissivity and storativity. Secondary objectives were to review the available data for evidence of other significant hydrologic phenomena, such as delayed yield due to gravity drainage, boundary effects, and leakage effects, which might provide insight into the presence and relative magnitude of double porosity as may be expected in an aquifer consisting of limited intergranular and fine fracture porosity coupled with larger aperture fractures and solution features.

In order to perform the Cooper-Jacob method, the data were plotted semi-logarithmically with drawdown on the y-axis and time plotted logarithmically on the x-axis. A line was then plotted through the straight line portion of the data and extended to find the intercept of the line of zero drawdown. Figure 5-3 is an example of the graphical determination of zero drawdown. The following equations were then applied.



EXAMPLE OF COOPER-JACOB GRAPHICAL METHOD OF PUMPING TEST ANALYSIS

FIGURE 5-3

REPORT NO.:	DOE/OR/21548-122	DRAWING NO.:	A/PI/013/0590		
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$$T = 264Q/s \quad (4)$$

$$S = Tt_o/4800r^2 \quad (5)$$

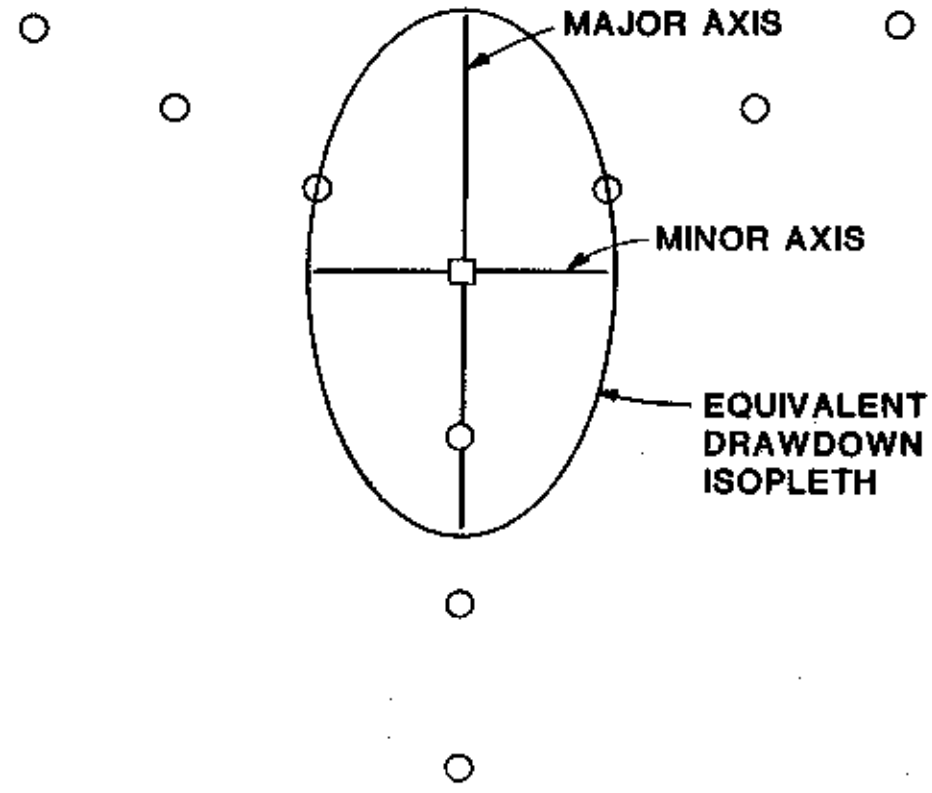
where:

T = transmissivity (gpd/ft)
Q = pumping rate (gpm)
s = change in drawdown per log cycle (ft/cycle)
S = storativity (dimensionless)
t_o = x-intercept of straight line portion of curve (minutes)
r = distance from pumping well to observation well (ft)

The resulting values of T and S are average values for the formation in the area between the pumping well and the specific observation well. The values also overlap along the lines of the observation wells.

The Hantush method provides a measure of the lateral anisotropy of a formation. Intermediate steps in the method also provide storativity and minimum and maximum transmissivity values. A summary of the analysis follows (Hantush and Thomas 1966).

Values of transmissivity and storativity are obtained for each observation well using a standard technique, such as the Cooper-Jacob method. These values of transmissivity are then averaged to obtain an effective transmissivity, T_e, of the system. The drawdown values, s, at a given time, t_r, are then plotted, and for a given drawdown, an ellipse is contoured with major and minor axes, A and B, respectively. The orientation of the ellipse, Ø, can be found graphically (Figure 5-4). The principal values of the transmissivity in the major and minor



○ OBSERVATION WELL

□ PUMPING WELL

1. PLOT SYNCHRONOUS DRAWDOWN AT EACH OBSERVATION WELL

2. DRAW ISOPLETH FOR EQUAL DRAWDOWNS

3. DETERMINE DIRECTION OF MAJOR AND MINOR AXES OF RESULTING ELLIPSE

EXAMPLE OF HANTUSH METHOD FOR DETERMINING DEGREE AND DIRECTION OF ANISOTROPY

FIGURE 5-4

REPORT NO.: DOE/OR/21548-122	DRAWING NO.: A/PI/014/0590	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 5/90

directions of the ellipse and the principal anisotropy can then be found from the following set of equations:

$$T_{max} = (a/b)T_e \quad (6)$$

$$T_{min} = (b/a)T_e \quad (7)$$

$$S = (4T_e t_f/ab)W^{-1}(4T_e s/Q) \quad (8)$$

$$\text{Principal Anisotropy} = T_{max}/T_{min} \quad (9)$$

where:

T_{max} = maximum transmissivity
T_{min} = minimum transmissivity
W^{-1} = inverse well function
Q = pumping rate

5.3 TRACER TESTS

Data obtained from the tracer tests were used to assess the effective porosity and dispersivity of the formation. Determination of the effective porosity was made using Darcy's law and the dispersivity was found by first using a common transport equation to find the hydrodynamic dispersion and then solving a direct relationship between hydrodynamic dispersion and dispersivity.

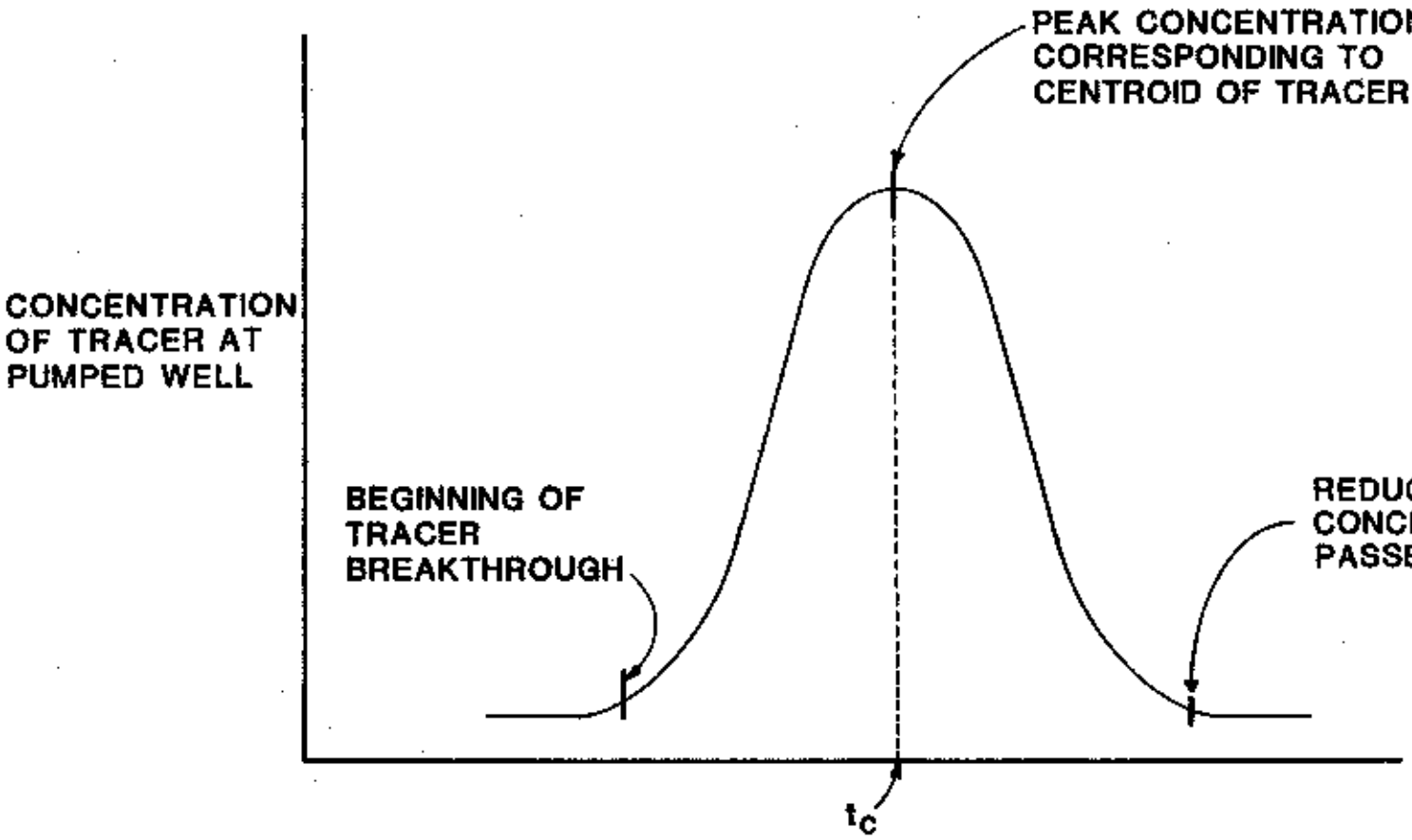
Darcy's law states that the specific discharge per unit area, q, of a formation is the product of the hydraulic conductivity, K, of the formation and the hydraulic gradient, i, across the formation. In order to obtain the effective porosity, n, the relationship $q = vn$, where v is the average linear velocity of the groundwater, must be substituted into Darcy's equation.

The hydraulic conductivity of the formation along the path of the tracer was found by dividing the transmissivity by the saturated thickness. In this case, the saturated thickness was taken to be the screened interval of the wells (40 feet). Equating saturated thickness to the screened interval is justified by the relative lack of vertical flow observed in the system (BNI 1987 and MKF and JEG 1989b). The transmissivity values that were used were estimated from the ellipses obtained in the Hantush analysis. The average hydraulic gradient between the injection well and pumping well, which is the value used in the calculation of effective porosity, is found by dividing the difference in hydraulic head between the injection and pumping wells by the distance between the two wells. Chloride and bromide ions are very conservative tracers, and therefore can be assumed to travel at the same velocity as the groundwater. Consequently, the average linear velocity can be determined by examining the breakthrough times of the tracers (Figure 5-5).

In order to find the dispersivity of the formation, the hydrodynamic dispersion, D_x, must first be determined. Hydrodynamic dispersion is found using the following transport equation (Bear 1972):

$$CA = \frac{M/n}{(4\pi D_x t)^{1/2}} \exp\left(\frac{(-x-Vt/n)^2}{4D_x t}\right) \qquad (10)$$

where: C = tracer concentration in sample
A = cross sectional area which the tracer originally occupies
M = original tracer mass
n = effective porosity of the formation
D_x = hydrodynamic dispersion



EXAMPLE OF TRACER BREAKTHROUGH CURVE FOR DETERMINATION OF AVERAGE LINEAR GROUNDWATER VELOCITY

FIGURE 5-5

REPORT NO.:	DOE/OR/21548-122	DRAWING NO.:	A/PI/015/0590		
ORIGINATOR:	JDC	DRAWN BY:	GLN	DATE:	5/90

t_c = ARRIVAL TIME OF CENTROID

t = time at which concentration, C, is determined

x = distance that tracer travels

v = average linear velocity of the groundwater

This equation is then rearranged to the form:

$$\frac{1}{D_x} \ln \frac{(M/n)}{(4\pi D_x t)^{1/2}} = - \frac{4t \ln(CA)}{(x-vt/n)^2} \qquad (11)$$

and D_x is found through iterative solutions of the equation.

Dispersivity is related to the hydrodynamic dispersion by the equation:

$$D_x = V\alpha_x + D^* \qquad (12)$$

where:

α_x = dispersivity

D^* = coefficient of molecular diffusion

Because the coefficient of molecular diffusion is several orders of magnitude smaller than the other terms, on the order of 10^{-10} (Freeze and Cherry 1979), it can be considered negligible and therefore can be omitted from the equation. Then, rearranging the resulting equation, dispersivity equals the coefficient of molecular diffusion divided by the average linear velocity.

6 RESULTS AND DISCUSSION

In the following sections the results of the slug tests, pumping tests, and tracer tests are presented and discussed.

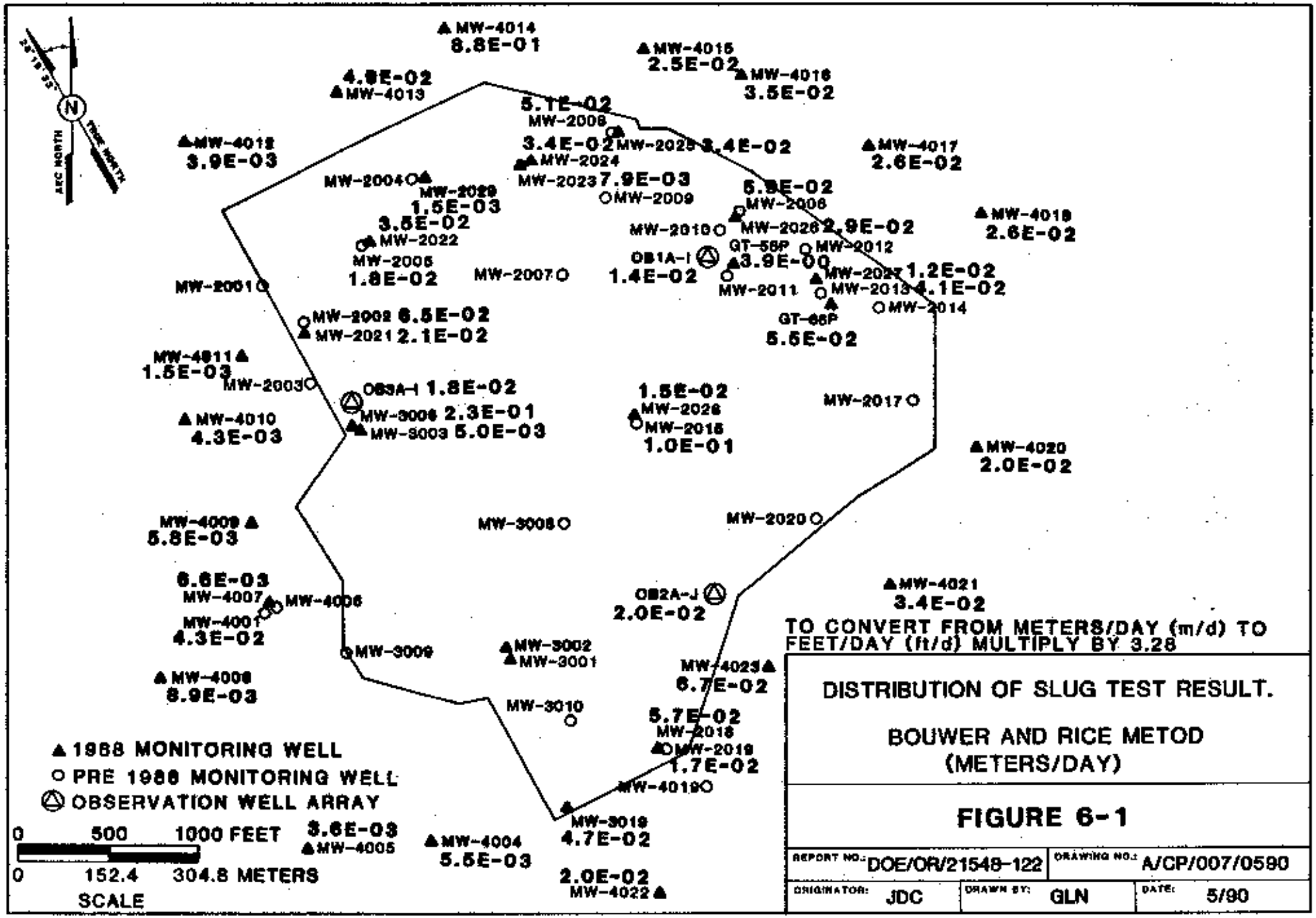
6.1 Slug Tests

Statistical analyses of slug test results were performed to facilitate presentation of results. Figure 6-1 shows the distribution of results of slug test data analyzed by the Bouwer and Rice method for all monitoring wells and piezometers tested. Values for each observation well network are average values of all observation wells tested at each network location. A frequency histogram and summary statistics for all wells tested are presented in Figure 6-2. Individual slug test data for all wells tested are contained in controlled files maintained at the project office.

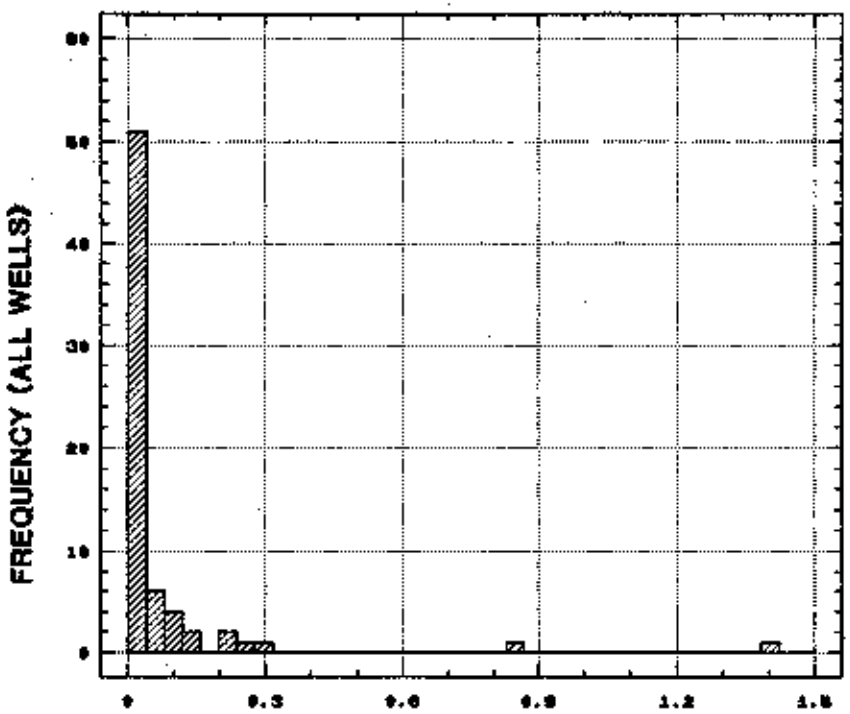
6.1.1 Monitoring Wells and Piezometers

Table 6-1 presents hydraulic conductivity values obtained by the Hvorslev and Bouwer and Rice methods for all monitoring wells and piezometers tested. Monitoring well designations are denoted by a MW prefix followed by a four-digit number, and piezometers are denoted by a GT prefix followed by a two-digit number and a P suffix.

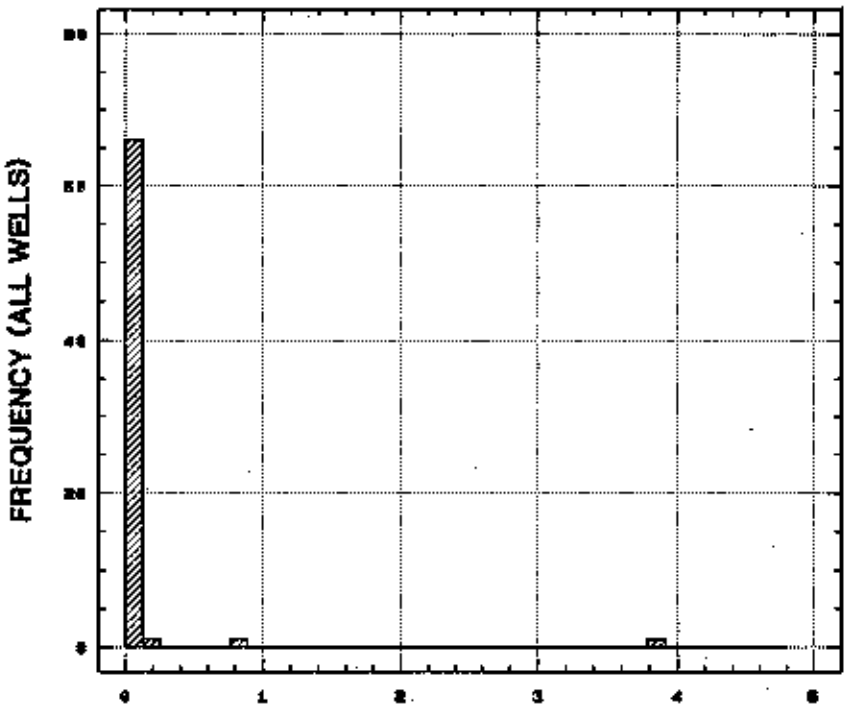
Analysis by the Hvorslev method yielded results which ranged from a high of 1.4 m/d (5.3E-05 ft/s) for MW-4014 to a low of 1.4E-03 m/d (5.35E-08 ft/s) for MW-4011. A frequency histogram and summary statistics are provided in Figure 6-3.


MW-4014
8.8E-01
MW-4015
2.5E-02
MW-4016
3.5E-02
4.8E-02
MW-4013
5.1E-02
MW-2008
MW-4012
3.9E-03
3.4E-02 MW-2025 3.4E-02
MW-4017
2.6E-02
MW-2024
MW-2004
MW-2029
1.5E-03
MW-2023 7.9E-03
MW-2009
5.8E-02
MW-2006
MW-4018
2.6E-02
3.5E-02
MW-2022
MW-2010
MW-2026 2.9E-02
GT-58P
MW-2012
MW-2005
1.8E-02
MW-2007
OB1A-I
1.4E-02
3.9E-00
MW-2027 1.2E-02
MW-2001
MW-2011
MW-2013 4.1E-02
MW-2014
GT-66P
MW-2002 6.5E-02
MW-2021 2.1E-02
5.5E-02
MW-4011
1.5E-03
MW-2003
OB3A-I 1.8E-02
MW-3006 2.3E-01
MW-3003 5.0E-03
1.5E-02
MW-2026
MW-2016
1.0E-01
MW-2017
MW-4010
4.3E-03
MW-4020
2.0E-02
MW-4009
5.8E-03
MW-3008
MW-2020
6.6E-03
MW-4007
MW-4006
MW-4001
4.3E-02
OB2A-J
2.0E-02
MW-4021
3.4E-02
MW-3009
MW-3002
MW-3001
MW-4023
6.7E-02
MW-4008
8.9E-03
MW-3010
5.7E-02
MW-2018
MW-2019
1.7E-02
MW-4019
MW-3019
4.7E-02
3.6E-03
MW-4005
MW-4004
5.5E-03
2.0E-02
MW-4022
▲1988 MONITORING WELL
○ PRE 1988 MONITORING WELL
OBSERVATION WELL ARRAY
0 500 1000 FEET
0 152.4 304.8 METERS
SCALE
TO CONVERT FROM METERS/DAY (m/d) TO FEET/DAY (ft/d) MULTIPLY BY 3.28
DISTRIBUTION OF SLUG TEST RESULT.
BOUWER AND RICE METOD
(METERS/DAY)
FIGURE 6-1
REPORT NO.: DOE/OR/21548-122
DRAWING NO.: A/CP/007/0590
ORIGINATOR: JDC
DRAWN BY: GLN
DATE: 5/90

HVORSLEV METHOD



BOUWER AND RICE METHOD



Variable:	HVORSLEV	BOUWER & RICE
Sample size	69	69
Average	0.0736072	0.0955145
Median	0.025	0.02
Standard deviation	0.196497	0.476955
Minimum	1.4E-3	1.5E-3
Maximum	1.4	3.9
Range	1.3986	3.8985

TO CONVERT FROM METERS/DAY (m/d) TO FEET/DAY (ft/d) MULTIPLY BY 3.28.

FREQUENCY HISTOGRAM AND SUMMARY STATISTICS OF SLUG TEST RESULTS FOR ALL WELLS TESTED (METERS/DAY)

FIGURE 6-2

REPORT NO.: DOE/OR/21548-122	DRAWING NO.: A/PI/016/0590	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 6/90

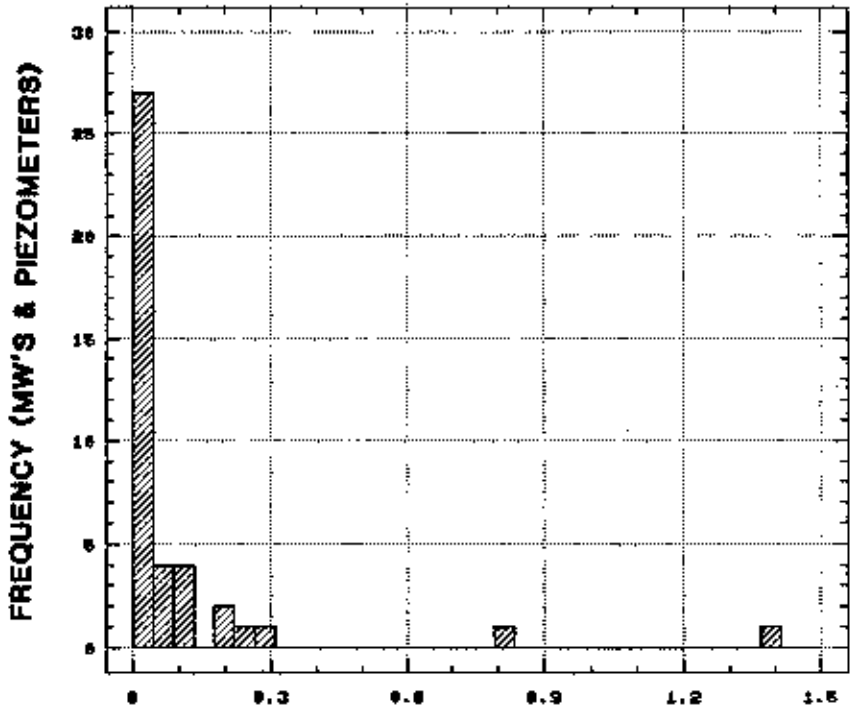
TABLE 6-1 Slug Test Values for Monitoring Wells and Piezometers

WELL ID	MID-SCREEN DEPTH BELOW TOP BDRK (m)	MEAN HYDRAULIC CONDUCTIVITY (m/d)* Hvorslev Method	Bouwer & Rice Method	RATIO OF HVORSLEV/ BOUWER &
MW-2002	8.74	1.20E-01	6.50E-02	1.85
MW-2005	7.88	2.20E-02	1.80E-02	1.22
MW-2006	11.56	1.20E-01	5.90E-02	2.03
MW-2008	5.64	1.10E-01	5.10E-02	2.16
MW-2013	10.83	9.50E-02	4.10E-02	2.32
MW-2015	9.76	4.20E-02	1.00E-01	0.42
MW-2018	7.78	2.10E-01	5.70E-02	3.68
MW-2019	24.14	7.00E-03	1.70E-02	0.41
MW-2021	24.86	2.00E-02	2.10E-02	0.95
MW-2022	23.24	2.50E-02	3.50E-02	0.71
MW-2023	9.64	6.60E-03	7.90E-03	0.84
MW-2024	28.24	3.30E-02	3.40E-02	0.97
MW-2025	20.77	3.30E-02	3.40E-02	0.97
MW-2026	28.41	1.50E-02	2.90E-02	0.52
MW-2027	26.50	1.00E-02	1.20E-02	0.83
MW-2028	24.49	1.50E-02	1.50E-02	1.00
MW-2029	19.32	1.50E-03	1.50E-03	1.00
MW-3003	18.15	5.30E-03	5.00E-03	1.06
MW-3006	30.65	2.60E-01	2.30E-01	1.13
MW-3019	13.51	6.00E-02	4.70E-02	1.28
MW-4001	6.41	5.30E-02	4.30E-02	1.23
MW-4004	14.18	3.30E-03	5.50E-03	0.60
MW-4005	13.24	2.80E-03	3.60E-03	0.78
MW-4007	20.13	6.00E-03	6.60E-03	0.91
MW-4008	16.36	8.50E-03	8.90E-03	0.96
MW-4009	16.04	5.60E-03	5.80E-03	0.97
MW-4010	17.14	2.50E-03	4.30E-03	0.58
MW-4011	12.29	1.40E-03	1.50E-03	0.93
MW-4012	11.38	2.30E-03	3.90E-03	0.59
MW-4013	4.39	8.30E-01	4.90E-02	16.94
MW-4014	6.07	1.40E+00	8.80E-01	1.59
MW-4015	12.22	7.00E-03	2.50E-02	0.28
MW-4016	14.85	2.20E-02	3.50E-02	0.63
MW-4017	12.05	3.60E-02	2.60E-02	1.38
MW-4018	9.01	3.30E-02	2.60E-02	1.27
MW-4020	7.87	2.50E-02	2.00E-02	1.25
MW-4021	10.52	5.20E-02	3.40E-02	1.53
MW-4022	13.36	7.90E-02	2.00E-02	3.95
MW-4023	4.58	3.60E-03	6.70E-02	0.05
GT58P	7.47	2.00E-01	3.90E+00	0.05
GT66P	5.58	3.00E-01	5.50E-02	5.45

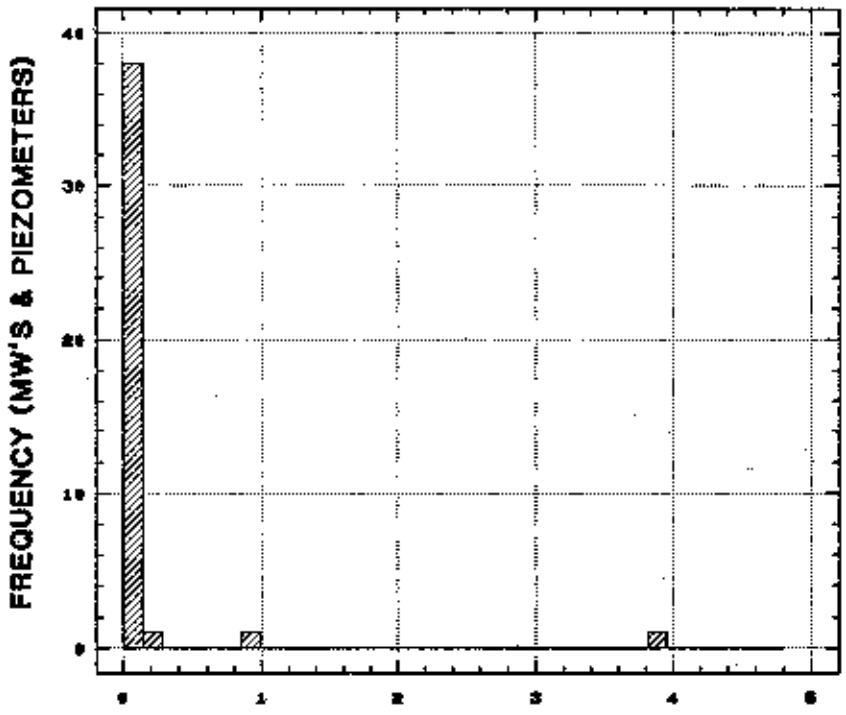
* To convert from meters/day (m/d) to feet/day multiply by 3.28

RICE

HVORSLEV METHOD



BOUWER AND RICE METHOD



Variable:	HVORSLEV	BOUWER & RICE
Sample size	41	41
Average	0.104473	0.148768
Median	0.025	0.026
Standard deviation	0.25091	0.616043
Minimum	1.4E-3	1.5E-3
Maximum	1.4	3.9
Range	1.3986	3.8985

TO CONVERT FROM METERS/DAY (m/d) TO FEET/DAY (ft/d) MULTIPLY BY 3.28

FREQUENCY HISTOGRAM AND SUMMARY STATISTICS OF SLUG TEST RESULTS FOR MONITORING WELLS AND PIEZOMETERS (METERS/DAY)

FIGURE 6-3

REPORT NO.: DOE/OR/21548-122	DRAWING NO.: A/PI/017/0590	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 5/90

Analysis by the Bouwer and Rice method yielded results which ranged from a high of 3.9 m/d (1.5E-04 ft/s) for GT-58P to a low of 1.5E-03 m/d (5.7E-08 ft/s) for MW-2029 and MW-4011. Summary statistics and a frequency histogram are presented in Figure 6-3. Data from piezometer GT58P was not suitable for analysis using the Hvorslev technique due to almost instantaneous equalization of that portion of the active head required for determination of the basic time lag. Use of a potable water slug to create a larger head displacement would probably eliminate this effect.

6.1.2 Observation Wells

Table 6-2 presents values obtained by Hvorslev and Bouwer and Rice methods for all observation wells tested. As with the monitoring well and piezometer data, values are either a mean or single test value depending on the integrity of the test data. Analysis by the Hvorslev method yielded results ranging from a maximum of 1.0E-01 m/d (3.8E-06 ft/s) for OB2I to a minimum of 8.1E-03 m/d (3.1E-07 ft/s) for OB2J.

Analysis by the Bouwer and Rice method yielded results ranging from a maximum of 4.4E-02 m/d (1.7E-06 ft/s) for OB3I and a minimum of 6.5E-03 m/d (2.5E-07 ft/s) for OB2J. Frequency histograms and summary statistics are presented in Figure 6-4.

6.1.3 Discussion

Calculated hydraulic conductivity values were compared by dividing the value obtained using the Hvorslev Method with the value obtained using the Bouwer and Rice Method. Ratios of Hvorslev to Bouwer and Rice values average 1.6 and range from 0.05 to 16.94. Individual ratios are included in Table 6-1.

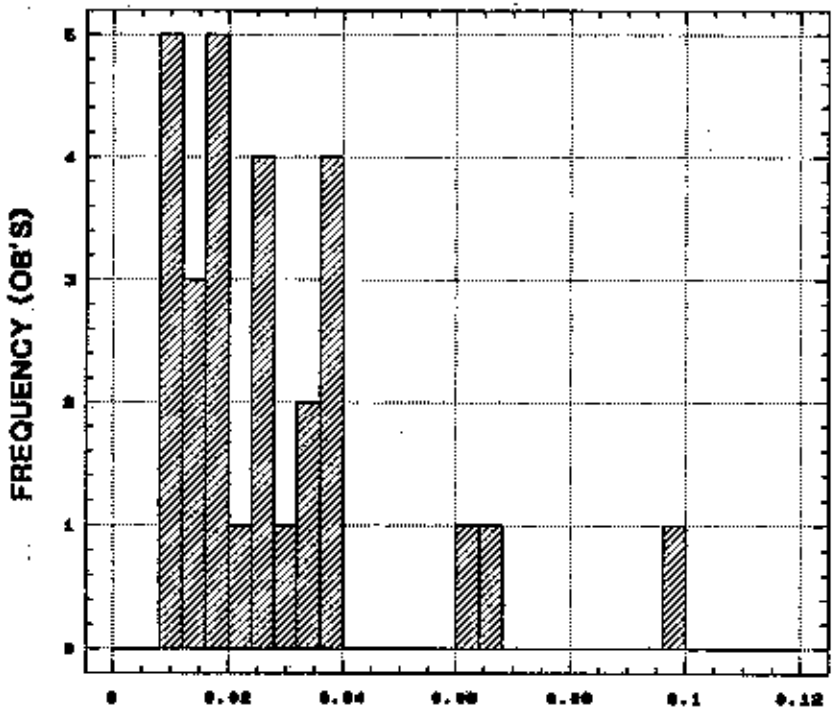
TABLE 6-2 Slug Test Values for Observation Wells

WELL ID	MID-SCREEN DEPTH BELOW TOP BDRK (m)	MEAN HYDRAULIC CONDUCTIVITY (m/d)* Hvorslev Method	Bouwer & Rice Method	RATIO OF HVORSLEV/ BOUWER &
OB1A	3.58	1.80E-02	1.30E-02	1.38
OB1B	3.93	1.30E-02	1.10E-02	1.18
OB1C	3.55	1.00E-02	8.20E-03	1.22
OB1D	3.57	1.60E-02	1.70E-02	0.94
OB1E	3.86	1.60E-02	1.10E-02	1.45
OB1F	3.46	2.80E-02	2.30E-02	1.22
OB1G	3.60	9.80E-03	6.80E-03	1.44
OB1H	3.80	2.50E-02	1.70E-02	1.47
OB1I	3.56	1.70E-02	1.90E-02	0.89
OB2A	1.93	1.10E-02	7.50E-03	1.47
OB2B	2.19	3.60E-02	1.50E-02	2.40
OB2C	1.88	3.90E-02	2.10E-02	1.86
OB2D	1.99	3.70E-02	1.60E-02	2.31
OB2E	2.11	6.20E-02	3.60E-02	1.72
OB2F	2.03	3.90E-02	2.70E-02	1.44
OB2G	2.04	3.70E-02	2.00E-02	1.85
OB2H	2.17	2.40E-02	1.50E-02	1.60
OB2I	1.99	1.00E-01	3.40E-02	2.94
OB2J	8.72	8.10E-03	6.50E-03	1.25
OB3A	2.53	1.90E-02	1.00E-02	1.90
OB3B	2.92	1.70E-02	1.10E-02	1.55
OB3C	0.03	1.90E-02	1.30E-02	1.46
OB3D	2.48	2.80E-02	1.80E-02	1.56
OB3E	2.82	2.70E-02	1.70E-02	1.59
OB3F	2.49	8.60E-03	1.30E-02	0.66
OB3G	2.50	3.50E-02	2.10E-02	1.67
OB3H	2.67	3.00E-02	2.00E-02	1.50
OB3I	2.53	6.60E-02	4.40E-02	1.50

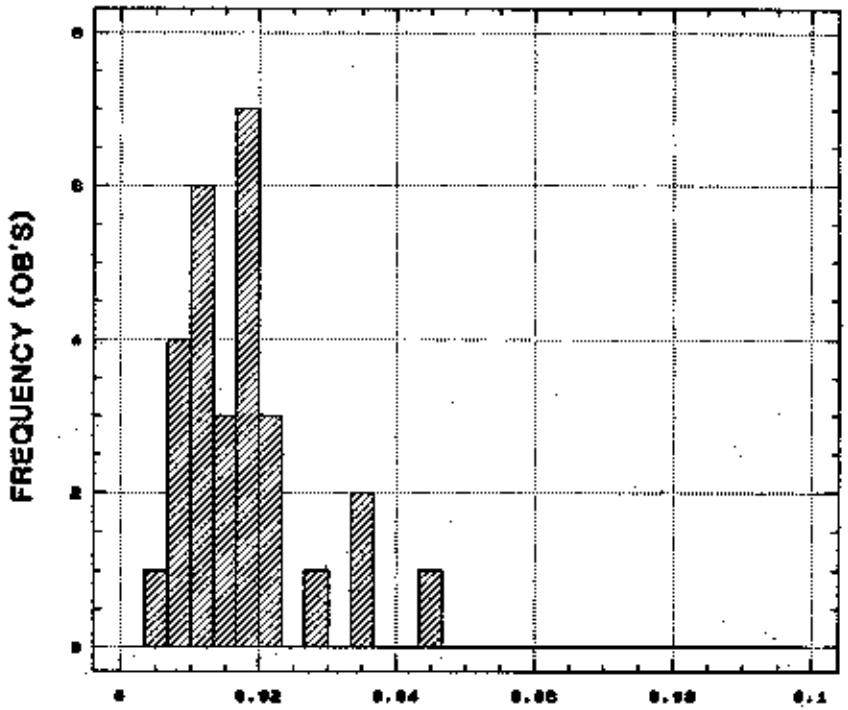
* To convert meters/day (m/d) to feet/day multiply by 3.28.

RICE

HVORSLEV METHOD



BOUWER AND RICE METHOD



Variable:	HVORSLEV	BOUWER & RICE
Sample size	28	28
Average	0.0284107	0.0175357
Median	0.0245	0.0165
Standard deviation	0.0202392	8.94001E-3
Minimum	8.1E-3	6.5E-3
Maximum	0.1	0.044
Range	0.0919	0.0375

TO CONVERT FROM METERS/DAY (m/d) TO FEET/DAY (ft/d) MULTIPLY BY 3.28

FREQUENCY HISTOGRAM AND SUMMARY STATISTICS FOR OBSERVATION WELLS (METERS/DAY)

FIGURE 6-4

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Values for test data analyzed by the Bouwer and Rice method are generally lower than values determined by the Hvorslev method. This is because the Hvorslev method assumes that the effective radius of influence for the test (i.e. the radius over which head loss or gain is dissipated) is equal to the distance from the bottom of the well to the potentiometric surface. Bouwer and Rice determined a method of calculating the effective radius of influence, R_e, from equation (1) based on an electrical resistance network analog for different test geometries with the assumption that drawdown of the water table around the well is negligible, that capillary drainage can be ignored, head losses as water enters the well (well losses) are negligible, and the aquifer is homogeneous and isotropic (Bouwer and Rice 1976). With this in mind, the Bouwer and Rice method was used to analyze all data because it is considered to more closely simulate test conditions. The Hvorslev technique was also used because it is widely used, hence levels itself to comparisons with other data.

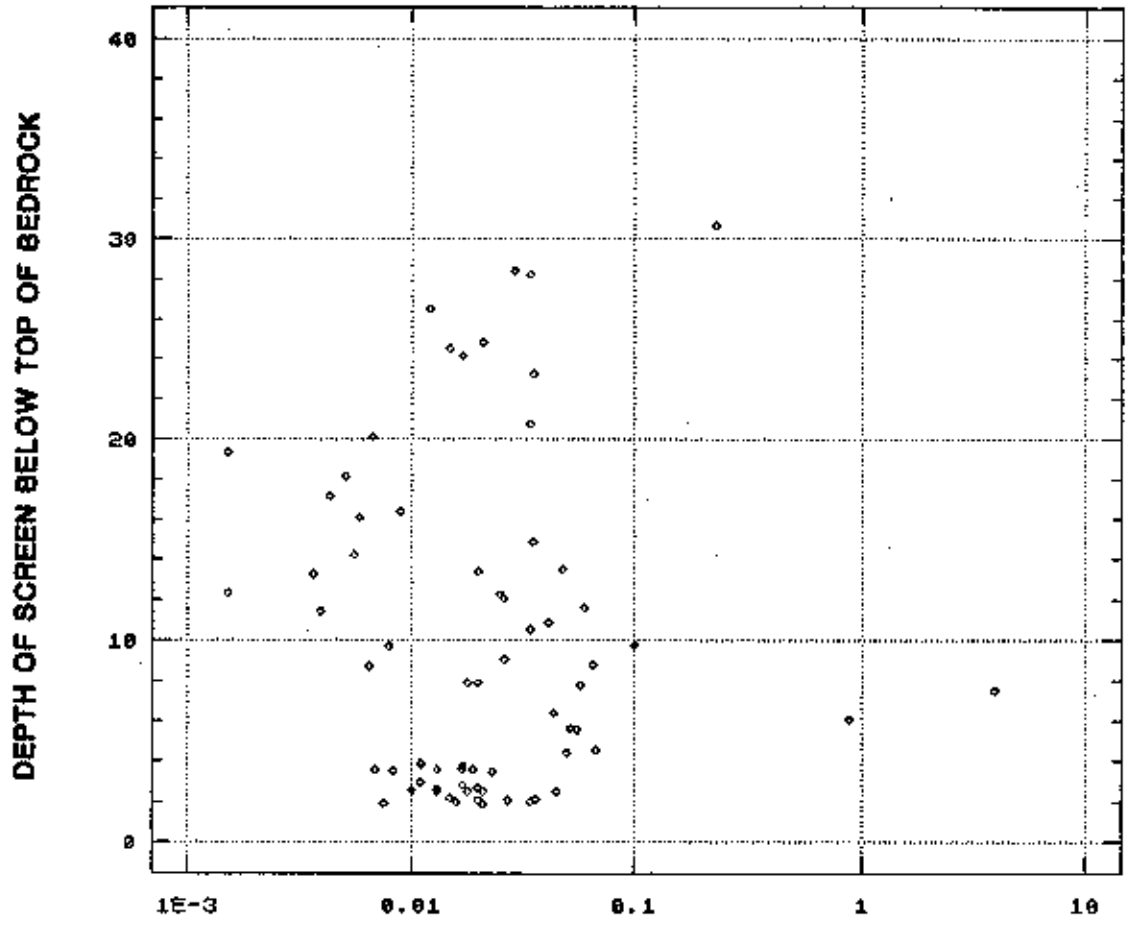
Analysis of slug test recovery data using the Bouwer and Rice Method was performed in general accordance with guidance supplied by Bouwer and Rice (1976) and Bouwer (1989). However, late time data was included in many cases so that it may appear that the data are not being treated in the manner prescribed by Bouwer and Rice, who suggest using straight line portions of the data which, in the examples, are displayed in early portions of the head recovery curve.

It should be noted that the examples in the literature are based on alluvial aquifer conditions where recovery occurs relatively rapidly, while conditions beneath the Weldon Spring site (WSS) more closely resemble aquitard properties in many instances. Almost all data exhibited fairly rapid early time recovery, which is considered to be indicative of filterpack or

annular influence. Future tests could use a potable water slug in order to minimize the effect of annular influence on recovery data. A water slug could be used to perform a falling head test by filling the well to the top of the casing with potable water. The active head would then be on the order of tens of feet rather than 2 to 5 feet. The larger active head would effectively exceed annular influence capacity (filterpack, developed zone), whereas most of the smaller active head (induced by relatively small solid slugs) is rapidly transmitted to the higher permeability filterpack and developed zone.

Figure 6-5 is a plot of the depth of the screened (mid-screen) interval below the top of bedrock on the vertical axis and hydraulic conductivity values increasing to the right on the horizontal axis. Plotted values are from all wells and were analyzed using the Bouwer and Rice method. The plot does not indicate any observable trend in hydraulic conductivity with respect to the depth of the screened interval below the top of bedrock. Hydraulic conductivity for MW-3006, one of the deepest wells tested, was significantly greater than the average and is probably a result of water-filled fractures at depth, as noted on the drilling log. Geochemical and contaminant data may be useful in determining whether water in this well is more like water in shallow wells than water in other deep wells.

While the lack of an observable trend with respect to the vertical distribution of hydraulic conductivity may seem to conflict with previous observations regarding a general decrease in hydraulic conductivity with increasing depth (BNI 1987), it should be noted that Bechtel conducted borehole permeability testing of both the unsaturated and saturated portions of the Burlington-Keokuk. It is well documented that the upper highly



DISTRIBUTION PLOT OF HYDRAULIC CONDUCTIVITY VALUES VERSUS DEPTH OF SCREEN BELOW TOP OF BEDROCK
(HYDRAULIC CONDUCTIVITY VALUES ARE BOUWER & RICE METHOD)

FIGURE 6-5

TO CONVERT FROM METERS/DAY (m/d) TO FEET/DAY (ft/d) MULTIPLY BY 3.28

REPORT NO.: DOE/OR/21548-122	DRAWING NO.: A/PI/019/0590	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 5/90

weathered portion of the bedrock is a zone of poor core recovery and frequent drilling fluid loss which is indicative of highly porous material (MKF and JEG 1990). However, this portion of the bedrock is generally not included in the slug test data due to the usually unsaturated nature of the high porosity zones. Possible exceptions to this are GT-58P and MW-4014, which are considered to reflect saturated conditions within the weathered bedrock. The values for these wells compare favorably with values reported by Bechtel for the unsaturated bedrock.

Drilling logs from these locations note loss of circulation, bit drop, and core loss during drilling. MW-4014 was injected with one pound of pyranine on July 1, 1988 as part of the Missouri Department of Natural Resources (MDNR) dye tracing program. The tracer was not detected at any of the sampling locations as of December 1988. However, the amount of dye used for the injection may have been insufficient to produce a positive detection. Based on slug test results as well as core loss, fluid loss during drilling, and quick recovery during development and purging for groundwater sampling, the hydraulic conductivities of these wells are considered to be typical of saturated portions of the upper weathered Burlington-Keokuk Limestone.

Slug test values for the observation well networks did not reveal any heterogeneities such as those discussed above. This is probably due to the fact that the highly weathered upper portion of the Burlington-Keokuk is not saturated in the vicinity of the observation well networks. Results of pumping conducted at the PW-3 network suggest that OB3I may not be functional due to lack of drawdown. However, slug tests performed on this well did not indicate poor hydraulic function of the well.

6.2 Pumping Tests

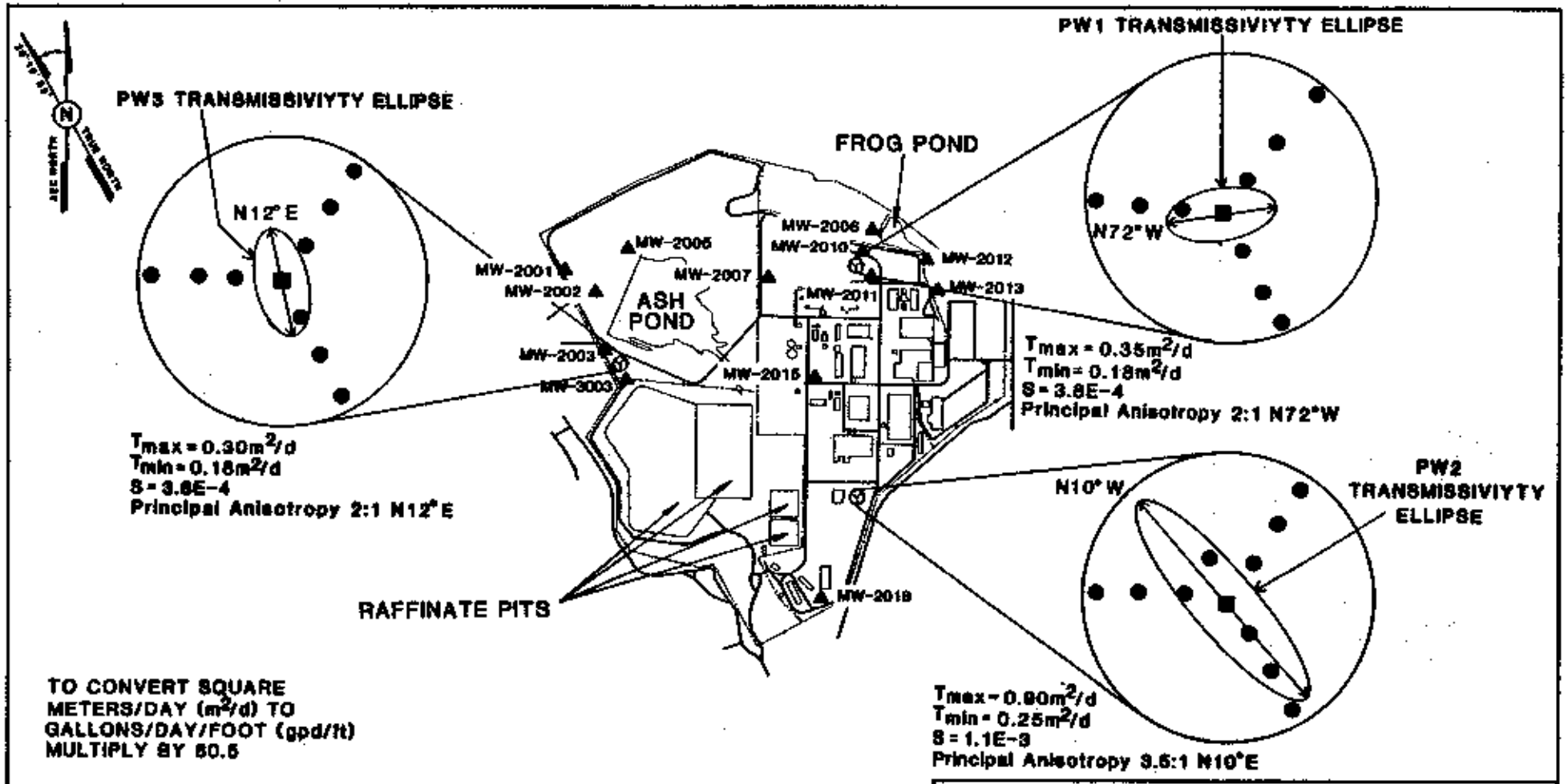
The following subsections present the results of pumping test data analyses. Transmissivity and storativity were determined using the Cooper-Jacob method. The Hantush method was used to determine anisotropy, transmissivity, and storativity. Additionally, hydraulic conductivity was calculated from pumping test data for correlation with slug test results.

6.2.1 PW-1 Results

All of the observation wells in the PW-1 network responded to pumping of PW-1. Data from these wells and PW-1 provided 10 sets of data for analysis. Figure 6-6 shows a summary of these results.

The values of transmissivity and storativity that were obtained using the Cooper-Jacob method are presented in Table 6-3. The values of transmissivity range from 3.6E-02 m^2/d (2.9 gpd/ft) to 5.8E-01 m^2/d (46.6 gpd/ft) with a mean of 2.0E-01 m^2/d (16.3 gpd/ft) and storativity values range from 1E-4 to 6.8E-04 with a mean of 2.9E-4. The Hantush method provided maximum and minimum values of transmissivity around PW-1 equal to 3.5E-01 m^2/d (28.4 gpd/ft) and 1.8E-01 m^2/d (14.4 gpd/ft), respectively, and a mean storativity of 1.7E-4.

Analysis using the Hantush method indicates the maximum transmissivity has a bearing of approximately N72°W. Comparingthe maximum and minimum transmissivities, it is apparent that the anisotropy ratio is approximately 2:1.



SUMMARY OF PUMPING TEST RESULTS

FIGURE 6-6

REPORT NO.: DOE/OR/21548-122		DRAWING NO.: A/CP/008/0590	
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TABLE 6-3 Hydraulic Properties Determined from Pumping Tests (Cooper Jacob Method)

Well	Pumping Data T* (m^2/d)	Pumping Data K** (m/d)	Pumping Data S	Recovery Data T (m^2/d)	Recovery Data K (m/d)	Recovery Data S
PW-1	0.078	0.0064		0.036	0.0030	
OB1A	0.19	0.016	0.00036	0.098	0.0080	0.00061
OB1B	0.30	0.025	0.00013	0.13	0.011	0.00020
OB1C	0.48	0.039	0.00013	0.26	0.021	0.00016
OB1D	0.19	0.016	0.00053	0.10	0.0082	0.00057
OB1E	0.31	0.025	0.00025	0.16	0.014	0.00026
OB1F	0.58	0.048	0.00018	0.31	0.025	0.00023
OB1G	0.20	0.017	0.00043	0.09	0.0078	0.00068
OB1H	0.23	0.019	0.00014	0.14	0.011	0.00018
OB1I	0.27	0.022	0.00010	0.14	0.011	0.00011
PW-2	0.11	0.0093		0.028	0.0023	
OB2A	0.42	0.035	0.00083	0.29	0.024	0.00116
OB2B	0.77	0.063	0.00158	0.65	0.054	0.00092
OB2C	0.94	0.077	0.00091	0.69	0.057	0.00047
OB2D	0.42	0.035	0.00081	0.20	0.016	0.00079
OB2E	0.62	0.051	0.00034	0.30	0.025	0.00033
OB2F	0.87	0.071	0.00043	0.57	0.047	0.00034
OB2G	0.41	0.034	0.00183	0.23	0.019	0.00101
OB2H	0.67	0.055	0.00102	0.47	0.038	0.00046
OB2I	0.69	0.057	0.00101	0.55	0.045	0.00040
OB2J	DID NOT RESPOND TO PUMPING					
PW-3	0.057	0.0047		0.032	0.0026	
OB3A	0.21	0.018	0.00054	0.11	0.0095	0.00052
OB3B	0.27	0.022	0.00023	0.18	0.015	0.00025
OB3C	0.31	0.026	0.00015	0.21	0.017	0.00017
OB3D	0.21	0.017	0.00055	0.10	0.0087	0.00070
OB3E	0.25	0.021	0.00015	0.13	0.011	0.00026
OB3F	0.37	0.031	0.00014	0.16	0.013	0.00018
OB3G	0.27	0.022	0.00046	0.13	0.011	0.00102
OB3H	0.30	0.025	0.00014	0.14	0.012	0.00028
OB3I	DID NOT RESPOND TO PUMPING					

T - Transmissivity
K - Hydraulic Conductivity
S - Storativity

* To convert transmissivity values from square meters per day (m^2/d) to gallons per day per foot (gpd/ft) multiply by 80.5.

** To convert hydraulic conductivity from meters per day (m/d) to feet per day (ft/d) multiply by 3.28.

Hydraulic conductivity values calculated from pumping and recovery data for the PW-1 array averaged 2.3E-02 m/d and 1.2E-02 m/d respectively.

6.2.2 PW-2 Results

Nine of the observation wells in the PW-2 network responded to the pumping of PW-2. Data from these wells and PW-2 provided 10 sets of data for analysis. Figure 6-6 summarizes these results. Deep observation well OB-2J (screened from 39.6-42.7 m [130-140 ft.]), at the PW-2 array did not respond to the pumping of PW-2.

The values of transmissivity and storativity obtained using the Cooper-Jacobs method are presented in Table 6-3. The values of transmissivity range from 2.8E-02 m^2/d (2.3 gpd/ft) to 8.7E-01 m^2/d (70.4 gpd/ft) with a mean of 4.9E-01 m^2/d (39.9 gpd/ft) and storativity values range from 3.3E-4 to 1.8E-3 with a mean of 8.1E-4. The Hantush method provided maximum and minimum values of transmissivity around PW-2 equal to 9.0E-01 m^2/d (72.4 gpd/ft) and 2.5E-01 m^2/d (20.5 gpd/ft), respectively, and an overall storativity of 1.3E-3.

Analyses using the Hantush method indicate the maximum transmissivity has a bearing of approximately N101°W. Comparing the maximum and minimum transmissivities, it is apparent that the anisotropy ratio is approximately 3.5:1.

Hydraulic conductivity values calculated from pumping and recovery data using the pumping and observation wells at the PW-2 location averaged 4.9E-02 m/d for pumping data and 3.3E-02 m/d for recovery data.

6.2.3 PW-3 Results

Eight of the nine observation wells at the PW-3 network responded to the pumping of PW-3. Data from these wells and PW-3 provided nine sets of data for analysis. A summary of results is presented in Figure 6-6. OB-3I did not show any response to the pumping of PW-3. A discussion of possible explanations for the lack of response at OB-3I is presented in Subsection 6.2.4.1.

The Cooper-Jacob analysis of the data from the PW-3 array provided many values of transmissivity and storativity (Table 6-3). The values of transmissivity range from 3.2E-02 m^2/d (2.6 gpd/ft) to 3.7E-01 m^2/d (29.9 gpd/ft) with a mean of 1.9E-01 m^2/d (15.5 gpd/ft) and storativity values range from 1.4E-4 to 1.0E-3, with a mean of 3.6E-4. The Hantush method provided maximum and minimum values of transmissivity around PW-3 equal to 3.0E-01 m^2/d (24.3 gpd/ft) and 1.8E-01 m^2/d (14.4 gpd/ft), respectively, and an overall storativity of 4.0E-4.

Analyses using the Hantush method indicate the maximum transmissivity has a bearing of approximately N12°E. Comparing the maximum and minimum transmissivities, it is apparent that the anisotropy ratio is approximately 2:1.

Hydraulic conductivity values calculated from pumping and recovery data using pumping and observation wells at the PW-3 locations averaged 2.1E-02 m/d for pumping data and 1.1E-02 m/d for recovery data.

6.2.4 Discussion

6.2.4.1 Pumping Test Data

The results of pumping test data analyses can be most readily compared by referring to Figure 6-6. Figure 6-6 shows that the major axis of transmissivity is aligned approximately north-south at the PW-2 and PW-3 networks. However, the effective transmissivity at PW-2 is approximately twice that for the vicinity of PW-3. Furthermore, the degree of anisotropy is greater near PW-2 than PW-3 and storativity was determined to be an order of magnitude higher near PW-2. Higher hydraulic properties for the PW-2 vicinity may be attributed to the fact that the PW-2 network is screened higher in the section and monitors a more highly weathered portion of the Burlington-Keokuk. Comparison of PW-2 results with those for PW-1 and PW-3 may indicate vertical anisotropy within the upper Burlington-Keokuk Limestone.

Figure 6-6 also shows that the major direction of anisotropy near PW-1 is aligned approximately parallel to the northwest trending observation well array, approximately 60° from the orientation of maximum transmissivity at PW-2 and PW-3. Note that the major axis of the apparent transmissivity tensor at PW-3 is oriented approximately parallel to the minor axis at PW-1. Also the values for transmissivity and storativity near wells PW-1 and PW-3 are approximately equal.

As noted previously, the current analyses have concentrated on observing and interpreting effects of lateral anisotropy. However, evidence of other phenomena has been observed in the test well data. Although quantification of such phenomena is

hindered by the quality of the data, the following statements can be made about some of the apparent phenomena:

- In general, the pumping test data were reviewed for evidence of short-term or long-term recharge effects, barrier-boundary effects, and hydraulic separation between pumped wells and observation wells.

- Although the data from wells near PW-1 showed evidence of recharge effects, as evidenced by declining rates of drawdown during the test, they also show increasing rates of drawdown during latter stages of the test. The variations in drawdown do not correlate to similar variations in pumping rates, indicating a likelihood of other hydraulic phenomena occurring. One possible explanation of the phenomenon would be classical delayed yield due to gravity drainage. This interpretation would be consistent with the very low values of storativity (1E-04 to 1E-03) calculated from earlier portions of the time-drawdown data, before the recharge effects began to be observed. However, the changes from declining to increasing rates of drawdown were generally more abrupt than would be expected from classical delayed yield effects, and the phenomena are not consistently observed for all three pumping well locations. An alternative interpretation might be recharge derived from draining a larger fracture or conduit near the pumping well, followed by barrier-boundary effects once the fracture has been locally drained.

For the vicinity of PW-2, recharge effects are generally observed only along the south-bearing ray of wells. This is also the approximate orientation of the major direction of

transmissivity. Along the other two rays, recharge effects are generally not observed, whereas barrier effects are definitely observed at two wells and possibly observed at two other wells. These results suggest that delayed yield may be due to a zone of discrete flow which parallels the south-bearing ray of wells. These results are consistent with possible recharge from fractures or conduits along the south-bearing ray, with no such features along the northwest- and northeast-bearing rays.

The fact that OB2J did not respond to pumping, yet lies along the principal axis of anisotropy, suggests that discrete flow influences present along the south-bearing ray do not extend to the depth of the screened interval of OB2J.

In the vicinity of PW-3, recharge effects are commonly observed and evidence of late time barrier effects is lacking. This again suggests that delayed yield is not a predominant phenomenon. This effect would, however, be consistent with more generalized dual-permeability conditions near PW-3. In this interpretation, diffuse-flow permeability, which is reflected in the calculated aquifer parameters, would provide the major response of the aquifer to pumping, with discrete-flow permeability providing generalized recharge later in the test. The diffuse-flow permeability could be attributed to intergranular or fine-fracture flow, with discrete-flow permeability resulting from larger, more widely spaced fractures or conduits.

In addition to the potential recharge effects described above there is also some evidence of short-term effects consistent with a dual-permeability aquifer. In data from several wells, there was a short-time rise in water levels, or brief flattening of the drawdown curve, which would be consistent with temporary recharge

from a fracture or conduit, followed by cessation of recharge consistent with drainage of the fracture. Such effects are seen in wells PW-1 (500 minutes), OB1A and OB1G (200-350 minutes), and possibly OB1I (400-500 minutes); note that wells OB1A and OB1G are aligned approximately parallel to the inferred major direction of anisotropy at PW-1. Since such effects are seen in all nine observation wells, this may partially explain the generally higher transmissivities and storativities inferred from data at PW-2 than from the other two wells. Similar short-term recharge effects are not readily observed in data from PW-3 observation wells indicating that the cone of influence for PW-3 is dominated by diffuse flow permeability.

Isolated evidence of barrier-boundary effects was also occasionally observed, notably in wells OB2C, OB2G, and OB3F, and possibly in test wells PW-2 and PW-3. Wells OB2C, OB2G, and PW-2 are aligned generally parallel to the direction of minimum transmissivity near PW-2 indicating a lack of discrete-flow permeability along this orientation.

Two observation wells did not readily respond to production from nearby pumping wells: OB2J and OB3I. OB3I is located about 18 m (60 ft) from PW-3 along ray 3, and is screened at an elevation comparable to that of PW-3. Slug test data indicate that OB3I responds in a manner similar to other observation wells near PW-3, so it does not appear to be hydraulically isolated due to any well construction or well development difficulties. A possible explanation could be the presence of a filled fracture (as have been observed during site drilling activities) lying between OB3H and OB3I. However, no boundary effects were seen in the drawdown curve of OB3H.

Well OB2J is located approximately 6 m (19 ft) from PW-2, but is screened within a much deeper interval of the limestone 40-43 m (130-140 ft) below ground surface for OB2J compared to approximately 14-26 m (45-85 ft) below ground surface for the other observation wells at PW-2). The lack of response at this well suggests a degree of hydraulic separation between shallower and deeper parts of the aquifer, consistent with the results of in situ aquifer tests and water-level observations. The hydraulic separation may be due to strong vertical anisotropy due to the layered nature of the aquifer, a general decline in hydraulic conductivity with depth due to smaller apertures and more widely spaced fractures, or a combination of such factors.

The drawdown data were reasonably consistent with the constraints of the Hantush approach for analyzing data in the presence of areal anisotropy. It was possible to readily match the observed drawdown distributions with families of ellipses having more-or-less parallel major and minor axes. Furthermore, it was generally possible to obtain reasonably consistent transmissivity estimates from different observation wells utilizing different analytical techniques (Jacob time-drawdown, Hantush time-drawdown, Jacob distance-drawdown, and Hantush distance-drawdown). Exceptions to this general conclusion are discussed above.

In general, many of the observation wells exhibited evidence of significant recharge in the later portion of the tests. This is consistent with classical delayed yield due to gravity drainage, leakage from overlying or underlying beds, or possibly to double porosity relationships such as could readily occur in a fractured rock with some degree of intergranular or fine-fracture porosity. The calculated storativity is relatively low, consistent with that of a classical confined, homogeneous

aquifer. Since the estimates of storativity are derived largely from early-time data during each test, this low storativity could be consistent with classical delayed yield. Observation wells at PW-1 exhibit some indication of a possible late-time return to a Theis curve, which is also typical of a delayed yield effect. On the other hand, the very-late-time return to an apparent Theis curve is more abrupt than would be expected from classical delayed yield theory. Since this phenomenon is not generally observed at the PW-2 and PW-3 observation wells, delayed yield does not appear to be a major cause of the observed drawdown behavior.

Leakage from overlying or underlying strata is not expected. The pumping and observation wells were designed to be completed in the uppermost saturated interval of the aquifer, so that overlying source beds generally do not exist. Perched groundwater zones are known to exist in the vicinity of the raffinate pits; however, drilling performed for installation of observation wells and pumping wells did not encounter perched conditions. Furthermore, the lack of response at well OB2J suggests that there is relatively little hydraulic connection between the depth interval tested and deeper portions of the Burlington-Keokuk; thus, significant upward leakage is unlikely.

Double porosity effects are quite possible at the site. As noted in previous site reports (MKF and JEG 1989b, BNI 1987), the Burlington-Keokuk Formation is generally expected to exhibit some aspects of both intergranular and fracture porosity. The low transmissivities and storativities observed would be consistent with a very fine-grained, low-permeability granular aquifer, or an aquifer with very fine interconnected fractures which behaves as an equivalent porous medium. The recharge effects would be consistent with secondary fracture porosity zones capable of

supplying recharge to the intergranular aquifer as water levels are drawn down. There is evidence in the drawdown data from some observation wells of temporary recharge effects, which might be consistent with the draining of relatively isolated fracture zones. There is also evidence in the data from a few wells of possible barrier-boundary effects, which might suggest poor lateral communication between wells such as might be expected under aquitard conditions.

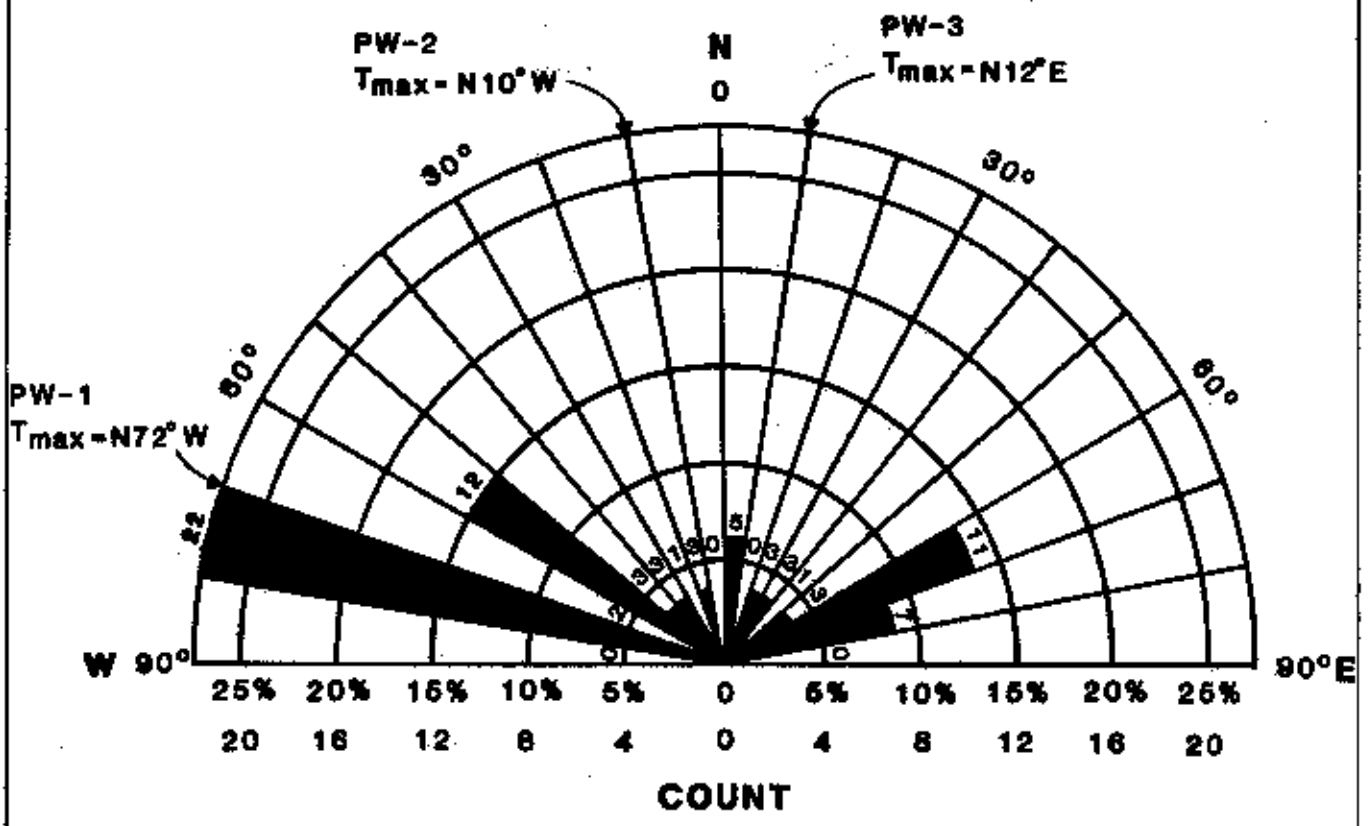
Radii of influence were determined for each of the test networks (ESI 1989). In general the radii are on the order of 60 m (200 ft). However, along OB1G, OB1H, and OB1I the distance where zero drawdown occurs is 275 m (900 ft). This ray of wells lies in the same direction as the primary direction of fractures in the formation (MKF and JEG 1989b). Therefore, a fracture may be transmitting the effects of pumping farther than expected.

Hydraulic conductivity values calculated from pumping and recovery data correlate well with values determined from slug testing. Table 6-4 presents a comparison of mean hydraulic conductivity values determined from pumping and observation wells and slug tests.

Anisotropic analyses of transmissivity indicated orientations of N72°W for PW-1, N10°W for PW-2 and N12°E for PW-3. In Figure 6-7, the orientations of maximum transmissivity are compared to fracture orientations observed in bedrock exposures in the vicinity of the Weldon Spring site. The orientation of maximum transmissivity at PW-1 coincides with a major fracture set whereas the orientations of maximum transmissivity at PW-2 and PW-3 are coincident with minor fracture features. This suggests that groundwater flow is controlled by lateral anisotropy in the form of horizontally oriented fractures and that vertical

TABLE 6-4 Comparison of Hydraulic Conductivity Values Determined from Slug Tests and Pumping Tests

Pump Well Array	Mean K-Value (m/d) from Pumping Test Data	Mean K-Value (m/d) from Slug Tests (Bouwer and Rice)	Ratio Pumping Test Mean/Slug Test Mean
PW-1	2.3E-02	1.4E-02	1.60
PW-2	4.9E-02	2.1E-02	2.30
PW-3	2.1E-02	1.8E-02	1.20



A PLOT OF THE STRIKE OF 80 FRACTURES MEASURED AT BEDROCK EXPOSURES IN THE VICINITY OF THE WELDON SPRING SITE AND THE ORIENTATION OF MAXIMUM TRANSMISSIVITY AT PW-1, PW-2 AND PW-3

DIP OF MOST FRACTURES IS NEARLY VERTICAL.

COMPARISON OF WELDON SPRING SITE VICINITY FRACTURE ORIENTATIONS AND ORIENTATIONS OF MAXIMUM TRANSMISSIVITY OF PW-1, PW-2 AND PW-3

FIGURE 6-7

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fracture orientation has little impact on orientation of lateral anisotropy.

6.2.4.2 Recovery Data

Recovery data were evaluated by the subcontractor, Earth Scientists, Inc. (ESI), using semi-logarithmic plots of elapsed recovery time versus residual drawdown to obtain values of transmissivity and storativity. A verification of the accuracy of the subcontractor recovery results was conducted to determine whether the recovery data warranted reevaluation. The verification process involved construction of time-recovery plots of observation wells to determine storativity values and construction of residual drawdown plots of pumping and observation wells to determine transmissivity. The time-recovery plots and residual drawdown plots were constructed according to Driscoll (1986). Results of the recovery data verification are compared to ESI's reported values in Table 6-5. The verification process did not indicate a significant difference in aquifer property values which could be attributed to the methods of recovery data evaluation.

6.3 Tracer Tests

The following sub subsections present the results of tracer test data analysis. The values obtained from the tracer test data were verified using RESSQ, a two-dimensional advection-adsorption contaminant transport modeling program (Javandel et al. 1984). Values of porosity and induced flow velocity were used to determine a calculated travel time.

Tracer tests were performed at the PW-2 and PW-3 locations which exhibited the upper and lower range, respectively, of

TABLE 6-5 Comparison of Aquifer Properties Determined from Evaluation of Recovery Data by the PMC and ESI

Well ID	PMC Results Transmissivity*	PMC Results Storativity	ESI Results Transmissivity	ESI Results Storativity
PW-1	0.033	- - -	0.036	- - -
OB1A	0.099	0.00066	0.098	0.00061
OB1B	0.15	0.00027	0.13	0.00020
OB1C	0.26	0.00018	0.26	0.00016
PW-2	0.05	- - -	0.028	- - -
OB2A	0.288	0.00012	0.294	0.00012
OB2B	0.544	0.00092	0.656	0.00092
OB2C	0.650	0.00046	0.690	0.00047
PW-3	0.031	- - -	0.032	- - -

* Square meters/day (m^2/d)

To convert from m^2/d to gallons per day/foot (gpd/ft) multiply by 80.5.

PMC - Project Management Contractor
ESI - Earth Scientists Incorporated

hydraulic properties determined from pumping tests. Tracer tests were not conducted at PW-1 since the hydraulic properties for this location were considered to be similar to those at PW-3.

6.3.1 PW-2 Results -- Chloride Tracer

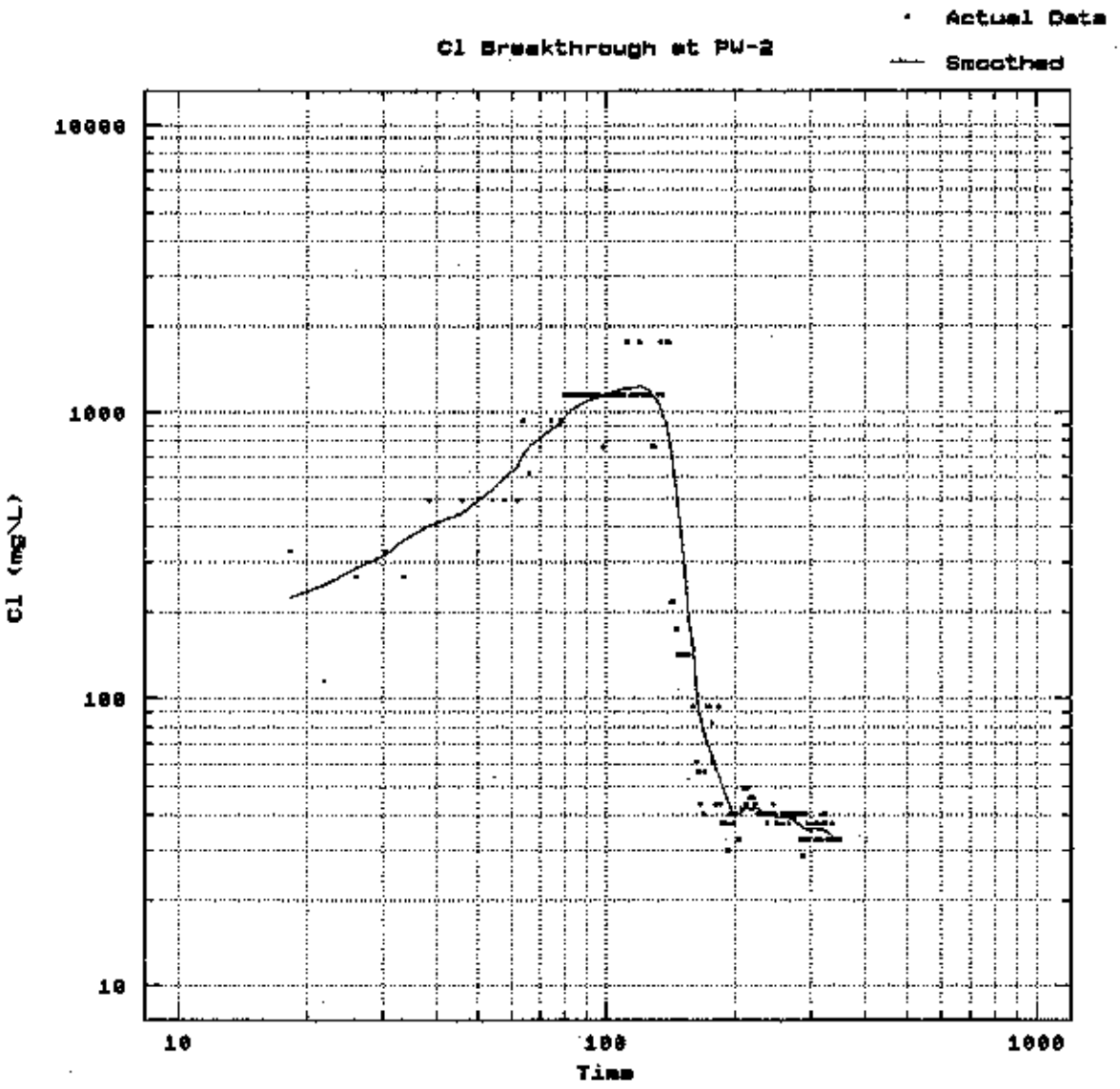
Using Figure 6-8, the tracer centroid arrival time was determined to be 125 hours after injection. Application of Darcy's law yielded an effective porosity of approximately 0.003 in the formation between OB2I and PW-2. Applying the transport equation and the relationship between dispersivity and hydrodynamic dispersion, the dispersivity was found to be approximately 0.049 m (0.16 ft).

6.3.2 PW-2 Results -- Bromide Tracer

Using Figure 6-9, the tracer centroid arrival time was determined to be 260 hours after injection. Application of Darcy's law yielded an effective porosity of approximately 0.015 in the formation between OB2E and PW-2. Applying the transport equation and the relationship between dispersivity and hydrodynamic dispersion, the dispersivity was found to be approximately 0.025 m (0.081 ft).

6.3.3 PW-3 Results -- Chloride Tracer

Using Figure 6-10, the tracer centroid arrival time was determined to be 190 hours after injection. Application of Darcy's law yielded an effective porosity of approximately 0.002 in the formation between OB3F and PW-3. The dispersivity was found to be about 0.014 m (0.047 ft).



PLOT OF CHLORIDE TRACER CONCENTRATION VERSUS TIME AT PW-2

FIGURE 6-8

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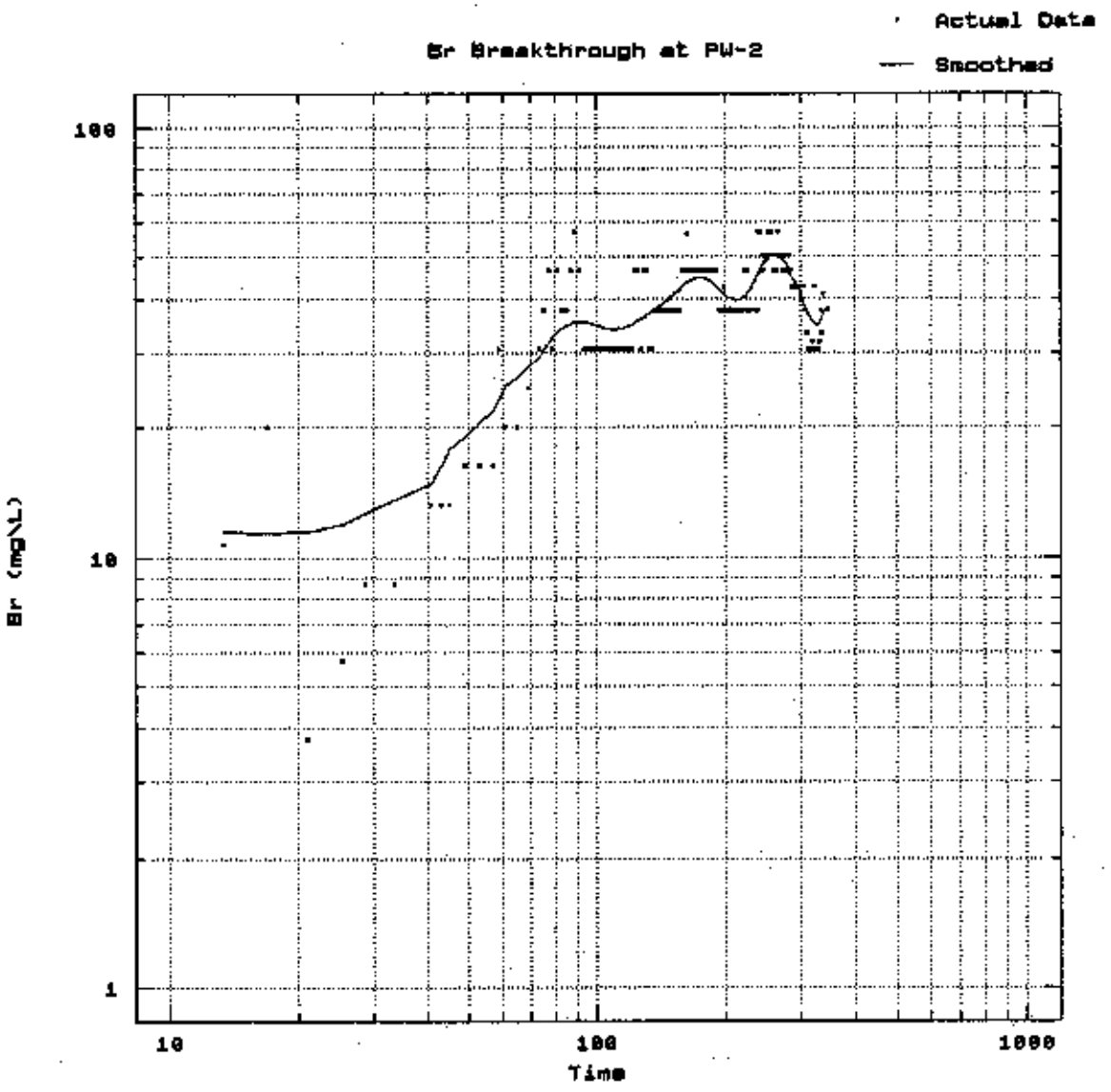

PLOT OF BROMIDE TRACER CONCENTRATION VERSUS TIME AT PW-2

FIGURE 6-9

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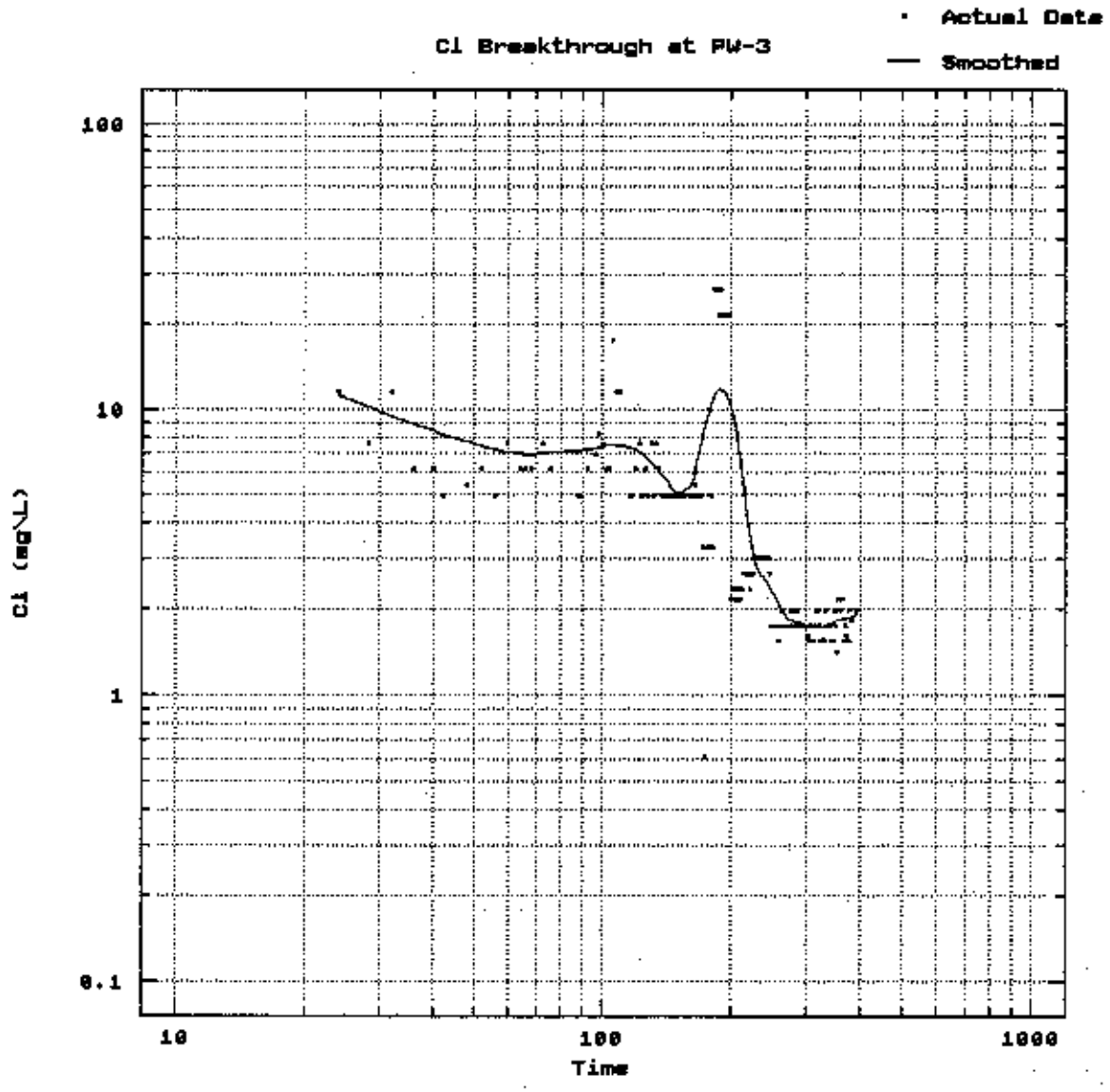


PLOT OF CHLORIDE TRACER CONCENTRATION VERSUS TIME AT PW-3

FIGURE 6-10

REPORT NO: DOE/OR/21548-122		DRAWING NO.: A/PV/024/0590	
ORIGINATOR: JDC	DRAWN BY: GLN	DATE: 5/90	

6.3.4 PW-3 Results -- Bromide Tracer

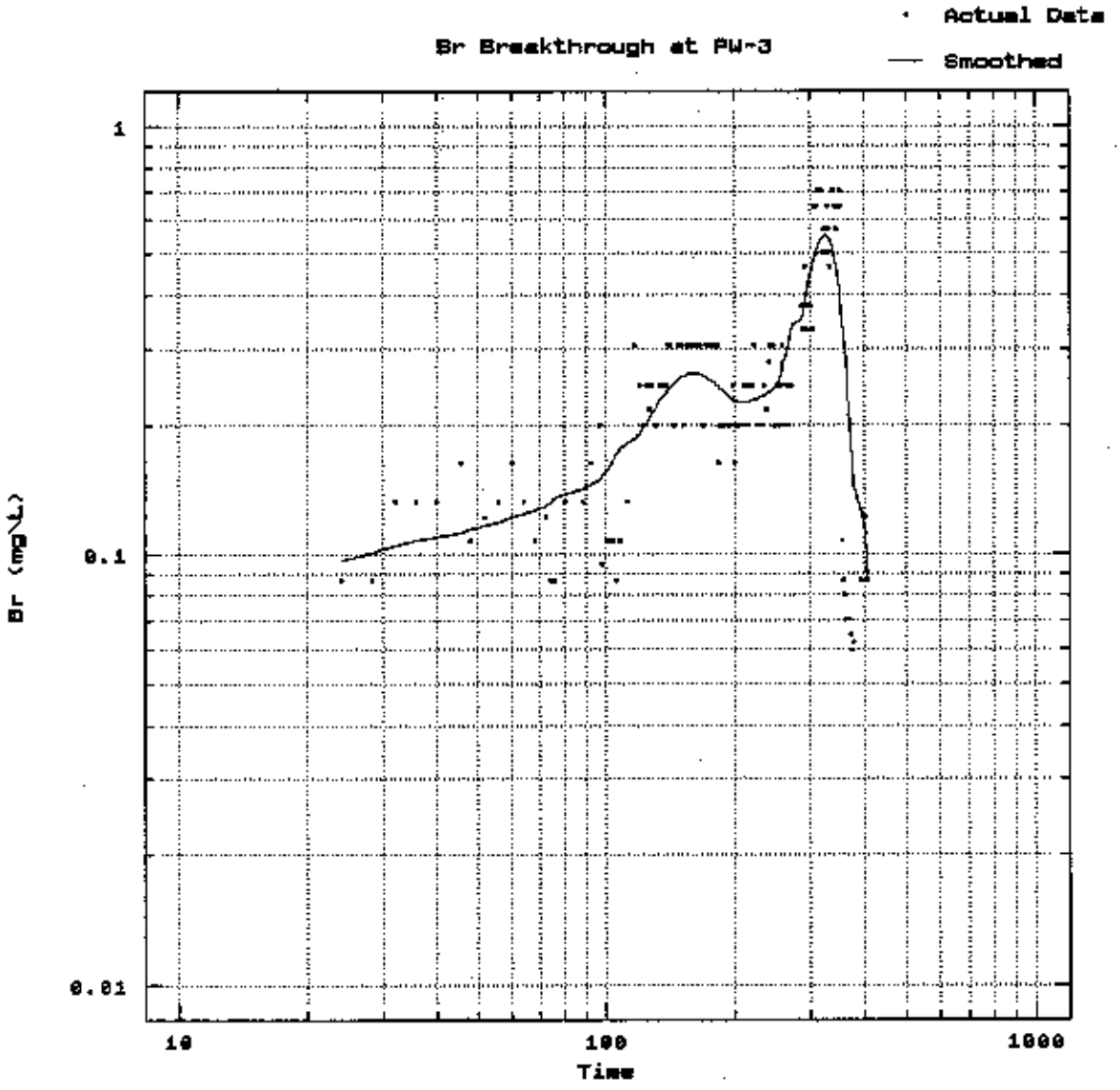
Using Figure 6-11, the tracer centroid arrival time was determined to be 320 hours after injection. Application of Darcy's law yielded an effective porosity of approximately 0.006 in the formation between OB3C and PW-3. The dispersivity was found to be about 0.0088 m (0.029 ft).

6.3.5 Discussion

Figures 6-8, 6-9, 6-10, and 6-11 are plots of time versus tracer concentration. A simple moving average technique was used to obtain a smoothed time-series vector for each tracer concentration data set.

The preinjection concentration of chloride at PW-2 was approximately 40 mg/l. From inspection of Figure 6-8 it appears that initial tracer breakthrough occurred prior to sample collection at PW-2. Peak concentration was determined to be at 125 hours. The asymmetric shape indicates dispersion of the tracer front under the induced gradient and a prompt return to preinjection concentrations after arrival of the tracer centroid. The tail dispersion may have been suppressed by the 275 liter chaser used to drive the tracer into the formation. The chaser may have diluted tail concentrations, while accentuating the centroid. The shape of the curve also suggests the tracer behaved as a single slug.

The concentration of bromide with time at PW-2 is shown in Figure 6-9. Preinjection concentrations for bromide were about 0.4 mg/l. While the tracer centroid was determined to have arrived 260 hours after injection, inspection of the data indicates initial breakthrough of peak concentration at



PLOT OF BROMIDE TRACER CONCENTRATION VERSUS TIME AT PW-3

FIGURE 6-11

REPORT NO.:	DOE/OR/21548-122	DRAWING NO.:	A/PI/025/0590		
ORIGINATOR:	JDC	DRAWN BY:	GLN	DATE:	5/90

approximately 88 hours after injection. The 88-hour time value for bromide breakthrough is not unreasonable considering the distance necessary for the bromide tracer to travel between OB-2E and PW-2, compared to the distance necessary for the chloride tracer to travel between OB-2I and PW-2. Additionally, if the orientation of maximum transmissivity is considered to be parallel to the bromide travel path, then a lower breakthrough time value is expected for the bromide tracer, given that bromide and chloride have essentially the same degree of conservativeness. The curve for bromide also exhibits a degree of oscillation in the centroid which may be the result of discrete tracer fractions traveling somewhat different travel paths (fractures), and therefore having different arrival times due to the relative distance of each travel path. The bromide concentrations did exhibit a sharp decline as with the chloride tracer.

Figure 6-10 is a plot of chloride versus time at PW-3. The preinjection concentration of chloride at PW-3 was about 6 mg/l. Concentrations of chloride at PW-3 were much lower in general than those at PW-2. The lower tracer concentrations may be the result of forcing the tracer into the formation where the bulk of the tracer entered fracture travel paths which were either of longer distance than that which could be evaluated with the available time, or were not connected to flow paths which intersected the pumping well. Centroid arrival was determined to be 190 hours after injection. The data also indicate a possible peak concentration at about 110 hours which may be due to tracer slug fractionation. Chloride concentrations decline sharply to below preinjection concentrations beginning at 200 hours and remain low for the remainder of the monitoring period. The rapid decline to preinjection levels may be due to dilution by the chaser water.

Bromide concentrations at PW-3 (Figure 6-11) were also lower than at PW-2. The preinjection bromide concentration was approximately 0.1 mg/l. Dispersion of the tracer front and dilution after the peak concentration is evident on the plot. Bromide also exhibited dual peaks, possibly due to tracer fractionation, similar to what was observed for chloride at PW-3 and bromide at PW-2. Use of the chaser seems to have diluted tail dispersion in a manner similar to what was observed at other locations.

The values of effective porosity obtained from the tracer tests are approximately one order of magnitude higher than the storativity values found from the pumping test data. It is believed that values obtained using the tracer test method are more reliable than values derived from pumping well drawdown data since tracer test values are a result of observed tracer travel times. As with the transmissivity, effective porosity was expected to be low. Results show that it ranges between 0.002 and 0.015. Local variations of the effective porosity, seen around both networks of wells, can be related to the directional variations in lateral anisotropy within the formation as determined by the Hantush analysis of pumping test data.

Dispersivity is a measure of the amount of mechanical mixing that occurs in a contaminant mass as it travels through a porous media. Causes of mixing include velocity differences within the pores and differences in the length of the pore channels through which the contaminant molecules move. Mixing causes some of the contaminant molecules to travel faster and some slower than the average linear groundwater velocity. Therefore, dispersivity causes the contaminant plume to grow in size as time increases. Dispersivities ranging from a minimum of 0.0088 m (0.029 ft) to a maximum of 0.049 m (0.16 ft) were determined from the tracer test

data. These values are relatively low and may indicate that a contaminant plume in the aquifer would increase in size very slowly. Correspondingly, contaminant concentrations may decrease, assuming that retardation mechanisms are negligible. The low values also indicate that the tested portions of the aquifer can, in a general sense, be treated as an equivalent porous medium since lower values would be indicative of fracture flow with less mixing.

Field-scale dispersivities are also considered to be proportional to the scale of the transport path under investigation (Fetter 1980). Since the tracer tests were applied to a rather small portion of the aquifer volume it is implicit that observed dispersivity values are smaller than what would be observed during a larger-scale test in more porous media. Consequently, it is difficult to make substantive inferences regarding the relative magnitudes of intergranular and fracture flow based solely on tracer test data. From inspection of tracer tests, it was determined that secondary porosity effects are evident as pulses in tracer concentration due to differential velocity through fractures. In the test horizon, primary porosity (intergranular) is considered to be very low while secondary porosity can be expected to exhibit a range of values. The lower end of this range is represented by tracer test data obtained during pumping. The upper end is represented by high slug test values (MW-4014 and GT-58P).

In order to increase confidence in the values for effective porosity derived from the tracer tests, the advection-adsorption contaminant transport model RESSQ was used to simulate tracer transport and verify initial arrival times of the tracers. RESSQ is normally used to simulate both contaminant transport from sources (e.g., injection wells, leaky tanks, or impoundments) to

sinks (e.g., extraction wells or natural groundwater discharge locations) and variations in contaminant concentrations with time. However, the program is considered applicable for verification of tracer travel times where the observation wells used for tracer injection are considered to represent sources and the pumped wells represent concentration sinks.

RESSQ was run for each tracer test using the effective porosities derived from each test. These values are reported in Section 6.3. Additional parameters required to run RESSQ include flow direction (which in this case was the bearing between the observation well used for tracer injection and the pumped well), average linear velocity due to pumping, aquifer thickness, and the adsorption capacity of the host media. Average linear velocity due to pumping ranged from 7.8E-03 m/day (2.5E-02 ft/day) for the chloride tracer traveling between OB-3F and PW-3, to 2.5E-02 m/day (8.2E-02 ft/day) for the bromide tracer traveling between OB-2E and PW-2. Aquifer thickness was assumed to be 12.5 m (41 ft) for all cases and adsorption capacity was considered to be zero for all cases.

Travel times determined using RESSQ ranged from 16 to 45 days, while actual travel times ranged from 8 to 10 days.

The differences in the range of observed tracer travel times and those determined using RESSQ are considered to be sufficiently small with respect to the validity of tracer-derived values for effective porosity. This is demonstrated by the observation that input porosity values for RESSQ would only decrease by a factor of four in order to obtain an RESSQ travel time equal to that seen in the tracer tests.

7 FLOW DYNAMICS

This section presents determinations of hydraulic gradients and calculations of groundwater velocities for selected flow paths using input values based on the results of slug tests and tracer tests.

7.1 Hydraulic Gradients

Horizontal hydraulic gradients were determined for six potential flow paths, four in the shallower portion of the Burlington-Keokuk Limestone and two in the deeper portion of the same formation. Flow paths were chosen to obtain values for average linear groundwater flow velocity under diffuse Darcian conditions. The horizontal flow paths were chosen to obtain a range of values for flow in a number of directions. The choice of deep flow paths is limited directionally due to the distribution of deep wells at the site. The selected flow paths do not suggest preferred flow paths. For horizontal flow situations, the hydraulic gradient is a measure of the slope of the potentiometric surface of the groundwater within an aquifer. It is defined as:

$$i = \frac{dh}{dl} \qquad (13)$$

where:

dh = difference in potentiometric head between two points
dl = distance between the two points.

The gradients that were obtained along the selected flow paths are presented in Table 7-1.

The vertical flow component has been inferred to be very low. The Phase II Groundwater Quality Assessment for the Weldon Spring Chemical Plant, Raffinate Pits and Vicinity Properties (MKF and JEG 1989a) suggests that there is poor communication between the upper and lower portions of the aquifer. This inference is based on vertical distributions of contaminants. Also, results of the pumping test at the PW-2 network showed that OB2J did not respond to pumping. This indicated that there is little or no communication between the upper (weathered) and lower (competent) portions of the aquifer.

Observed hydraulic gradients at well pairs exhibited a range of values from approximately 0.6 for MW-2018 and MW-2019 to 0.009 for MW-3006 and MW-3003. This range of observed gradients, along with the lack of response in OB2J during pumping, probably reflects the limitations of an equivalent porous medium approach, where diffuse flow, occurring within fine fractures, and a strong horizontal anisotropy inhibit vertical flow which can be assessed through Darcian principles. Some variation in vertical gradient may be due to the relative proximity of the various well pairs to widely spaced vertical fractures. Distributions of contaminant levels in paired deep and shallow wells do not correlate well with values of observed hydraulic gradients. For example, the vertical gradient between MW-3003 and MW-3006 is 0.009, which suggests relatively good hydraulic communication. However, nitrate concentrations reported in the 1989 Annual Site Environmental Report (MKF and JEG 1990b) ranged from 312,000 mg/l to 1,885 mg/l for MW-3003. The range for nitrate in MW-3006 during the same time period was 188.0 mg/l to undetected which,

TABLE 7-1 Hydraulic Gradients and Hydraulic Conductivities and Resulting Average Linear Velocities of Groundwater

Flow Path	Hydraulic Gradient	Hydraulic Conductivity (m/d)		Average Linear Velocity (m/d) *	
		Bouwer and Rice	Hvorslev	Bouwer and Rice	Hvorslev
MW-3003 to MW-2002	7.5E-03	2.5E-02	6.3E-02	2.8E-02	6.8E-02
MW-2013 TO MW-4017	1.6E-02	3.3E-02	6.6E-02	7.6E-02	1.5E-01
OB2F TO MW-4021	5.0E-03	3.1E-02	4.6E-02	2.2E-02	3.3E-02
MW-2018 TO MW-4022	2.2E-02	3.8E-02	1.4E-01	1.2E-01	4.4E-01
MW-3006 TO MW-2022**	4.0E-03	1.3E-01	1.4E-01	7.4E-02	8.0E-02
MW-2028 TO MW-2024**	1.9E-02	2.5E-02	2.4E-02	6.7E-02	6.8E-02

* To convert the velocity to units of ft/d, multiply by 3.28.

** Flow path in the deeper portion of the Burlington-Keokuk aquifer.

on the basis of contaminant distribution, suggests poor hydraulic communication.

7.2 Groundwater Velocities

7.2.1 Results

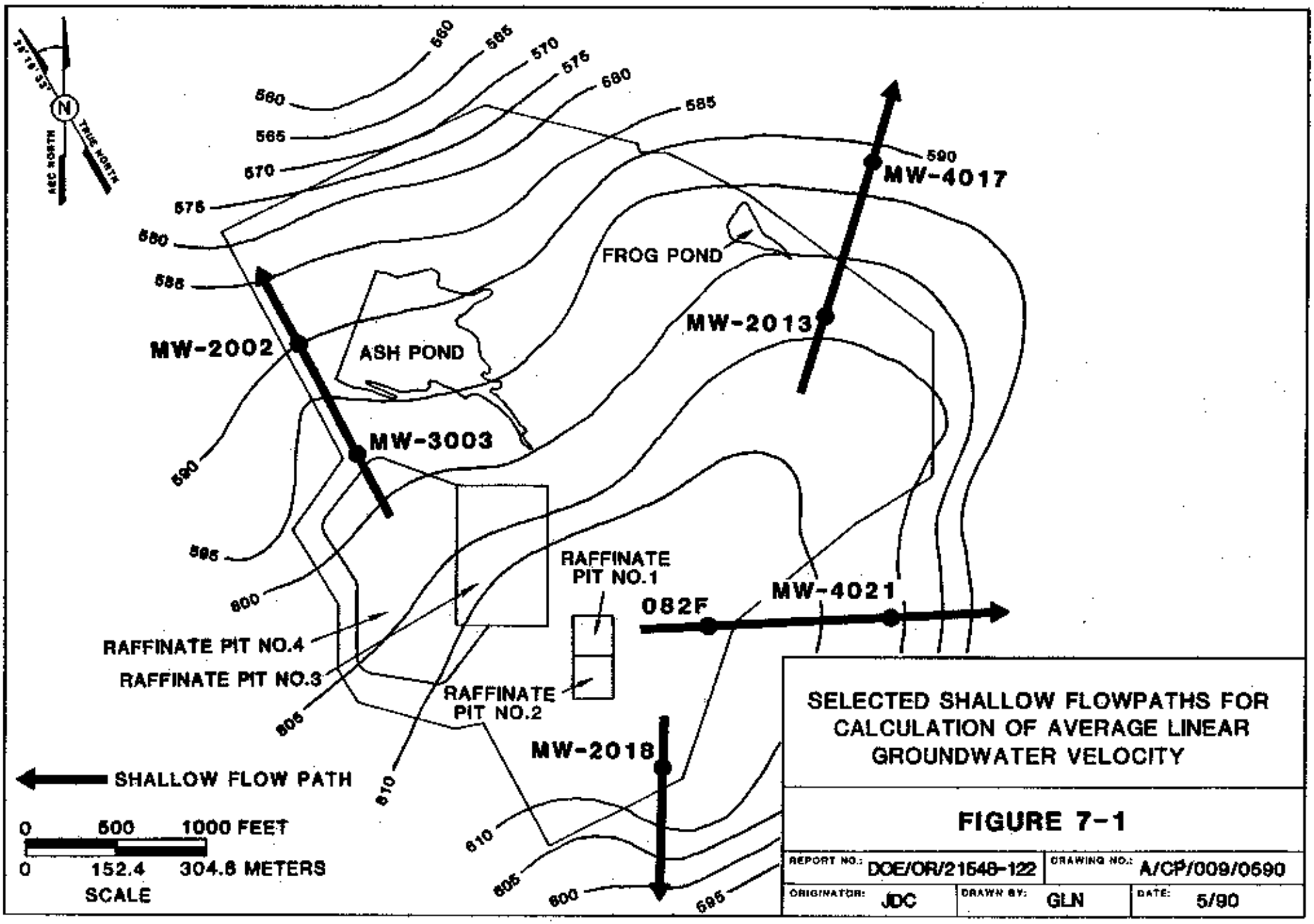
Determination of effective porosity from the tracer test data allows for the calculation of natural average linear groundwater velocities. The average linear velocity is determined using Darcy's law in the form:

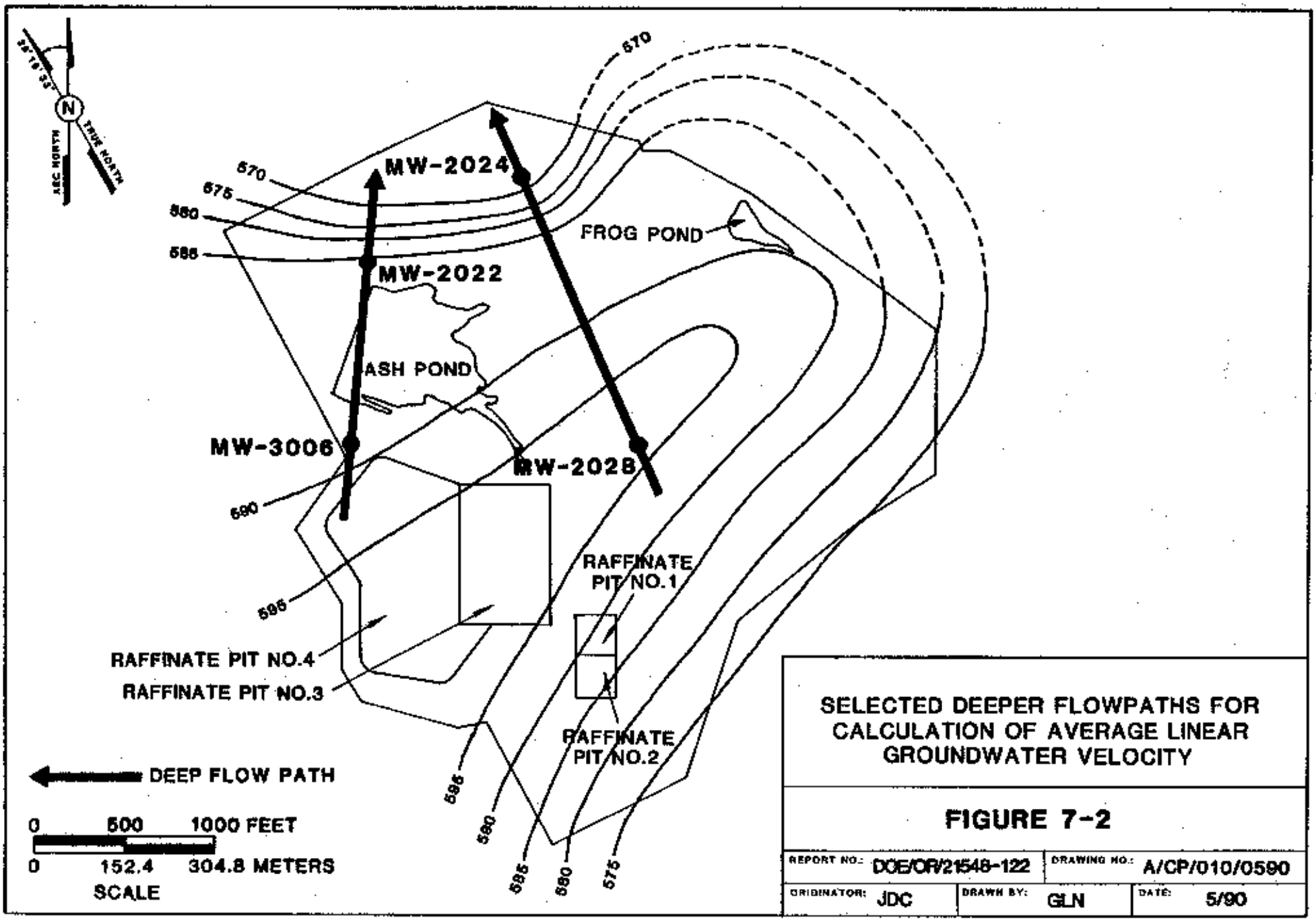
$$v = \frac{Ki}{n} \qquad (14)$$

where:

v = average linear groundwater velocity
K = hydraulic conductivity
i = hydraulic gradient
n = effective porosity (0.007 as determined from tracer tests)

Groundwater velocities were calculated for the five potential flow paths described above. These flow paths refer to the path that a molecule of water follows from point A to point B assuming an equivalent porous medium approach; they do not account for velocity anomalies due to free flow conditions (heterogeneities), or horizontal anisotropy (i.e. the calculation assumes a homogeneous isotropic flow media). Figure 7-1 shows the selected shallow flow paths and Figure 7-2 shows the deeper flow paths.


560
565
570
575
580
585
590
595
600
605
610
MW-4017
FROG POND
MW-2013
MW-2002
ASH POND
MW-3003
RAFFINATE PIT NO.1
082F
MW-4021
RAFFINATE PIT NO.4
RAFFINATE PIT NO.3
RAFFINATE PIT NO.2
MW-2018
SHALLOW FLOW PATH
0 500 1000 FEET
0 152.4 304.8 METERS
SCALE
SELECTED SHALLOW FLOWPATHS FOR CALCULATION OF AVERAGE LINEAR GROUNDWATER VELOCITY
FIGURE 7-1
REPORT NO.: DOE/OR/21548-122
DRAWING NO.: A/CP/009/0690
ORIGINATOR: JDC
DRAWN BY: GLN
DATE: 5/90



SELECTED DEEPER FLOWPATHS FOR CALCULATION OF AVERAGE LINEAR GROUNDWATER VELOCITY

FIGURE 7-2

REPORT NO.:	DOE/OR/21548-122	DRAWING NO.:	A/CP/010/0590		
ORIGINATOR:	JDC	DRAWN BY:	GLN	DATE:	5/90

Average hydraulic conductivities of wells along the selected flow paths were used. Values of the hydraulic gradients and hydraulic conductivities and the resulting velocities along each flow path are presented in Table 7-1.

Using hydraulic conductivities determined by the Bouwer and Rice method, average linear velocities ranged from a minimum of 0.022 m/day (0.072 ft/day) between OB2F and MW-4021 to a maximum of 0.12 m/day (0.39 ft/day) between MW-2018 and MW-4022. Using hydraulic conductivities determined by the Hvorslev method, average linear velocities ranged from a minimum of 0.033 m/day (0.11 ft/day) between OB2F and MW-4021 to a maximum of 0.44 m/day (1.40 ft/day) between MW-2018 and MW-4022.

7.2.2 Discussion

To verify the values of average linear velocity presented in Section 7.2.1 and the underlying assumption that Darcian diffuse flow principles can be applied to assess contaminant transport, a comparison of calculated travel times to observed contaminant distribution can be made. Using the concentrations of nitrate along the flow path from MW-3003 to MW-2002 as presented in the Phase II Groundwater Quality Assessment for the WSCP/WSRP/WSVP (MKF and JEG 1989a), a travel time of about 30 years can be used to delineate the time since raffinate wastes were first introduced into the holding pits. Seepage rates for the raffinate pits (BNI 1986) and isopach thicknesses for the overburden of 12 m (40 ft) were used to calculate a velocity and travel time, assuming a hydraulic gradient of 1, and a porosity of 0.36 (BNI 1987).

The calculated travel time for nitrate to reach the phreatic surface is about 13.5 years, without taking into account initial

unsaturated flow which would conceivably lengthen travel time. This leaves a balance of 16.5 years for contaminants to reach their present distribution. The estimated travel time for flow from the middle of Raffinate Pit 3, the approximate center (and source) of the nitrate plume, to MW-2002, near the edge of the plume, is about 21 years using average hydraulic conductivity values obtained along the flow path between MW-3003 and MW-2002. Combining the time required for nitrate to reach the phreatic surface and the time required for the plume to reach its present horizontal extent yields a total estimated travel time of about 35 years. While these values are admittedly only rough estimates, the fact that they are fairly close corroborates the calculated values for hydraulic conductivity (Section 6.1) and average linear velocity (Section 7.2.1).

From Table 7-1 it can be seen that the calculated velocities in the flow paths in the deeper portion of the Burlington-Keokuk are not substantially lower, as might be expected for flow in the unweathered bedrock, than the velocities calculated for the shallower flow paths. This is probably because observed gradients between the deep wells imply the existence of a direct lateral connection, which may not be the case. In fact flow paths in the shallow and deep portions of the aquifer are probably not linear as assumed in the derivation of horizontal hydraulic gradients, but probably exhibit some degree of tortuosity which would result in lower hydraulic gradients and velocities. Therefore, the velocities presented in Section 7.2.1 represent maximum average linear velocities.

Conduit flow is considered to be limited to the highly permeable portion of the weathered Burlington-Keokuk Formation. No effort was made in this study to determine conduit flow velocities. However, results of surface injection dye tracing

studies conducted by the Missouri Department of Natural Resources indicate that dye lost to conduit flow in the subsurface had flow velocities ranging from 0.4- to 0.7-m/min (1.5 to 2.2 ft/min) (MKF and JEG 1989b).

8 FINDINGS AND CONCLUSIONS

Findings and conclusions resulting from slug tests, pumping tests, and tracer tests performed to characterize the shallow Mississippian-Devonian aquifer in the vicinity of the WSS are presented below.

8.1 Findings

8.1.1 Slug Tests

- The average hydraulic conductivity value for all wells tested was 7.4E-02 m/day as determined by the Hvorslev technique and 9.6E-02 m/day as determined by the Bouwer and Rice method.

- Piezometer GT-58P yielded the maximum value for hydraulic conductivity, which was 3.9 m/day as determined by the Bouwer and Rice method.

- Groundwater velocities calculated using hydraulic conductivity data obtained using the Hvorslev method yielded an average value of 1.8×10^{-1} m/day.

- Groundwater velocities calculated using hydraulic conductivity data obtained using the Bouwer and Rice method yielded an average value of 1.1×10^{-1} m/day.

8.1.2 Pumping Tests

- Mean transmissivity values were determined to be 2.34E-06 m^2/s (16.3 gpd/ft) for PW-1, 5.74E-06 m^2/s (39.9 gpd ft) for PW-2 and 2.23E-06-m^2/s (15.5 gpd ft) for PW-3.

- The average storativity determined by pumping tests was 4.9E-04.

- Hantush analysis yielded maximum apparent transmissivity tensor orientations of N72°W for PW-1, N10°W for PW-2, and N12°E for PW-3.

- Comparison of maximum and minimum transmissivity values yielded anisotropy ratios of 2:1 for PW-1 and PW-3, and 3.5:1 for PW-2.

- The radius of influence due to pumping is, generally, approximately 60 m (200 ft). However, along the line of OB1G, OB1H, and OB1I, the projected distance to zero drawdown was 275 m (900 ft).

- Hydraulic conductivity values determined from pumping tests averaged 2.3E-02 m/day for PW-1, 4.9E-02 m/day for PW-2 and 3.1E-02 m/day for PW-3.

8.1.3 Tracer Tests

- Effective porosities determined by tracer tests ranged from 0.002 to 0.015.

- Dispersivity values determined by tracer tests ranged from 8.8E-03 m for PW-3 (bromide) to 4.9E-02 m at PW-2 (chloride).

- Breakthrough curves for tracers did not exhibit double porosity effects.

8.2 Conclusions

Results of slug tests, pumping tests, and tracer tests conducted at the Weldon Spring site (WSS) have yielded valuable information about the shallow bedrock aquifer underlying the site. The results presented herein represent a substantive body of data which will be useful for remedial planning, assessing aquifer restoration alternatives, feasibility assessments and/or further monitoring programs, and groundwater modeling. With these applications in mind, the following conclusions are offered:

- The aquifer of concern at the Weldon Spring site, is composed of saturated rocks of the Burlington-Keokuk Limestone which constitute the upper portion of the Mississippian-Devonian aquifer. The aquifer of concern is a heterogeneous anisotropic medium which can be described in terms of diffuse Darcian flow overlain by high porosity discrete flow zones and conduits.

- Pumping and tracer tests did not intercept free flow zones or conduits capable of supplying sustained pump discharge yields in excess of approximately 1.5 liters/minute (0.4 gpm).

- Slug tests performed on wells GT-58P, MW-4014, and

MW-4013 had high hydraulic conductivity values relative to the average which was 9.6E-02 m/day (Bouwer and Rice Method) for all wells tested. These values are considered to be representative of discrete flow in the fractured and weathered zones found in the upper Burlington-Keokuk Limestone and indicate heterogeneities within the upper Mississippian-Devonian aquifer. Aquifer heterogeneity in the horizontal plane is believed to be distributed randomly and is a function of fracture spacing, solution voids, and preglacial weathering phenomena. The relatively high hydraulic conductivities that may be encountered in deeper portions of the aquifer (e.g., MW-3006 with a hydraulic conductivity of 2.3E-01 m/day) are thought to be due to the presence of widely spaced fractures.

- Piezometer GT-58P is a good location in which to consider an additional pump test because it has the highest hydraulic conductivity value of all wells tested. All indications suggest that flow at this location is discrete and, as such, sustained yields may be substantially in excess of rates required for the pumping tests addressed in this report (0.75-1.5 l pm [0.2-0.4 gpm]).

- Results of pumping tests indicate a primary lateral anisotropy and poor hydraulic communication between the pumped interval and deeper portions of the Burlington-Keokuk; thus, there is not likely to be significant upward leakage.

- Calculated groundwater velocities and travel times appear to be consistent with observed contaminant distribution due to diffuse Darcian flow, although flow paths may exhibit nonlinear aspects resulting in significant variations in velocity.

- Limited evidence of delayed yield such as that observed near PW-1 may indicate double porosity effects.

- Results of pumping tests, tracer tests, and slug tests indicate limitations to an assessment of hydrologic phenomena within the Burlington-Keokuk Limestone using an equivalent porous medium approach. Additional pumping tests of high hydraulic conductivity features such as GT-58P may provide insight toward how heterogeneous features influence the saturated zone.

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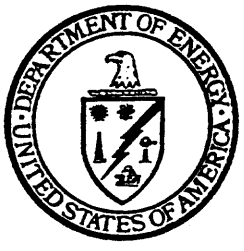
Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

Prepared by MK-Ferguson Company and Jacobs Engineering Group

NOVEMBER 1990 REV. 1



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Weldon Spring Site Remedial Action Project

Annual Site Environmental Report 1989

Revision 1

November 1990

Prepared by

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Prepared for

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
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ABSTRACT

Environmental monitoring continued at the Weldon Spring Site in 1989. Numerous exposure pathways were monitored in 1989, including groundwater, surface water, and air. Analytical parameters included radionuclides, nitroaromatic compounds, inorganic anions, and direct gamma exposure. The results are being used to calculate exposure doses (where applicable) so the impact of the site on potentially exposed populations can be assessed.

Off-site exposures did not dramatically increase in 1989 over exposures calculated in previous years. Contaminated groundwater did not affect private water supplies or the St. Charles County Well Field. Surface water containing elevated uranium activity continued to impact the Femme Osage Slough and several lakes in the August A. Busch Memorial Wildlife Area. Elevated radon exposures at the Weldon Spring Quarry continued in 1989 due to the unusually dry conditions. Off-site gamma, radon and air particulate exposures remained indistinguishable from background. Off-site monitoring demonstrated that exposure at the Francis Howell High School, the Busch Wildlife Area Headquarters, and the Weldon Spring Training Area is indistinguishable from background levels. No spills occurred at the Weldon Spring Site in 1989.

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1 INTRODUCTION

This report presents the findings of the environmental monitoring program conducted at the Weldon Spring Site (WSS) in 1989. Annual environmental monitoring reports have been prepared for this site (or portions thereof) since 1981. The WSS is part of the Department of Energy (DOE) Surplus Facilities Management Program (SFMP), one of the remedial action programs under the direction of the Office of Environmental Restoration and Waste Management. The WSS is comprised of the Weldon Spring Raffinate Pits (WSRP), the Weldon Spring Chemical Plant (WSCP), and the Weldon Spring Quarry (WSQ). These areas encompass 20.7, 67.2 and 3.6 hectares (ha) (51, 166, and 9 acres), respectively. The WSRP and WSCP areas are contiguous. The WSQ is approximately 6.4 kilometers (km) (4 miles) to the south-southwest.

When custody of the WSCP was transferred in 1985 from the Department of the Army (DA) to the DOE, the WSCP became part of the WSS. In conjunction with this transfer, the Weldon Spring Site Remedial Action Project (WSSRAP) was created as DOE Major Project Number 182 (DOE Order 4240.1E - 05/14/85). Consistent with the DOE mission under SFMP, the WSSRAP will eliminate potential hazards to the public and the environment and make surplus real property available for other uses.

During the years 1981 through 1985, the WSRP and WSQ were under DOE caretaker status. The WSCP was controlled by the DA. The DOE conducted environmental monitoring programs during this period to identify changes (if any) in the radiological levels in and around the WSRP and WSQ. The DA did not collect environmental monitoring data in and around the WSCP. When the WSCP was transferred to the DOE in 1985, the DOE began revision of the overall Environmental Monitoring Program to more

adequately determine the levels of contamination in and around the WSCP, WSRP, and the WSQ. A description of the WSS environmental monitoring program for 1989 is provided in Section 1.4 of this report.

DOE Order 5400.1 requires that an environmental radioactivity monitoring program be maintained at existing sites and, as determined on a case-by-case basis, at certain former sites to determine:

- Background levels and site contribution of radioactivity and other pollutants from DOE operations to the site environs.

- Compliance with applicable and appropriate environmental standards for radioactivity and other pollutants specified by the DOE and the U.S. Environmental Protection Agency (EPA).

- Compliance with environmental commitments in official documents such as environmental impact statements and Federal Facility Agreements (FFA).

This DOE Order also requires a listing of environmental permits. The only permit in effect at the WSS in 1989 was the National Pollutant Discharge Elimination System (NPDES) - Storm Water Runoff Permit Number MO-0107701. Compliance with this permit is discussed in Section 2.2.1 of this report.

This Annual Site Environmental Report is the DOE's vehicle for documenting the results of its extensive monitoring program at the WSSRAP. The report provides the public and concerned regulatory agencies with summary level discussions regarding the

routine environmental monitoring program. It explains how the WSSRAP environmental monitoring program meets the requirements of the NPDES program and compares the measured contaminant levels to applicable standards. Further, the report indicates whether changes are occurring in contaminant distribution or contaminant source conditions on and around the site--changes which might equate to variations in potential exposure scenarios to the public or environmental receptors.

Environmental monitoring is the WSSRAP's most effective means by which to assess the impacts from the site. The data and evaluations contained in the report provide the summary of that monitoring for 1989. Section 2 reports results of the contaminant level measurements and compares the environmental levels of radioactivity and chemical contaminants released from the site with applicable standards. Quarterly data is presented in Appendix A.

In addition to the routine environmental monitoring conducted in 1989, a number of related activities and special studies were performed. These activities and studies are directly applicable to the assessment of the overall impact of site operations on the environment. Therefore, these activities are described and the results are discussed in Section 3.

Section 4 presents the results of calculations, based on the 1989 sampling results, of the maximum radiation dose to a hypothetical maximally exposed individual at the WSCP/WSRP and WSQ areas. Calculations of the doses to the general population in the vicinity of the WSS are also reported.

For definitions of selected terms used in this report, the reader may consult Appendix B. Although each acronym used in

this report is defined when it is first used in each main section, a list of all abbreviations used is provided in Appendix C. Appendix D contains a description of the quality assurance methods that are applied to sampling and analysis activities in this monitoring program. Appendix E presents a discussion of the environmental guidelines that apply to the monitoring program. Appendix F provides a useful conversion table, and Appendix G the distribution list for this report.

1.1 Location and Description

The WSS is located in St. Charles County, Missouri, about 48 km (30 mi) west of St. Louis. The WSRP and WSCP areas are reached from Missouri State Route 94, 3.2 km (2 mi) southwest of the junction of Route 94 and U.S. Route 40/61. The WSQ is also reached from Route 94, 6.4 km (4 mi) south-southwest of the WSRP and WSCP areas. The Missouri River is located approximately 2.4 km (1.5 mi) southeast of the WSRP and WSCP areas and 1.6 km (1 mi) east of the WSQ. The Mississippi River lies approximately 22 km (14 mi) northeast of the WSRP and WSCP areas and roughly 29 km (18 mi) northeast of the WSQ. The general locations of these properties are illustrated in Figure 1-1.

Uranium and thorium residues, waste materials, and contaminated rubble are stored at the WSS. In addition to environmental monitoring, engineering activities are being conducted to minimize the migration of contaminants from these facilities into surface water and groundwater.

Additional characterization activities have been conducted at the WSCP and WSRP during 1989. These activities provide information on the types and magnitudes of the contamination. The complete picture of characterization information will be

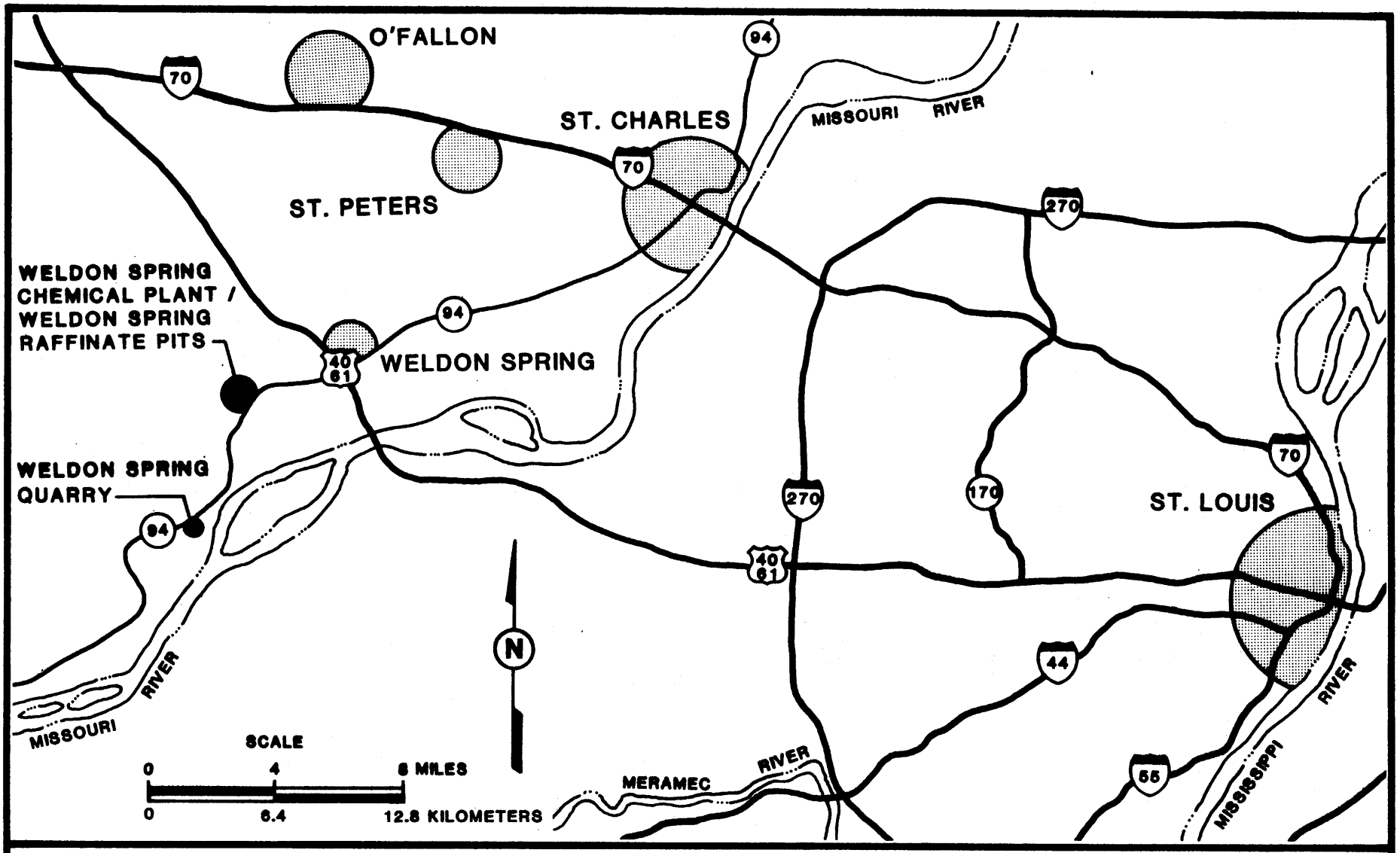


FIGURE 1-1

LOCATION OF THE WELDON SPRING SITE

presented in a Remedial Investigation (RI) report scheduled to be completed in 1990 and this information will be used to evaluate the course of remedial actions.

Brief descriptions of each major area of the site are given below.

Weldon Spring Raffinate Pits

Figure 1-2 is an aerial view of the WSRP area with part of the WSCP in the background. The 20.7-ha (51-acre) area includes four pits that cover approximately 10.5 ha (26 ac) (see Figure 1-3). The raffinate pits were constructed by excavating into the existing clay soils and using the removed clay for construction of dikes. These pits contain radioactive residues (raffinates) from uranium and thorium processing operations at the former Weldon Spring Uranium Feed Materials Plant (WSUFMP) which is now the WSCP.

Access to the area is controlled by a 2.1-meter (m) (7-ft) high fence that encloses the DOE property. In addition, each pit is enclosed by a fence at least 1.3 m (4 ft) high. All drains and transfer lines from the pits to the WSCP process sewer have been sealed (Ficker, 1981). During the 1989 monitoring year, surface water covered the vast majority of the residues in the pits.

Weldon Spring Chemical Plant

The 67.2-ha (166-ac) WSCP is located to the north and east of the WSRP area (Figure 1-3). The WSCP, which operated as the Weldon Spring Uranium Feed Materials Plant until 1966, comprises 13 major buildings and 27 smaller buildings. Of the former, five

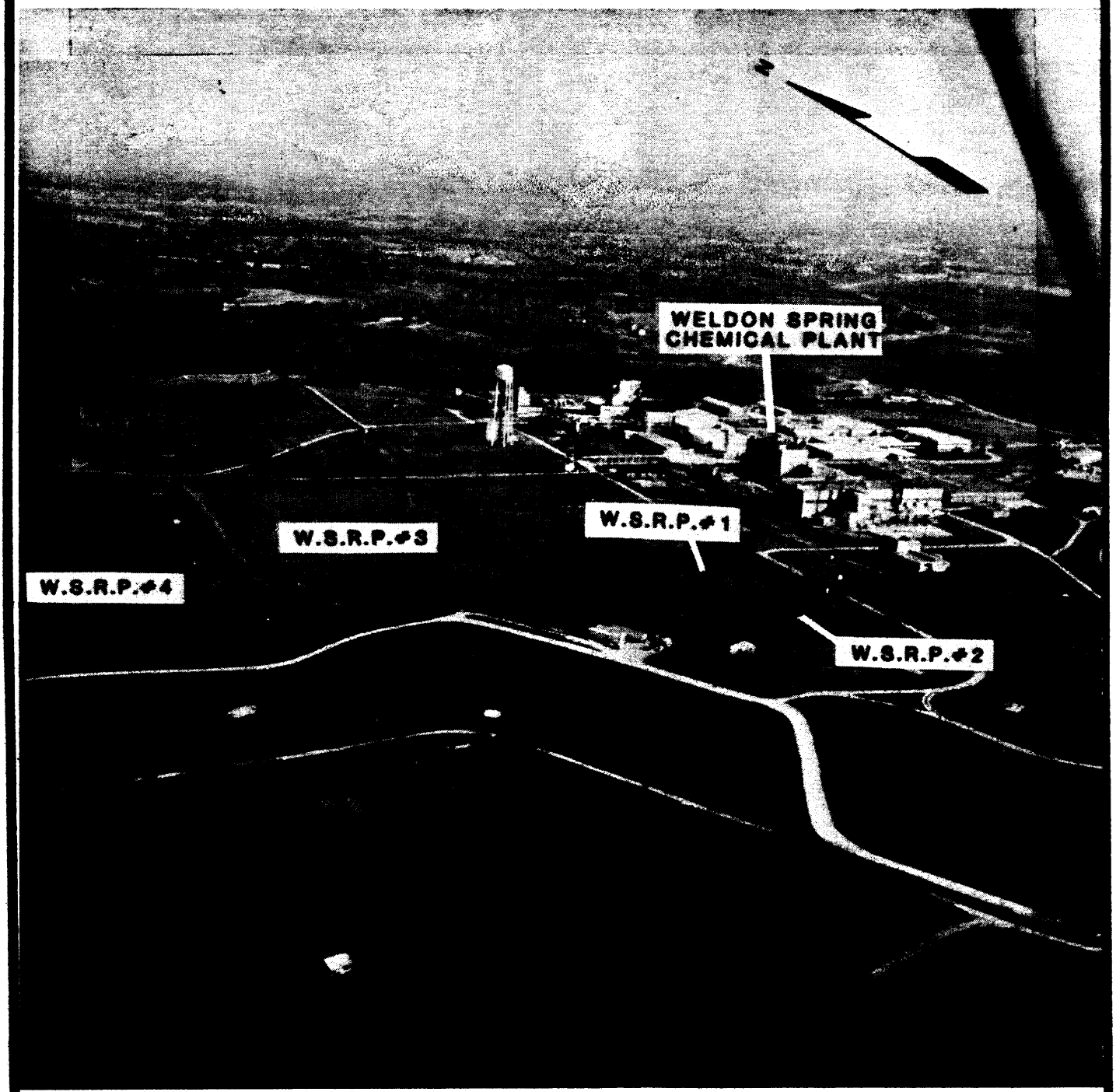


FIGURE 1-2

AERIAL PHOTOGRAPH OF THE WSRP AREA

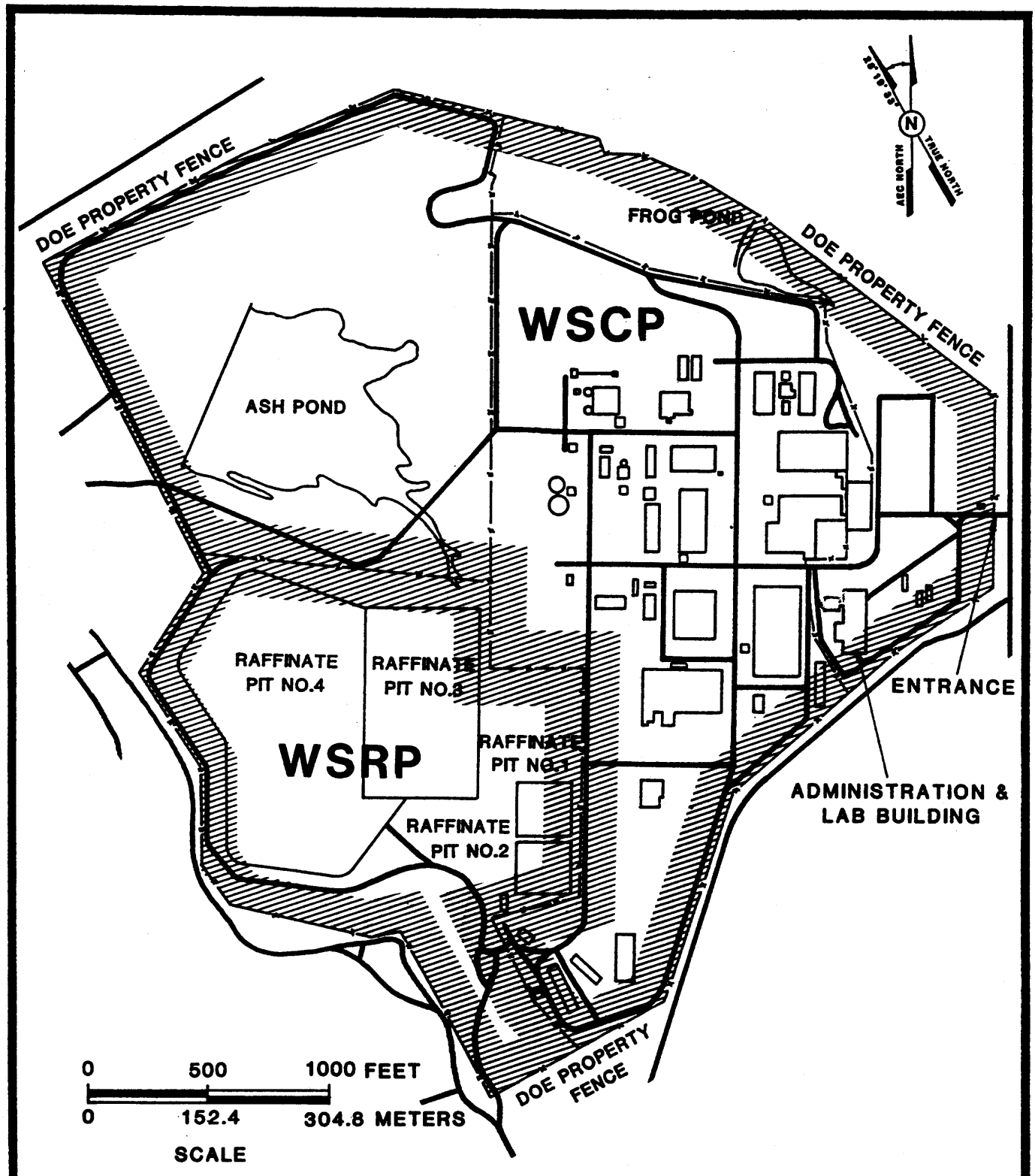


FIGURE 1-3

MAP OF THE WSCP & WSRP

were used as process buildings, and eight were major support buildings. The entire site is fenced. Access is controlled at a manned gate-house and site security continues to be maintained by guards periodically patrolling the site 24 hours per day.

The interiors of the eight major support buildings are heavily contaminated with uranium that is mostly "fixed" on surfaces. The rest of the buildings contain only small quantities of uranium contamination.

Surface water runoff from the WSCP drains primarily along three corridors. These include the natural drainageways leading to Ash Pond and Frog Pond, and the complex of tributaries which exits the site to the southeast. Surface water drains into these ponds and drainageways where it transports uranium off-site. These drainageways are more thoroughly discussed in Sections 1.3 and 2.2.

Small quantities of chemically hazardous substances are also present both in the buildings and as contamination in the soil in several areas of the site. These substances include asbestos, polychlorinated biphenyls (PCBs), dinitrotoluene, ammonia, hydrofluoric acid, sulfuric acid, and nitric acid. The data on these substances and their impacts to the environment will be detailed in the previously mentioned RI report.

Weldon Spring Quarry

The WSQ, an abandoned 3.6-ha (9-ac) limestone quarry, is located approximately 6.4 km (4 mi) south-southwest of the WSRP/WSCP area. Figure 1-4 is an aerial photograph of the WSQ. As shown in Figure 1-5, the WSQ is accessible at both the upper and lower levels from Missouri State Route 94. An unused

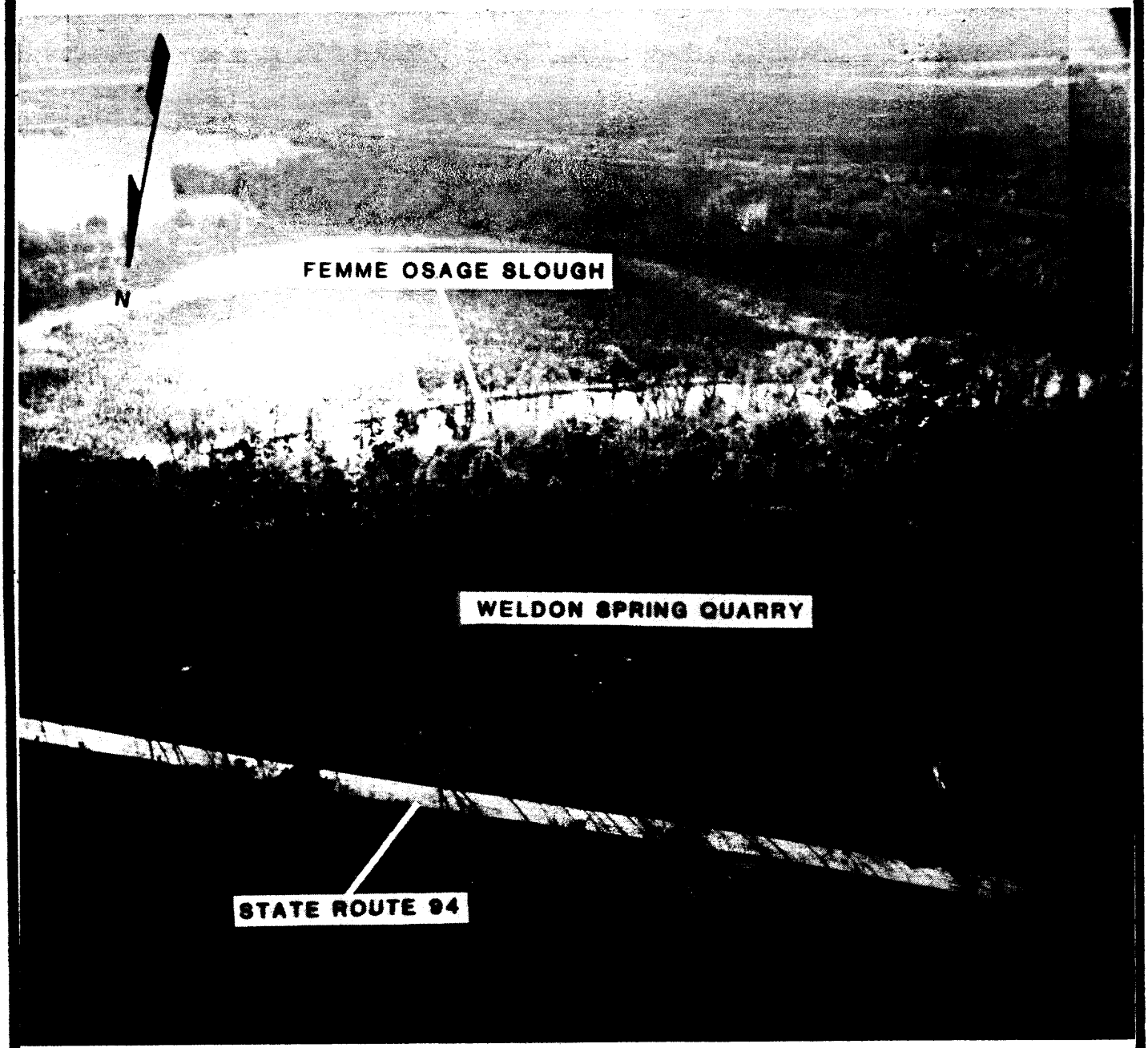


FIGURE 1-4

AERIAL PHOTOGRAPH OF THE WSQ

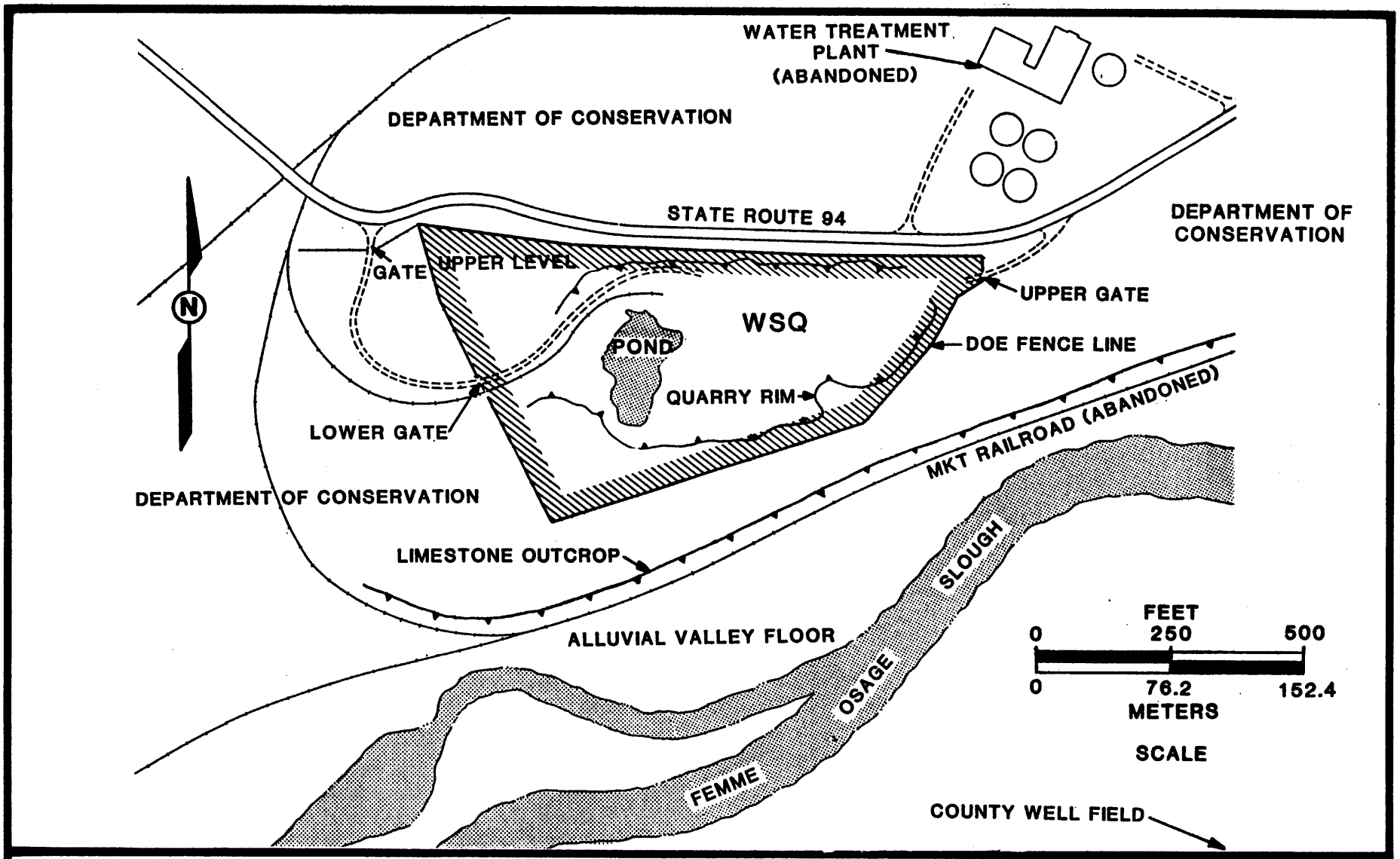


FIGURE 1-5

MAP OF THE WSQ

railroad spur enters the site at the lower level and extends approximately one-third of the way into the WSQ. The WSQ is essentially a closed basin; surface water within the rim flows to the quarry floor and into a pond which covers approximately 0.2 ha (0.5 ac). The pond contains approximately 12 million liters (3 million gallons) of water and is 6.1 m (20 ft) deep at its deepest point. The amount of water in the pond varies according to seasonal variations in precipitation and evaporation.

The only structures at the WSQ site are a small storage shed and a sampling platform in the pond area. Access to the site is restricted by a locked, 2.1-m (7-ft) high chain link fence. The amounts and types of wastes in the WSQ are summarized in the Remedial Investigation Report for Quarry Bulk Wastes (MKF and JEG, 1989b).

1.2 Site History

The WSS has a complex history of production processes within its boundaries. Between 1941 and 1944, the Department of Army (DA) occupied the property (Weldon Spring Ordnance Works--WSOW) and located four of its 20 explosives production lines across the WSS area (the remaining 16 production lines were distributed across an adjacent property which is now referred to as the U.S. Army's Weldon Spring Training Area). The WSOW produced dinitrotoluene and trinitrotoluene (DNT and TNT) for the Allied Forces during World War II.

In 1955, 83 ha (205 ac) of the former ordnance works property was transferred to the Atomic Energy Commission (AEC) for construction of the Weldon Spring Uranium Feed Materials Plant (WSUFMP). Until 1966, the AEC operated an integrated facility for the conversion of processed uranium ore concentrates

to pure uranium trioxide, intermediate compounds and uranium metal. A small amount of thorium was also processed. The wastes generated from these operations were stored in four raffinate pits on the site property.

In 1958, the AEC acquired title to the WSQ from the DA. The WSQ had been used earlier by the DA for disposal of TNT-contaminated rubble during the operation of the WSOW. The AEC used the WSQ as a disposal area for a small amount of thorium residue, but most of the material disposed of there consisted of uranium- and radium-contaminated building rubble and soils from the demolition of a uranium ore processing facility in St. Louis.

In February 1985, the DOE proposed designating the control and decontamination of the WSRP, WSCP, and WSQ as a major project. Designation was effected by DOE Order 4240.1E dated May 14, 1985. A Project Management Contractor (PMC) for the Weldon Spring Site Remedial Action Project (WSSRAP) was selected in February 1986. In July 1986, a DOE project office was established on site. The PMC, MK-Ferguson Company, assumed control of the WSS on October 1, 1986. The WSQ was placed on the Environmental Protection Agency's National Priorities List (NPL) in July 1987. The WSCP/WSRP was added to the NPL in March 1989.

Remedial investigations were conducted at the WSCP/WSRP area in 1988 and 1989. The investigations included characterization of the groundwater, on-site soil contamination, contaminated sediments in off-site surface drainages and lakes, surface water, and springs; the chemical and radiological characteristics of the raffinate wastes; and other smaller scale efforts. The results of each of these investigations are presented in stand-alone documents on the respective efforts and are brought together and

summarized in the RI report for the WSCP/WSRP, which is in the final stage of production following agency review.

Several small-scale actions have been conducted to mitigate or eliminate conditions that pose immediate or potential threats to worker safety, public health or the environment. These have included removal of exposed friable asbestos and overhead piping, power pole and wire removal, nonprocess-building demolition, Ash Pond isolation, and containerized chemical consolidation. Section 3.2 of this report details the interim response actions (IRAs) in process or completed during 1989.

The WSSRAP evolved from a National Environmental Policy Act (NEPA) authority decommissioning and cleanup project in 1986 into a remedial action project under combined NEPA-Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) authority requiring a Remedial Investigation/Feasibility Study (RI/FS) and complete environmental documentation as of autumn of 1987. In 1989, the environmental documentation process necessary to begin the excavation of the bulk waste from the WSQ was completed. The residual contamination within the quarry confines can be characterized when the excavation is completed.

A more detailed presentation of the production, ownership and waste history of the WSS is available in the Remedial Investigation reports for the WSQ and the WSCP/WSRP prepared by and available from the DOE Project Office.

1.3 Environmental Setting

The environmental setting of the WSCP/WSRP and the WSQ are described briefly below. A more detailed description is provided in the RI/FS-EIS Work Plan for the WSS (MKF and JEG, 1988a). The

WSRP/WSCP area is located on the Missouri- Mississippi River surface-drainage divide. The topography is gently undulating and generally slopes northward toward the Mississippi River. To the southeast are bluffs that overlook the Missouri River floodplain. Though the bedrock under the site is fractured, it is overlain by low permeability clays ranging from 1 to 9 m (3 to 30 ft) thick.

Burlington-Keokuk cherty limestone is the first bedrock unit and the first aquifer underlying the WSCP/WSRP. Bedrock topography varies in elevation from about 178.3 m (585 ft) National Geodesic Vertical Datum (NGVD) to 193 m (635 ft) NGVD.

The Burlington-Keokuk limestone is vertically fractured with two primary joint sets trending between N30°E and N72°E and between N30°W and N65°W (Roberts, 1951) and is susceptible to natural solution processes. Burlington-Keokuk solution features normally develop along fractures and bedding planes. Most solution features are small (up to several centimeters wide) and may or may not be clay filled.

Most surface water runoff from the WSCP/WSRP area discharges either through an intermittent stream in the Army Reserve Training Area or through the Ash Pond diversion structure on the WSCP property to Schote Creek. An additional surface drainage system reaching Schote Creek exits the WSCP area along the Frog Pond drainage. That drainageway carries storm water from most of the plant area where concrete surfaces drain into a storm water sewer system. The Frog Pond drainageway also carries runoff from the northeastern portion of the WSCP. Drainage from the southern portion of the WSCP property travels southeast to the Missouri River.

Schote Creek combines with Dardenne Creek and flows northeast to the Mississippi River. Schote Creek and several of its tributaries are impounded on the August A. Busch Memorial Wildlife Area. Dardenne Creek, portions of Schote Creek, and lakes on the August A. Busch Memorial Wildlife Area support aquatic life and are accessible to the public for recreational activities, such as fishing.

The WSQ is located on the northern bluff of the Missouri River valley. The unconsolidated upland material overlying bedrock consists of up to 10 m (30 ft) of silty clay soil developed from loess deposits. A residual soil is present in some areas between the silty clay and bedrock.

Sediments along the Missouri River vary from clays and silts through sands, gravels, cobbles, and boulders. The maximum alluvium thickness near the WSQ is approximately 30 m (100 ft). The alluvium "pinches out" at the base of the bedrock bluffs along the now-abandoned Missouri-Kansas-Texas (MKT) rail line. The alluvium thickness increases dramatically as distance from the Missouri River valley wall increases and then levels out.

Approximately 210 m (700 ft) to the south of the WSQ, toward the Missouri River, lies a 2.4 km (1.5 mi) section of the original Femme Osage Creek that was dammed at both ends between 1960 and 1963 by the University of Missouri. This section is now called the Femme Osage Slough. Southwest of the slough lies the area of floodplain alluvium from which St. Charles County draws its drinking water. Eight production wells are in this area, of which only five usually operate at one time. Average production from the well field is about 40 million liters (10 million gallons) per day.

Figure 1-6 shows silts and clays with minor amounts of sand as the primary sediments between the bluff and the Femme Osage Slough. The water-producing sands and gravels, 15 to 20 m (50 to 60 ft) thick, appear to pinch out southeast of the slough near the WSQ.

The WSQ bedrock consists of three distinct Ordovician formations. In descending order, they are the Kimmswick Formation, the Decorah Formation, and the Plattin Formation. The Bushberg Formation (the lowermost Mississippian formation in the area of the WSS) overlies the Kimmswick Formation to the north, west, and east of the WSQ at higher elevations but is not present at the WSQ.

With the exception of the Missouri River floodplain to the south, the topography of the WSQ area is rugged. Surface drainage in the area flows to the Missouri River, 1.6 km (1 mi) to the east, through the Femme Osage Creek and Little Femme Osage Creek (Figure 1-7).

Groundwater Occurrence

Groundwater in the vicinity of the WSRP and WSCP areas occurs in two separate zones: perched lenses and the underlying bedrock. Perched groundwater is present in small, isolated deposits of coarse-grained glacial drift.

A groundwater divide at the WSCP/WSRP trends roughly northeast to southwest through the eastern portion of the plant. Groundwater in the Burlington-Keokuk Formation flows to the northwest and to the southeast on opposite sides of the divide. Groundwater contamination sources include the raffinate pits, Ash and Frog ponds, and losing streams draining the site. The

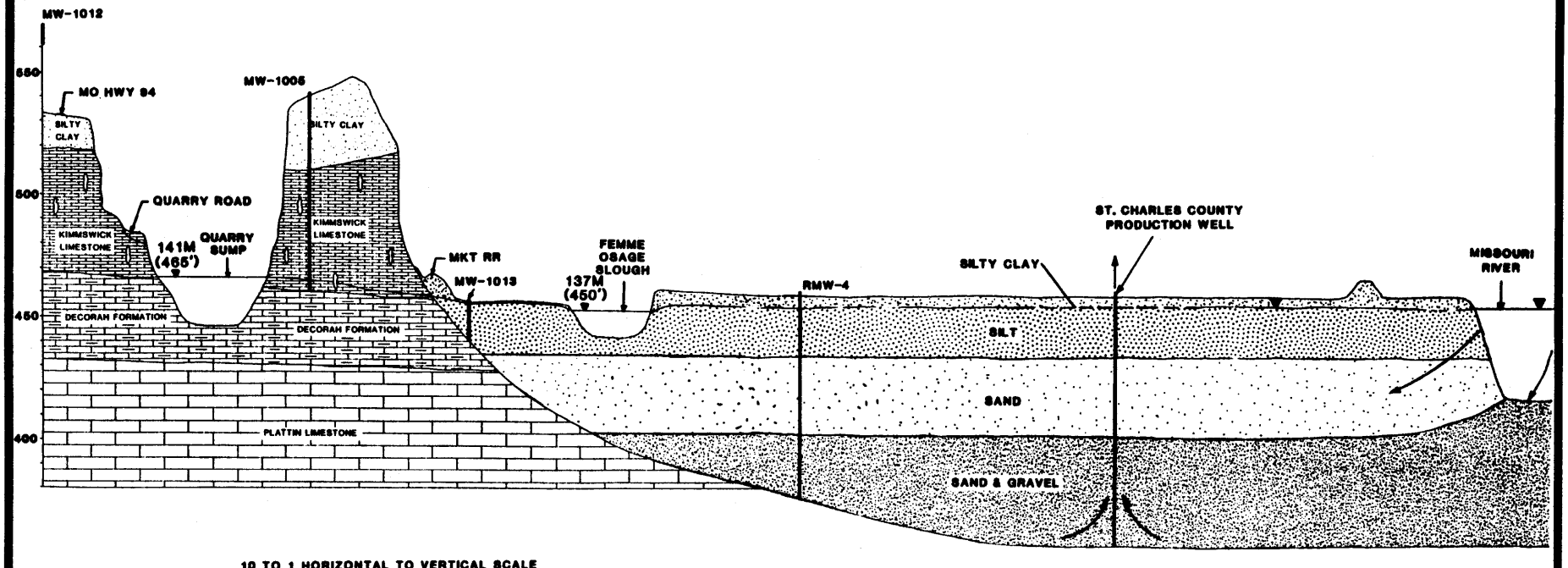


FIGURE 1-6

TYPICAL HYDRO-GEOLOGIC CROSS-SECTION OF WSQ AREA

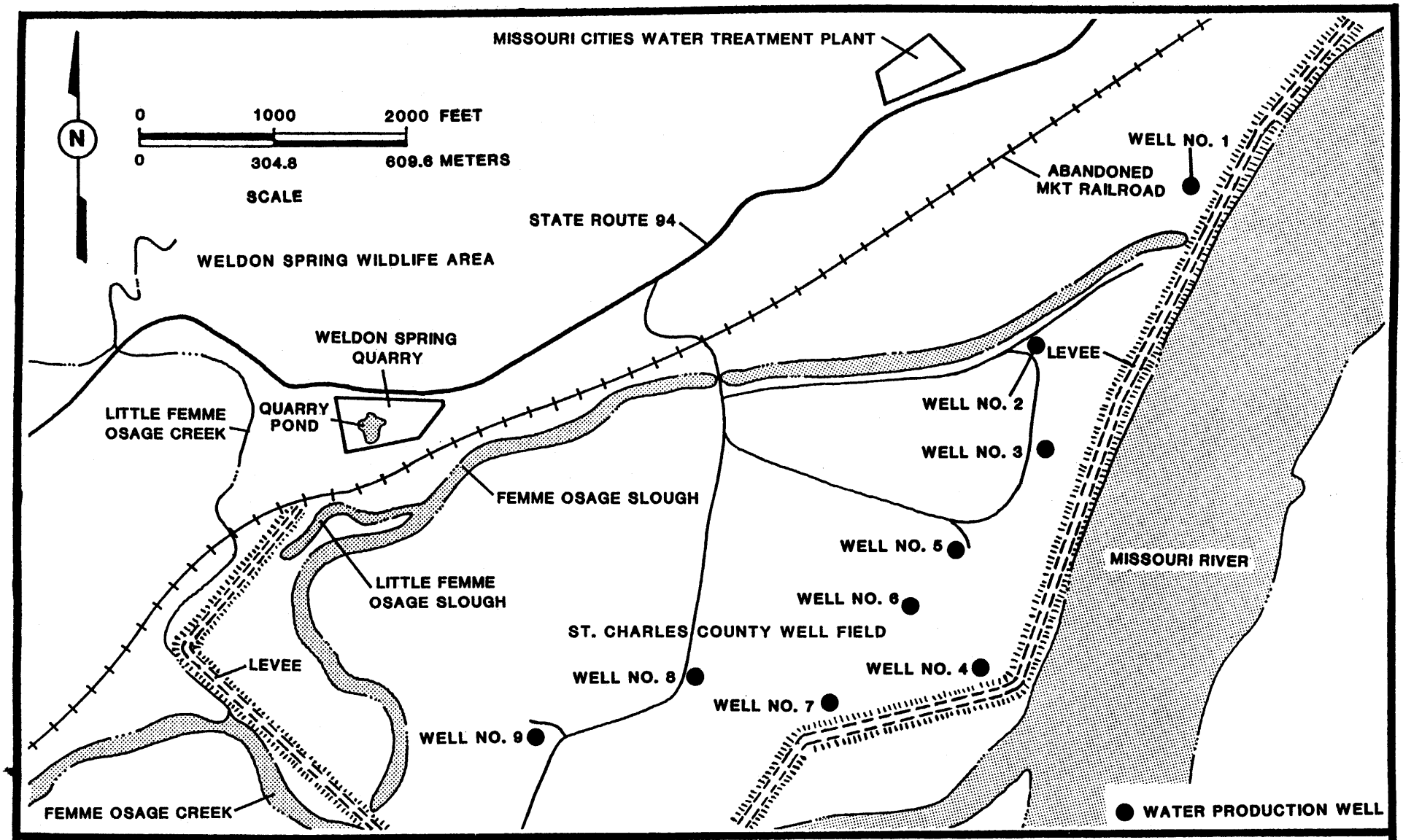


FIGURE 1-7

WELDON SPRING QUARRY & ST. CHARLES COUNTY WELL FIELD

Burlington-Keokuk Formation is not a heavily utilized aquifer, but private wells do supply households in rural areas. No private wells are currently utilized in the Burlington-Keokuk Formation within 2 km (1.25 mi) of the WSCP/WSRP.

Groundwater in the WSQ vicinity occurs both in bedrock and Missouri River alluvium (Figure 1-6). Groundwater flow near the WSQ is influenced by the Missouri River and pumpage from the St. Charles County well field, and varies with river stages and pumping rates. These production wells are controlled and monitored under public drinking water regulations. No additional active water supply wells are completed in the alluvial aquifer near the WSQ.

Local Climate Summary

The climate in the WSS area is continental, with moderately cold winters and warm summers. Alternating warm/cold, wet/dry air masses converge and pass eastward through the area almost daily. Normal annual precipitation in the area is approximately 85 centimeters (cm) (39 in.), with the heaviest rainfall occurring in spring and early summer. The total measured precipitation at the WSCP in 1989 was 72 cm (28.5 in.). The average temperature is 13° C (56° F). Prevailing winds in the vicinity of the WSS are from the south during the summer and fall. Wind speeds during these months average 13.9 km/h (8.7 mph). Winds during the winter months are from the northwest and west-northwest, averaging 17.6 km/h (11 mph) (GRC, 1985).

1.4 Summary of 1989 Environmental Monitoirng Activities

The 1989 Environmental Monitoring Program was carried out in order to identify, characterize and monitor release pathways for

both radiological and chemical constituents. Following the extensive characterization efforts conducted in 1988 as part of the remedial investigations of the site, an expanded quarterly monitoring program was instituted to collect additional data to allow for evaluation of seasonal or time based trends in contaminant concentrations. Groundwater sampling locations were added to the previous year's monitoring program to include the extended monitoring well network.

The surface water monitoring program was modified to include three additional locations on the Missouri River, one location at the west end of the Femme Osage Slough and additional on-site surface water bodies. Samples were collected quarterly at each location.

The program is dynamic, changing to meet the monitoring needs of the site as new physical and analytical data are assimilated and as release pathways are better understood. These release pathways include groundwater (via subsurface migration), surface water (via storm-water runoff), and air.

In 1989, 91 monitoring wells were sampled, compared with 50 wells sampled in 1988. This includes 59 wells installed at the chemical plant and raffinate pits, and 32 wells at the WSQ.

Surface water samples were collected from a total of 45 locations where measurable impacts from drainage originating at the Weldon Spring Site might be detected. These samples include 39 quarterly sampling locations and samples of storm water runoff from the six permitted outfalls at the WSCP and WSRP as required by the National Pollutant Discharge Elimination System (NPDES) Permit (storm water) for the Weldon Spring Site. The 39

quarterly sampling locations include 13 around the WSQ and 26 around the WSCP and WSRP.

A total of 22 locations were monitored quarterly for radon gas and external gamma exposure. Duplicate radon gas detectors were installed at each location to improve the precision and accuracy of the measurements. Four additional off-site monitoring locations were used to determine annual average background gamma exposure rates and radon concentrations near the WSSRAP.

Air particulate sampling for radiological parameters at the site perimeter continued on a weekly basis through 1989. Two new sampling stations were installed at the WSQ perimeter. A third station was installed one-half mile west (up prevailing wind direction) to provide background measurements. The air was monitored at these locations to establish ambient baseline data and to monitor for potential off-site releases. Data from this program will also be used to assess the effectiveness of engineering controls at the site during future remedial action activities.

1.5 Compliance Summary

The PMC is responsible for the management of hazardous waste at WSSRAP including the characterization, consolidation, inventory, storage, transportation, and disposal of hazardous and other wastes that remained on-site after closure of the WSUFMP and for wastes generated during remedial action activities. All WSSRAP waste management activities are performed in accordance with the Resource Conservation and Recovery Act and the Toxic Substances Control Act (RCRA and TSCA), as well as Occupational Safety and Health Act, (OSHA), Department of Transportation (DOT)

and Missouri regulations concerning the storage, labeling, transport and disposal of hazardous materials, and DOE Order 5820.2A, Radioactive Waste Management.

Compliance issues were determined through continuing internal evaluation and a series of audits conducted by the DOE and the PMC. These issues, their resolution and status are presented in Table 1-1 and the open issues explained in more detail in the text. Those issues identified as closed in Table 1-1 are considered closed by the PMC/DOE WSSRAP Office. Only four of 19 compliance issues remain open at this time. These issues should be resolved in 1990; they are described in the following subsections.

1.5.1 Improper Storage of PCB Contaminated Materials (40 CFR 761.65)

Issue: All non-radiologically contaminated PCB articles have previously been removed and appropriately disposed of by off-site treatment, storage, and disposal facilities. Except for the capacitors in Building 301, the remaining PCB-contaminated equipment has been placed in proper storage, labelled, and inspected weekly. The capacitors in Building 301 are stored in a cabinet and offer minimal threat of release.

Corrective Action: The capacitors are labelled and inspected monthly, and are scheduled for removal during the first half of 1990 through the ongoing chemical containerization interim response action at WSSRAP (Section 3.2.5).

TABLE 1-1 Regulatory Compliance Summary

Issue	Regulation	Resolution/Date	Status
Inadequate separation of wastes	40 CFR 264.177(o)	Proper storage in Bldg 434 - 04/90	Closed
Run-on into waste storage area	40 CFR 264.175(b)(4)	Proper storage in Bldg 434 - 04/90	Closed
Inadequate aisle space	40 CFR 264.35	Proper storage in Bldg 434 - 04/90	Closed
Inadequate characterization of wastes	40 CFR 264.13(a)(1)	Wastes are being characterized - 05/90	Closed
Waste Analysis Plan inadequately describes methods	40 CFR 264.13(a)	Waste Analysis Plan revised - 05/90	Closed
Inadequate inspection records	40 CFR 264.15(d)	Procedure revised 11/89	Closed
Contingency Plan did not address emergencies	40 CFR 264.52	Plan revised 04/90	Closed
Improper storage of PCB contaminated RCRA liquid	40 CFR 761.65	Containment Structure built 11/89	Closed
Improper storage of PCB contaminated materials	40 CFR 761.65	Routine inspection/ labelling-Removal planned for 1990	Open
Storage of PCB contaminated material in excess of 1 year	40 CFR 761.61a	Removal scheduled for 1990	Open
Annual PCB Report not completed by July 1	40 CFR 761.180	Report submitted 11/89	Closed
PCB items not inspected every 30 days	40 CFR 761.65(c)(5)	Inspections performed 09/89	Closed
PCB items not properly labelled	40 CFR 761	Items properly labelled	Closed
Radionuclide emission monitoring not confirmed by EPA as suitable for NESHAP	40 CFR 61.93	Under discussion with EPA	Open
Inadequate water supply for RCRA storage	40 CFR 264.32(d)	Sprinkler system in Building 434	Closed

TABLE 1-1 Regulatory Compliance Summary (Continued)

Issue	Regulation	Resolution/Date	Status
Receipt of improper radiological shipment	49 CFR 172.20, .300, .400, 173.400	Vehicle surveyed; no contamination	Closed
Offsite release of radionuclide	Clean Water Act (CWA) Section 311(b)(1)	CWA satisfied. Ongoing remedial action (Ash Pond Diversion 05/89)	Closed
Offsite release of nitroaromatic compounds	Clean Water Act Section 311(b)(1)	CWA satisfied. Ongoing remedial action	Closed
Storage of PCB and land ban wastes beyond 1 year	40 CFR 761.65(a) and 268.50(a)	Destruction scheduled for 1990	Open

1.5.2 Storage of PCB Contaminated Material in Excess of the One Year Limit (40 CFR 761.61a)

Issue: Remaining PCB capacitors and equipment have been stored for more than one year. These items remained from WSUFMP operation and were recently identified and characterized.

Corrective Action: All PCB contaminated capacitors and equipment currently in temporary storage are properly labelled and inspected weekly. They are scheduled to be radioactively decontaminated and removed during the first half of 1990 as a part of the chemical containerization interim response action.

1.5.3 Storage of PCB and Land Ban Wastes Beyond the One Year Storage Requirement (40 CFR 761.65(a) and 40 CFR 268.50(a))

Issue: There are approximately 7,400 gallons of tributyl phosphate (TBP) stored at WSSRAP which is RCRA and TSCA regulated as well as being contaminated with radionuclides. The TBP remains stored in the same two tanks it was placed in during the late 1960s.

Corrective Action: WSSRAP is addressing this issue in three ways. The primary effort involves dialogue with the Oak Ridge Gaseous Diffusion Plant (ORGDP) to have the TBP prioritized for destruction by their permitted incinerator. In October, the WSSRAP resampled the material to verify that it meets ORGDP's analytical acceptance criteria, and the results were forwarded to ORGDP in eary 1990.

Another approach has been to reply to an ORO request for input seeking a nationwide extension for storage of

radiologically contaminated land ban waste. Also a request to EPA Region VII for a variance from the storage requirements for radiologically contaminated land ban and PCB wastes was submitted in eary 1990.

1.5.4 Radionuclide Emissions Monitoring that is Currently Conducted at Weldon Spring Does Not Meet the Requirement for the Radionuclide NESHAPS (40 CFR 61.93)

Issue: The WSSRAP is currently using an environmental monitoring network which monitors the source (the entire WSS). However, the WSSRAP is not in strict compliance with NESHAPS requirements since it does not measure "annual air concentration where a maximally exposed individual resides."

Corrective Action: On March 18, 1989, WSSRAP personnel met with EPA Region VII personnel to outline the off-site Radionuclide Monitoring Plan. EPA Region VII agreed that the proposed monitoring plan would meet the requirements of 40 CFR 61, and the regional EPA staff will brief EPA Headquarters. Region VII will then convey Headquarters' comments to the WSSRAP during 1990. If the Radionuclide Monitoring Plan is acceptable, the PMC will issue the proposed monitoring plan in writing for EPA approval. This written plan will be completed and reviewed by the WSSRAP DOE in 1990.

2 ENVIRONMENTAL MONITORING RESULTS

Environmental monitoring is the first line of defense in protecting the public and environmental health and safety. Additionally, environmental monitoring is done to ensure that any potential public exposure is documented and quantified, and to demonstrate compliance with applicable legal and regulatory requirements; to confirm adherence to the U.S. Department of Energy (DOE) environmental protection policies; and to support environmental management decisions.

This portion of the report presents monitoring results and includes discussions about the environmental conditions at the Weldon Spring Site (WSS). The Weldon Spring Remedial Action Project (WSSRAP) is moving toward compliance with DOE Order 5900.2 by presenting parenthetically the standard international (SI) units following the more commonly used unit for these measurements. The WSSRAP is phasing into full compliance by the year 1992 as DOE Order 5900.2 requires.

2.1 Groundwater Monitoirng

All Weldon Spring Chemical Plant/Raffinate Pits/Vicinity Properties (WSCP/WSRP/WSVP) and Weldon Spring Quarry (WSQ) monitoring wells were sampled at least annually during 1989. Wells installed during 1988 or wells of particular importance or interest were sampled quarterly. Through routine monitoring and investigations at the site, an understanding of groundwater quality and hydrogeology has been established over the past several years. Therefore the groundwater monitoring program has been changed since earlier years and made more efficient by avoiding unnecessary or redundant sampling and analysis. Through

these modifications, a high quality program which effectively assesses the groundwater quality has been maintained.

The WSSRAP continues to monitor for uranium, inorganic anions (nitrate, sulfate, chloride, fluoride), and nitroaromatic compounds in the groundwater. Six nitroaromatic compounds have been associated with the WSOW; 1,3,5-trinitrobenzene, 1,3-dinitrobenzene, nitrobenzene, 2,4,6-trinitrotoluene, 2,4-dinitrotoluene and 2,6-dinitrotoluene.

Data tables of all laboratory analytical results presented in this section contain annual concentrations calculated from data generated during 1989 where more than one analysis was conducted. These values are usually compared to background concentrations and/or to U.S. Environmental Protection Agency (EPA) or DOE guidelines. The guidelines are for discussion purposes and may not be strictly applicable. The annual concentration is stated in each column with a fraction in parentheses adjacent to that value. The numerator is the number of samples used to calculate the annual concentration. If only one sample was collected, it was reported as the annual concentration. The denominator is the number of times that particular well was sampled during 1989. An "ND" indicates "Not Detected" and appears only if a particular parameter was not detected above the detection limit in any analyses done on samples obtained from that well during 1989. If the analytical laboratory reported an "ND" for a particular parameter for a particular sampling event, the ND was not used to calculate the annual concentration. Individual quarterly results are presented in data tables in Appendix A.

Groundwater quality trend analyses are presented in this report. Chemical and radiological concentrations for each monitoring well included in the monitoring program in 1987, 1988,

and 1989 are presented graphically. Uranium, nitroaromatic compounds, nitrate, and sulfate data were analyzed for trends at both the WSCP/WSRP/WSVP and the WSQ areas, and are presented in this section.

Groundwater monitoring wells are grouped in the trend analyses by location on the horizontal axis of the graph while parameter concentrations are listed on the vertical axis. Symbols representing the annual concentrations for 1987, 1988, and 1989 are plotted for each well. For each well sampled, a symbol appears on the graph at a point intersecting the vertical location line and the horizontal concentration line for that year. The graphic analysis enables the reader at a glance to see consistencies or fluctuations over time.

2.1.1 Groundwater Monitoring at the Weldon Spring Chemical Plant/Raffinate Pits

Groundwater at the WSCP/WSRP became contaminated as a result of the Weldon Spring Ordnance Works (WSOW) operations during World War II and operations at the Uranium Feed Materials Plant during the 1950s and 1960s. The Phase I Water Quality Assessment Report (MKF and JEG, 1987) reported that: "groundwater near the raffinate pits contains elevated amounts of uranium; nitroaromatic compounds are present at low to high levels over much of the site; and relatively widespread nitrate and sulfate contamination problems are the result of leaking raffinate pits and other sources." The Phase II Groundwater Quality Assessment Report (MKF and JEG, 1989a), an expanded, comprehensive evaluation of groundwater quality at the WSCP/WSRP/WSVP area during the third quarter of 1988, is essentially in agreement with the Phase I report. Two notable exceptions are that the nitrate plume has been more clearly defined and that the original

sulfate plume reported in the Phase I Water Quality Assessment is actually several isolated plumes, and its source is not exclusively the raffinate pits. These exceptions were detected as a result of additional monitoring well installations.

The groundwater monitoring network consists of 59 wells, 28 at the WSCP, eight at the WSRP, and 23 at the WSVP. Figure 2-1 shows the locations of individual wells in the WSCP/WSRP/WSVP monitoring well network. All of these wells are screened in the uppermost unconfined aquifer. The wells are completed in a range of depths in order that the entire uppermost aquifer is monitored. Detailed well construction information for individual wells is available in the 1990 Environmental Monitoring Plan (MKF and JEG, 1990a).

2.1.1.1 Radiological Results

The upper bound for natural uranium background concentrations in groundwater at the WSCP/WSRP/WSVP was determined to be 3.4 pCi/l (0.125 Bq/l) (MKF and JEG, 1989a). EPA has not yet established drinking water standards for uranium; however studies leading to proposed rulemaking are using uranium in the 10 to 40 pCi/l (0.37 to 1.48 Bq/l) range (MKF and JEG, 1989a). The DOE has a derived concentration guideline (DCG) of 550 pCi/l (20.35 2Bq/l).

Each groundwater monitoring well was sampled and analyzed for total natural uranium during 1989. Table 2-1 provides the annual concentrations.

Forty-five of the groundwater monitoring wells have total uranium concentrations below the upper bound for natural background. Eight monitoring wells--MW-2003, MW-2020, MW-2028,

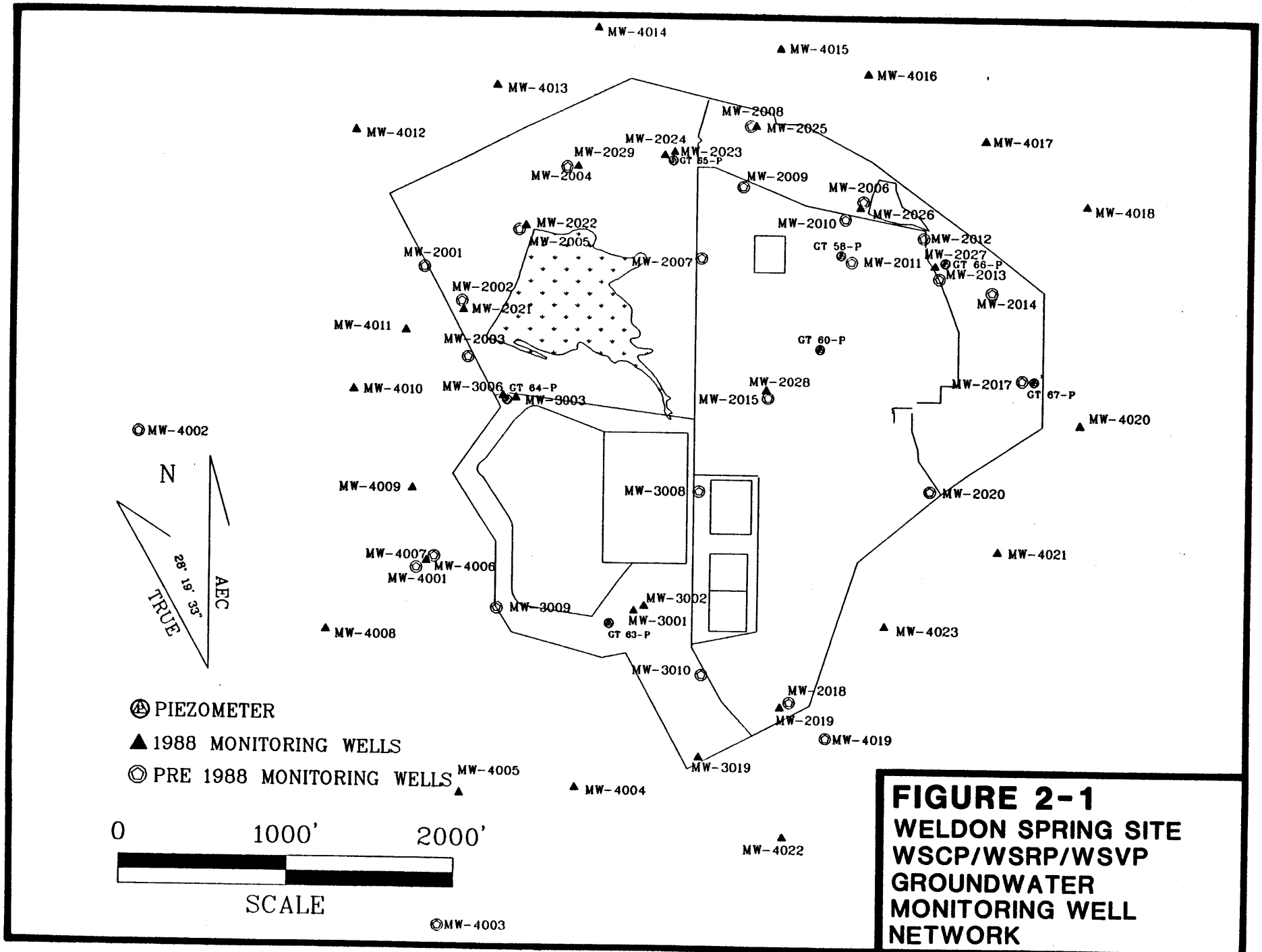


FIGURE 2-1
WELDON SPRING SITE
WSCP/WSRP/WSVP
GROUNDWATER
MONITORING WELL
NETWORK

TABLE 2-1 Summary of 1989 Data for Inorganic Anions and Uranium, Weldon Spring Chemical Plant/Raffinate Pits

	Chloride mg/l (0.25)*		Fluoride mg/l (0.25)*		Nitrate mg/l (0.1)*		Sulfate mg/l (1.0)*		Total Uranium pCi/l (1.0)*	
GW-2001	5.80	(1/1) @	ND	(1/1)	50.20	(1/1)	5.80	(1/1)	1.80	(1/1)
GW-2002	7.10	(1/1)	ND	(1/1)	1010.0	(1/1)	95.0	(1/1)	ND	(1/1)
GW-2003	17.20	(1/1)	ND	(1/1)	3330.00	(1/1)	288.00	(1/1)	3.60	(1/1)
GW-2004	1.30	(1/1)	ND	(1/1)	3.80	(1/1)	1.90	(1/1)	1.90	(1/1)
GW-2005	1.60	(1/1)	ND	(1/1)	117.00	(1/1)	3.40	(1/1)	2.40	(1/1)
GW-2006	278.00	(1/1)	ND	(1/1)	29.05	(2/2)	32.40	(1/1)	ND	(1/1)
GW-2007	0.80	(1/1)	ND	(1/1)	ND	(1/1)	14.10	(1/1)	2.40	(1/1)
GW-2008	108.00	(1/1)	ND	(1/1)	16.00	(1/1)	39.50	(1/1)	ND	(1/1)
GW-2009	17.60	(1/1)	ND	(1/1)	6.30	(1/1)	99.20	(1/1)	2.90	(1/1)
GW-2010	82.60	(1/1)	ND	(1/1)	4.30	(1/1)	42.80	(1/1)	1.10	(1/1)
GW-2011	7.70	(1/1)	ND	(1/1)	0.80	(1/1)	37.30	(1/1)	ND	(1/1)
GW-2012	37.20	(1/1)	ND	(1/1)	4.00	(1/1)	415.00	(1/1)	1.00	(1/1)
GW-2013	4.60	(1/1)	ND	(1/1)	3.20	(1/1)	11.90	(1/1)	1.00	(1/1)
GW-2014	22.80	(1/1)	ND	(1/1)	9.00	(1/1)	34.80	(1/1)	1.00	(1/1)
GW-2015	1.40	(1/1)	ND	(1/1)	1.80	(1/1)	96.40	(1/1)	2.60	(1/1)
GW-2017	13.10	(1/1)	ND	(1/1)	1.50	(1/1)	1830.00	(1/1)	15.00	(1/1)
GW-2018	10.60	(1/1)	ND	(1/1)	2.30	(1/1)	9.50	(1/1)	3.10	(1/1)
GW-2019	1.95	(4/4)	0.26	(1/4)	ND	(4/4)	20.12	(4/4)	2.15	(4/4)
GW-2020	15.00	(1/1)	ND	(1/1)	3.70	(1/1)	144.00	(1/1)	9.00	(1/1)
GW-2021	1.15	(4/4)	0.14	(1/4)	ND	(4/4)	12.93	(4/4)	2.67	(3/4)
GW-2022	1.16	(4/4)	0.14	(1/4)	ND	(4/4)	13.98	(4/4)	1.83	(2/4)
GW-2023	1.25	(4/4)	0.25	(1/4)	0.27	(3/4)	32.15	(4/4)	2.77	(4/4)
GW-2024	1.83	(4/4)	0.29	(1/4)	ND	(4/4)	31.58	(4/4)	1.36	(1/4)
GW-2025	1.43	(4/4)	0.25	(1/4)	ND	(4/4)	16.90	(4/4)	1.64	(4/4)
GW-2026	1.38	(4/4)	0.16	(1/4)	0.50	(1/4)	13.05	(4/4)	2.58	(4/4)
GW-2027	1.18	(4/4)	0.17	(1/4)	0.31	(4/4)	12.6	(3/3)	1.73	(3/4)
GW-2028	2.28	(4/4)	0.24	(2/4)	ND	(4/4)	107.18	(4/4)	5.48	(4/4)
GW-2029	2.28	(3/3)	0.19	(1/3)	0.11	(1/4)	23.20	(4/4)	1.79	(4/4)
GW-3001	7.70	(4/4)	0.20	(1/4)	793.50	(4/4)	23.05	(4/4)	3.00	(2/4)
GW-3002	8.15	(4/4)	0.25	(1/4)	0.19	(2/4)	19.30	(4/4)	3.98	(4/4)
GW-3003	10.10	(4/4)	0.22	(1/4)	2036.00	(3/4)	176.75	(4/4)	13.33	(4/4)
GW-3006	5.78	(4/4)	0.28	(2/4)	64.43	(3/4)	59.93	(4/4)	2.07	(3/4)
GW-3008	8.80	(1/1)	ND	(1/1)	4010.00	(1/1)	43.60	(1/1)	5.90	(1/1)
GW-3009	2.60	(1/1)	ND	(1/1)	294.00	(1/1)	58.00	(1/1)	48.00	(1/1)
GW-3010	1.60	(1/1)	ND	(1/1)	5.50	(1/1)	7.60	(1/1)	2.10	(1/1)
GW-3019	1.07	(3/3)	0.25	(1/3)	0.40	(2/3)	7.37	(3/3)	7.61	(3/3)

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

* Detection Limit

@ Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1989. For example, 2.00 (2/4) indicates that 4 samples were taken in 1989, 2 of which average 2.00 and the other 2 samples were ND.

TABLE 2-1 Summary of 1989 Data for Inorganic Anions and Uranium, Weldon Spring Chemical Plant/Raffinate Pits (Continued)

	Chloride mg/l (0.25)*		Fluoride mg/l (0.25)*		Nitrate mg/l (0.1)*		Sulfate mg/l (1.0)*		Total Uranium pCi/l (1.0)*	
GW-4001	3.00	(1/1) @	ND	(1/1)	149.00	(1/1)	64.10	(1/1)	1.20	(1/1)
GW-4002	2.50	(1/1)	ND	(1/1)	9.00	(1/1)	25.20	(1/1)	ND	(1/1)
GW-4003	6.28	(4/4)	0.21	(1/4)	3.2	(3/4)	29.50	(4/4)	1.70	(1/4)
GW-4004	3.75	(4/4)	0.34	(4/4)	1.60	(4/4)	30.68	(4/4)	2.73	(4/4)
GW-4005	7.73	(4/4)	0.32	(2/4)	5.12	(4/4)	19.03	(4/4)	1.71	(4/4)
GW-4006	1.60	(1/1)	ND	(1/1)	21.90	(1/1)	32.90	(1/1)	ND	(1/1)
GW-4007	1.08	(4/4)	0.25	(1/4)	ND	(4/4)	12.90	(4/4)	1.70	(4/4)
GW-4008	1.25	(4/4)	0.36	(1/4)	ND	(4/4)	14.60	(4/4)	2.93	(3/4)
GW-4009	1.93	(3/3)	0.30	(2/3)	13.33	(3/3)	28.23	(3/3)	2.20	(3/3)
GW-4010	2.20	(4/4)	0.23	(1/4)	0.42	(4/4)	29.70	(4/4)	4.22	(3/4)
GW-4011	6.00	(4/4)	0.81	(2/4)	87.53	(4/4)	49.83	(4/4)	3.27	(3/4)
GW-4012	4.13	(4/4)	0.30	(1/4)	0.44	(2/4)	46.08	(4/4)	2.41	(4/4)
GW-4013	8.43	(4/4)	0.07	(1/4)	499.00	(4/4)	52.60	(4/4)	1.60	(2/4)
GW-4014	3.78	(4/4)	0.21	(1/4)	39.35	(4/4)	25.45	(4/4)	ND	(4/4)
GW-4015	2.63	(4/4)	0.12	(1/4)	8.78	(4/4)	7.43	(3/4)	1.35	(3/4)
GW-4016	4.43	(4/4)	0.19	(1/4)	ND	(4/4)	21.25	(4/4)	5.09	(4/4)
GW-4017	1.93	(4/4)	0.16	(1/4)	1.84	(4/4)	7.55	(4/4)	2.85	(4/4)
GW-4018	11.10	(4/4)	0.15	(1/4)	6.85	(4/4)	11.35	(4/4)	1.68	(3/4)
GW-4019	1.10	(1/1)	ND	(1/1)	0.84	(1/1)	8.90	(1/1)	1.50	(1/1)
GW-4020	8.58	(4/4)	0.22	(1/4)	2.84	(2/4)	133.00	(4/4)	23.33	(4/4)
GW-4021	1.55	(4/4)	0.15	(1/4)	ND	(4/4)	312.00	(4/4)	12.06	(4/4)
GW-4022	11.63	(4/4)	0.28	(1/4)	1.72	(4/4)	56.38	(4/4)	3.73	(3/4)
GW-4023	15.85	(4/4)	0.18	(1/4)	22.03	(4/4)	137.60	(4/4)	2.50	(3/4)

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

* Detection Limit

@ Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1989. For example, 2.00 (2/4) indicates that 4 samples were taken in 1989, 2 of which average 2.00 and the other 2 samples were ND.

MW-3002, MW-3008, MW-3019, MW-4010 and MW-4016--show annual concentrations above background but below 10 pCi/l. Four wells, MW-2017, MW-3003, MW-4020 and MW-4021 have annual concentrations of uranium in the 10 to 40 pCi/l range. Monitoring wells MW-3009 and MW-4004 have the highest annual concentrations, 50 and 70.50 pCi/l (1.85 and 2.59 Bq/l), 9% and 12% of the DCG respectively. Figure 2-2 highlights those wells with above background (3.4 pCi/l) annual natural uranium concentration. These results are generally consistent with 1988 monitoring and characterization results.

WSCP/WSRP/WSVP URANIUM TREND ANALYSIS

The annual average uranium concentrations reported in previous monitoring reports and this report are displayed for comparison in Figure 2-3. Since 1987, groundwater uranium concentrations generally has not varied dramatically. The exceptions to this are MW-2020 and MW-3009 each of which has both decreased and increased concentrations of uranium with time. The source of uranium contamination in these wells has not yet been removed; therefore it might be expected that concentrations of uranium in groundwater will continue to fluctuate until remedial action removes the source. Monitoring Well 2017 is the only well that continually increased from 1987 to 1989. The cause of this increase is not known. All monitoring wells, with the exception of MW-3009, which is adjacent to the raffinate pits, had annual concentrations of uranium below 40 pCi/l during this three-year period. Overall, increases of uranium concentrations have not been observed.

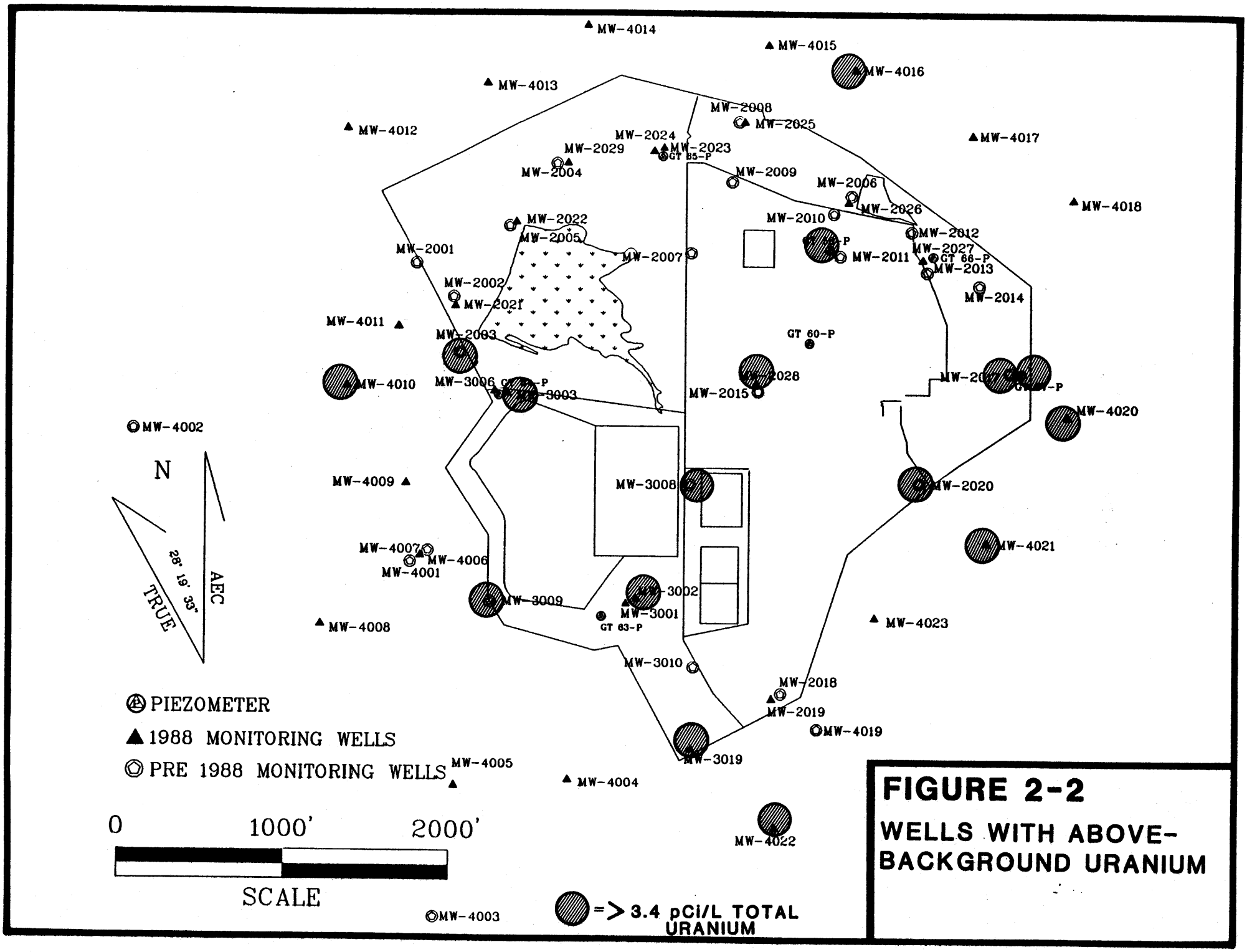


FIGURE 2-2

WELLS WITH ABOVE-BACKGROUND URANIUM

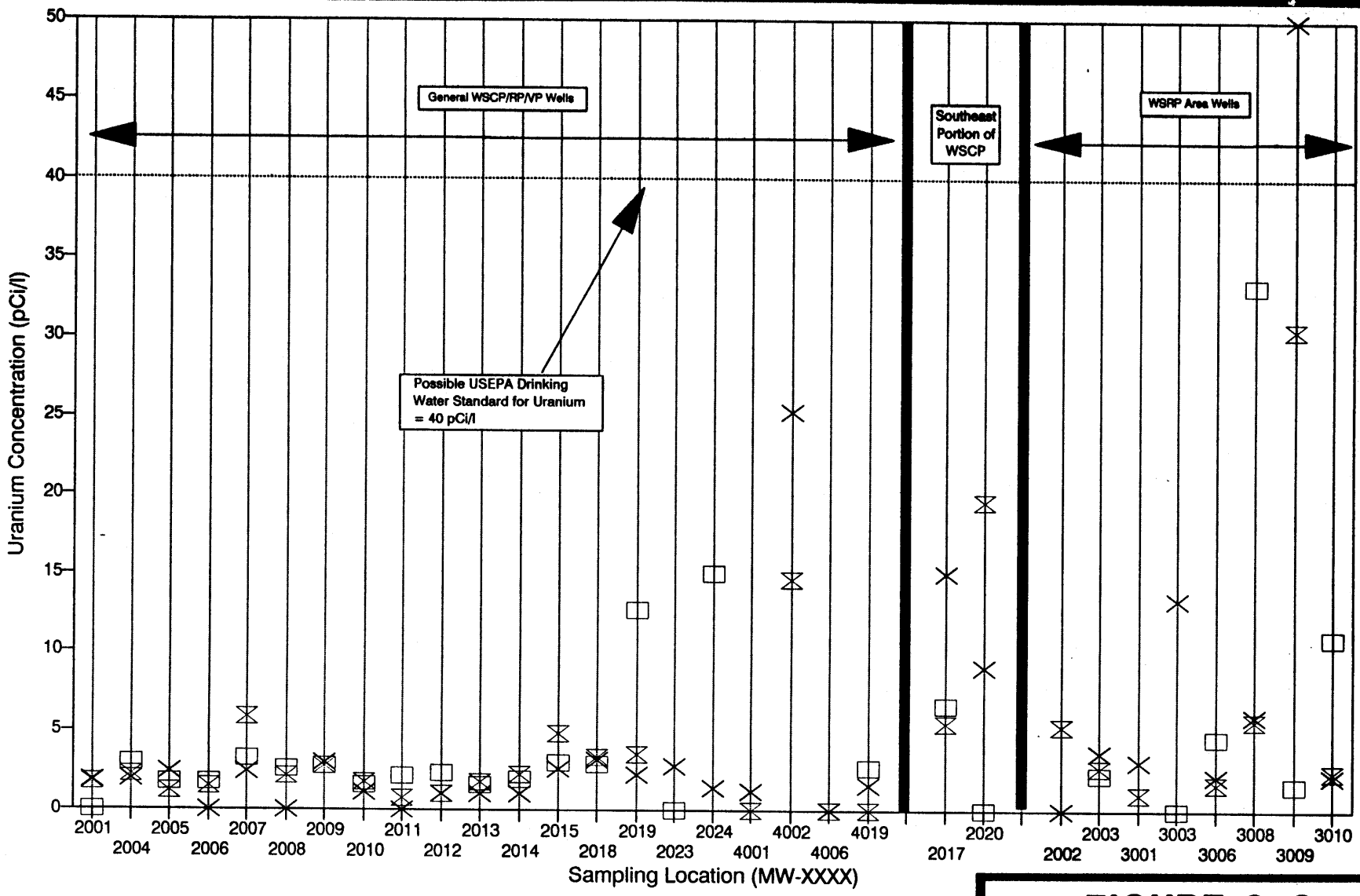


FIGURE 2-3
ANNUAL URANIUM CONCENTRATIONS WSCP/RP/VP GROUNDWATER 1987-1989

2.1.1.2 Analytical Results for Nitroaromatic Compounds

No primary or secondary drinking water standards have been promulgated for any of the six nitroaromatic compounds previously listed. However, standards set by the Clean Water Act-Federal Ambient Water Quality Criteria may be utilized as a reference for discussion. The criteria for 2,4-DNT is 0.11 µg/l based on a lifetime 10^{-6} cancer risk. For nitrobenzene, the criteria is 30 µg/l based on toxicity. Both 2,4-DNT and 2,6-DNT are suspected carcinogens. Nitroaromatic compounds are not naturally occurring; therefore any concentration detected indicates contamination of the groundwater system.

Each groundwater monitoring well was sampled and analyzed for nitroaromatic compounds during 1989. Table 2-2 provides a summary of the results. Nitroaromatic compounds were not detected in 28 monitoring wells. Twenty-four monitoring wells exhibited a cumulative annual nitroaromatic compounds concentration above ND, but below 10 µg/l. Six wells exhibited annual concentrations greater than 10 µg/l. They are MW-2006, MW-2013, MW-4001, MW-4006, MW-4009, and MW-4013. Figure 2-4 shows the locations of these wells and their respective annual concentrations.

Six groundwater monitoring wells--MW-2003, MW-2008, MW-2013, MW-3001, MW-4001 and MW-4006--exhibited annual concentrations of 2,4-DNT above the ambient water quality criteria (0.11 µg/l). Figure 2-5 highlights the locations of wells exhibiting annual concentrations of 2,4-DNT above these criteria. No monitoring wells contained annual concentrations of nitrobenzene exceeding 30 µg/l. Overall the nitroaromatic results are consistent with past environmental monitoring and characterization studies.

TABLE 2-2 Summary of 1989 Data for Nitroaromatic Compounds, Weldon Spring Chemical Plant/Raffinate Pits

	1,3,5-TNB ug/l (0.01)*		1,3-DNB ug/l (0.13)*		2,4,6-TNT ug/l (0.17)*		2,4-DNT ug/l (0.05)*		2,6-DNT ug/l (0.17)*		Nitrobenzene ug/l (0.2)*		Total Nitroaromatics ug/l
GW-2001	ND	(1/1)@	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2002	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.16	(1/1)	ND	(1/1)	0.46
GW-2003	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.55	(1/1)	0.75	(1/1)	ND	(1/1)	1.3
GW-2004	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2005	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.08	(1/1)	ND	(1/1)	ND	(1/1)	0.08
GW-2006	9.62	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	1.60	(1/1)	ND	(1/1)	11.22
GW-2007	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2008	ND	(1/1)	0.58	(1/1)	ND	(1/1)	0.13	(1/1)	ND	(1/1)	ND	(1/1)	0.71
GW-2009	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.19	(1/1)	ND	(1/1)	0.19
GW-2010	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.92	(1/1)	ND	(1/1)	0.92
GW-2011	0.55	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	1.91	(1/1)	ND	(1/1)	2.46
GW-2012	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2013	5.48	(1/1)	ND	(1/1)	2.29	(1/1)	2.47	(1/1)	7.83	(1/1)	ND	(1/1)	18.07
GW-2014	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2015	0.21	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.63	(1/1)	ND	(1/1)	0.84
GW-2017	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2018	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2019	0.07	(2/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.07
GW-2020	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2021	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND
GW-2022	0.03	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	6.00	(1/4)	6.03
GW-2023	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-2024	0.05	(2/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.05
GW-2025	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-2026	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-2027	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(3/3)	ND	(4/4)	ND
GW-2028	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(3/3)	1.22	(1/4)	ND
GW-2029	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND
GW-3001	0.10	(4/4)	ND	(4/4)	ND	(4/4)	0.39	(2/4)	ND	(4/4)	ND	(4/4)	0.49
GW-3002	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(2/4)	ND	(4/4)	ND	(4/4)	ND
GW-3003	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(2/4)	ND	(4/4)	ND	(4/4)	ND
GW-3006	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(2/4)	ND	(4/4)	ND	(4/4)	ND
GW-3008	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.06	(1/1)	ND	(1/1)	ND	(1/1)	0.06
GW-3009	0.06	(1/1)	ND	(1/1)	ND	(1/1)	0.07	(1/1)	ND	(1/1)	ND	(1/1)	0.13
GW-3010	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-3019	0.04	(1/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	0.04

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

* Detection Limit

@ Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1989. For example, 2.00 (2/4) indicates that 4 samples were taken in 1989, 2 of which were ND and the other 2 samples average 2.00.

TABLE 2-2 Summary of 1989 Data for Nitroaromatic Compounds, Weldon Spring Vicinity Properties (Continued)

	1,3,5-TNB ug/l (0.01)*		1,3-DNB ug/l (0.13)*		2,4,6-TNT ug/l (0.17)*		2,4-DNT ug/l (0.05)*		2,6-DNT ug/l (0.17)*		Nitrobenzene ug/l (0.2)*		Total Nitroaromatics ug/l
GW-4001	47.06	(1/1)	2.31	(1/1)	1.75	(1/1)	0.85	(1/1)	2.68	(1/1)	6.08	(1/1)	60.73
GW-4002	0.02	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.02
GW-4003	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4004	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4005	0.10	(2/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.1
GW-4006	1.93	(1/1)	1.93	(1/1)	ND	(1/1)	0.39	(1/1)	3.50	(1/1)	3.34	(1/1)	11.09
GW-4007	0.02	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.02
GW-4008	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4009	16.52	(1/3)	ND	(3/3)	7.78	(1/3)	ND	(3/3)	1.70	(1/3)	ND	(3/3)	26.00
GW-4010	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4011	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4012	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4013	55.54	(3/4)	0.80	(1/4)	ND	(4/4)	ND	(4/4)	0.95	(2/4)	ND	(4/4)	57.29
GW-4014	0.34	(2/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.34
GW-4015	0.12	(3/4)	0.25	(1/4)	ND	(4/4)	ND	(4/4)	1.36	(4/4)	0.42	(1/4)	2.15
GW-4016	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND
GW-4017	0.05	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.05
GW-4018	0.13	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	013
GW-4019	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-4020	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4021	0.02	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.02
GW-4022	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4023	0.30	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.30

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

* Detection Limit

@ Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1989. For example, 2.00 (2/4) indicates that 4 samples were taken in 1989, 2 of which were ND and the other 2 samples average 2.00.

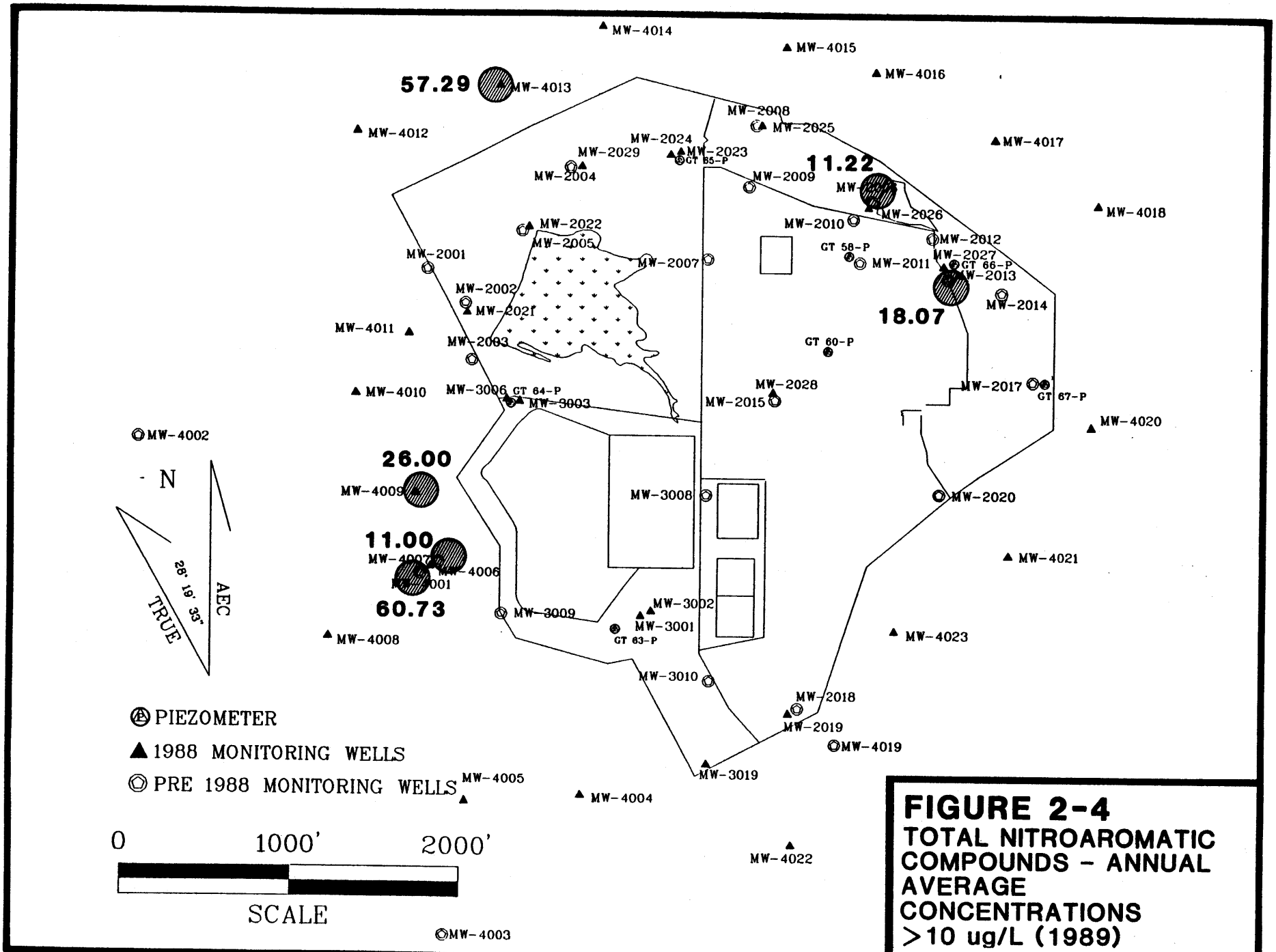


FIGURE 2-4
TOTAL NITROAROMATIC COMPOUNDS - ANNUAL AVERAGE CONCENTRATIONS >10 ug/L (1989)

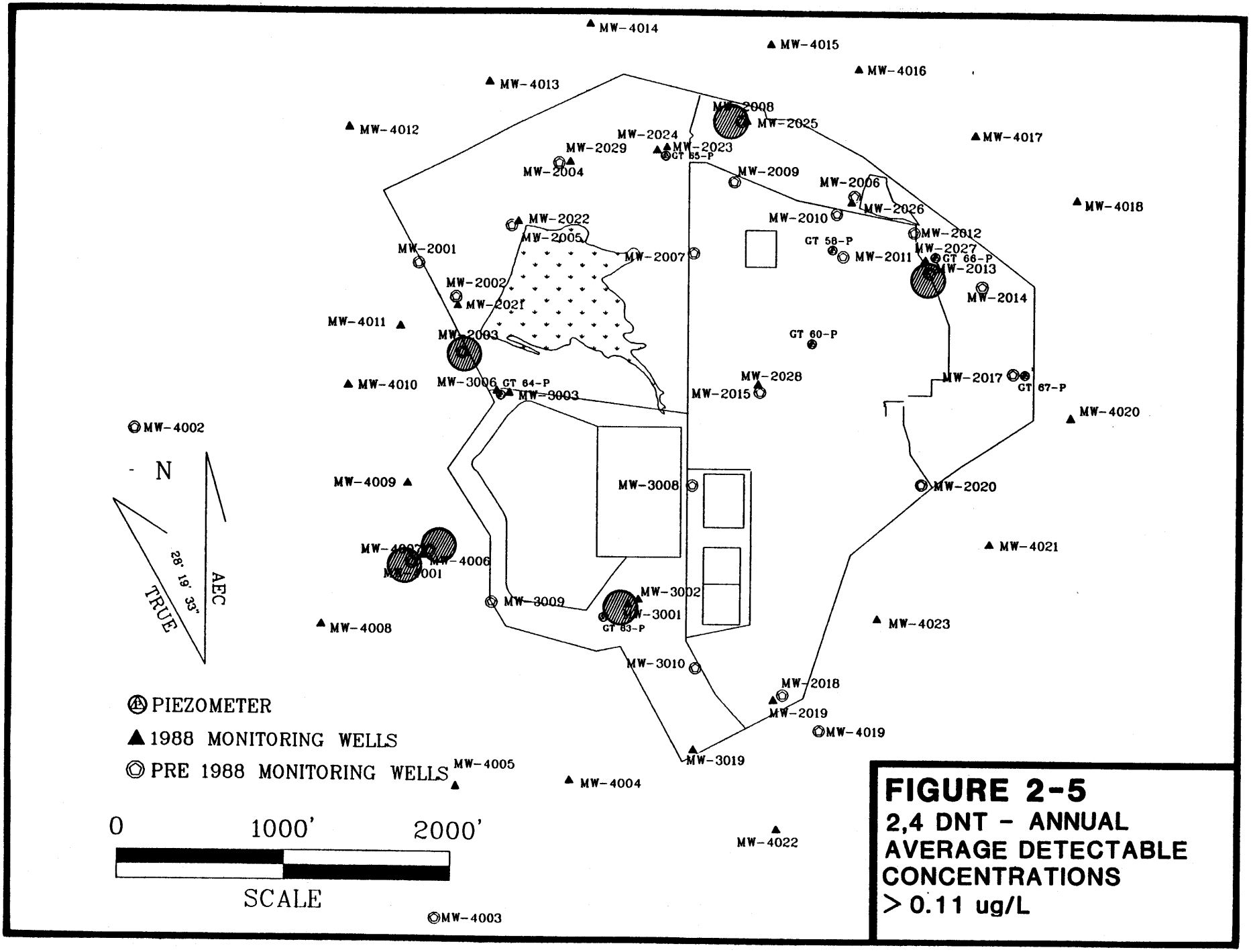


FIGURE 2-5
2,4 DNT - ANNUAL AVERAGE DETECTABLE CONCENTRATIONS > 0.11 ug/L

WSCP/WSRP/WSVP TOTAL NITROAROMATIC COMPOUNDS TREND ANALYSIS

The annual concentrations of total nitroaromatic compounds reported in previous monitoring reports and this report are displayed for comparison in Figure 2-6.

Monitoring wells within the section of the graph labeled "General WSCP/WSRP/WSVP Wells" show a very uniform, relatively low total nitroaromatic compound concentration history. Wells located within the northeast portion of the WSCP historically have had the highest concentrations of total and individual nitroaromatic compounds. Total nitroaromatic compounds concentration in all of these "northeast portion" wells, with the exception of MW-2012, have continually decreased in the period since 1987. MW-2012 had higher concentrations in 1988 than 1987. The cause of this general decrease is not known but may be due to drilling activities in 1988 and 1989.

Groundwater monitoring wells located on the Weldon Spring Training Area (WSTA) generally have displayed consistent levels of nitroaromatic compounds. MW-4001 remained the well with the highest total nitroaromatic compound concentration on the WSTA in 1989.

2.1.1.3 Inorganic Anions Results

As previously discussed, nitrate, sulfate, chloride and fluoride are included in the WSSRAP environmental monitoring program. Table 2-1 displays the annual concentrations of inorganic anions for 1989 at the WSCP/WSRP/WSVP area.

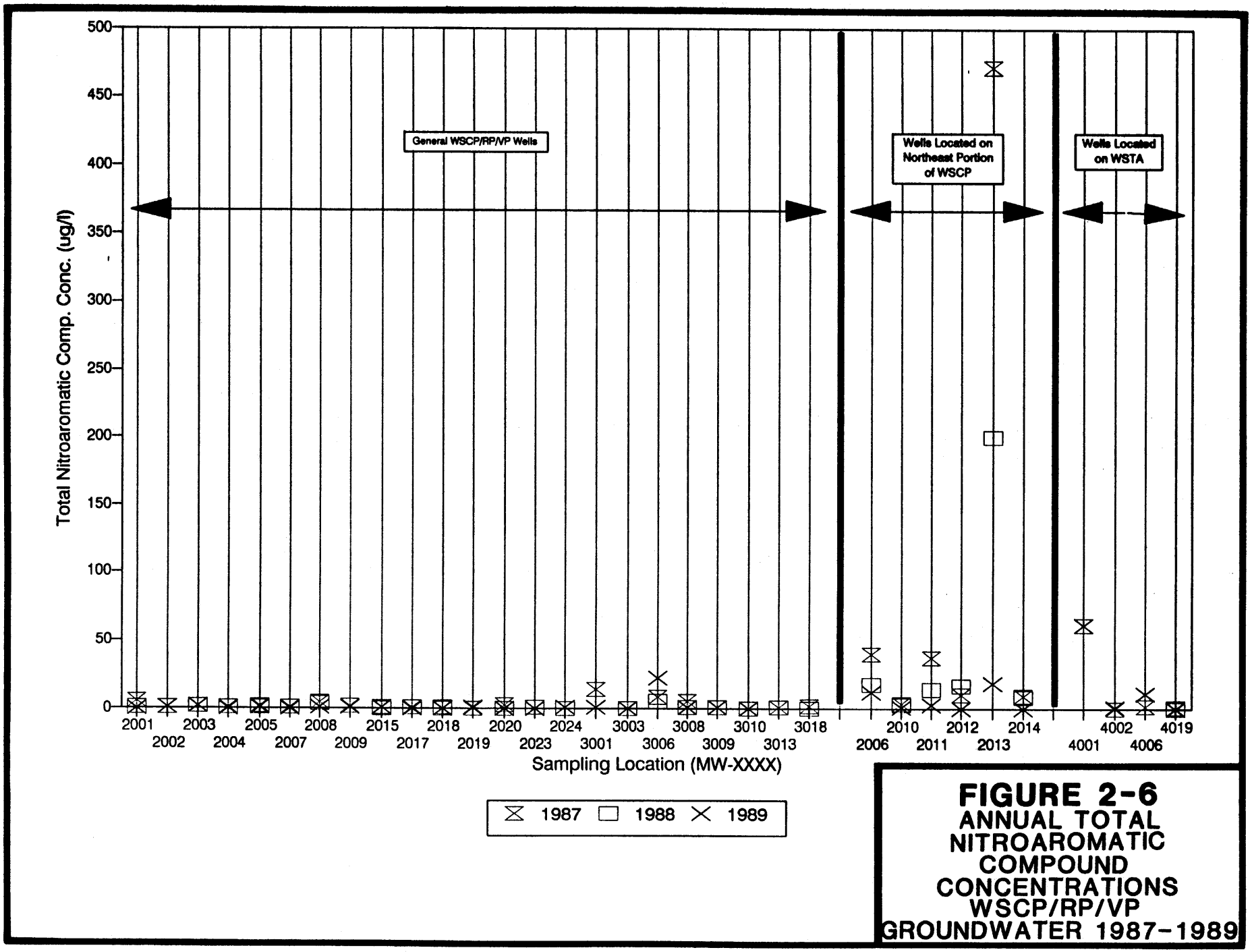


FIGURE 2-6
ANNUAL TOTAL NITROAROMATIC COMPOUND CONCENTRATIONS WSCP/RP/VP GROUNDWATER 1987-1989

NITRATE

The standard issued in the Safe Drinking Water Act for nitrate as nitrogen is 10 mg/l. Converted, this standard is 45 of nitrate. Background nitrate concentrations are below 14.43 mg/l (MKF and JEG, 1989a). During 1989, concentrations exceeding the standard occurred in 12 groundwater monitoring wells. The range of values for these wells is 50.20 mg/l in MW-2001 to 3330.00 mg/l in MW-2003. Figure 2-7 shows the locations of these wells at the WSCP/WSRP/WSVP area.

WSCP/WSRP/WSVP NITRATE TREND ANALYSIS

The nitrate concentrations reported in the previous monitoring reports and this report are displayed for comparison in Figure 2-8. Groundwater monitoring wells in the general WSCP/WSRP/WSVP area have consistently had nitrate concentrations below the drinking water standard of 45 mg/l from 1987 through 1989.

Monitoring wells shown on Figure 2-8 under "Wells at or near WSRP" are located adjacent to or closer to the raffinate pits than the general WSCP/WSRP/WSVP wells discussed above. Generally, they display a trend of increasing nitrate concentration with time. Because the raffinate pits provide hydraulic head to the groundwater system, and because they are a source of nitrate, this increasing concentration of nitrate in groundwater may be expected to continue with time, until the source is eliminated. The size of the nitrate plume does not appear to be changing, indicating that the groundwater velocity is slow.

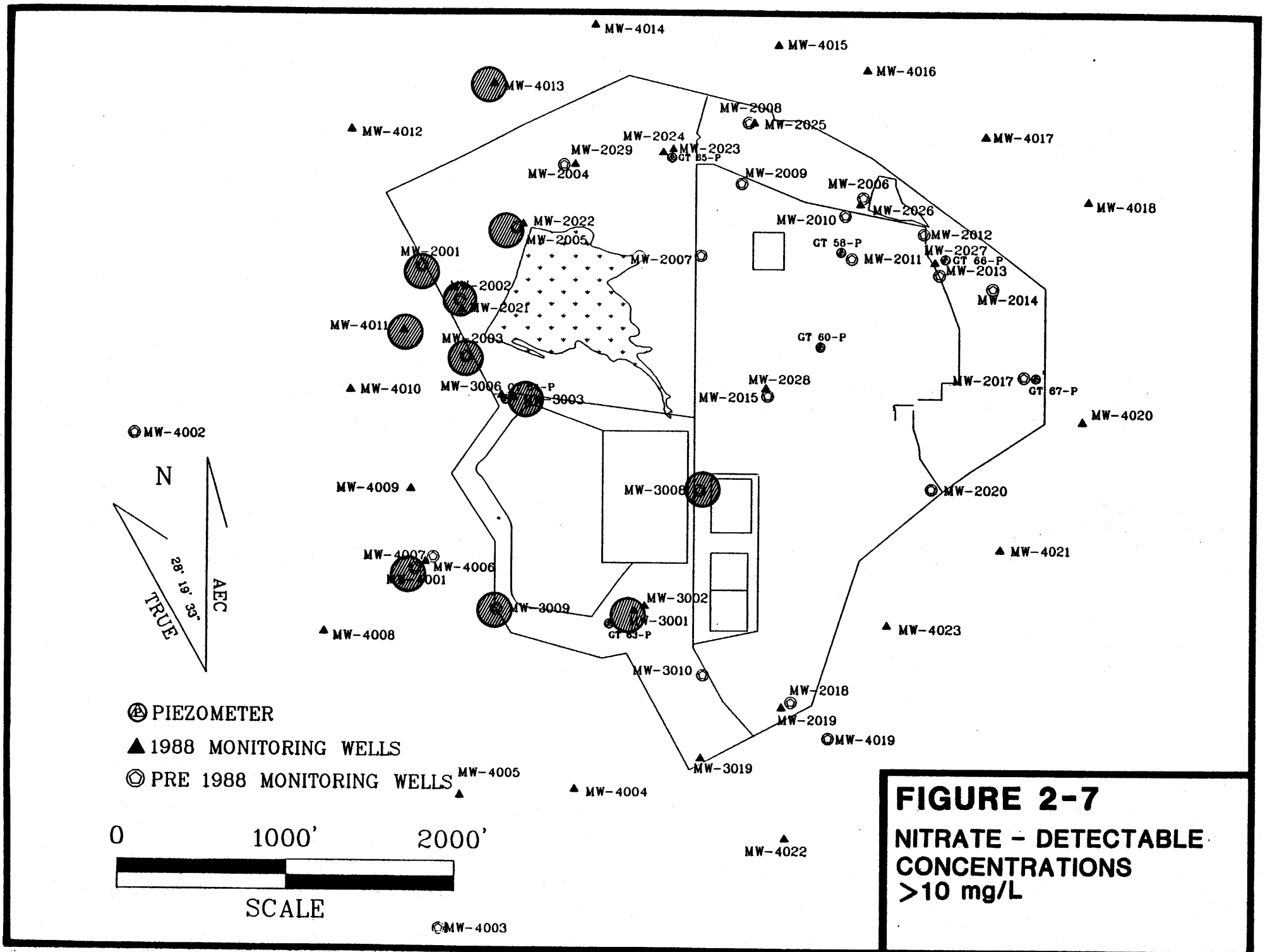


FIGURE 2-7

NITRATE - DETECTABLE CONCENTRATIONS >10 mg/L

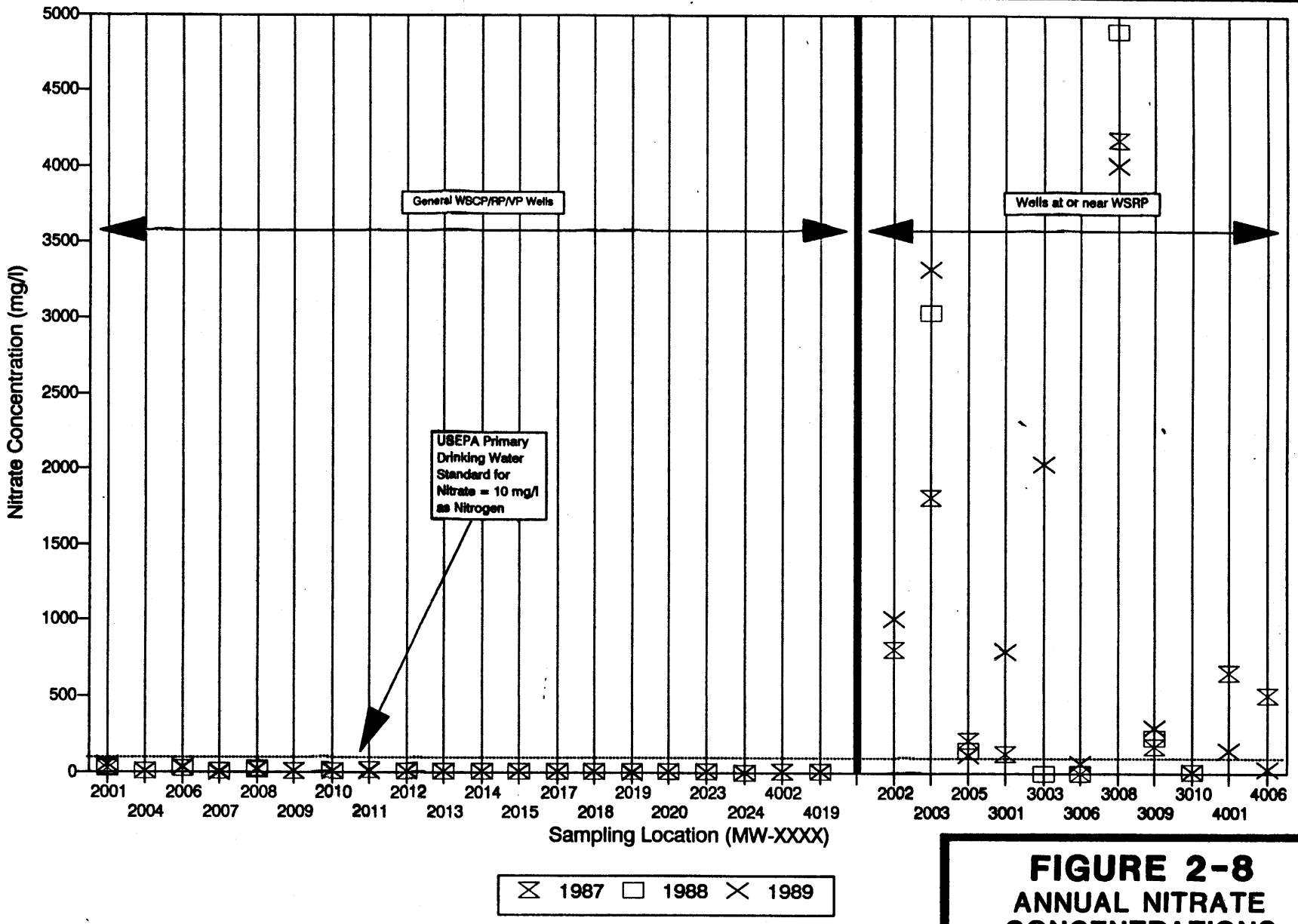


FIGURE 2-8
ANNUAL NITRATE CONCENTRATIONS WSCP/RP/VP GROUNDWATER 1987-1989

SULFATE

The upper bound of natural background sulfate concentrations in the aquifer at the WSCP/WSRP/WSVP was determined to be 50 mg/l (MKF and JEG, 1989a). The EPA secondary drinking water standard for sulfate is 250 mg/l. Twelve wells--MW-2009, MW-2015, MW-2020, MW-2028, MW-3003, MW-3006, MW-3009, MW-4001, MW-4013, MW-4020, MW-4022, and MW-4023--have annual sulfate concentrations between the upper bound of background and the EPA secondary drinking water standard. Four groundwater monitoring wells--MW-2003, MW-2012, MW-2017, and MW-4021--have an annual sulfate concentration higher than the EPA secondary drinking water standard. Figure 2-9 shows locations of wells with annual concentrations either above background and/or above the EPA secondary drinking water standard. The Phase II Groundwater Quality Assessment established that former WSOW processes were the primary source of these areas of sulfate contamination.

WSCP/WSRP/WSVP SULFATE TREND ANALYSIS

The annual concentrations of sulfate reported in previous monitoring reports and this report are displayed for comparison in Figure 2-10. The majority of groundwater monitoring wells on the "General WSCP/WSRP/WSVP Wells" portion of the graph have consistently yielded concentrations of sulfate below the EPA secondary drinking water standard of 250 mg/l during the years 1987 through 1989. The single exception to this is MW-2012, which was sampled during the second quarter of 1989 and contained 415 mg/l sulfate. This may be related to the increase in nitroaromatic concentrations in this well. One well, MW-2017, located in the southern portion of the WSCP, has exhibited

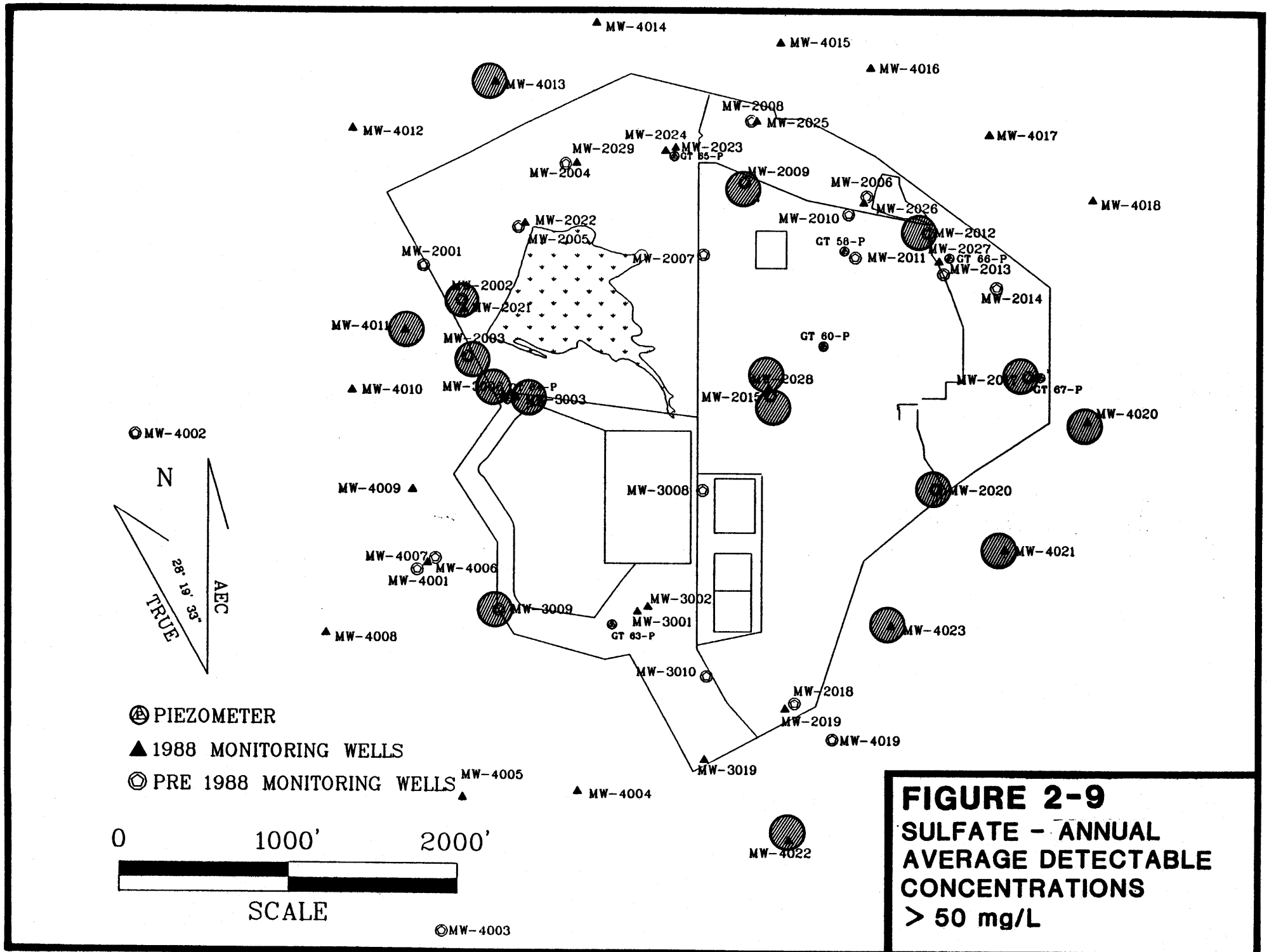


FIGURE 2-9
SULFATE - ANNUAL AVERAGE DETECTABLE CONCENTRATIONS > 50 mg/L

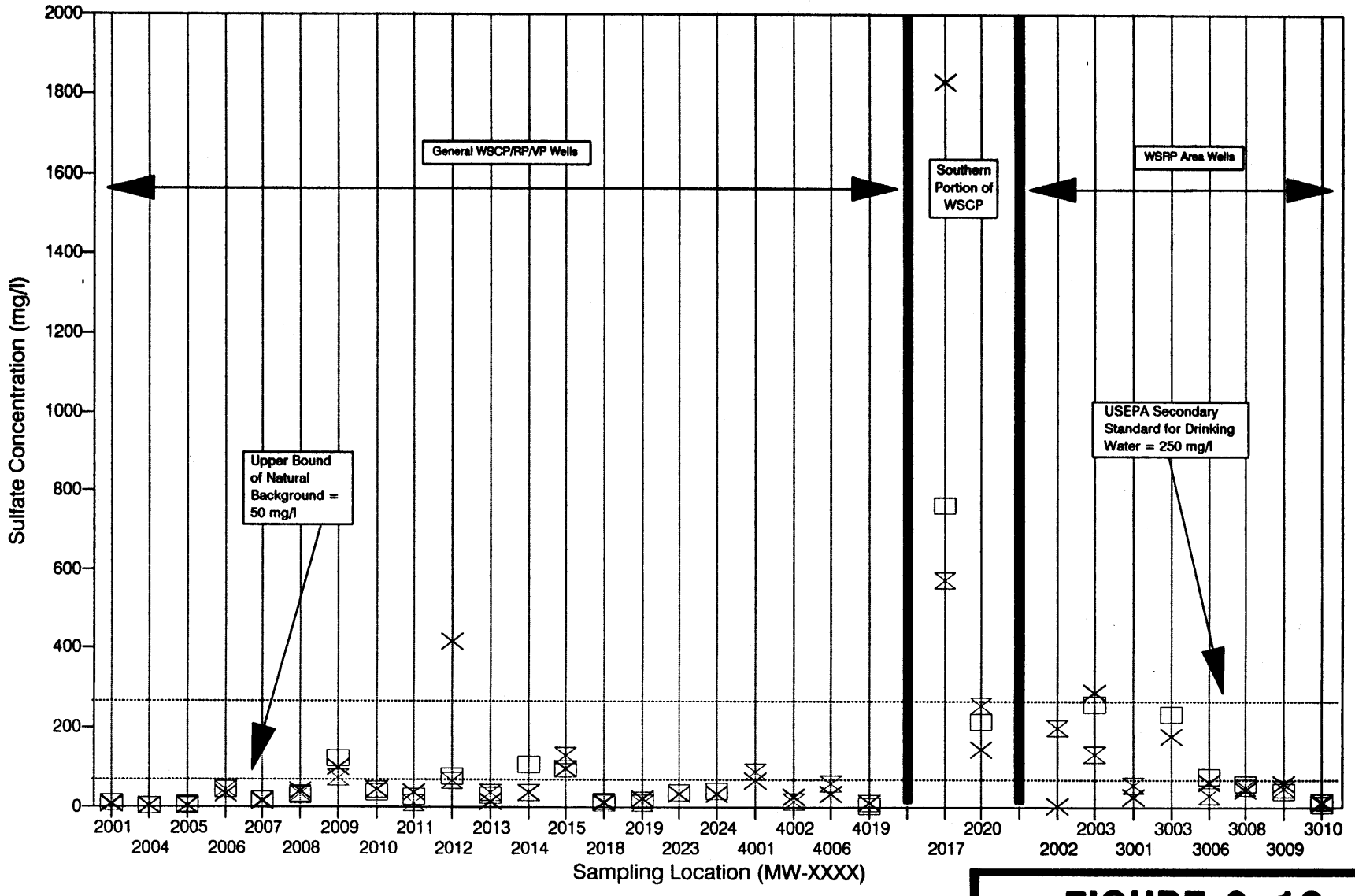


FIGURE 2-10
ANNUAL SULFATE CONCENTRATIONS WSCP/RP/VP GROUNDWATER 1987-1989

increased sulfate concentrations since 1987. Further complicating the picture, a nearby well (MW-2020) considered to be positioned in the same sulfate plume as MW-2017 (MKF and JEG, 1989a), has decreased in sulfate concentration since 1987. The cause of these fluctuations is not known. Another noticeable trend is the increase in nitrate and sulfate concentrations at well MW-2003 and the decreasing concentrations in MW-2002. The cause of these fluctuations is not known but they demonstrate consistency.

CHLORIDE

The upper limit of background concentration of chloride in groundwater at the WSCP/WSRP/WSVP area is 22 mg/l (MKF and JEG, 1989a). The EPA secondary standard for chloride in drinking water is 250 mg/l. Four wells-- MW-2008, MW-2010, MW-2012, and MW-2014-- exhibited annual detectable concentrations of chloride above natural background. Groundwater taken from one well only, MW-2006, exceeded the EPA standard with an annual average detectable concentration of 278.00 mg/l. All five of these wells are located adjacent to a surface drainage that drains a salt (sodium chloride) depot of the Missouri Highway Department off Highway 94. All of these wells have exhibited elevated chloride concentrations in the past.

FLUORIDE

Background fluoride concentrations are below 1 mg/l. The maximum contaminant level (MCL) for fluoride is 4.0 mg/l. A secondary MCL is 2.0 mg/l. No samples exceeded background concentrations. This is consistent with previous monitoring.

2.1.2 Groundwater Monitoring at the WSQ

Groundwater near the WSQ has become contaminated as a result of contact with or migration from the radioactive and hazardous substances present in the WSQ. Twenty-six DOE groundwater monitoring wells located at or near the Weldon Spring Quarry were sampled and analyzed during 1989 to monitor for the presence of WSQ related contaminants. Figures 2-11A and 2-11B show the locations of the groundwater monitoring wells. Groundwater samples were analyzed for natural uranium, nitroaromatic compounds, and inorganic anions. The groundwater monitoring wells are screened in a range of geologic formations from the Ordovician-aged Plattin Limestone, upsection to and including the unconsolidated Quaternary-aged Missouri River alluvium. Samples from four monitoring wells screened in the Missouri River alluvium and owned by St. Charles County were also analyzed during 1989. During 1988 and 1989, samples of groundwater were taken from a private water well which produces from the Missouri River alluvium and is located several miles upstream of the WSQ and St. Charles County well field. These samples were analyzed for a suite of parameters including total uranium, metals and inorganic anions. Four separate uranium analyses were run on samples from this background well and the results ranged from 4.8 pCi/l to 9.0 pCi/l with an average value of 6.8 pCi/l. Although not a comprehensive background study, it appears that values in the range of 5 pCi/l or slightly above can constitute background concentrations in the Missouri River alluvium.

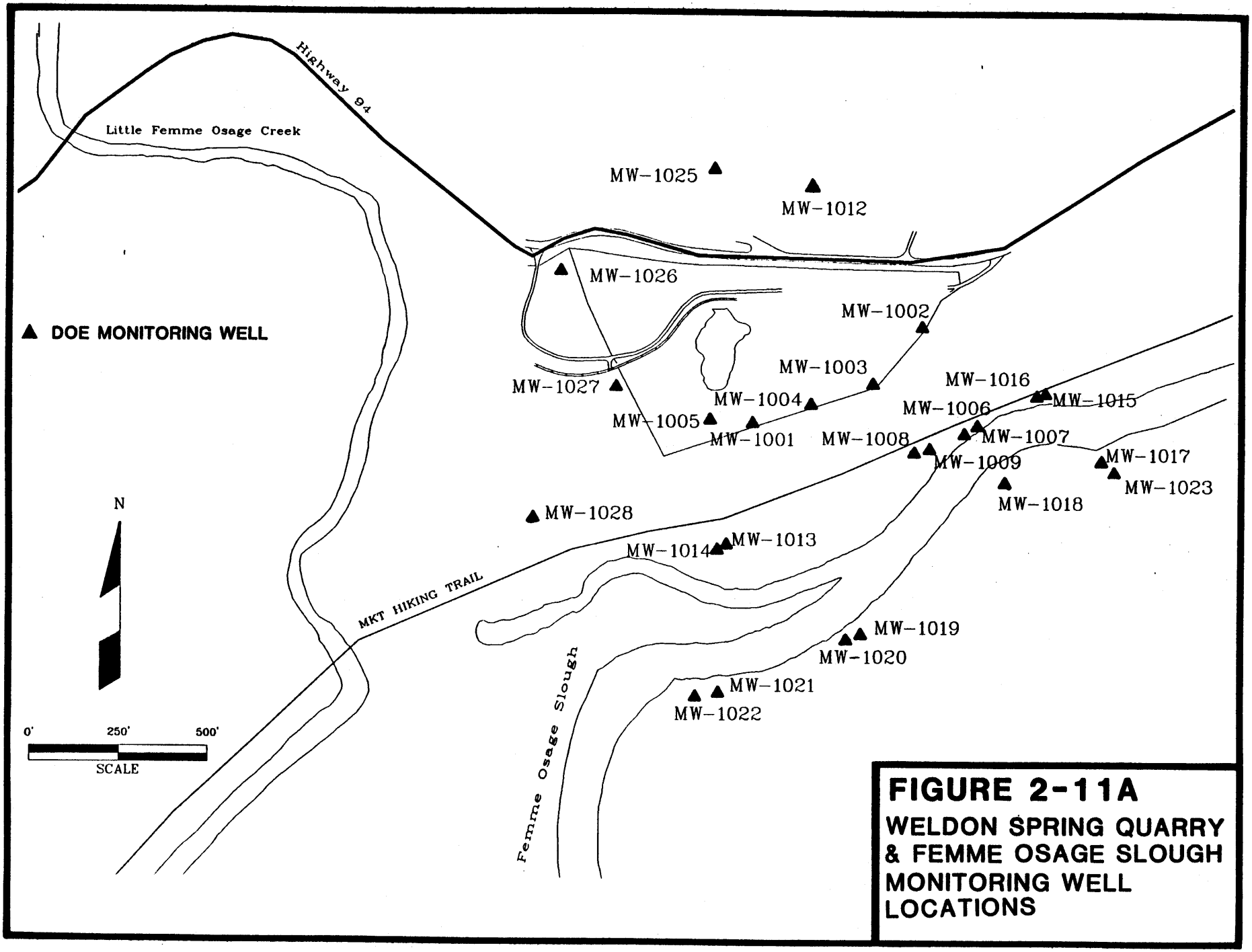


FIGURE 2-11A
WELDON SPRING QUARRY & FEMME OSAGE SLOUGH MONITORING WELL LOCATIONS

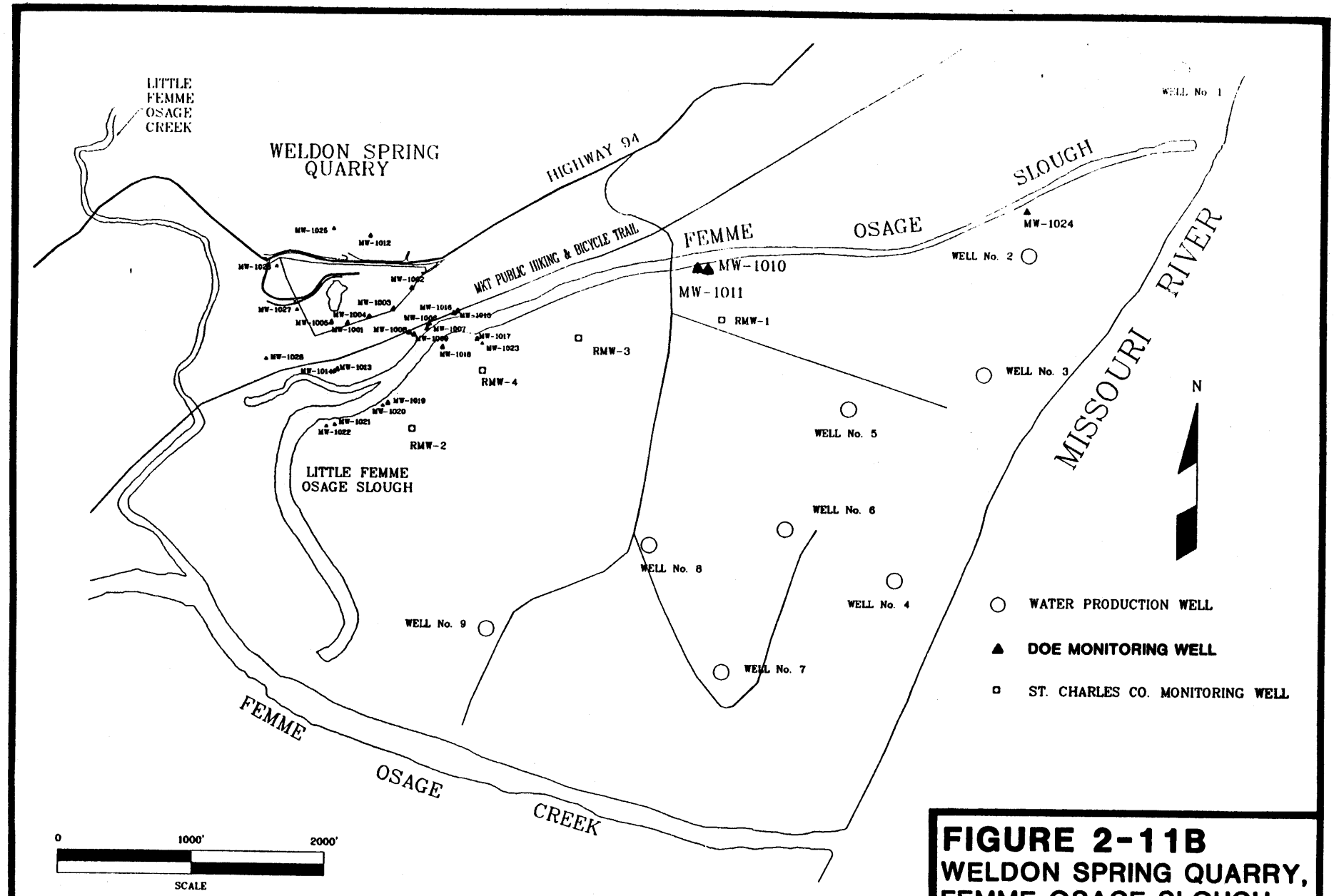


FIGURE 2-11B
WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, & ST. CHARLES CO. WELL FIELD MONITORING WELL LOCATIONS

2.1.2.1 Radiological Results

Groundwater samples from 26 DOE monitoring wells and the four St. Charles County monitoring wells were analyzed for total uranium during 1989. Table 2-3 presents the results of these analyses. The results of the 1989 monitoring near the WSQ indicate that, although uranium concentrations have changed in individual wells, elevated uranium levels remain isolated to the bedrock adjacent to the quarry and the alluvium on the north side of the Femme Osage Slough. Samples from monitoring wells south of the slough exhibited average concentrations below 5 pCi/l. Elevated uranium levels north of the slough ranged from 260 pCi/l at MW-1016 to 4400 pCi/l in MW-1004, immediately adjacent to the quarry waste. Figure 2-12 highlights the wells with above-background uranium concentrations.

Groundwater samples from five wells--MW-1012 and the four St. Charles County groundwater monitoring wells--were analyzed for radium-226, thorium-230 and thorium-232. All analyses for these radionuclides indicated that the levels were below the minimum detection limit with the exception of MW-1012 (with a history of measurable thorium-230) which averaged 1.2 pCi/l thorium-230.

WSQ URANIUM TREND ANALYSIS

The concentrations of uranium at the WSQ reported in previous monitoring reports and this report are displayed for comparison in Figure 2-13. This figure illustrates that uranium is not and has not been present in elevated levels in DOE groundwater monitoring wells located south of the Femme Osage

TABLE 2-3 Summary of 1989 Data for Inorganic Anions and Radionuclides--Weldon Spring Quarry

	Chloride mg/l (0.25)*	Fluoride mg/l (0.25)*	Nitrate mg/l (0.1)*	Sulfate mg/l (1.0)*	Total Uranium pCi/ml (1.0)*	Radium 226 pCi/l (0.2)*	Thorium 230 pCi/l (1.0)*	Thorium 232 pCi/l (1.0)*
GW-1002	16.60 (1/1) @	ND (1/1)	16.30 (1/1)	79.30 (1/1)	3.00 (1/1)			
GW-1004	14.50 (1/1)	0.60 (1/1)	1.90 (1/1)	1000.00 (1/1)	4350.00 (1/1)			
GW-1005	19.90 (1/1)	0.50 (1/1)	ND (1/1)	598.00 (1/1)	1750.00 (1/1)			
GW-1006	31.60 (1/1)	ND (1/1)	9.30 (1/1)	441.00 (1/1)	2400.00 (1/1)			
GW-1007	61.10 (1/1)	ND (1/1)	0.20 (1/1)	184.00 (1/1)	438.00 (1/1)			
GW-1008	14.40 (1/1)	ND (1/1)	2.40 (1/1)	292.00 (1/1)	1380.00 (1/1)			
GW-1009	24.80 (1/1)	ND (1/1)	ND (1/1)	240.00 (1/1)	7.40 (1/1)			
GW-1010	9.80 (1/1)	ND (1/1)	ND (1/1)	ND (1/1)	ND (1/1)			
GW-1011	NOT SAMPLED -- DRY DURING SCHEDULED SAMPLING PERIOD (Q289)							
GW-1012	9.70 (1/1)	ND (1/1)	8.10 (1/1)	81.20 (1/1)	6.0 (3/3)	ND (2/2)	1.20 (1/2)	ND (2/2)
GW-1013	23.40 (4/4)	0.42 (2/4)	ND (4/4)	125.50 (4/4)	802.00 (4/4)			
GW-1014	20.20 (4/4)	0.46 (1/4)	1.30 (1/4)	125.60 (4/4)	874.00 (4/4)			
GW-1015	14.00 (1/1)	ND (1/1)	9.80 (1/1)	219.00 (1/1)	382.00 (4/4)			
GW-1016	10.50 (1/1)	ND (1/1)	2.40 (1/1)	160.00 (1/1)	260.00 (4/4)			
GW-1017	19.30 (1/1)	ND (1/1)	0.40 (1/1)	ND (1/1)	ND (4/4)			
GW-1018	28.80 (1/1)	ND (1/1)	ND (1/1)	49.40 (1/1)	ND (4/4)			
GW-1019	7.70 (1/1)	ND (1/1)	2.40 (1/1)	ND (1/1)	ND (4/4)			
GW-1020	13.90 (1/1)	ND (1/1)	ND (1/1)	ND (1/1)	0.68 (1/4)			
GW-1021	8.60 (1/1)	ND (1/1)	ND (1/1)	ND (1/1)	ND (4/4)			
GW-1022	14.00 (1/1)	ND (1/1)	ND (1/1)	ND (1/1)	ND (4/4)			
GW-1023	5.30 (1/1)	ND (1/1)	ND (1/1)	6.80 (1/1)	1.36 (1/4)			
GW-1024	14.00 (1/1)	0.28 (1/3)	0.20 (1/1)	4.2 (2/3)	1.36 (1/4)			
GW-1025	9.10 (1/1)	ND (1/1)	0.50 (1/1)	131.90 (1/1)	4.08 (4/4)			
GW-1026	2.00 (1/1)	ND (1/1)	ND (1/1)	ND (1/1)	ND (1/1)			
GW-1027	11.80 (1/1)	ND (1/1)	1.00 (1/1)	82.80 (1/1)	649.5 (4/4)			
GW-1028	8.10 (1/1)	ND (1/1)	ND (1/1)	63.80 (1/1)	1.64 (4/4)			
GW-RMW1	9.45 (3/3)	ND (1/1)	ND (1/1)	28.05 (2/3)	1.00 (1/4)	ND (1/1)	ND (1/1)	ND (1/1)
GW-RMW2	2.7 (3/3)	ND (1/1)	ND (1/1)	36.85 (2/2)	4.47 (9/9)	ND (1/1)	ND (1/1)	ND (1/1)
GW-RMW3	13.20 (3/3)	ND (1/1)	ND (1/1)	83.97 (3/3)	1.36 (1/5)	ND (1/1)	ND (1/1)	ND (1/1)
GW-RMW4	6.33 (3/3)	ND (1/1)	1.65 (3/3)	15.23 (3/3)	1.62 (4/5)	ND (1/1)	ND (1/1)	ND (1/1)

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

* Detection Limits

@ Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1989. For example, 2.00 (2/4) indicates that 4 samples were taken in 1989, 2 of which average 2.00 and the other 2 samples were ND.

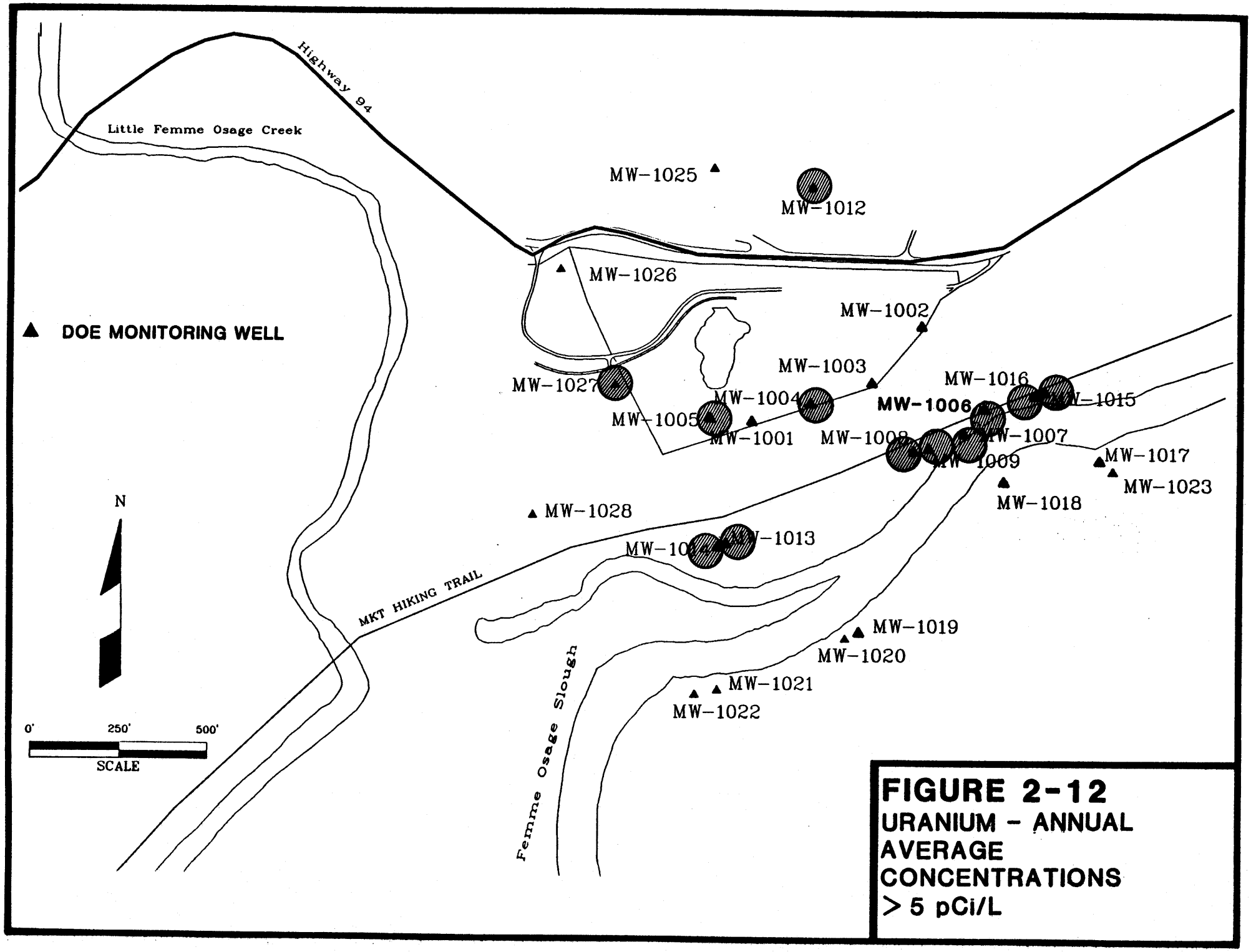


FIGURE 2-12
URANIUM - ANNUAL AVERAGE CONCENTRATIONS > 5 pCi/L

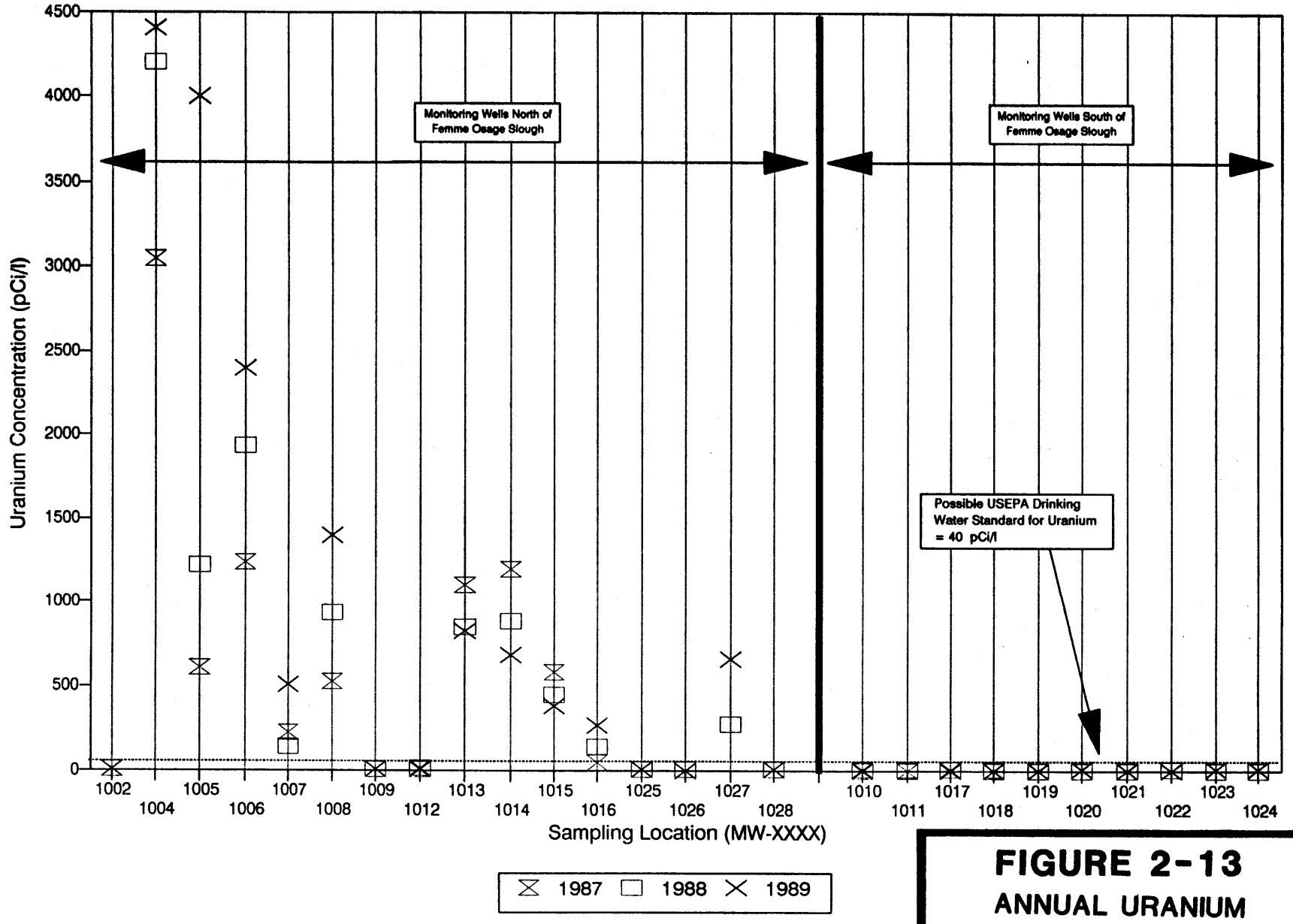


FIGURE 2-13

ANNUAL URANIUM CONCENTRATIONS WSQ GROUNDWATER 1987-1989

Slough. These wells south of the slough each have shown concentrations of uranium within the range of background since 1987.

Wells to the north of the slough and those adjacent to the WSQ display varying degrees and directions of change from 1987 to 1989. The most notable changes and trends have occurred as increases of uranium concentrations in the groundwater monitored by wells MW-1004 and MW-1005 along the WSQ rim and MW-1006 and MW-1008 in the Missouri River alluvium. Other small to moderate concentration variations occurred, both increases and decreases, in the wells in the WSQ area as presented in Figure 2-13. Although the increasing trends in uranium concentrations at select wells call for heightened awareness and review of the groundwater situation, the data continues to indicate no cause for immediate concern for the integrity of the St. Charles County well field and water supply.

2.1.2.2 Analytical Results for Nitroaromatic Compounds

During 1989, samples from the WSQ wells were analyzed for nitroaromatic compounds. Eleven monitoring wells yielded no detectable concentrations of any of the six nitroaromatic compounds during 1989. Analytical results are presented in Table 2-4. Figures 2-14A and 2-14B are maps of the WSQ area annotated with the annual average concentrations of total nitroaromatic compounds.

The 1,3,5-TNB concentrations in monitoring wells MW-1017 through MW-1023 are the result of laboratory contamination based on contamination of the blank sample. No monitoring wells south of the slough showed detectable concentrations of nitroaromatic compounds during 1989.

TABLE 2-4 Summary of 1989 Data for Nitroaromatic Compounds, Weldon Spring Quarry

	1,3,5-TNB ug/l (0.01)*		1,3-DNB ug/l (0.13)*		2,4,6-TNT ug/l (0.17)*		2,4-DNT ug/l (0.05)*		2,6-DNT ug/l (0.17)*		Nitrobenzene ug/l (0.2)*		Total Nitroaromatics ug/l
GW-1002	ND	(1/1)@	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1004	0.86	(1/1)	ND	(1/1)	5.56	(1/1)	0.56	(1/1)	2.42	(1/1)	ND	(1/1)	9.4
GW-1005	0.04	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.04
GW-1006	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	3.24	(1/1)	0.71	(1/1)	3.95
GW-1007	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1008	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1009	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1010	0.02	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.02
GW-1011	NOT SAMPLED -- DRY DURING SCHEDULED SAMPLING PERIOD (Q289)												
GW-1012	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.06	(1/1)	ND	(1/1)	ND	(1/1)	0.06
GW-1013	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.15	(1/1)	ND	(1/1)	ND	(1/1)	0.15
GW-1014	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1015	41.03	(3/4)	ND	(4/4)	5.92	(3/4)	ND	(4/4)	ND	(4/4)	ND	(1/1)	46.95
GW-1016	2.82	(2/4)	0.24	(1/3)	0.79	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	3.85
GW-1017	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1018	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1019	0.06	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.06
GW-1020	0.52	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.52
GW-1021	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1022	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1023	**	(0/0)	**	(0/0)	**	(0/0)	**	(0/0)	**	(0/0)	**	(0/0)	**
GW-1024	0.06	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.06
GW-1025	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1026	0.04	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.04
GW-1027	0.17	(1/1)	ND	(1/1)	6.23	(1/1)	1.14	(1/1)	1.40	(1/1)	ND	(1/1)	8.94
GW-1028	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-RMW1	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-RMW2	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-RMW3	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-RMW4	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

* Detection Limits

@ Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1989. For example, 2.00 (2/4) indicates that 4 samples were taken in 1089, 2 of which were ND and the other 2 samples average 2.00.

** No analysis was performed for this parameter at this location during 1989.

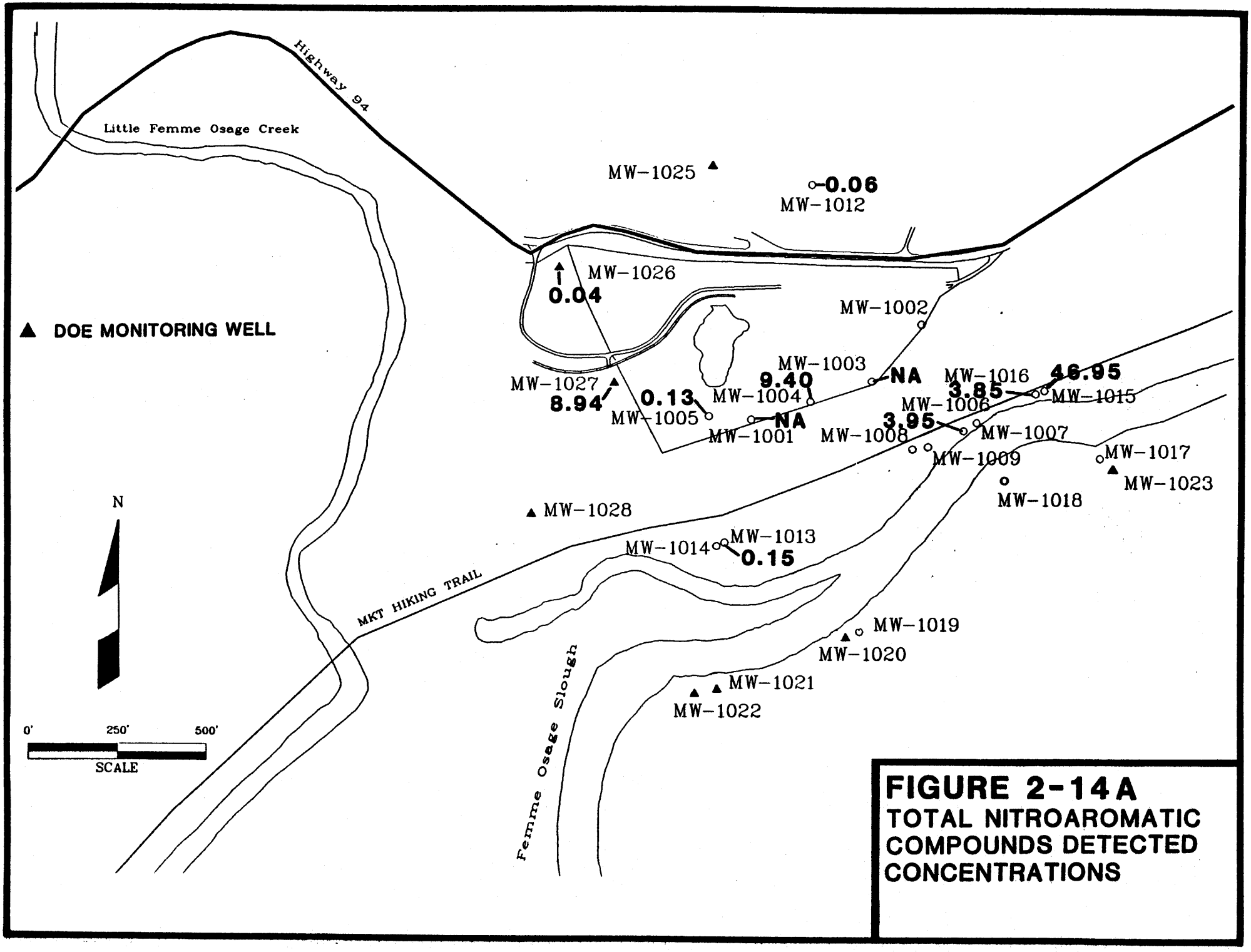


FIGURE 2-14A
TOTAL NITROAROMATIC COMPOUNDS DETECTED CONCENTRATIONS

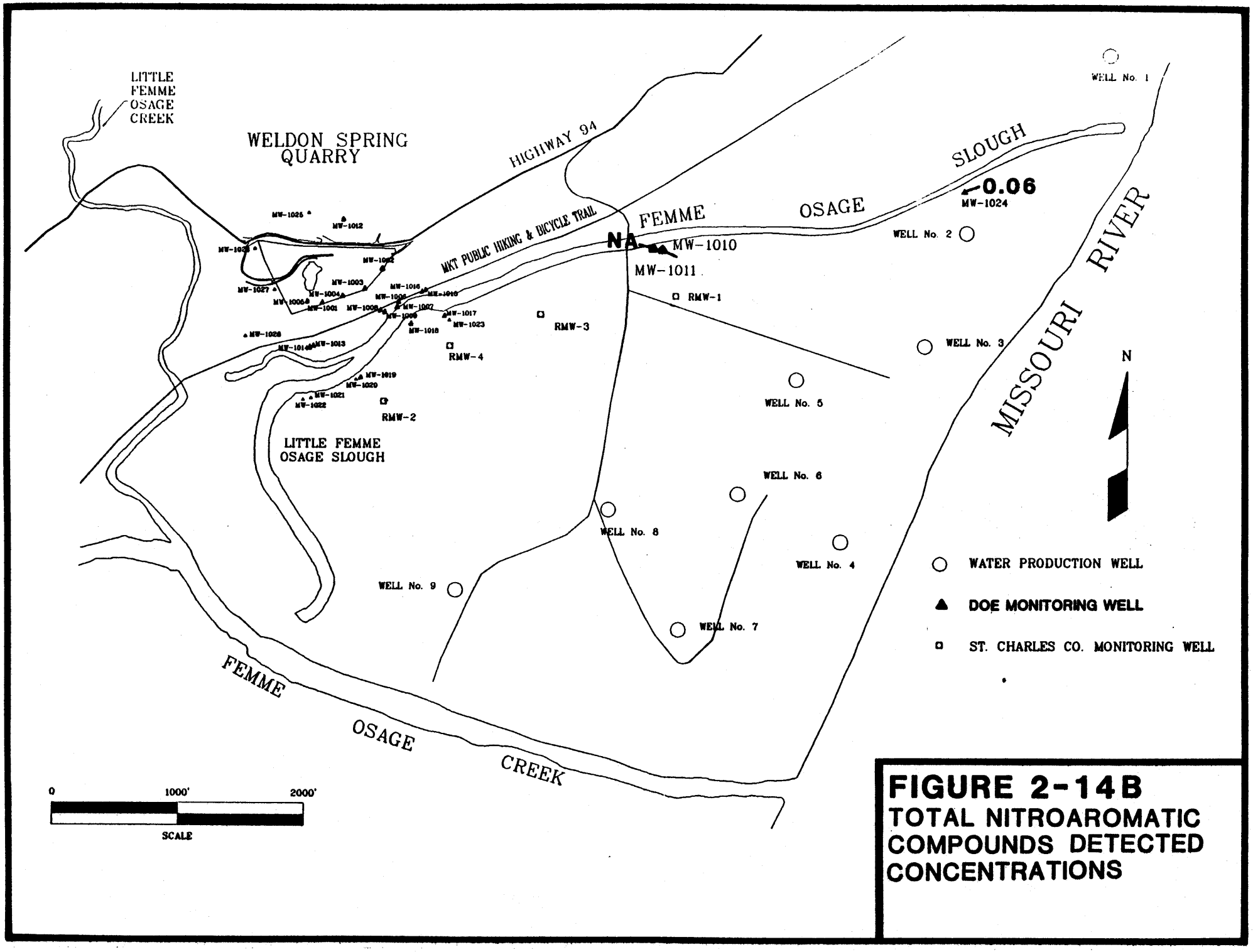


FIGURE 2-14B
TOTAL NITROAROMATIC COMPOUNDS DETECTED CONCENTRATIONS

CONCENTRATIONS OF TOTAL NITROAROMATIC COMPOUNDS IN GROUNDWATER - TREND AT THE WSQ

A comparison of data for years 1989, 1988, and 1987 suggest that concentrations of nitroaromatic compounds in groundwater are generally constant over the three years.

Figure 2-15 plots the historical averages of total nitroaromatic compounds in the WSQ groundwater. No particularly noteworthy trends in contaminant distribution or concentration were detected.

2.1.2.3 Inorganic Anions Results

Monitoring wells were sampled once in 1989 for inorganic anions. Previous WSS annual environmental monitoring reports and characterization sampling events have detected elevated inorganic anion levels in the groundwater in the vicinity of the WSQ. Four inorganic anions--nitrate, sulfate, chloride and fluoride--were targeted for study. Table 2-3 displays the 1989 annual concentrations of inorganic anions for the WSQ area. Inorganic anion results from 1989 are consistent with data reported in both the 1988 and the 1987 environmental monitoring reports. In 1988 and 1989, groundwater samples collected from the upgradient background well referenced in Section 2.1.2.1 provided some limited data on inorganic anions showing background nitrate and sulfate in the alluvial groundwater of <0.1 mg/l and 95 mg/l, respectively.

NITRATE

Table 2-3 presents the measured nitrate levels in the groundwater near the WSQ. The groundwater samples continue to

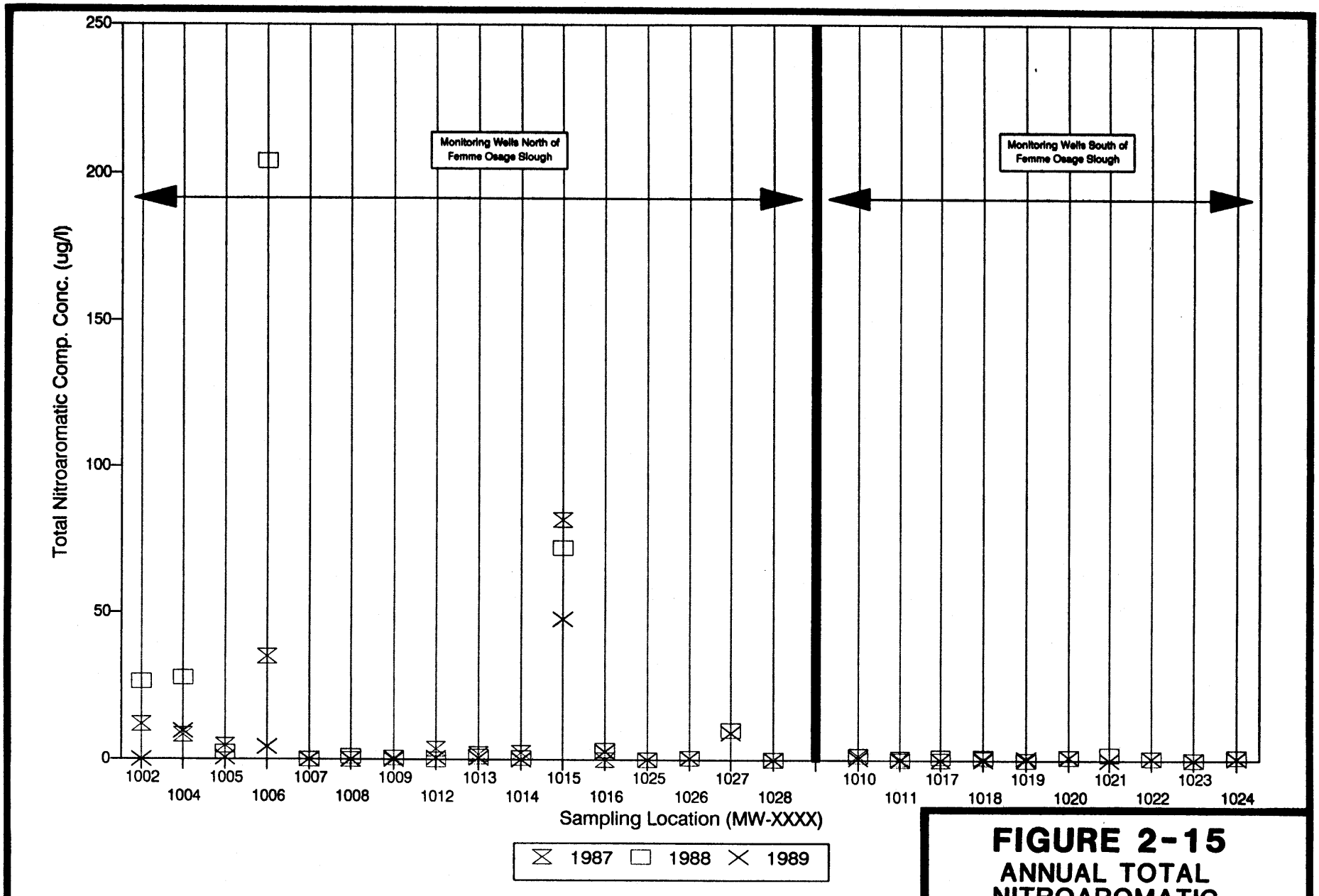


FIGURE 2-15
ANNUAL TOTAL NITROAROMATIC COMPOUND CONCENTRATIONS WSQ GROUNDWATER 1987-1989

indicate no notable groundwater contamination by nitrate, with the highest measured level observed at MW-1002 adjacent to the WSQ. This value is not attributed to contaminant migration from the WSQ, however, since the levels of nitrate in the quarry pond indicate little impact by nitrate from the quarry wastes. Further, the uranium levels in the water of MW-1002 show little impact from quarry migration. Nitrate does not constitute a particular threat to the groundwater system near the WSQ.

WSQ NITRATE TREND ANALYSIS

The annual concentrations of nitrate in groundwater near the WSQ reported in previous monitoring reports and this report are displayed for comparison in Figure 2-16. Overall, nitrate concentrations in individual wells from 1987 to 1989 remained nearly constant.

SULFATE

As will be discussed further in Section 2.2 of this report, the quarry bulk waste is a source of sulfate contamination to the surface water in the WSQ pond and subsequently to the groundwater surrounding the quarry. Sulfate levels in most of the wells adjacent to the WSQ and in the alluvium north of the Femme Osage Slough appear to be elevated as a result of migration from the quarry. The highest 1989 sulfate value of 1,000 mg/l was measured at MW-1004. Wells to the south of the slough remain at background concentration levels.

WSQ SULFATE TREND ANALYSIS

The concentrations of sulfate at the WSQ reported in previous monitoring reports and this report are displayed for

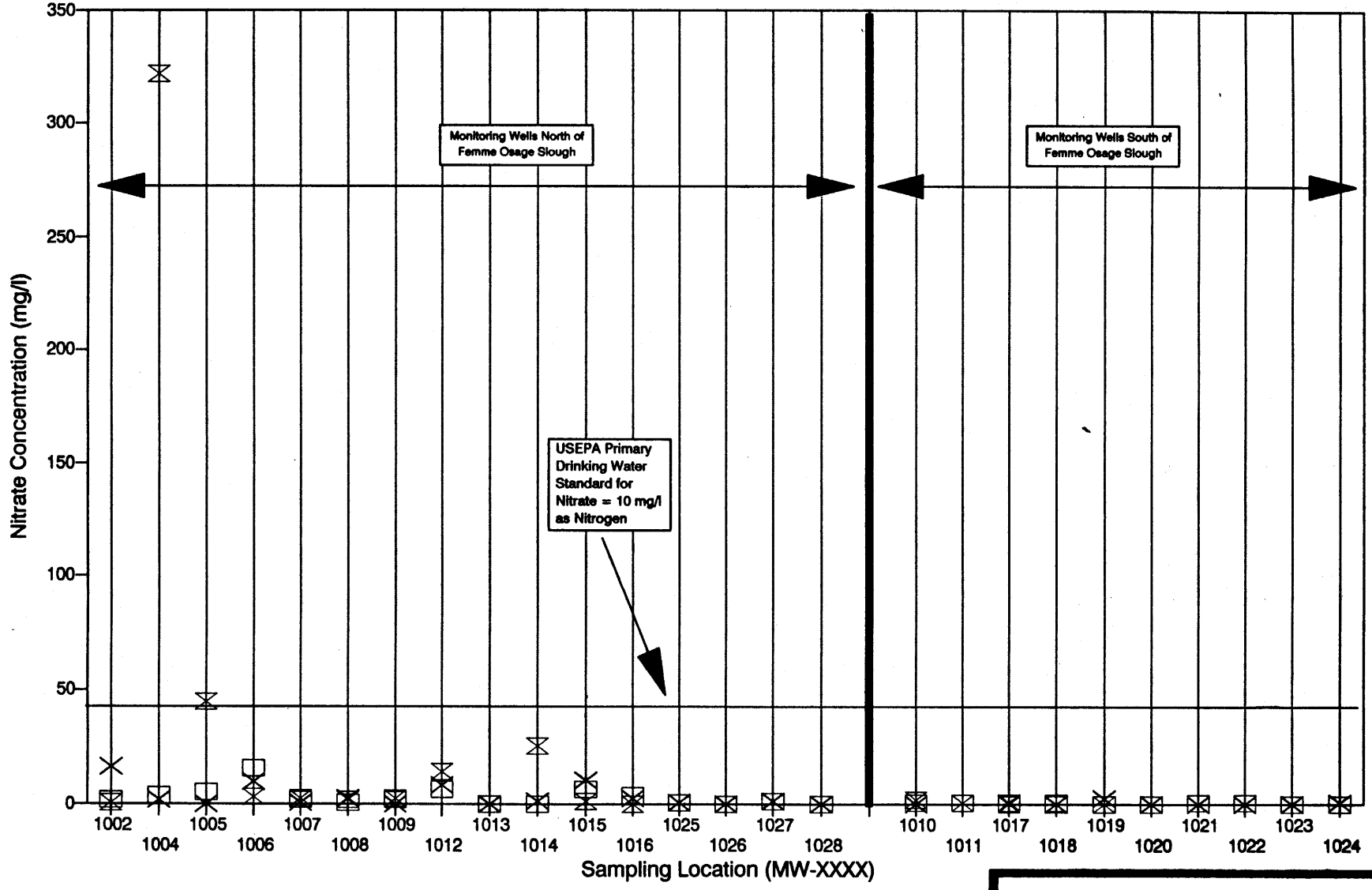


FIGURE 2-16

ANNUAL NITRATE CONCENTRATIONS WSQ GROUNDWATER 1987-1989

comparison in Figure 2-17. Evaluation of the historical sulfate data from samples from near the WSQ indicate a slight but consistent upward trend in concentration. The groundwater between the WSQ and the slough appears to have increased slightly in sulfate content from 1987 to 1989. This trend is consistent with the trend for uranium activity in the groundwater in that same area.

CHLORIDE

Chloride levels were measured once in 1989 from the WSQ monitoring wells. Those data are also presented in Table 2-3. The upper limit for background chloride levels in the bedrock aquifer near the WSCP/WSRP was established in the WSSRAP's 1988 Environmental Monitoring Report at 22 mg/l and it appears from the data from Missouri River alluvial water samples that the background for the alluvium is similar. Based upon comparison with background, chloride levels in the groundwater near the WSQ are slightly elevated in some alluvial wells north of the Femme Osage Slough. The elevated chloride levels remain well below the EPA secondary drinking water standard of 250 mg/l for chloride. Further, the measured chloride levels in groundwater south of the slough remain at background and show no evidence of contaminant migration beyond the slough.

FLUORIDE

Fluoride levels ranged from 0.1 mg/l to 0.6 mg/l in the groundwater near the WSQ. No noteworthy fluoride concentrations were detected, as compared to the EPA's maximum contaminant level of 4.0 mg/l.

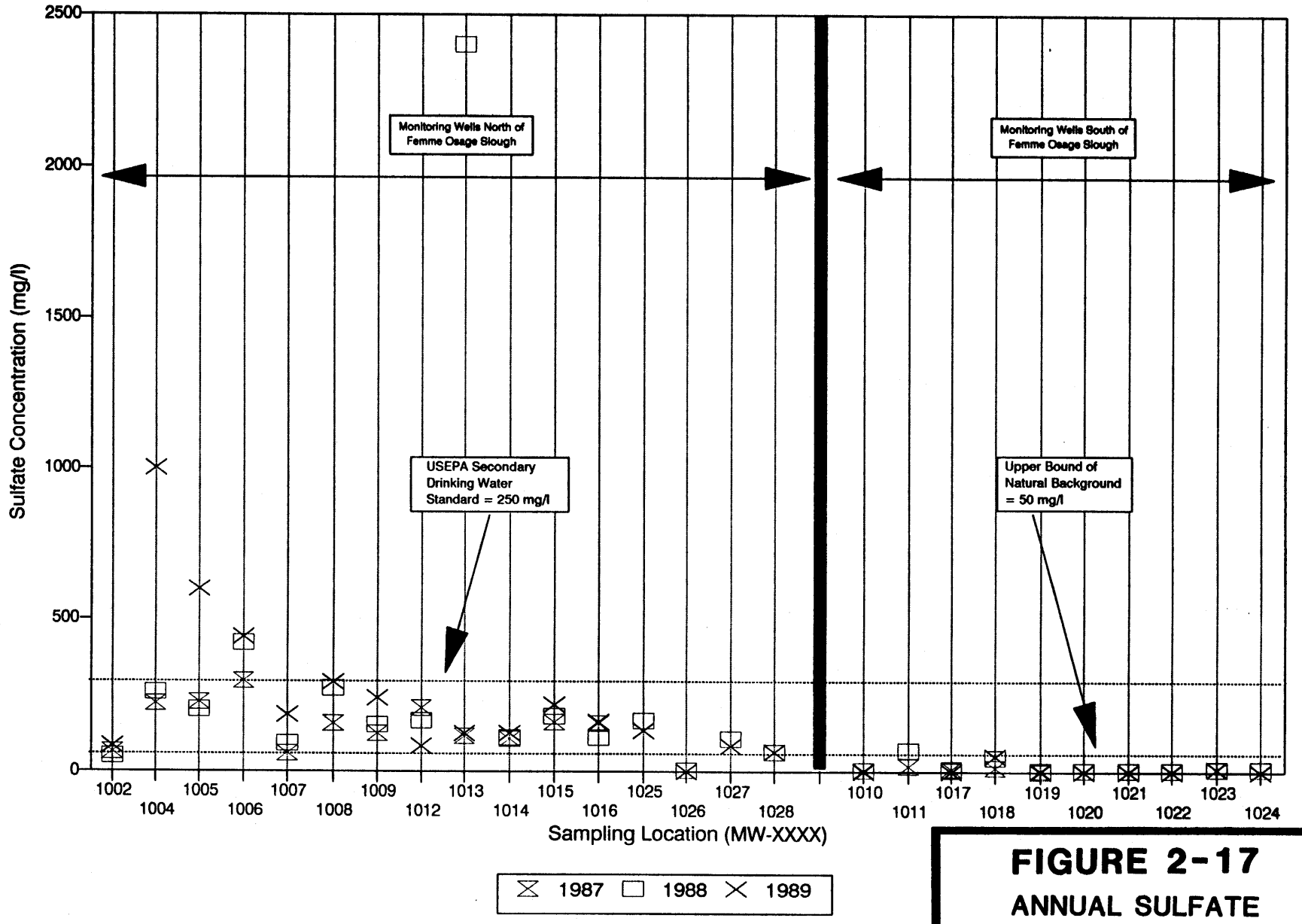


FIGURE 2-17

ANNUAL SULFATE CONCENTRATIONS WSQ GROUNDWATER 1987-1989

CONCLUSIONS OF WSQ GROUNDWATER MONITORING

Groundwater in the vicinity of the WSQ was sampled and analyzed for uranium (and other radiological species at certain wells), nitroaromatics and inorganic anions. The results indicate a slight but consistent increase in the concentrations of the contaminants in the groundwater between the WSQ bulk waste and the Femme Osage Slough. The results further indicate that the integrity of the alluvial groundwater south of the slough remains intact. Overall, the current data indicate that the groundwater contamination present near the WSQ does not pose an imminent threat to the St. Charles County water supply source.

2.2 Surface Water Monitoirng

Surface water samples were collected during 1989 under two distinct programs at the WSS. In one program, samples were collected at the WSCP boundary to monitor the off-site discharge of contaminants via surface water runoff. These samples were collected in compliance with the WSS's National Pollutant Discharge Elimination System (NPDES) permit, issued in November 1988, for storm water runoff and wastewater discharges. The permit requirements and 1989 analytical results are discussed in Section 2.2.1.

In the second program, routine samples were collected quarterly from both on-site and off-site locations where measurable impacts might be detected as part of the WSS Environmental Monitoring Program. This program was designed to fulfill the environmental surveillance requirements of DOE Order 5400.1. Environmental monitoring quantifies and documents any potential public exposure via the surface water pathway and ensures, through detection and implementation of response

measures, the protection of the public's health and safety. All surface water samples collected are analyzed without filtering unless a specific comparison of dissolved versus total contaminant concentrations is desired.

2.2.1 Effluent Monitoring Results

The Weldon Spring Site (WSS) NPDES Permit No. MO-0107701 requires monitoring of five stormwater discharge locations (NP-0001 to NP-0005) and one sanitary wastewater treatment plant discharge (NP-0006). These locations are illustrated in Figure 2-18. A summary of the permit requirements including monitoring parameters and frequencies is presented in Table 2-5. Currently, only discharges from outfall NP-0006, the administration building sanitary wastewater treatment plant, have limitations placed on them. The other five outfalls have monitoring requirements only.

Annual averages of analytical results for the stormwater locations are presented in Table 2-6. This table presents an annual summary of the individual sampling events. Tables presenting analytical results for the individual NPDES sampling events for each outfall may be found in Appendix A.

2.2.1.1 Radiological Analysis

Annual average uranium levels ranged from 6.5 pCi/l (0.241 Bq/l), about 1% of the DCG at the minimum concentration discharge point (NP-0004) to 368 pCi/l (13.62 Bq/l), about 61% of the DCG at the maximum concentration discharge point (NP-0001). The highest average uranium concentration was measured at the off-site discharge of the abandoned sanitary and process sewer outfall (NP-0001). Uranium concentrations measured at NP-0001

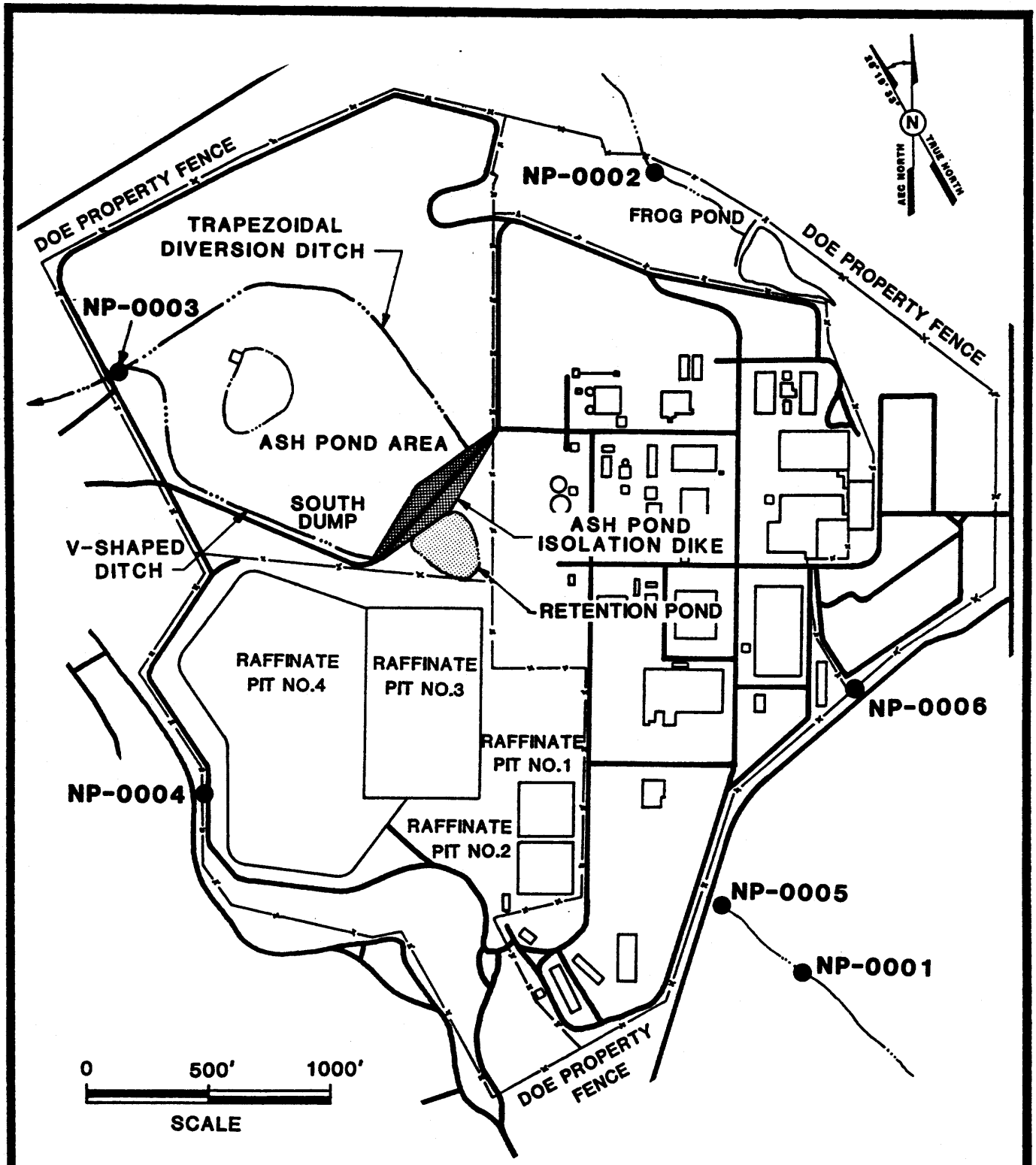


FIGURE 2-18

NPDES MONITORING LOCATIONS

TABLE 2-5 National Pollutant Discharge Elimination System Permit Monitoring Requirements

PARAMETERS	OUTFALL NUMBER **					
	0001	0002	0003	0004	0005	0006
Flow*	Q	M	M	Q	M	M
Settleable Solids*	Q	M	M	Q	M	-
Total Suspended Solids*F	Q	M	M	Q	M	Q
Nitrate*	Q	M	M	Q	M	-
Uranium*	Q	M	M	Q	M	-
Lithium*	Q	M	M	Q	M	-
Gross Alpha*	Q	M	M	Q	M	-
pH*	Q	M	M	Q	M	Q
BOD F	-	-	-	-	-	Q
Fecal Coliforms F	-	-	-	-	-	Q

* - Monitoring requirements only; no discharge limits

** - See Figure 2-18 for locations

F - Limits set for Outfall NP-0006

Q - Quarterly sampling

M - Monthly sampling

TABLE 2-6 1989 Annual Average NPDES Results for WSS Outfalls

LOCATION	NO. OF SAMPLES	pH	TOTAL URANIUM pCi/l	GROSS ALPHA pCi/l	NITRATE mg/l	LITHIUM mg/l	SETTL. SOLIDS ml/l	SUSP. SOLIDS mg/l	FLOW GPD
NP-0001	4	7.20	368	258	3.95	ND	<0.1	24	47333
NP-0002	11	6.80	145	79	1.87	ND	<0.1	58	214063
NP-0003	14	6.94	280	192	16.45	0.061*	8.0*	574	125870
NP-0004	3	6.90	6.5	3.9	2.47	ND	<0.1	9	1133
NP-0005	11	6.98	347	247	32.23	ND	<0.1	19	57776

* These values were present in a single sample obtained in January. All other values at NP-0003 for lithium and settleable solids were ND and <0.1, respectively.

ranged from 120 to 590 pCi/l (4.44 to 21.83 Bq/l) during 1989. Flows from the process and sanitary sewer outfall (NP-0001) combine with surface runoff from the southeast portion of the WSCP (NP-0005) and discharge into the southeast drainage easement. Uranium concentrations measured at NP-0005 exhibited similar levels with an annual average of 347 pCi/l, 58% of the DCG, and a range of 95 to 570 pCi/l (3.52 to 21.09 Bq/l).

Frog Pond's off-site discharge (NP-0002) exhibited an annual average uranium concentration of 145 pCi/l (5.36 Bq/l), 26% of the DCG. Individual monthly measurements ranged from 25 to 400 pCi/l (0.93 to 14.8 Bq/l). Off-site runoff from the area of Raffinate Pit 4 (NP-0004) exhibited an annual average uranium concentration of 6.5 pCi/l (.24 Bq/l) 1% of the DCG with a range of individual measurements from 3 to 9.7 pCi/l (0.11 to 0.36 Bq/l).

Results for the four NPDES outfalls discussed above are consistent with previous years' monitoring results. In contrast, uranium concentrations measured at Outfall NP-0003, the off-site discharge of the Ash Pond drainage, exhibited a marked decrease compared to previous years' data. The 1988 annual average uranium concentration for this outfall was 1,178 pCi/l (43.59 Bq/l), 214% of the DCG. The 1989 annual average is 280 pCi/l (10.36 Bq/l), 51% of the DCG with an individual sample range from 16 to 1,000 pCi/l (0.59 to 37.0 Bq/l). This marked decrease can be attributed to the completion of the Ash Pond Isolation Project in April 1989 (MKF and JEG, 1990b). This Interim Response Action (IRA) was designed and constructed to divert surface runoff around contaminated areas (South Dump and Ash Pond) thereby decreasing the off-site discharge of uranium at Outfall NP-0003. This IRA is discussed in more detail in Section 3.2.4.

Annual average gross alpha levels generally followed the same pattern as the natural uranium results. The generally good correlation between the average uranium and gross alpha values indicates that virtually all of the offsite radionuclide release is in the form of soluble uranium. However, gross alpha measurements are biased low, probably due to measurement interference from dissolved solids.

If it is assumed that the entire annual precipitation runoff is discharged from these points and that the discharge from each point is proportional to the portion of the site that each point drains, an upper bound estimate of the total uranium released off-site during 1989 can be calculated. The results of these calculations are presented in Table 2-7.

2.2.1.2 Chemical Analysis

The annual average total settleable solids (ml/l) and total suspended solids (mg/l) were highest at the off-site discharge of the Ash Pond drainage (NP-0003). These elevated average values were primarily caused by high values from a sample taken in January. Total settleable solids and suspended solids for that month were measured at 8.0 ml/l and 7,018 mg/l, respectively. Lithium was also detected at 0.061 µg/l, slightly above the detection limit. During that time, the Ash Pond Isolation Project was underway in the Ash Pond drainage causing increased erosion during storm events. Additional erosion control measures were implemented in response to these high values.

The other NPDES locations also exhibited the highest suspended solids concentrations during January. Surface water runoff and resulting flows off-site were highest in January when the site received over four inches of rainfall. Settleable

TABLE 2-7 1989 Estimated Annual Release of Natural Uranium from NPDES Outfalls

OUTFALL LOCATION *	DRAINAGE AREA (acres)	PERCENT OF PRECIPITATION AS RUNOFF**	AVERAGE CONC. (pCi/l)	UPPER BOUND TOTAL VOLUME (Mgal/yr)	UPPER BOUND TOTAL URANIUM (Ci/yr)	UPPER BOUND TOTAL URANIUM (kg/yr)
NP-0001 & NP-0005	20.2	60%	358	12.8	0.017	25.6
NP-0002	39.1	65%	145	26.9	0.015	21.7
NP-0003	60.1	20%	280	12.7	0.014	19.8
NP-0004	5.6	50%	6.5	3.0	0.00007	0.107

* = SEE FIGURE 2-18
** = ESTIMATED

solids measurements were less than 0.1 ml/l at all other storm water monitoring locations. Lithium was not detected at any of the other outfalls during 1989.

Annual average nitrate values ranged from a low of 1.87 mg/l at Outfall NP-0002 to a high of 32.23 mg/l at Outfall NP-0005. These values are generally consistent with the analytical results from 1988.

Outfall NP-0006 is the discharge for the site administration building wastewater treatment facility. The NPDES permit has placed limits on discharges from this outfall for biochemical oxygen demand (BOD) and total suspended solids of 15 and 10 mg/l, respectively. Samples were analyzed quarterly for these parameters by the subcontractor operating this facility. NPDES Permit limitations for the outfall were not exceeded at any time during 1989. Results are presented in a table in Appendix A.

2.2.2 Quarterly Surface Water Monitoring at the WSCP/WSRP Area

Surface water samples were collected quarterly from the eleven locations shown on Figure 2-19 in an effort to maintain a current understanding of site-related contaminant concentrations in potentially affected off-site surface water features. Five of those locations are within or upstream of lakes on the August A. Busch Memorial Wildlife Area. Many of these locations have been sampled by the WSSRAP for three consecutive monitoring years and are considered to be the most representative for monitoring contaminants that may pose a risk to the public health or the environment. The samples were analyzed for radiological species at all locations and for nitroaromatic compounds and inorganic anions at select locations.

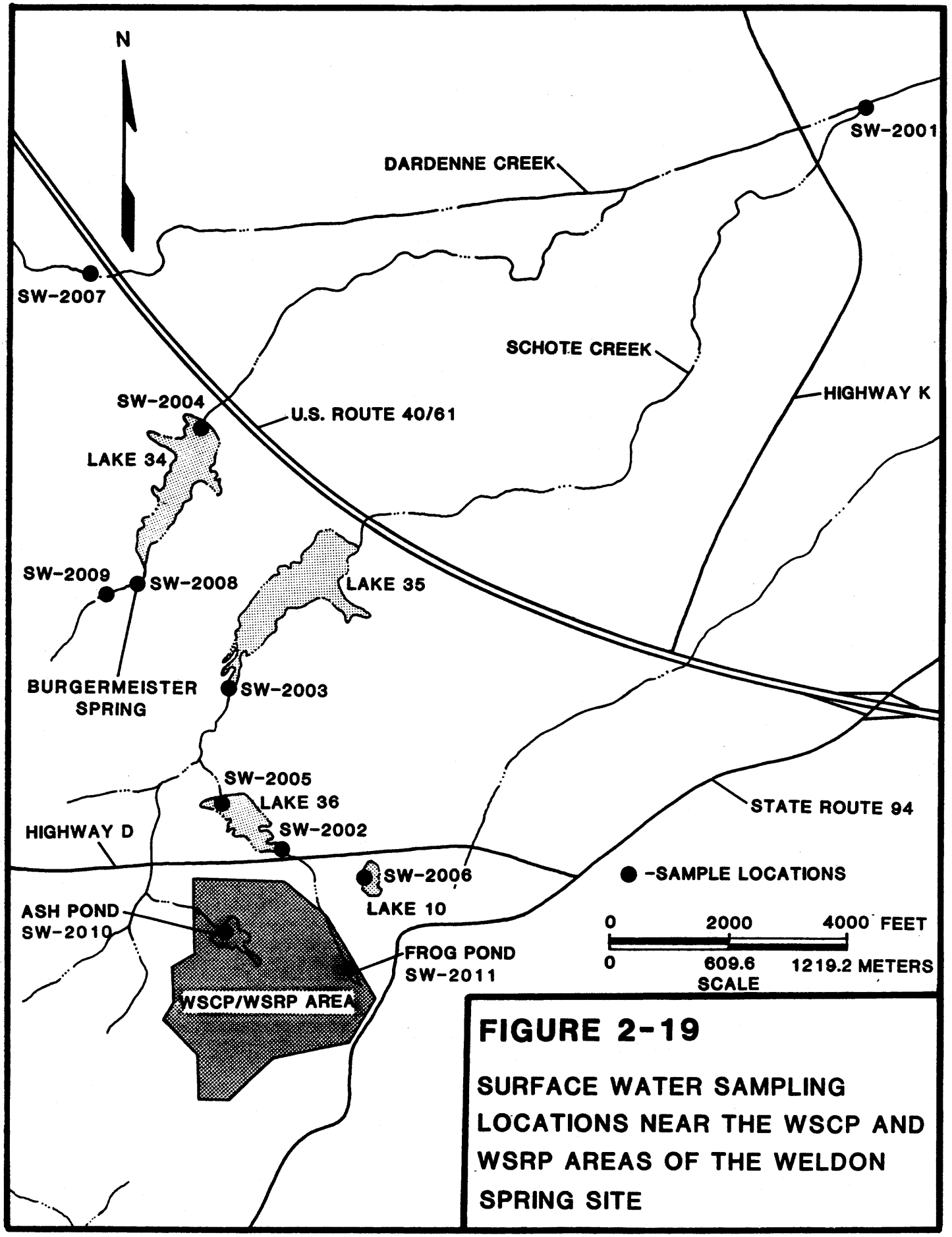


FIGURE 2-19

SURFACE WATER SAMPLING LOCATIONS NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

2.2.2.1 Radiological Results

URANIUM MONITORING

The total uranium activities at off-site locations ranged from below the detection limit of 1 pCi/l (0.037 Bq/l) up to 240 pCi/l (8.88 Bq/l) at Burgermeister Spring. The on-site surface water impoundments, two of which were added as sampling locations to the routine monitoring program in 1989, measured levels up to 3,200 pCi/l (118.4 Bq/l).

No significant changes were observed between the average measured values of 1988 and 1989 at any of the quarterly locations. At the furthest downstream location SW-2001 (the confluence of Schote and Dardenne creeks) the average of the quarterly measurements remained unchanged from 1988 while the maximum value declined only slightly. All of the quarterly measured values for that furthest location were within the range of background. No notable pattern in the values was observed relative to time of year.

The quarterly sampling results indicate that uranium continues to migrate from the site at relatively low levels in surface water along known discharge pathways. The concentration (activity) of the dissolved total uranium is reduced by dilution and natural processes to the point that the level falls to within the range of natural background at the measurement location SW-2001.

A substantial reduction in the concentration of uranium leaving the NP-0003 outfall was achieved with the completion of the diversion structure. Refer to Section 3.2.4 for a full

description of the diversion structure and its environmental protection benefits.

The on-site surface water bodies that were monitored quarterly include the four raffinate pits, the Ash Pond and Frog Pond. The radiological results from those locations are presented in Table 2-8. The highest measured uranium value in the 1989 surface water monitoring program came from Ash Pond at 3,200 pCi/l (118.4 Bq/l). It is important to note that after April 1989 the only on-site surface water body that released directly to off-site surface water pathways was Frog Pond.

THORIUM, RADIUM ISOTOPE MONITORING

Other radiological species (radium and thorium) were monitored in 1989 at the raffinate pits only. Historically, no other monitoring locations have detected elevated levels of those species. The raffinate pits were sampled once in 1989 to maintain a baseline on the radioisotope levels.

According to the 1989 measurements, the quarry pond water contains no radium-226 or thorium-232 above 1 pCi/l (0.037 Bq/l), and thorium-230 activities were measurable at the detection limit of 1 pCi/l (0.037 Bq/l) during two quarters.

2.2.2.2 Chemical Results

The environmental monitoring program for chemical constituents in surface water was slightly expanded from 1988 in the number of monitored locations, but was reduced in the frequency of analyses for selected parameter categories. These changes were made based upon the detailed information available from findings of past investigations at the site. During the

TABLE 2-8 Summary of Analytical Results for 1989 Surface Water Monitoring Locations Near the WSCP/WSRP Area (mg/l)

Location Number	Chloride (0.25)*	Fluoride (0.25)*	Nitrate (0.1)*	Sulfate (1.0)*	Uranium (1 pCi/l)
Chemical Plant					
SW-2001	2	ND	7	9	2
SW-2002	78	ND	ND	51	61
SW-2003	14	ND	1	16	14
SW-2004	13	ND	4	20	25
SW-2005	73	ND	2	24	15
SW-2006	13	ND	ND	10	3
SW-2007	14	ND	3	29	ND
SW-2010	102	0.4	4	40	1356
SW-2011	244	ND	ND	53	209
Raffinate Pits					
SW-3001	14	2	1450	339	307
SW-3002	7	3	ND	623	1161
SW-3003	7	5	925	195	755
SW-3004	8	19	9	370	1666

* Detection Limits (in mg/l)

1989 program, inorganic anions were measured at all locations annually. Nitroaromatic compounds were monitored once at locations that have historically indicated the presence of those compounds.

INORGANIC ANION ANALYSES

The inorganic anions of interest at the Weldon Spring Chemical Plant include chloride, fluoride, nitrate and sulfate. The following sections detail the results and implications of the anion analyses. Annual average results of these analyses are presented in Table 2-8.

CHLORIDE

The chloride levels measured in the eight off-site surface water locations ranged from a low of 1.9 mg/l at SW-2001 (Schote and Dardenne creeks) to 77 mg/l at SW-2002 (the head of Lake 36). SW-2002 and SW-2005 are directly downstream of the Missouri Department of Transportation's maintenance facility, adjacent to the site where road de-icing salt is stockpiled. The SW-2011 sampling location (Frog Pond) also receives direct discharge from the salt storage areas and shows the highest concentration of chloride of all the monitored locations (368 mg/l). Location SW-2011 yielded the only concentration level that exceeded the EPA's secondary drinking water standard of 250 mg/l for chloride.

These results indicate that the chloride levels off-site do not pose a threat to health or safety. No standards exist for protection of aquatic life or biota.

FLUORIDE

The measured fluoride concentrations at all off-site sampling locations remained below the detection limit of 0.25 mg/l. The concentration measured highest in Ash Pond at 0.5 mg/l which remains well within the EPA's maximum contaminant level (MCL) of 4 mg/l for fluoride. Fluoride does not constitute a major contamination problem at the WSCP/WSRP.

NITRATE

Nitrate concentrations ranged from below the detection limit of 1.0 mg/l to a quarterly high at Burgermeister Spring of 124 mg/l. Two distinct categories of nitrate concentrations are apparent in the measurements from 1989. At locations SW-2001 through SW-2007, and SW-2010 and SW-2011 the nitrate levels ranged from below the detection limit up to 4.2 mg/l. The Burgermeister Spring concentrations consistently are measured at approximately ten times that level. These findings are consistent with the 1988 Environmental Monitoring Report (EMR) and reinforce the conclusion drawn in the 1988 WSS EMR that contaminated groundwater is apparently contributing to the elevated nitrate levels in the Burgermeister Spring. At most locations, the levels of nitrate that are present in the surface water are below drinking water standards and therefore constitute no particular threat to human health or the environment, but they do provide valuable information on the mechanics of contaminant migration from the WSS. Further discussion regarding Burgermeister Spring contamination is presented in Section 2.2.2.3 of this report.

SULFATE

The sulfate measurements made under the surface water monitoring program yielded levels ranging between 9 mg/l at SW-2001 and 56 mg/l at SW-2011.

The pattern of high sulfate values is similar to that of the chlorides migrating from the Highway Department Facility with relative highs at Frog Pond and Lake 36. In addition, however, relatively elevated sulfate levels were detected at Ash Pond and Burgermeister Spring during 1989. These results suggest the presence of an on-site surface source for sulfates within the Ash Pond drainage. Also the sulfate value of 45 mg/l at Burgermeister Spring might suggest a component of sulfate-contaminated groundwater discharging at that point. The measured levels are well below the EPA's secondary drinking water standard of 250 mg/l for sulfate.

The WSSRAP measurements of inorganic anions in the surface water medium around the WSS indicated consistently elevated nitrate, sulfate and chloride levels. The nitrates and sulfates can in most instances be attributed to an on-site source on the WSS; the source for chlorides is located on the adjacent state highway department property. None of the measured anion levels exceeded existing water quality criteria and inorganic anions around the WSS pose no particular environmental or health and safety threat.

NITROAROMATICS MONITORING

The monitoring program for nitroaromatics in 1989 involved annual sampling at each of the off-site locations SW-2001 through SW-2008 (SW-2009 was dry) and quarterly monitoring of the on-site

locations at Ash Pond (SW-2010) and Frog Pond (SW-2011). No monitoring for nitroaromatic compounds was performed during 1989 at the raffinate pit locations (SW-3001 through SW-3004).

The monitoring results confirm what has been detected historically at the off-site monitoring locations. Nitroaromatics were detected at levels above the detection limits only at Burgermeister Spring. A possible positive result was indicated at Lake 34 downstream of Burgermeister Spring; however, a duplicate analysis of the sample did not confirm that result.

The analyzed sample from Lake 10 on the Busch Wildlife Area did indicate a low-level positive result for two nitroaromatic compounds during the second quarter. However, no confidence is placed in those positives since there have been no previous detections in Lake 10, there are no known source areas upstream of that lake, the lake is isolated from subsurface conduit flow influences, blank samples were also contaminated, and at these low quantifiable limits the analyses have proven to be susceptible to false positive results. The positive results in Lake 10 are therefore dismissed as false and Lake 10 is not considered to be contaminated with nitroaromatics. The 1990 sampling and analytical program will include Lake 10 for nitroaromatics to verify the presence or absence of those compounds.

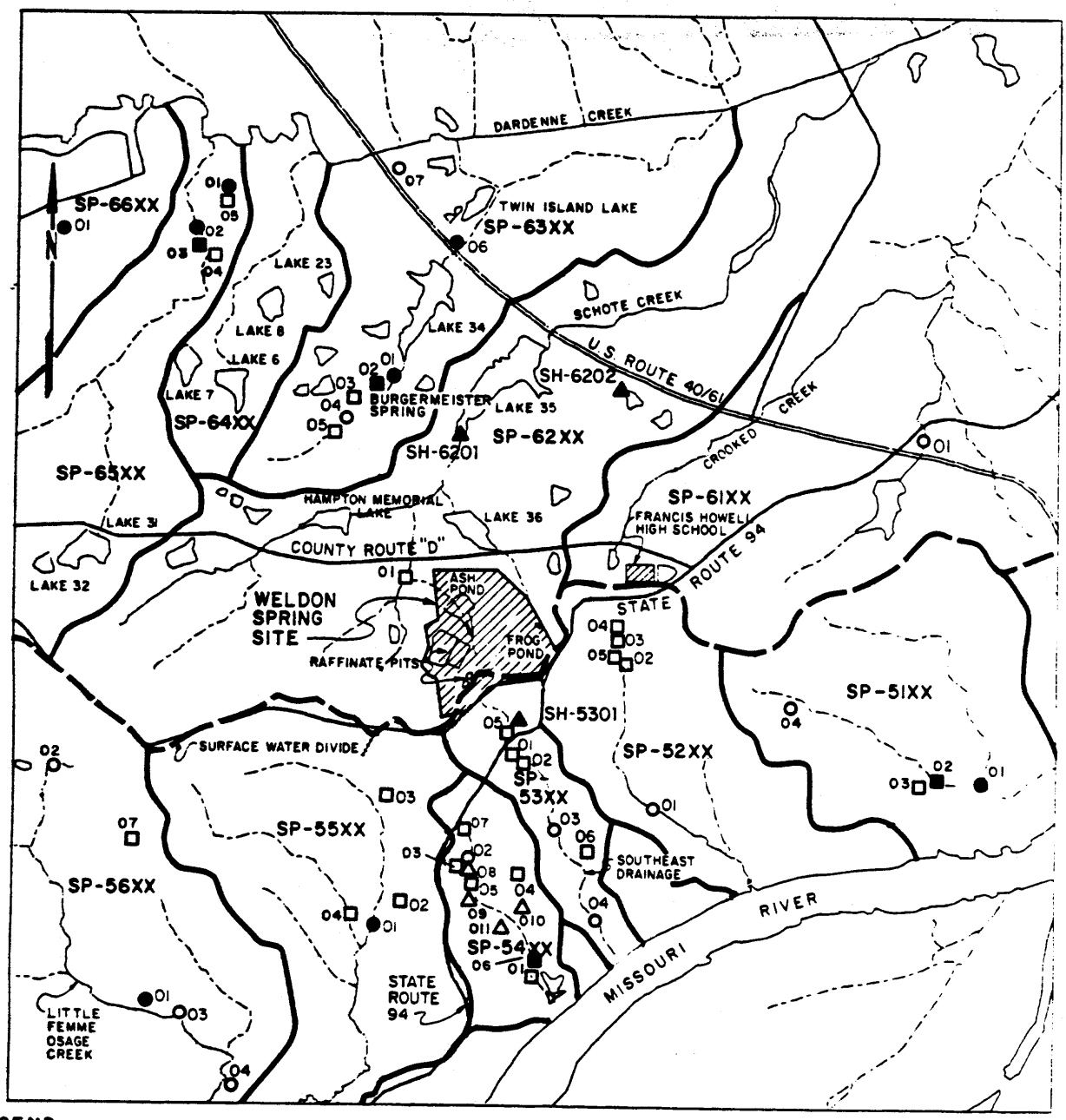
Mixed results were obtained from Frog Pond and again the positive detection of nitroaromatic compounds is questionable. At the Frog Pond, two samples collected during 1989 indicated no nitroaromatic compounds above the detection limit; however during second quarter, relatively high positive levels were detected for three of the six compounds monitored. The pattern of results suggests that again the second quarter positive results probably

constitute laboratory contamination or false positive interpretation. This is substantiated by the contamination of blank samples. Analyses for nitroaromatic compounds will continue at Frog Pond to verify the absence or presence of these contaminants.

2.2.2.3 Spring Monitoring

Other surface water features monitored under the environmental monitoring program are various springs near the WSCP/WSRP area. Some of the springs that are routinely monitored are known to issue contaminated water while others are located geographically so that contamination could reach the spring. Monitoring provides a baseline for establishing that connection. Figure 2-19A displays the spring sampling locations in the WSS area.

The results of the 1989 monitoring of springs in the WSS area are presented in Table 2-9 and indicate no change in the distribution or levels of contaminants at the springs of concern. The highest levels of uranium issue from SP-5301 through SP-5304 in the southeast drainage easement at annual averages ranging from 377 pCi/l (13.95 Bq/l) to 135 pCi/l (4.99 Bq/l). Burgermeister Spring and the estavelle spring (SP-6301 and SP-6302) remain within their historical range at an annual average of 98 pCi/l (3.63 Bq/l) and 90 pCi/l (3.33 Bq/l) respectively. (Note: Location SP-6301 and location SW-2008 are both Burgermeister Spring as they were sampled under two separate programs. That location will be assigned SP-6301 designation exclusively in 1990.)



LEGEND :

SOURCE: MDNR, 1989

- SURFACE WATER DIVIDE BETWEEN MISSISSIPPI RIVER AND MISSOURI RIVER
- DRAINAGE BOUNDARY
- CREEK OR SURFACE DRAINAGE
- POND OR LAKE
- ● PERENNIAL SPRING WITH LARGE MAXIMUM FLOW
- ○ PERENNIAL SPRING WITH SMALL MAXIMUM FLOW
- ■ WET WEATHER SPRING WITH LARGE MAXIMUM FLOW
- □ WET WEATHER SPRING WITH SMALL MAXIMUM FLOW
- ▲ SHALLOW HOLE (SH)
- △ SEEP
- SP-63XX SPRING OR SEEP IN DESIGNATED DRAINAGE AREA NUMBER 63. XX REPRESENTS THE DESIGNATED SPRING NUMBER IN DRAINAGE 63.

0 3200 6400
SCALE FEET

FIGURE 2-19A

SPRINGS AND SEEPS IN THE VICINITY OF THE WSS

TABLE 2-9 Summary of Annual Averages for Inorganic Anions and Uranium at Springs Near the WSS (mg/l)

Location Number	Chloride (0.25)*	Fluoride (0.25)*	Nitrate (0.1)*	Sulfate (1.0)*	Uranium (1.0 pCi/l)*
SP-5201	17	ND	0.15	70	ND
SP-5203	68	0.3	27	59	2
SP-5301	14	0.4	13	61	324
SP-5302	15	0.4	17	137	362
SP-5303	12	0.3	10	60	231
SP-5304	8.1	ND	6	45	135
SP-5503	10	ND	2.3	55	ND
SP-6301	21	0.2	65	48	98
SP-6302	--	--	--	--	90
SP-6303	14	ND	35	54	3
SP-6306	13	0.3	0.8	8	3

-- No data available for that location.

* Detection Limit

An inconsistently high quarterly sulfate measurement at SP-5302 drove the 1989 annual average for sulfate up to a level unusual for local springs. The source for this unusually high quarterly measurement is uncertain; however laboratory error is suspected. None of the other springs connected to that same flow system, either upstream or downstream, indicated similarly high levels. All of the measured levels remain below the EPA's secondary drinking water standard of 250 mg/l.

At 68 mg/l, the chloride levels at SP-5203 remain elevated, as was documented in the Phase I Spring and Seep Study (MKF and JEG, 1988b). The source for these elevated chloride levels is hypothesized to be the stockpiles of sodium chloride (de-icing salt) at the highway department maintenance facility adjacent to the WSS. No other chloride levels in springs were noteworthy.

The fluoride measurements lay well within the range established as background for fluoride during the Phase I study. No quarterly values were noteworthy.

Nitrate levels above the maximum calculated background level of 14.5 mg/l were detected at three springs--SP-5203, SP-6301 and SP-6303. The highest quarterly nitrate level was detected at Burgermeister Spring (SP-6301) at 124 mg/l with an annual average of 59 mg/l. The annual average for nitrate at Burgermeister Spring is slightly above the EPA's primary drinking water standard equivalent for nitrate of 45 mg/l. It is important to note that Burgermeister Spring does not serve as a regular drinking water/tap water source to which primary drinking water standards apply; however the standard serves as an effective health-based numerical comparison for the purposes of this document. These elevated values indicate contaminant influences to the groundwater system feeding those springs. It is currently

not known whether the sources for the nitrates issuing from these springs is similar or disparate. Spring SP-6301 water contains low-level nitroaromatics, uranium and nitrates; SP-6303 contains higher nitroaromatics, no uranium, and elevated nitrates, and SP-5203 contains high anions and no nitroaromatics or uranium.

In summary, the conditions influencing the resurging water at local springs appear to be remaining constant with no notable variations in contaminant levels or distribution.

2.2.3 Quarterly Surface Water Sampling at the WSQ Area

The nine surface water locations in Figures 2-20 and 2-21 were sampled quarterly and analyzed for uranium, with select locations analyzed additionally for radium-226, thorium-230, thorium-232, nitrate, sulfate, chloride, and fluoride. These locations were chosen for routine monitoring to investigate and document the possibility that surface waters near the WSQ might pose a risk to human health or the environment.

Locations SW-1001 and SW-1002 monitor the Little Femme Osage Creek at points upstream and downstream of the WSQ. Five sampling locations--SW-1003 through SW-1005, SW-1009 and SW-1010--are distributed along the Femme Osage Slough west of, adjacent to, and east of the WSQ. Location SW-1008 monitors the ponded water within the WSQ. The samples from this location permit a rough determination of the concentrations of the various contaminants in the ponded surface water that may migrate to groundwater. Locations SW-1011, SW-1012, and SW-1013 were added to the monitoring program in 1989 to provide baseline water quality data from the Missouri River. SW-1011 is the Missouri River location furthest upstream above any potential influences

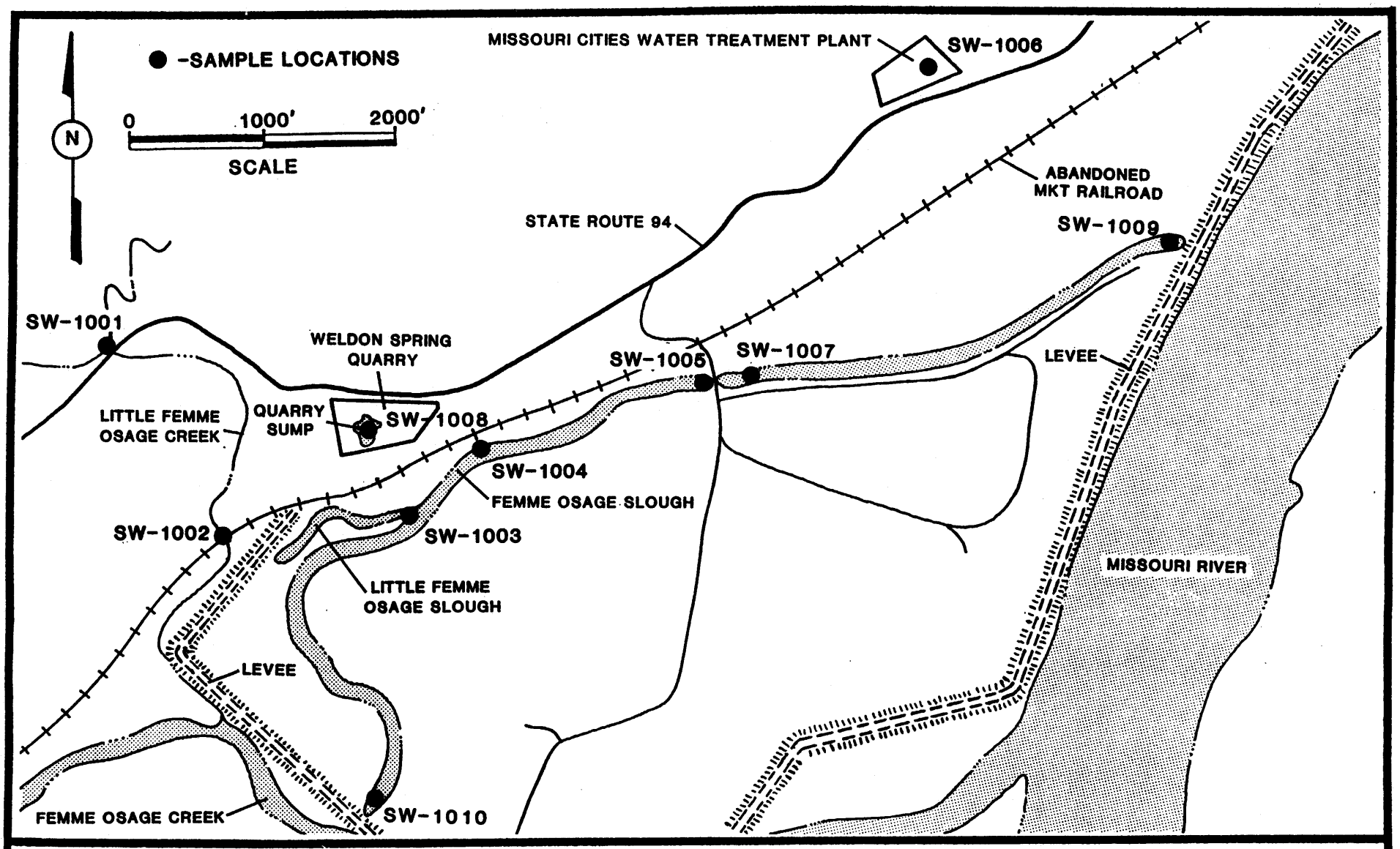


FIGURE 2-20

SURFACE WATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

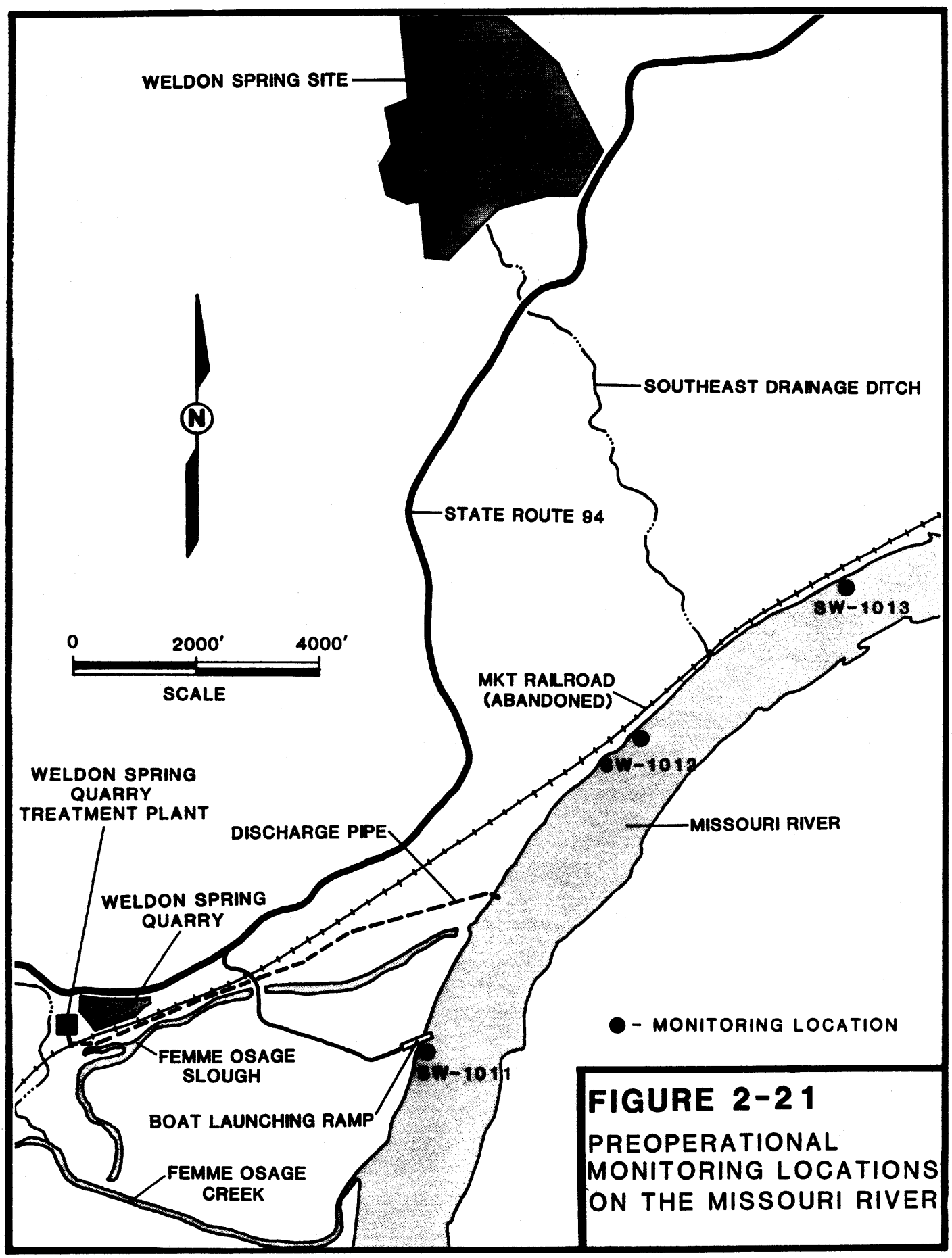


FIGURE 2-21

PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

from WSS contamination, while SW-1013 is furthest downstream below the outfall point of the southeast drainage easement.

2.2.3.1 Radiological Results

URANIUM

All surface water monitoring locations were sampled quarterly for uranium. Select locations including SW-1008, SW-1011, SW-1012, and SW-1013 were also analyzed for radium-226 and two thorium isotopes once during the monitoring year.

The primary radionuclide of concern at the WSQ and surrounding area is uranium, which was detected at levels ranging from below the detection limit of 1 pCi/l (0.037 Bq/l) to a high of 2,400 pCi/l (88.8 Bq/l) in the quarry pond water within the access-controlled area.

As has been determined in previous monitoring years, no elevated uranium activities were detected in the waters of the Little Femme Osage Creek either up or downstream of the quarry.

The Femme Osage Slough, which is the former channel of the Femme Osage Creek prior to rerouting that stream course, is a nearly unmoving water body. The slough has been known for several years to be receiving uranium contamination from the contaminated groundwater in the bedrock and alluvium to the north. In 1989, the average uranium activities ranged from 18 pCi/l (0.67 Bq/l), 3% of the DCG at SW-1009 to 161 pCi/l (1.68 Bq/l), 29% of the DCG at SW-1004. The annual average results for SW-1003 and SW-1004 were influenced by apparently elevated uranium levels in these portions of the slough. The levels returned to the usual range for those locations by third

quarter. This departure is atrributed to uranium contaminated groundwater discharging to the slough from the north side. The interception of this contaminated groundwater by the slough with evidence of no continued migration south of the slough is consistent with the DOE's data that show the slough has been acting as a barrier to contamination. With uranium activity measured at SW-1010 it is believed that the west end of the slough receives contaminants as water flows westward up the slough during periods of high river stage. The 1990 monitoring program will concentrate on this situation to attempt to characterize the mechanism and define the potential impacts.

Locations SW-1011 to SW-1013 are spaced along the north bank of the Missouri River to provide samples of river water for water quality testing in preparation for effluent discharge from the WSQ water treatment plant. The results of the measurements yielded average uranium activities which ranged from 2.9 pCi/l (0.107 Bq/l) at SW-1013 (downstream) to 4.4 pCi/l (0.16 Bq/l), less than 1% of the DCG, at SW-1011 (upstream). The values are virtually the same when considering the average counting error at plus or minus 1.0 pCi/l (0.037 Bq/l). The highest measured uranium activity in the Missouri River was detected during the first quarter of 1989 at 6.3 pCi/l (0.23 Bq/l).

Finally, the quarry pond water (SW-1008) was monitored quarterly during 1989 for uranium. The average measured uranium activity was 1,830 pCi/l (67.71 Bq/l), 332% of the DCG, which is similar to the levels measured in 1988 at an average of 1,300 pCi/l (48.1 Bq/l), or 236% of the DCG. The quarry pond remains within the access-controlled area of the quarry and poses little direct threat to the public health.

2.2.3.2 Chemical Results

INORGANIC ANION RESULTS

Inorganic anions were analyzed on an annual basis in samples from locations SW-1001 through SW-1010 (except SW-1006) and more frequently on samples from the quarry pond and on Missouri River water samples (SW-1011 to SW-1013). The inorganic anions category includes chlorides, fluorides, nitrates and sulfates. The results of the analyses are presented below. Table 2-10 presents the annual averages for each parameter measured.

CHLORIDE

The highest measured chloride values were detected in the three Missouri River water samples at annual averages ranging from 23 mg/l at SW-1013 to 29 µg/l at SW-1012. All other measured levels remained well below the Missouri River background concentrations.

The levels measured in 1989 at SW-1001 to SW-1009 have decreased or remained very nearly the same. The relatively slight variations were of a magnitude that can be accounted for by natural dilutional effects.

FLUORIDE

Fluoride levels remained below the detectable limit of 0.25 mg/l at eight of the 12 monitored locations. At the quarry pond, the annual average was 0.57 mg/l while the Missouri River ranged from 0.49 mg/l at SW-1011 to 0.55 mg/l at SW-1013 during the fourth quarter of 1989.

TABLE 2-10 Summary of Analytical Results for 1989 Surface Water Monitoring Locations Near the Weldon Spring Quarry (mg/l)

Location **	Chloride (0.25)*	Fluoride (0.25)*	Nitrate (0.1)*	Sulfate (1.0)*	Uranium + (1.0 pCi/l)*
SW-1001	14	ND	4	ND	2
SW-1002	6	ND	1	38	2
SW-1003	10	ND	ND	125	86
SW-1004	12	ND	ND	141	161
SW-1005	12	ND	ND	91	44
SW-1007	7	ND	ND	90	19
SW-1008	14	0.7	0.4	141	1827
SW-1009	7	ND	ND	96	18
SW-1010	4	ND	ND	101	44
SW-1011	23	ND	3.2	130	4
SW-1012	29	ND	2.3	170	4
SW-1013	23	0.3	2.5	111	3

\+ Units for uranium are in pCi/l.
* Detection Limit
** SW-1006 was removed from the surface water sampling program.

NITRATE

The nitrate levels measurable above the detection limit of 0.1 mg/l ranged to as high as 4.2 mg/l at SW-1011 in the Missouri River. All of the levels were insignificantly low as compared to the EPA's primary drinking water standard of 45 mg/l.

SULFATE

The sulfate measurements ranged from below the detection limit of 40 mg/l to as high as 171 mg/l at all locations in the Missouri River during the third quarter of 1989. No unusual patterns are visible in the data other than the relatively high sulfate as background in the Missouri River. The average sulfate level for all quarters from all three locations along the Missouri River was 149 mg/l. All measured levels remained well below the EPA's secondary drinking water standard for sulfate of 250 mg/l.

NITROAROMATICS

Samples were collected at three locations along the slough once annually (SW-1003 to SW-1005) to assess whether detectable levels of nitroaromatics were present in slough water. No levels above the detection limits were discovered.

The quarry pond was sampled quarterly for nitroaromatic compounds. The total quantified concentrations of all six compounds ranged from 2.4 µg/l in the first quarter to 68 µg/l in the fourth quarter. Samples will continue to be collected from the quarry pond to maintain accurate information on the levels in the water. The ponded water will ultimately be treated for nitroaromatic compounds and other organics upon completion of the quarry water treatment plant.

2.3 Radon Gas Monitoring

Radon is a naturally occurring radioactive gas in the uranium and thorium decay series. Radon-222 (Rn-222) is formed by the natural radioactive decay of radium-226 (Ra-226) which is a decay product of uranium-238 (U-238) found in soil and rock. Radon-220 (Rn-220) (also referred to historically as thoron--Tn) is formed by the natural radioactive decay of radium-224 (Ra-224) which is a decay product of thorium-232 (Th-232) found in soil and rock. A fraction of the radon diffuses into the atmosphere and accounts for natural background radon concentrations. Radon is also produced at the WSS as the Ra-226 and Ra-224 contained in the waste materials undergo decay.

Radon concentrations fluctuate with both soil conditions and meteorological dispersion conditions. This is because the amount of radon that actually enters the atmosphere varies depending on the following parameters: radium concentrations, moisture content, soil porosity, soil density, emanating fraction, and atmospheric pressure.

The emanating fraction is the portion of radon that escapes from soil particles into the pore spaces, which are the voids found in all soils regardless of density. Only the radon entering these pore spaces is available for release to the atmosphere.

Porosity is a measure of the amount of pore space or fraction of total volume occupied by the pore spaces. The higher the porosity the more pore spaces for the radon to move through.

Some fraction of the total pore space volume is typically filled with water, and soil moisture content provides a measure

of this fraction. Radon diffuses easier through air-filled pore spaces than water-filled ones, so the higher the soil moisture content, the lower the radon emanation from the exposed surface. The moisture content of the soil is the most variable of these parameters and is primarily responsible for quarterly and annual changes in radon concentrations.

Radon exposure is a potential environmental impact from the WSS. Therefore, radon has been monitored since 1981. This section discusses the monitoring program and presents a summary of the monitoring results.

2.3.1 Radon Gas Monitoring Program

The radon gas monitoring program uses one pair of radon detectors at 22 permanent locations that are exchanged quarterly. These detectors are deployed at six locations at the Weldon Spring Chemical Plant, six locations at the Weldon Spring Quarry, four locations at the Weldon Spring Raffinate Pits, and six off-site locations. Radon monitoring locations are shown in Figures 2-22, 2-23 and 2-24. On-site detectors were spaced around the perimeter fences to ensure adequate detection of radon dissipating from the properties under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005 and RD-4006 were used to monitor background levels near the WSS.

The radon detectors used in this program were Terradex Track Etch Type F. Type F detectors are sensitive to all isotopes of radon. These detectors were housed in protective plastic cups and mounted inverted on posts. The detectors were placed and collected at the beginning and end of each calendar quarter. The detectors were deployed in pairs to evaluate and reduce the natural uncertainties associated with this type of measurement.

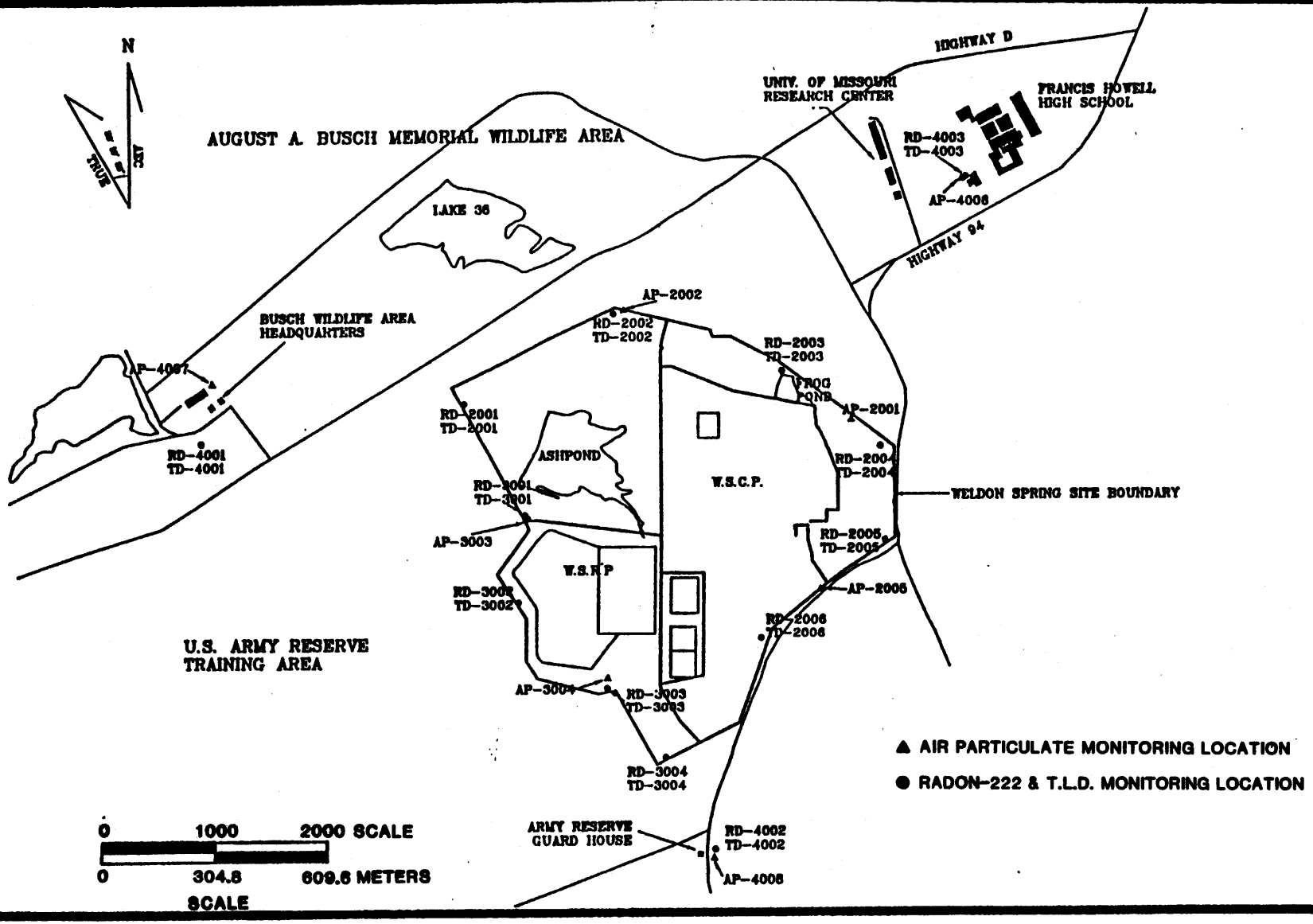
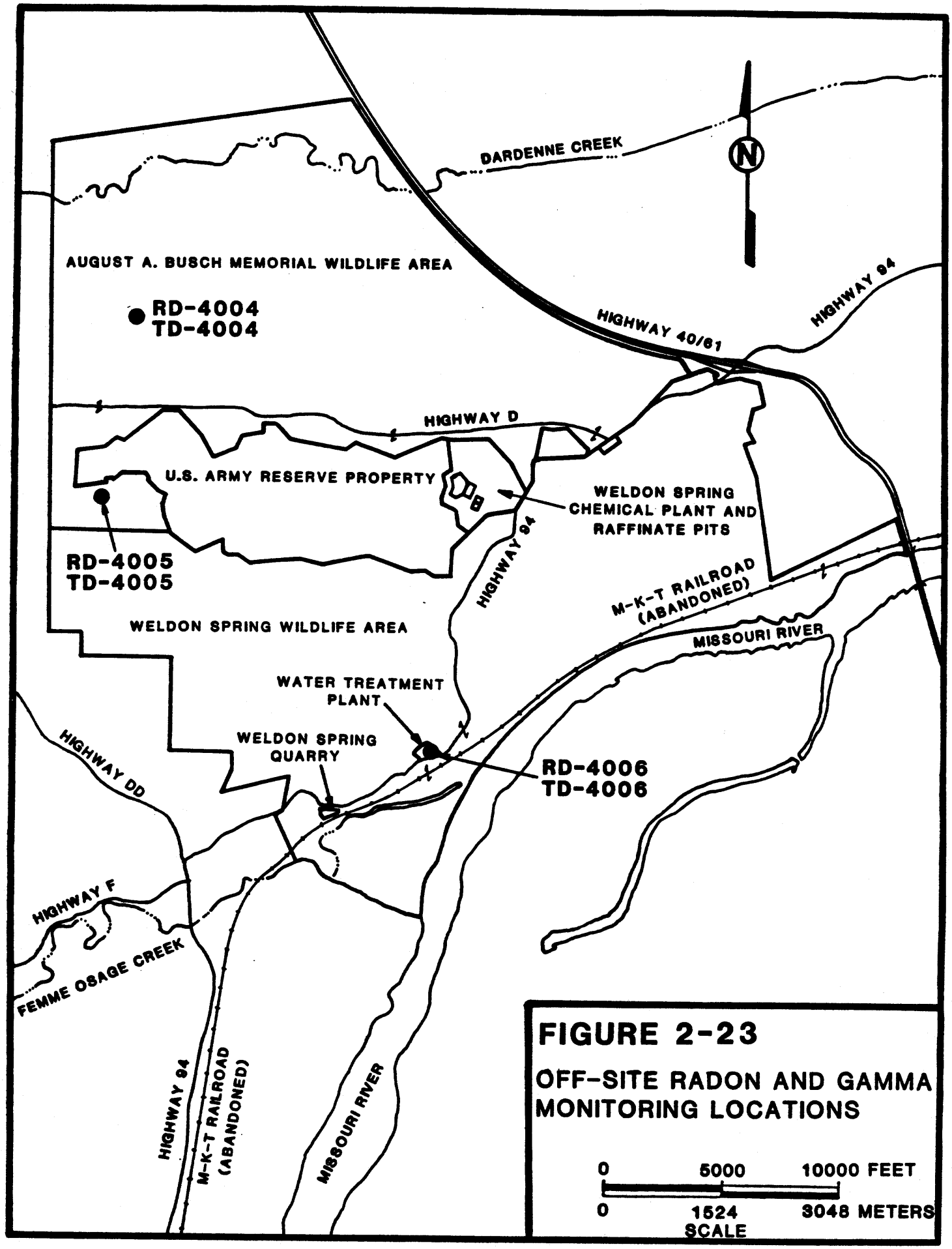


FIGURE 2-22

RADON-222, TLD, AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSCP/WSRP AREA


DARDENNE CREEK
N
AUGUST A. BUSCH MEMORIAL WILDLIFE AREA
RD-4004
TD-4004
HIGHWAY 40/61
HIGHWAY 94
HIGHWAY D
U.S. ARMY RESERVE PROPERTY
WELDON SPRING
CHEMICAL PLANT AND
RAFFINATE PITS
RD-4005
TD-4005
HIGHWAY 94
M-K-T RAILROAD
(ABANDONED)
WELDON SPRING WILDLIFE AREA
MISSOURI RIVER
WATER TREATMENT
PLANT
WELDON SPRING
QUARRY
RD-4006
TD-4006
HIGHWAY DD
HIGHWAY F
FEMME OSAGE CREEK
HIGHWAY 94
M-K-T RAILROAD
(ABANDONED)
MISSOURI RIVER
FIGURE 2-23
OFF-SITE RADON AND GAMMA
MONITORING LOCATIONS
0
5000
10000 FEET
0
1524
3048 METERS
SCALE

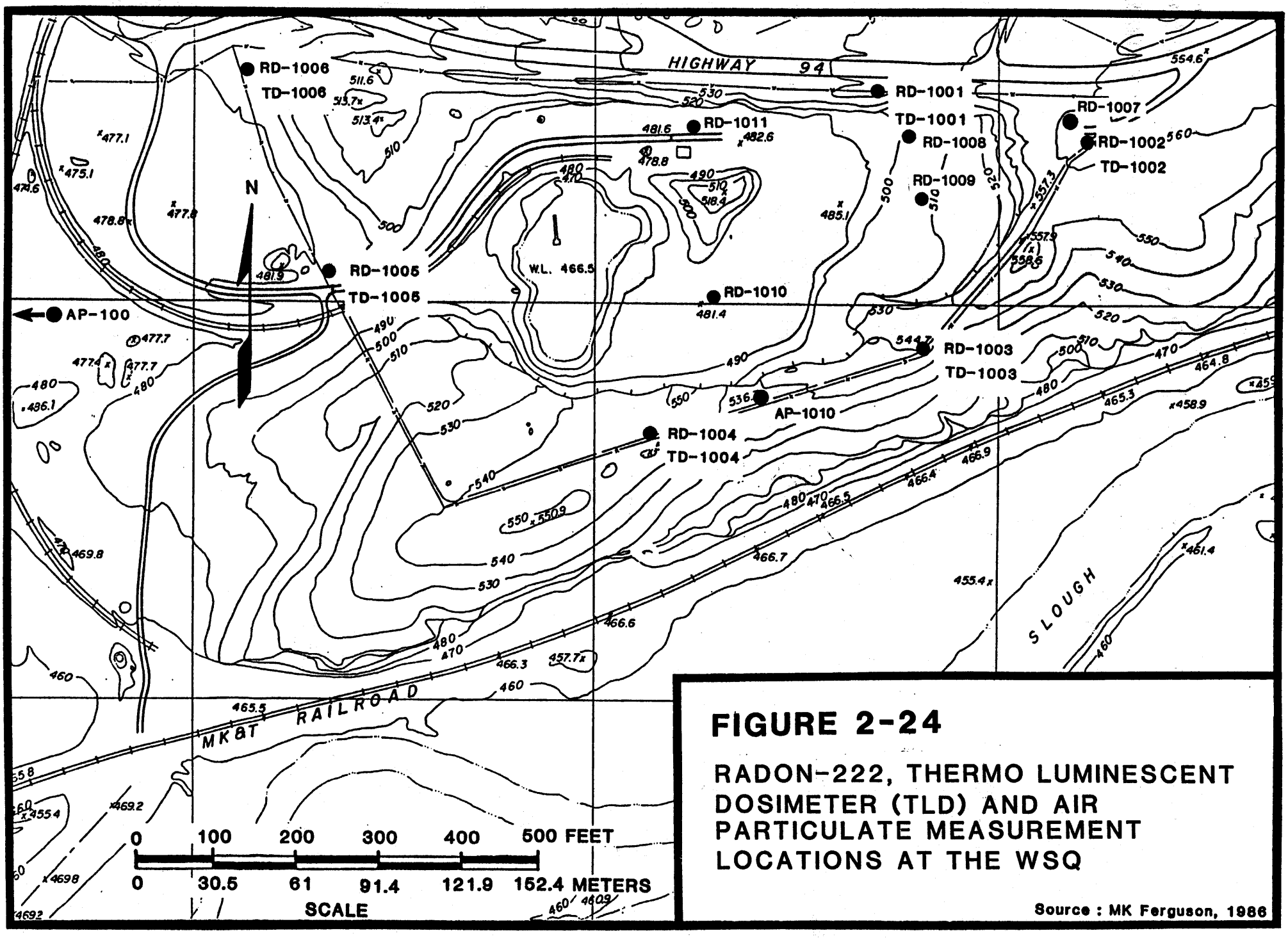


FIGURE 2-24

RADON-222, THERMO LUMINESCENT DOSIMETER (TLD) AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSQ

Source : MK Ferguson, 1986

In addition to the Type F detectors, Terradex Track Etch Type M detectors were placed at the permanent quarry monitoring stations in the second quarter of 1989. Type M detectors have a barrier which effectively screens out Rn-220 while allowing Rn-222 to pass through. These detectors were deployed in pairs, adjacent to the Type F detectors. These measurements were taken in order to determine the percentage of Rn-220 which is contributing to the total radon concentration at the quarry perimeter.

2.3.2 Radon Gas Monitoring Results

Table 2-11 summarizes the quarterly and annual average concentration of radon detected at all WSS perimeter and off-site monitoring locations. Also contained in Table 2-11 is a comparison of the measured annual average concentration to the federally permitted concentration for unrestricted areas of 3 pCi/l (110 $Bq/^3$) as authorized by DOE Order 5400.5.

For each monitoring station, annual averages in Table 2-11 were calculated by finding the arithmetic average of the four quarterly replicate values. The standard deviation was calculated by computing the square root of the sum of the squared errors divided by four for each quarterly replicate data point. Due to vandalism, monitoring stations RD-1001 and RD-4005 were missing one of the replicate detectors in the first and third quarter, respectively. In these cases the values of the single remaining detector were reported.

Ambient background concentrations were determined by calculating the arithmetic average of concentrations for the four background locations. These four locations are: RD-4001, RD-4004, RD-4005, and RD-4006. These data yielded an annual

TABLE 2-11 1989 Track Etch Radon Results(a)

Location I.D.	1st Quarter pCi/l	2nd Quarter pCi/l	3rd Quarter pCi/l	4th Quarter pCi/l	ANNUAL AVERAGE(b) pCi/l	Std. DEV.	PERCENT OF GUIDELINE(c)
WSQ							
RD-1001	1.0	1.5	2.0	1.5	1.5	0.2	32
RD-1002	1.8	1.3	1.3	2.1	1.6	0.2	35
RD-1003	4.7	0.8	1.3	1.6	2.1	0.4	52
RD-1004	1.1	0.5	0.7	1.2	0.8	0.1	8
RD-1005	1.8	0.7	0.8	1.3	1.1	0.2	18
RD-1006	0.4	0.4	0.7	1.1	0.6	0.1	-
WSCP							
RD-2001	0.7	0.4	0.4	0.7	0.5	0.1	-
RD-2002	0.5	0.4	0.6	0.6	0.5	0.1	-
RD-2003	0.6	0.4	1.1	0.6	0.6	0.1	-
RD-2004	0.3	0.4	0.8	0.6	0.5	0.1	-
RD-2005	0.3	0.3	0.5	0.5	0.4	0.1	-
RD-2006	0.4	0.5	0.7	0.7	0.6	0.1	-
WSRP							
RD-3001	0.6	0.3	0.5	0.6	0.5	0.1	-
RD-3002	0.3	0.3	0.5	0.6	0.4	0.1	-
RD-3003	0.3	0.4	0.7	0.6	0.5	0.1	-
RD-3004	0.3	0.4	0.7	0.4	0.4	0.1	-
OFF SITE							
RD-4001*	0.3	0.4	1.2	0.5	0.6	0.1	-
RD-4002	0.3	0.3	0.4	0.3	0.3	0.1	-
RD-4003	0.3	0.3	0.8	0.3	0.4	0.1	-
RD-4004*	0.4	0.3	0.4	0.6	0.4	0.1	-
RD-4005*	0.6	0.4	0.6	0.4	0.5	0.1	-
RD-4006*	1.3	0.4	0.8	0.5	0.7	0.2	-

(a) RESULTS INCLUDE NATURAL BACKGROUND
(b) DUE TO ROUNDING THE AVERAGED QUARTERLY DATA MAY NOT EQUAL THE ANNUAL AVERAGE
(c) THE DOE CONCENTRATION GUIDELINE FOR Rn-222 IS 3pCi/l (110 Bq/m^3)(ANNUAL AVERAGE ABOVE BACKGROUND) FOR UNCONTROLLED AREAS.
* DENOTES BACKGROUND STATION

background value for radon (Rn-222 plus Rn-220) in 1989 of 0.6 pCi/l (20.5 Bq/m^3).

The quarterly radon concentrations at each monitoring location were compared statistically, at the 95 percent confidence level, to the quarterly concentrations of the four background locations. Only those monitoring locations that were statistically different from background were compared to the DOE guideline.

Radon concentrations at the WSS perimeter and at off-site locations were lower in 1989 than in 1988. Abnormally high values were recorded in 1988 because of the regional drought. The 1988 drought reduced the moisture content of soils; radium-containing wastes thus allowed a greater fraction of radon in the soil and waste voids to diffuse into the atmosphere. The lower radon concentrations measured in 1989 are comparable to concentrations reported in past annual environmental monitoring reports (prior to 1988) and are typical of values expected during years of normal precipitation levels.

Radon concentrations found in the quarry are higher than concentrations measured at other WSS properties because the radium concentrations in quarry wastes are typically higher than other areas and because the quarry is a large depression in the terrain with side walls ranging from 3 to 15 meters high (10 to 50 feet). In conjunction with stable meteorological conditions, this tends to trap emanating radon within the quarry and raises the concentrations along the quarry perimeter.

Radon concentrations measured at the quarry perimeter with Type M detectors, which effectively screen out Rn-220 (thoron), are listed in Table 2-12. Table 2-12 lists the average

TABLE 2-12 Type M Detectors at WSQ in 2nd Quarter of 1989

Location I.D.	No. of[a] Samples	Radon Concentrations pCi/l Type F Detector	STD Dev.	Type M Detector	STD Dev.	Difference	Percentage of Thoron
RD-1001	2	1.45	0.18	1.85	0.28	-0.40	0
RD-1002	2	1.25	0.17	0.75	0.14	0.50	40
RD-1003	2	0.75	0.13	1.05	0.21	-0.30	0
RD-1004	2	0.45	0.10	0.55	0.15	-0.10	0
RD-1005	2	0.70	0.13	1.00	0.21	-0.30	0
RD-1006	2	0.40	0.10	0.45	0.13	-0.05	0

(a) Two samples for each Type F and Type M

concentration of the Type F and Type M detectors at the WSQ monitoring station for the second quarter of 1989. Also contained in the table is the percentage of thoron contribution to the total concentration of radon (Rn-222 plus Rn-220) recorded by the Type F detector at each station.

The concentration at each location was determined by taking the arithmetic average of the replicate values. The estimate of error was calculated by finding the square root of the sum of the squared errors divided by the number of data points.

In Table 2-12 the results of the Type M detectors were subtracted from the results of the Type F detectors to show if Rn-220 (thoron) was contributing to the total radon concentration. Only one location (RD-1002) showed a positive difference between the Type F and Type M detectors. The remaining comparisons of results were equal or showed a negative difference. Because the Type F detectors measure both Rn-222 and Rn-220, a negative difference between the Type F detection result and Type M detector results should not occur. The overall differences are attributable to the uncertainty in the measurement methods. The one positive result, which was measured in the second quarter, is not sufficient evidence to conclude that thoron is contributing to the radon concentration at that location or at the WSQ perimeter. The WSSRAP will evaluate this further by taking measurements during 1990 using continuous monitors.

2.4 Gamma Radiation Exposure Rate Monitoring

Gamma rays are electromagnetic radiation that are emitted from the nucleus of atoms following alpha or beta emissions. The environment naturally contains radioactive substances which emit

gamma radiation. Terrestrial radiation sources are natural radioactive elements in the environment (soil, water). Cosmic radiation is high-energy radiation that originates in outer space and filters through the atmosphere reaching the earth surface. Together, these two sources account for natural background gamma radiation. Terrestrial and cosmic radiation fluctuates depending on the soil composition and elevation above sea level.

Gamma radiation is emitted by many radionuclides of the U-238 and Th-232 decay series. These radionuclides are found in above-background concentrations on the WSS properties. Therefore, gamma radiation is monitored at the WSS. This section discusses the monitoring program and presents the summary of the results.

2.4.1 Gamma Radiation Exposure Rate Monitoring Program

To monitor exposure from gamma radiation at the WSS, 22 monitoring stations using spherical environmental thermoluminescent dosimeters (TLDs) were deployed. The monitoring station locations are the same as the ambient radon monitoring locations.

Ten monitoring stations are located at the WSCP/WSRP along the perimeter fence (Figure 2-22), six monitoring stations are located along the WSQ perimeter fence (Figure 2-24) and six monitoring stations are located off-site (Figures 2-22 and 2-23). Monitoring stations TD-4001, TD-4004, TD-4005, and TD-4006 measure natural background at locations unaffected by the site.

The TLDs are composed of five lithium fluoride chips in a durable spherical polyethylene holder which is designed with internal filters to measure penetrating radiation. The TLDs are

exchanged quarterly and returned to TMA/Eberline Laboratory for processing.

In addition to monitoring gamma radiation with TLDs, natural background gamma radiation exposure rates were measured one meter from the ground surface with a pressurized ionization chamber (PIC) from October through December 1988. Total gamma exposure was integrated with the PIC over time intervals ranging from one to three hours at each measurement location.

Five measurements were made in each of three distinct geographical regions in the vicinity of the WSS. These regions have differing soil characteristics and potentially have differing terrestrial gamma exposure rates. The three distinct regions are the dissected glacial till deposits, the alluvial deposition of the Missouri River Valley, and the Salem Plateau.

The WSCP/WSRP is located in a transitional region between the glacial till deposits and the Salem Plateau. The WSQ is located on the Salem Plateau just north of the alluvial deposition region of the Missouri River Valley.

2.4.2 Gamma Radiation Exposure Rate Monitoring Results

Natural background exposure rates measured with the PIC averaged 8.3 $\pm$ 1.8 microroentgen (μR)/hr, 9.3 $\pm$ 1.1 μR/hr, and 9.1 $\pm$ 1.7 μR/hr at two standard deviations for the dissected glacial till, Salem Plateau, and the alluvial deposition of the Missouri River, respectively. At the 95 percent confidence level there is no reason to suspect a difference in gamma exposure rates for the three geological regions. Averaging the results among the regions yields an estimate of the natural background surrounding the WSS of 8.9 $\pm$ 0.9 μR/hr at two standard

deviations. This translates to a yearly average gamma exposure of 78 ± 7.9 mR at two standard deviations (8.9 µR/hr times 8,760 hours per year).

To determine background levels of gamma radiation as measured with the TLDs, the gamma exposure at the four background monitoring stations were averaged. This yielded 68 ± 8.0 mR/year at two standard deviations.

The average exposure as measured by the TLDs is significantly lower than the average exposure as measured by the PIC at the 95 percent confidence level. This is probably due to the fact that the PIC measurements were short-term measurements (i.e., hourly) while the TLDs integrate gamma exposure for 13 weeks. Thus the TLD results provide a better estimate of natural background exposure.

Yearly background gamma exposures have been measured previously by the PMC and other contractors for the DOE around the WSS. Results have ranged from 60 to 104 mR/year (BNI, 1985a; BNI, 1985b; BNI, 1984; and MKF and JEG, 1989a). There continues to be agreement between previous monitoring results and current results. This is expected because nothing has significantly changed the configuration or location of the wastes at the WSS.

Table 2-13 summarizes the quarterly and annual total gamma radiation monitoring results at the 16 WSS perimeter monitoring stations, Francis Howell High School, the Weldon Spring Army Reserve Training Area, and at the four background monitoring stations. The results reported in the table include two standard deviations.

TABLE 2-13 Gamma Radiation Exposure Rate Monitoring Results(a) (mR/year)

LOCATION I.D.	FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER	ANNUAL TOTAL(b)	2 ST DEV
			QUARRY			
TD-1001	27	TE	21	25	98	7
TD-1002	27	TE	16	18	80	6
TD-1003	23	TE	17	22	82	8
TD-1004	22	TE	16	18	75	15
TD-1005	23	TE	17	21	80	16
TD-1006	20	TE	15	19	71	11
			CHEMICAL PLANT			
TD-2001	18	TE	13	22	71	7
TD-2002	20	TE	15	17	68	8
TD-2003	26	TE	13	20	79	20
TD-2004	20	TE	14	18	69	11
TD-2005	18	TE	13	16	62	4
TD-2006	18	TE	15	20	70	11
			RAFFINATE PITS			
TD-3001	20	TE	15	20	73	12
TD-3002	16	TE	11	15	56	7
TD-3003	18	TE	14	18	67	6
TD-3004	18	TE	15	15	65	10
			OFF SITE			
TD-4001*	21	TE	15	21	75	12
TD-4002	15	TE	11	13	52	7
TD-4003	18	TE	12	14	59	10
TD-4004*	-	TE	-	17	70	3
TD-4005*	17	TE	-	16	66	7
TD-4006*	17	TE	14	16	62	6

(a) RESULTS INCLUDE NATURAL BACKGROUND
(b) DUE TO ROUNDING THE SUMMED QUARTERLY DATA MAY NOT EQUAL THE ANNUAL TOTAL.
* DENOTES BACKGROUND STATION
TE TRANSPORTATION EXPOSURE - NOT REPORTED

A control TLD accompanies each quarterly shipment of TLDs to assess exposure during mailing. All second quarter TLDs (including the control and the background TLDs) had results four times higher than typical quarterly results. This may have been caused by the shipment being x-rayed during transit. For this reason the results for the second quarter were disregarded and the average of the remaining quarterly data was used for the missing second quarter data in order to calculate the annual total.

The first quarter TLD was missing for monitoring station TD-4004 and the third quarter TLD was missing for monitoring station TD-4004 and TD-4005. In order to calculate an annual total gamma exposure rate the missing data was replaced with the average of the remaining quarterly TLD results for those monitoring stations.

At the WSCP/WSRP site perimeters the annual exposures ranged from 56 to 79 mR. At the WSQ site perimeter, the annual exposures ranged from 72 to 98 mR. Annual exposure at the Francis Howell High School was 59 mR. At the Weldon Spring Army Reserve Training Area the annual exposure was 52 mR.

Except for monitoring stations TD-1001, TD-1002, TD-1003, and TD-1005, all of which are located at the WSQ perimeter, there was no reason to suspect at the 95 percent confidence level that gamma exposures exceeded natural background. This conclusion was based on a comparison of the gamma exposure measured at each station to the gamma exposure measured at the four background TLD monitoring stations. Thus at the WSCP/WSRP perimeter, Francis Howell High School, and the Army Reserve Training Area there were no external gamma exposures above natural background levels.

At four of the six quarry monitoring stations gamma exposures exceeded natural background by amounts ranging from 12 to 30 mR/year. Although gamma exposures exceeded background at four quarry stations, the DOE standard authorized in DOE Order 5400.5 of 100 mR/yr above background in unrestricted areas was not exceeded. This information is summarized in Table 2-14. In Table 2-14 the percent of DOE standard was calculated by subtracting the annual average (68 mR/year) from the annual exposure at each station and then dividing by the 100 mR/year DOE standard.

2.5 Radioactive Air Particulate Monitoring

Radioactive air particulates are dust particles that carry radioactive contaminants. The main contributors to long-lived natural background radioactivity on dust particles are Po-210 and Pb-210, naturally occurring radon-222 decay products. Surface soils also naturally contain radioactivity that becomes airborne and accounts, to a much lesser extent, for natural background concentrations of radioactive air particulates. Background concentrations of radioactive air particulates vary depending on soil moisture, wind, and geological conditions.

Many areas of the WSS properties contain elevated concentrations of radionuclides in the soil which could result in increased radioactive air particulate concentrations. Increased concentrations and possible emission from the WSS could result from work activities such as movement of equipment or vehicles in contaminated areas or from wind erosion. This section discusses the air particulate monitoring program and presents a summary of the results.

TABLE 2-14 Summary of TLD Monitoring Results of Stations That Exceeded Natural Background*

Station Number	Location	Annual Exposure (mR/year)	Percent of DOE Standard
TD-1001	WSQ North Perimeter	98	30
TD-1002	WSQ East Perimeter	80	12
TD-1003	WSQ SE Perimeter	82	14
TD-1005	WSQ West Perimeter	80	12

* 95 Percent Confidence Level

2.5.1 Radioactive Air Particulate Monitoring Program

Eleven air particulate samplers are used to monitor the WSS properties. Five of these (AP-2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the WSCP perimeter as shown on Figure 2-22. Two monitoring stations (AP-4006 and AP-4008) are located off-site at sensitive receptor locations, which are Francis Howell High School and the Army Reserve property. The monitoring station at the August A. Busch Wildlife Area (AP-4007) is used to monitor background levels in the vicinity of the WSCP. The off-site monitoring stations are also shown on Figure 2-22.

In the second quarter of 1989, monitoring of the WSQ was initiated. Two monitors (AP-1009 and AP-1010) were installed at the quarry and one (AP-4011) placed off-site to monitor background levels in the vicinity of the quarry. The quarry monitoring stations are shown on Figures 2-25 and 2-26.

Due to the different geological conditions at the quarry and the WSCP, two background stations are utilized. The quarry background monitoring station is located approximately 0.8 km (0.5 mi) to the west of the quarry. This station is suitable because at that location the predominant wind direction is toward the quarry, and the station is not influenced by radioactive air particulate releases from the quarry, yet it is close enough to the quarry to have the same regional environmental and meteorological characteristics.

The sampling station near the August A. Busch Wildlife Area (ABWA) headquarters is used as a WSCP/WSRP background air monitoring station. This station is approximately 0.8 km (0.5 mile) from the WSCP perimeter in a northwestern direction. The terrain between the WSCP and this sampling station is hilly and

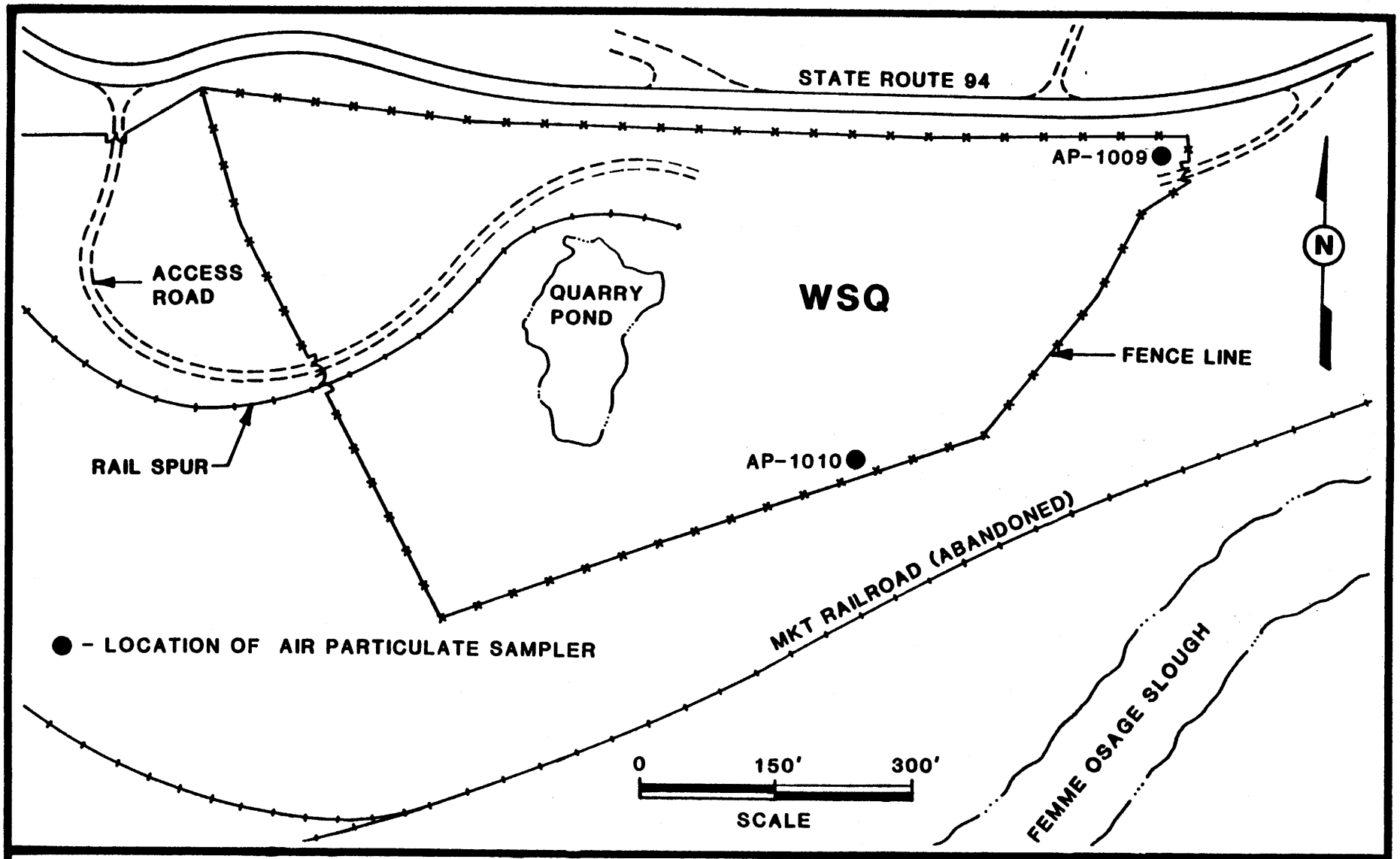


FIGURE 2-25

AIR SAMPLER LOCATIONS AT THE WSQ PERIMETER

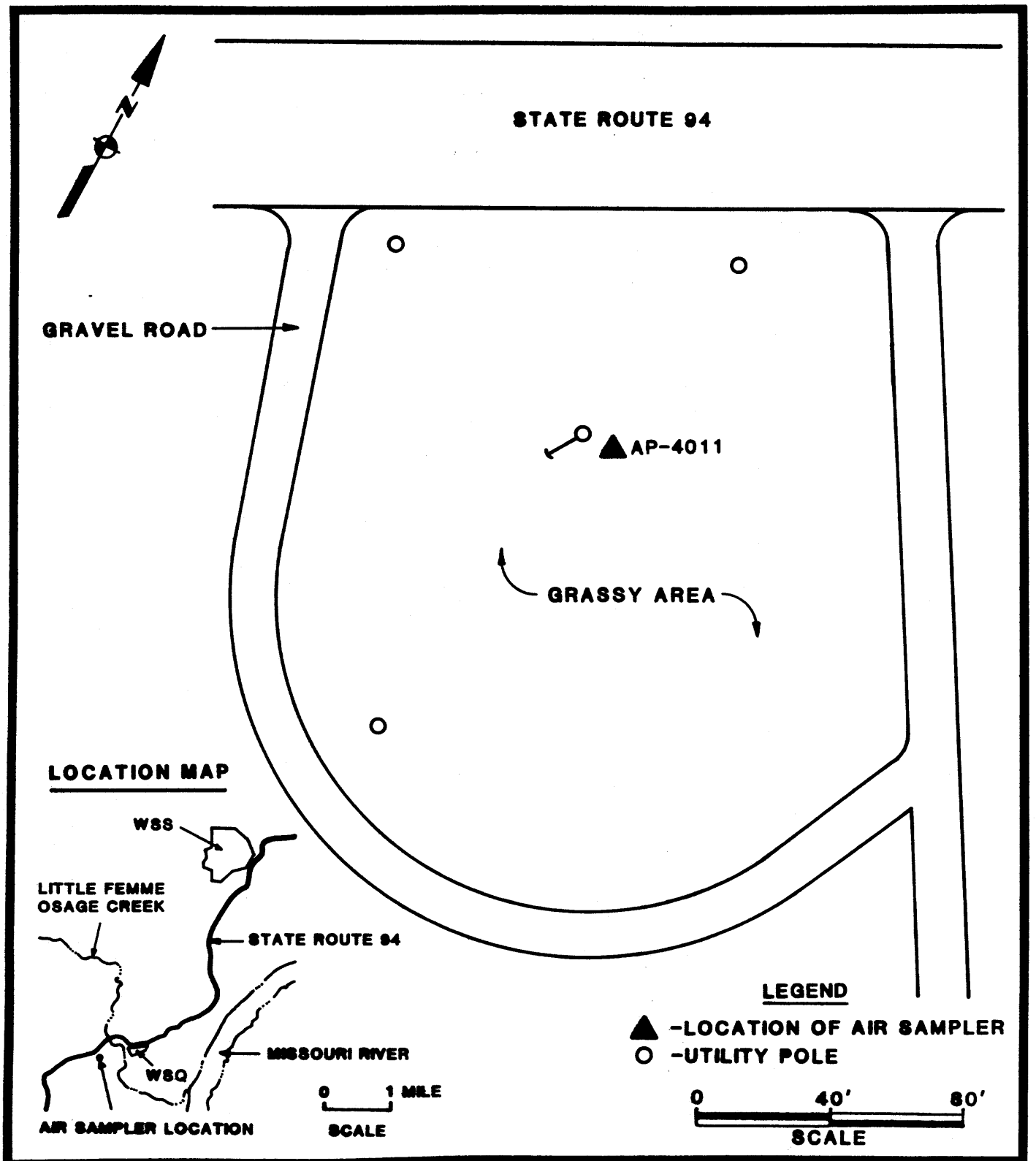


FIGURE 2-26

QUARRY BACKGROUND AIR SAMPLER LOCATION

forested, providing a significant physical barrier to airborne particulates originating from the WSCP/WSRP. In addition, winds from the southeast are relatively rare at the WSCP.

The five air particulate samplers used at the WSCP, the two nearby off-site locations, and the background station at ABWA headquarters were continuous flow dichotomous virtual impactor units operating at a constant total flow of one cubic meter per hour (35 ft^3/hour). These samplers divide suspended particles into two sizes: 2.5 to 10 micrometers in diameter (coarse respirable particles) and less than 2.5 micrometers in diameter (fine respirable particles). Particles larger than 10 micrometers (non-respirable) were not collected because they do not pose a significant risk to human health through inhalation.

Samples were collected on 37-millimeter diameter membrane filters with an effective pore size of 0.8 micrometers. All filters were collected once per week.

The three air particulate samplers used in the quarry monitoring program are constant flow dual diaphragm units operating at a continuous total flow of 2.4 cubic meters per hour (85 ft^3/hour). These monitors use open-face sampling heads and do not segregate the air flow according to particle size. This results in the collection of respirable and non-respirable particles. Therefore subsequent analysis is conservative when determining radioactivity concentrations of air because some of the collected particles would pose no human health impact. Samples, consisting of 47-millimeter diameter membrane filters with an effective pore size of 0.45 micrometers, were exchanged weekly.

The majority of the radionuclides present at the WSS and in the quarry waste are from the natural U-238 and Th-232 decay chains. Many of these radionuclides emit alpha particles during decay which pose the greatest hazard when deposited internally in the respiratory tract and lung. Therefore air particulate samples were analyzed for long-lived gross alpha activity. The long-lived gross alpha method of analysis sums the alpha activity from all of the long-lived alpha-emitting radionuclides.

2.5.2 Radioactive Air Particulate Monitoring Results7

The gross alpha measurements were made with a standard zinc-sulfide detector. The alpha counts per filter were converted to radioactivity per volume of air for that filter and reported in μCi/ml (Bq/m^3).

Table 2-15 summarizes the annual average concentration and the standard deviations for the 11 air monitoring locations. The annual average concentration for each monitoring location was calculated by averaging the weekly air particulate analysis results, or the counting instrument's lower limit of detection (LLD), whichever was greater. All of the monitoring stations exhibited some weekly sample concentrations less than the LLD. The < sign in Table 2-15 indicates that the actual average is less than the calculated average. The cause for this was the use of LLD values in calculation of the annual average concentration. When a value was reported as less than the LLD, the LLD value was used in the calculation. The standard deviation for each of the monitoring locations was calculated using only analysis results that were above the LLD because the weekly LLD values were nearly the same and to have used them would have resulted in a low bias in the annual standard deviation. If only one or less weekly

TABLE 2-15 Radiological Air Particulate Results 1989

MONITOR IDENTIFICATION NUMBER	AIR PARTICULATE TYPE	ANNUAL AVG. CONCENTRATION (1E-15 uCi/ml)		STANDARD DEVIATION	NUMBER OF VALUES ABOVE LLD
AP-2001	COARSE	<1.60		--	1
	FINE	<2.67	2	1.30	36
AP-2002	COARSE	<1.60		--	0
	FINE	<2.88		1.63	41
AP-3003	COARSE	<1.52		--	1
	FINE	<3.28		1.72	40
AP-3004	COARSE	<1.59		0.60	3
	FINE	<3.60		5.24	38
AP-2005	COARSE	<1.60		--	1
	FINE	<3.14		1.53	40
AP-4006	COARSE	<1.62		0.97	8
	FINE	<3.37		1.64	41
AP-4007*	COARSE	<1.62		0.35	5
	FINE	<2.87		1.11	34
AP-4008	COARSE	<1.60		0.94	4
	FINE	<3.27		1.48	43
AP-1009	ALL	<4.27		1.81	30
AP-1010	ALL	<4.36		1.75	30
AP-4011*	ALL	<3.83		1.58	30

* INDICATES BACKGROUND MONITOR STATION
TO CONVERT uCi/ml TO Bq/M^3 MULTIPLY BY 3.7E10

result was greater than the LLD, no standard deviation was calculated. This is indicated by NA in the table.

The typical LLD for the dichotomous virtual impactor units used at the WSCP/WSRP was approximately 1.6 x 10^{-15} µCi/ml (.06 mBq/m^3). The dual diaphragm units at the WSQ typically achieved an LLD of approximately 6.4 x 10^{-16} µCi/ml (.02 mBq/m^3). These LLDs are low enough for the detection of Th-232, the radionuclide with the lowest derived concentration guideline (DCG) found at the WSS. The DCG for Th-232 is 7 x 10^{-15} µCi/ml (.26 mBq/m^3). The DOE provides DCGs for airborne contaminants which, inhaled by a member of the public continuously for one year, would result in a committed effective dose equivalent of 100 mrem (1 mSv).

The annual average net alpha activity for each monitoring station was not statistically different at the 95% confidence level from the corresponding background station activity. This is significant because it indicates that there is no release of radioactivity from the site that can be distinguished from background levels.

2.6 Unrestricted-Area Radiological Contamination Monitoirng

The WSS contains many areas of radiological contamination due to waste deposition and spillage during former uranium and thorium refining operations. Also, due to atmospheric releases of radioactivity during operations at the WSS, all structures and roads potentially have surficial contamination. The majority of the processing involved refining uranium and thus it is the primary contaminant at the site.

Since 1986 the WSSRAP has employed an unrestricted-area monitoring program to ensure that radioactive materials are not

migrating from the site (as a result of the remedial construction) to areas used by the general public.

2.6.1 Unrestricted-Area Radiological Monitoring Program

This program includes radiological surveys of the WSSRAP Administration Building, laboratory, access control point for the site controlled area, WSSRAP trailers and subcontractor trailers, vehicles, site roadways and a portion of the Katy Trail. Radiological surveys are performed at least quarterly and usually monthly. The surveys consist of performing in situ measurements and collecting swipe samples.

In situ measurements are taken with a beta-gamma detector. Measurements are collected over a one-minute counting interval and then converted to disintegrations per minute per 100 cm^2 (dpm/cm^2). These measurements determine the total radioactivity, fixed plus removable.

Measurements of removable surficial radiation levels are made at each beta-gamma measurement location using a dry cloth or paper swipe. The swipes are wiped (smeared) over a surface area of approximately 100 cm^2. Swipes are analyzed for one minute on a standard alpha scintillation detector. The count rate results are corrected for detector efficiency to yield measurement results in dpm/cm^2.

2.6.2 Unrestricted-Area Radiological Monitoring Results

For the purpose of this report, only the monitoring results for the WSSRAP roadways outside the controlled area and the Katy Trail are presented. These areas are discussed because they represent areas accessible by the public. All other monitoring

results are on file at the WSSRAP. Performance of these surveys to date confirms that contaminated materials are not being carried into unrestricted areas.

Figure 2-27 shows the monitoring locations for the roadways outside the controlled area. Table 2-16 lists the annual average beta-gamma and alpha monitoring results at each location. Also included in the table are the associated errors of the beta-gamma and alpha results. The reported errors of the beta-gamma results are given as a percentage of the average result.

The results of the monitoring show that only fixed contamination is present at a few locations, but at levels well below the DOE uranium surface contamination guidelines for unrestricted use of 5,000 dpm/100 cm^2. The probable cause of the contamination is deposition of atmospheric releases of uranium dust during the operational period of the Weldon Spring Uranium Feed Materials Plant (WSUFMP). Since monitoring began, no increase in levels has been shown on the uncontrolled area of the roadways at the WSS. Also no removable activity has been found during the monitoring of the roadways.

The Katy Trail is shown on Figure 2-28. An approximate 1,130-m (3,700-ft) stretch of the trail is monitored due to its proximity to the WSQ and Femme Osage Slough. Beta-gamma measurements are taken at 10 locations along a section of the trail that are positioned so as to appropriately represent the entire length of the section monitored.

Table 2-17 lists the average beta-gamma monitoring results for each location. The majority of the monthly survey measurements at each location are below the lower limit of

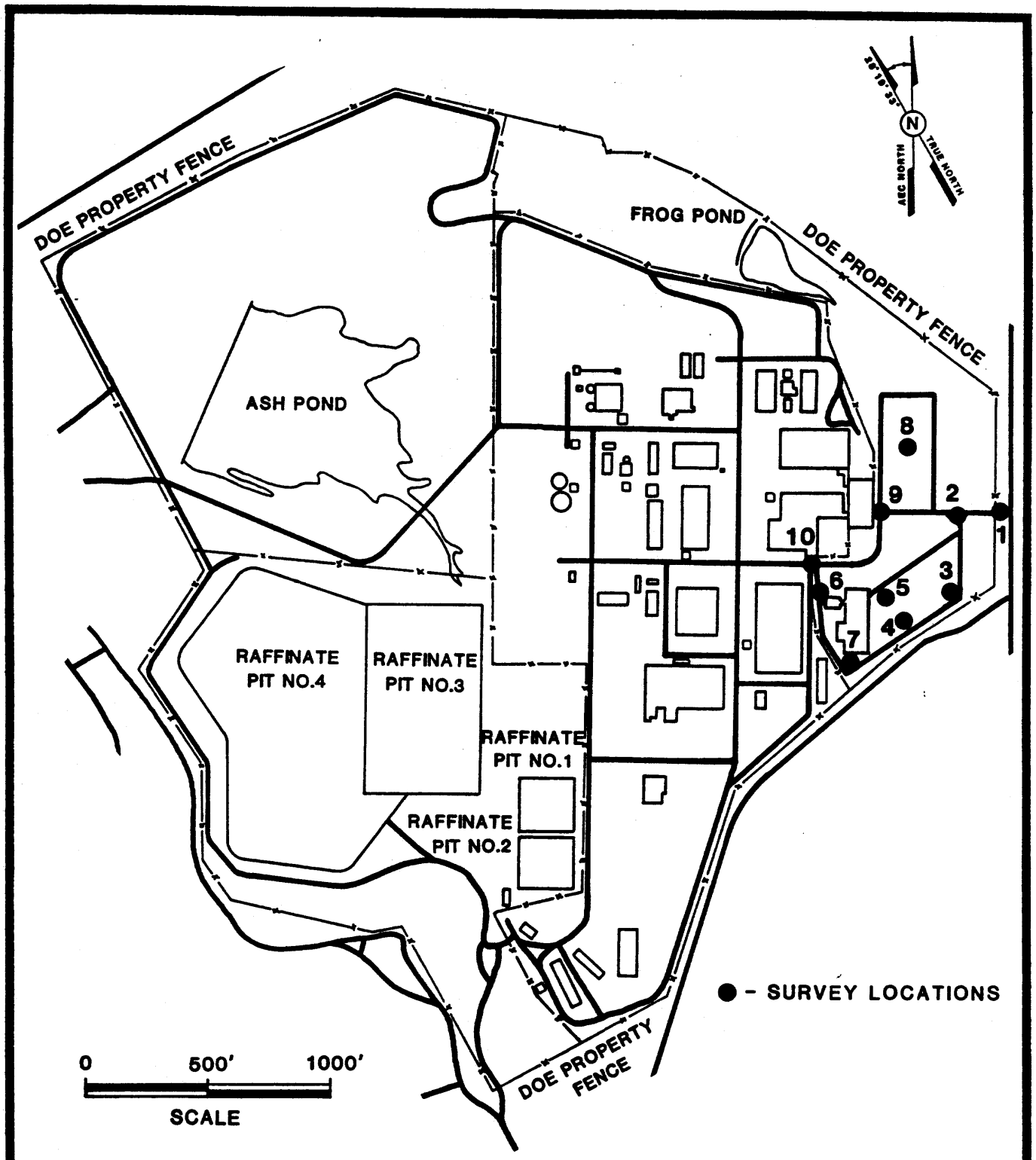


FIGURE 2-27

ROAD SURVEY LOCATIONS

TABLE 2-16 1989 Unrestricted Roadway Monitoring Results(a)

LOCATION I.D.	BETA-GAMMA RESULTS ANNUAL AVERAGE	BETA-GAMMA RESULTS PERCENT DEVIATION	ALPHA RESULTS ANNUAL AVERAGE	ALPHA RESULTS 2 STD. DEV.
1	<672	57	2	3
2	<665	48	2	4
3	<645	37	2	4
4	<1084	43	2	3
5	<1004	55	1	2
6	<816	66	0	2
7	2610	38	1	4
8	1615	23	1	2
9	<1333	35	1	2
10	<914	33	0	0

(a) RESULTS GIVEN IN DISINTEGRATIONS PER MINUTE PER 100 SQUARE CENTIMETERS AREA (DPM/cm^2).

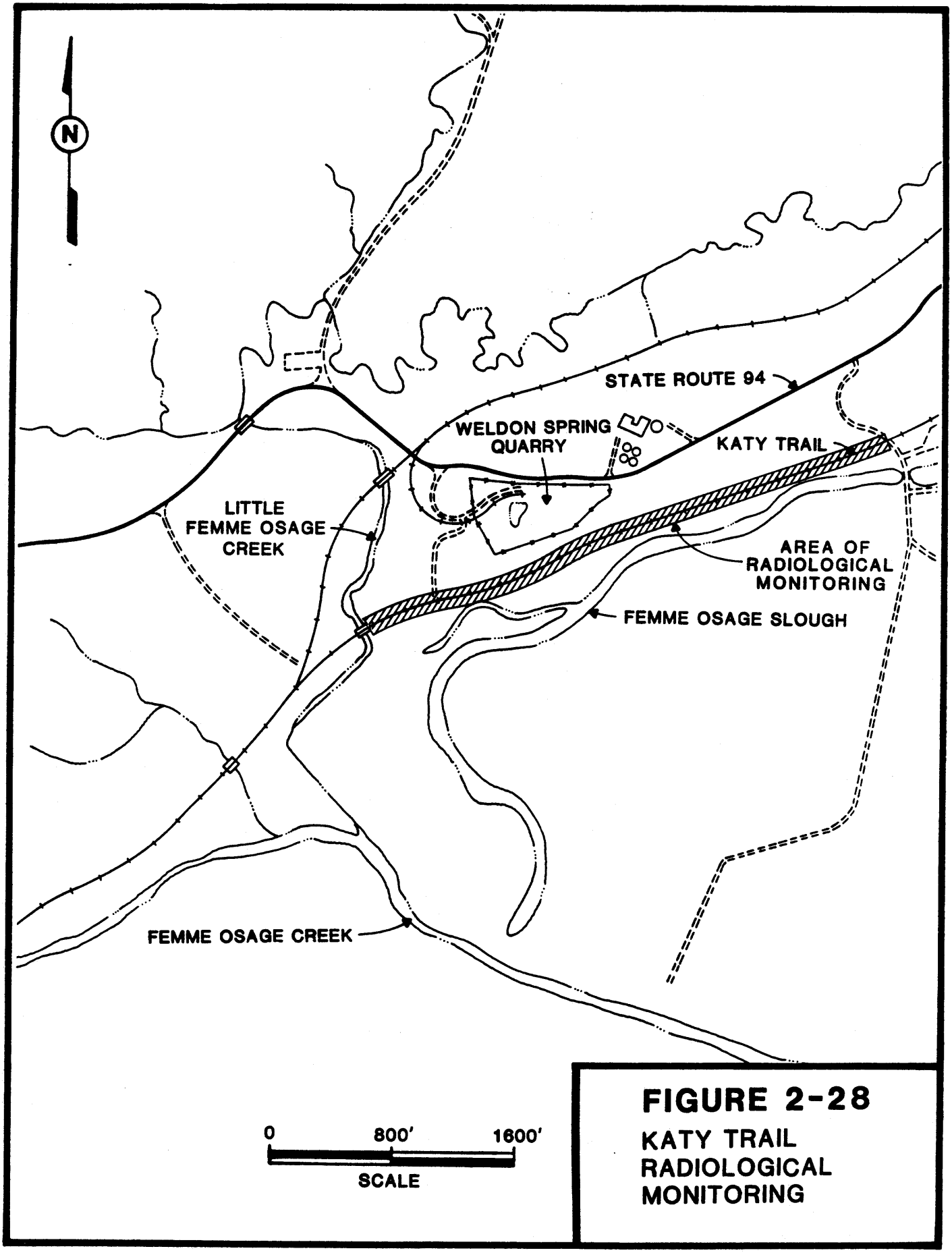


FIGURE 2-28
KATY TRAIL
RADIOLOGICAL
MONITORING

TABLE 2-17 1989 Katy Trail Monitoring Results

LOCATION NUMBER	AVERAGE* BETA-GAMMA MONITORING RESULTS (DPM/100 cm^2)
1	<727
2	<709
3	<709
4	<709
5	<709
6	<709
7	<709
8	<709
9	<709
10	<709

* Lower limit of detection is 709 dpm/100 cm^2.

detection (LLD) and therefore no standard deviations are reported.

The results of all monitoring locations show that the average beta-gamma results are below the LLD. However, a small isolated area represented by location number one consistently shows higher beta-gamma activity than the other monitoring locations and during one of the surveys had detectable beta-gamma radioactivity. This area is located in the far eastern section of the monitoring area. A soil sample was collected at location number one and analyzed for uranium-238, radium-226, radium-228, thorium-230 and potassium-40. The analysis did not indicate any radionuclide concentrations above background levels. This area will be investigated further to determine the reason for elevated beta-gamma radioactivity. There is no evidence of radioactive material migrating from the WSQ or Femme Osage Slough area onto the Katy Trail and thus there is no identifiable risk from radiological contamination to users of the Katy Trail.

2.6.3 Asbestos Monitoring

Environmental monitoring for asbestos was performed at five site perimeter monitoring locations and at the Francis Howell High School (FHHS) monitoring location. At these locations, worker exposure monitoring and work area sampling were conducted during asbestos abatement operations and at other times when asbestos-containing materials were being handled on the site.

During 1989, three interim response actions were completed which involved asbestos abatement activities, i.e., Administration Building (Building 409) Demolition, Steam Plant (Building 401) Demolition, and Overhead Piping and Support Removal. The asbestos abatement operations associated with these

projects were initiated in November 1988 and were completed in September 1989.

During the period from January through September 1989, site perimeter samples were collected on a weekly basis. Two concurrent samples were collected each week. Sample locations at the site perimeter were selected on the basis of the observed wind direction at the beginning of the sampling period; one sample was designated as an upwind sample and the other sample was designated as a downwind sample.

Also during this period, daily samples were collected at AP-4006, the Francis Howell High School monitoring station. Following completion of asbestos abatement activities, sampling at FHHS station was reduced to a frequency of one sample per week.

Samplers were generally operated for 7-8 hours per day, corresponding to the period during which operations were being conducted at the site.

Two different methods of sample analysis were utilized in the asbestos air monitoring program. All samples were analyzed by Phase Contrast Microscopy (PCM). This method provides a total airborne fiber concentration for fibers having a size and shape which are characteristic of asbestos fibers. This method does not distinguish between asbestos fibers and other airborne fibers having similar characteristics. The results of the PCM samples are reported in fibers per cubic centimeter of air (f/cc). Selected samples were also analyzed using Transmission Electron Microscopy (TEM). This method is capable of positively identifying asbestos fibers, whereas the PCM method is not. The

results of the TEM samples are reported in structures per cubic centimeter of air (s/cc).

The results of the environmental samples collected at the FHHS and site perimeter monitoring stations are provided in Tables 2-18 and 2-19, respectively. The results of the PCM and TEM analyses are reported separately therein.

The average fiber concentration (as determined by PCM analysis) at the upwind monitoring stations (0.001 f/cc), the downwind monitoring stations (0.001 f/cc) and the FHHS monitoring station (0.001 f/cc) are all considered to be within the range of normal background fiber concentrations, indicating that asbestos fibers were effectively contained during the asbestos abatement operations.

This conclusion is also supported by the results of the on-site asbestos monitoring activities. The results of personnel exposure monitoring conducted by site personnel indicate an average worker exposure concentration of 0.065 f/cc. Further, all major asbestos operations which involved stripping of friable asbestos-containing materials from the piping and other building components were performed within specially constructed enclosures having high efficiency particulate air (HEPA) ventilation systems. The purpose of the enclosure is to contain any airborne fibers within the work area and to filter the air as it is discharged to the atmosphere. Asbestos monitoring was performed at each HEPA filter outlet on a daily basis. A total of 174 such samples were collected, with a range from <0.001 f/cc to 0.027 f/cc and an average concentration of 0.006 f/cc.

Thirteen samples collected at the FHHS and site perimeter monitoring stations were analyzed using TEM. (See Tables 2-18

TABLE 2-18 Summary of Asbestos Air Monitoring Results at Francis Howell High School

PCM ANALYSIS

MO/YR	NO. OF SAMPLES COLLECTED	FIBER CONCENTRATION (f/cc) RANGE	AVERAGE(1)
01/89	18	<0.0005--<0.002	0.001
02/89	18	<0.0005--<0.001	0.001
03/89	21	<0.0005-- 0.0007	0.001
04/89	20	<0.0005-- 0.001	0.001
05/89	21	<0.0005-- 0.004	0.001
06/89	16	<0.001 -- 0.017	0.001
07/89	12	0.0006--<0.001	0.001
08/89	21	<0.0005-- 0.003	0.001
09/89	18	<0.001 -- 0.004	0.001
10/89	4	<0.001 -- 0.003	0.002
11/89	4	<0.001 -- 0.001	0.002
12/89	13	<0.001 --<0.001	0.001
		ANNUAL AVE:	0.001

TEM ANALYSIS

MO/YR	NO. OF SAMPLES COLLECTED	FIBER CONCENTRATION (s/cc) RANGE	AVERAGE(1)
03/89	1	<0.002	0.001
05/89	1	<0.001	0.002
06/89	2	<0.001--<0.001	0.001
07/89	2	<0.001-- 0.060	0.031
08/89	1	<0.002	0.002
09/89	1	<0.001	0.001
10/89	1	<0.001	0.001
11/89	1	0.004	0.004
12/89	1	<0.001	0.001
		ANNUAL AVE:	0.001

(1) For purposes of averaging,the detection limits were treated as actual fiber concentrations for those samples reported as below detectable quantities.

TABLE 2-19 Summary of Asbestos Air Monitoring Results for Upwind and Downwind Samples from the Weldon Spring Site Perimeter

PCM ANALYSIS

MO/YR	UPWIND NO. OF SAMPLES COLLECTED	UPWIND FIBER CONCENTRATION (f/cc) RANGE	UPWIND AVERAGE(1)	DOWNWIND NO. OF SAMPLES COLLECTED	DOWNWIND FIBER CONCENTRATION (f/cc) RANGE	DOWNWIND AVERAGE(1)
01/89	5	<0.001 --<0.001	0.001	8	<0.0005--<0.001	0.001
02/89	4	<0.0005--<0.001	0.001	3	<0.001 --<0.001	0.001
03/89	4	<0.0005--<0.0005	0.001	4	<0.0005-- 0.002	0.001
04/89	4	<0.0005--<0.001	0.001	4	<0.0005--<0.001	0.001
05/89	5	<0.001 --<0.002	0.001	5	<0.0005--<0.001	0.001
06/89	4	<0.001 --<0.001	0.001	4	<0.001 -- 0.001	0.001
07/89	4	<0.001 --<0.001	0.001	4	0.0006--<0.001	0.001
08/89	2	<0.001 --<0.001	0.001	2	<0.001 -- 0.001	0.001
09/89	5	0.001 --<0.002	0.002	6	<0.001 --<0.002	0.002
10/89	4	<0.001 -- 0.007	0.003	5	<0.001 -- 0.007	0.004
11/89	5	<0.001 -- 0.001	0.001	6	<0.001 -- 0.001	0.001
12/89	3	<0.001 --<0.001	0.001	3	<0.001 -- 0.001	0.001
		ANNUAL AVE:	0.001		ANNUAL AVE:	0.001

TEM ANALYSIS

MO/YR	UPWIND NO. OF SAMPLES COLLECTED	UPWIND FIBER CONCENTRATION (s/cc) RANGE	UPWIND AVERAGE(1)	DOWNWIND NO. OF SAMPLES COLLECTED	DOWNWIND FIBER CONCENTRATION (s/cc) RANGE	DOWNWIND AVERAGE(1)
07/89	1	<0.001	0.001	1	<0.001	0.001

(1) For purposes of averaging,the detection limits were treated as actual fiber concentrations for those samples reported as below detectable quantities.

and 2-19.) These samples ranged from <0.001 s/cc to 0.060 s/cc. One of the TEM samples collected at the FHHS monitoring station xhibited a relatively high concentration of asbestos, i.e., 0.060 s/cc for the sample collected on July 7, 1989. This sample could not be analyzed by PCM because of the amount of dust loading on the filter. The sample was subsequently analyzed by TEM; however the sample had to be ashed and resuspended prior to TEM analysis. The laboratory indicated that the sample pretreatment procedure could have biased the subsequent analysis on the high side by a factor of up to 10 times the actual concentration, due to the fact that the pretreatment procedure has been shown to fracture the fibers and thereby result in a higher fiber count.

Although the specific cause of the elevated asbestos concentration is not known, an evaluation of the prevailing wind conditions and the TEM results from the site perimeter samples during the same time period suggests that the apparently anomalous asbestos result was unrelated to WSSRAP activities. Another positive asbestos measurement of 0.004 s/cc was obtained at the FHHS monitoring station sample collected on November 1, 1989. This result can be explained on the basis of normal background variability.

As a quality assurance measure, blank samples are periodically submitted to the laboratory for analysis. These samples are subjected to the same analysis as the regular air samples. During calendar year 1989 a total of 61 blank samples were submitted for analysis. Fiber loadings on all of the blank filters were less than 7 fibers per 100 fields which conforms to the requirements of the analytical method.

3 RELATED ACTIVITIES AND SPECIAL STUDIES

Numerous activities were conducted during 1989 to further characterize and improve the environmental conditions at the Weldon Spring Site (WSS). These activities were performed to provide better detail on contaminant distribution and migration mechanisms from the site and enable the U.S. Department of Energy (DOE) to more precisely and completely conduct its remedial actions. Also, several interim response actions were conducted during this monitoring year to reduce or eliminate immediately hazardous conditions at the site. Each of those activities is described below. Table 3-1 presents a list of the related and special study activities accomplished during this monitoring year.

3.1 Characterization Studies

During 1989 four characterization studies were performed to support the Remedial Investigation/Feasibility Study (RI/FS). These characterization studies included the radiological characterization of the Weldon Spring Chemical Plant (WSCP) buildings, the characterization of minor storm water discharge points, studies of the results from the new groundwater monitoring wells, and additional radon monitoring. Principal points of each characterization study are discussed in subsections 3.1.1 through 3.1.5.

3.1.1 Radiological Characterization of WSCP Buildings

To supplement radiological characterization data previously obtained in WSCP buildings, radiation measurements were collected from October 1988 through April 1989 in 25 non-process buildings. No measurements were required in buildings which processed

TABLE 3-1 Characterization Studies and Interim Response Actions Performed in 1989 at the Weldon Spring Site

Activity Name	Area Investigated	Status
Characterization Studies		
Radiological Characterization of the WSCP Buildings	WSCP	Complete
Characterization of Minor Storm Water Discharge Points	WSCP/RP	Complete
Shallow Groundwater Monitoring Wells Results	WSCP/RP	Complete
Radon Decay Product Monitoring	WSQ	Complete
Radon Gas Monitoring Above Quarry Wastes	WSQ	Complete
Interim Response Actions		
Overhead Piping Removal	WSCP	Complete
Building 409 Demolition	WSCP	Complete
Building 401 Demolition	WSCP	Complete
Ash Pond Diversion Project	WSCP/RP	Complete
Containerized Chemical Consolidation	WSCP	Ongoing

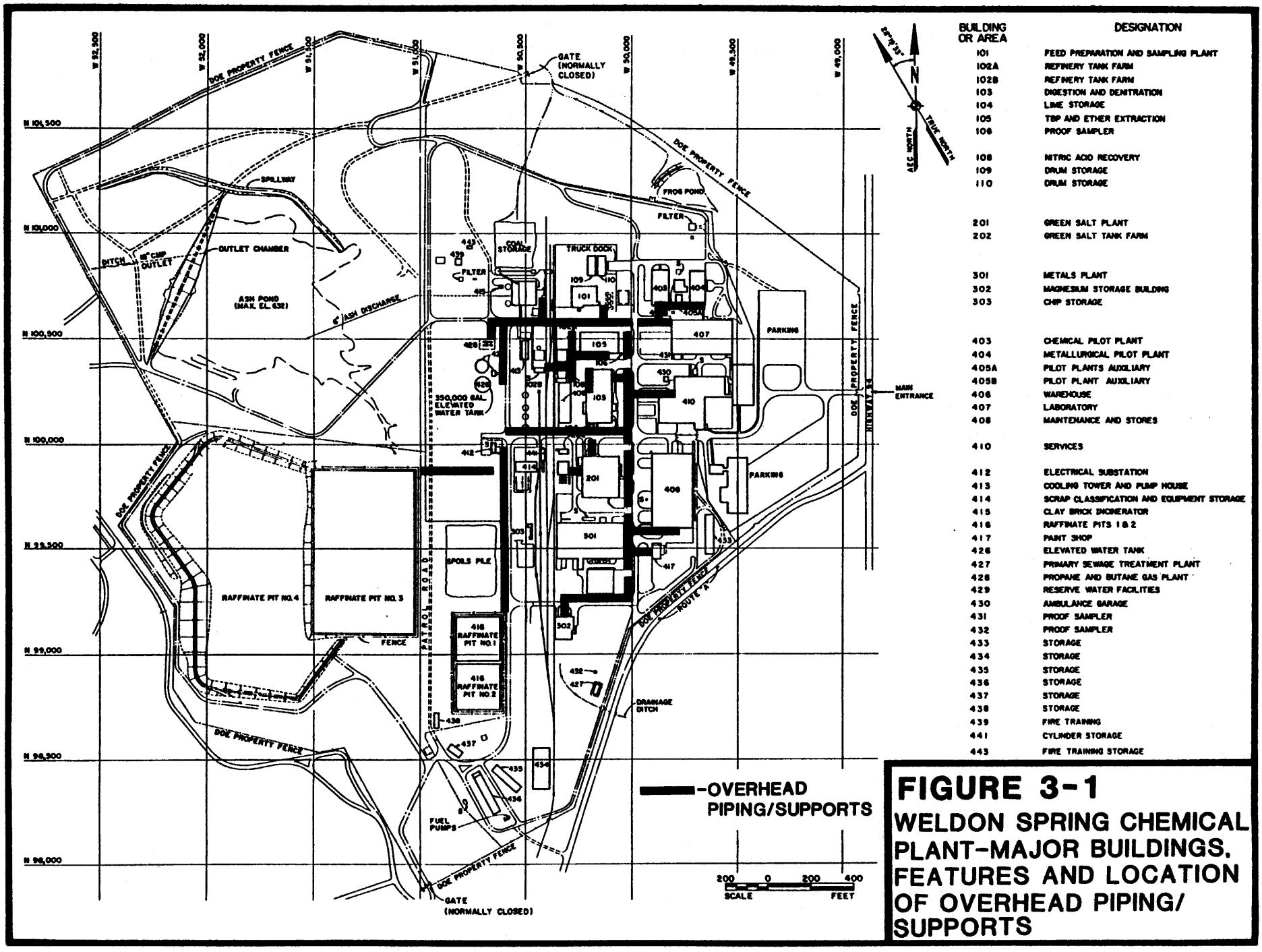
WSCP/RP - Weldon Spring Chemical Plant/Raffinate Pits
WSQ - Weldon Spring Quarry

uranium and thorium because sufficient information had been collected by other investigations. The characterization efforts allowed estimation of which building structural components and equipment were radiologically contaminated and an assessment of the radiation hazards within each building.

Six types of samples or measurements were collected. These were: (1) total beta-gamma radioactivity, (2) removable alpha radioactivity, (3) core samples, (4) bulk samples, (5) 100% scans, and (6) air monitoring.

Results of this characterization effort were combined with previous survey results to provide a comprehensive radiological assessment of all WSCP buildings. This information is detailed in the "Weldon Spring Chemical Plant Buildings Radiological Characterization Report" (MKF and JEG, 1989d).

These surveys have revealed that all structural components and equipment within process buildings (Buildings 101, 103, 105, 108, 201, 301, 403, and 404, see Figure 3-1) are contaminated and cannot be released from the site without decontamination. The contamination level varies in the non-process buildings. Much of the equipment stored in the non-process buildings is contaminated. Some structural components of non-process buildings are not contaminated. In general, horizontal surfaces in non-process buildings have a higher probability of being contaminated than do vertical surfaces. No structural component or equipment in non-process buildings can be released from the site until further radiation measurements are performed on areas which were inaccessible to characterization measurements and to verification of the results of characterization measurements.



BUILDING OR AREA	DESIGNATION
101	FEED PREPARATION AND SAMPLING PLANT
102A	REFINERY TANK FARM
102B	REFINERY TANK FARM
103	DIGESTION AND DENITRATION
104	LIME STORAGE
105	TBP AND ETHER EXTRACTION
106	PROOF SAMPLER
108	NITRIC ACID RECOVERY
109	DRUM STORAGE
110	DRUM STORAGE
201	GREEN SALT PLANT
202	GREEN SALT TANK FARM
301	METALS PLANT
302	MAGNESIUM STORAGE BUILDING
303	CHIP STORAGE
403	CHEMICAL PILOT PLANT
404	METALLURGICAL PILOT PLANT
405A	PILOT PLANTS AUXILIARY
405B	PILOT PLANT AUXILIARY
406	WAREHOUSE
407	LABORATORY
408	MAINTENANCE AND STORES
410	SERVICES
412	ELECTRICAL SUBSTATION
413	COOLING TOWER AND PUMP HOUSE
414	SCRAP CLASSIFICATION AND EQUIPMENT STORAGE
415	CLAY BRICK INCINERATOR
416	RAFFINATE PITS 1 & 2
417	PAINT SHOP
426	ELEVATED WATER TANK
427	PRIMARY SEWAGE TREATMENT PLANT
428	PROPANE AND BUTANE GAS PLANT
429	RESERVE WATER FACILITIES
430	AMBULANCE GARAGE
431	PROOF SAMPLER
432	PROOF SAMPLER
433	STORAGE
434	STORAGE
435	STORAGE
436	STORAGE
437	STORAGE
438	STORAGE
439	FIRE TRAINING
441	CYLINDER STORAGE
443	FIRE TRAINING STORAGE

FIGURE 3-1

WELDON SPRING CHEMICAL PLANT-MAJOR BUILDINGS, FEATURES AND LOCATION OF OVERHEAD PIPING/ SUPPORTS

3.1.2 Characterization of Minor Storm Water Discharge Points

Surface water discharge from the site has been routinely monitored at five major discharge points in the past and analyzed for a broad range of contaminants including metals, inorganic anions, nitroaromatics and radiochemical species. Surface water from the areas of known contamination leaves the site at these major discharge points. However, little data existed regarding the character of the runoff crossing the site boundary at the smaller discharge points.

As a result of land surface contours and the configuration of the storm sewer system across the site, approximately 210 acres of land surface drain their surface runoff across the site boundary, either onto or off of the site property. Roughly 30% of that flux is not routinely monitored for contaminants. Where surface water enters the site, it is ultimately discharged via one of the three routinely monitored discharge routes. However it was unknown whether the run-on was contaminated before entering the site.

Sampling was initiated in 1989 to assess the unmonitored surface water exiting the site via minor drainageways.

Measurement data are presented on Figure 3-2. The data indicate that small quantities of surface water contaminated with low levels of uranium are leaving the site at various locations. The results also indicate that at three drainage crossings on the eastern boundary, surface water with slightly elevated uranium levels is flowing onto the site. These results are possibly due to atmospheric deposition off-site during Weldon Spring Uranium Feed Materials Plant (WSUFMP) operations since no other known sources exist within these off-site drainages. Since the levels

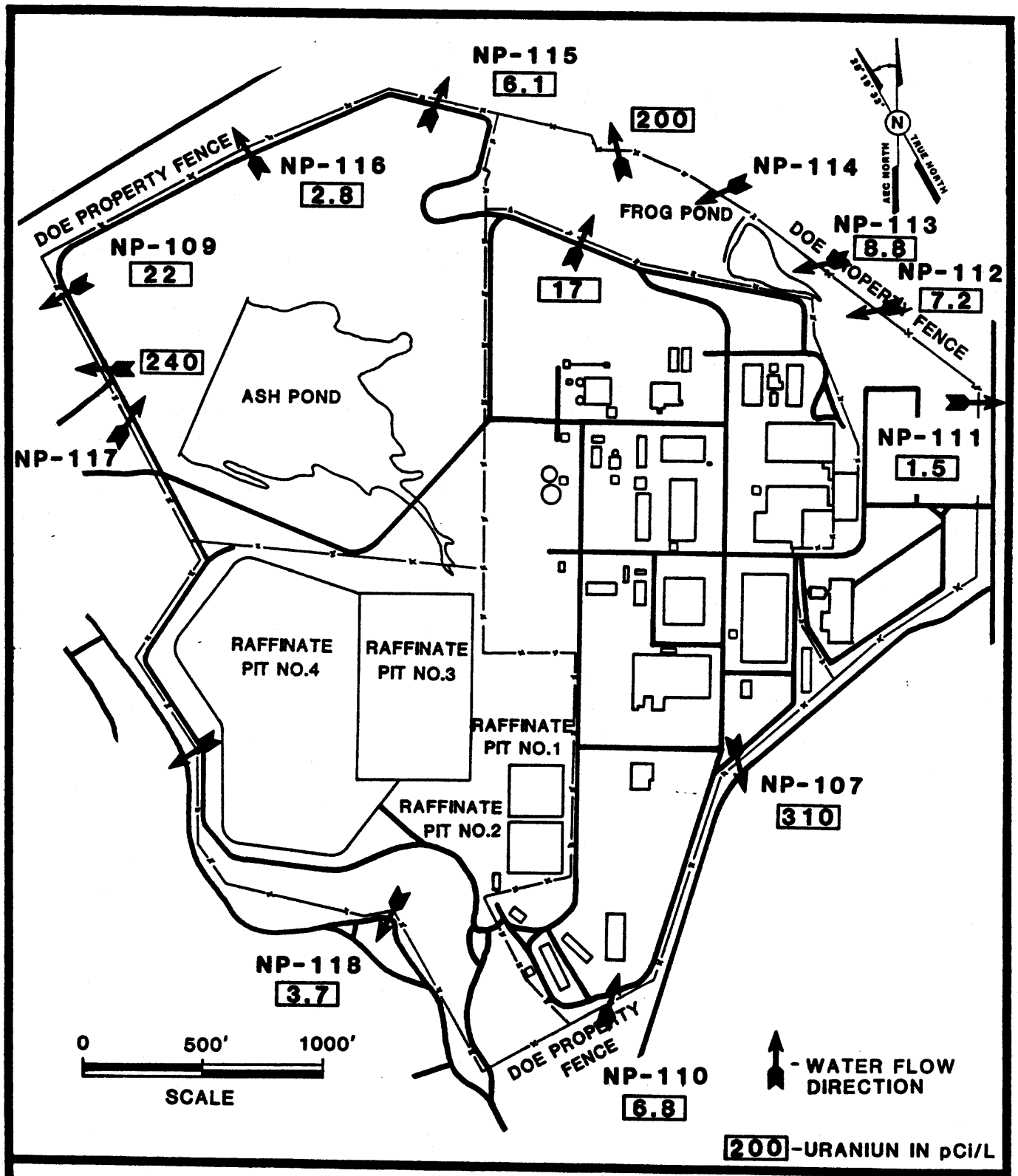


FIGURE 3-2

URANIUM LEVELS MEASURED AT MINOR DISCHARGE POINTS AROUND WSS

are very near to background concentrations and no duplicate data are available to verify or refute the preliminary results, further sampling is needed to determine the source of the uranium.

The highest release from a non-routinely monitored drainage was found to be along a small tributary to the Ash Pond drainage which drains part of the North Dump Area. At a concentration of 22 pCi/l (0.81 Bq/l) in the discharged water, the quantity of uranium contributed to the environment at this release point is relatively insignificant compared with the three major discharge points.

Based on the average annual precipitation rate of 85 cm (Section 1.3), and 65% surface runoff of that precipitation, an average of 22 pCi/l (0.81 Bq/l) would result in 0.66 kg (1.5 lb) of uranium released annually through that discharge point. This represents less than 1% of the total uranium released from the site through the major discharge routes.

3.1.3 Shallow Groundwater Monitoring Well Results

Seven additional groundwater monitoring wells were installed at the WSCP/WSRP area during the summer of 1989 as part of a geotechnical drilling program in support of the WSS RI/FS process being conducted under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The wells were designed and installed to monitor the uppermost saturated zone of the water table aquifer in order to gain additional information regarding the vertical distribution of contaminants present in groundwater. The monitoring wells are identified as GT-58P, GT-60P, GT-63P, GT-64P, GT-65P, GT-66P, and GT-67P. They are

represented by the symbol designated for piezometers in Figure 2-1.

Complete results of the 1989 fourth quarter sampling of the GT-series monitoring wells will be reported in detail in the Groundwater Quality and Hydrogeologic Assessment of the GT-series Monitoring Wells (MKF and JEG, in preparation).

In general, analyses of groundwater samples from these wells did not significantly change the present understanding of groundwater contamination beneath the site. Nitroaromatic compounds were detected in four wells up to a level of 52 µg/l (2,6-dinitrotoluene) in GT-58P. Concentrations up to 8.5 µg/l of other semi-volatile or volatile compounds were detected in six wells. Nitrate was the inorganic ion detected in highest concentration (1,132 mg/l in GT-64P). Analyses for total metals in unfiltered samples revealed concentrations of chromium, copper, cobalt, nickel, and lead in the suspended solids. Metals analysis of filtered samples detected sodium in concentrations above the upper bound of background (MKF and JEG, 1989a).

3.1.4 Radon Decay Product Monitoring

Radon (Rn-222) and thoron (Rn-220) decay products were monitored in the quarry during the first half of 1989. Because elevated radon levels were observed in the WSQ (Section 2.3), monitoring was performed in areas not accessible to the public to evaluate the level of hazard to which workers in the quarry may be exposed. Thus results should be compared to the Derived Air Concentrations (DAC) guidelines for occupational workers. The DAC is used primarily for radiation protection planning purposes. The DAC for Rn-222 decay products is 0.33 Working Level (WL)

(7 micro Joules/cubic meter) ($\mu J/m^3$). The DAC for Rn-220 decay products is 1.0 WL (21 $\mu J/m^3$).

The radon decay product monitoring program involved collecting grab (5-minute) samples with a low-volume air sampler. Samples were collected on the upper gate plateau on the east end of the WSQ and near the quarry sump at RD-1010 and RD-1007 respectively, as shown on Figure 3-3. At each location samples were collected at heights of 15 cm (6 in.) and 1 m (39 in.). Sampling at the two heights was intended to identify possible radon and/or thoron daughter concentration gradients in the atmosphere directly above the waste.

A decay product (daughter) is the resulting element formed by the decay of a radionuclide. As the Rn-222 and Rn-220 decay chain progresses, radon decay products are produced. All the decay products of both Rn-222 and Rn-220 are particles and both decay chains terminate with stable isotopes of lead (Pb).

Concentrations of radon decay products are dependent on the amount of radon gas entering the atmosphere and the state of equilibrium between the activity of the radon and its daughters. The concentration of radon gas changes depending on many variables, as discussed in Section 2.3. Therefore, the daughter concentrations will fluctuate.

At 100-percent equilibrium, the activity of the radon decay products and the parent would be equal. As radon decays, the particles formed attach to airborne particles (dust). Some of these radioactive particles settle out on surfaces, reducing the activity of the airborne daughters. Also, radon disperses before the daughters can grow into equilibrium, so the equilibrium of environmental air is usually less than 50 percent.

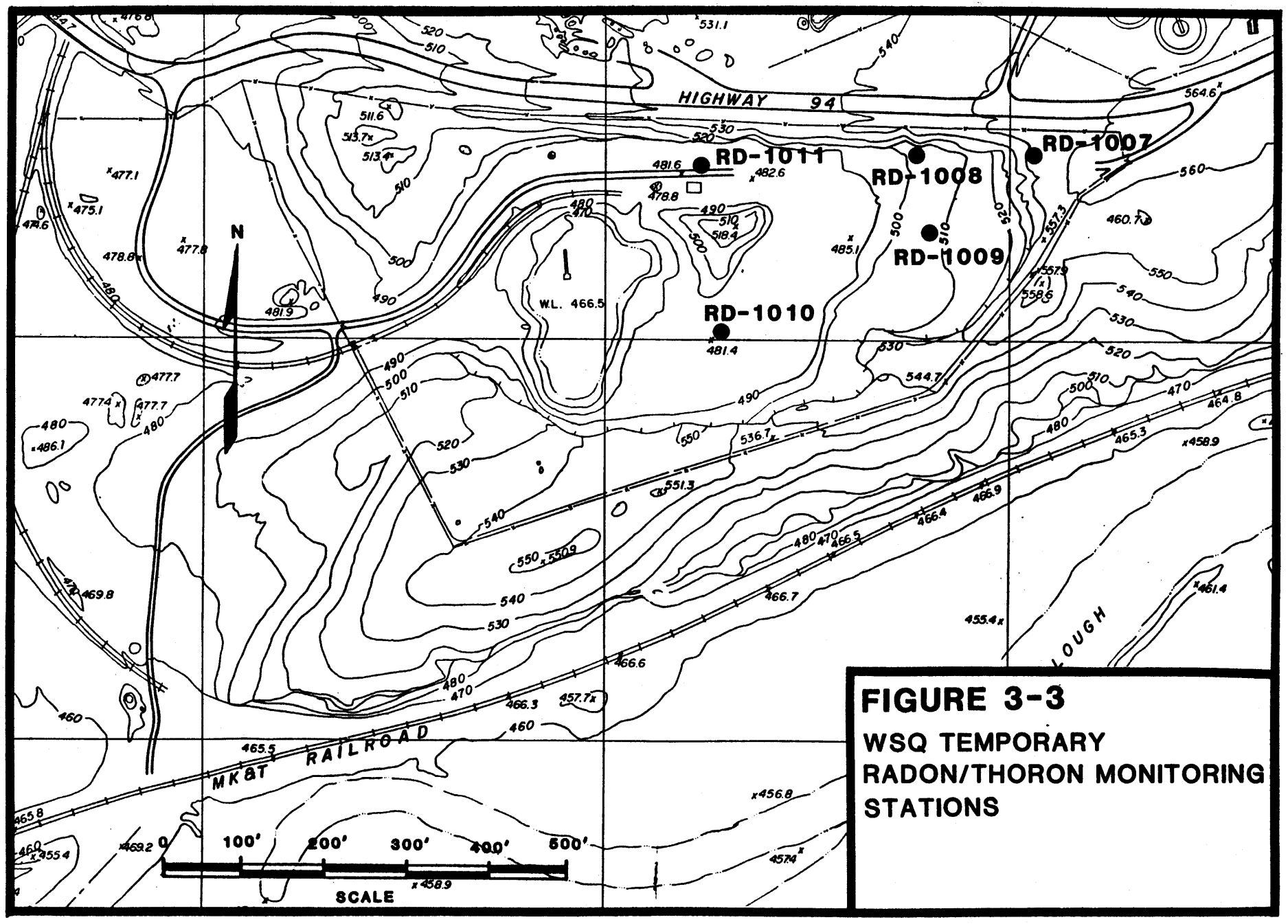


FIGURE 3-3

WSQ TEMPORARY RADON/THORON MONITORING STATIONS

Table 3-2 lists the results of the radon daughter concentration (RDC) and thoron daughter concentration (TDC) measurements at each location and the average concentration is given for the 15 cm and 1 m samples at each location. Results ranged from below the minimum detectable activity (MDA) of 0.0001 WL (0.002 $\mu J/m^3$) to 0.009 WL (0.19 $\mu J/m^3$) for Rn-222 daughters and ranged from less than the MDA of 0.001 WL (0.002 $\mu J/m^3$) to 0.003 WL (0.27 $\mu J/m^3$) for Rn-220 daughters. These concentrations are well below the DAC guidelines. In fact they are below the 0.02 WL (0.4 $\mu J/m^3$) concentration which EPA recommends as a level at which steps should be considered to reduce levels in homes.

Overall data regarding the possible existence of a concentration gradient is inconclusive. No significant concentration gradient was observed, although a few of the measurements at Location No. 2 showed a possible thoron concentration gradient between the two heights.

3.1.5 Radon Gas Monitoring Above Quarry Waste

In March 1989 the WSSRAP installed Type F and Type M track etch detectors within the quarry in order to monitor Rn-222 and Rn-220 concentrations directly above the quarry waste. Type M detectors have a membrane which screens out most Rn-220 (thoron) but allows Rn-222 to pass through, while the Type F allows both gases to pass through. Thus results of Type F monitors would be expected to be greater than or equal to results of Type M monitors. Section 2.3 provides a more detailed description of these detectors.

Ten Type F and ten Type M detectors were placed in duplicate at five temporary monitoring stations within the quarry at a height

TABLE 3-2 Radon Decay Product Monitoring

	LOCATION #1 UPPER RIDGE				LOCATION #2 QUARRY SUMP			
	RADON WL x 10^{-3}		THORON WL x 10^{-3}		RADON WL x 10^{-3}		THORON WL x 10^{-3}	
	GROUND	ONE METER	GROUND	ONE METER	GROUND	ONE METER	GROUND	ONE METER
	1.20		2.60		0.41		0.06	
	3.00		5.00		0.80		1.00	
	1.70	6.50	3.00	0.10	2.60		1.00	
	7.00	6.00	2.00	2.00	1.00	2.00	13.00	4.00
	2.60	6.00	6.30	1.00	1.70	2.00	0.00	2.00
	9.00	3.70	0.10	0.10	4.60	2.70	2.00	0.10
	6.20	4.10	2.20	3.10	3.50	2.90	0.62	2.40
	1.30	0.00	1.00	4.60	1.10	1.00	2.80	2.80
	1.40	1.00	0.00	1.50	2.30	1.90	0.60	0.60
	7.50	5.70	4.40	1.60	5.40	3.60	4.40	2.60
	9.00	5.70	2.00	2.00	5.00	4.90	3.00	3.00
	7.60	5.70	2.50	4.40	5.00	4.20	5.20	2.50
	0.11	0.10	1.30	1.20	0.30	1.50	11.00	1.30
	3.10	1.40	1.00	3.90	1.70	1.60	1.50	1.50
AVE.	4.34	3.83	2.39	2.13	2.53	2.57	3.30	2.07

TO CONVERT TO uJ/m^3 MULTIPLY BY .021

of one meter. In addition, duplicate Type F and Type M detectors were placed at two of the stations (RD-1007 and RD-1008) at a height of 5 cm (2 in.) above the ground to determine if a Rn-222 or Rn-220 gradient exists in the atmosphere directly above the bulk waste. The locations of these temporary monitoring stations are shown on Figure 3-3.

The detectors were deployed for two different intervals: the last month of the first calendar quarter and the entire second calendar quarter of 1989. Table 3-3 contains the results of the monitoring for each period of exposure. The reported concentrations are averages of the two duplicate detectors. Also, two standard deviations of the average reported results are given to define the 95% confidence level (the average plus or minus two standard deviations). The second exposure period was for the entire second quarter of 1989 and is a better representation of long-term concentrations than the first exposure period which was only one month.

The overall results indicate an elevated concentration of radon within the quarry walls compared to the perimeter fence monitors. This is due to the location of the temporary monitors directly above the quarry waste materials. The increase in radon concentrations with respect to the location of the waste is seen through comparison of temporary monitoring station RD-1007 to the perimeter station RD-1002 (see Figure 2-24). These monitoring stations are approximately 15 m (50 ft) apart and at nearly the same elevation. However, station RD-1007, located directly above the waste, has a radon concentration two to three times higher than station RD-1002. The fact that radon concentrations are strongly influenced by proximity to quarry waste materials is further demonstrated by comparison of measurements taken at 5 cm

TABLE 3-3 Radon Monitoring Results Above Quarry Waste~

MONITORING STATION I.D.	HEIGHT FROM GROUND (m)	1st PERIOD TYPE F pCi/l	1st PERIOD TYPE F TWO STD. DEV.	1st PERIOD TYPE M pCi/l	1st PERIOD TYPE M TWO STD. DEV.	2nd PERIOD TYPE F pCi/l	2nd PERIOD TYPE F TWO STD. DEV.	2nd PERIOD TYPE M pCi/l	2nd PERIOD TYPE M TWO STD. DEV.
RD-1007	1	4.7	0.4	1.4	0.3	3.4	0.2	14.5	0.7
	0.05	1410.2	63.0	2062.5	97.7	125.2	6.3	82.5	4.8
RD-1008	1	10.4	0.6	6.0	0.6	29.1	2.4	48.7	2.4
	0.05	23.1	1.1	14.9	1.0	199.9	11.9	152.1	6.0
RD-1009	1	4.6	0.4	3.7	0.5	6.9	0.4	12.9	0.7
RD-1010	1	2.1	0.3	2.3	0.4	8.1	0.4	3.8	0.3
RD-1011	1	3.0	0.4	3.9	0.5	4.2	0.2	4.1	0.3

~ INCLUDES NATURAL BACKGROUND
TO CONVERT TO Bq/m^3, MULTIPLY BY 37

(2 in.) versus measurements taken at 1 m (39 in.) above the waste.

The detectors located 5 cm (2 in.) above the quarry waste at station RD-1007 and RD-1008 both show that Rn-220 (thoron) is contributing to the total radon concentration. The data from the one-meter detectors at all the locations are inconclusive overall to determine the amount of thoron present. In fact, at locations RD-1007 and RD-1009, the Type M detector results are significantly higher than Type F detector results. The inconsistencies are probably due to the different calibration factors employed for the two detector types. The WSSRAP will investigate these apparent inconsistencies further by taking radon decay product measurements during 1990 using continuous monitors.

3.2 Interim Response Actions (IRAs) Performed at the WSS During 1989

During 1989 three Interim Response Actions (IRAs) were conducted that involved release of building structural materials and equipment from the site for unrestricted use or disposal. These IRAs were: (1) dismantling of a network of overhead piping and structural steel supports; (2) dismantling of Building 409, the administration building; and (3) dismantling of Building 401, the steam plant. Salient points of each IRA are discussed in Sections 3.2.1, 3.2.2 and 3.2.3.

Another IRA performed in 1989 was the Ash Pond Isolation project. This project was performed in order to reduce uranium releases from the Ash Pond Outfall. The construction of a diversion dike and channel system around Ash Pond has limited flow of surface water over adjacent contaminated areas, thus

reducing releases of uranium off site. This IRA is discussed in Section 3.2.4.

The containerized chemical consolidation IRA involved consolidation and recontainerization of chemicals remaining from WSUFMP operations. Disposal has been delayed. This IRA is discussed in Section 3.2.5.

IRAs are designed to ensure the health and safety of on-site personnel and to minimize or preclude off-site releases of contamination. They are limited to work that can be performed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and also remain within the constraints of the Council on Environmental Quality Regulations for the National Environmental Policy Act (i.e., they are limited to those actions that do not have an adverse environmental impact and do not limit the choice of remedial alternatives for the site as a whole).

All items that potentially came in contact with radioactive materials were surveyed according to radiological survey and release plans reviewed and approved by the DOE, EPA, and Missouri Department of Health. Structural materials and equipment were not released from the site unless they satisfied the criteria contained in the survey and release plans. These criteria were applied only to rigid surfaces. Liquids, soils, sediments, asbestos or other porous materials that could have been volumetrically (as opposed to surficially) contaminated were not released from the site if they contained any detectable radioactivity in excess of natural background levels.

To provide assurance that results of radiation surveys were accurate an independent verification contractor, Oak Ridge Associated Universities (ORAU), performed spot checks on

materials previously surveyed by the Project Management Contractor (PMC). ORAU personnel found no discrepancies with PMC survey results.

3.2.1 Overhead Piping Removal

During the operation of the chemical plant, overhead piping was used to transfer process chemicals, steam, air, brine, fuel gas, and process waste (raffinates). The pipe network was supported by steel-pipe poles, structural steel, and pipe bents, along with several structural-steel bridges. The piping structures were supported by reinforced concrete foundations. The overhead pipe network lay among several of the chemical plant buildings depicted in Figure 3-1. The overhead pipe distribution system consisted of 15,482 m (50,794 ft) of carbon and stainless steel pipe, 330 bents and 20 bridges. Approximately 33% of the piping was sheathed in asbestos- containing pipe insulation, much of which was in a deteriorated condition. The degradation of the pipe insulation caused sections of the insulation to separate from the pipe. Since the insulation contained asbestos, it posed a potential occupational hazard and as such was designated as an IRA. Dismantlement of the overhead piping and support structures started in January 1989.

Between January 20, 1989 and June 9, 1989, 23 loads of pipe, structural supports, and wire were released for unrestricted use. The released materials weighed approximately 300 metric tons (330 tons).

All pipes that transferred source or by-product (radioactive) materials were assumed to be contaminated and not released from the site. Approximately 200 metric tons (220 tons) of pipe and structural material were not released and are

currently stockpiled adjacent to Building 109. All asbestos-containing insulation was retained on site in Building 434. A detailed discussion of the processes by which the overhead piping was characterized and dismantled is presented in the Radiological and Chemical Completion Report for Overhead Piping Removal, (MKF and JEG, 1990c).

3.2.2 Building 409 Demolition

Building 409, the former Administration Building for the Weldon Spring Chemical Plant (WSCP), was a two-story rectangular structure located in the eastern portion of the WSCP approximately 180 m (600 ft) east of the process building as shown on Figure 3-1. The deteriorating condition of the building (e.g., loose floor tiles, weakened roof, and friable asbestos insulation) posed an occupational hazard to workers. Therefore, the dismantling of the building was proposed as an IRA. Dismantling of the building began in November 1988 and was completed in April 1989.

On the basis of radiation measurements taken by the PMC, it was determined that the majority of the building structure and equipment could be released from the site. This was as expected since the building housed administrative workers and no radioactive materials were processed or stored in the building.

Radiologically contaminated materials retained on the site included tar and gravel roofing, some interior furnishings, and air-handling equipment such as exhaust vents, furnace blowers, and cooling units. Air-handling equipment, especially filters, tended to concentrate any airborne uranium dust during the WSUFMP operations. It is speculated that any interior furnishings found

to be contaminated were moved from other process buildings into Building 409.

The radiologically contaminated roofing material and air handling equipment was placed on pad 303 (see Figure 3-1). The friable roofing material was covered with a protective tarp to prevent spread of contamination by wind or runoff. A detailed discussion of the processes by which Building 409 was characterized and dismantled is presented in the Building 409 Completion Report (MKF and JEG, 1990d).

3.2.3 Building 401 Demolition

Building 401, which was the steam plant for the WSUFMP was a multi-story rectangular structure located in the northwestern section of the WSCP as shown on Figure 3-1.

The deteriorating condition of the building (e.g., weakened roof and friable asbestos insulation) posed a hazard to workers and potential trespassers on the property. Therefore, it was determined that dismantling the building as an IRA would be beneficial to the project. Dismantling of the building began in December 1988 and was completed in December 1989.

Based on the results of radiation measurements performed on Building 401 the following materials were released from the WSSRAP: 459 m^3 (600 yd^3) of rubble, 620 metric tons (683 tons) of scrap metal; 61 m^3 (80 yd^3) of asbestos, and 1.5 m^3 (2 yd^3) of wood.

Radiologically contaminated materials associated with the dismantlement of Building 401 that were retained on the site included 336 m^3 (440 yd^3) of rubble and scrap metal, and 63

metric tons (70 tons) of equipment. The majority of those materials are stored on site in Buildings 109 and 110. The tar and gravel roofing material was drummed and stored on site in Building 434. In addition to the radiologically contaminated materials stored on the site, the asbestos and PCB light ballasts were retained and await radiological assessment. A detailed discussion of the processes by which Building 401 was characterized and dismantled is presented in the Building 401 Completion Report to be issued by the WSSRAP in 1990.

3.2.4 Ash Pond Diversion Project

The surface-water impoundment referred to as Ash Pond was designed and built as a fly ash sedimentation pond for the coal-fired steam plant at the WSUFMP. The main source of radioactive contamination in the Ash Pond area is the South Dump (Figure 3-4). Contaminated materials were burned and disposed of in this area during the operation and decontamination efforts at the WSUFMP. As a result of these activities, contaminants (mainly uranium) in the form of loose sediments and dissolved or suspended materials were freely transported by runoff and associated sediments, thereby contaminating the ash in Ash Pond.

Runoff flowing through the 25 ha (65-acre) Ash Pond watershed intermittently accumulated in Ash Pond and discharged off site when the pond was sufficiently full. This discharge flowed to an unnamed tributary of Schote Creek and eventually affected Lakes 34 and 35 in the August A. Busch Memorial Wildlife Area. Therefore it was determined that performing an Interim Response Action (IRA) by constructing a diversion dike that would redirect the surface water runoff around Ash Pond and the South Dump would be beneficial. This would eliminate leaching and

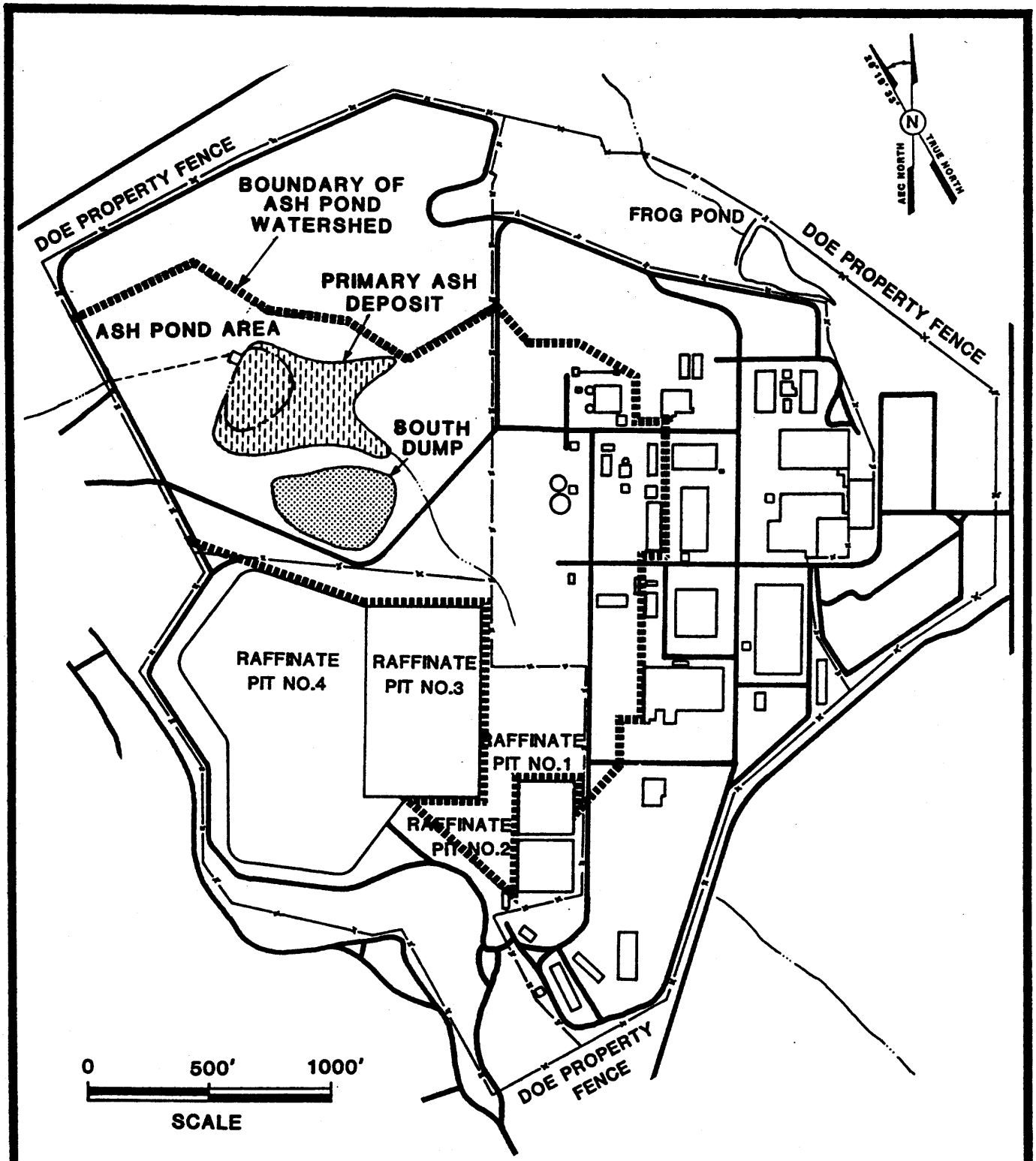


FIGURE 3-4

ASH POND AREA BEFORE CONSTRUCTION OF THE DIVERSION SYSTEM

transport of contaminated materials in these areas, thereby reducing off-site releases of uranium from the Ash Pond discharge.

Construction was initiated in November 1988 and was completed in April 1989. Figure 2-18 shows the final configuration of the Ash Pond diversion dike and how the diversion dike diverts flow through the ditches around the South Dump and Ash Pond areas.

Water samples were collected monthly from the Ash Pond outfall which discharges at the site perimeter as required in the WSCP National Pollutant Discharge Elimination System (NPDES) Permit (see Section 2.2). These samples were collected following a rainfall that produced surface runoff. Prior to the completion of the Ash Pond Diversion Project the uranium concentrations for these samples averaged 1,498 pCi/l (55 Bq/l). Since completion of the project the average uranium concentration in samples collected from May through October 1989 is 145 pCi/l (5.37 Bq/l). The data indicate a tenfold reduction in uranium released at this outfall. Discharges of uranium are now below the DOE DCG level of 550 pCi/l (20.4 Bq/l). A complete description of the isolation project is presented in the WSSRAP document entitled Assessment of Ash Pond Isolation Project Effectiveness issued in February 1990 (MKF and JEG, 1990b).

3.2.5 Containerized Chemical Consolidation

In the fall of 1988, a program was initiated to handle various chemical wastes left behind following closure of the WSCP. The WSSRAP identified, characterized, consolidated, repackaged, and temporarily stored chemical wastes throughout the chemical plant. Due to the complexity of this undertaking, and

in the absence of viable alternatives for the treatment or disposal of radioactive chemical wastes, the chemical-consolidation project has been expanded in scope. What began as a short-term Interim Response Action evolved into an ongoing program.

Work completed to date has addressed radiochemical characterization and repackaging of small containers of chemicals throughout the WSCP. Certain areas of the plant, such as the Building 407 Laboratory, were either omitted or excluded from the initial phase of this project, but are currently being addressed. To date, over 450 drums and storage bags containing various materials have been placed in a secure storage facility.

The original goal to dispose of the containerized chemicals at off-site facilities was not attained in 1989. Disposal methods were not available for chemical wastes mixed with low levels of radioactivity. Continued on-site storage is necessary until appropriate technologies become available. A state-of-the-art storage facility was created on-site during 1989 to ensure that strict administrative control of the waste inventory is maintained. This facility was designed to comply with all applicable statutes, regulations, DOE orders, and best-management practices pertaining to the storage of hazardous waste.

Current activities include handling of containerized chemicals that have not yet been consolidated as well as consolidation of residual chemical substances remaining in tanks, sumps, and process vessels. In-depth chemical and radiological characterization of the hazardous wastes will be performed during 1990.

4 RADIOLOGICAL EXPOSURE

In assessing the health effects of the radioactive materials stored at the chemical plant/raffinate pits, (WSCP/WSRP), quarry (WSQ), and vicinity properties (WSVP) as required by U.S. Department of Energy (DOE) Order 5484.1, radiological exposure was evaluated of persons at Francis Howell High School, the Busch Wildlife Area lakes and the Femme Osage Slough; of the general population within 50 miles of the Weldon Spring Site (WSS); and of a maximally exposed individual.

Individuals could be exposed to radioactivity from the WSS via five principal pathways: (1) direct external gamma radiation, (2) inhalation of radon and radon daughters, (3) inhalation of airborne radioactive dust particles, (4) ingestion of fish from nearby lakes that receive runoff from the WSS, and (5) ingestion of drinking water from sources contaminated with radionuclides from the WSS. All five pathways were included for the hypothetical maximally exposed individual. Pathway 4 was not considered in the population dose assessments because it is not reasonable or realistic to expect all members of a population to eat fish from bodies of water that receive runoff from the WSS. An evaluation of radiological exposures from these lakes when they are used for recreational purposes was included to ensure that the assessment would be thorough.

Although radiation doses can be calculated or measured for individuals, it is not practical to predict the health risk to a single individual. Estimates of health risk are based on statistical data on large groups of people exposed to radiation under various circumstances. Statistical models are not applicable to single individuals. Therefore, dose equivalents to single individuals are estimated by hypothesizing a maximally

exposed individual and placing this individual in a reasonable, but very conservative scenario.

Exposures of maximally exposed individuals and individuals near the off-site water bodies are given in terms of an effective dose equivalent. Exposures of people in neighboring facilities and populations within 80 km (50 mi) of the WSS are expressed in terms of collective effective dose equivalents or person-rems (person-sievert). All calculations were performed using the methodology described in International Commission on Radiation Protection (ICRP) reports 26 and 30 for a 50-year committed effective dose equivalent (ICRP, 1977, and ICRP 1979).

4.1 Radiation Dose From the WSCP/WSRP to a Maximally Exposed Individual

This section identifies an estimated committed effective dose equivalent to a hypothetical individual assumed to frequent the perimeter of the WSCP/WSRP and to receive a radiation dose by the five pathways identified above. No private residences are adjacent to the WSCP/WSRP sites; therefore, all calculations of direct gamma exposure, airborne dust particle inhalation exposure, and radon daughter inhalation exposure assume a realistic, less than 100% residence time. The amount of fish obtained and ingested from lakes receiving effluents from the WSCP/WSRP site assumes the average consumption rate per year according to U.S. Environmental Protection Agency statistics (EPA, 1988). None of these bodies of water are used as sources of drinking water. However, an evaluation of this pathway is included on the assumption that people could conceivably drink from them.

Gamma exposure rates were determined by means of thermoluminescent detector (TLD) monitoring stations at the Weldon Spring Training Area, the Missouri State Highway Department facility, and the Busch Wildlife Area. Airborne radiological particulates were sampled using continuous air samplers, and radon exposures were measured with track-etch radon monitoring stations at the above three locations. As shown in Section 2 there is no reason to suspect, with 95 percent confidence, that gamma exposure rates, airborne particle concentrations, and radon gas concentrations exceed natural background; therefore, the effective dose equivalent to a hypothetical individual receiving the maximum reasonable exposure from these three pathways is not measurable above normal background exposure.

Three off-site bodies of water (Busch Lakes 34, 35, and 36) receive runoff from drainage originating at the WSCP/WSRP site. All three lakes are used for fishing and boating. In 1988 a bio-uptake study (MKF and JEG, 1989d) was performed to investigate the possible exposure of humans to chemical and radiological contamination from ingestion of fish and game affected by previous operations at the WSS. This study included fish samples from the three Busch lakes. No measurable radionuclide concentrations above the detection limits were detected.

If it is assumed that the uranium concentration in the fish is equal to the detection limits of the analyses performed on the fish tissue, the concentration in fish from the three lakes would be 0.01, 0.02, and 0.01 pCi/g (0.37, 0.74, and 0.37 mBq/g), respectively. Radium and thorium concentrations in lake sediments and water were not above normal background levels and thus were not considered as a source of possible exposure. Using an average consumption rate of 6.5 grams/day for fresh-water fish

(EPA, 1988), the highest calculated annual dose from ingestion of fish living in these lakes would be less than 1 mrem (0.01 mSv).

None of the lakes are presently used for drinking or irrigation, but ingestion of lake water by an individual could possibly occur during recreational activities. In this scenario it is assumed that an individual could ingest lake water while swimming. Swimming can result in the ingestion of 0.05 liters per hour on average (EPA, 1988). Assuming that the individual swims in Lake 34, which has the highest average surface water concentration (25 pCi/l, or 925 Bq/m^3) for 12 hours per year, the calculated dose would be less than 1 mrem (0.01 mSv).

It is also possible for an individual to ingest lake sediments during visits to the lakes. The hypothetical individual is assumed to spend an average of approximately two days per year at the lakes consuming 200 mg per day. Using the average uranium concentration of surface sediments for Lake 34 which has the highest value of 46.8 pCi/g (1.7 Bq/g), the calculated dose would be below 1 mrem (0.01 mSv).

A maximally exposed individual would receive a total dose less than 1 mrem (0.01 mSv) from direct gamma exposure, inhalation of airborne dust particles, inhalation of radon daughters, ingestion of water and sediment, and ingestion of fish from contaminated waters.

4.2 Radiation Dose From the WSQ to a Maximally Exposed Individual

This section discusses the committed estimated effective dose equivalent to a hypothetical individual assumed to frequent the perimeter of the WSQ and receive a radiation dose by three of

the five pathways identified above. No private residences are adjacent to the WSQ site; therefore, all calculations of direct gamma exposure, airborne particle concentrations, and radon daughter inhalation assume a realistic, less than 100% residence time. Access to the quarry is controlled by a barbed wire fence; thus fishing, swimming, and drinking water from the quarry pond need not be evaluated.

The exposure scenario consists of a hypothetical individual who routinely walks along the northern boundary of the quarry on State Route 94. The individual is assumed to make this trip twice per day, 250 days per year. Average residence time per day is estimated to be 12 minutes (ANL, 1989). An actual exposure would occur of an individual who drives by the site twice per day, but it would be so insignificant relative to the walking scenario that it was not used in the calculation.

Data from three environmental TLD monitoring stations were used to evaluate the dose by direct gamma exposure to the hypothetical individual. The dose from external gamma radiation was calculated by multiplying the length of time the individual is exposed by the radiation field strength. Using these conservative assumptions and the highest measured gamma exposure rate (30 μR/hr at TD-1001), the calculated dose equivalent would be 1.5 mrem (0.015 mSv).

Airborne particulate monitoring at the WSQ was initiated in May and resulted in an average alpha concentration of 4.3×10^{-15} μCi/ml (.16 mBq/m^3). At the 95% confidence level there is no reason to suspect that airborne particle concentrations measured from May to December exceeded natural background. Thus it is assumed that no measurable exposure from this pathway occurred.

The risk associated with radon-222 is due primarily to inhalation of its short-lived decay products. Data from the three track-etch radon monitoring stations closest to State Route 94 were used to evaluate the dose by inhalation of radon daughters for the hypothetical individual. The highest average measured radon gas concentration at these monitoring stations was 1.0 pCi/l (37 Bq/m^3) above normal background. Assuming 50% equilibrium between radon gas and its daughters and 1.7 rem/ working level month (WLM) (17 mSv/WLM) (NCRP, 1985; ICRP, 1977), the annual calculated effective dose equivalent from inhalation of radon daughters is 2 mrem (.02 mSv).

The dose to the maximally exposed individual from the three pathways discussed above consists of a total of 3.5 mrem (0.055 mSv) from direct gamma exposure, inhalation of radon daughters and inhalation of radioactive air particulates.

4.3 Radiation Dose From WSVPs to a Maximally Exposed Individual

This section discusses the estimated effective dose equivalent to a hypothetical individual assumed to frequent the largest vicinity property (VP), the Femme Osage Slough, located south of the WSQ. This scenario provides a very conservative but plausible exposure assessment. No private residences are adjacent to the slough (it is on land that is currently managed by the Missouri Department of Conservation as part of the Weldon Spring Wildlife Refuge); therefore, all direct gamma exposure calculations assume a realistic, less than 100% time of residence. The slough is not suspected of having radioactive airborne particle concentrations and radon daughter concentrations above normal background because it is in a floodplain with saturated soil. The water in the soil minimizes

airborne migration. In addition, the slough is contaminated only with uranium, implying that above-background concentrations of radon are not possible.

The amount of fish obtained and ingested from the Femme Osage Slough assumes the average consumption rate of 6.5 g per day according to EPA estimates (EPA, 1988). Because of the stagnant water conditions, the slough is not a source of drinking water, nor is it a place for recreational swimming. Therefore, these pathways were not included in the dose calculations, and airborne particles and radon daughter concentrations were not measured.

Gamma exposure rate measurements were used to derive the effective dose equivalent by direct gamma exposure for the maximally exposed individual who is assumed to sit on the bank of the slough and fish four hours per week, 50 weeks per year. The measurements were taken with a pressurized ion chamber (PIC) on the bank of the slough in an area of known radiological soil contamination. Using the measured gamma exposure rate of 10.3 μR/hr, which is 2.5 μR/hr in excess of natural background, the calculated dose equivalent would be 2 mrem (.02 mSv).

As part of the bio-uptake study, fish samples were collected and analyzed for total uranium, Th-230, Th-232, and Ra-226. All results were below detection limits. Uranium is the only radionuclide in the slough sediments and water that is elevated above background concentrations; therefore, uranium and its decay products are the only radionuclides that were considered for possible uptake. Assuming that the uranium concentration in fish is equal to the detection limit achieved during tissue analysis, the fish tissue concentration is 0.01 pCi/g (0.37 mBq/g). Using the average annual consumption rate of 6.5 grams/year (EPA,

1988), the calculated effective dose equivalent to the maximally exposed individual from ingestion of fish living in contaminated waters would be less than 1 mrem (0.01 mSv).

The dose to the maximally exposed individual from the two pathways discussed above consists of a total of less than 1 mrem (.055 mSv) from direct gamma exposure and consumption of fish tissue.

4.4 Population Doses

The risk from radiation exposure to the general population is a function of the number of persons exposed, duration of exposure, and concentration or exposure rate to which the population is exposed. Below an absorbed dose of 10 rad (0.1 Gy) the projection of risk is uncertain. This is more than 30 times the typical yearly natural background exposure in the United States. In fact, no statistically significant adverse effects of radiation exposure have ever been proven at low doses of radiation. This is substantiated by studies of human populations exposed in regions of the world where natural background exposures are several times higher than those typically incurred in the United States. In these regions of higher background radiation exposures, the rate of adverse health effects has not been shown to increase above those which occur due to other factors.

This section summarizes the radiation exposure potential for populations surrounding the WSS. The exposures are shown to be indistinguishable from natural background. Therefore, no risks are projected.

4.4.1 Dose to Francis Howell High School Population

To determine dose equivalents accurately, the radiation exposure should be measured at the point where the collective dose equivalent is to be estimated. Collective dose equivalent is determined by multiplying calculated doses by the number of persons exposed. The Francis Howell High School (FHHS) is located 0.8 kilometers (0.5 miles) northeast of the WSCP.

Samples of radioactive airborne particles were collected weekly at the FHHS station, and radon concentrations and external gamma exposure rates were monitored quarterly. Water supplied to the school from the St. Charles County well field was also sampled and analyzed quarterly.

No radiation level or radionuclide concentration in air or water has ever exceeded natural or normal background radioactivity at the 95 percent confidence level at the FHHS station. This being the case, no risk is determined and no measurable adverse health effects are predicted to occur.

4.4.2 Population Doses Within 80 Kilometers (50 Miles)

The collective effective dose equivalent to the general public within an 80-km (50-mi) radius of the WSS must be calculated or estimated, since it is unreasonable to attempt pathway-specific measurements relative to every individual. The exposure pathways considered were: external exposure to gamma radiation, inhalation of radon and radon daughters, inhalation of radioactive airborne particles, and ingestion of water, fish, or game containing radioactivity.

At the three off-site gamma radiation monitoring stations, all measurements were at normal background levels (see Section 2.4). Likewise, measurements at the four off-site radon monitoring stations and air particulate monitoring stations were indistinguishable from background levels (see Sections 2.3 and 2.5, respectively). Therefore, the WSS does not contribute any measurable radiation dose to the general public via these three pathways.

None of the surface water or groundwater bodies that receive runoff or recharge from the WSS are used as drinking water sources; therefore, this pathway was not included in the dose evaluation. It is not realistic to expect that a significant fraction of persons living within 80 km (50 mi) of the site consumes fish or game affected by the WSS; hence this is not a significant exposure pathway (see Section 4.3). Therefore, cumulative radiation dose to the population within an 80-km (50-mi) radius resulting from radioactive materials present at the WSS is indistinguishable from the dose that the same population receives from naturally occurring radiation sources.

4.5 Radiation Dose To Individuals From Contaminated Lakes

This section calculates the realistic effective dose equivalent of an individual who uses Lakes 34, 35, 36, and the Femme Osage Slough solely for recreational purposes. The lakes are located in the Busch Wildlife Area and the Femme Osage Slough in the Weldon Spring Wildlife Area. They are used for recreational activities such as fishing and boating. None of the water bodies are presently used for drinking water or irrigation. In contrast to the previous sections, the analyses presented here attempt to realistically estimate the dosage to an individual in very plausible settings.

The potential radiation dose to individuals resulting from recreational activities at these lakes was estimated for the following potential pathways:

External: Swimming, boating, and direct exposure from the water body; and
Internal: Accidental ingestion of contaminated water.

The assumed individual spent 12 hours per year swimming and boating at the location of the contaminated water bodies. Also, this individual was assumed to ingest one liter of water from a canteen filled from one of the water bodies.

For purposes of calculation, thorium-234, protactinium-234, and uranium-234 were assumed to be in a state of secular equilibrium. In this analysis, the dose represents the 50-year effective committed dose equivalent expressed in millisievert per year (mSv/yr) and millirem per year (mrem/yr).

The total dose commitments estimated for a hypothetical individual from these exposure assumptions is much less than 1 mrem (0.01 mSv). These radiation pathways contribute an insignificant health risk to individuals or the general population.

5 FUTURE ENVIRONMENTAL MONITORING AT THE WELDON SPRING SITE

The environmental monitoring approach employed at the Weldon Spring Site (WSS) in 1990 has been modified from previous programs by several factors including issuance of DOE Order 5400.1 and the completion of numerous characterization activities. The effects of these factors are detailed in the Environmental Monitoring Plan (MKF and JEG, 1990a) for the WSS.

The groundwater monitoring program for 1990 will generally consist of semi-annual sampling of all Weldon Spring Chemical Plant/Weldon Spring Raffinate Pits (WSCP/WSRP) wells and all Weldon Spring Quarry (WSQ) wells north of the Femme Osage Slough. These samples will be analyzed for nitroaromatic compounds, inorganic anions and natural uranium. This program is designed to detect changes in contaminant concentrations and distribution. Quarterly monitoring is performed on monitoring and production wells south of the Femme Osage Slough. This portion of the groundwater monitoring program has been developed with the Missouri Department of Natural Resources and St. Charles County and is designed to document the safety of the well field, as well as detect contamination south of the slough. Analytical parameters include an annual scan for compounds known or suspected to be present in the WSQ and quarterly analyses for uranium, inorganic anions and nitroaromatic compounds.

The surface water monitoring program remains essentially unchanged from 1989. Surface water samples will generally be analyzed for uranium, with select locations analyzed for inorganic anions and/or nitroaromatic compounds. Preoperational monitoring (as required by DOE Order 5400.1) will continue in 1990. Effluent monitoring will continue as detailed in the National Pollutant Discharge Elimination System (NPDES) Permit.

Radon, gamma exposure and air particulate monitoring will be performed at the same locations and frequencies as in 1989.

Meteorological monitoring will be expanded during 1990 to include on-site measurements of hourly windspeed, wind direction, air temperature and precipitation.

The entire scope of routine effluent monitoring and environmental surveillance is detailed in the 1990 Environmental Monitoring Plan (EMP) for the WSS. The EMP discusses rationale, monitoring locations, and analytical methods to be used.

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APPENDIX A
Quarterly Monitoring Data

TABLE A-1 Quarterly Results -- Total Uranium-Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		3.0		
GW-1004		4350		
GW-1005		1750		
GW-1006		2400		
GW-1007		438		
GW-1008		1380		
GW-1009		7.4		
GW-1010		ND		
GW-1012	5.6	4.9	6.0	ND
GW-1013	865	752	776	816.00
GW-1014		907	764	952.00
GW-1015	207	487	154	680
GW-1016	106	98	672	163
GW-1017	ND	ND	ND	ND
GW-1018	ND	ND	ND	
GW-1019	ND	ND	ND	ND
GW-1020	ND	ND	ND	.680
GW-1021	ND	ND	ND	ND
GW-1022	ND	ND	ND	ND
GW-1023	ND	ND	ND	1.36
GW-1024	ND	ND	ND	1.36
GW-1025	2.5	3.8	3.8	4.08
GW-1026	ND	ND		ND
GW-1027	447	823	913	415.0
GW-1028	1.6	1.4	1.5	2.04
GW-2001		1.8		
GW-2002		ND		
GW-2003		3.6		
GW-2004		1.90		
GW-2005		2.4		
GW-2006		ND		
GW-2007		2.4		
GW-2008		ND		
GW-2009		2.9		
GW-2010		1.1		
GW-2011		ND		
GW-2012		1.0		
GW-2013		1.0		
GW-2014		1.0		
GW-2015		2.6		
GW-2017		15		

TABLE A-1 Quarterly Results -- Total Uranium-Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2018		3.1		
GW-2019	2.7	2.6	2.6	0.68
GW-2020		9.0		
GW-2021	2.8	3.0	2.2	ND
GW-2022	2.3	ND	ND	1.36
GW-2023	2.0	2.0	3.0	4.08
GW-2024	ND	2.8	ND	1.36
GW-2025	1.9	1.6	1.7	1.36
GW-2026	1.6	1.6	4.4	2.72
GW-2027	2.6	ND	1.9	0.680
GW-2028	1.5	2.6	11	6.80
GW-2029	1.3	2.8	1.0	2.04
GW-3001	2.6	ND	3.4	ND
GW-3002	2.6	7.8	2.8	2.72
GW-3003	9.8	17	17	9.52
GW-3006	1.2	ND	2.3	2.72
GW-3008		5.9		
GW-3009		48		
GW-3010		2.1		
GW-3019		7.8	5.5	9.52
GW-4001		1.2		
GW-4002		ND		
GW-4003	ND	1.7	ND	ND
GW-4004	4.3	2.0	1.9	272
GW-4005	2.1	1.7	1.0	2.04
GW-4006		ND		
GW-4007	1.4	3.4	1.3	.680
GW-4008	2.8	1.9	ND	4.08
GW-4009	1.4	1.8		3.40
GW-4010		5.4	2.5	4.76
GW-4011	2.5	4.4	2.9	ND
GW-4012	1.3	3.5	2.8	2.04
GW-4013	ND	1.8	1.4	ND
GW-4014	ND	ND	ND	ND
GW-4015	ND	1.6	1.1	1.36
GW-4016	5.1	4.6	5.2	5.44
GW-4017	3.2	2.1	2.7	3.40
GW-4018	ND	1.7	1.3	2.04
GW-4019		1.5		
GW-4020	26	25	28	14.3

TABLE A-1 Quarterly Results -- Total Uranium-Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-4021	11	18	9.7	9.52
GW-4022	2.1	4.2	4.9	ND
GW-4023	2.3	3.2	2.0	ND

TABLE A-2 Quarterly Results -- 2,4-Dinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		ND		
GW-1004		0.56		
GW-1005		ND		
GW-1006		ND		
GW-1007		ND		
GW-1008		ND		
GW-1009		ND		
GW-1010		ND		
GW-1012		0.06		
GW-1013		0.15		
GW-1014		ND		
GW-1015	ND	ND	ND	ND
GW-1016	ND	ND	ND	ND
GW-1017		ND		
GW-1018		ND		
GW-1019		ND		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND		
GW-1024			ND	ND
GW-1025		ND		
GW-1026		ND		
GW-1027		1.14		
GW-1028		ND		
GW-2001		ND		
GW-2002		ND		
GW-2003		0.55		
GW-2004		ND		
GW-2005		0.08		
GW-2006		ND		
GW-2007		ND		
GW-2008		0.13		
GW-2009		ND		
GW-2010		ND		
GW-2011		ND		
GW-2012		ND		
GW-2013		2.47		
GW-2014		ND		
GW-2015		ND		
GW-2017		ND		

TABLE A-2 Quarterly Results -- 2,4-Dinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2018		ND		
GW-2019	ND	ND	ND	
GW-2020		ND		
GW-2021		ND	ND	ND
GW-2022	ND	ND	ND	ND
GW-2023	ND	ND	ND	ND
GW-2024	ND	ND	ND	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND
GW-2027	ND	ND	ND	ND
GW-2028	ND	ND	ND	ND
GW-2029	ND		ND	ND
GW-3001	0.42	0.35	ND	ND
GW-3002	ND	ND	ND	ND
GW-3003	ND	ND	ND	ND
GW-3006	ND	ND	ND	ND
GW-3008		0.06		
GW-3009		0.07		
GW-3010		ND		
GW-3019		ND	ND	ND
GW-4001		0.85		
GW-4002		ND		
GW-4003	ND	ND	ND	ND
GW-4004	ND	ND	ND	ND
GW-4005	ND	ND	ND	ND
GW-4006		0.39		
GW-4007	ND	ND	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	ND	ND		ND
GW-4010	ND	ND	ND	ND
GW-4011	ND	ND	ND	ND
GW-4012	ND	ND	ND	ND
GW-4013	ND	ND	ND	ND
GW-4014	ND	ND	ND	ND
GW-4015	ND	ND	ND	ND
GW-4016		ND	ND	ND
GW-4017	ND	ND	ND	ND
GW-4018	ND	ND	ND	ND
GW-4019		ND		

TABLE A-2 Quarterly Results -- 2,4-Dinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-4020	ND	ND	ND	ND
GW-4021	ND	ND	ND	ND
GW-4022	ND	ND	ND	ND
GW-4023	ND	ND	ND	ND

TABLE A-3 Quarterly Results -- 2,6-Dinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		ND		
GW-1004		2.42		
GW-1005		ND		
GW-1006		3.24		
GW-1007		ND		
GW-1008		ND		
GW-1009		ND		
GW-1010		ND		
GW-1012		ND		
GW-1013		ND		
GW-1014		ND		
GW-1015	ND	ND	ND	ND
GW-1016	ND	ND	ND	ND
GW-1017		ND		
GW-1018		ND		
GW-1019		ND		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND		
GW-1024			ND	ND
GW-1025		ND		
GW-1026		ND		
GW-1027		1.40		
GW-1028		ND		
GW-2001		ND		
GW-2002		0.47		
GW-2003		0.75		
GW-2004		ND		
GW-2005		ND		
GW-2006		1.60		
GW-2007		ND		
GW-2008		ND		
GW-2009		0.19		
GW-2010		0.92		
GW-2011		1.91		
GW-2012		ND		
GW-2013		7.83		
GW-2014		ND		
GW-2015		0.63		
GW-2017		ND		
GW-2018		ND		

TABLE A-3 Quarterly Results -- 2,6-Dinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2019	ND	ND	ND	ND
GW-2020		ND		
GW-2021		ND	ND	ND
GW-2022	ND	ND	ND	ND
GW-2023	ND	ND	ND	ND
GW-2024	ND	ND	ND	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND
GW-2027	ND	ND	ND	
GW-2028	ND	ND	ND	ND
GW-2029	ND		ND	ND
GW-3001	ND	ND	ND	ND
GW-3002	ND	ND	ND	ND
GW-3003	ND	ND	ND	ND
GW-3006	ND	ND	ND	ND
GW-3008		ND		
GW-3009		ND		
GW-3010		ND		
GW-3019		ND	ND	ND
GW-4001		2.68		
GW-4002		ND		
GW-4003	ND	ND	ND	ND
GW-4004	ND	ND	ND	ND
GW-4005	ND	ND	ND	ND
GW-4006		3.50		
GW-4007	ND	ND	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	ND	1.70		ND
GW-4010	ND	ND	ND	ND
GW-4011	ND	ND	ND	ND
GW-4012	ND	ND	ND	ND
GW-4013	ND	1.21	0.68	ND
GW-4014	ND	ND	ND	ND
GW-4015	1.21	2.04	0.83	ND
GW-4016		ND	ND	ND
GW-4017	ND	ND	ND	ND
GW-4018	ND	ND	ND	ND
GW-4019		ND		
GW-4020	ND	ND	ND	ND
GW-4021	ND	ND	ND	ND

TABLE A-3 Quarterly Results -- 2,6-Dinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-4022	ND	ND	ND	ND
GW-4023	ND	ND	ND	ND

TABLE A-4 Quarterly Results -- 2,4,6-Trinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		ND		
GW-1004		5.56		
GW-1005		ND		
GW-1006		ND		
GW-1007		ND		
GW-1008		ND		
GW-1009		ND		
GW-1010		ND		
GW-1012		ND		
GW-1013		ND		
GW-1014		ND		
GW-1015	2.45	4.81	10.50	ND
GW-1016	ND	ND	0.79	ND
GW-1017		ND		
GW-1018		ND		
GW-1019		ND		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND	ND	ND
GW-1025		ND		
GW-1026		ND		
GW-1027		6.23		
GW-1028		ND		
GW-2001		ND		
GW-2002		ND		
GW-2003		ND		
GW-2004		ND		
GW-2005		ND		
GW-2006		ND		
GW-2007		ND		
GW-2008		ND		
GW-2009		ND		
GW-2010		ND		
GW-2011		ND		
GW-2012		ND		
GW-2013		2.29		
GW-2014		ND		
GW-2015		ND		
GW-2017		ND		
GW-2018		ND		
GW-2019	ND	ND	ND	ND

TABLE A-4 Quarterly Results -- 2,4,6-Trinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2020		ND		
GW-2021		ND	ND	ND
GW-2022	ND	ND	ND	ND
GW-2023	ND	ND	ND	ND
GW-2024	ND	ND	ND	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND
GW-2027	ND	ND	ND	ND
GW-2028	ND	ND	ND	ND
GW-2029	ND		ND	ND
GW-3001	ND	ND	ND	ND
GW-3002	ND	ND	ND	ND
GW-3003	ND	ND	ND	ND
GW-3006	ND	ND	ND	ND
GW-3008		ND		
GW-3009		ND		
GW-3010		ND		
GW-3019		ND	ND	ND
GW-4001		1.75		
GW-4002		ND		
GW-4003	ND	ND	ND	ND
GW-4004	ND	ND	ND	ND
GW-4005	ND	ND	ND	ND
GW-4006		ND		
GW-4007	ND	ND	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	ND	7.78		ND
GW-4010	ND	ND	ND	ND
GW-4011	ND	ND	ND	ND
GW-4012	ND	ND	ND	ND
GW-4013	ND	ND	ND	ND
GW-4014	ND	ND	ND	ND
GW-4015	ND	ND	ND	ND
GW-4016		ND	ND	ND
GW-4017	ND	ND	ND	ND
GW-4018	ND	ND	ND	ND
GW-4019		ND		
GW-4020	ND	ND	ND	ND
GW-4021	ND	ND	ND	ND
GW-4022	ND	ND	ND	ND
GW-4023	ND	ND	ND	ND

TABLE A-5 Quarterly Results -- Nitrobenzene Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		ND		
GW-1004		ND		
GW-1005		ND		
GW-1006		0.71		
GW-1007		ND		
GW-1008		ND		
GW-1009		ND		
GW-1010		ND		
GW-1012		ND		
GW-1013		ND		
GW-1014		ND		
GW-1015	ND	ND	ND	ND
GW-1016	ND	ND	ND	ND
GW-1017		ND		
GW-1018		ND		
GW-1019		ND		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND	ND	ND
GW-1025		ND		
GW-1026		ND		
GW-1027		ND		
GW-1028		ND		
GW-2001		ND		
GW-2002		ND		
GW-2003		ND		
GW-2004		ND		
GW-2005		ND		
GW-2006		ND		
GW-2007		ND		
GW-2008		ND		
GW-2009		ND		
GW-2010		ND		
GW-2011		ND		
GW-2012		ND		
GW-2013		ND		
GW-2014		ND		
GW-2015		ND		
GW-2017		ND		
GW-2018		ND		
GW-2019	ND	ND	ND	ND
GW-2020		ND		

TABLE A-5 Quarterly Results -- Nitrobenzene Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2021		ND	ND	ND
GW-2022	6.00	ND	ND	ND
GW-2023	ND	ND	ND	ND
GW-2024	ND	ND	ND	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND
GW-2027	ND	ND	ND	ND
GW-2028	1.22	ND	ND	ND
GW-2029	ND		ND	ND
GW-3001	ND	ND	ND	ND
GW-3002	ND	ND	ND	ND
GW-3003	ND	ND	ND	ND
GW-3006	ND	ND	ND	ND
GW-3008		ND		
GW-3009		ND		
GW-3010		ND		
GW-3019		ND	ND	ND
GW-4001		6.08		
GW-4002		ND		
GW-4003	ND	ND	ND	ND
GW-4004	ND	ND	ND	ND
GW-4005	ND	ND	ND	ND
GW-4006		3.34		
GW-4007	ND	ND	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	ND	ND		ND
GW-4010	ND	ND	ND	ND
GW-4011	ND	ND	ND	ND
GW-4012	ND	ND	ND	ND
GW-4013	ND	ND	ND	ND
GW-4014	ND	ND	ND	ND
GW-4015	ND	0.42	ND	ND
GW-4016		ND	ND	ND
GW-4017	ND	ND	ND	ND
GW-4018	ND	ND	ND	ND
GW-4019		ND		
GW-4020	ND	ND	ND	ND
GW-4021	ND	ND	ND	ND
GW-4022	ND	ND	ND	ND
GW-4023	ND	ND	ND	ND

TABLE A-6 Quarterly Results -- 1,3-Dinitrobenzene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		ND		
GW-1004		ND		
GW-1005		ND		
GW-1006		ND		
GW-1007		ND		
GW-1008		ND		
GW-1009		ND		
GW-1010		ND		
GW-1012		ND		
GW-1013		ND		
GW-1014		ND		
GW-1015	ND	ND	ND	ND
GW-1016	ND	0.24	ND	
GW-1017		ND		
GW-1018		ND		
GW-1019		ND		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND	ND	ND
GW-1025		ND		
GW-1026		ND		
GW-1027		ND		
GW-1028		ND		
GW-2001		ND		
GW-2002		ND		
GW-2003		ND		
GW-2004		ND		
GW-2005		ND		
GW-2006		ND		
GW-2007		ND		
GW-2008		0.58		
GW-2009		ND		
GW-2010		ND		
GW-2011		ND		
GW-2012		ND		
GW-2013		ND		
GW-2014		ND		
GW-2015		ND		
GW-2017		ND		
GW-2018		ND		
GW-2019	ND	ND	ND	ND

TABLE A-6 Quarterly Results -- 1,3-Dinitrobenzene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2020		ND		
GW-2021		ND	ND	ND
GW-2022	ND	ND	ND	ND
GW-2023	ND	ND	ND	ND
GW-2024	ND	ND	ND	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND
GW-2027	ND	ND	ND	ND
GW-2028	ND	ND	ND	ND
GW-2029	ND		ND	ND
GW-3001	ND	ND	ND	ND
GW-3002	ND	ND	ND	ND
GW-3003	ND	ND	ND	ND
GW-3006	ND	ND	ND	ND
GW-3008		ND		
GW-3009		ND		
GW-3010		ND		
GW-3019		ND	ND	ND
GW-4001		2.31		
GW-4002		ND		
GW-4003	ND	ND	ND	ND
GW-4004	ND	ND	ND	ND
GW-4005	ND	ND	ND	ND
GW-4006		1.93		
GW-4007	ND	ND	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	ND	ND		ND
GW-4010	ND	ND	ND	ND
GW-4011	ND	ND	ND	ND
GW-4012	ND	ND	ND	ND
GW-4013	ND	0.80	ND	ND
GW-4014	ND	ND	ND	ND
GW-4015	ND	ND	ND	ND
GW-4016		ND	ND	ND
GW-4017	ND	ND	ND	ND
GW-4018	ND	ND	ND	ND
GW-4019		ND		
GW-4020	ND	ND	ND	ND
GW-4021	ND	ND	ND	ND
GW-4022	ND	ND	ND	ND
GW-4023	ND	ND	ND	ND

TABLE A-7 Quarterly Results -- 1,3,5-Trinitrobenzene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		ND		
GW-1004		0.86		
GW-1005		0.04		
GW-1006		ND		
GW-1007		ND		
GW-1008		ND		
GW-1009		ND		
GW-1010		0.02		
GW-1012		ND		
GW-1013		ND		
GW-1014		ND		
GW-1015	11.82	38.42	72.94	ND
GW-1016	0.18	ND	5.46	ND
GW-1017		ND		
GW-1018		ND		
GW-1019		0.06		
GW-1020		0.52		
GW-1021		ND		
GW-1022		ND	ND	ND
GW-1025		ND		
GW-1026		0.04		
GW-1027		0.17		
GW-1028		ND		
GW-2001		ND		
GW-2002		0.03		
GW-2003		ND		
GW-2004		ND		
GW-2005		ND		
GW-2006		9.62		
GW-2007		ND		
GW-2008		ND		
GW-2009		ND		
GW-2010		ND		
GW-2011		0.55		
GW-2012		ND		
GW-2013		5.48		
GW-2014		ND		
GW-2015		0.21		
GW-2017		ND		
GW-2018		ND		
GW-2019	ND	0.06	0.07	ND

TABLE A-7 Quarterly Results -- 1,3,5-Trinitrobenzene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2020		ND		
GW-2021		ND	ND	ND
GW-2022	ND	0.03	ND	ND
GW-2023	ND	ND	ND	ND
GW-2024	ND	0.03	0.07	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND
GW-2027	ND	ND	ND	ND
GW-2028	ND	ND	ND	ND
GW-2029	ND		ND	ND
GW-3001	0.17	0.04	0.09	ND
GW-3002	ND	ND	ND	ND
GW-3003	ND	ND	ND	ND
GW-3006	ND	ND	ND	ND
GW-3008		ND		
GW-3009		0.06		
GW-3010		ND		
GW-3019		0.04	ND	ND
GW-4001		47.06		
GW-4002		0.02		
GW-4003	ND	ND	ND	ND
GW-4004	ND	ND	ND	ND
GW-4005	ND	0.02	0.18	ND
GW-4006		17.33		
GW-4007	ND	0.02	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	ND	16.52		ND
GW-4010	ND	ND	ND	ND
GW-4011	ND	ND	ND	ND
GW-4012	ND	ND	ND	ND
GW-4013	ND	44.80	32.81	89.0
GW-4014	ND	0.27	0.41	ND
GW-4015	0.10	0.12	0.13	ND
GW-4016		ND	ND	ND
GW-4017	ND	0.05	ND	ND
GW-4018	ND	ND	0.13	ND
GW-4019		ND		
GW-4020	ND	ND	ND	ND
GW-4021	ND	0.015	ND	ND
GW-4022	ND	ND	ND	ND
GW-4023	ND	ND	0.30	ND

TABLE A-8 Quarterly Results -- Nitrate Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		16.30		
GW-1004		1.90		
GW-1005		ND		
GW-1006		9.30		
GW-1007		0.20		
GW-1008		2.40		
GW-1009		ND		
GW-1010		ND		
GW-1012		8.10		
GW-1013	ND	ND	ND	ND
GW-1014	ND	1.30	ND	ND
GW-1015		9.80		
GW-1016		2.40		
GW-1017		0.40		
GW-1018		ND		
GW-1019		2.40		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND		
GW-1023		ND	ND	ND
GW-1025		0.50		
GW-1026		ND		
GW-1027		1.00		
GW-1028		ND		
GW-2001		50.20		
GW-2002		1010.00		
GW-2003		3330.00		
GW-2004		3.80		
GW-2005		117.00		
GW-2006	29.4	28.70		
GW-2007		ND		
GW-2008		16.00		
GW-2009		6.30		
GW-2010		4.30		
GW-2011		0.80		
GW-2012		4.00		
GW-2013		3.20		
GW-2014		9.00		
GW-2015		1.80		
GW-2017		1.50		
GW-2018		2.30		
GW-2019	ND	ND	ND	ND

TABLE A-8 Quarterly Results -- Nitrate Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2020		3.70		
GW-2021	ND	ND	ND	ND
GW-2022	ND	ND	ND	ND
GW-2023	0.20	0.20	0.40	ND
GW-2024	ND	ND	ND	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	0.5
GW-2027	0.20	0.53	0.20	ND
GW-2028	ND	ND	ND	ND
GW-2029	ND	0.11	ND	ND
GW-3001	1050.00	935.00	893	296.0*
GW-3002	0.20	ND	0.18	ND
GW-3003	2050.00	2175.00	1885	312,000.0a
GW-3006	ND	1.30	4.00	188.0
GW-3008		4010.00		
GW-3009		294.00		
GW-3010		5.50		
GW-3019		0.59	0.20	ND
GW-4001		149.00		
GW-4002		9.00		
GW-4003	3.30	3.20	3.10	2100.0**
GW-4004	1.70	1.90	2.30	.50
GW-4005	6.30	6.50	6.20	1.47*
GW-4006		21.90		
GW-4007	ND	ND	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	0.60	0.40		39*
GW-4010	0.30	1.00	0.29	0.09
GW-4011	95.10	101.00	133.00	21.0*
GW-4012	ND	0.33	0.55	ND
GW-4013	657.00	522.00	456	361.0
GW-4014	9.40	7.90	13.10	127.0
GW-4015	5.40	22.40	6.00	1.3
GW-4016	ND	ND	ND	ND
GW-4017	2.30	2.00	2.60	0.47*
GW-4018	8.20	8.20	9.70	1.3
GW-4019		0.84		

TABLE A-8 Quarterly Results -- Nitrate Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-4020	5.50	0.18	ND	ND
GW-4021	ND	ND	ND	ND
GW-4022	3.00	2.00	1.80	0.09*
GW-4023	25.70	23.30	28.90	10.2*

* Value is suspect since analytical holding time was exceeded.

a Documented laboratory error responsible for erroneously high result. Not entered into Annual Average.

** Value inconsitent with all previous historical data; holding time exceeded. Laboratory error suspected. Value not entered into annual average.

TABLE A-9 Quarterly Results -- Sulfate Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		79.30		
GW-1004		1000.00		
GW-1005		598.00		
GW-1006		441.00		
GW-1007		184.00		
GW-1008		292.00		
GW-1009		240.00		
GW-1010		ND		
GW-1012		81.20		
GW-1013	136.00	130	124.00	112
GW-1014	131.50	126.00	125.00	120
GW-1015		219.00		
GW-1016		160.00		
GW-1017		ND		
GW-1018		49.40		
GW-1019		ND		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND		
GW-1023		6.80	3.2	5.2
GW-1025		131.90		
GW-1026		ND		
GW-1027		82.80		
GW-1028		63.80		
GW-2001		5.80		
GW-2002		95.00		
GW-2003		288.00		
GW-2004		1.90		
GW-2005		3.40		
GW-2006		32.40		
GW-2007		14.10		
GW-2008		39.50		
GW-2009		99.20		
GW-2010		42.80		
GW-2011		37.30		
GW-2012		415.00		
GW-2013		11.90		
GW-2014		34.80		
GW-2015		96.40		
GW-2017		1830.00		
GW-2018		9.50		
GW-2019	18.70	21.30	17.9	22.6

TABLE A-9 -- Quarterly Results -- Sulfate Weldon Spring Site (Continued)

	Q189	Q289	Q389	Q489
GW-2020		144.00		
GW-2021	13.50	13.40	12.80	12.0
GW-2022	16.20	13.40	12.50	13.8
GW-2023	55.40	25.90	25.20	22.1
GW-2024	35.80	34.80	32.50	23.2
GW-2025	18.70	16.70	16.10	16.1
GW-2026	13.60	13.70	13.00	11.9
GW-2027	12.40	14.90	10.50	
GW-2028	112.00	95.70	108	113.0
GW-2029	27.10		16.60	26.2
GW-3001	23.30	28.0	20.50	20.4
GW-3002	19.50	19.4	19.0	19.3
GW-3003	190.00	191.00	153.00	173.0
GW-3006	45.00	80.40	71.10	43.2
GW-3008		43.60		
GW-3009		58.00		
GW-3010		7.60		
GW-3019		10.30	6.60	5.2
GW-4001		64.10		
GW-4002		25.20		
GW-4003	29.90	28.50	32.00	27.6
GW-4004	35.20	28.10	30.40	29
GW-4005	18.80	16.10	19.20	22
GW-4006		32.90		
GW-4007	14.80	13.90	13.00	9.9
GW-4008	14.30	16.90	15.00	12.2
GW-4009	29.60	16.10		39
GW-4010	24.10	42.70	25.80	26.2
GW-4011	51.40	49.70	52.40	45.8
GW-4012	50.70	47.90	45.80	39.9
GW-4013	61.30	54.90	51.00	43.2
GW-4014	24.90	29.00	26.40	21.5
GW-4015	4.80	11.50	6.00	ND
GW-4016	19.70	32.90	20.80	11.6
GW-4017	7.70	10.20	5.10	7.2
GW-4018	11.60	13.70	8.20	11.9
GW-4019		8.90		
GW-4020	127.50	136.00	148.00	121.0
GW-4021	282.00	308.00	315.00	343.0
GW-4022	67.90	70.90	43.20	43.5
GW-4023	82.40	285.00	94.50	88.5

TABLE A-10 1989 Quarterly NPDES Results for Outfall NP-0001

DATE	pH	TOTAL URANIUM pCi/l	GROSS ALPHA pCi/l	NITRATE mg/l	LITHIUM mg/l	SETTL. SOLIDS ml/l	SUSP. SOLIDS mg/l	FLOW GPD
JAN. 5	6.77	120 +/- 10	80 +/- 9	2.20	ND	<0.1	84	70000
APR. 4	7.18	500 +/- 50	290 +/- 30	4.10	ND	<0.1	7	14400
JUL. 21	7.60	590 +/- 60	470 +/- 50	5.90	ND	<0.1	4	28800
OCT. 6	7.25	260 +/- 30	190 +/- 20	3.60	ND	<0.1	2	57600
MINIMUM	6.77	120	80	2.20	ND	<0.1	2	14400
MAXIMUM	7.60	590	470	5.90	ND	<0.1	84	70000
AVERAGE	7.20	368	258	3.95	ND	<0.1	24	42700

TABLE A-11 1989 MONTHLY NPDES RESULTS FOR OUTFALL NP-0002

DATE	pH	TOTAL URANIUM pCi/l	GROSS ALPHA pCi/l	NITRATE mg/l	LITHIUM mg/l	SETTL. SOLIDS ml/l	SUSP. SOLIDS mg/l	FLOW GPD
JAN. 5	6.51	26 +/- 2	16 +/- 5	3.80	ND	<0.1	320	720000
FEB. 3	6.45	220 +/- 30	140 +/- 21	1.40	ND	<0.1	55	50093
MAR. 9	6.13	400 +/- 40	95 +/- 10	2.30	ND	<0.1	35	61920
APR. 4	7.13	97 +/- 10	57 +/- 8	3.20	ND	<0.1	54	626832
MAY 9	7.23	110 +/- 20	54 +/- 6	1.80	ND	<0.1	6	123840
JUN. 19	7.19	86 +/- 9	49 +/- 8	0.82	ND	<0.1	25	52704
JUL. 20	6.85	200 +/- 20	150 +/- 20	2.20	ND	<0.1	12	131789
AUG. 22	6.90	150 +/- 20	86 +/- 13	ND	ND	<0.1	34	35107
AUG. 24	6.26	91 +/- 10	66 +/- 11	1.40	ND	<0.1	53	385444
SEP. 1	6.93	110 +/- 20	87 +/- 13	0.53	ND	<0.1	46	161665
OCT. 6	7.17	100 +/- 10	65 +/- 9	1.20	ND	<0.1	3	5299
NOV. (NO FLOW)								0
DEC. (NO SAMPLE)								
MINIMUM	6.13	26	16	ND	ND	<0.1	3	5299
MAXIMUM	7.23	400	150	3.80	ND	<0.1	320	720000
AVERAGE	6.80	145	79	1.87*	ND	<0.1	58	214063

TABLE A-12 1989 Monthly NPDES Results for Outfall NP-0003

MONTH	pH	TOTAL URANIUM pCi/l	GROSS ALPHA pCi/l	NITRATE mg/l	LITHIUM mg/l	SETTL. SOLIDS ml/l	SUSP. SOLIDS mg/l	FLOW GPD
JAN. 5	6.80	200 +/- 20	280 +/- 55	4.90	0.061	8.0	7018	927360
FEB. 3	6.24	1000 +/- 100	620 +/- 60	75.60	ND	<0.1	66	30617
MAR. 9	6.21	370 +/- 40	240 +/- 30	98.80	ND	<0.1	20	50256
APR. 4	6.99	750 +/- 80	460 +/- 50	12.80	ND	<0.1	6	246384
MAY 9	7.44	140 +/- 20	67 +/- 8	0.85	ND	<0.1	13	19728
JUN. 19	7.25	250 +/- 30	71 +/- 9	0.20	ND	<0.1	12	6062
(Dup.)	7.25	200 +/- 20	89 +/- 10	0.21	ND	<0.1	16	
JUL. 21	6.86	240 +/- 30	230 +/- 30	1.40	ND	<0.1	6	82901
AUG. 24	6.94	16 +/- 2	9 +/- 5	0.43	ND	<0.1	178	94882
SEP. 1	7.04	86 +/- 9	85 +/- 12	0.82	ND	<0.1	46	22094
(Dup.)	7.04	87 +/- 9	75 +/- 12	0.83	ND	<0.1	63	
OCT. 6	7.09	150 +/- 20	74 +/- 13	0.50	ND	<0.1	11	14530
NOV. 15	7.06	326 #	270 +/- 50	ND	ND	<0.1	ND	5443
DEC. 29	6.92	109 #	120 +/- 10	ND	ND	<0.1	4	10181
MINIMUM	6.21	16	9	ND	ND	<0.1	4	5443
MAXIMUM	7.44	1000	620	19.80	0.061	8.0	7018	927360
AVERAGE	6.94	280	192	16.45*	ND**	<0.1**	574*	125870

TABLE A-13 1989 Quarterly NPDES Results for Outfall NP-0004

DATE	pH	TOTAL URANIUM pCi/l	GROSS ALPHA pCi/l	NITRATE mg/l	LITHIUM mg/l	SETTL. SOLIDS ml/l	SUSP. SOLIDS mg/l	FLOW GPD
JAN. 11	6.82	6.8 +/- 1.7	ND	5.00	ND	<0.1	2	1000
APR. 13	6.78	9.7 +/- 1.6	3.9 +/- 2.7	2.40	ND	<0.1	4	1400
AUG. 22	7.09	3.0 +/- 0.9	ND	ND	ND	<0.1	21	1000
4th QTR. (NO FLOW)								0
MINIMUM	6.78	3.0	3.9	ND	ND	<0.1	2	0
MAXIMUM	7.09	9.7	3.9	5.00	ND	<0.1	21	1400
AVERAGE	6.90	6.5	3.9	3.70*	ND	<0.1	9	850

* = Averages do not include ND (not detected) values.

TABLE A-14 1989 Monthly NPDES Results for Outfall NP-0005

DATE	pH	TOTAL URANIUM pCi/l	GROSS ALPHA pCi/l	NITRATE mg/l	LITHIUM mg/l	SETTL. SOLIDS ml/l	SUSP. SOLIDS mg/l	FLOW GPD
JAN. 5	6.99	95 +/- 10	70 +/- 8	17.80	ND	<0.1	51	400320
FEB. 3	6.37	540 +/- 50	420 +/- 40	48.00	ND	<0.1	25	5229
MAR. 9	6.37	400 +/- 40	240 +/- 30	117.00	ND	<0.1	8	22020
APR. 4	7.23	440 +/- 50	310 +/- 40	30.70	ND	<0.1	56	47376
MAY 9	7.31	490 +/- 50	240 +/- 30	61.00	ND	<0.1	9	14688
(Dup.)	7.31	380 +/- 40	240 +/- 30	61.4	ND	<0.1	12	
JUN. 19	7.33	470 +/- 50	210 +/- 30	13.80	ND	<0.1	18	7200
JUL. 21	7.11	570 +/- 60	580 +/- 60	1.40	ND	<0.1	6	15379
AUG. 24	6.46	150 +/- 20	140 +/- 20	1.00	ND	<0.1	23	32602
SEP. 1	7.08	180 +/- 20	200 +/- 20	1.20	ND	<0.1	ND	27643
OCT. 6	7.17	100 +/- 10	65 +/- 9	1.20	ND	<0.1	3	5299
NOV. (NO FLOW)								0
DEC. (NO SAMPLE)								
MINIMUM	6.37	95	65	1.00	ND	<0.1	ND	0
MAXIMUM	7.33	570	580	117.00	ND	<0.1	56	400320
AVERAGE	6.98	347	247	32.23	ND	<0.1	21*	52523

TABLE A-15 1989 Quarterly NPDES Results for Outfall NP-0006

DATE	pH	SUSP. SOLIDS mg/l	FECAL COLIFORMS #/100ml	BOD mg/l	FLOW GPD
MAR. 1	7.80	2	<1	<6.0	2800
JUN. 14	7.20	5	<1	<6.0	6912
AUG. 1	7.20	5	<2	<3.0	2045
MINIMUM	7.20	2			2045
MAXIMUM	7.80	5			6912
AVERAGE	7.40	4			3919

TABLE A-16 Quarterly Uranium Activities for Surface Water at the Weldon Spring Quarry (pCi/L)

Location Number	Q1	Q2	Q3	Q4
SW-1001	ND	--	ND	2.0
SW-1002	ND	ND	ND	2.0
SW-1003	26	252	24	42
SW-1004	40	557	38	40
SW-1005	49	90	21	21
SW-1006	ND			ND
SW-1007	21	16	--	--
SW-1008	1600	2400	1200	2108
SW-1009	15	28	12	17
SW-1010	31	39	59	45
SW-1011	6.3	4.5	3.5	2.0
SW-1012	2.4	--	4.0	2.7
SW-1013	2.0	2.8	4.1	4.1

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (e.g. dry).

TABLE A-17 Quarterly Sulfate Concentrations for Surface Water at the Weldon Spring Quarry (mg/L)

Location Number	Q1	Q2	Q3	Q4
SW-1001		--		
SW-1002		37.9		
SW-1003		125.7		
SW-1004		141.3		
SW-1005		91.3		
SW-1006				
SW-1007		89.7		
SW-1008	132	142	121	167
SW-1009		95.5		
SW-1010		101.2		
SW-1011		88.8	171	147
SW-1012		--	170	151
SW-1013	126	37.2	171	124

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (e.g. dry).

TABLE A-18 Quarterly Nitrate Concentrations for Surface Water at the Weldon Spring Quarry (mg/L)

Location Number	Q1	Q2	Q3	Q4
SW-1001		--		
SW-1002		0.8		
SW-1003		ND		
SW-1004		ND		
SW-1005		ND		
SW-1006				
SW-1007		ND		
SW-1008	0.2	ND	0.37	0.64
SW-1009		ND		
SW-1010		ND		
SW-1011		4.2	2.2	1.0
SW-1012		--	2.3	0.72
SW-1013	0.43	0.8	2.3	0.69

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (e.g. dry).

TABLE A-19 Quarterly Chloride Concentrations for Surface Water at the Weldon Spring Quarry (mg/L)

Location Number	Q1	Q2	Q3	Q4
SW-1001		--		
SW-1002		5.7		
SW-1003		9.8		
SW-1004		11.5		
SW-1005		12.2		
SW-1006				
SW-1007		7.3		
SW-1008	12.1	13.2	11.6	17.6
SW-1009		7.3		
SW-1010		4.4		
SW-1011		14	20.9	35.0
SW-1012		--	20.7	37.5
SW-1013	24.5	8.8	20.7	37.5

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (e.g. dry).

TABLE A-20 Quarterly Fluoride Concentrations for Surface Water at the Weldon Spring Quarry (mg/L)

Location Number	Q1	Q2	Q3	Q4
SW-1001		--		
SW-1002		ND		
SW-1003		ND		
SW-1004		ND		
SW-1005		ND		
SW-1006				
SW-1007		ND		
SW-1008	0.6	0.54	0.61	0.99
SW-1009		ND		
SW-1010		ND		
SW-1011		ND	ND	0.49
SW-1012		--	ND	0.53
SW-1013	0.3	ND	ND	0.55

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (e.g. dry).

TABLE A-21 Quarterly Uranium Activities for Surface Water at the Weldon Spring CP/RP Area (pCi/L)

Location Number	Q1	Q2	Q3	Q4
SW-2001	160	3.2	2.0	1.4
SW-2002	110	65	6.4	--
SW-2003	20	10	12	--
SW-2004	39	22	15	23
SW-2005	24	20	5.4	8.8
SW-2006	4.4	ND	ND	1.4
SW-2007	ND	ND	ND	ND
SW-2008		90	100	82
SW-2009	--	--	--	--
SW-2010	3200	719	--	--
SW-2011	280	320	150	28

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (dry).

TABLE A-22 Quarterly Sulfate Concentrations for Surface Water at the Weldon Spring CP/RP Area (mg/l)

Location Number	Q1	Q2	Q3	Q4
SW-2001		8.5		
SW-2002		50.6		
SW-2003		15.6		
SW-2004		19.6		
SW-2005		23.6		
SW-2006		9.7		
SW-2007		28.6		
SW-2008		36.4		
SW-2009	--	--	--	--
SW-2010	52	23.1	--	--
SW-2011	50.4	55.2	44.9	52.5

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (dry).

TABLE A-23 Quarterly Nitrate Concentrations for Surface Water at the Weldon Spring CP/RP Area (mg/l)

Location Number	Q1	Q2	Q3	Q4
SW-2001		6.9		
SW-2002		nd		
SW-2003		0.8		
SW-2004		4.2		
SW-2005		1.5		
SW-2006		ND		
SW-2007		2.9		
SW-2008		42.2		
SW-2009	--	--	--	--
SW-2010	3.8	ND	--	--
SW-2011	ND	ND	ND	0.6

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (dry).

TABLE A-24 Quarterly Chloride Concentrations for Surface Water at the Weldon Spring CP/RP Area (mg/l)

Location Number	Q1	Q2	Q3	Q4
SW-2001		1.9		
SW-2002		77.5		
SW-2003		13.9		
SW-2004		13.3		
SW-2005		72.5		
SW-2006		13.1		
SW-2007		14		
SW-2008		11.9		
SW-2009	--	--	--	--
SW-2010	7.6	2.6	--	--
SW-2011	122	368	297	165

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (dry).

TABLE A-25 Quarterly Fluoride Concentrations for Surface Water at the Weldon Spring CP/RP Area (mg/l)

Location Number	Q1	Q2	Q3	Q4
SW-2001		ND		
SW-2002		ND		
SW-2003		ND		
SW-2004		ND		
SW-2005		ND		
SW-2006		ND		
SW-2007		ND		
SW-2008		ND		
SW-2009	--	--	--	--
SW-2010	0.5	0.3	--	--
SW-2011	ND	ND	ND	ND

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (dry).

APPENDIX B
Glossary of Technical Terms

APPENDIX B

GLOSSARY OF TECHNICAL TERMS

ABSORBED DOSE: The amount of energy absorbed in any material from incident radiation. Measured in rads, where 1 rad equals 100 ergs of energy absorbed in 1 gram of matter.

ACTIVITY: A measure of the rate at which radioactive material is undergoing radioactive decay; usually given in terms of the number of nuclear disintegrations occurring in a given quantity of material over a unit of time. The unit of activity is the Curie (Ci) (see also Bequerel and Curie).

ALARA: An acronym for "As Low as Reasonably Achievable." This refers to the U.S. Department of Energy goal of keeping releases of radioactive substances to the environment and exposures of humans to radiation as far below regulatory limits as "reasonably achievable."

ALLUVIAL AQUIFER: A subsurface zone, formed by the deposition of sediments by running water, capable of yielding usable quantities of groundwater to wells.

ALPHA PARTICLE: A positively charged particle emitted from the nucleus during the radioactive decay of certain radionuclides. It consists of two protons and two neutrons bound together; it is identical to the nucleus of a helium-4 atom.

BACKGROUND RADIATION: Radiation due to cosmic rays and radiation from the naturally radioactive elements in the surface of earth.

BEDROCK: A rock formation usually underlying one or more unconsolidated formations.

BEQUEREL: SI unit for activity. 1 bequerel (Bq) = 1 disintegration/second = 2.703×10^{-11} Ci (curie).

BETA PARTICLE: Charged particle emitted from the nucleus of an atom, with a mass and charge equal in magnitude to that of the electron.

CHAIN OF CUSTODY: Standardized form tracing the possession and handling of individual samples from the time of field collection through laboratory analysis.

COMMITTED DOSE EQUIVALENT: The total dose equivalent averaged throughout a tissue in the 50 years after intake of a radionuclide into the body.

CONTAMINATION: A foreign substance in or on the surfaces of soils, structures, areas, objects, or personnel.

COUNTING STATISTICS: Statistical analysis required to process the results of nuclear counting experiments and to make predictions about the expected precision of quantities derived from these measurements.

CURIE: A measure of the rate of radioactive decay. One Curie (Ci) is equal to 37 billion disintegrations per second (3.7×10^{10} dps), which is equal to the decay rate of one gram of radium-226.

DAUGHTER: An element that results immediately from the disintegration of a radioactive element.

DECAY PRODUCTS: Isotopes that are formed by the radioactive decay of some other isotope. In the case of radium-226, for example, there are 10 successive decay products, ending in the stable isotope Lead-206.

DERIVED CONCENTRATION GUIDE (DCG): Concentrations of radionuclides in water and air that could be continuously consumed or inhaled and not exceed an effective dose equivalent of 100 mrem/year.

DISCHARGE: In groundwater hydrology, the rate of flow (usually from a well or spring) at a given instant in terms of volume per unit of time.

DOSE: Total radiation delivered to a specific part of the body, or to the body as a whole; also called dose equivalent.

DOSE RATE: Dose or dose equivalent per unit of time (i.e., millirem per year) as it is being delivered to the body.

DOSIMETER: A device used in measuring radiation dose, such as a lithium fluoride (LiF) thermoluminescent detector (TLD).

EFFECTIVE DOSE EQUIVALENT: The proportion of the stochastic risk resulting from irradiation of a tissue to the total risk when the whole body is irradiated uniformly. A term used to express the amount of effective radiation when modifying factors have been considered, it is the product of absorbed dose (rads) multiplied by a quality factor and any other modifying factors. It is measured in rem (Roentgen Equivalent Man).

ERG: 1 ERG = 2.8×10^{-14} KWH

EXPOSURE PATHWAY: The route by which a contaminant/health hazard may enter and move through the environment or individual.

EXPOSURE RADIATION: The amount of ionization produced in air by X-rays or gamma rays, measured in Roentgens (R).

GAMMA RADIATION: Penetrating high energy, short wave-length, electromagnetic radiation (similar to x-rays) emitted during radioactive decay. Gamma rays are very penetrating and can be attenuated only by dense materials such as lead.

GROSS ALPHA: Measurement of all alpha-emitting radionuclides in a sample.

GROSS BETA: Measurement of all beta-emitting radionuclides in a sample. Gross alpha and beta are useful analyses for screening to determine whether further analyses for specific radionuclides are merited.

HALF LIFE: The time it takes for half the atoms of a quantity of a particular radioactive element to decay into another form. Half-lives of different isotopes vary from millionths of a second or less to billions of years.

HECTARE: A unit of area in the metric system equal to approximately 2.5 acres. It is 10,000 square meters.

HYDROLOGIC: Pertaining to study of the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

ISOTOPE: Nuclides having the same atomic number but different mass numbers.

NATURAL URANIUM: A naturally occurring radioactive element that consists of 99.2830% by weight uranium-238, 0.7110% uranium-235 and 0.0054% uranium-234.

NUCLIDE: A general term referring to isotopes, both stable (279) and unstable (about 500), of the chemical elements.

PERCHED LENSES: A small, localized water-saturated zone of subsurface material surrounded by unsaturated material.

RAD: Unit of absorbed dose; acronym for radiation absorbed dose.

RADIATION: A very general term that covers many forms of particles and energy, from sunlight and radiowaves to the energy that is released from inside an atom. Radiation can be in the form of electromagnetic waves (gamma rays, x-rays) or particles (alpha particles, beta particles, protons, neutrons).

RADIONUCLIDE: An unstable nuclide that undergoes radioactive decay.

RAFFINATE: A waste product from a refining process, i.e., that portion of a treated liquid mixture that is not dissolved and not removed by a selective solvent.

REM (Roentgen Equivalent Man): A quantity used in radiation protection to express the effective dose equivalent for all forms of ionizing radiation. A rem is the product of the absorbed dose in rads and factors related to relative biological effectiveness.

SI: International System of Units.

SIEVERT: SI unit used to express the effective dose equivalent for all forms of ionizing radiation. 1 Sv = 100 rem

STOCHASTIC: "Stochastic" effects are those for which the probability of an effect occurring, rather then its severity, is regarded as a function of dose, without a threshold.

WORKING LEVEL: Any combination of radon-222 decay products in 1 liter of air that will result in the ultimate emission of 0.21 erg of alpha energy is defined as 1 WL. It is based on the 0.21 erg of alpha energy that would be emitted by the decay products of 100 pCi of radon-222 in 1 liter of air, where the decay products are in radioactive equilibrium with the parent.

WORKING LEVEL MONTH: The product of WL and duration of exposure, normalized to a 1-month exposure period.

X-RAYS: Penetrating electromagnetic radiation having a wave length that is much shorter than that of visible light. It is customary to refer to rays originating in the nucleus as gamma rays and to those originating in the electron field of the atom as x-rays.

APPENDIX C
Acronyms and Abbreviations

APPENDIX C

ACRONYMS AND ABBREVIATIONS

AABMWA	August A. Busch Memorial Wildlife Area
ACM	Asbestos Containing Material
AEC	Atomic Energy Commission
ANL	Argonne National Laboratory
BNI	Bechtel National Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
DA	Department of the Army
DCG	Derived Concentration Guides
DI	Deionized Water
DNT	Dinitrotoluene
DOC	Department of Conservation
DOE	U.S. Department of Energy
EMPP	Environmental Monitoring Program Plan
EMR	Environmental Monitoring Report
EPA	Environmental Protection Agency
FCCA	Federal Facilities Compliance Agreement
FIDLER	Field Instrument for the Detection of Low Energy Radiation
HSL	Hazardous Substance List
ICRP	International Commission on Radiation Protection
LCS	Laboratory Control Samples
MDNR	Missouri Department of Natural Resources
MSHD	Missouri State Highway Department
NCRP	National Council on Radiation Protection
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIOSH	National Institute for Occupational Safety & Health
NLO	National Lead of Ohio
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NVLAP	National Voluntary Laboratory Accreditation Program
ORNL	Oak Ridge National Laboratory
ORAU	Oak Ridge Associated Universities
OSHA	Occupational Safety & Health Administration
PCB	Polychlorinated Biphenyl
PCM	Phase Contrast Microscopy
PE	Performance Evaluation
PIC	Pressurized Ionization Chamber
PMC	Project Management Contractor
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act

ACRONYMS AND ABBREVIATIONS (Continued)

RPD	Relative Percent Difference
SARA	Superfund Amendments and Reauthorization Act
SFMP	Surplus Facilities Management Program
SWMU	Solids Waste Management Unit
TBP	Tributyl Phosphate
TEM	Transmission Electron Microscopy
TLD	Thermoluminescent Dosimeter
TNT	Trinitrotoluene
TSCA	Toxic Substance Control Act
TSD	Treatment Storage or Disposal Facility
TWA	Time-Weighted Average
UNC	United Nuclear Corporation
USDA	United States Department of Agriculture
WSCP	Weldon Spring Chemical Plant
WSOW	Weldon Spring Ordnance Works
WSQ	Weldon Spring Quarry
WSRP	Weldon Spring Raffinate Pits
WSS	Weldon Spring Site
WSSRAP	Weldon Spring Site Remedial Action ProjectWSTA
Weldon Spring Training Area	
WSUFMP	Weldon Spring Uranium Feed Materials Plant
WSVP	Weldon Spring Vicinity Property

APPENDIX D
Quality Assurance

APPENDIX D
QUALITY ASSURANCE

The quality assurance (QA) program implemented in 1989 was greatly expanded from the previous year's program. In addition to increasing the number of field quality control blanks and duplicates collected, a data verification program was initiated to ensure that samples were preserved, shipped, maintained and analyzed in accordance with established procedures. The scope of this QA program includes all routine environmental and radiological characterization activities. The QA program is composed of two components: field and analytical QA evaluations.

The QA program for field activities included the following:

- Preparation of site-specific sampling plans and sampling procedures for collection of all environmental samples.

- Proper documentation of sample collection including sample collection forms, field logbooks, chain-of-custody records and quarterly summary sheets.

- Review of all sample tracking documentation and analytical results in accordance with the Environmental Monitoring Data Verification SOP 4.9.1.

- Collection of quality control (QC) blanks, trip blanks, and equipment blanks for characterization sampling.

- Annual audit of all field procedures with follow-up corrective programs, if required.

The analytical QA program for laboratory analyses used a number of different types of quality control samples to document the validity of the data generated. These samples included:

- Method Blanks (one per batch, each batch not to exceed 20 samples). Method blanks contain all the reagents used in the preparation and analysis of samples to assess contamination arising from reagents, glassware and other materials used in the analysis.

- Laboratory Control Samples/Spiked Blanks (LCS - one per batch, each batch not to exceed 20 samples). These samples were prepared by adding known quantities of compounds of interest to deionized water. They were used to establish that instruments and procedures were in control.

- Calibration Check Samples (as needed, or per method). Calibration standards were periodically used to verify that the original calibrations were still valid.

- Duplicate and Spiked Samples (5% duplicate; 5% spike). Duplicate samples were analyzed to enable an estimate of the precision of the analytical procedures. Spiked samples were measured to determine the accuracy of the analytical procedure and assess matrix effects. For analyses conducted according to the Contract Laboratory Program (CLP) methodology, these controls are termed matrix spike and matrix spike duplicate samples.

- Blind QC Samples (one per 20 samples). Blind QC samples were inserted into the sample load in a fashion unrecognizable to the laboratory. These samples were

used in addition to the standard duplicate sample analysis discussed above, to assess analytical precision.

- Interlaboratory Evaluation (annually). In order to assess comparability of data, sample splits were shipped to different laboratories to provide a measure of analytical or method bias.

The laboratories performing analyses maintained internal quality assurance programs that involved routine calibration of counting instruments, source and background counts, routine yield determinations for radiochemical procedures, and replicate analyses to check precision.

The specific monitoring activities included in the environmental monitoring program were measurements of radon concentration, air particulate analysis for radioactivity, and surface water and groundwater analyses for various organic, inorganic, and radioactive species. The quality assurance results for each monitoring activity, except radon, are discussed in the following text. Due to its unique measurement method, the radon quality assurance results are already included in Section 2.3 of this report.

Groundwater Quality Assurance

Field Evaluation

Field audits of all procedures associated with the collection of environmental samples were conducted during 1989. These audits were conducted by individuals from the Quality Assurance staff, who function independently from the field sampling team. All field personnel are trained and knowledgeable of the procedures used for sample collection. Standard Operating Procedures associated with the collection of environmental samples included:

- Groundwater sampling
- pH measurement in water
- Specific conductance measurement in water
- Water sample filtering
- Sampling equipment decontamination
- Sampling packaging for shipment
- Chain-of-custody

QA/QC audit reports of field procedures cited no findings of nonconformance, and no corrective action resulted.

Quality Assurance Field Blanks

Evaluation of equipment and water blanks were audited quarterly to assess field performance. Table D-1 shows the results from all equipment and water blanks taken during 1989. The equipment blanks were taken at locations which do not have dedicated well samplers in order to ensure that equipment decontamination procedures are effective in preventing contaminant carryover. The equipment blanks were designated as

TABLE D-1 QA Blank Analytical Results

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
QUARTER 2 SAMPLING RESULTS:											
GW-2022	ND	ND	ND	ND	0.03*	ND	ND	0.93	ND	13.40	ND
GW-2022-PB	ND	ND	ND	ND	0.06*	ND	ND	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND	ND	ND	ND	1.40	ND	13.70	1.6(0.6)
GW-2026-FB	ND	ND	ND	ND	0.13*	0.14	ND	ND	ND	ND	ND
GW-3008	ND	0.06	ND	ND	ND	ND	ND	8.80	4010	43.60	5.9(1.4)
GW-3008-FB	ND	ND	ND	ND	0.31*	ND	ND	ND	ND	ND	ND
GW-3008-WB	ND	ND	ND	ND	0.06*	ND	ND	ND	ND	ND	ND
GW-4003	ND	ND	ND	ND	ND	ND	ND	6.40	3.20	28.50	1.7(0.7)
GW-4003-BB	ND	ND	ND	ND	0.43*	ND	ND	ND	ND	ND	ND
GW-4013	ND	ND	1.21	ND	44.80	0.80	ND	8.50	522.00	54.90	1.8(0.8)
GW-4113-WB	ND	ND	ND	ND	0.24*	ND	ND	ND	ND	ND	ND
GW-4017	ND	ND	ND	ND	0.05	ND	ND	1.90	2.00	10.20	2.1(0.9)
GW-4017-PB	ND	0.09	ND	ND	ND	ND	ND	ND	ND	ND	ND
QUARTER 3 SAMPLING RESULTS:											
GW-1013	-	-	-	-	-	-	ND	18.90	ND	124.00	890
GW-1013-WB	-	-	-	-	-	-	ND	ND	ND	ND	ND
GW-1027	-	-	-	-	-	-	-	-	-	-	910(100)
GW-1027-PB	-	-	-	-	-	-	-	-	-	-	ND
GW-4020	ND	ND	ND	ND	ND	ND	ND	9.70	ND	148.00	28(3)
GW-4020-PB	ND	ND	ND	ND	0.28*	ND	ND	ND	ND	ND	ND
GW-0000-WB	ND	ND	ND	0.29	ND	ND	ND	ND	ND	ND	ND

TABLE D-1 QA Blank Analytical Results (Continued)

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
QUARTER 4 SAMPLING RESULTS:											
GW-0000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.04
GW-1026	-	-	-	-	-	-	-	-	-	-	<0.68
GW-1026-PB	-	-	-	-	-	-	-	-	-	-	<0.68
GW-1026-PB	-	-	-	-	-	-	-	-	-	-	<0.68
GW-2019	ND	ND	ND	ND	ND	ND	0.260	2.2	ND	22.6	-
GW-2019-FB	ND	ND	ND	ND	ND	ND	ND	2.2	ND	ND	-
GW-4013	ND	ND	ND	ND	89	ND	0.070	8.5	361.0	43.2	<2.04
GW-4013-PB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16.32
GW-4021	-	-	-	-	-	-	-	-	-	-	9.52
GW-4021-PB	-	-	-	-	-	-	-	-	-	-	<0.68

FB-Distilled water blank taken in the field.
BB-Bailer blank.
PB-Pump blank.
WB-Distilled water blank taken from onsite lab.
*-Suspect due to method blank contamination.

either pump or bailer blanks based upon the method of sample collection utilized at that particular well. The equipment blanks were prepared by adding deionized water into the sampling pump and bailer after normal field decontamination. The deionized water was then transferred into the sample containers and analyzed. Since 1,3,5-trinitrobenzene (TNB) was present in method blanks as well as equipment and water blanks, it was dismissed as a laboratory contamination problem. The results from the pump blank taken at GW-4017 indicate possible carryover of low levels of 2,4-dinitrotoluene (DNT); however since the sample taken at GW-4017 does not contain 2,4-DNT this result is questionable. None of the equipment blanks indicated inorganic anion contamination. The equipment blanks in general indicate that decontamination methods are every effective in preventing contaminant carryover.

Water blanks and field blanks were the two types of deionized water blanks taken in 1989. The samples designated as water blanks were deionized water taken from the on-site laboratory supply. The water blanks were generally clean for all parameters except 1,3,5-TNB which, as previously explained, was also in the method blank. One water blank taken in the third quarter contained trace levels of nitrobenzene; however since the result is lower than the USATHAMA detection limit it is suspect. Field blanks were deionized water blanks taken while out in the field to evaluate the possible introduction of contaminants during field activities. One field blank contained 1,3-dinitrobenzene (DNB), once again at levels lower than the USATHAMA detection limit making this result questionable. All other field blanks were generally clean. A total of 17 equipment and water blanks were analyzed during 1989 and contamination as a result of field activities was not indicated.

Analytical Quality Assurance

Expanded data verification and validation programs were initiated in 1989 to ensure that all analytical results were precise, accurate, representative, complete, and comparable to the historical database. Data verification is a preliminary review of sampling documentation and analytical results performed on 100% of the samples in accordance with Environmental Monitoring Data Verification SOP 4.9.1. Data validation is a much more comprehensive review and analysis of laboratory results and documentation.

The number of duplicate samples taken in 1989 was double that taken from the previous year. The results of duplicate analyses are presented in Table D-2. Generally good agreement exists between duplicate samples. Relative percent difference (RPD) between duplicates was calculated and appeared to be within acceptable analytical intervals for precision. As expected, variance between laboratories was observed for 1,3,5-TNB due to laboratory contamination of the primary lab. There are also slight variances in nitrate values between labs. These variances appear to be related to differing methodologies employed for nitrate analysis.

Radiological Air Particulate Quality Assurance

After an initial gross alpha analysis was performed on the samples (filters), quality control (QC) measurements were obtained through subsequent gross alpha analysis without changing any of the analytical parameters. There were 51 QC measurements obtained; approximately 6% of the total samples were analyzed twice. The precision of the gross alpha measurements were determined by comparing the original gross alpha analysis to the

TABLE D-2 QC Blind Duplicate Analytical Results

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
Average relative percent difference:							12%	27%	56%	19%	
QUARTER 1 SAMPLING RESULTS:											
GW-RMW1	-	-	-	-	-	-	-	-	-	-	ND
GW-RMW1-DU1	-	-	-	-	-	-	-	-	-	-	ND
GW-RMW1-DU2	-	-	-	-	-	-	-	-	-	-	0.68
GW-1015	2.45	ND	ND	ND	11.82	ND	-	-	-	-	210(20)
GW-1015-DU	2.40	0.40	ND	ND	10.25	ND	-	-	-	-	160(20)
GW-1023	-	-	-	-	-	-	-	-	-	-	ND
GW-1023-DU1	-	-	-	-	-	-	-	-	-	-	ND
GW-1023-DU2	-	-	-	-	-	-	-	-	-	-	0.68
GW-2019	ND	ND	ND	ND	ND	ND	ND	1.6	ND	18.7	2.7(1.1)
GW-2019-DU1	ND	ND	ND	ND	ND	ND	ND	1.4	ND	17.9	4.9(1.4)
GW-2021	-	-	-	-	-	-	ND	1.20	ND	13.50	2.8(0.8)
GW-2021-DU1	-	-	-	-	-	-	0.140	ND	ND	12	-
GW-2021-DU2	-	-	-	-	-	-	-	-	-	-	4.08
GW-2026	ND	ND	ND	ND	ND	ND	-	-	-	-	1.6(0.5)
GW-2026-DU	ND	ND	ND	ND	ND	ND	-	-	-	-	-
GW-2029	-	-	-	-	-	-	-	-	-	-	1.3(0.8)
GW-2029-DU	-	-	-	-	-	-	-	-	-	-	<0.68
GW-3001	ND	0.42	ND	ND	0.17	ND	ND	8.40	10.50	23.30	2.6(0.7)
GW-3001-DU1	ND	0.53	ND	ND	0.07	ND	ND	8.10	9.70	23.70	3.1(0.8)
GW-3001-DU2	-	-	-	-	-	-	-	-	-	-	3.4
GW-3001-DU3	ND	ND	ND	ND	ND	ND	-	-	-	-	-
GW-4003	ND	ND	ND	ND	ND	ND	ND	6.50	3.30	29.90	ND
GW-4003-DU	ND	ND	ND	ND	ND	ND	ND	6.50	3.30	29.90	ND
GW-4008	-	-	-	-	-	-	-	-	-	-	2.8(0.7)
GW-4008-DU	-	-	-	-	-	-	-	-	-	-	5.44

TABLE D-2 QC Blind Duplicate Analytical Results (Continued)

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
Average relative percent difference:							12%	27%	56%	19%	
QUARTER 1 SAMPLING RESULTS: (Continued)											
GW-4016	-	-	-	-	-	-	ND	4.20	ND	19.70	-
GW-4016-DU	ND	ND	ND	ND	ND	ND	0.240	ND	ND	8	-
GW-4022	ND	ND	ND	ND	ND	ND	ND	16.2	3.00	67.90	2.1(0.7)
GW-4022-DU	ND	ND	ND	ND	ND	ND	ND	16.5	2.60	64.80	2.8(1.0)
QUARTER 2 SAMPLING RESULTS:											
GW-1006	ND	ND	3.24	0.71	ND	ND	ND	31.60	9.30	441.00	2400(300)
GW-1006-DU1	25.20	0.19	2.36	ND	105.74	ND	ND	33.00	9.30	447.00	3500(400)
GW-1006-DU3	ND	ND	ND	ND	18	ND	0.200	41	1.77	495	-
GW-1006-DU2	-	-	-	-	-	-	-	-	-	-	2992
GW-1007	-	-	-	-	-	-	-	-	-	-	510(60)
GW-1007-DU	-	-	-	-	-	-	-	-	-	-	38.08
GW-1015	4.81	ND	ND	ND	38.42	ND	ND	14.0	9.8	219	490(50)
GW-1015-DU1	ND	ND	ND	ND	ND	ND	0.300	18	2.01	168	-
GW-1015-DU2	-	-	-	-	-	-	-	-	-	-	360.4
GW-1017	ND	ND	ND	ND	ND	ND	ND	19.30	0.40	ND	ND
GW-1017-DU	ND	ND	ND	ND	0.37	ND	ND	13.90	ND	ND	ND
GW-2002	ND	ND	0.47	ND	0.03	ND	ND	7.10	1010	95	ND
GW-2002-DU	ND	ND	ND	ND	ND	ND	ND	9	182	80	-
GW-2006	ND	ND	1.60	ND	9.62	ND	ND	278	28.70	32.40	ND
GW-2006-DU1	ND	ND	1.66	ND	9.75	ND	ND	277	27.90	31.90	1.3(0.6)
GW-2006-DU2	ND	ND	ND	ND	ND	ND	ND	256	6.2	30	-
GW-2006-DU3	-	-	-	-	-	-	-	-	-	-	<0.68
GW-2013	2.29	2.47	7.83	ND	5.48	ND	ND	4.60	3.20	11.90	1.0(0.5)
GW-2013-DU	0.60	1.03	2.88	ND	0.43	ND	ND	4.50	3.20	11.80	2.9(0.9)

TABLE D-2 QC Blind Duplicate Analytical Results (Continued)

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
Average relative percent difference:							12%	27%	56%	19%	
QUARTER 2 SAMPLING RESULTS: (Continued)											
GW-2021	-	-	-	-	-	-	-	-	-	-	3.0(0.8)
GW-2021-DU	-	-	-	-	-	-	-	-	-	-	4.08
GW-3001	-	-	-	-	-	-	-	-	-	-	ND
GW-3001-DU	-	-	-	-	-	-	-	-	-	-	3.4
GW-3002	-	-	-	-	-	-	-	-	-	-	7.8(1.3)
GW-3002-DU	-	-	-	-	-	-	-	-	-	-	2.04
GW-3009	-	-	-	-	-	-	-	-	-	-	50(5)
GW-3009-DU	-	-	-	-	-	-	-	-	-	-	58.48
GW-4008	-	-	-	-	-	-	-	-	-	-	1.9(0.7)
GW-4008-DU	-	-	-	-	-	-	-	-	-	-	5.44
GW-4010	ND	ND	ND	ND	ND	ND	ND	3.7	1.00	42.70	5.4(1.3)
GW-4010-DU1	ND	ND	ND	ND	ND	ND	ND	4.0	1.00	43.30	4.1(1.2)
GW-4010-DU2	ND	ND	ND	ND	ND	ND	0.220	4	0.1	37	-
GW-4013	ND	ND	1.21	ND	44.80	0.80	ND	8.5	522.00	ND	1.8(0.8)
GW-4013-DU	ND	ND	ND	ND	0.24	ND	ND	ND	ND	ND	ND
GW-4015	ND	ND	2.04	0.42	0.12	ND	ND	5.70	22.40	11.50	1.6(0.8)
GW-4015-DU	ND	ND	ND	ND	ND	ND	0.130	ND	1.64	7	-
GW-4022	ND	ND	ND	ND	ND	ND	ND	13.0	2.00	70.90	4.2(1.1)
GW-4022-DU1	ND	ND	ND	ND	ND	ND	ND	12.9	2.00	70.90	3.9(1.0)
GW-4022-DU2	ND	ND	ND	ND	ND	ND	0.290	15	0.3	63	-
GW-4022-DU3	-	-	-	-	-	-	-	-	-	-	<0.68
QUARTER 3 SAMPLING RESULTS:											
GW-RMW4	ND	ND	ND	ND	ND	ND	ND	11.50	0.65	11.50	1.6(0.9)
GW-RMW4-DU	ND	ND	ND	ND	ND	ND	ND	11.40	0.19	11.60	1.6(0.8)

TABLE D-2 QC Blind Duplicate Analytical Results (Continued)

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
Average relative percent difference:							12%	27%	56%	19%	
QUARTER 3 SAMPLING RESULTS: (Continued)											
GW-1014	-	-	-	-	-	-	ND	19.20	ND	125.00	880(90)
GW-1014-DU1	-	-	-	-	-	-	ND	19.10	ND	125.00	1000(100)
GW-1014-DU2	-	-	-	-	-	-	0.351	21.5	ND	129	-
GW-1017	-	-	-	-	-	-	-	-	-	-	ND
GW-1017-DU	-	-	-	-	-	-	-	-	-	-	<0.68
GW-2019	ND	ND	ND	ND	0.07	ND	ND	1.50	ND	17.9	2.6(0.8)
GW-2019-DU	ND	ND	ND	ND	ND	ND	0.202	1.50	ND	85	-
GW-2023	ND	ND	ND	ND	ND	ND	ND	1.20	0.40	25.20	3.0(0.8)
GW-2023-DU	ND	ND	ND	ND	ND	ND	ND	1.20	0.40	25.20	1.7(0.7)
GW-2028	ND	ND	ND	ND	ND	ND	ND	1.80	ND	108	-
GW-2028-DU	ND	ND	ND	ND	ND	ND	0.194	1.8	ND	114	-
GW-3003	ND	ND	ND	ND	ND	ND	ND	8.70	1885	153.00	-
GW-3003-DU	ND	ND	ND	ND	ND	ND	0.194	16.3	436	144	-
GW-4003	ND	ND	ND	ND	ND	ND	ND	6.00	3.10	32.00	-
GW-4003-DU	ND	ND	ND	ND	ND	ND	0.228	6.8	0.65	33	-
GW-4011	ND	ND	ND	ND	ND	ND	ND	5.90	133	52.4	2.9(1.4)
GW-4011-DU	ND	ND	ND	ND	ND	ND	ND	5.70	133	51.7	5.9(1.8)
GW-4013	ND	ND	0.68	ND	32.81	ND	ND	7.20	456	51.00	-
GW-4013-DU	ND	ND	ND	ND	76	ND	0.089	6.8	63.2	40	-
GW-4014	-	-	-	-	-	-	-	-	-	-	ND
GW-4014-DU	-	-	-	-	-	-	-	-	-	-	O.68
GW-4018	ND	ND	ND	ND	0.13	ND	ND	9.60	9.70	8.20	1.3(0.6)
GW-4018-DU	ND	ND	ND	ND	ND	ND	ND	9.60	9.80	8.00	1.0(0.6)

TABLE D-2 QC Blind Duplicate Analytical Results (Continued)

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
Average relative percent difference:							12%	27%	56%	19%	
QUARTER 4 SAMPLING RESULTS:											
GW-RMW2	-	-	-	-	-	-	-	-	-	-	3.4
GW-RMWX-DU	-	-	-	-	-	-	-	-	-	-	4.76
GW-1013	-	-	-	-	-	-	ND	18.90	ND	124.00	-
GW-1013-DU	-	-	-	-	-	-	0.439	20.7	0.05	120	-
GW-1016	-	-	-	-	-	-	-	-	-	-	163.2
GW-1016-DU	-	-	-	-	-	-	-	-	-	-	190.0
GW-1026	-	-	-	-	-	-	-	-	-	-	<0.68
GW-1026-DU	-	-	-	-	-	-	-	-	-	-	<0.68
GW-2025	ND	ND	ND	ND	ND	ND	0.250	1.2	ND	16.1	1.36
GW-2025-DU	ND	ND	ND	ND	ND	ND	0.202	1.2	ND	15.4	<0.68
GW-2027	ND	ND	ND	ND	ND	ND	0.167	1.3	ND	10.5	0.68
GW-2027-DU	ND	ND	ND	ND	ND	ND	0.174	1.2	ND	14.1	0.68
GW-3003	ND	ND	ND	ND	ND	ND	0.219	14.0	312,000	173.0	9.52
GW-3003-DU	ND	ND	ND	ND	ND	ND	0.219	16.8	112,000	157.0	10.2
GW-3006	ND	ND	ND	ND	ND	ND	0.258	3.4	188.0	43.2	2.72
GW-3006-DU	ND	ND	ND	ND	ND	ND	0.210	3.8	0.2	35.1	<0.68
GW-4009	-	-	-	-	-	-	-	-	-	-	3.4
GW-4009-DU	-	-	-	-	-	-	-	-	-	-	2.04
GW-4012	ND	ND	ND	ND	ND	ND	0.304	3.4	ND	39.9	2.04
GW-4012-DU	ND	ND	ND	ND	ND	ND	0.304	3.4	ND	33.0	5.44
GW-4016	ND	ND	ND	ND	ND	ND	0.190	3.8	ND	11.6	5.44
GW-4016-DU	ND	ND	ND	ND	ND	ND	0.210	3.7	ND	10.8	4.76
GW-4020	ND	ND	ND	ND	ND	ND	0.219	6.2	ND	121.0	14.28
GW-4020-DU	ND	ND	ND	ND	ND	ND	0.219	5.9	ND	121.0	14.96

QC analysis. The standard deviation of the initial results and the QC result was calculated and then divided by the average of the two measurements to obtain the precision of each measurement. The average precision of this sample group was calculated to be 16.6% ± 2.5% at a 90% confidence level.

External Gamma Monitoring Quality Assurance

During each calendar quarter the radiation levels at two gamma monitoring stations were measured with duplicate thermoluminescent dosimeters, allowing an assessment of the precision of the external gamma measurements.

The field duplicate results for 1989 are summarized per station and per quarter in Table D-3. All second quarter measurement results, including the control and background TLDs, had results four times higher than typical quarterly results. This was probably caused by the shipment being x-rayed during transit. For this reason the second quarter results were disregarded. Overall, the duplicate dosimeters are consistent with the primary detectors, indicating good precision.

TABLE D-3 External Gamma Monitoring Quality Assurance - Duplicate and Control Results

Location Number	Results mrem/Quarter
1ST QUARTER	
Control	12.22
TD-1005	22.62
TD-1005 - Duplicate	19.89
2ND QUARTER	
Control *	77.61
3RD QUARTER	
Control	6.89
TD-1004	14.95
TD-1004 - Duplicate	15.60
4TH QUARTER	
Control	10.01
TD-1005	20.67
TD-1005 - Duplicate	20.15
TD-3001	20.02
TD-3001 - Duplicate	17.81

* All 2nd Quarter badges exposed during transportation

APPENDIX E
Standards for Protection of the Public in the Vicinity of DOE Facilities

APPENDIX E
STANDARDS FOR PROTECTION OF THE PUBLIC IN THE VICINITY OF DOE FACILITIES

RADIATION STANDARDS

A. DOSE LIMITS

1. All Pathways

The effective dose equivalent for any member of the public from all routine DOE operations[1] (natural 2background and medical exposures excluded) shall not exceed the values given below:

	Effective dose equivalents[2] mrem/year	(mSv/year)
Occasional annual exposures	500	(5)
Prolonged period of exposures[3]	100	(1)

No individual organ shall receive an annual dose equivalent in excess of 5 rem/year (50 mSv/year).

2. Air Pathway Only (Limits of 40 CFR 61, Subpart H)

	Dose Equivalent mrem/year	(mSv/year)
Whole body dose	25	(.25)
Any organ	75	(.75)

1. Routine DOE operations means normal planned operations and does not include actual or potential accidental or unplanned releases.

2. Effective dose equivalent will be expressed in rem (or millirem) with the corresponding value in sievert (or millisievert) in parenthesis. As used in this standard, effective dose equivalent includes both the effective dose equivalent from external radiation and the committed effective dose equivalent to individual tissues from ingestion and inhalation during the calendar year.

3. For the purposes of these standards, a prolonged exposure will be one that lasts, or is predicted to last, longer than 5 years.

B. DERIVED CONCENTRATION GUIDES (DCG)

The following table contains a listing of the DCG values for the ingestion of drinking water and inhalation of air for members of the public. The values are based on an annual dose equivalent rate of 100 mrem/yr. Five columns of information are shown in the table: 1) radionuclide; 2) drinking water ingestion DCG in units of μCi/ml; 3) drinking water DCG in units of Bq/ml; 4) inhalation DCG in units of μCi/ml; 5) inhalation DCG in units of Bq/mL.

Only a single mode of exposure was considered--either ingestion or inhalation.

The DCG values are given for individual radionuclides. For known mixtures of radionuclides, the sum of the ratio of the observed concentration of a particular radionuclide and its corresponding DCG for all radionuclides in the mixture must not exceed 1.0.

It should be noted that the values given in the table only account for drinking water and inhaling air, and do not include other potentially significant environmental pathways. A more complete pathway analysis is required for calculating public radiation dose equivalent resulting from the operation of DOE facilities when more complex environmental pathways are involved.

	Drinking Water		Inhaled Air	
Radionuclide	µCi/mL	Bq/mL	µCi/mL	Bq/mL
Uranium-238	6.0E-07	2.2E-02	1.0E-13	3.07-09
Uranium-235	6.0E-07	2.2E-02	1.0E-13	3.7E-09
Uranium-234	5.0E-07	1.9E-02	9.0E-14	3.3E-09
Thorium-232	5.0E-08	1.9E-03	7.0E-15	2.6E-10
Thorium-230	3.0E-07	1.1E-02	4.0E-14	1.5E-09
Radium-228	1.0E-07	3.7E-03	3.0E-12	1.1E-07
Radium-226	1.0E-07	3.7E-03	1.0E-12	3.7E-08

C. RADON

Above-background radon-222 concentrations in the atmosphere at or above any location outside the facility site shall not exceed an annual average concentration of 3 pCi/L (DOE Order 5480.1A, Attachment XI-1).

CHEMICAL STANDARDS

U.S. EPA Drinking Water Standards (mg/l) as noted in 40 CFR Parts 141 and 143

Drinking water standards are presented only for comparison purposes. These should not necessarily be construed as relevant cleanup standards.

A. HSL-Metals

Aluminum	NS	Lithium	NS
Antimony	NS	Magnesium	NS
Arsenic	0.05*	Manganese	0.05**
Barium	1.0*	Mercury	0.002
Beryllium	NS	Nickel	NS
Cadmium	0.01*	Potassium	NS
Calcium	NS	Selenium	0.01
Chromium	0.05*	Silver	0.05
Cobalt	NS	Sodium	NS
Copper	1.0**	Thallium	NS
Iron	0.3**	Vanadium	NS
Lead	0.05	Zinc	5.0**

B. Inorganic Anion and Water Quality

Nitrate (as N)	10*
Sulfate	250**
Chloride	250**
Fluoride	4*2**
Hardness	NS
TDS	500**
TOC	NS

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* Primary maximum contaminant level
** Secondary maximum contaminant level
NS - No Drinking Water Standard

APPENDIX F
Conversion Factors

CONVERSION FACTORS

1 millisievert (mSv)	=	100 mrem
1 milliroentgen (mR)	=	1 mrem (for gamma radiation)
1 Curie (Ci)	=	3.7 X 10^{10}dps (disintegration/sec)
1 Bequerel (Bq)	=	1 disintegration per second
1 M^3	=	1000 litres
1 Bq/M^3	=	3.7 X 10^{-2} pCi/M^3
1 Bq/l	=	3.7 X 10^{-2} pCi/l
1 Bq/kg	=	3.7 x 10^{-2} pCi/kg
1 km	=	.62 miles
1 m	=	3.28 ft
1 m^3	=	1.31 cy
1 mm	=	.039 inches
1 ha	=	2.47 acres

APPENDIX G
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CHEMICAL PLANT ADMINISTRATIVE RECORD FILE

ARFS FILE # C-202-2

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	C-200-202-1.06	QUARTERLY ENVIRONMENTAL DATA SUMMARY 4TH QUARTER 1990
	C-200-202-1.07	QUARTERLY ENVIRONMENTAL DATA SUMMARY 1ST QUARTER 1991
	C-200-202-1.08	WSSRAP ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

CHEMICAL PLANT
202-1.05

DOE/OR/21548-161
CONTRACT NO. DE-AC05-86OR21548

QUARTERLY ENVIRONMENTAL DATA SUMMARY THIRD QUARTER 1990

For the
Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

Prepared by MK-Ferguson Company and Jacobs Engineering Group

JANUARY 1991 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

010791

DOE/OR/21548-161

Weldon Spring Site Remedial Action Project

Quarterly Environmental Data Summary
Third Quarter 1990

January 1991

Prepared by

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and
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Prepared for

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Oak Ridge Operations Office
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ABSTRACT AND WELDON SPRING SITE QUARTERLY SELF ASSESSMENT THIRD QUARTER 1990

This is the second Quarterly Environmental Data Summary for the Weldon Spring Site Remedial Action Project (WSSRAP). The purpose of this document is to provide preliminary data acquired as part of the WSSRAP environmental monitoring program. The document summarizes the environmental data, highlights any potentially significant findings, and offers tentative interpretations. Validated data and final interpretations will appear in the 1990 Annual Site Environmental Report.

This report includes data from environmental monitoring at the Weldon Spring Site during the third quarter of 1990. Groundwater, surface water, and air were sampled in order to monitor potential exposure pathways. Analytical parameters included radionuclides, nitroaromatic compounds, inorganic anions, and direct gamma exposure. The results are used to calculate exposure doses (where applicable) and assess the impact of the contaminants at the site on potentially exposed populations.

No significant differences were observed in off-site exposures during the third quarter of 1990 relative to exposures calculated in previous quarters. Contaminated groundwater did not affect private water supplies or the St. Charles County well field. Surface water containing elevated uranium activity continued to impact the Femme Osage Slough and several lakes in the August A. Busch Memorial Wildlife Area. Off-site gamma, radon and air particulate exposures remained indistinguishable from background. Off-site monitoring demonstrated that exposure levels at the Francis Howell High School, the Busch Wildlife Area Headquarters, and the Weldon Spring Training Area remain indistinguishable from background levels. No EPA reportable spills or releases of hazardous or radioactive materials occurred at the Weldon Spring Site during the third quarter of 1990.

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1 INTRODUCTION

This document is the second in a series of documents designed to provide a summary of the findings from the routine environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). These documents supplement the Annual Site Environmental Reports (ASER) by providing interested outside agencies and organizations with more frequent access to WSSRAP data. They provide data resulting from routine environmental sampling as described in the WSSRAP Environmental Monitoring Plan and a brief interpretation of that data.

It is the goal of this document to summarize and briefly discuss the data, highlighting those which differ significantly from observations made in previous reports. The full interpretation of these data (as well as data in other quarterly summaries) will be undertaken in the 1990 ASER. It is recommended that interested readers refer to previous Environmental Monitoring Plans (EMPs), ASERs, and project documents for more information on existing site conditions, site history, transport mechanisms, and quantified contaminant levels. The monitoring scheme for every calendar year is established prior to that year in the annual EMP. Each sampling location to be used during the upcoming year is identified in the EMP and the analytical parameters are tabulated for easy reference. These reports may be obtained by visiting the WSSRAP reading room or contacting Mr. James McKee (the WSSRAP Community Relations Manager at 314-441-8086).

These quarterly reports are intended to include data from all quarterly environmental monitoring programs conducted at the WSSRAP including groundwater, surface water, National Pollutant Discharge Elimination System, radon, gamma radiation, and air

particulates (including asbestos and radioactive particulates). However, because of delays in data delivery from the analytical laboratories, much of the data which was expected to be included in this report are not yet available for reporting. The unavailability of data is due to a nationwide shortage in analytical services. WSSRAP is taking corrective action to ensure more timely availability of data in the future. These data will be reported in the fourth quarter data summary or in the 1990 Annual Site Environmental Report (ASER). Sludges, soils, and biological specimens are not sampled on a routine basis; therefore, analytical results for these parameters are not included in this report.

2 GROUNDWATER MONITORING

The groundwater is sampled regularly at both the Weldon Spring Chemical Plant/Raffinate Pits/Vicinity Properties (WSCP/RP/VP) and the Weldon Spring quarry (WSQ). Due to differences in the environmental settings and sources of contaminants, separate monitoring schedules are followed. Therefore, results of groundwater monitoring at the WSCP/RP/VP and WSQ will be discussed separately.

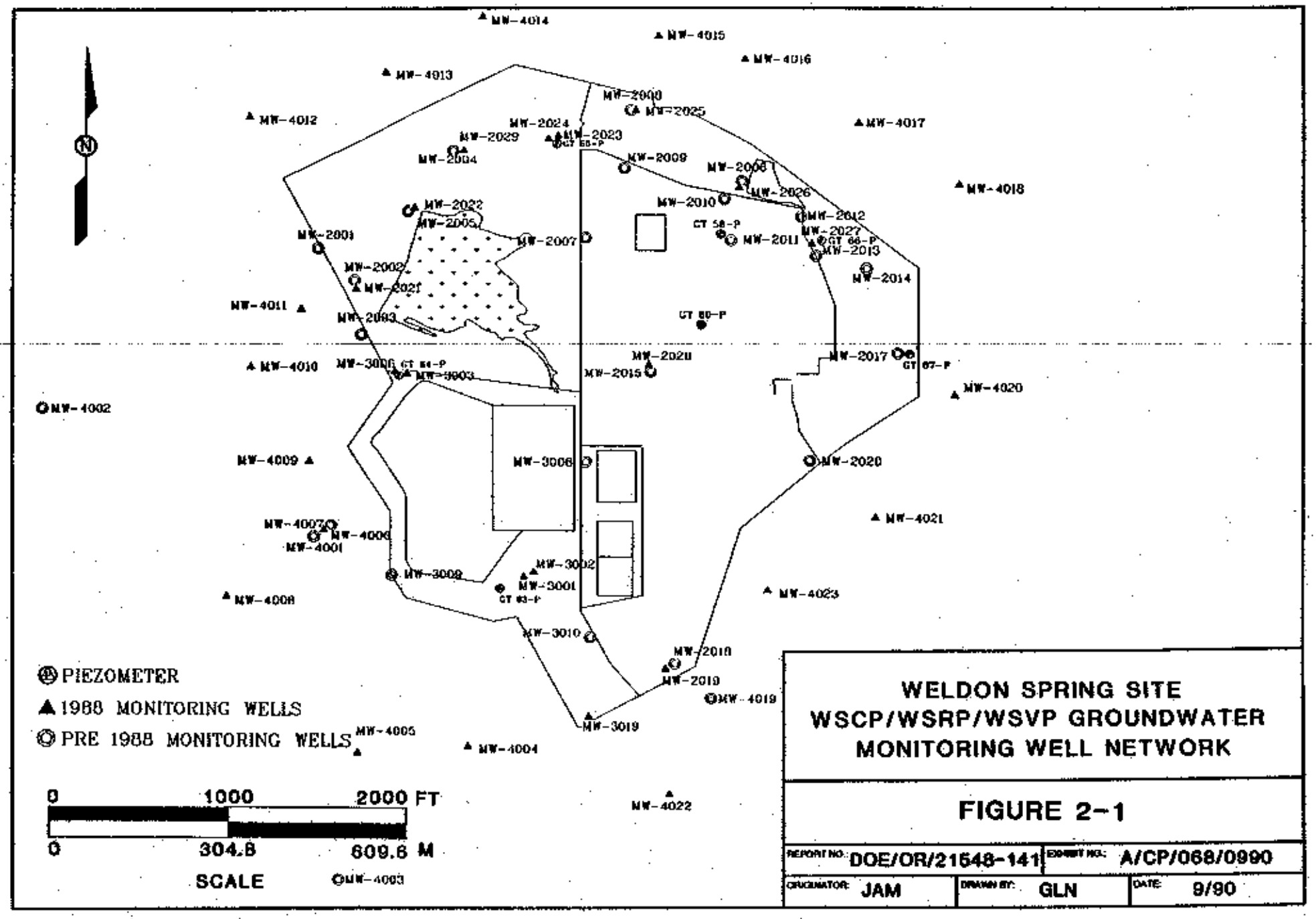
2.1 Chemical Plant/Raffinate Pits/Vicinity Properties

The groundwater at the chemical plant/raffinate pits/vicinity properties area is monitored on a semi-annual basis. Monitoring well locations are shown in Figure 2-1. Data from the semiannual groundwater monitoring for the second half of 1990 will be presented in its entirety in the fourth quarter data summary which will allow the reader to see the whole picture of groundwater quality conditions.

Nitroaromatic and radiological data from first semester semiannual sampling which was not available in the previous data summary is presented in Tables 2-1 and 2-2. These results are discussed in Sections 2.1.1 and 2.1.2.

2.1.1 Nitroaromatic Results

Table 2-1 contains nitroaromatic data from samples of 25 monitoring wells for which data was unavailable in the previous quarterly environmental data summary. Nitroaromatic compounds were detected in nine of these samples. However, the data continues to reflect historical trends found in previous environmental reports.



WELDON SPRING SITE
WSCP/WSRP/WSVP GROUNDWATER MONITORING WELL NETWORK

FIGURE 2-1

REPORT NO: DOE/OR/21548-141	EXHIBIT NO: A/CP/068/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90

TABLE 2-1 First Semester Nitroaromatic Data for Groundwater at the WSCP/RP/VP

SAMPLE ID	1,3,5-TNB (µG/l)	1,3-DNB (µG/l	2,4,6-TNT (µG/l)	2,4-DNT (µG/l)	2,6-DNT (µG/l)	NB (µG/l)
GW-2004-061990	ND	ND	ND	ND	ND	ND
GW-2005-061390	ND	ND	ND	0.08	0.07	ND
GW-2006-061190	12.0	0.14	ND	0.06	1.4	ND
GW-2008-061190	12.0	0.14	ND	ND	1.6	ND
GW-2019-062590	ND	ND	ND	ND	ND	ND
GW-2020-062190	ND	ND	ND	ND	ND	ND
GW-2021-062590	ND	ND	ND	ND	ND	ND
GW-2022-062590	ND	ND	ND	ND	ND	ND
GW-2023-062190	ND	ND	ND	ND	ND	ND
GW-2025-061390	ND	ND	ND	ND	ND	ND
GW-2026-061290	ND	ND	ND	ND	ND	ND
GW-2028-062690	ND	ND	ND	ND	ND	ND
GW-2029-061990	ND	ND	ND	ND	ND	ND
GW-3001-062690	0.09	ND	ND	0.38	0.17	ND
GW-3002-062590	ND	ND	ND	ND	ND	ND
GW-3003-061290	ND	ND	ND	ND	ND	ND
GW-3006-061290	ND	ND	ND	0.06	0.11	ND
GW-3008-062790	ND	ND	ND	0.08	0.04	ND
GW-3009-062090	0.36	ND	ND	0.17	0.14	ND
GW-3010-062690	ND	ND	ND	ND	ND	ND
GW-4002-061490	0.20	ND	1.90	ND	0.56	ND
GW-4009-061490	ND	ND	ND	ND	ND	ND
GW-4010-021490	ND	ND	ND	ND	ND	ND
GW-4015-062190	0.48	ND	ND	ND	1.80	ND
GW-4020-062190	ND	ND	ND	ND	ND	ND

ND = Not Detected

TABLE 2-2 First Semester Uranium Data in Groundwater at WSCP/RP/VP

SAMPLE ID	URANIUM, TOTAL (pCi/l)
GW-2002-053190	3.40
GW-2015-053190	6.80
GW-2019-062590	3.40
GW-2020-062190	9.52
GW-2021-062590	2.04
GW-2022-062590	ND
GW-2023-062190	3.40
GW-2028-062690	1.36
GW-3001-062690	1.36
GW-3002-062590	2.04
GW-3008-062790	231.2
GW-3009-062090	29.92
GW-3010-062690	2.722
GW-4015-062190	3.40
GW-4020-062190	13.6

ND - Not Detected

2.1.2 Radiological Results

The radiological results for samples from wells at the WSCP/RP/VP are presented in Table 2-2. The upper bound for natural uranium background concentrations in groundwater at the WSCP/WSRP/WSVP has been determined to be 3.4 pCi/l. The EPA has not yet established drinking water standards for uranium. However, studies leading to proposed rulemaking are using uranium in the 10 to 40 pCi/l range. The U.S. Department of Energy (DOE) has a derived concentration guidelines (DCG) of 550 pCi/l.

The highest uranium level detected was 231.2 pCi/l from a sample obtained from Monitoring Well 3008. This level indicates a higher value than has previously been detected from MW-3008. The second semester sample results to be reported in the fourth quarter environmental data summary will provide more insight to this elevated level. The other concentrations reported in Table 2-2 are consistent with data from previous environmental reports.

2.2 Weldon Spring Quarry

Chemical and radiological wastes at the quarry are of particular concern because of their proximity to the St. Charles County well field. The well field is located approximately one-half mile to the south. Monitoring of contaminants in groundwater and the protection of the the well field is a top WSSRAP priority.

Groundwater is monitored in 30 wells in and around the quarry. Twenty-six monitoring wells installed by the U.S. Department of Energy (DOE) currently exist in or near the quarry. Four additional monitoring wells were installed by St. Charles County in 1986. All monitoring well locations are shown in

Figures 2-2 and 2-3. The wells currently draw water from both bedrock and alluvial aquifers.

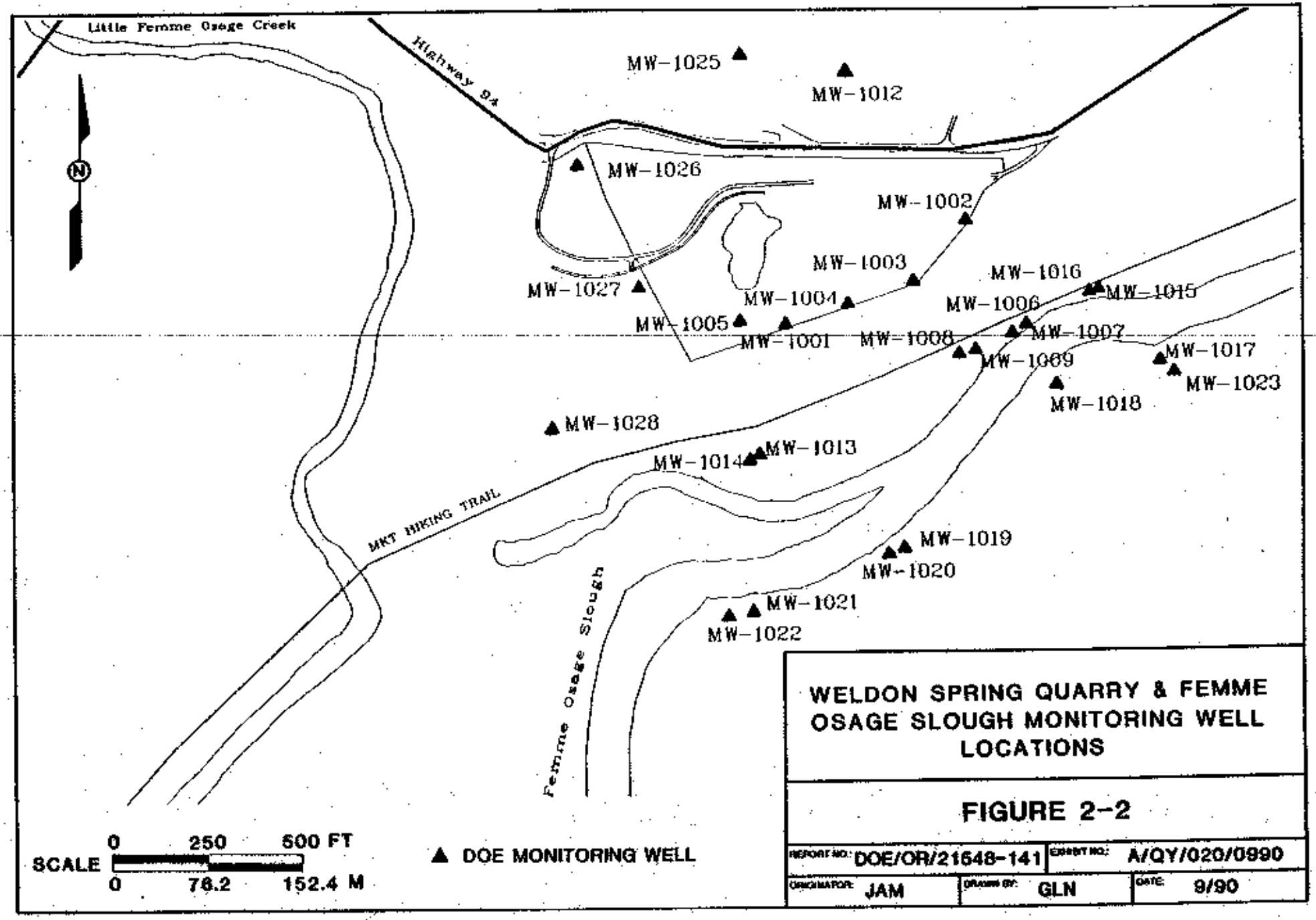
Two separate groundwater monitoring programs have been developed for the quarry. The first program is a semiannual sampling of all wells north of the Femme Osage Slough.

The second program monitors the area south of the Femme Osage Slough, including the St. Charles County well field. Active production wells and monitoring wells are sampled quarterly. The raw and treated waters from the St. Charles County water treatment plant are also sampled. This portion of the quarry groundwater monitoring program has been jointly developed by representatives of the DOE, the Missouri Department of Natural Resources (MDNR), the U.S. Environmental Protection Agency (EPA) and St. Charles County.

Data from the second semiannual semester groundwater sampling in the quarry area will be presented in their entirety in the fourth quarter data summary. Second quarter data that were not available for the previous quarterly summary are presented in this report with third quarter data.

2.2.1 Radiological Results

Radiological data from groundwater samples taken from quarry wells south of the Femme Osage Slough are exhibited on Table 2-3. Some uranium data for third quarter have not yet been received from the analytical laboratory and will be reported in the 1990 ASER. The available results of third quarter 1990 groundwater monitoring are consistent with historical results in that they continue to indicate background uranium levels in the



WELDON SPRING QUARRY & FEMME OSAGE SLOUGH MONITORING WELL LOCATIONS

FIGURE 2-2

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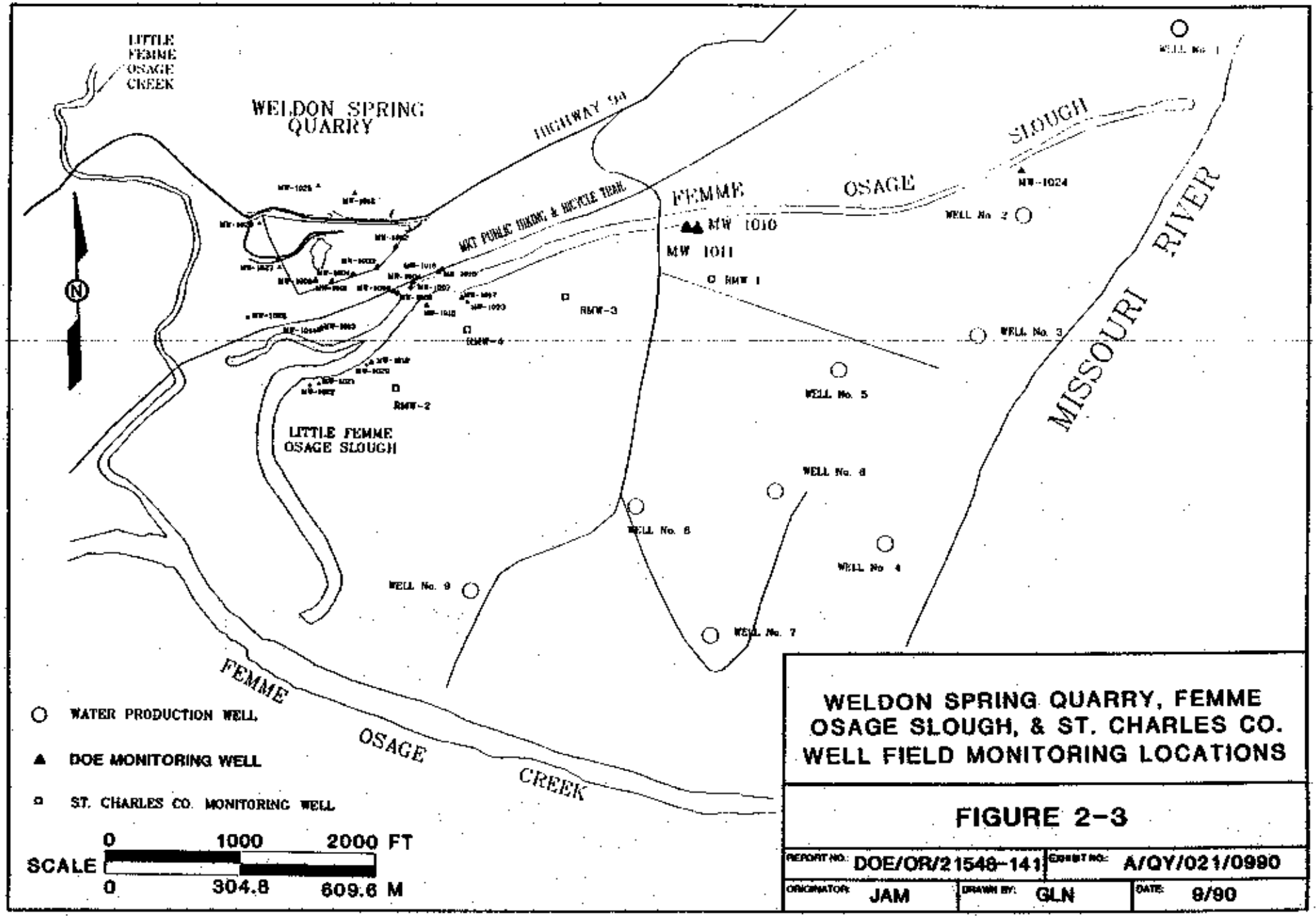


WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, & ST. CHARLES CO. WELL FIELD MONITORING LOCATIONS

FIGURE 2-3

REPORT NO: DOE/OR/21548-141	EXHIBIT NO: A/QY/021/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90

TABLE 2-3 Results of Analyses for Inorganic Anions and Radiological Parameters in Groundwater for WSQ

3rd Quarter	Nitrate (mg/l)	Sulfate (mg/l)	Chloride (mg/l)	Fluoride (mg/l)	Uranium (pCi/l)	Gross Alpha (pCi/l)
GW-1017-Q390	ND	14.0	19.0	ND	ND	NA
GW-1018-Q390	ND	21.0	5.9	ND	NR	NA
GW-1019-Q390	ND	ND	6.1	ND	NR	NA
GW-1020-Q390	ND	20.0	9.2	ND	NR	NA
GW-1021-Q390	ND	1.6	12.0	ND	NR	NA
GW-1022-Q390	ND	ND	6.0	ND	NR	NA
GW-1023-Q390	ND	4.0	4.4	ND	ND	NA
GW-1024-Q390	ND	5.5	8.9	ND	ND	ND
GW-RMW1-Q390	ND	29.0	6.9	ND	1.1	ND
GW-RMW2-Q390	ND	32.0	2.1	ND	7.1	13.1
GW-RMW3-Q390	ND	36.0	9.0	ND	ND	ND
GW-RMW4-Q390	ND	10.0	5.4	ND	2.3	ND
GW-PW02-Q390	NA	NA	NA	NA	0.1	ND
GW-PW03-Q390	NA	NA	NA	NA	0.08	ND
GW-PW04-Q390	NA	NA	NA	NA	0.01	ND
GW-PW06-Q390	NA	NA	NA	NA	0.17	ND
GW-PW07-Q390	NA	NA	NA	NA	0.12	ND
GW-PW08-Q390	NA	NA	NA	NA	0.32	ND
GW-PW09-Q390	NA	NA	NA	NA	0.22	ND
GW-RAWW-Q390	NA	NA	NA	NA	ND	ND
GW-FINW-Q390	NA	NA	NA	NA	ND	ND

ND - Not Detected
NA - Not Applicable
NR - Data Not Received

alluvium on the south side of the Femme Osage Slough. Analytical results from St. Charles County Monitoring Well RMW-2 indicate a level of 7.1 pCi/l which is the highest uranium level detected in the wellfield for third quarter, but agrees with historical data from the well field.

The results of third quarter gross alpha monitoring south of the Femme Osage Slough indicated only one detected level of 13.1 pCi/l. This result was found in RMW-2 which corresponds to the highest uranium level detected from third quarter monitoring.

These findings indicate that the groundwater quality south of the Femme Osage Slough remains uncompromised.

2.2.2 Nitroaromatic Compounds Results

Analytical results for nitroaromatic compounds are presented in Table 2-4. No monitoring wells south of the Femme Osage Slough showed detectable concentrations of nitroaromatic compounds during the third quarter 1990. The scenario for nitroaromatic contamination near the quarry remains unchanged.

2.2.3 Inorganic Anions Results

Four inorganic anions--nitrate, sulfate, chloride, and fluoride--were measured in quarry wells. Table 2-3 displays the analytical results for the third quarter of 1990, which are consistent with data reported in the 1989 Annual Site Environmental Report, as well as previous environmental monitoring reports.

TABLE 2-4 Third Quarter Nitroaromatic Data for Groundwater at the WSQ

SAMPLE ID	1,3,5-TNB (µg/l)	1,3-DNB (µg/l)	2,4,6-TNT (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	NB (µg/l)
GW-1017-Q390	ND	ND	ND	ND	ND	ND
GW-1018-Q390	ND	ND	ND	ND	ND	ND
GW-1019-Q390	ND	ND	ND	ND	ND	ND
GW-1020-Q390	ND	ND	ND	ND	ND	ND
GW-1021-Q390	ND	ND	ND	ND	ND	ND
GW-1022-Q390	ND	ND	ND	ND	ND	ND
GW-1023-Q390	ND	ND	ND	ND	ND	ND
GW-1024-Q390	ND	ND	ND	ND	ND	ND
GW-RMW1-Q390	ND	ND	ND	ND	ND	ND
GW-RMW2-Q390	ND	ND	ND	ND	ND	ND
GW-RMW3-Q390	ND	ND	ND	ND	ND	ND
GW-RMW4-Q390	ND	ND	ND	ND	ND	ND
GW-PW02-Q390	ND	ND	ND	ND	ND	ND
GW-PW03-Q390	ND	ND	ND	ND	ND	ND
GW-PW04-Q390	ND	ND	ND	ND	ND	ND
GW-PW06-Q390	ND	ND	ND	ND	ND	ND
GW-PW07-Q390	ND	ND	ND	ND	ND	ND
GW-PW08-Q390	ND	ND	ND	ND	ND	ND
GW-PW09-Q390	ND	ND	ND	ND	ND	ND
GW-RAMW-Q390	ND	ND	ND	ND	ND	ND
GW-FIRW-Q390	ND	ND	ND	ND	ND	ND

ND - Not Detected

2.2.3.1 Nitrate

The groundwater samples continue to indicate no significant groundwater contamination by nitrate.

2.2.3.2 Sulfate

The groundwater samples continue to indicate background concentrations of sulfate in wells south of the Femme Osage Slough.

2.2.3.3 Chloride and Fluoride

Results of chloride analyses of groundwater south of the Femme Osage Slough continue to indicate background concentrations. Results of fluoride analyses indicate no detectable levels for third quarter 1990.

2.2.4 Metals Results

A selected group of quarry wells located south of the Femme Osage Slough were sampled for arsenic and barium. Analytical results for these metals are presented in Table 2-5. Results from third quarter analyses of arsenic and barium continue to indicate elevated concentrations in selected wells. The highest levels reported for the third quarter are 51.2 µg/l for arsenic and 630 µg/l for barium as detected in Monitoring Well RMW-3.

TABLE 2-5 Results for Metals in Groundwater for WSQ

QUARRY	ARSENIC µg/l	BARIUM µg/l
2ND QUARTER		
GW-RMW2-Q290	19.4	195
GW-RMW3-Q290	30.7	560
3RD QUARTER		
GW-1024-Q390	8.0	423
GW-RMW1-Q390	6.4	478
GW-RMW2-Q390	19.3	244
GW-RMW3-Q390	51.2	630
GW-RMW4-Q390	23.2	219
GW-RAWW-Q390	ND	366
GW-FINW-Q390	ND	84.8 B

ND - Not Detected
B - Contamination found in lab blank

3 SURFACE WATER MONITORING

Routine samples were collected during the third quarter of 1990 from both on-site and off-site surface water locations. All surface water samples were analyzed without filtering, unless a specific comparison of dissolved versus total contaminant concentrations was desired.

3.1 Chemical Plant/Raffinate Pits/Vicinity Properties

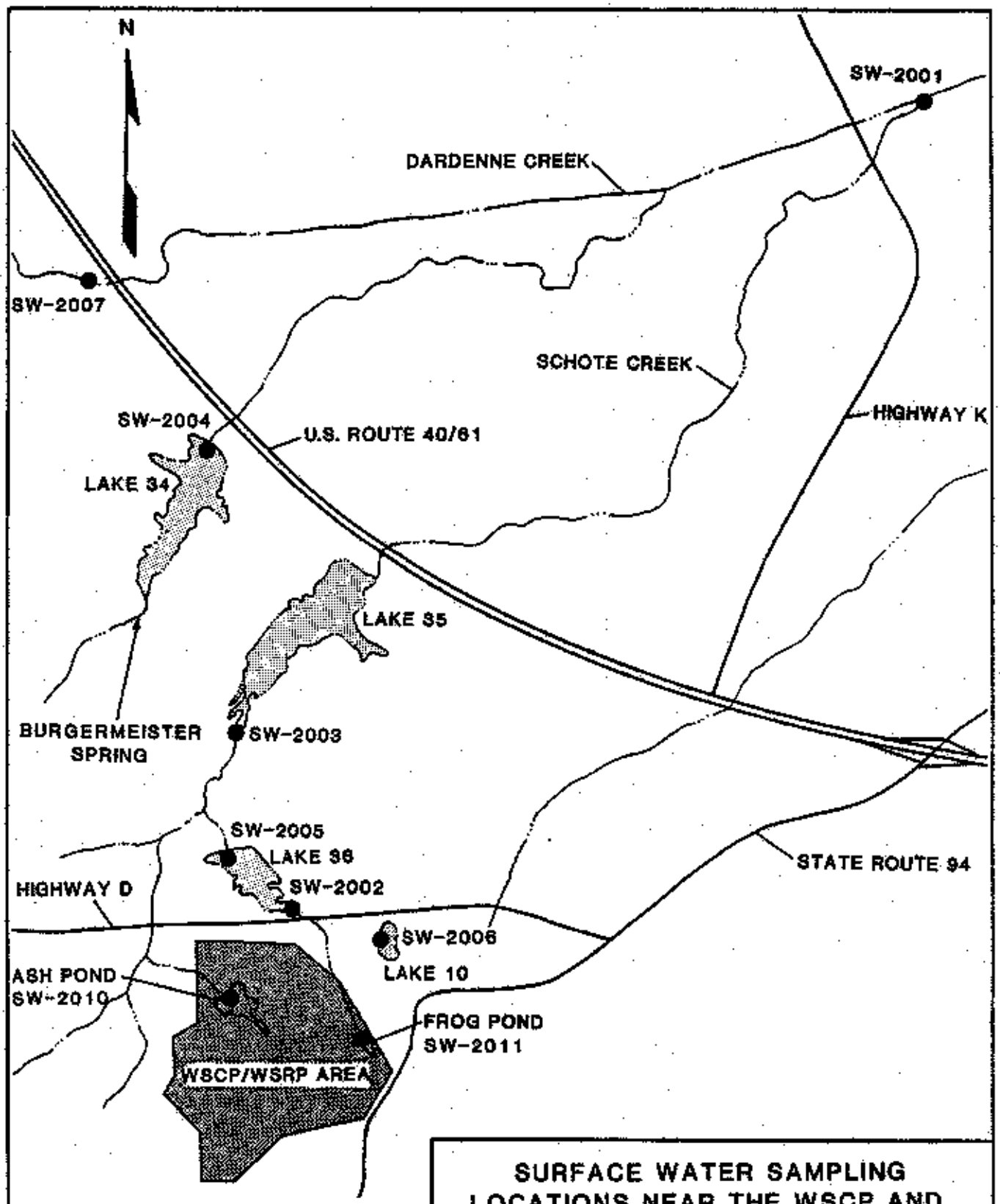
During the third quarter, surface water samples were collected from the nine locations shown in Figure 3-1; however, radiological and chemical analyses are not yet available from the contract laboratory. Sampling results for uranium, chloride, flouride, nitrate, and sulfate for the nine locations will be presented in the 1990 Annual Site Environmental Report.

3.2 Weldon Spring Quarry

Samples from the nine surface water locations in Figure 3-2, and three surface water locations in Figure 3-3, were analyzed for uranium. Certain locations were also analyzed for radium-226, thorium-230, thorium-232, nitrate, sulfate, chloride, flouride, 1,3,5-TNB, 1,3-DNB, 2,4,6-TNT, 2,4-DNT, 2,6-DNT, and Nitrobenzene. Only the results of analyses for nitroaromatic compounds are presently available from the laboratory. Results of all other analyses will be presented in the 1990 Annual Site Environmental Report.

3.2.1 Nitroaromatics

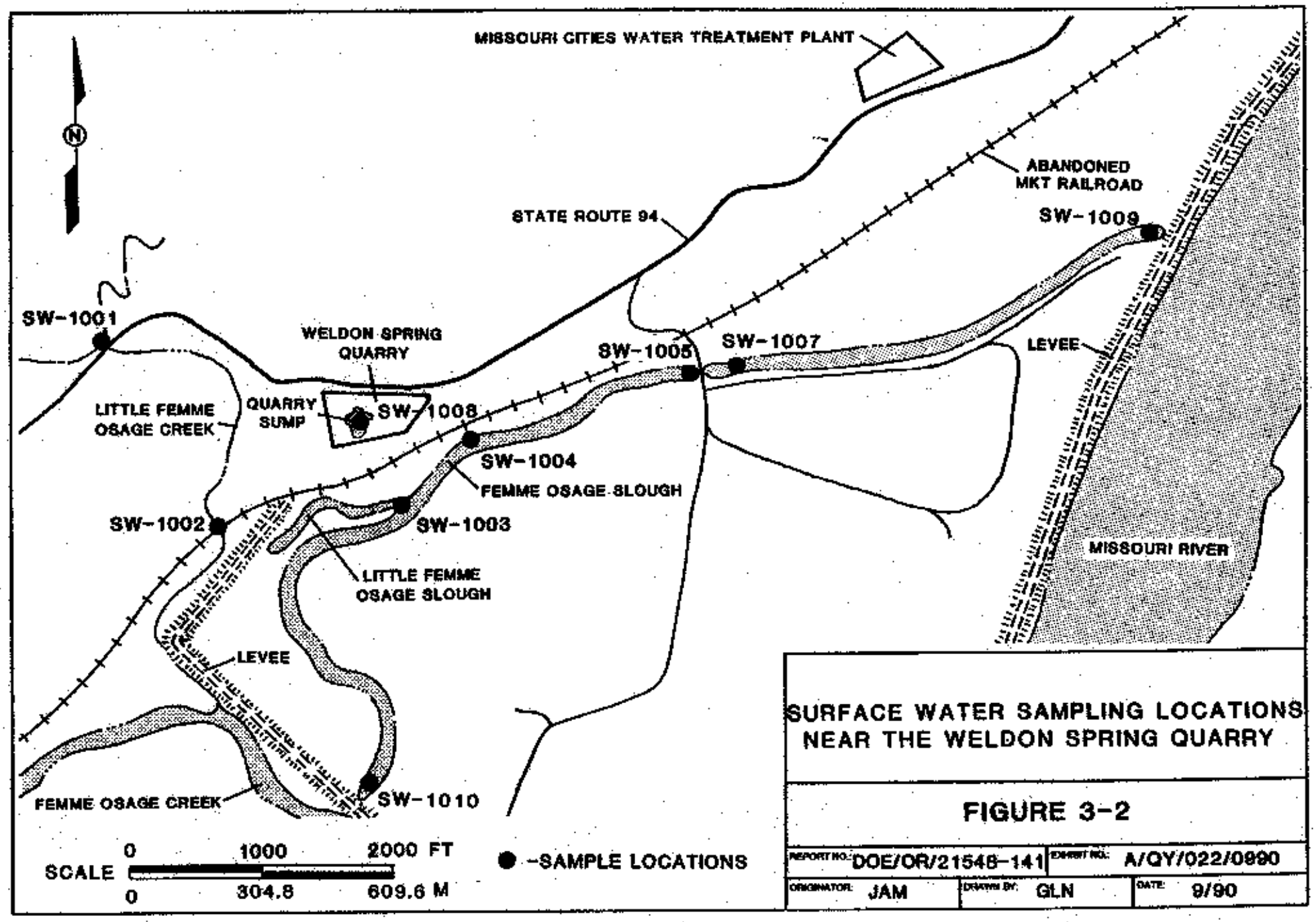
A sample was collected at one location, the quarry sump (SW-1008), to quantify nitroaromatic concentrations. Results of



SURFACE WATER SAMPLING LOCATIONS NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

FIGURE 3-1

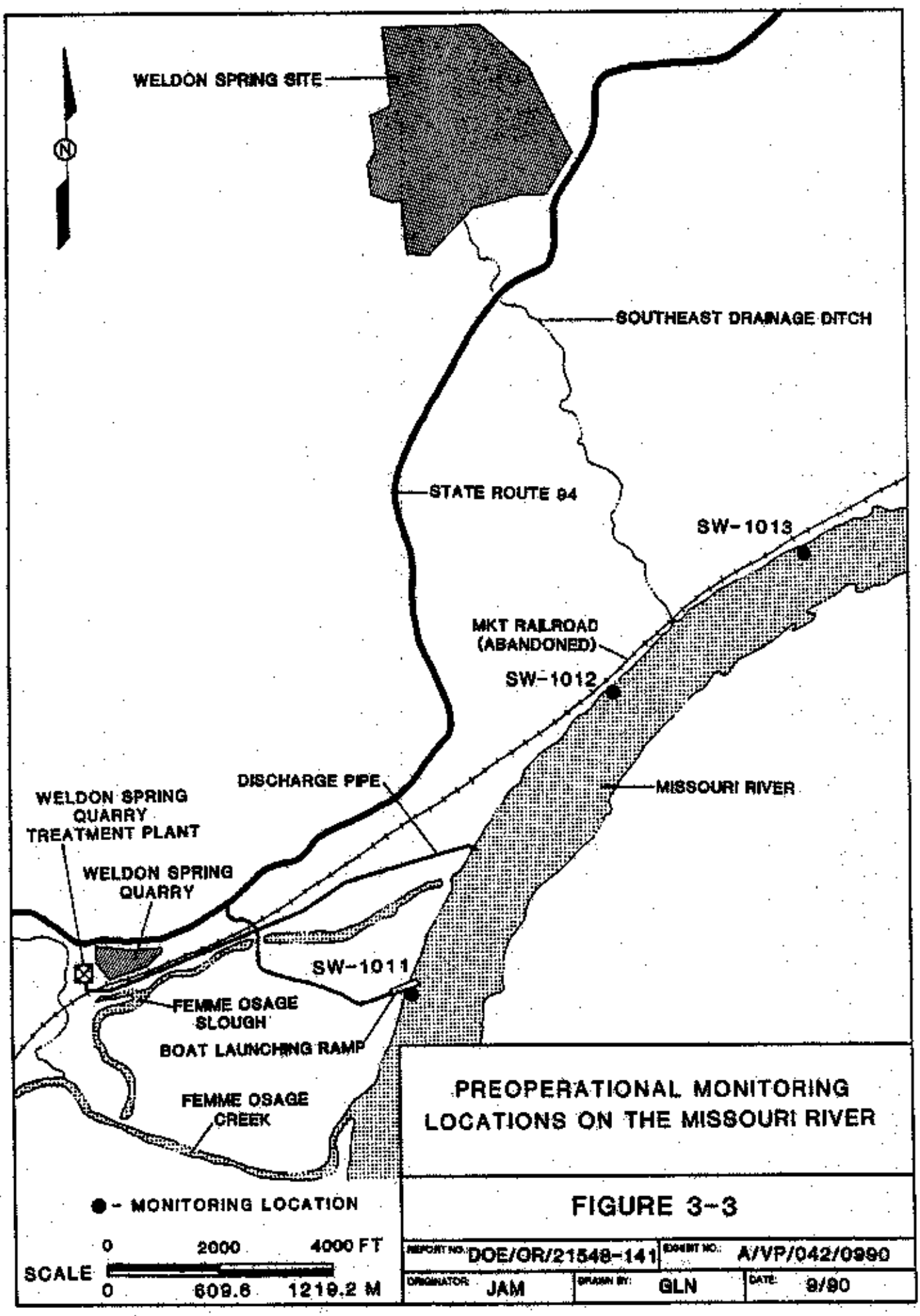
REPORT NO: DOE/OR/21548-141	EXHIBIT NO: A/VP/041/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90



SURFACE WATER SAMPLING LOCATIONS
NEAR THE WELDON SPRING QUARRY

FIGURE 3-2

REPORT NO: DOE/OR/21548-141	EXHIBIT NO: A/QY/022/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90



PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

FIGURE 3-3

REPORT NO. DOE/OR/21548-141	EXHIBIT NO. A/VP/042/0990	
ORIGINATOR JAM	DRAWN BY: GLN	DATE: 9/90

this sampling are presented in Table 3-1. The quantified concentrations of the six nitroaromatic compounds ranged from below the detection limit to 35.0 µg/l for 2,4,6-TNT. The ponded water will be treated for nitroaromatic compounds and other organics upon completion of the quarry water treatment plant. Nitroaromatic results for the third quarter of 1990 were near the values reported in the 1989 ASER, but were higher than the values during the first and second quarters of 1990.

3.3 Springs

Eleven springs around the WSS are sampled on a quarterly basis. (See Figure 3-4 for spring locations). Previous spring monitoring has indicated that waters from six perennial springs and one wet-weather spring are measurably influenced by site-related contaminants. These springs include SP-6301, SP-6302, SP-6306, and SP-5301 through SP-5304. All spring samples are analyzed for uranium, and select spring samples are analyzed for inorganic ions, metals, and nitroaromatics. Results for nitroaromatics only are available from the laboratory at this time. All other results will be presented in the 1990 Annual Site Environmental Report.

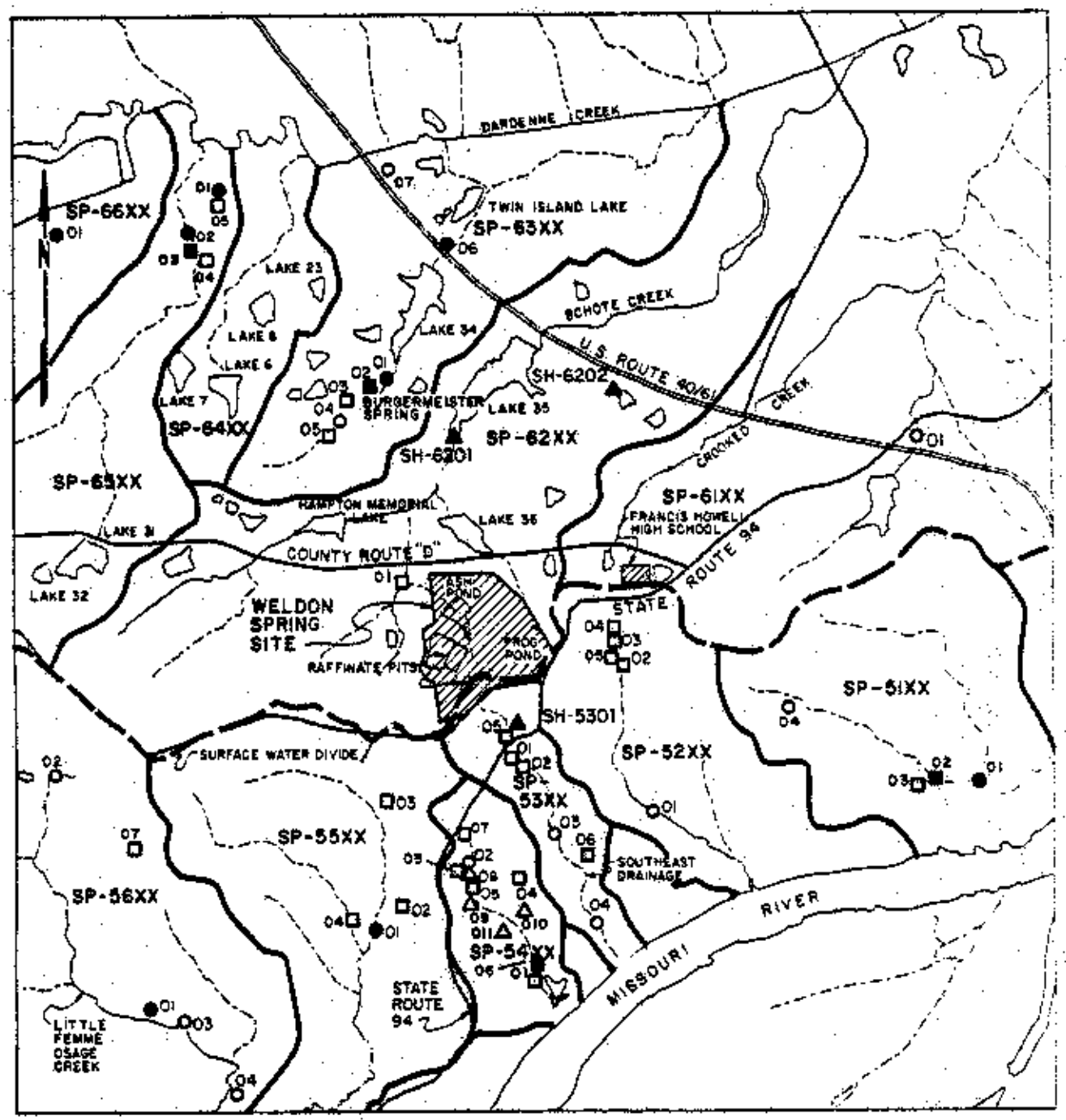
3.3.1 Nitroaromatics

Of the five routinely monitored springs, four were analyzed for nitroaromatic compounds because of the historical presence of nitroaromatic compounds at those locations. Spring SP-6302 was dry; therefore, a sample could not be collected. The results of these analyses are in Table 3-2 and are consistent with previous results.

TABLE 3-1 Third Quarter Nitroaromatic Concentrations For Surface Water (µg/l)

WSSRAP-ID	QUARTER	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NITROBENZENE
SW-1008	THIRD	0.28	ND	35.0	24.0	4.1	ND

NS - NOT SAMPLED, DRY
ND - NOT DETECTED



SOURCE: MDNR, 1989

LEGEND:

- SURFACE WATER DIVIDE BETWEEN MISSISSIPPI RIVER AND MISSOURI RIVER
- DRAINAGE BOUNDARY
- CREEK OR SURFACE DRAINAGE
- POND OR LAKE
- ● PERENNIAL SPRING WITH LARGE MAXIMUM FLOW
- ○ PERENNIAL SPRING WITH SMALL MAXIMUM FLOW
- ■ WET WEATHER SPRING WITH LARGE MAXIMUM FLOW
- □ WET WEATHER SPRING WITH SMALL MAXIMUM FLOW
- ▲ SHALLOW HOLE (SH)
- △ SEEP
- SP-63XX SPRING OR SEEP IN DESIGNATED DRAINAGE AREA NUMBER 63. XX REPRESENTS THE DESIGNATED SPRING NUMBER IN DRAINAGE 63.

SCALE 0 3200 6400 FT
0 976.4 1950.7 M

SPRINGS AND SEEPS IN THE VICINITY OF THE WSS

FIGURE 3-4

REPORT NO: DOE/OR/21548-141	EXHIBIT NO: A/VP/048/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90

TABLE 3-2 Third Quarter Nitroaromatic Concentrations for Surface Water (µg/l)

WSSRAP-ID	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NITROBENZENE
SP-5201	ND	ND	1.8	ND	0.49	ND
SP-6301	0.031	ND	0.23	ND	0.48	ND
SP-6302	NS	NS	NS	NS	NS	NS
SP-6303	ND	ND	0.24	0.056	0.66	ND
SP-6306	ND	ND	ND	ND	ND	ND

NS - NOT SAMPLED, DRY
ND - NOT DETECTED

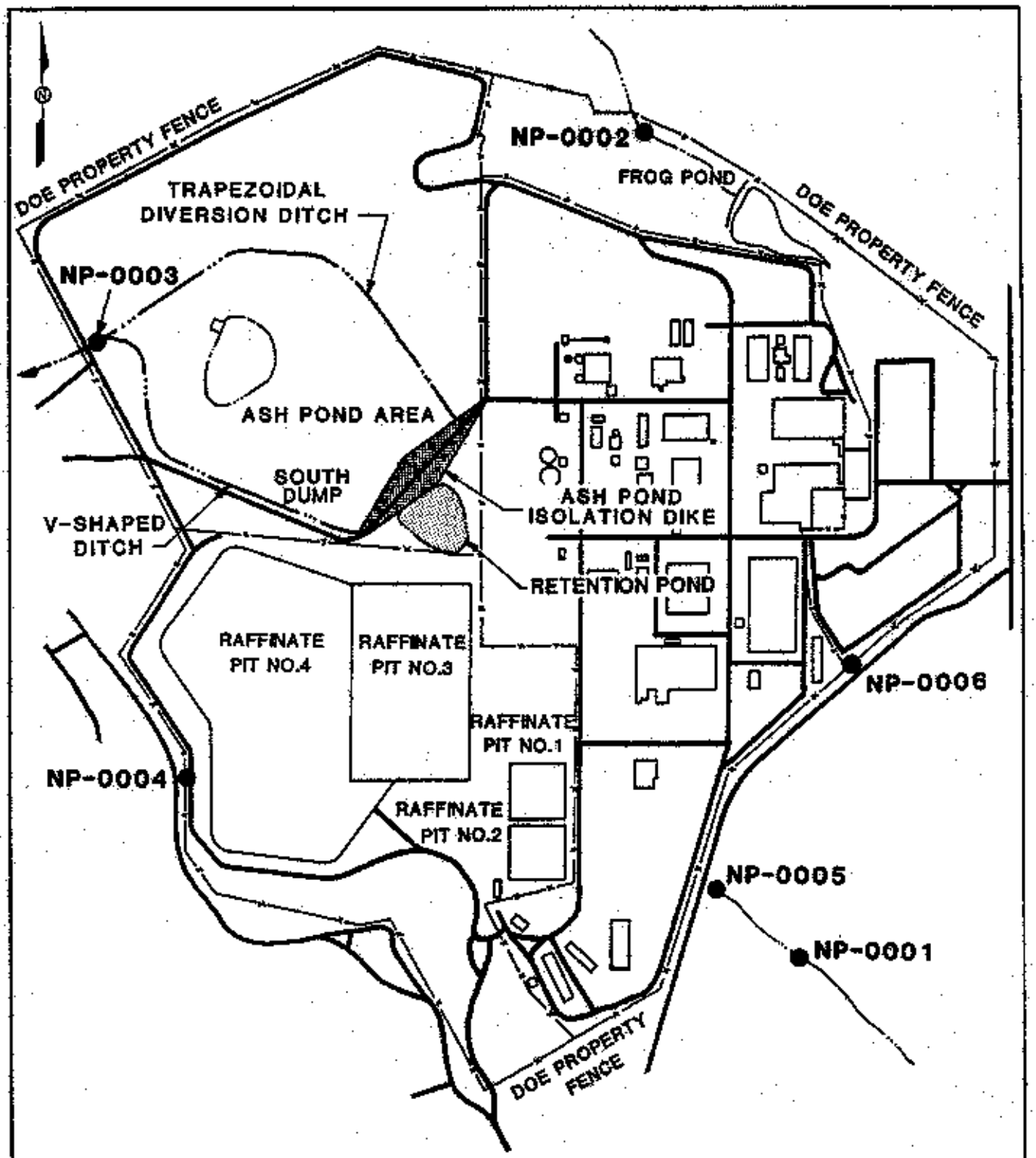
3.4 National Pollutant Discharge Elimination System Data Review

Surface water and effluent samples were collected and analyzed in compliance with the Weldon Spring Site National Pollutant Discharge Elimination System (NPDES) permit. This permit (Number MO-0107701) was issued in November 1988, and addresses storm water and wastewater discharges. Six discharge points or outfalls are included in this permit, and are shown on Figure 3-5. Outfalls NP-0001 through NP-0005 represent surface water discharge and NP-0006 represents the treated effluent discharge associated with the Administration Building sanitary wastewater treatment plant. Currently NP-0006 is the only outfall with effluent limitations. The five surface water outfalls have monitoring requirements only. Analytical data for the third quarter of 1990 is presented for each outfall in Table 3-3.

Radiological analyses of samples collected on September 27 are not yet available. This is indicated on the data tables for outfalls NP-0001, NP-0002, and NP-0005. No discharge due to precipitation occurred in September. Samples obtained on September 27 were associated with artificial flow events. Water hydrants supplied by the St. Charles County distribution system were utilized in performing flow studies during this time. Flow studies were conducted in the southeast drainage by the PMC and in the Frog Pond drainage by MDNR/DGLS. For this reason, these values may not be representative of normal flows associated with precipitation events.

Radiological Analysis

Gross Alpha and Total Uranium analyses correspond well with 1989 data. The highest uranium levels were present at NP-0001



SCALE 0 500 1000 FT
0 152.4 304.8 M

NPDES MONITORING LOCATIONS

FIGURE 3-5

REPORT NO: DOE/OR/21548-141	EXHIBIT NO: A/CP/069/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90

TABLE 3-3 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006

Outfall NP-0001 NPDES data for Q3 1990

DATE SAMPLED	FLOW GPD	SUSP. SOLIDS mg/l	SET. SOLIDS ml/l	NITRATE mg/l	pH mg/l	LITHIUM µg/l	GROSS ALPHA pCi/l	TOTAL URANIUM pCi/l
Jul. 11	28800	2.00	<0.1	1.09	6.84	ND	204.00	197.20
Sep. 27	14400	3.00	<0.1	1.67	7.28	0.0225	*	*
Maximum	28800	3.00	0.00	1.67	7.28	0.023	204.00	197.28
Minimum	14400	2.00	0.00	1.09	6.84	0.000	0.00	0.00
Average	21600	2.50	0.00	1.38	7.06	0.011	102.00	98.60

*Indicates data not yet available

Outfall NP-0002 NPDES data for Q3 1990

DATE SAMPLED	FLOW GPD	SUSP. SOLIDS mg/l	SET. SOLIDS ml/l	NITRATE mg/l	pH mg/l	LITHIUM µg/l	GROSS ALPHA pCi/l	TOTAL URANIUM pCi/l
Jul. 11	119687	380.00	<0.1	0.920	6.80	0.0070	113.00	86.00
Aug. 3	315260	488.00	0.1	0.560	6.55	0.0110	29.90	20.40
Sep. 27	159906	7.00	<0.1	0.208	8.60	0.0104	*	*
Maximum	315260.00	488.00	0.10	0.920	8.60	0.0110	113.00	86.00
Minimum	119687.00	7.00	0.00	0.208	6.55	0.0070	0.00	0.00
Average	198284.33	291.67	0.03	0.563	7.32	0.0095	47.63	35.47

* Indicates data not yet available

TABLE 3-3 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006 (Continued)

Outfall NP-0003 NPDES data for Q3 1990

DATE SAMPLED	FLOW GPD	SUSP. SOLIDS mg/l	SET. SOLIDS ml/l	NITRATE mg/l	pH mg/l	LITHIUM µg/l	GROSS ALPHA pCi/l	TOTAL URANIUM pCi/l
Jul. 11	11183	12.80	0.1	0.19	6.84	ND	70.30	95.00
Aug. 3	369540	104.00	<0.1	0.10	6.65	ND	5.09	5.24
Maximum	369540	104.00	0.10	0.19	6.84	0.000	70.30	95.00
Minimum	11183	12.80	0.00	0.10	6.65	0.000	5.09	5.24
Average	190361.5	58.40	0.05	0.15	6.75	0.000	38.20	51.12

Outfall NP-0004 NPDES data for Q3 1990

DATE SAMPLED	FLOW GPD	SUSP. SOLIDS mg/l	SET. SOLIDS ml/l	NITRATE mg/l	pH mg/l	LITHIUM µg/l	GROSS ALPHA pCi/l	TOTAL URANIUM pCi/l
Aug. 8	2880	34.00	<0.1	0.20	7.31	ND	9.38	6.45

TABLE 3-3 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006 (Continued)

Outfall NP-0005 NPDES data for Q3 1990

DATE SAMPLED	FLOW GPD	SUSP. SOLIDS mg/l	SET. SOLIDS ml/l	NITRATE mg/l	pH mg/l	LITHIUM mg/l	GROSS ALPHA pCi/l	TOTAL URANIUM pCi/l
Jul. 11	15300	<1.0	<0.1	0.93	6.58	ND	115.00	135.00
Aug. 3	243216	42.00	<0.1	1.90	6.74	ND	22.10	28.97
Sep. 27	330426	3.00	<0.1	1.29	7.39	0.0256	*	*
Maximum	330426	42.00	0.00	1.90	7.39	0.0256	115.00	135.00
Minimum	15300	0.00	0.00	0.93	6.58	0.0000	0.00	0.00
Average	196314	15.00	0.00	1.37	6.90	0.0085	45.70	54.66

* Indicates data not yet available

Outfall NP-0006 NPDES data for Q3 1990

DATE SAMPLED	FLOW GPD	SUSP. SOLIDS mg/l	BOD mg/l	FECAL COLIFORMS No./100ml	pH
Jul. 11	1090	3.00	3.00	<1.0	6.8

(discharge from the process sewer) followed by NP-0005 (surface flow from the southeast portion of the site combined with discharge from NP-0001). These relatively higher levels are consistent with 1989 data. Maximum values for uranium were 197.2 pCi/l at NP-0001 and 135 pCi/l at NP-0005, which are lower than maximum values for 1989.

Other outfalls exhibited the following range of uranium concentrations. NP-0002, the drainage from the Frog Pond area, ranged from 20.4 pCi/l to 88 pCi/l, which is slightly lower than 1989 values. NP-0003, drainage from the Ash Pond Diversion, ranged from 6.24 pCi/l to 96 pCi/l, which is lower than the 1989 values indicating the continued positive effect of the Ash Pond Diversion project. A uranium concentration of 6.45 was present in the third third quarter sample collected from NP-0004, raffinate pit #4 area.

Other Analysis

Other analyses include physical analysis (settleable solids and suspended solids) and chemical analysis (nitrate, pH, and lithium). Third quarter 1990 values generally correspond to 1989 values for the majority of parameters.

Settleable solids were less than 0.1 ml/l with the following two exceptions which were measured at 0.1 ml/l: NP-0003 on Jul. 11 and NP-0002 on Aug. 3. Suspended solids ranged from <1.0 mg/l (NP-0005 on Jul. 11) to 488 mg/l (NP-0002 on Aug. 3). The high suspended solids measurement for NP-0002 was caused in part by an accumulation of silt in the small basin above the weir. This accumulation of silt has been removed and subsequent suspended solids measurements have decreased significantly.

Nitrate values are slightly lower than 1989 values for all surface water outfalls and ranged from 0.1 mg/l (NP-0003 on August 3) to 1.90 mg/l (NP-0005 on August 3). Lithium was detected in outfalls NP-0001, NP-0002, and NP-0005 during the third quarter of 1990 and ranged from 0.0070 mg/l (NP-0002 on July 11) to 0.0256 mg/l (NP-0005 on September 27). These levels are relatively low and no Maximum Contaminant Level (MCL) exists for lithium in drinking water. Lithium levels were detected at all three outfalls in samples obtained on September 27. The sources of flow on this date were water hydrants supplied by the St. Charles County distribution network. As a control measurement during future flow study, additional samples will be collected directly from the hydrant source and analyzed for NPDES parameters. Lithium was detected in all three samples for third quarter 1990 at NP-0002. The PMC will continue to monitor these levels and attempt to determine the source of lithium in this drainage.

The discharge from the Administration Building treatment plant, NP-0006, has effluent limitations for quarterly samples. In addition to this quarterly monitoring, the subcontractor monitors the same parameters monthly, to assess plant performance. All data reported for third quarter 1990 was in compliance with permit effluent limitations.

Sampling was conducted in the Little Femme Osage Creek, near the Weldon Spring Quarry in order to assess erosion control measures associated with construction of the Quarry Staging Area and Water Treatment Plant Facilities. Although the treatment plant has not yet been constructed, the NPDES permit for this discharge (MO-0108987) requires that all runoff from construction and material storage areas remain within the following limits:

Total Suspended Solids: Less than 50.0 mg/l
pH greater than 6.0 and less than 9.0 (standard units)

Samples were collected from SW-1001 and SW-1002 on August 29 (See Figure 3-2). SW-1001 is located upstream of the Quarry Staging Area, and represents normally occurring concentrations in this drainage. SW-1002 is located immediately downstream of the Quarry Staging Area. Water quality impacts from QSA construction erosion are assessed by comparing values from these two locations. Results from these samples were as follows:

SW-1001	pH = 6.90	TSS=1.6 mg/l
SW-1002	pH = 7.17	TSS=<1.0 mg/l

These results indicate compliance with permit requirements.

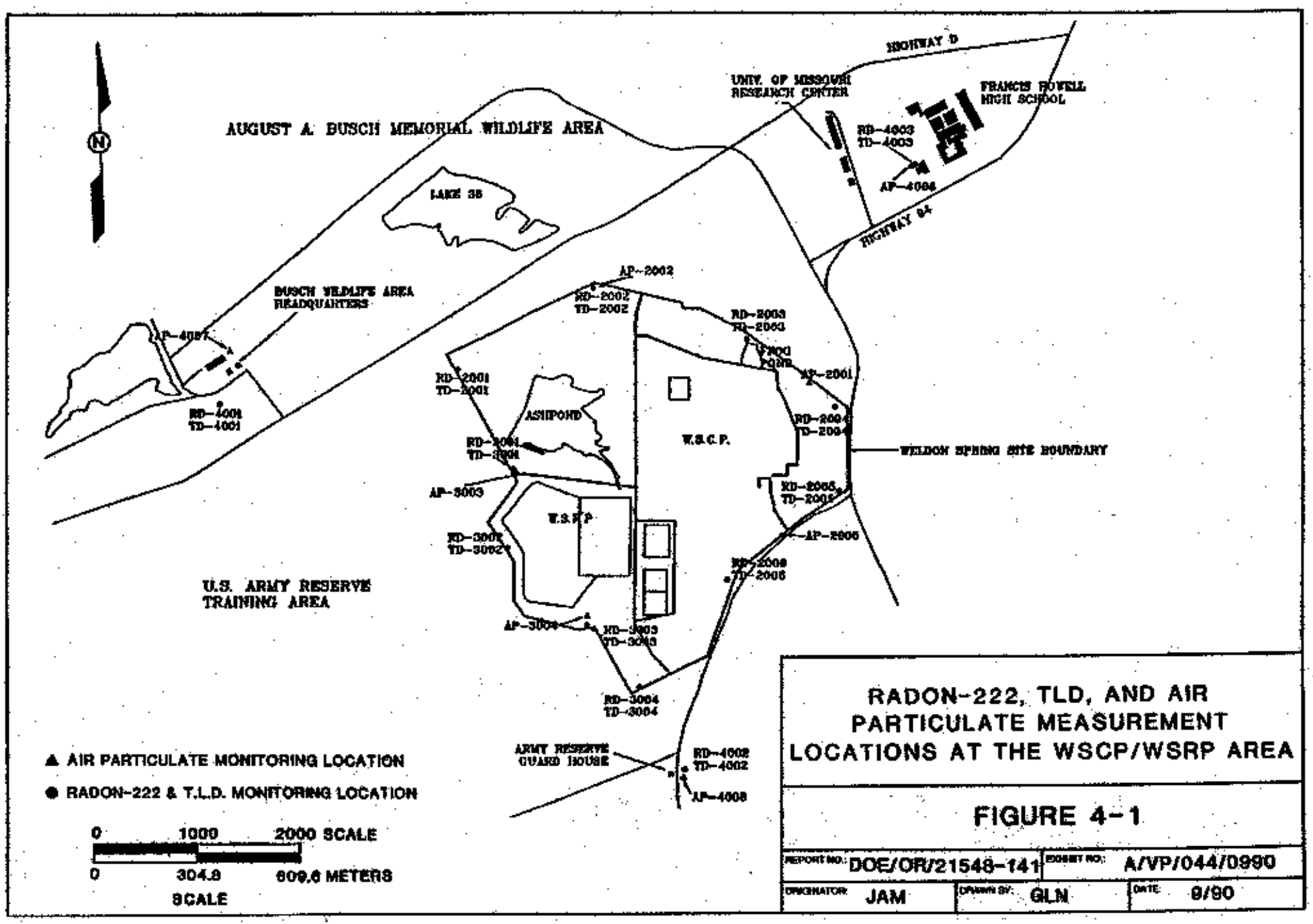
4 AIR MONITORING

4.1 Radon Gas

The radon gas monitoring program utilizes a pair of radon detectors at each of 22 permanent locations; each detector is exchanged quarterly. These detectors are deployed at six locations at the Weldon Spring chemical plant, six locations at the Weldon Spring quarry, four locations at the Weldon Spring raffinate pits, and six off-site locations. Radon monitoring locations are shown in Figures 4-1, 4-2, and 4-3. On-site detectors are spaced around the perimeter fences to ensure adequate detection of radon dispersing from the properties under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005, and RD-4006 were used to monitor background levels near the site.

Table 4-1 summarizes the quarterly and year-to-date average radon concentrations detected at all site perimeter and off-site monitoring locations. Also contained in Table 4-1 is a comparison of the measured year-to-date average concentration with the Federally permitted radon concentration for unrestricted areas of 3 pCi/l (110 Bq/m^3) above background as authorized by U.S. Department of Energy (DOE) Order 5400.5.

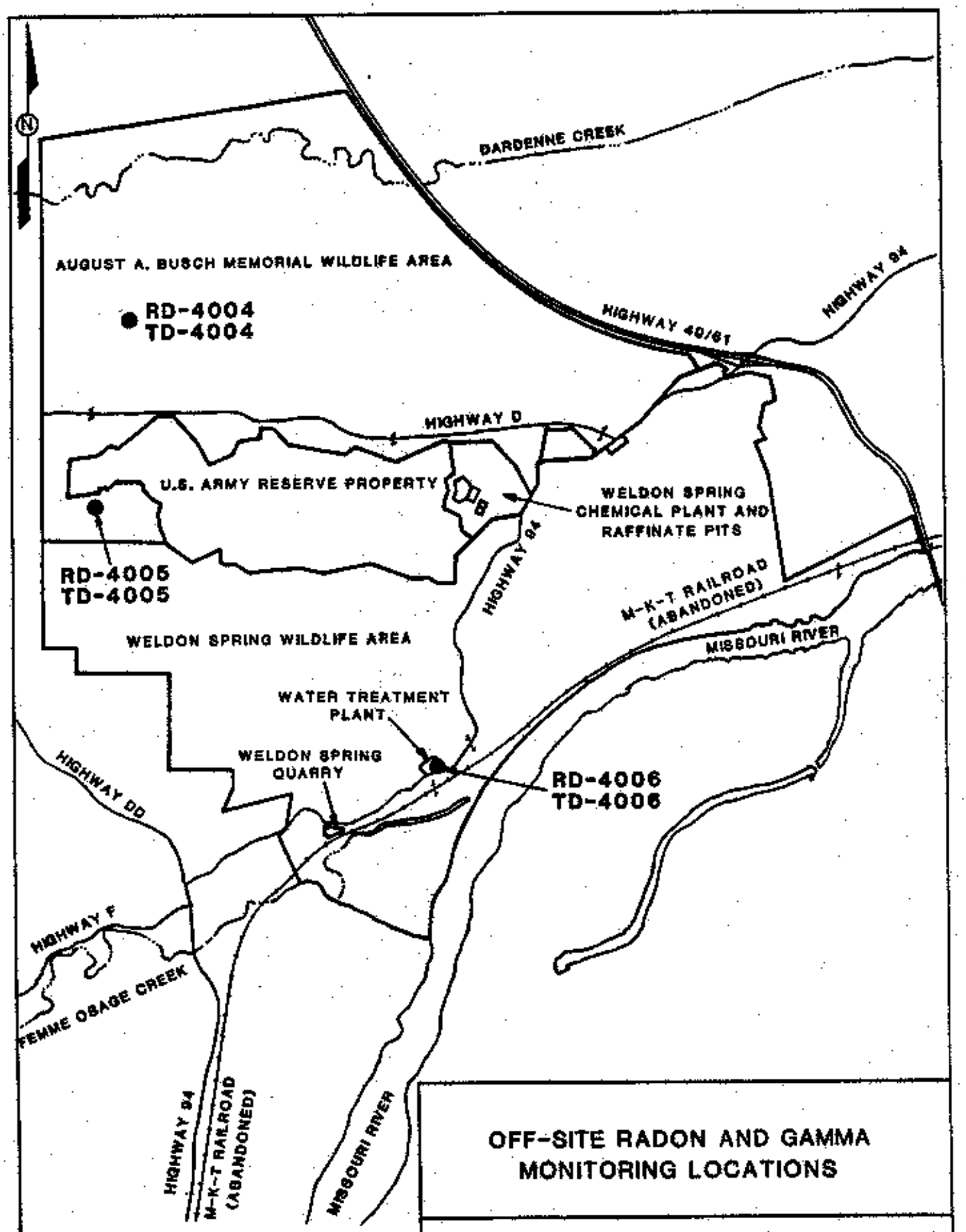
An average ambient background concentration was determined by calculating the arithmetic average for the four background locations. This data yielded a year-to-date average ambient background radon concentration of 0.33 pCi/l for the first three quarter of 1990. This concentration was then subtracted from the year-to-date average concentration for each monitoring station, and then compared to the DOE guideline of 3 pCi/l above background.



RADON-222, TLD, AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 4-1

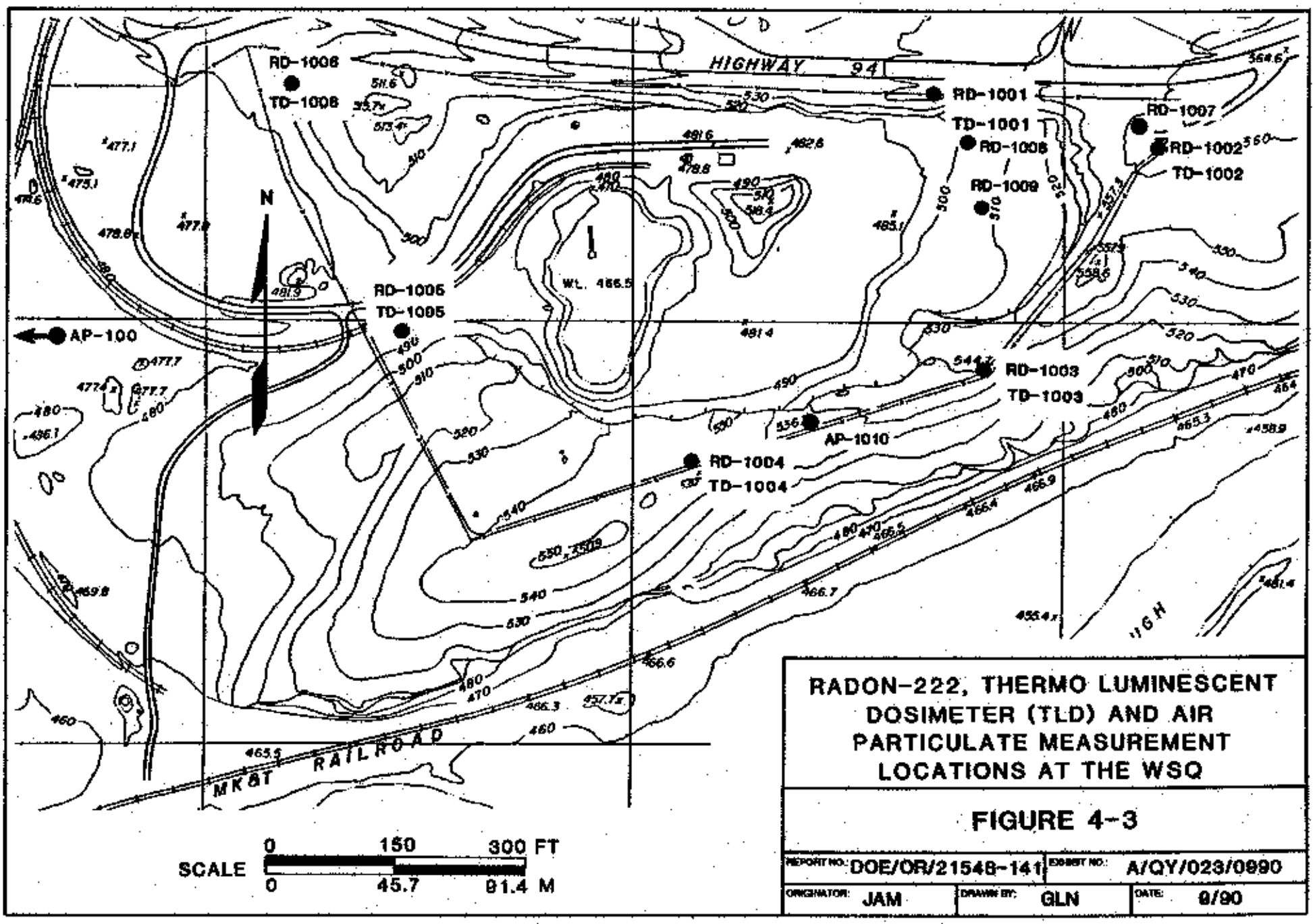
REPORT NO: DOE/OR/21548-141		DOCKET NO:	A/VP/044/0990
ORIGINATOR: JAM	DRAWN BY: GLN	DATE:	9/90



OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

FIGURE 4-2

REPORT NO.: DOE/OR/21548-141	EXHIBIT NO.: A/VP/045/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90



RADON-222, THERMO LUMINESCENT DOSIMETER (TLD) AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSQ

FIGURE 4-3

REPORT NO:	DOE/OR/21548-141	ESSBST NO:	A/QY/023/0990		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	9/90

TABLE 4-1 Calander Quarters 1, 2, and 3, 1990
Track Etch Radon Results (a)

LOCATION ID	1st QUARTER pCi/l	2nd QUARTER pCi/l	3rd QUARTER pCi/l	YEAR TO DATE AVERAGE pCi/l	PERCENT OF GUIDELINE (b)
WSQ					
RD-1001	1.1	1.4	2.4	1.6	43
RD-1002	1.4	2.1	3.1	2.2	62
RD-1003	1.0	0.5	1.0	0.8	17
RD-1004	0.3	0.4	0.8	0.5	6
RD-1005	0.8	0.5	0.8	0.7	12
RD-1006	0.5	0.3	0.5	0.4	3
WSCP					
RD-2001	0.4	0.3	0.5	0.4	2
RD-2002	0.4	0.1	0.4	0.3	0
RD-2003	0.4	0.1	0.7	0.4	2
RD-2004	0.3	0.1	0.4	0.3	0
RD-2005	0.5	0.1	0.4	0.3	0
RD-2006	0.4	0.2	0.4	0.3	0
WSRP					
RD-3001	0.3	0.1	0.5	0.3	0
RD-3002	0.3	0.1	0.4	0.3	0
RD-3003	0.5	0.1	0.5	0.4	1
RD-3004	0.3	0.1	0.5	0.3	0
OFF-SITE					
*RD-4001	0.3	0.1	0.7	0.4	1
RD-4002	0.3	0.1	0.3	0.2	0
RD-4003	0.3	0.1	0.4	0.3	0
*RD-4004	0.3	0.1	0.7	0.4	1
*RD-4005	0.5	0.1	0.3	0.3	0
*RD-4006	0.3	0.1	0.5	0.3	0

(a) Results include natural background.
(b) Percent of guideline calculated by taking the year-to-date average minus the average of the background stations divided by the DOE concentration guideline for RN-222 is 3 pCi/l (100 Bq/m^3) (Annual average above background) for uncontrolled areas.
* Denotes background station

Radon concentrations at the site perimeter and at off-site locations were lower for the third quarter of 1990 than for the third quarter of 1989. However, they are within the typical range expected during years of normal precipitation. The quarterly radon concentrations (background included) ranged from 0.3 pCi/l at two locations to 3.1 pCi/l at monitoring location RD-1002.

Radon concentrations found in the quarry are higher than concentrations measured at other locations because the radium concentrations in quarry wastes are typically much higher than other areas, and because the quarry is a large depression in the terrain with side walls ranging from 3 to 15 meters (10 to 50 feet) high. In conjunction with stable meteorological conditions, this configuration tends to trap emanating radon within the quarry and raise the concentrations along the quarry perimeter.

4.2 Gamma Radiation Exposure

To monitor exposure from gamma radiation, 22 monitoring stations using spherical environmental thermoluminescent dosimeters (TLDs) were deployed. The monitoring station locations are the same as the ambient radon monitoring locations (see Section 4.1).

Table 4-2 summarizes the quarterly and year-to-date results of total gamma radiation monitoring at the 16 WSS perimeter monitoring stations, Francis Howell High School, the Weldon Spring Army Reserve Training Area, and at the four background monitoring stations.

TABLE 4-2 1990 Environmental TLD Results (a)

LOCATION ID	1ST QUARTER MR	2ND QUARTER MR	3RD QUARTER MR	YEAR TO DATE TOTAL (b) MR
WBQ				
TD-1001	21	21	26	68
TD-1002	17	17	22	56
TD-1003	20	16	24	60
TD-1004	18	15	21	54
TD-1005	18	17	-	53
TD-1006	15	14	21	50
WSCP				
TD-2001	16	16	18	50
TD-2002	15	14	22	51
TD-2003	15	15	18	48
TD-2004	16	17	18	51
TD-2005	-	14	17	47
TD-2006	17	15	19	51
WSRP				
TD-3001	-	16	20	54
TD-3002	13	12	-	38
TD-3003	17	17	20	54
TD-3004	12	13	18	43
OFF-SITE				
*TD-4001	15	16	-	47
TD-4002	14	13	15	42
TD-4003	12	11	13	36
*TD-4004	14	16	20	50
*TD-4005	12	-	-	36
*TD-4006	13	13	19	45

(a) Results include natural background.
- Denotes loss of TLD
* Denotes background station.

(b) Year-to-date totals for locations where some quarterly data is unavailable was calculated using the average of the existing quarterly data in place of the unavailable data. Due to rounding of values, the sum of the quarterly data may not equal the year-to-date total.

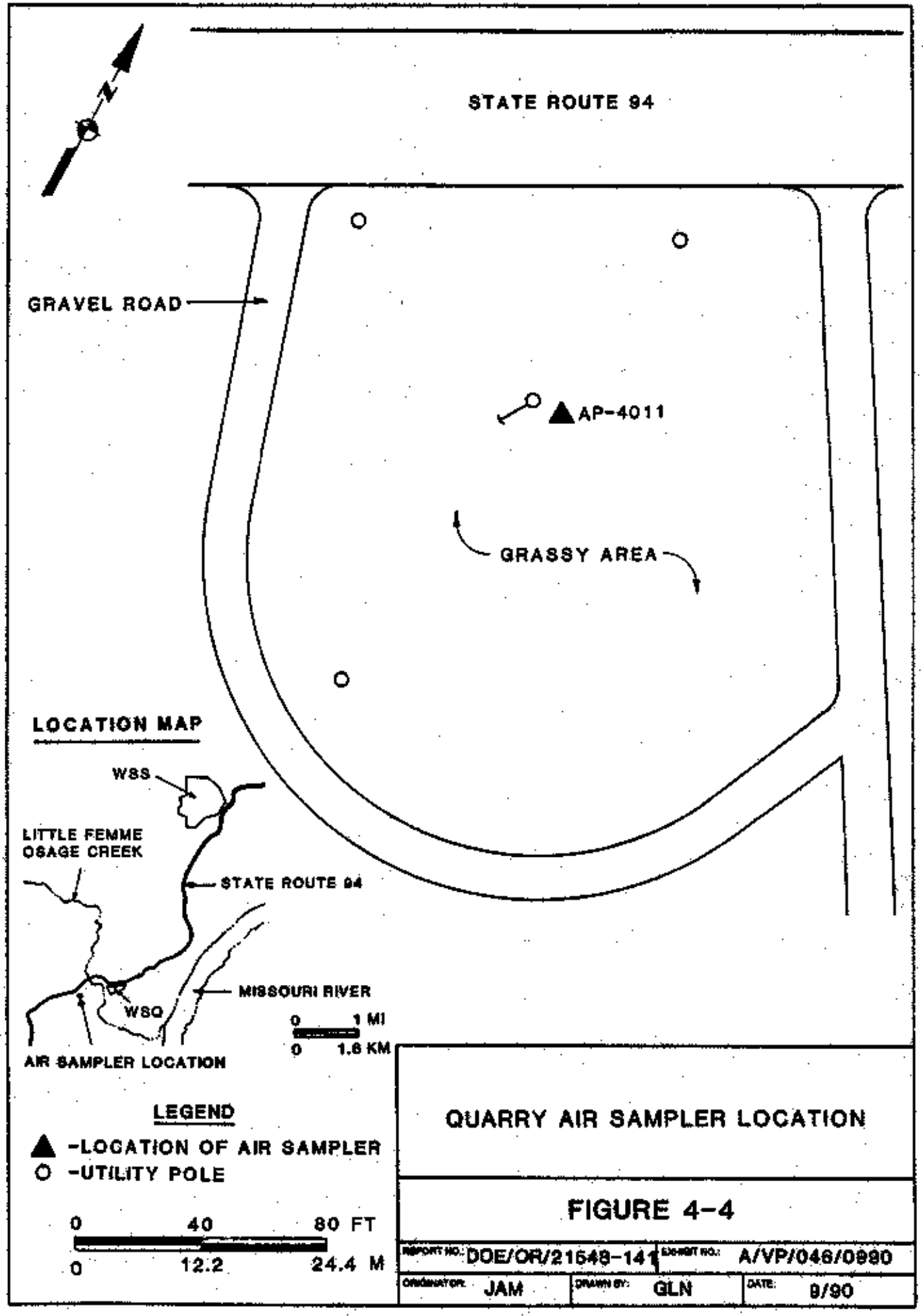
The yearly average background gamma exposure as measured with TLDs in 1989 was 68 mR/year. This would be equivalent to 51 mR/9 months which is comparable to the monitoring results of 45 mR/9 months obtained in the third quarter of 1990. This agreement with 1989 monitoring results was expected because no significant changes in the configuration or location of the wastes has occurred.

Due to external vandalism, the third quarter TLDs were missing for monitoring stations TD-1005, TD-3002, TD-4001, and TD-4005. In order to calculate a year-to-date total gamma exposure rate, the missing quarterly data were replaced with the average of the remaining quarterly TLD results for those monitoring stations.

4.3 Radioactive Air Particulates

Eleven air particulate samplers monitor the Weldon Spring site. Five of these (AP-2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the chemical plant (WSCP) perimeter and two are located around the quarry perimeter as shown in Figure 4-3. Three monitoring stations (AP-4006, AP-4008, and AP-4011) are located off site at sensitive receptor locations, including Francis Howell High School, the Army Reserve property, and a residential site west of the quarry. The monitoring station at the August A. Busch Wildlife Area (AP-4007) is used to monitor background levels in the vicinity of the WSCP. The off-site monitoring stations are also shown in Figure 4-4.

The sampling station near the August A. Busch Wildlife Area (ABWA) headquarters is used as a background air monitoring station. This station is approximately 0.8 km (0.5 mile) from the WSCP perimeter in a northwestern direction. The terrain



QUARRY AIR SAMPLER LOCATION

FIGURE 4-4

REPORT NO.: DOE/OR/21548-141	EXHIBIT NO.: A/VP/046/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90

between the WSCP and this sampling station is hilly and forested, providing a significant physical barrier to airborne particulates originating from the WSCP/WSRP. In addition, winds from the southeast are relatively rare at the WSCP.

Table 4-3 summarizes the quarterly average concentrations and the standard deviations for the 11 air monitoring locations. The quarterly average concentration for each monitoring location was calculated by averaging either the weekly air particulate analysis results or the counting instrument's lower limit of detection (LLD), whichever was greater. The "<" sign in Table 4-3 appears when the actual average is less than the calculated average due to the use of LLD values in the calculation. Locations AP-1009 and AP-1010 were not in operation for five weeks due to vandalism. All of the other measurements at the two locations were above the LLD values. The standard deviation for each of the monitoring locations was calculated using only results that were above the LLD.

The third quarter net alpha concentrations ranged from $<1.34 \times 10^{-15}$ µCi/ml to 2.12×10^{-15} µCi/ml with $<1.69 \times 10^{-15}$ µCi/ml detected at the background station.

4.4 Asbestos

Air sampling for asbestos has been performed on a routine basis for two years. The monitoring data indicate no elevated levels of airborne asbestos during both asbestos abatement operations and during periods when no asbestos activities were in progress at the site. Since asbestos removal and handling operations were not in progress during the third quarter, perimeter asbestos sampling was not performed. Upon commencement

TABLE 4-3 Third Quarter 1990 Radiological Air Particulate Results

IDENTIFICATION NUMBER	QUARTERLY AVG. CONCENTRTION (1E-15 µCi/ml)	STANDARD DEVIATION (1E-15 µCi/ml)	NUMBER OF VALUES ABOVE LLD
AP-1009	1.57	4.24	8
AP-1010	2.12	7.96	8
AP-2001	<1.36	3.5	9
AP-2002	<1.72	5.17	12
AP-2005	<1.59	3.08	11
AP-3003	<1.19	1.89	8
AP-3004	<1.36	4.54	10
AP-4006	<1.4	3.37	8
*AP-4007	<1.51	6.36	12
AP-4008	<1.56	6.57	11
AP-4011	<1.3	4.25	10

* Indicates background monitor station.
To convert µCi/ml to Bq/M^3 multiply by 3.7E10.

of any additional asbestos abatement activities, asbestos air particulate monitoring will resume.

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QUARTERLY ENVIRONMENTAL DATA SUMMARY FOURTH QUARTER 1990

For the
Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

Prepared by MK-Ferguson Company and Jacobs Engineering Group

MARCH 1991 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

032291

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Weldon Spring Site Remedial Action Project

Quarterly Environmental Data Summary
Fourth Quarter 1990

March 1991

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ABSTRACT AND WELDON SPRING SITE QUARTERLY SELF ASSESSMENT FOURTH QUARTER 1990

The purpose of this Quarterly Environmental Data Summary is to provide preliminary data acquired as part of the Weldon Spring Site Remedial Action Project (WSSRAP) environmental monitoring program. The document summarizes the environmental data, highlights any potentially significant findings, and offers tentative interpretations. Validated data and final interpretations will appear in the 1990 Annual Site Environmental Report.

This report includes data from environmental monitoring at the Weldon Spring site (WSS) during the fourth quarter of 1990. Groundwater, surface water, and air were sampled in order to monitor potential exposure pathways. Analytical parameters included radionuclides, nitroaromatic compounds, inorganic anions, and direct gamma exposure. The results are used to calculate exposure doses (where applicable) and assess the impact of the contaminants at the site on potentially exposed populations.

No significant differences were observed in off-site exposures during the fourth quarter of 1990 relative to exposures calculated in previous quarters. The WSS experienced a National Pollution Discharge Elimination System (NPDES) noncompliance on fecal coliform in December of 1990. The necessary steps have been taken to return the discharge to a compliance level. Contaminated groundwater did not affect private water supplies or the St. Charles County well field. Surface water containing elevated uranium activity continued to impact the Femme Osage Slough and several lakes in the August A. Busch Memorial Wildlife Area. Off-site gamma, radon and air particulate exposures remained indistinguishable from background. Off-site monitoring demonstrated that exposure levels at the Francis Howell High School, the Busch Wildlife Area Headquarters, and the Weldon Spring Training Area remain indistinguishable from background levels.

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1 INTRODUCTION

This document is the third in a series of documents designed to provide a summary of the findings from the routine environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). These documents supplement the Annual Site Environmental Reports (ASER) by providing interested outside agencies and organizations with more frequent access to WSSRAP data. They provide data resulting from routine environmental sampling as described in the WSSRAP Environmental Monitoring Plan and a brief interpretation of that data.

It is the goal of this document to summarize and briefly discuss the data, highlighting data that differ significantly from observations made in previous reports. The full interpretation of these data (as well as data in other quarterly summaries) will be undertaken in the 1990 ASER. It is recommended that interested readers refer to previous Environmental Monitoring Plans (EMPs), ASERs, and project documents for more information on existing site conditions, site history, transport mechanisms, and quantified contaminant levels. The monitoring scheme for every calendar year is established prior to that year in the annual EMP. Each sampling location to be monitored during the upcoming year is identified in the EMP and the analytical parameters are tabulated for easy reference. These reports may be obtained by visiting the WSSRAP reading room or contacting the WSSRAP Community Relations Manager at 314-441-8086.

These quarterly reports are intended to include data from all quarterly environmental monitoring programs conducted at the WSSRAP including groundwater, surface water, National Pollutant Discharge Elimination System, radon, gamma radiation, and air particulates (including asbestos and radioactive particulates). However, because of delays in data delivery from the analytical laboratories, some of the data that was expected to be included in this report are not yet available for reporting. The unavailability of data is due to a nationwide shortage in analytical services. WSSRAP is taking corrective action to ensure more timely availability of data in the future. These data will be reported in the 1990 Annual Site Environmental Report (ASER). Sludges, soils, and biological specimens are not sampled on a routine basis; therefore, analytical results for these parameters are not included in this report. Trend analyses are being prepared from historical data for surface water, groundwater and air pathways. These analyses will be presented in the 1990 ASER.

2 GROUNDWATER MONITORING

The groundwater is sampled regularly at both the Weldon Spring Chemical Plant/raffinate pits/vicinity properties (WSCP/RP/VP) and the Weldon Spring quarry (WSQ). Due to differences in the environmental settings and sources of contaminants, separate monitoring schedules are followed. Therefore, results of groundwater monitoring at the WSCP/RP/VP and WSQ will be discussed separately.

2.1 Chemical Plant/Raffinate Pits/Vicinity Properties

The groundwater at the chemical plant/raffinate pits/vicinity properties area is monitored on a semi-annual basis. Monitoring well locations are shown in Figure 2-1. Data from the semiannual groundwater monitoring for the second half of 1990 are presented in this fourth quarter data summary.

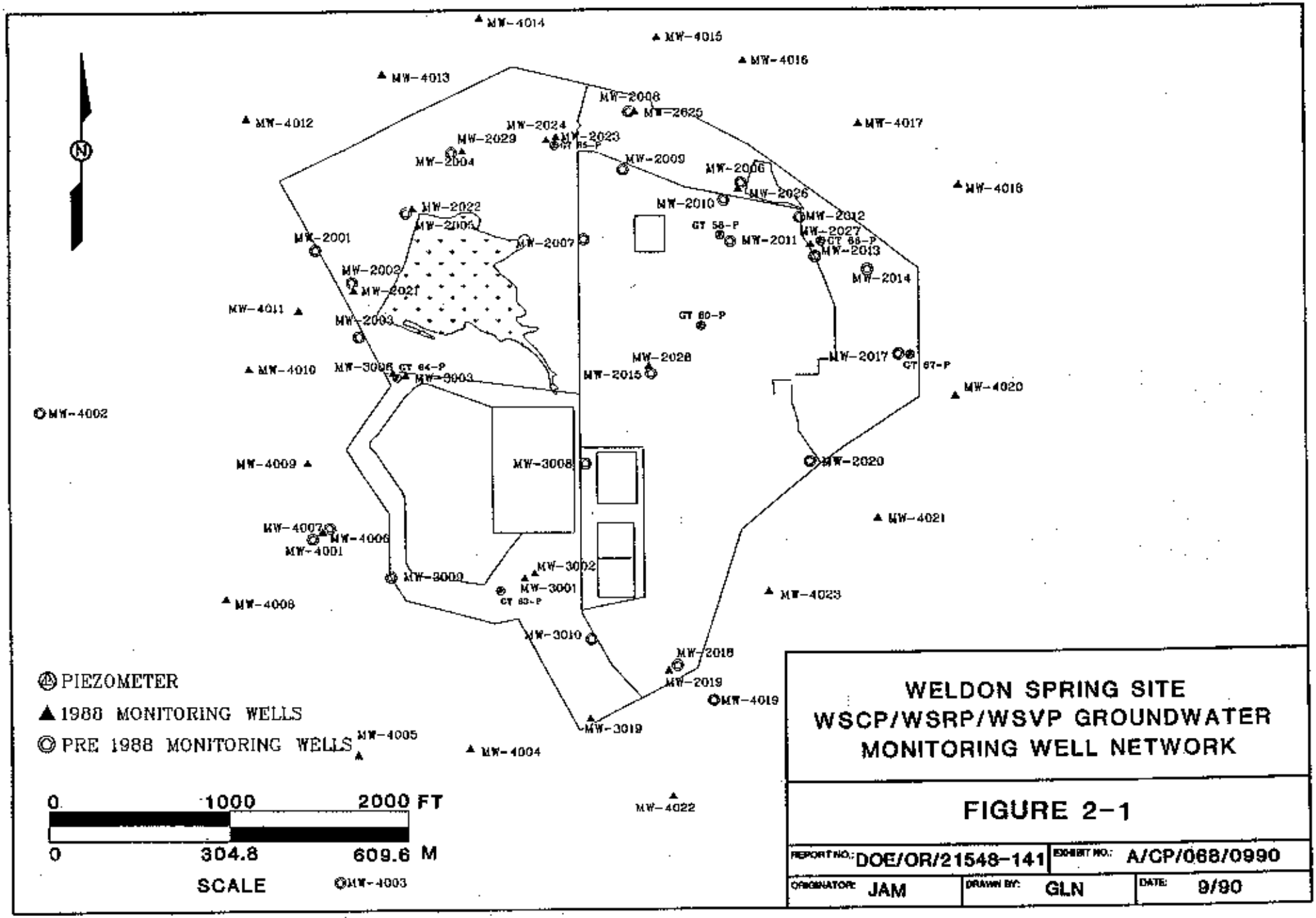
2.1.1 Nitroaromatic Results

Table 2-1 contains nitroaromatic data from samples from the monitoring wells at the CP/RP/VP area. Nitroaromatic compounds were detected in twenty samples. However, the data continue to reflect levels historically found and documented in previous environmental reports.

2.1.2 Radiological Results

The radiological results for samples from wells at the WSCP/RP/VP are presented in Table 2-2. The upper bound for natural uranium background concentrations in groundwater at the WSCP/WSRP/WSVP has been determined to be 3.4 pCi/l. The EPA has not yet established drinking water standards for uranium; however, studies leading to proposed rulemaking are using uranium in the 10 to 40 pCi/l range. The U.S. Department of Energy (DOE) has a derived concentration guideline (DCG) of 550 pCi/l.

The highest uranium level detected was 74.8 pCi/l from a sample obtained from Monitoring Well 3009; however, the data is not yet available from MW-3008 which previously has indicated higher levels. The other concentrations reported in Table 2-2 continue to indicate levels below the proposed drinking water standard for uranium;



WELDON SPRING SITE
WSCP/WSRP/WSVP GROUNDWATER MONITORING WELL NETWORK

FIGURE 2-1

REPORT NO.:	DOE/OR/21548-141	EXHIBIT NO.:	A/CP/068/0990		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	9/90

TABLE 2-1 Second Semester Nitroaromatic Data for Groundwater at the WSCP/RP/VP

SAMPLE ID	NB	1,3-DNB	2,4-DNT	2,6-DNT	2,4,6-TNT	1,3,5-TNB
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
GW-2001-082190	ND	ND	0.071	0.048	ND	0.032
GW-2002-101190	ND	ND	0.083	0.49	ND	ND
GW-2003-071790	ND	ND	0.28	1.2	ND	ND
GW-2004-090590	ND	ND	ND	ND	ND	ND
GW-2005-071890	ND	ND	0.079	0.050	ND	ND
GW-2006-090690	ND	ND	ND	1.6	0.039	11
GW-2007-090690	ND	ND	ND	ND	ND	ND
GW-2008-090690	ND	ND	ND	0.72	0.036	0.91
GW-2009-081690	ND	ND	ND	0.35	ND	ND
GW-2010-071890	ND	0.20	0.032	0.75	0.55	0.24
GW-2011	Not Available					
GW-2012-082190	ND	ND	ND	1.4	0.74	3.5
GW-2013						
GW-2014	NA					
GW-2015-071990	ND	ND	ND	ND	ND	ND
GW-2017-090490	ND	ND	ND	1.2	ND	0.074
GW-2018-101790	ND	ND	ND	ND	ND	ND
GW-2019-111390	ND	ND	ND	ND	ND	ND
GW-2020						
GW-2021-101190	ND	ND	ND	ND	ND	ND
GW-2022-101190	ND	ND	ND	ND	ND	ND

TABLE 2-1 Second Semester Nitroaromatic Data for Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	NB	1,3-DNB	2,4-DNT	2,6-DNT	2,4,6-TNT	1,3,5-TNB
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
GW-2023-121990 *	ND	ND	ND	ND	ND	ND
GW-2024-121890 *	ND	ND	ND	ND	ND	ND
GW-2025-101890	ND	ND	ND	ND	ND	ND
GW-2026-121890 *	ND	ND	ND	ND	ND	ND
GW-2027-112090	ND	ND	ND	ND	ND	ND
GW-2028-120490	ND	ND	ND	ND	ND	ND
GW-2029-090590	ND	ND	ND	ND	ND	ND
GW-3001-092090	ND	ND	0.66	0.2	ND	0.14
GW-3002-112090	ND	ND	ND	ND	ND	ND
GW-3003-082290	ND	ND	0.034	0.073	ND	ND
GW-3006-082290	ND	ND	ND	ND	ND	ND
GW-3008	NA					
GW-3009-111390	ND	ND	0.11	0.057	ND	0.11
GW-3010-112890	ND	ND	ND	ND	ND	ND
GW-3019-073190	ND	ND	ND	ND	ND	ND
GW-4001-072490	ND	ND	3.1	3.1	2.0	58.0
GW-4002-091990	ND	ND	ND	0.13	0.2	0.27
GW-4003	ND	ND	ND	ND	ND	ND
GW-4004-121090	ND	ND	ND	ND	ND	ND
GW-4005-110190	ND	ND	ND	ND	ND	ND
GW-4006-072490	ND	ND	ND	3.5	ND	17.0

TABLE 2-1 Second Semester Nitroaromatic Data for Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	NB	1,3-DNB	2,4-DNT	2,6-DNT	2,4,6-TNT	1,3,5-TNB
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
GW-4007-121190	ND	ND	ND	ND	ND	ND
GW-4008-101890	ND	ND	ND	ND	ND	ND
GW-4009-072690	ND	ND	ND	ND	ND	ND
GW-4010-110190	ND	ND	ND	ND	ND	ND
GW-4011-110890	ND	ND	ND	ND	ND	ND
GW-4012-072590	ND	ND	ND	ND	ND	ND
GW-4013-120590	ND	ND	0.043	1.3	0.067	34.0
GW-4014-120590	ND	ND	ND	0.12	0.057	0.48
GW-4015-120590	ND	ND	0.047	2.2	0.03	0.15
GW-4016-073190	ND	ND	ND	ND	ND	ND
GW-4017-073190	ND	ND	ND	ND	ND	ND
GW-4018-062090	ND	ND	ND	ND	ND	ND
GW-4019-102290	ND	ND	ND	ND	ND	ND
GW-4020-102490	ND	ND	ND	ND	ND	ND
GW-4021-072690	ND	ND	ND	ND	ND	ND
GW-4022-062090	ND	ND	ND	ND	ND	ND
GW-4023-072690	ND	ND	0.075	0.028	ND	0.10

TABLE 2-2 Second Semester Uranium Data in Groundwater at WSCP/RP/VP

SAMPLE ID	Uranium
	pCi/l
GW-2002-101190	ND
GW-2003-071790	1.6
GW-2005-071890	4.7
GW-2010-071890	18.7
GW-2013-070590	0.9
GW-2013-121990	ND
GW-2014-121990	ND
GW-2015-071890	2.5
GW-2018-101790	2.7
GW-2019-111390	4.76
GW-2020-120490	5.4
GW-2021-101190	1.4
GW-2022-101190	1.4
GW-2023-121990	10.9
GW-2024-121890	1.4
GW-2025-101890	ND
GW-2026-121890	0.7
GW-2027-112090	1.4
GW-2028-120490	2.0
GW-3002-112090	3.4
GW-3009-111390	74.8
GW-3010-112890	ND
GW-3019-073190	6.7
GW-4001-072490	1.0
GW-4004-120190	2.7
GW-4005-110190	24.5
GW-4006-072490	1.3
GW-4007-121190	5.4
GW-4008-101890	1.4

TABLE 2-2 Second Semester Uranium Data in Groundwater at WSCP/RP/VP (Continued)

SAMPLE ID	Uranium
	pCi/l
GW-4009-072690	3.7
GW-4010-110190	8.2
GW-4011-110690	3.4
GW-4012-072590	3.5
GW-4013-120590	14.3
GW-4014-120590	1.4
GW-4015-120590	3.4
GW-4016-073190	5.4
GW-4017-073190	1.1
GW-4018-102290	4.6
GW-4020-102490	19.7
GW-4021-072690	7.7
GW-4023-072690	2.0

ND – Not Detected

however, several wells do indicate higher levels than historically present at those locations. The ASER will evaluate these levels and trends.

2.2 Weldon Spring Quarry

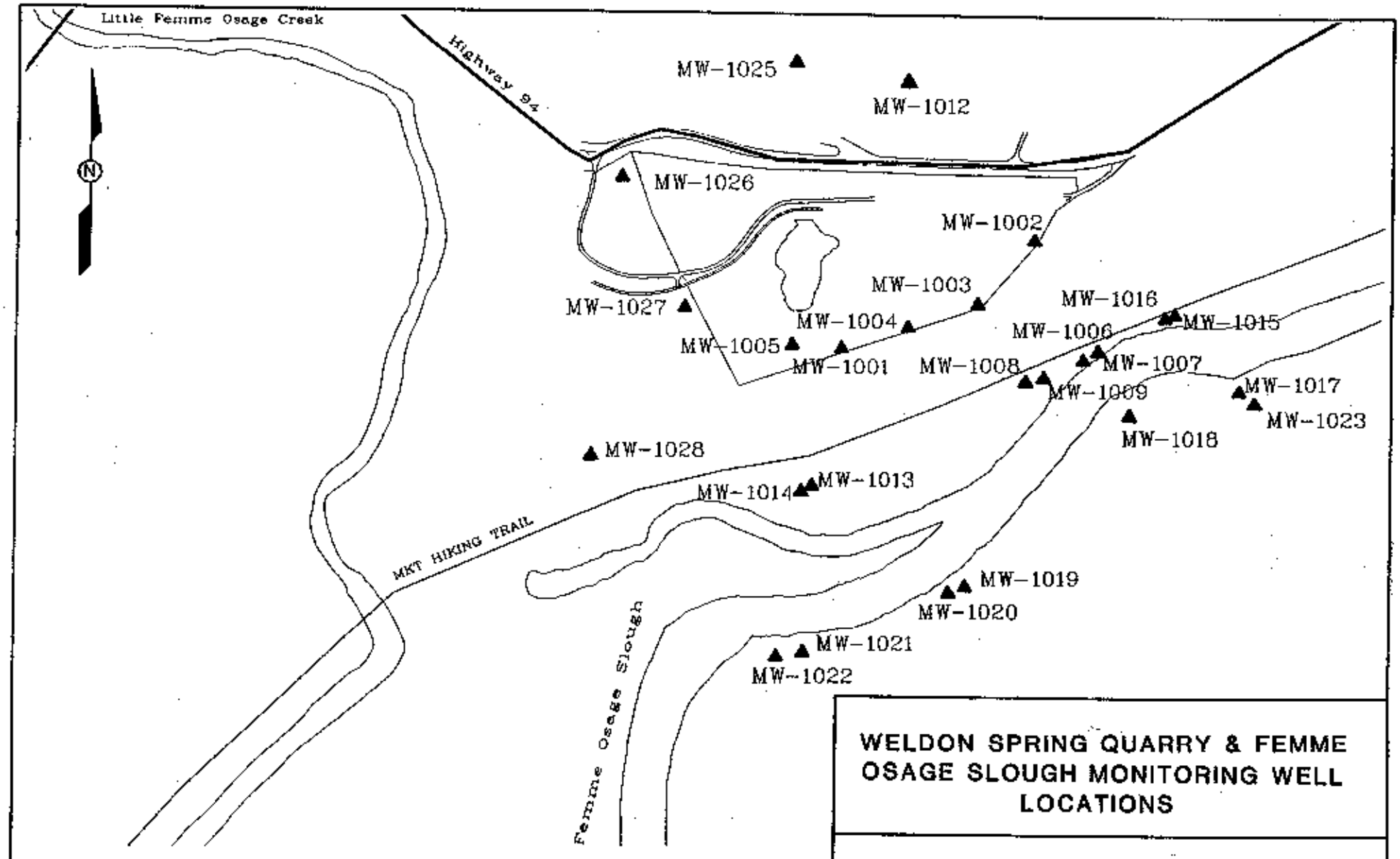
Chemical and radiological wastes at the quarry are of particular concern because of their proximity to the St. Charles County well field. The well field is located approximately one-half mile to the south. Monitoring of contaminants in groundwater and the protection of the well field is a top WSSRAP priority.

Groundwater is monitored in 30 wells in and around the quarry. Twenty-six monitoring wells installed by the U.S. Department of Energy (DOE) currently exist in or near the quarry. Four additional monitoring wells were installed by St. Charles County in 1986. All monitoring well locations are shown in Figures 2-2 and 2-3. These wells currently draw water from both bedrock and alluvial aquifers.

Two separate groundwater monitoring programs have been developed for the quarry. The first program is a semiannual sampling of all wells north of the Femme Osage Slough. The second program monitors the area south of the Femme Osage Slough, including the St. Charles County well field. Active production wells and monitoring wells are sampled quarterly. The raw and treated waters from the St. Charles County water treatment plant are also sampled. This portion of the quarry groundwater monitoring program has been jointly developed by representatives of the DOE, the Missouri Department of Natural Resources (MDNR), the U.S. Environmental Protection Agency (EPA), and St. Charles County.

2.2.1 Radiological Results

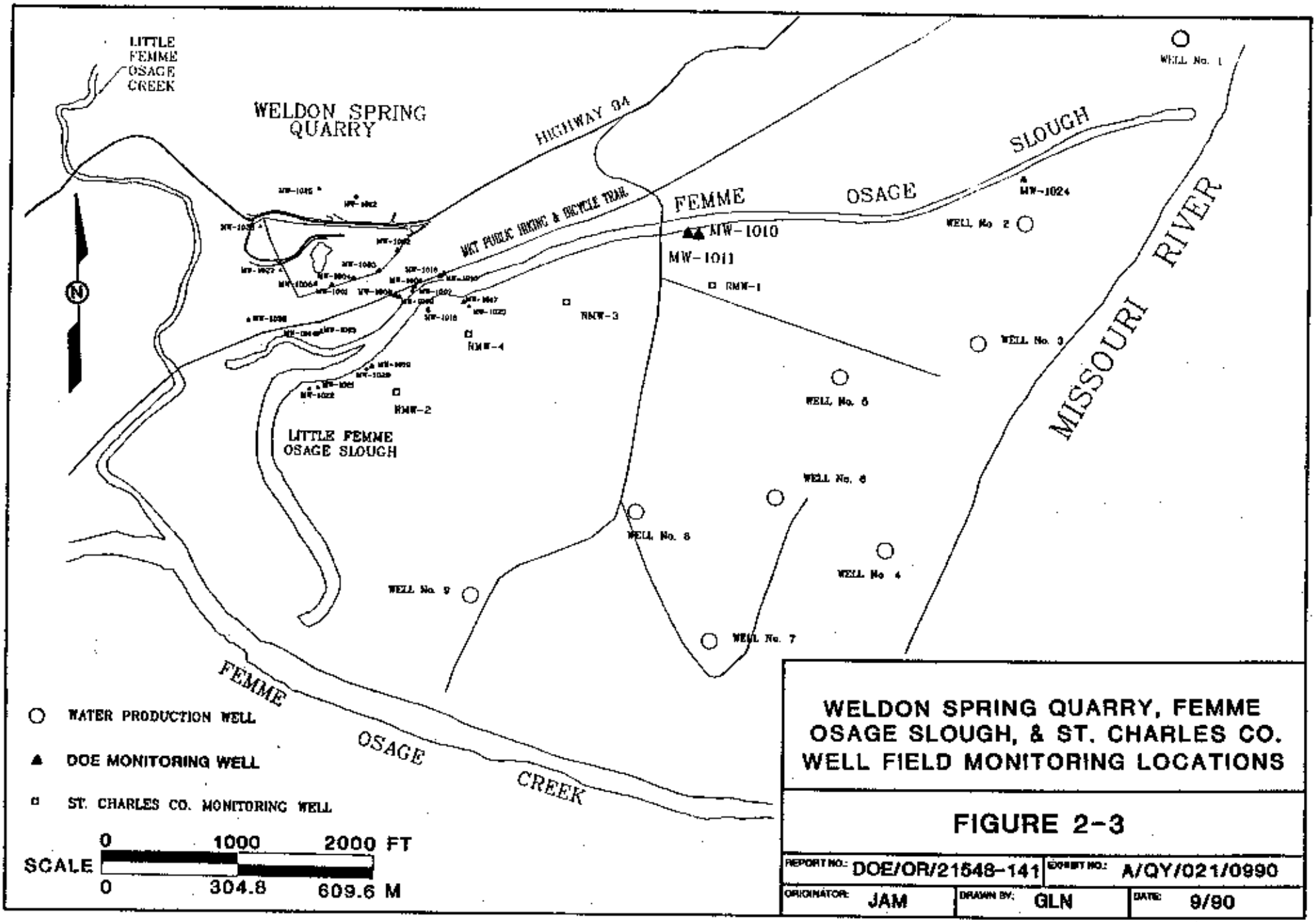
Radiological data are presented in Tables 2-3A and 2-3B for samples collected on semi-annual and quarterly bases, respectively. Some radiological data are not yet received from the analytical laboratory but will be included in the 1990 ASER. The results show fluctuations around the average levels in the WSQ area with no dramatic increases evident. Trend analyses will be presented in the 1990 ASER. The data in Table 2-3B also indicate no uranium levels of concern south of the slough.



WELDON SPRING QUARRY & FEMME OSAGE SLOUGH MONITORING WELL LOCATIONS

FIGURE 2-2

REPORT NO.: DOE/OR/21548-141	EXHIBIT NO.: A/QY/020/0990		
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90	



WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, & ST. CHARLES CO. WELL FIELD MONITORING LOCATIONS

FIGURE 2-3

REPORT NO.: DOE/OR/21548-141		EDMS/IDC NO.: A/QY/021/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90	

TABLE 2-3A Second Semester Results of Analyses for Inorganic Anions and Radiological Parameters in Groundwater for the WSQ

	Nitrate	Sulfate	Chloride	Fluoride	Uranium	Gross Alpha
QUARRY	(mg/l)	(mg/l)	(mg/l)	(mg/l)	pCi/l	pCi/l
GW-1002-103190	0.7	55.0	9.4	0.4	0.7	NA
GW-1004-103190	0.6	330	27.8	1.2	5864	NA
GW-1005-103190	ND	268	25.2	1.0	2992	NA
GW-1006-110790	1.3	675	37.0	0.4	3332	NA
GW-1007-110790	ND	28.8	64.5	0.4	177	NA
GW-1008-110690	ND	351	24.0	0.5	3536	NA
GW-1009-110690	ND	268	25.5	0.4	8.2	NA
GW-1010-061490	ND	ND	5.4	ND	0.2 +/- 0.02	NA
GW-1011-061490	ND	34.0	9.4	ND	6.9 +/- 0.7	NA
GW-1012-121290	1.3	35.2	8.1	0.4	2.0	NA
GW-1013-110690	ND	120	20.5	0.5	952	NA
GW-1014-110690	ND	134	23.0	0.5	962	NA
GW-1015-110790	1.9	474	29.0	0.4	639	NA
GW-1016-110790	1.8	229	19.0	0.4	190	NA
GW-1025-121390	ND	134	5.5	ND		NA
GW-1026-121290	ND	ND	2.0	ND	ND	NA
GW-1027-102490	Not Available	NA	NA	NA	653	NA

TABLE 2-3A Second Semester Results of Analyses for Inorganic Anions and Radiological Parameters in Groundwater for the WSQ (Continued)

	Nitrate	Sulfate	Chloride	Fluoride	Uranium	Gross Alpha
QUARRY	(mg/l)	(mg/l)	(mg/l)	(mg/l)	pCi/l	pCi/l
GW-1028-102490	NA	NA	NA	NA	7.5	NA
GW-1027-122090	ND	156	14.8	0.4	NA	NA
GW-1028-122090	ND	50.1	8.9	ND	NA	NA

ND -- Not Detected
NA -- Not Applicable

TABLE 2-3B Fourth Quarter Inorganic Anions and Radiological Data Summary for the WSQ

QUARRY	Nitrate (mg/l)	Sulfate (mg/l)	Chloride (mg/l)	Fluoride (mg/l)	Uranium pCi/l	Gross Alpha pCi/l
GW-PW02-Q490	NA	NA	NA	NA	ND	0 ± 3
GW-PW03-Q490	NA	NA	NA	NA	3.4	2 ± 3
GW-PW04-Q490	NA	NA	NA	NA	2.0	1 ± 3
GW-PW05-Q490	NA	NA	NA	NA	ND	0 ± 3
GW-PW06-Q490	NA	NA	NA	NA	ND	1 ± 4
GW-PW07-Q490	NA	NA	NA	NA	ND	0 ± 4
GW-PW08-Q490	NA	NA	NA	NA	ND	0 ± 4
GW-PW09-Q490	NA	NA	NA	NA	ND	3 ± 4
GW-RAWW-Q490					2.7	2 ± 3
- Untreated water from water treatment plant						
GW-FINW-Q490	NA	NA	NA	NA	ND	1 ± 2
- Treated water from water treatment plant						
GW-RMW1-Q490	ND	23.5	7.75	ND	1.4	2 ± 5
GW-RMW2-Q490	ND	26.6	4.24	0.35	4.6	10 ± 6
GW-RMW3-Q490	ND	61.6	12.2	ND	ND	0 ± 6
GW-RMW4-Q490	ND	18.5	10.2	0.27	3.4	4 ± 6
GW-1024-Q490	ND	11.0	11.7	0.35	ND	1 ± 5
GW-1017-Q490	ND	2.7	18.9	0.2	1.4	NS
GW-1018-Q490	ND	105	22.6	0.2	ND	NS

TABLE 2-3B Fourth Quarter Inorganic Anions and Radiological Data Summary for the WSQ (Continued)

	Nitrate	Sulfate	Chloride	Fluoride	Uranium	Gross Alpha
QUARRY	(mg/l)	(mg/l)	(mg/l)	(mg/l)	pCi/l	pCi/l
GW-1019-Q490	ND	4.5	6.3	0.2	ND	NS
GW-1020-Q490	ND	25.2	9.4	0.3	3.4	NS
GW-1021-Q490	ND	ND	9.4	0.2	ND	NS
GW-1022-Q490	ND	2.0	9.4	0.2	ND	NS
GW-1023-Q490	ND	3.8	5.3	0.3	1.4	NS

ND – Not Detected
NA -- Not Analyzed

TABLE 2-4A Fourth Quarter Nitroaromatic Data for Groundwater at the WSQ

SAMPLE ID	NB	1,3-DNB	2,4-DNT	2,6-DNT	2,4,6-TNT	1,3,5-TNB
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
GW-1002-103190	ND	0.27	ND	4.4	10.0	52.0
GW-1004-103190	ND	ND	1.6	3.8	4.2	0.79
GW-1005-103190	ND	ND	0.16	0.062	ND	ND
GW-1006-110790	ND	0.19	0.16	7.4	16.0	120
GW-1007-110790	ND	ND	ND	ND	ND	ND
GW-1008-110690	ND	0.14	ND	ND	ND	ND
GW-1009-110690	ND	ND	ND	ND	ND	ND
GW-1010-081490	ND	ND	ND	ND	ND	ND
GW-1011-081490	ND	ND	ND	ND	ND	ND
GW-1012-121290	ND	ND	ND	ND	ND	ND
GW-1013-110690	ND	ND	0.038	ND	ND	ND
GW-1014-110690	ND	ND	0.031	ND	ND	ND
GW-1015-110790	ND	0.22	ND	0.56	4.9	11.0
GW-1016-110790	ND	0.20	ND	0.070	0.28	0.48
GW-1025-121390	ND	ND	ND	ND	ND	ND
GW-1026-121290	ND	ND	ND	ND	ND	ND
GW-1027-102490	ND	ND	12	6.7	28	0.13
GW-1028-102490	ND	ND	ND	ND	ND	ND

ND – Not Detected

TABLE 2-4B Fourth Quarter Nitroaromatic Data for Groundwater at the WSQ

SAMPLE ID	NB	1,3-DNB	2,4-DNT	2,6-DNT	2,4,6-TNT	1,3,5-TNB
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
GW-1017-Q490	ND	ND	ND	ND	ND	ND
GW-1018-Q490	ND	ND	ND	ND	ND	ND
GW-1019-Q490	ND	ND	ND	ND	ND	ND
GW-1020-Q490	ND	ND	ND	ND	ND	ND
GW-1021-Q490	ND	ND	ND	ND	ND	ND
GW-1022-Q490	ND	ND	ND	ND	ND	ND
GW-1023-Q490	ND	ND	ND	ND	ND	ND
GW-1024-Q490	ND	ND	ND	ND	ND	ND
GW-RMW1-Q490	ND	ND	ND	ND	ND	ND
GW-RMW2-Q490	ND	ND	ND	ND	ND	ND
GW-RMW3-Q490	ND	ND	ND	ND	ND	ND
GW-RMW4-Q490	ND	ND	ND	ND	ND	ND
GW-PW02-Q490	ND	ND	ND	ND	ND	ND
GW-PW03-Q490	ND	ND	ND	ND	ND	ND
GW-PW04-Q490	ND	ND	ND	ND	ND	ND
GW-PW05-Q490	ND	ND	ND	ND	ND	ND
GW-PW06-Q490	ND	ND	ND	ND	ND	ND
GW-PW07-Q490	ND	ND	ND	ND	ND	ND
GW-PW08-Q490	ND	ND	ND	ND	ND	ND

TABLE 2-4B Fourth Quarter Nitroaromatic Data for Groundwater at the WSQ (Continued)

SAMPLE ID	NB	1,3-DNB	2,4-DNT	2,6-DNT	2,4,6-TNT	1,3,5-TNB
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
GW-PW09-Q490	ND	ND	ND	ND	ND	ND
GW-RAWW-Q490	ND	ND	ND	ND	ND	ND
GW-FINW-Q490	ND	ND	ND	ND	ND	ND

2.2.2 Nitroaromatic Compounds Results

Analytical results for nitroaromatic compounds are presented in Tables 2-4A and 2-4B. No monitoring wells south of the Femme Osage Slough showed detectable concentrations of nitroaromatic compounds during the third quarter 1990. The distribution of nitroaromatic contamination near the quarry remains unchanged.

2.2.3 Inorganic Anions Results

Four inorganic anions--nitrate, sulfate, chloride, and fluoride--were measured in quarry wells. Tables 2-3A and 2-3B display the analytical results for the fourth quarter of 1990, which are consistent with data reported in the previous environmental monitoring reports. The WSQ groundwater samples continue to indicate no significant groundwater contamination by nitrate. The groundwater samples continue to indicate background concentrations of sulfate in wells south of the Femme Osage Slough. Results of chloride analyses of groundwater south of the Femme Osage Slough continue to indicate background concentrations. Results of fluoride analyses indicate no detectable levels for fourth quarter 1990.

2.2.4 Metals Results

A selected group of quarry wells located south of the Femme Osage Slough were sampled for arsenic and barium. Analytical results for these metals are presented in Table 2-5. Results from fourth quarter analyses of arsenic and barium continue to indicate elevated concentrations in selected wells. The highest levels reported for the fourth quarter are 37.9 µg/l for arsenic in RMW-3 and 458 µg/l for barium as detected in Monitoring Well RMW-1.

TABLE 2-5 Fourth Quarter Results for Metals in Groundwater at the WSQ

QUARRY	ARSENIC µg/l	BARIUM µg/l
GW-1024-Q3Q0	ND	182
GW-RMW1-Q3Q0	6.8	458
GW-RMW2-Q3Q0	16.1	158
GW-RMW3-Q3Q0	37.9	394
GW-RMW4-Q3Q0	35.3	159
GW-RAWW-Q3Q0	6.4	311
GW-FINW-Q3Q0	ND	69.2

ND - Not Detected

3 SURFACE WATER MONITORING

Routine samples were collected during the fourth quarter of 1990 from both on-site and off-site surface water locations. All surface water samples were analyzed without filtering, unless a specific comparison of dissolved versus total contaminant concentrations was desired.

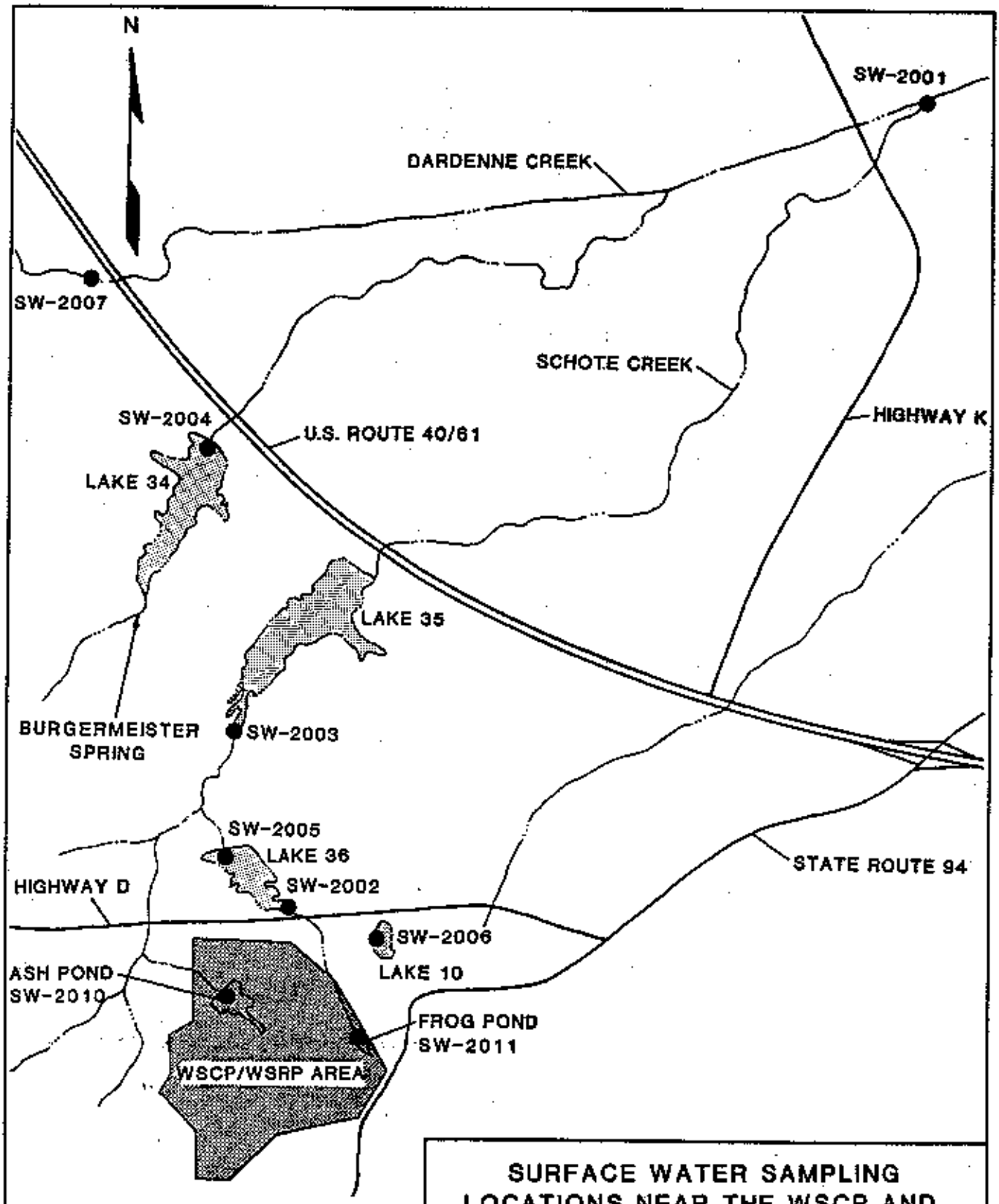
3.1 Chemical Plant/Raffinate Pits/Vicinity Properties

During the fourth quarter, surface water samples were collected from the nine locations shown in Figure 3-1 and analyzed for uranium. The results, presented in Table 3-1, indicate that conditions remain similar with values within the range measured historically with the highest level (102 pCi/l) again detected at inflow to Lake 36 on the Busch Wildlife Area. Dilution and/or other factors within that lake decreased the concentration to 16.32 pCi/l at its outflow. All other values at off-site locations remain relatively low and consistent with historical values.

3.2 Weldon Spring Quarry

Surface water samples were collected from the nine locations shown in Figure 3-2 and three locations in Figure 3-3. Samples were analyzed for uranium and the results are presented in Table 3-1A. The results of all samples except the Missouri River samples indicate no apparent changes in environmental conditions, although the uranium level of the pond within the access-controlled area of the quarry was higher than in previous quarters of 1990. This level is not cause for concern. The uranium levels in the water of the quarry pond have historically fluctuated due to precipitation and dilution within that pond. The concentrations of the six nitroaromatic compounds ranged from below the detection limit to 12.0 µg/l for 2,4,6-TNT. The ponded water will be treated for nitroaromatic compounds and other organics upon completion of the quarry water treatment plant.

The fourth quarter uranium values measured in the Missouri River attract attention due to their apparent upward trend in the downstream direction. Although cause for focused attention, these values are not believed to represent a real influence from site-related uranium sources. The levels of uranium at these locations have historically fluctuated at each of the sampling locations (due to either natural fluctuations or analytical



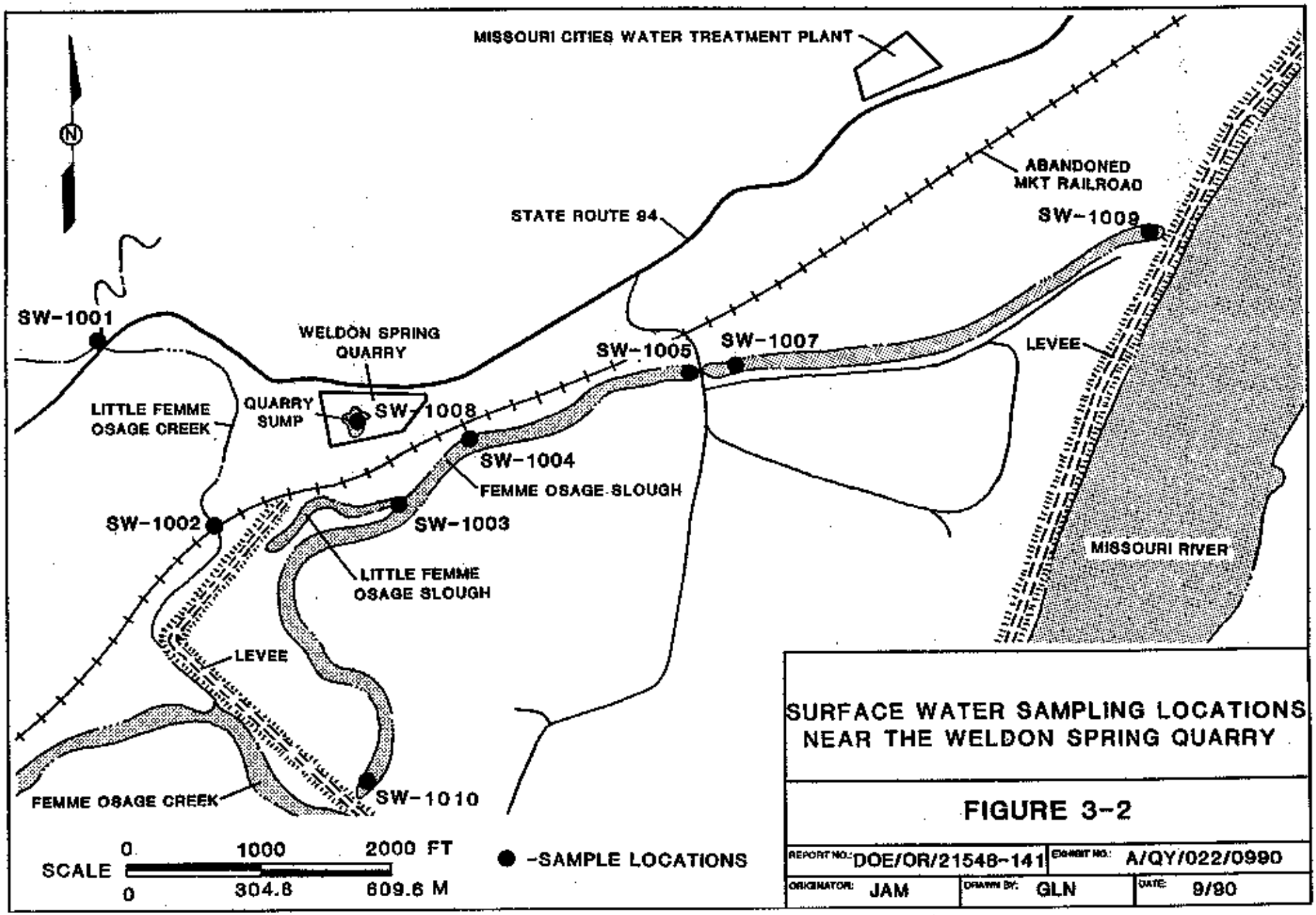
SURFACE WATER SAMPLING LOCATIONS NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

FIGURE 3-1

REPORT NO.: DOE/OR/21548-141	EXHIBIT NO.: A/VP/041/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90

TABLE 3-1 Fourth Quarter Uranium Results in Surface water at the WSCP/RP Area

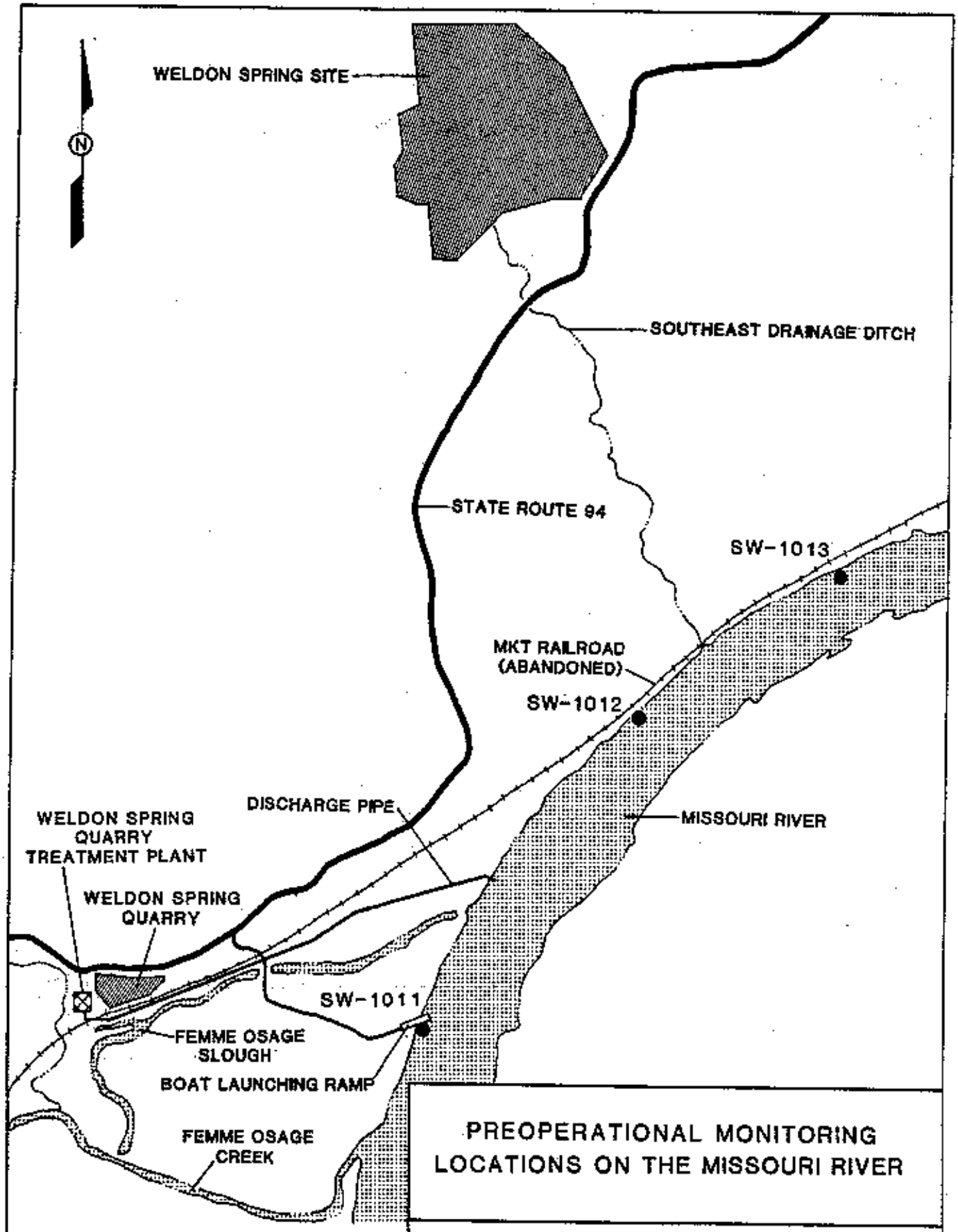
Sampling ID	Uranium
SW-2001	ND
SW-2002	102
SW-2003	12.24
SW-2004	13.6
SW-2005	16.32
SW-2006	ND
SW-2007	4.76
SW-2010	Not Available
SW-2011	170



SURFACE WATER SAMPLING LOCATIONS
NEAR THE WELDON SPRING QUARRY

FIGURE 3-2

REPORT NO.: DOE/OR/21548-141		EXHIBIT NO.: A/QY/022/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90	



PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

FIGURE 3-3

REPORT NO.: DOE/OR/21548-141	EXHIBIT NO.: A/VP/042/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90

variability) such that uranium concentrations have been higher at upstream locations than below the southeast drainage/Missouri River confluence. The U.S. Department of Energy (DOE) has increased monitoring of the Missouri River prior to the operation of the Weldon Spring Site Remedial Action Project (WSSRAP) quarry water treatment plant to ascertain the preoperational (background) levels. In addition, the National Pollution Discharge Elimination System (NPDES) permit for the quarry water treatment plant requires additional monitoring of the river. Permit monitoring will begin in 1991. This monitoring will increase the DOEs capability to ensure the safety of the public and the environment.

3.3 Springs

Eleven springs around the Weldon Spring site (WSS) are sampled quarterly (see Figure 3-4 for spring locations). Previous spring monitoring indicated that waters from six perennial springs and one wet-weather spring are measurably influenced by site-related contaminants. These springs are SP-6301, SP-6302, SP-6306, and SP-5301 through SP-5304. All spring samples are analyzed for uranium.

3.3.1 Uranium

The levels of uranium measured in the springs are consistent with values measured at those locations and drainages in the past. Table 3-1 presents the results of fourth quarter uranium analyses.

3.4 National Pollutant Discharge Elimination System Data Review

Surface water and effluent samples were collected and analyzed in compliance with the Weldon Spring Site National Pollutant Discharge Elimination System (NPDES) permit. This permit (Number MO-0107701) was issued in November 1988 and addresses storm water and wastewater discharges. Six discharge points or outfalls included in this permit are shown in Figure 3-5. Outfalls NP-0001 through NP-0005 represent surface water discharge and NP-0006 represents the treated effluent discharge associated with the administration building sanitary wastewater treatment plant. Currently NP-0006 is the only outfall with effluent limitations. The five surface water outfalls have monitoring requirements only. Fourth quarter 1990 analytical data for each outfall is presented in Table 3-3.

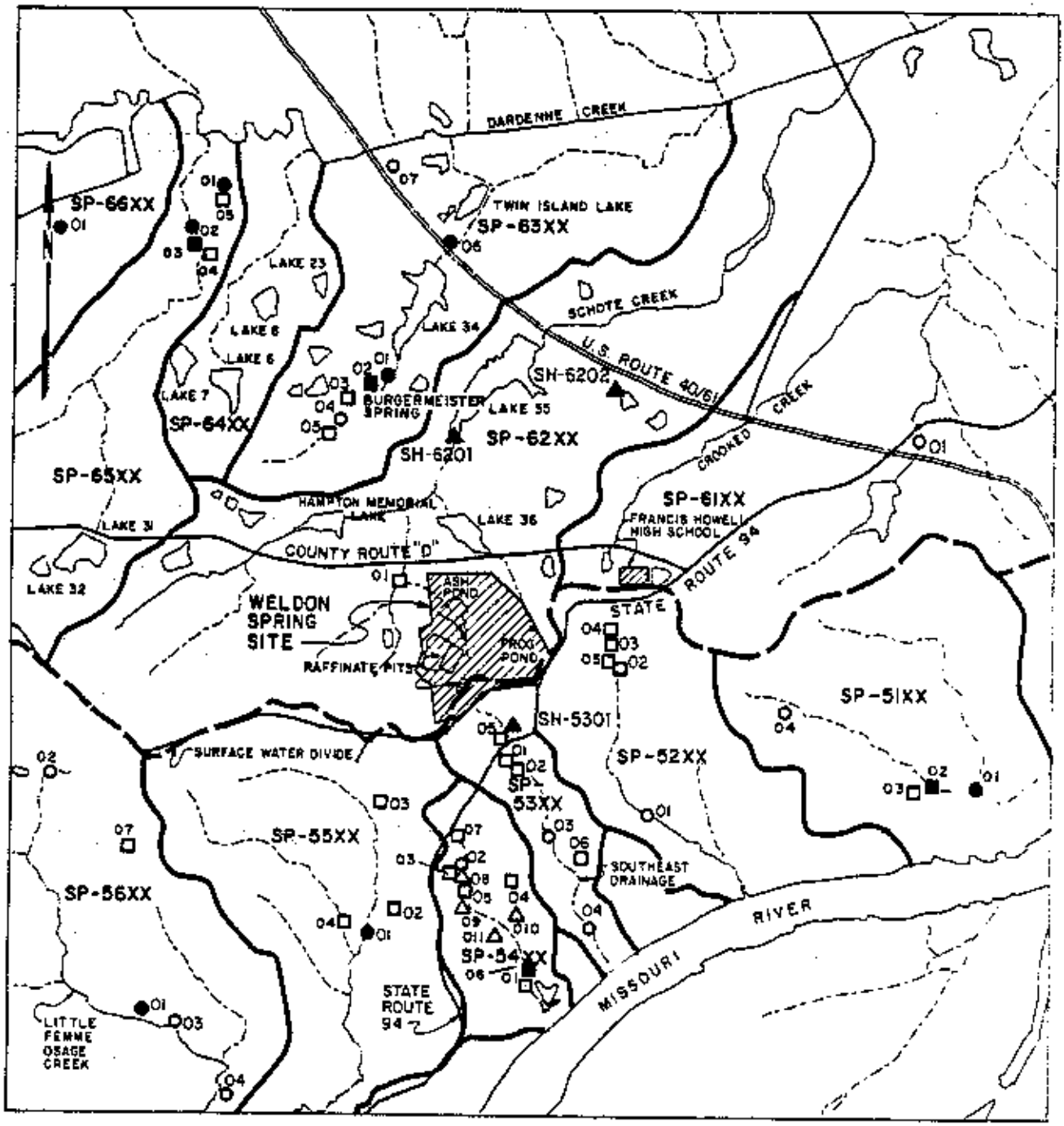
TABLE 3-1A Fourth Quarter Results for Uranium in Surface Water at the WSQ

WSSRAP ID	QUARTER 4
SW-1001	ND
SW-1002	ND
SW-1003	58.5
SW-1004	57.1
SW-1005	13.6
SW-1007	19.0
SW-1008	3130
SW-1009	21.1
SW-1010	41.5
SW-1011	4.1
SW-1012	7.5
SW-1013	9.5

TABLE 3-1B Fourth Quarter Nitroaromatic Concentrations For Surface Water (µg/l)

WSSRAP-ID	QUARTER	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NITROBENZENE
SW-1008	THIRD	ND	ND	12.0	3.0	1.2	ND

ND - NOT DETECTED



SOURCE: MDNR, 1989

LEGEND:

- SURFACE WATER DIVIDE BETWEEN MISSISSIPPI RIVER AND MISSOURI RIVER
- DRAINAGE BOUNDARY
- CREEK OR SURFACE DRAINAGE
- POND OR LAKE
- ● PERENNIAL SPRING WITH LARGE MAXIMUM FLOW
- ○ PERENNIAL SPRING WITH SMALL MAXIMUM FLOW
- ■ WET WEATHER SPRING WITH LARGE MAXIMUM FLOW
- □ WET WEATHER SPRING WITH SMALL MAXIMUM FLOW
- ▲ SHALLOW HOLE (SH)
- △ SEEP
- SP-63XX SPRING OR SEEP IN DESIGNATED DRAINAGE AREA NUMBER 63. XX REPRESENTS THE DESIGNATED SPRING NUMBER IN DRAINAGE 63.

SCALE 0 3200 6400 FT
0 975.4 1960.7 M

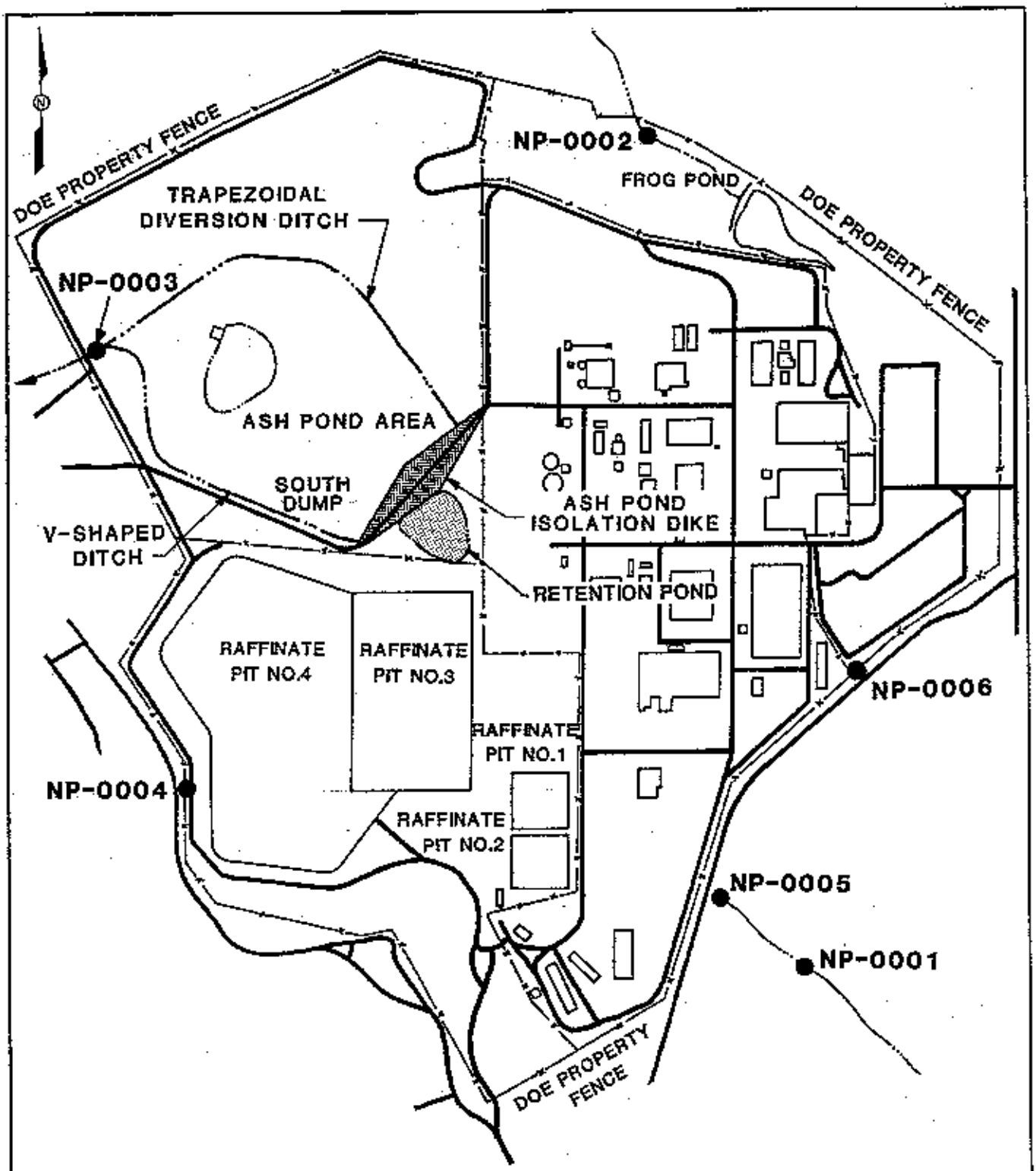
SPRINGS AND SEEPS IN THE VICINITY OF THE WSS

FIGURE 3-4

REPORT NO: DOE/OR/21548-141	EXHIBIT NO: A/VP/043/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90

TABLE 3-2 Fourth Quarter Uranium Levels in Springs Near the WSS (pCi/l)

WSSRAP-ID	Quarter 4
SP-5203	1.36
SP-5301	592
SP-5302	544
SP-5303	374
SP-5304	221
SP-5503	
SP-6301	102
SP-6302	
SP-6303	ND
SP-6306	6.16



NPDES MONITORING LOCATIONS

FIGURE 3-5

SCALE 0 500 1000 FT
0 152.4 304.8 M

REPORT NO: DOE/OR/21548-141	EXHIBIT NO.: A/CP/069/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90

TABLE 3-3 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006

Outfall NP-0001 NPDES data for Q4 1990

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM
	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	pCi/l
Oct. 4	2880	10	<0.1	1.11	7.36	0.0052	**	**
Oct. 9 *	28800	*	<0.1	*	7.27	*	360	381

*Samples obtained on Oct. 9 for radioactivity analysis only
**Samples obtained in Oct. 4 for chemical analysis only

Outfall NP-0002 NPDES data for Q4 1990

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM
	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	pCi/l
Oct. 4	101678	3.00	<0.1	ND	7.26	0.0116	NA	NA
Oct. 9	532858	NA	<0.1	NA	7.05	NA	170.0	190.0
Nov. 5	371232	18.00	<0.1	0.384	6.30	ND	130.0	10.2
Dec. 12	879840	35.00	<0.1	0.642	6.43	ND	61.0	95.2
Maximum	879840	35.00	<0.1	0.642	7.26	0.0116	170.00	190.00
Minimum	101678	3.00	<0.1	ND	6.30	ND	61.00	10.20
Average	471402	18.67	<0.1	0.513	6.76	0.0116	127.00	96.47

Non-detect values not included in average calculations

*Samples obtained on Oct. 9 for radioactivity analysis only

NA-Not available at time of report

TABLE 3-3 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006 (Continued)

Outfall NP-0003 NPDES data for Q4 1990

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM
	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	pCi/l
Oct. 4	4105	10.00	<0.1	ND	7.13	ND	NA	NA
Oct. 9 *	254880	NA	<0.1	NA	7.00	NA	70.00	82.00
Nov. 5	168624	7.00	<0.1	0.384	6.25	ND	110.00	8.16
Dec. 12	1111680	15.00	<0.1	4.85	6.14	ND	79.00	88.40
Maximum	1111680	15.00	<0.1	4.85	7.13	ND	110.00	88.40
Minimum	4105	7.00	<0.1	ND	6.14	ND	70.00	8.16
Average	384822	10.67	<0.1	2.62	6.63	ND	86.33	59.52

Non-detect values not included in average calculations

*Samples obtained on Oct. 9 for radioactivity analysis only

Outfall NP-0004 NPDES data for Q4 1990

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM
	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	pCi/l
Nov. 12	1440	12.00	<0.1	ND	6.55	ND	10	4.2

TABLE 3-3 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006 (Continued)

Outfall NP-0005 NPDES data for Q4 1990

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM
	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	pCi/l
Oct. 4	5000	7.00	<0.1	0.313	7.13	ND	NA	NA
Oct. 9 *	286000		<0.1	NA	7.03	NA	540.00	551.00
Nov. 5	53128	6.00	<0.1	8.80	6.53	ND	630.00	63.92
Dec. 3	336816	8.00	<0.1	4.54	6.53	ND	430.00	489.60
Maximum	336816	8.00	<0.1	8.800	7.13	ND	630.00	551.00
Minimum	5000	6.00	<0.1	0.313	6.53	ND	430.00	63.92
Average	170236	7.00	<0.1	4.551	6.81	ND	533.33	368.17

Non-detect samples not included in average calculation

*Samples obtained on Oct. 9 analyzed for radioactivity only

Outfall NP-0006 NPDES data for Q4 1990

DATE SAMPLED	FLOW	SUSP. SOLIDS	BOD	FECAL COLIFORMS	pH
	GPD	mg/l	mg/l	No./100 ml	
Nov. 17	2520	ND	<2.0	<1.0	6.4
Dec. 5	2970	4.00	3.3	*7000	6.5
Maximum	2970	4.00	3.3	7000.0	6.5
Minimum	2520	ND	<2.0	ND	6.4
Average	2745	4.00	3.3	7000.0	6.5

* Indicates value which exceeded effluent limitation

Radiological Analysis

Gross Alpha and Total Uranium analyses correspond well with 1989 data. The highest uranium levels were present at NP-0005 (surface flow from the southeast portion of the site combined with discharge from NP-0001) followed by NP-0001 (discharge from the process sewer). These relatively higher levels are consistent with 1989 data. Maximum values for uranium were 381 pCi/l at NP-0001 and 551 pCi/l at NP-0005.

Other outfalls exhibited the following range of uranium concentrations. NP-0002, the drainage from the Frog Pond area, ranged from 10.2 pCi/l to 190 pCi/l. NP-0003, drainage from the Ash Pond diversion, ranged from 8.16 pCi/l to 88.4 pCi/l. A uranium concentration of 4.2 was present in the fourth quarter sample collected from NP-0004, raffinate pit No. 4 area.

Other Analysis

Other analyses include physical analysis (settleable solids and suspended solids) and chemical analysis (nitrate, pH, and lithium). Fourth quarter 1990 values generally correspond to 1989 values for the majority of parameters.

The discharge from the administration building treatment plant, NP-0006, has effluent limitations for quarterly samples. In addition to this quarterly monitoring, the subcontractor monitors the same parameters monthly, to assess plant performance. Outfall NP-0006 is the discharge for the site administration building wastewater treatment facility. The NPDES permit contains effluent limitations on biochemical oxygen demand (BOD), total suspended solids (TSS), and fecal coliform at this outfall. These limits are 15 mg/l (BOD), 10 mg/l (TSS), and 400 colonies/100 ml (fecal coliform). NPDES permit limits were exceeded in fourth quarter 1990 at this outfall. The fecal coliform value for December 5 was 7000 colonies/100 ml. This was due to removal of additional chlorine in the chlorine contact chamber by the Subcontractor. This was done at the direction of Missouri Department of Natural Resources (MDNR) due to a concern that excess residual chlorine might be present in the effluent. The Subcontractor has since replaced this additional chlorine in a more acceptable manner resulting in a return to compliance for fecal coliform levels, while maintaining a minimal level of residual chlorine.

4 AIR MONITORING

4.1 Radon Gas

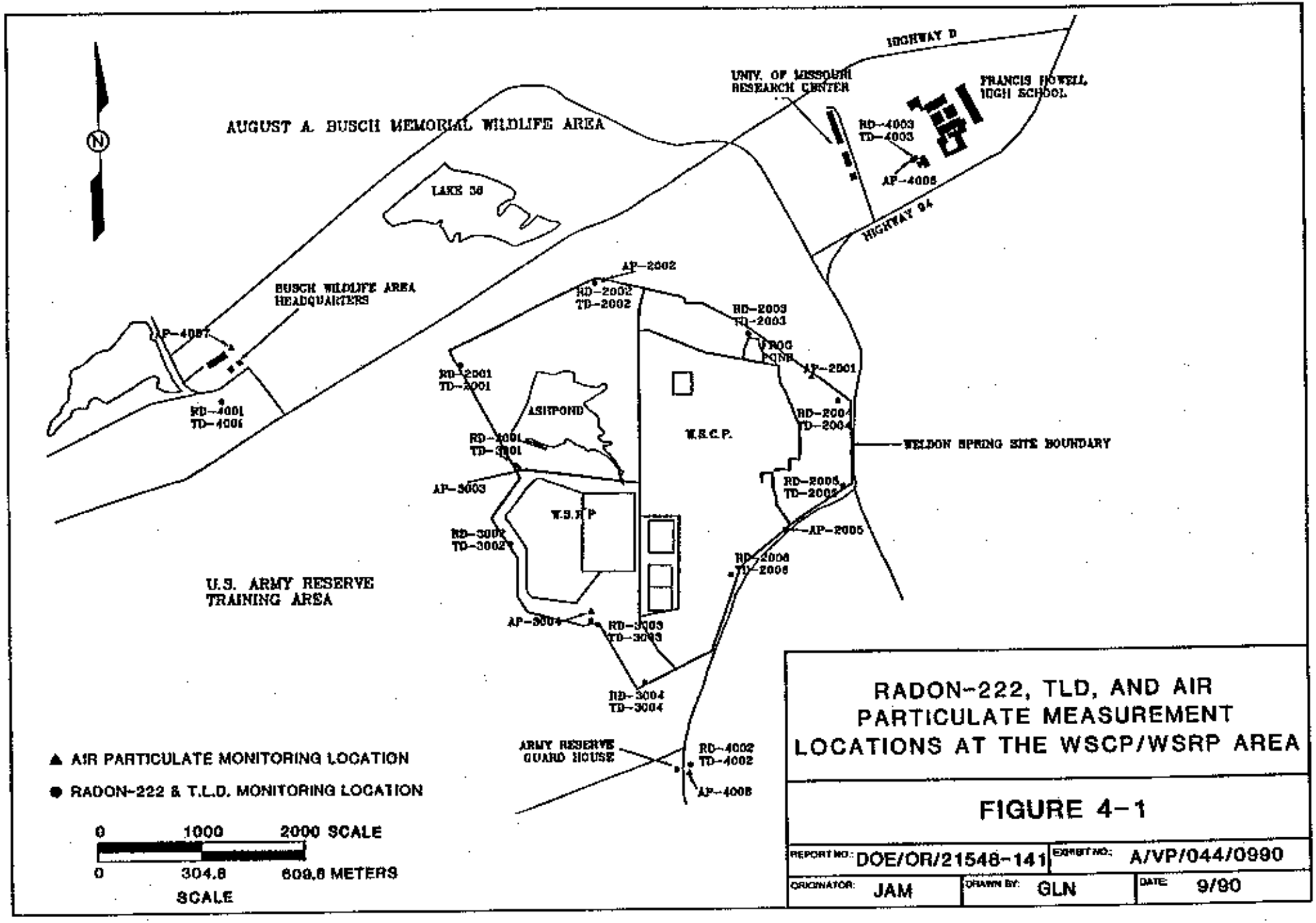
The radon gas monitoring program utilizes a pair of radon detectors at each of 22 permanent locations; each detector is exchanged quarterly. These detectors are deployed at six locations at the Weldon Spring Chemical Plant, six locations at the Weldon Spring quarry, four locations at the Weldon Spring raffinate pits, and six off-site locations. Radon monitoring locations are shown in Figures 4-1, 4-2, and 4-3. On-site detectors are spaced around the perimeter fences to ensure adequate detection of radon dispersing from the properties under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005, and RD-4006 were used to monitor background levels near the site.

Table 4-1 summarizes the quarterly and year-to-date average radon concentrations detected at all site perimeter and off-site monitoring locations. Also contained in Table 4-1 is a comparison of the measured year-to-date average concentration with the Federally permitted radon concentration for unrestricted areas of 3 pCi/l (110 Bq/m^3) above background as authorized by U.S. Department of Energy (DOE) Order 5400.5.

An average ambient background concentration was determined by calculating the arithmetic average for the four background locations. This data yielded a year-to-date average ambient background radon concentration of 0.17 pCi/l for the first three quarters of 1990. This concentration was then subtracted from the year-to-date average concentration for each monitoring station, and compared to the DOE guideline of 3 pCi/l above background.

Radon concentrations at the site perimeter and at off-site locations for the fourth quarter of 1990 were within the typical range expected during years of normal precipitation. The quarterly radon concentrations (background included) ranged from 0.1 pCi/l at two locations to 1.7 pCi/l at monitoring location RD-1002.

Radon concentrations found in the quarry are higher than concentrations measured at other locations because the radium concentrations in quarry wastes are typically much higher than other areas, and because the quarry is a large depression in the terrain with side walls ranging from 3 to 15 meters (10 to 50 feet) high. In conjunction with stable



RADON-222, TLD, AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 4-1

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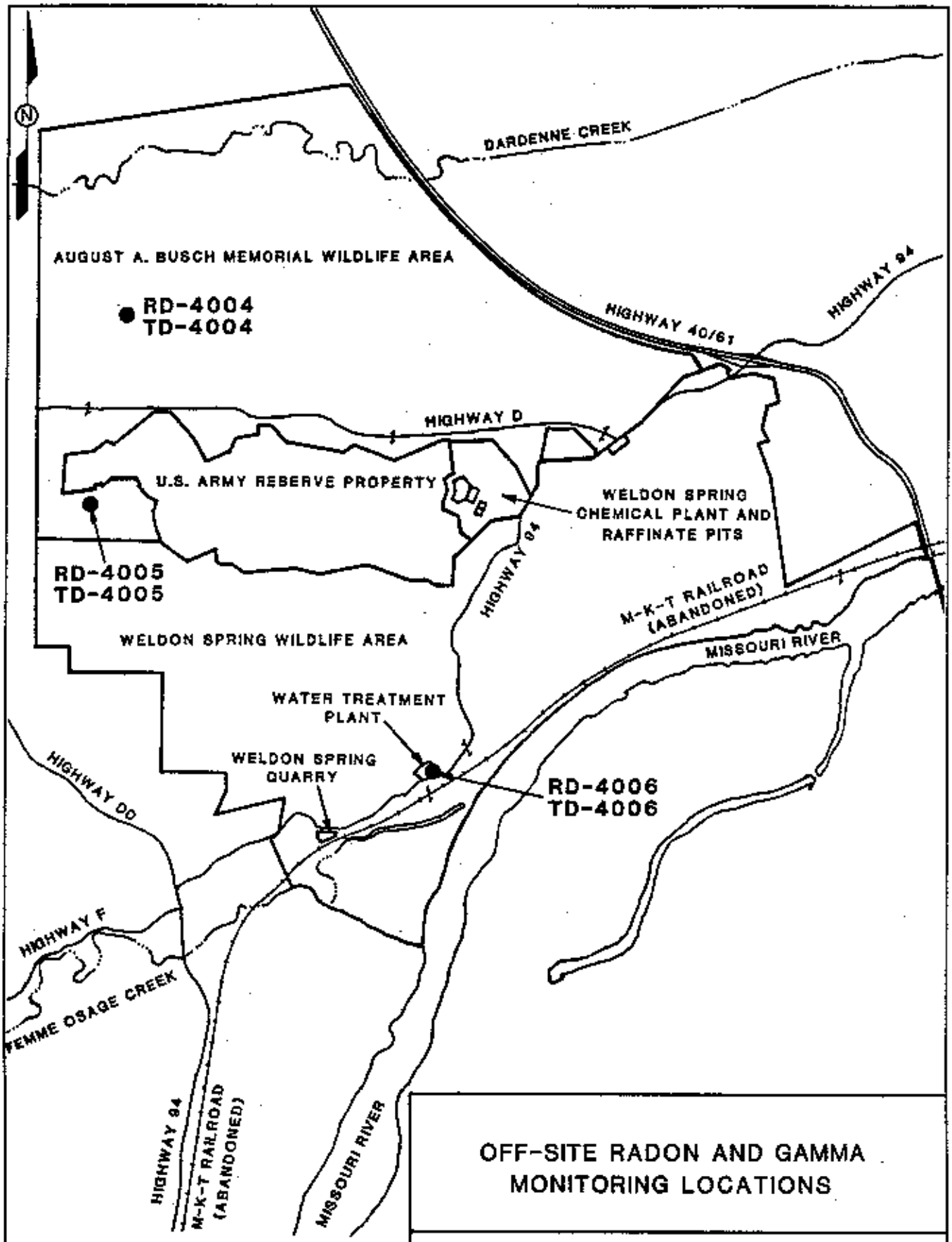

OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

FIGURE 4-2

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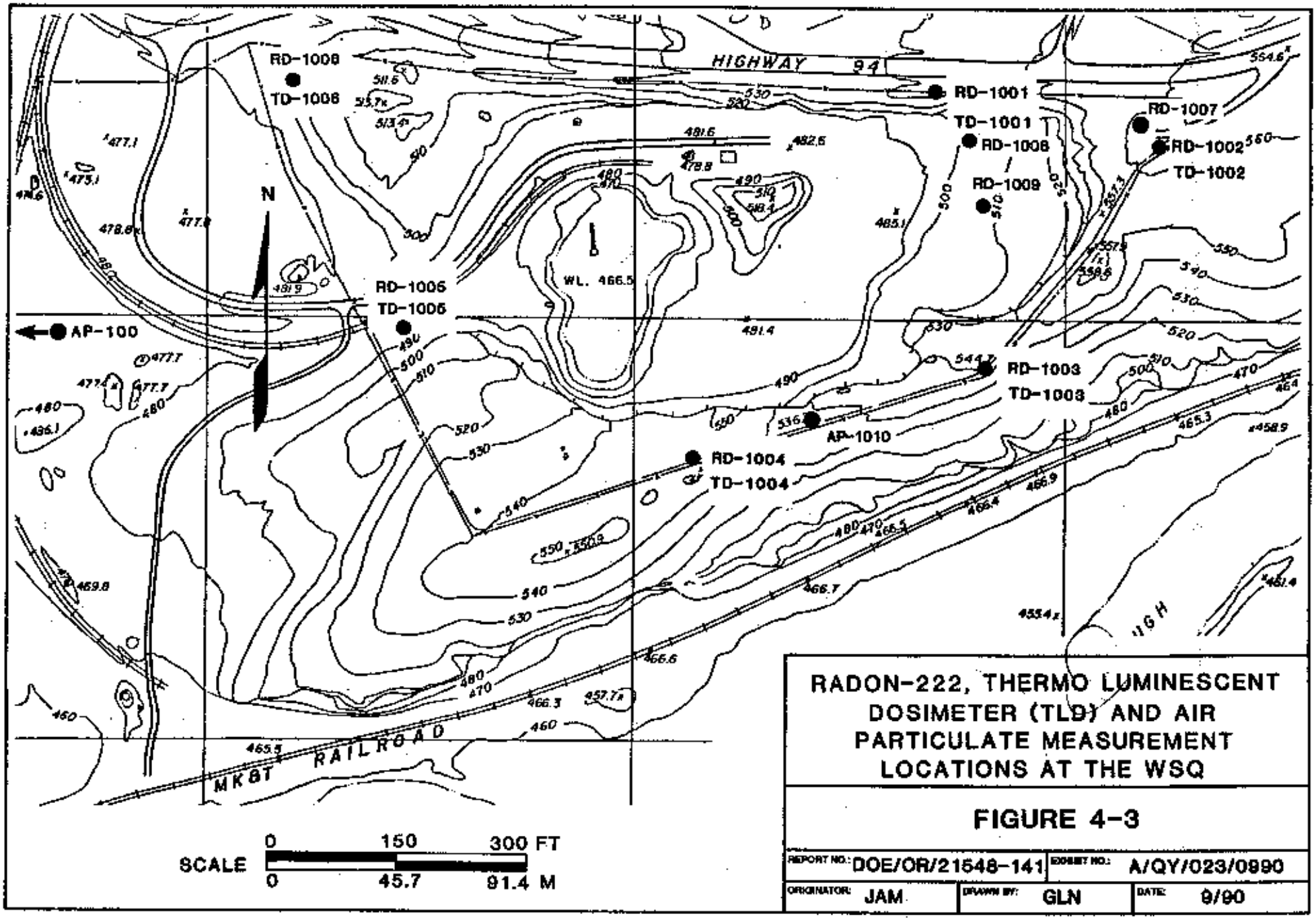


RADON-222, THERMO LUMINESCENT DOSIMETER (TLD) AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSQ

FIGURE 4-3

REPORT NO.: DOE/OR/21548-141		EXHIBIT NO.: A/QY/023/0990	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 9/90	

TABLE 4-1 1990 Track Etch Radon Results[a]

Location I.D.	1st Quarter pCi/l	2nd Quarter pCi/l	3rd Quarter pCi/l	4th Quarter pCi/l	Annual Average		Percent of Guideline[b]
					pCi/l	Dev.	
WSQ							
RD-1001	1.1	1.4	2.4	1.1	1.5	0.3	41
RD-1002	1.4	2.1	3.1	1.7	2.1	0.4	60
RD-1003	1.0	0.5	1.0	1.0	0.9	0.3	20
RD-1004	0.3	0.4	0.8	0.4	0.5	0.2	6
RD-1005	0.8	0.5	0.8	0.6	0.7	0.2	13
RD-1006	0.5	0.3	0.5	0.7	0.5	0.2	7
WSCP							
RD-2001	0.4	0.3	0.5	0.7	0.5	0.2	6
RD-2002	0.4	0.1	0.4	0.2	0.3	0.1	0
RD-2003	0.4	0.1	0.7	0.3	0.4	0.2	3
RD-2004	0.3	0.1	0.4	0.2	0.3	0.1	0
RD-2005	0.5	0.1	0.4	0.2	0.3	0.1	1
RD-2006	0.4	0.2	0.4	0.2	0.3	0.1	0
WSRP							
RD-3001	0.3	0.1	0.5	0.1	0.3	0.1	0
RD-3002	0.3	0.1	0.4	0.1	0.2	0.1	0

TABLE 4-1 1990 Track Etch Radon Results[a] (Continued)

Location I.D.	1st Quarter pCi/l	2nd Quarter pCi/l	3rd Quarter pCi/l	4th Quarter pCi/l	Annual Average		Percent of Guideline[b]
					pCi/l	Dev.	
RD-3003	0.5	0.1	0.5	0.1	0.3	0.1	1
RD-3004	0.3	0.1	0.5	0.1	0.3	0.1	0
OFF-SITE							
RD-4001	0.3	0.1	0.7	0.1	0.3	0.1	1
RD-4002	0.3	0.1	0.3	0.2	0.2	0.1	0
RD-4003	0.3	0.1	0.4	0.4	0.3	0.1	0
RD-4004	0.3	0.1	0.7	0.3	0.4	0.2	2
RD-4005	0.5	0.1	0.3		0.2	0.1	0
RD-4006	0.3	0.1	0.5	0.1	0.3	0.1	0

(a) Results include natural background.
(b) Percent of guideline calculated by taking the year-to-date average minus the average of the background stations divided by the DOE concentration guideline for RN-222 is 3 pCi/l (100 Bq/m^3)(Annual average above background) for uncontrolled areas.
* DENOTES BACKGROUND STATION

meteorological conditions, this configuration tends to trap emanating radon within the quarry and raise the concentrations along the quarry perimeter.

4.2 Gamma Radiation Exposure

To monitor exposure from gamma radiation, 22 monitoring stations using spherical environmental thermoluminescent dosimeters (TLDs) were deployed. The monitoring station locations are the same as the ambient radon monitoring locations (see Section 4.1).

Table 4-2 summarizes the quarterly and year-to-date results of total gamma radiation monitoring at the 16 Weldon Spring site (WSS) perimeter monitoring stations, Francis Howell High School, the Weldon Spring Army Reserve Training Area, and at the four background monitoring stations.

The yearly average background gamma exposure as measured with TLDs in 1989 was 68 mR/year. The yearly average background gamma exposure as measured with TLDs in 1990 was 62 mR/year. This corresponds to 1989 monitoring results and was expected because no significant changes in the configuration or location of the wastes have occurred.

Due to external vandalism, the fourth quarter TLDs were missing for monitoring stations TD-3004, and TD-4005. In order to calculate a year-to-date total gamma exposure rate, the missing quarterly data were replaced with the average of the remaining quarterly TLD results for those monitoring stations.

4.3 Radioactive Air Particulates

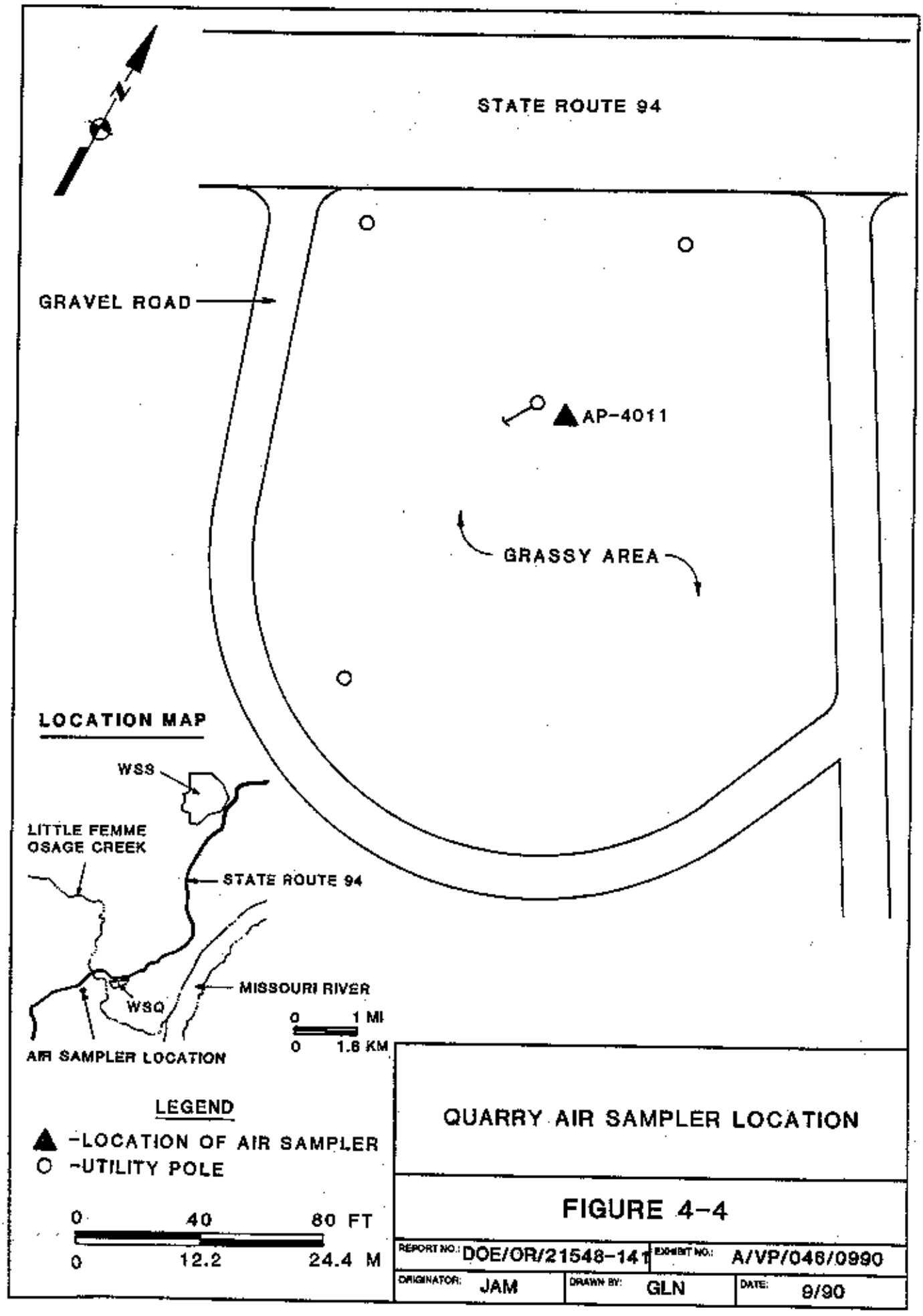
Eleven air particulate samplers monitor the Weldon Spring site. Five of these (AP-2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the Weldon Spring Chemical Plant (WSCP) perimeter and two are located around the quarry perimeter as shown in Figure 4-3. Three monitoring stations (AP-4006, AP-4008, and AP-4011) are located off site at sensitive receptor locations, including Francis Howell High School, the Army Reserve property, and a residential site west of the quarry. The monitoring station at the August A. Busch Wildlife Area (AP-4007) is used to monitor background levels in the vicinity of the WSCP. The off-site monitoring stations are also shown in Figure 4-4.

TABLE 4-2 1990 Environmental TLD Results[a]

Location I.D.	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Total[b]	2 Std. Dev.
	MR	MR	MR	MR	MR	
WSQ						
TD-1001	21	21	26	24	92	4
TD-1002	17	17	22	20	76	5
TD-1003	20	16	24	15	76	7
TD-1004	18	15	21	19	72	4
TD-1005	18	17	-	21	74	4
TD-1006	15	14	21	19	69	5
WSCP						
TD-2001	16	16	18	16	66	2
TD-2002	15	14	22	17	68	6
TD-2003	15	15	18	17	68	3
TD-2004	16	17	18	18	68	2
TD-2005	-	14	17	17	64	3
TD-2006	17	15	19	17	67	3
WSRP						
TD-3001	-	16	20	19	73	4
TD-3002	13	12	-	14	53	2
TD-3003	17	17	20	18	71	3
TD-3004	12	13	18	-	57	5
OFF-SITE						
TD-4001	15	16	-	18	66	2
TD-4002	14	13	15	14	57	1
TD-4003	12	11	13	13	51	2
TD-4004	14	16	20	18	69	4
TD-4005	12	-	-	-	48	0
TD-4006	13	13	19	18	64	6

(a) Results include natural background.
- Denotes loss of TLD.
* Denotes background station.

(b) Year-to-date totals for locations where some quarterly data is unavailable were calculated using the average of the existing quarterly data in place of the unavailable data. Due to rounding of values, the sum of the quarterly data may not equal the year-to-date total.



QUARRY AIR SAMPLER LOCATION

FIGURE 4-4

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The sampling station near the August A. Busch Wildlife Area (ABWA) headquarters is used as a background air monitoring station. This station is approximately 0.8 km (0.5 mile) from the WSCP perimeter in a northwestern direction. The terrain between the WSCP and this sampling station is hilly and forested, providing a significant physical barrier to airborne particulates originating from the WSCP/ Weldon Spring raffinate pits (WSRP). In addition, winds from the southeast are relatively rare at the WSCP.

Table 4-3 summarizes the quarterly average concentrations and the standard deviations for the 11 air monitoring locations. The quarterly average concentration for each monitoring location was calculated by averaging either the weekly air particulate analysis results or the counting instrument's lower limit of detection (LLD), whichever was greater. The "<" sign in Table 4-3 appears when the actual average is less than the calculated average due to the use of LLD values in the calculation. Locations AP-1009 and AP-1010 were not in operation for five weeks due to vandalism. All of the other measurements at the two locations were above the LLD values. The standard deviation for each of the monitoring locations was calculated using only results that were above the LLD.

The third quarter net alpha concentrations ranged from $<1.34 \times 10^{-15}$ µCi/ml to 2.12×10^{-15} µCi/ml with $<1.69 \times 10^{-15}$ µCi/ml detected at the background station.

4.4 Asbestos

Air sampling for asbestos has been performed on a routine basis for two years. The monitoring data indicate no elevated levels of airborne asbestos during both asbestos abatement operations and during periods when no asbestos activities were in progress at the site. Since asbestos removal and handling operations were not in progress during the third quarter, perimeter asbestos sampling was not performed. Upon commencement of any additional asbestos abatement activities, asbestos air particulate monitoring will resume.

TABLE 4-3 Radiological Air Particulate 1990

MONITOR IDENTIFICATION NUMBER	ANNUAL AVG. CONCENTRATION (1E-15 µCi/ml)	STANDARD DEVIATION	NUMBER OF VALUES ABOVE LLD
AP-2001	2.10e-15	2.00e-15	42
AP-2002	2.50e-15	8.60e-16	45
AP-3003	2.20e-15	1.00e-15	41
AP-3004	2.30e-15	1.20e-15	43
AP-2005	2.40e-15	1.40e-15	46
AP-4006	2.20e-15	1.00e-15	39
AP-4007*	2.20e-15	7.50e-16	49
AP-4008	2.40e-15	1.60e-17	47
AP-1009	2.40e-15	7.40e-16	45
AP-1010	2.70e-15	8.00e-16	43
AP-4011	2.10e-15	1.30e-15	45

* Indicates background monitor station.
To convert µCi/ml to Bq/M ^ 3 multiply by 3.7E10.

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June 19, 1991

ADDRESSEES:

QUARTERLY ENVIRONMENTAL DATA SUMMARY FOR THE FIRST QUARTER, 1991 FOR THE WELDON SPRING SITE REMEDIAL ACTION PROJECT

Enclosed for your information and use is a copy of the Quarterly Environmental Data Summary Report. The document summarizes the environmental monitoring data for the first quarter, highlights any potentially significant findings, and offers preliminary interpretations. Final interpretations will appear in the 1991 Annual Site Environmental Report.

The report concludes that no significant differences or changes in off-site exposures resulting from Weldon Spring Site contaminates have occurred during this reporting period.

If you have any questions please call Ken Lawver at (314)441-8978.

Sincerely,

Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

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As stated

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CONTRACT NO. DE-AC05-86OR21548

QUARTERLY ENVIRONMENTAL DATA SUMMARY FIRST QUARTER 1991

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

JUNE 1991 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

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Quality Assurance Manager	Date 6/14/91
Environmental Compliance Manager	Date 6/14/91
Deputy Project Director	Date 6/14/91
Project Director	Date 6/14/91

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Weldon Spring Site Remedial Action Project

Quarterly Environmental Data Summary First Quarter 1991

Revision 0

June 1991

Prepared by

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for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
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ABSTRACT AND WELDON SPRING SITE QUARTERLY SELF ASSESSMENT FIRST QUARTER 1991

The purpose of this Quarterly Environmental Data Summary is to provide preliminary data acquired as part of the Weldon Spring Site Remedial Action Project (WSSRAP) environmental monitoring program. The document summarizes the environmental data, highlights any potentially significant findings, and offers tentative interpretations. Validated data and final interpretations will appear in the 1991 Annual Site Environmental Report.

This report includes data from environmental monitoring activities at the Weldon Spring site (WSS) during the first quarter of 1991. Groundwater, surface water, and air were sampled in order to monitor potential exposure pathways. Analytical parameters included radionuclides, nitroaromatic compounds, inorganic anions, and direct gamma exposure. The results are used to calculate exposure doses (where applicable) and assess the impact of the contaminants at the site on potentially exposed populations.

In summary, significant differences were observed in off-site exposures during the first quarter of 1991 relative to exposures calculated in previous quarters. Contaminated groundwater did not affect private water supplies or the St. Charles County well field. Surface water containing elevated uranium activity continued to impact the Femme Osage Slough and several lakes in the August A. Busch Memorial Wildlife Area. Off-site gamma, radon and air particulate exposures remained indistinguishable from background. Off-site monitoring demonstrated that exposure levels at the Francis Howell High School, the Busch Wildlife Area Headquarters, and the Weldon Spring Training Area remain indistinguishable from background levels.

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1 INTRODUCTION

This document is the fourth in a series of documents designed to provide a summary of the findings from the routine environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). These documents supplement the *Annual Site Environmental Report* (ASER) by providing interested outside agencies and organizations with more frequent access to WSSRAP data. They provide data resulting from routine environmental sampling as described in the WSSRAP Environmental Monitoring Plan and a brief interpretation of that data.

It is the goal of this document to summarize and briefly discuss the data, highlighting data that differ significantly from observations made in previous reports. The full interpretation of these data (as well as data in other quarterly summaries) will be undertaken in the 1991 ASER. It is recommended that interested readers refer to previous Environmental Monitoring Plans (EMPs), ASERs, and project documents for more information on existing site conditions, site history, transport mechanisms, and quantified contaminant levels. The monitoring scheme for every calendar year is established prior to that year in the annual EMP. Each sampling location to be monitored during the upcoming year is identified in the EMP and the schedule of analytical parameters are tabulated for easy reference. These reports may be obtained by visiting the WSSRAP reading room or contacting the WSSRAP Community Relations Manager at 314-441-8086.

These quarterly reports are intended to include data from all quarterly environmental monitoring programs conducted at the WSSRAP including groundwater, surface water, National Pollutant Discharge Elimination System (NPDES), radon gas, gamma radiation, and air particulates (including asbestos and radioactive particulates). However, because of delays in data delivery from the analytical laboratories, some of the data that was expected to be included in this report are not yet available for reporting. The unavailability of data is due to a nationwide shortage in analytical services. The WSSRAP is taking corrective action to ensure more timely availability of data in the future. These data will be reported in the 1991 ASER. Sludges, soils, and biological specimens are not sampled on a routine basis; therefore, analytical results for these parameters are not included in this report. Trend analyses are being prepared from historical data for surface water, groundwater and air pathways. These analyses will be presented in the 1991 ASER.

2 GROUNDWATER MONITORING

The groundwater is sampled regularly at both the Weldon Spring Chemical Plant/raffinate pits/vicinity properties (WSCP/RP/VP) and the Weldon Spring quarry (WSQ). Due to differences in the environmental settings and sources of contaminants, separate monitoring schedules are followed. Therefore, results of groundwater monitoring at the WSCP/RP/VP and WSQ will be discussed separately.

2.1 Chemical Plant/Raffinate Pits/Vicinity Properties

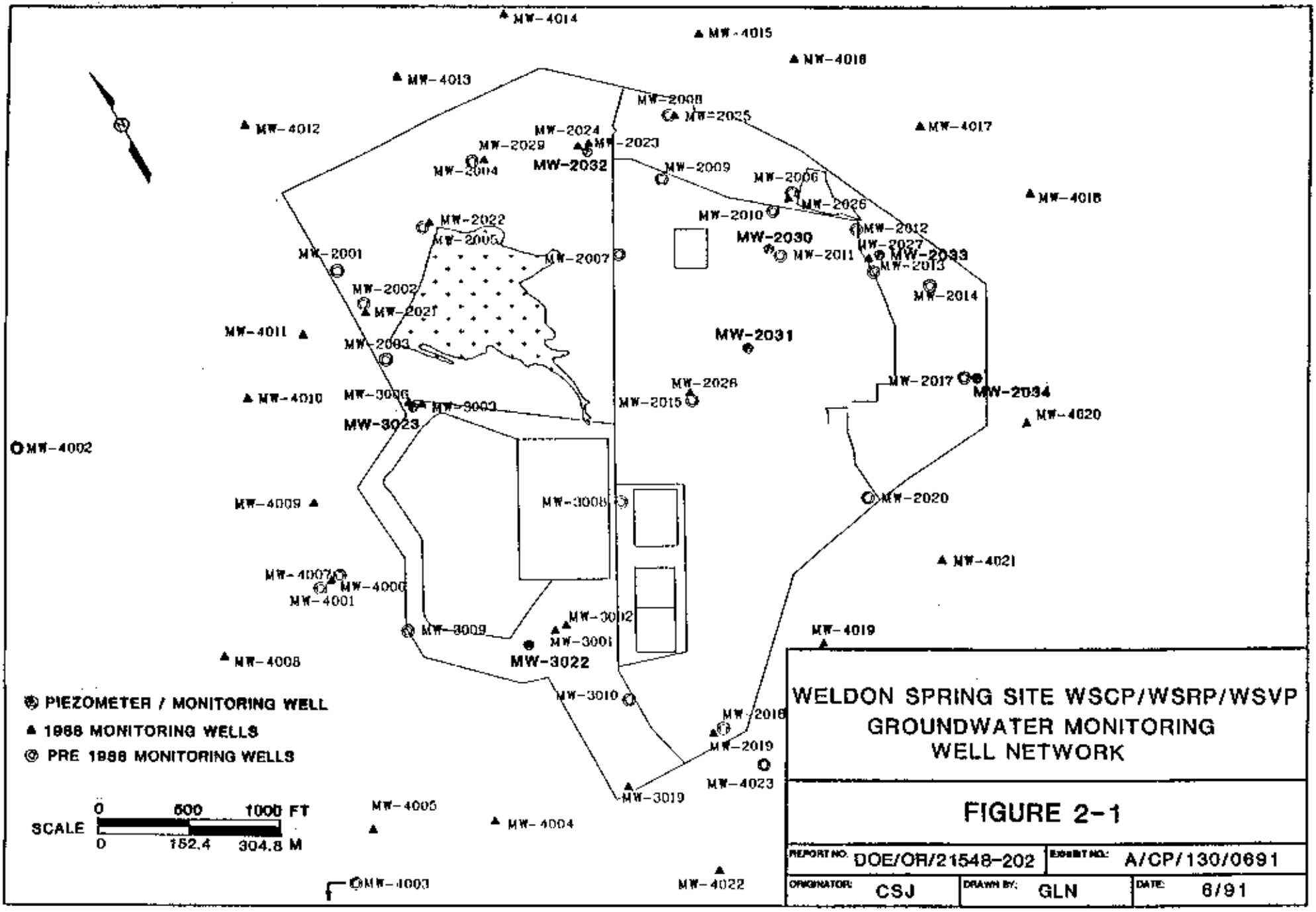
The groundwater at the chemical plant/raffinate pits/vicinity properties area is monitored on a semi-annual basis with the exception of MW-2001, MW-2002, MW-2003, MW-3003, MW-3006, MW-3008, MW-3009, MW-3023, MW-4012 and MW-4013 which are monitored quarterly. Monitoring well locations are shown in Figure 2-1. Data from the semiannual groundwater monitoring for the first half of 1991 will be presented in the second quarter data summary, however, data from the quarterly monitored wells are presented in each QEDS.

2.1.1 Nitroaromatic Results

Table 2-1 contains nitroaromatic data from samples collected from the quarterly monitored groundwater wells at the CP/RP/VP area. Nitroaromatic compounds were detected in seven samples. However, the data continue to reflect levels historically found and documented in previous environmental reports.

2.1.2 Radiological Results

The radiological results for samples from quarterly monitored wells at the WSCP/RP/VP are presented in Table 2-2. The upper bound for natural uranium background concentrations in groundwater at the WSCP/RP/VP has been determined to be 3.4 pCi/l. The EPA has not yet established drinking water standards for uranium; however, studies leading to proposed rulemaking are using uranium in the 10 pCi/l to 40 pCi/l range. The U.S. Department of Energy (DOE) has a health based derived concentration guideline (DCG) of 600 pCi/l in surface water effluent.



WELDON SPRING SITE WSCP/WSRP/WSVP GROUNDWATER MONITORING WELL NETWORK

FIGURE 2-1

REPORT NO:	DOE/OR/21548-202	EXHIBIT NO:	A/CP/130/0691		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	6/91

TABLE 2-1 First Quarter Nitroaromatic Data for Groundwater at the WSCP/RP/VP

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-2001-Q191	ND	ND	0.073	0.049	ND	ND
GW-2002-Q191	ND	ND	0.063	0.34	ND	ND
GW-2003-Q191	ND	ND	0.15	0.65	ND	ND
GW-3003-031891	ND	ND	0.059	0.085	ND	ND
GW-3006-031991	ND	ND	ND	ND	ND	ND
GW-3006-Q191	ND	ND	0.08	0.16	ND	ND
GW-3009-Q191	ND	ND	ND	ND	ND	ND
GW-3023-031991	ND	ND	2.6	4.5	ND	ND
GW-4012-Q191	ND	ND	ND	ND	ND	ND
GW-4013-Q191	ND	ND	0.049	1.1	0.55	34

ND - Not Detected

Table 2-2 First Quarter Uranium and Inorganic Anion Data in Groundwater at the WSCP/RP/VP

Sample ID	Nitrate as (N) (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-2001-Q191	20.7	5.4	ND
GW-2002-Q191	23	109	ND
GW-2003-Q191	414	114	0.7
GW-3003-Q191	4	149	19
GW-3006-Q191	1	24.2	ND
GW-3008-Q191	1050	51.6	4.1
GW-3009-Q191	89	39.8	49.6
GW-3023-Q191	275	558	7.5
GW-4012-Q191	ND	54	4.1
GW-4013-Q191	84.1	42	1.4

ND – Not Detected

The highest uranium level detected was 49.6 pCi/l from a sample obtained from Monitoring Well 3009 adjacent to raffinate pit No. 4. The other concentrations reported in Table 2-2 continue to indicate levels below the proposed drinking water standard for uranium.

2.1.3 Geochemical Results

Geochemical results for samples from quarterly monitored wells at the WSCP/RP/VP are presented in Table 2-3. Geochemical parameters were added to the *Environmental Monitoring Plan* for the 1991 monitoring year.

2.1.4 Inorganic Anion Results

Inorganic anion results for the quarterly monitored WSCP/RP/VP wells are shown in Table 2-2. The results reflect levels historically found in these wells.

2.2 Weldon Spring Quarry

Chemical and radiological wastes at the quarry are of particular concern because of their proximity to the St. Charles County well field. The well field is located approximately 0.8 km (0.5 mile) to the south of the Weldon Spring quarry. Monitoring of contaminants in groundwater and the protection of the well field is a top WSSRAP priority.

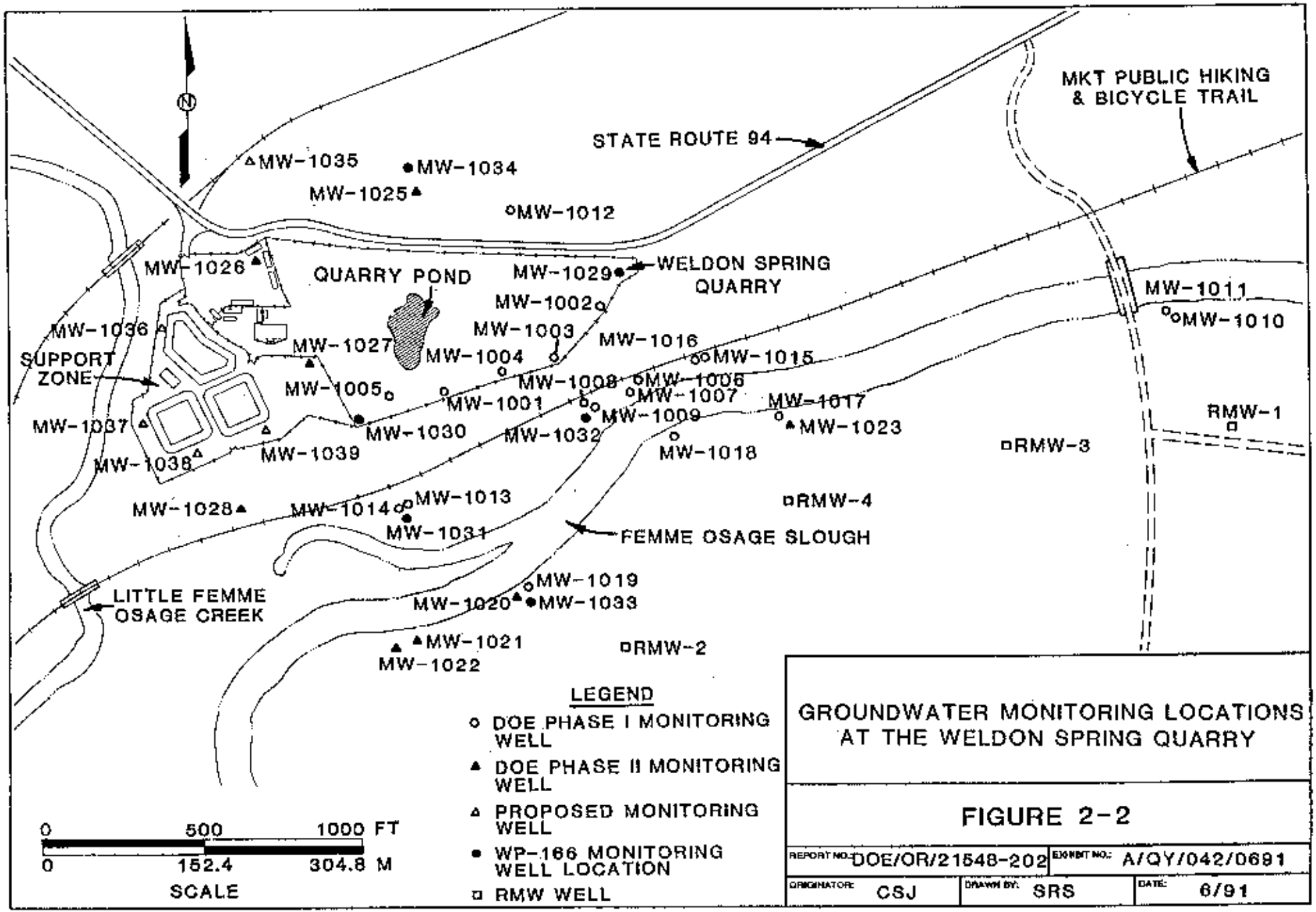
Groundwater is currently being monitored in 35 wells in and around the quarry. Thirty-one monitoring wells installed by the U.S. Department of Energy (DOE) currently exist in or near the quarry, with the addition of wells MW-1035 through MW-1039 to be included in the monitoring program beginning in the second quarter, 1991. Four monitoring wells were installed by St. Charles County in 1986 and are currently included in the DOE's monitoring program. All monitoring well locations are shown in Figures 2-2 and 2-3. These wells draw water from both bedrock and alluvial aquifers.

Two separate groundwater monitoring programs have been developed for the quarry. The first program is a bimonthly sampling of all wells north of the Femme Osage Slough. The second program is a quarterly sampling of all wells south of the Femme Osage Slough,

TABLE 2-3 First Quarter Geochemical Data For Groundwater at the WSCP/RP/VP

	As (µg/l)	Ba (µg/l)	Ca (µg/l)	Cr (µg/l)	Co (µg/l)	Fe (µg/l)	Li (µg/l)	Mg (µg/l)	Mn (µg/l)	Ni (µg/l)	K (µg/l)	Na (µg/l)	Sr (µg/l)	Nitrite (µg/l)	Bromide (µg/l)	Chloride (µg/l)	Phosphorus, Total (µg/l)	Silica, Dissolved (µg/l)	Alkalinity (µg/l)
GW-2001-Q191	ND	200	75200	ND	ND	ND	ND	39200	ND	ND	1670	9050	91.4	ND	682	5070	47.4	9860	343000
GW-2002-Q191	ND	161	244000	ND	ND	ND	362	82600	ND	ND	8720	96300	319	ND	881	10700	35.1	13200	303000
GW-2003-Q191	ND	112	268000	ND	ND	ND	433	97100	ND	ND	7660	127000	463	ND	764	8970	38.6	6670	281000
GW-3003-Q191	ND	150	258000	ND	ND	ND	518	90800	155	ND	10200	177000	620	ND	226	9430	64.4	9800	281000
GW-3006-Q191	4	109	47300	ND	ND	133	ND	43800	90.3	ND	1490	16800	200	625	557	ND	ND	10900	374000
GW-3008-Q191	ND	343	736000	ND	ND	ND	177	97400	ND	ND	2610	231000	620	ND	531	17000	60	12400	242000
GW-3009-Q191	ND	1400	80300	ND	10.3	90	ND	49600	18.8	ND	1060	18900	620	203	ND	3.6	14.7	8680	122000
GW-3023-031991	ND	39.9	344000	ND	ND	36	768	87400	18.4	ND	4630	231000	630	225	ND	15.1	65	11900	247000
GW-4012-Q191	ND	90.9	49400	ND	ND	38	ND	32100	5.1	ND	13200	33200	172	ND	605	3510	74.5	11400	297000
GW-4013-Q191	4	124	125000	ND	ND	ND	52.5	43800	ND	ND	6350	33300	200	ND	453	1040	53.4	9510	315000

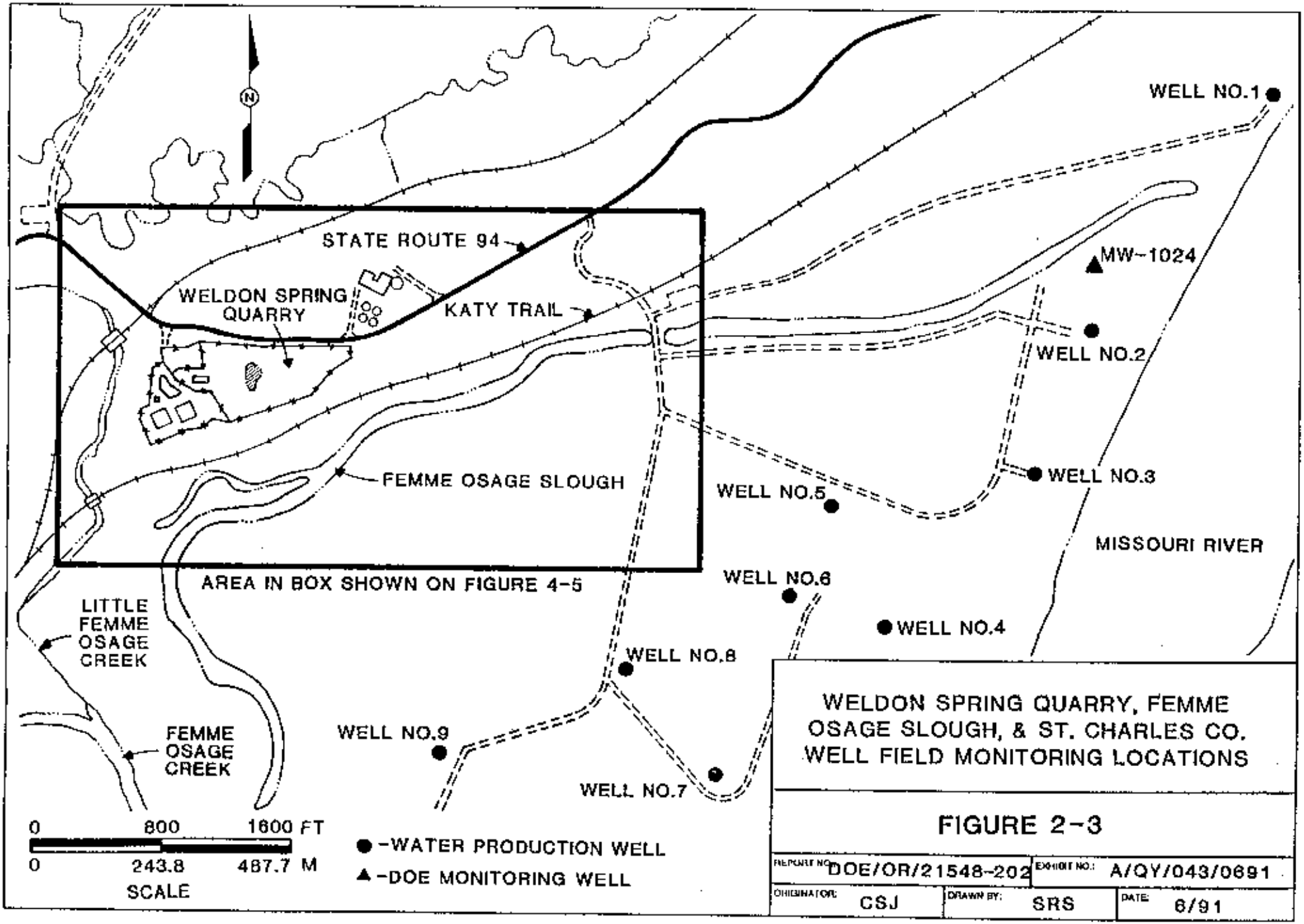
ND - Not Detected



GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 2-2

REPORT NO: DOE/OR/21548-202	EXHIBIT NO: A/QY/042/0691	
ORIGINATOR: CSJ	DRAWN BY: SRS	DATE: 6/91


N
WELL NO.1
STATE ROUTE 94
MW-1024
WELDON SPRING QUARRY
KATY TRAIL
WELL NO.2
FEMME OSAGE SLOUGH
WELL NO.3
WELL NO.5
MISSOURI RIVER
AREA IN BOX SHOWN ON FIGURE 4-5
WELL NO.6
LITTLE FEMME OSAGE CREEK
WELL NO.4
WELL NO.8
FEMME OSAGE CREEK
WELL NO.9
WELL NO.7
0 800 1600 FT
0 243.8 487.7 M
SCALE
●-WATER PRODUCTION WELL
▲-DOE MONITORING WELL
WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, & ST. CHARLES CO. WELL FIELD MONITORING LOCATIONS
FIGURE 2-3
REPORT NO: DOE/OR/21548-202
EXHIBIT NO.: A/QY/043/0691
ORIGINATOR: CSJ
DRAWN BY: SRS
DATE: 6/91

including the St. Charles County well field. Both the raw and treated waters from the St. Charles County water treatment plant are also sampled. This second portion of the quarry groundwater monitoring program has been jointly developed by representatives of the DOE, the Missouri Department of Natural Resources (MDNR), and St. Charles County.

2.2.1 Radiological Results

Radiological data are presented in Tables 2-4, 2-5, and 2-5A for samples collected on a bimonthly and quarterly bases. The results show fluctuations around the average levels in the WSQ area with no dramatic increases evident except in MW-1028 and MW-1011. MW-1028 had a level of 88.4 pCi/l during the January and February bimonthly sampling event. Previous results from this monitoring location have indicated levels less than 10 pCi/l of uranium, therefore the result of 88.4 pCi/l appears unusual. All pertinent analytical QC data has been requested from the analytical laboratory performing the analysis so that the analytical results can be validated. MW-1011 (located immediately south of the slough) indicated an unusually elevated concentration of uranium (20.4 pCi/l) during the first quarter, 1991. Through a meeting with representatives of St. Charles County and MDNR, it was decided that the DOE would pursue weekly sampling of MW-1011 and adjacent well MW-1010 and expedited analysis of the samples from that well for one month. The results of that sampling are provided in Table 2-4. The results of the weekly sampling indicate that there is no continuing, upward trend to the concentrations of uranium in the groundwater monitored by MW-1011. In fact, the last three data points represent successively lower concentrations. Throughout this incident, the uranium level in the adjacent, deeper-nested well (MW-1010) remained less than 1 pCi/l. The St. Charles County Wellfield remains safe and is not under any imminent threat from WSQ-related contamination.

The WSSRAP has increased the sampling schedule for these wells from semiannually to monthly for three months. Upon receipt of the monthly sampling results, the DOE/PMC may then assess the appropriateness of resuming the sampling schedule prescribed in the WSSRAP 1991 *Environmental Monitoring Plan*. Trend analyses for radiological results will be presented in the 1991 ASER.

TABLE 2-4 First Bimonthly (Jan/Feb) Inorganic Anions and Radiological Results in Groundwater for the WSQ

SAMPLE ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)	Gross Alpha (pCi/l)
GW-1002-022691	0.8	51	2	NS
GW-1004-012991	0.3	283	6324	NS
GW-1005-012991	ND	218	2516	NS
GW-1006-012991	1.7	375	2720	NS
GW-1007-012991	ND	50.6	129.2	NS
GW-1008-013191	ND	271	4692	NS
GW-1009-013191	ND	218	11.6	NS
GW-1010-022691*	NS	NS	ND	0 +/- 3
GW-1011-022691*	ND	11.7	30.6	NS
GW-1010-030591*	NS	NS	ND	-4 +/- 4
GW-1011-030591*	NS	NS	19	8 +/- 9
GW-1010-031391*	NS	NS	ND	NS
GW-1011-031391*	NS	NS	23.1	NS
GW-1010-031891*	NS	NS	ND	2 +/- 3
GW-1011-031891*	NS	NS	18.4	23 +/- 9
GW-1010-032691*	NS	NS	ND	NS
GW-1011-032691*	NS	NS	13.6	NS
GW-1012-020691	1.7	69.5	4.1	NS
GW-1013-022091	0.3	95	884	NS
GW-1014-022091	ND	101	1156	NS
GW-1015-021191	2.2	221	605	NS
GW-1016-021191	0.5	168	163	NS
GW-1026-020691	ND	ND	ND	NS
GW-1027-020491	ND	153	496.4	NS
GW-1028-020491	ND	64	88.4	NS

* 1010, 1011 Special Study (radiological only)
ND Not Detected
NS Not Sampled

TABLE 2-5 First Quarter Inorganic Anions and Radiological Results for the WSQ

SAMPLE ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-1010-Q191	ND	ND	ND
GW-1011-Q191	ND	16.7	20.4
GW-1017-Q191	ND	1.3	2.7
GW-1018-Q191	ND	29	ND
GW-1019-Q191	ND	ND	0.7
GW-1020-Q191	ND	ND	1.4
GW-1021-Q191	ND	4.4	0.7
GW-1022-Q191	ND	3.2	1.4
GW-1023-Q191	ND	8.1	ND
GW-1034-042291			ND

ND Not Detected

TABLE 2-5A First Quarter Inorganic Anions and Radiological Results for the St. Charles County Wellfield

SAMPLE ID	Nitrate (mg/l)	Sulfate (mg/l)	Total Uranium (pCi/l)	Gross Alpha (pCi/l)	Gross Beta (pCi/l)	Ra-226 (pCi/l)	Ra-228 (pCi/l)	Th-230 (pCi/l)	Th-232 (pCi/l)
GW-1024-Q191	ND	ND	0.7	2 +/- 4	4 +/- 4	.4 +/- .3	2.3 +/- 1.2	.1 +/- .1	0 +/- .1
GW-RMW1-030591	NA	NA	ND	NS	NS	NS	NS	NS	NS
GW-RMW1-Q191	ND	4.9	ND	-1 +/- 4	3 +/- 4	.8 +/- .3	1.2 +/- 1.1	0 +/- .1	0 +/- .1
GW-RMW2-Q191	ND	19.4	6.8	8 +/- 5	7 +/- 3	.4 +/- .4	-.1 +/- .5	0 +/- .1	0 +/- .1
GW-RMW3-Q191	ND	ND	ND	3 +/- 5	4 +/- 4	.7 +/- .3	2.2 +/- 1.1	.1 +/- .1	0 +/- .1
GW-RMW4-Q191	0.5	27.3	5.4	1 +/- 4	2 +/- 3	.1 +/- .2	.3 +/- 1.1	.1 +/- .1	0 +/- .1
GW-RAWW-Q191	ND	57.5	ND	0 +/- 3	6 +/- 3	.6 +/- .3	1.3 +/- .8	0 +/- .1	0 +/- .1
GW-FINW-Q191	0.2	84	ND	-1 +/- 2	6 +/- 2	.5 +/- .3	.4 +/- .5	0 +/- .1	0 +/- .1
GW-PW02-Q191	ND	95.6	0.7	-1 +/- 3	6 +/- 2	.7 +/- .3	1.8 +/- .8	0 +/- .1	0 +/- .1
GW-PW03-Q191	ND	82	ND	1 +/- 3	6 +/- 2	.4 +/- .4	1.7 +/- .7	0 +/- .1	0 +/- .1
GW-PW04-Q191	ND	89.5	ND	0 +/- 3	6 +/- 3	.5 +/- .3	1.6 +/- .8	0 +/- .1	0 +/- .1
GW-PW05-Q191	ND	49.8	ND	0 +/- 3	5 +/- 2	.6 +/- .3	1.2 +/- .7	0 +/- .1	0 +/- .1
GW-PW06-Q191	ND	59	ND	2 +/- 3	6 +/- 3	.4 +/- .3	2.1 +/- .8	0 +/- .1	0 +/- .1
GW-PW07-Q191	ND	13.4	2.7	0 +/- 4	7 +/- 4	.5 +/- .4	2.6 +/- .8	.1 +/- .1	0 +/- .1
GW-PW08-Q191	ND	12	ND	2 +/- 4	5 +/- 3	.5 +/- .3	1.8 +/- .8	0 +/- .1	0 +/- .1
GW-PW09-	NOT ON LINE IN FIRST QUARTER 1991								
GW-PW09-Q291*	ND	49.6	ND	0 +/- .1	4 +/- 3	.5 +/- .4	1.1 +/- .8	-.1 +/- .1	0 +/- .1

* Annual sampling for PW09 took place 2nd quarter
ND Not Detected
NS Not Sampled

2.2.2 Nitroaromatic Compounds Results

Analytical results for nitroaromatic compounds are presented in Tables 2-6 and 2-7. No monitoring wells south of the Femme Osage Slough showed detectable concentrations of nitroaromatic compounds during the first quarter 1991. The distribution and magnitude of nitroaromatic contamination near the quarry remains unchanged.

2.2.3 Inorganic Anions Results

Two inorganic anions--nitrate and sulfate--were measured in quarry wells. Tables 2-4, 2-5, and 2-5A display the analytical results for the first quarter of 1991, which are consistent with data reported in the previous environmental monitoring reports. The WSQ groundwater samples continue to indicate no significant groundwater contamination by nitrate. The groundwater samples continue to indicate background concentrations of sulfate in wells south of the Femme Osage Slough.

2.2.4 Metals Results

A selected group of quarry wells located south of the Femme Osage Slough were sampled for cadmium, lead, and mercury in addition to arsenic and barium. Analytical results for these metals are presented in Tables 2-8 and 2-9. Results from the first bimonthly and first quarter analyses of arsenic and barium continue to indicate elevated concentrations in selected wells. The highest levels reported are 153 μg/l for arsenic in MW–1017 and 950 μg/l for barium also detected in MW-1017.

TABLE 2-6 First Bimonthly (Jan/Feb) Nitroaromatic Data for Groundwater at the WSQ

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1002-022691	ND	0.12	ND	6.5	14	75
GW-1004-012991	ND	ND	2	3.8	8.5	2.8
GW-1005-012991	ND	ND	0.14	0.05	ND	ND
GW-1006-012991	ND	ND	0.15	3	15	92
GW-1007-012991	ND	ND	ND	ND	ND	ND
GW-1008-013191	ND	ND	ND	0.22	0.44	0.15
GW-1009-013191	ND	ND	ND	ND	ND	ND
GW-1012-020691	ND	ND	ND	ND	ND	ND
GW-1013-022091	ND	ND	0.15	0.04	ND	ND
GW-1014-022091	ND	ND	ND	ND	ND	ND
GW-1015-021191	ND	ND	ND	0.4	5.4	34
GW-1016-021191	ND	ND	ND	0.07	0.46	1.6
GW-1026-020691	ND	ND	ND	ND	ND	ND
GW-1027-020491	ND	ND	12	6.6	19	0.11
GW-1028-020491	ND	ND	ND	ND	ND	ND

ND Not Detected

TABLE 2-7 First Quarter Nitroaromatic Data for Groundwater at the WSQ

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1010-Q191	ND	ND	ND	ND	ND	ND
GW-1011-Q191	ND	ND	ND	ND	ND	ND
GW-1011-022691	ND	ND	ND	ND	ND	ND
GW-1017-Q191	ND	ND	ND	ND	ND	ND
GW-1018-Q191	ND	ND	ND	ND	ND	ND
GW-1019-Q191	ND	ND	ND	ND	ND	ND
GW-1020-Q191	ND	ND	ND	ND	ND	ND
GW-1021-Q191	ND	ND	ND	ND	ND	ND
GW-1022-Q191	ND	ND	ND	ND	ND	ND
GW-1023-Q191	ND	ND	ND	ND	ND	ND
GW-1024-Q191	ND	ND	ND	ND	ND	ND
GW-RMW1-Q191	ND	ND	ND	ND	ND	ND
GW-RMW2-Q191	ND	ND	ND	ND	ND	ND
GW-RMW3-Q191	ND	ND	ND	ND	ND	ND
GW-RMW4-Q191	ND	ND	ND	ND	ND	ND
GW-RAWW-Q191	ND	ND	ND	ND	ND	ND
GW-FINW-Q191	ND	ND	ND	ND	ND	ND
GW-PW02-Q191	ND	ND	ND	ND	ND	ND
GW-PW03-Q191	ND	ND	ND	ND	ND	ND
GW-PW04-Q191	ND	ND	ND	ND	ND	ND
GW-PW05-Q191	ND	ND	ND	ND	ND	ND
GW-PW06-Q191	ND	ND	ND	ND	ND	ND
GW-PW07-Q191	ND	ND	ND	ND	ND	ND
GW-PW08-Q191	ND	ND	ND	ND	ND	ND
GW-PW09-	NOT ON LINE IN FIRST QUARTER 1991					

ND Not Detected

TABLE 2-8 First Bimonthly (Jan/Feb) Results for Metals in Groundwater at the WSQ

	Arsenic (µg/l)	Barium (µg/l)
GW-1002-022691	ND	118
GW-1004-012991	ND	31
GW-1005-012991	ND	43.3
GW-1006-012991	ND	22.3
GW-1007-012991	18.7	243
GW-1008-013191	ND	36.6
GW-1009-013191	5.7	333
GW-1012-020691	ND	118
GW-1013-022091	5.5	153
GW-1014-022091	ND	123
GW-1015-021191	ND	97.2
GW-1016-021191	4.4	101
GW-1026-020691	26.2	389
GW-1027-020491	ND	111
GW-1028-020491	ND	288

ND Not Detected

TABLE 2-9 First Quarter Results for Metals in Groundwater at the WSQ

	Arsenic (µg/l)	Barium (µg/l)	Cadmium (µg/l)	Lead (µg/l)	Mercury (µg/l)
GW-1010-Q191	92.8	376	NS	NS	NS
GW-1011-Q191	4.7	216	NS	NS	NS
GW-1017-Q191	153	950	NS	NS	NS
GW-1018-Q191	123	550	NS	NS	NS
GW-1019-Q191	2	9.4	NS	NS	NS
GW-1020-Q191	2	9.4	NS	NS	NS
GW-1021-Q191	4	9.4	NS	NS	NS
GW-1022-Q191	8	9.4	NS	NS	NS
GW-1023-Q191	71.6	276	NS	NS	NS
GW-1024-Q191	8.3	478	NS	NS	NS
GW-RMW1-Q191	8.3	511	NS	NS	NS
GW-RMW2-Q191	9.2	204	NS	NS	NS
GW-RMW3-Q191	45.3	516	NS	NS	NS
GW-RMW4-Q191	10.2	134	NS	NS	NS
GW-RAWW-Q191	ND	345	ND	ND	ND
GW-FINW-Q191	ND	104	ND	ND	ND
GW-PW02-Q191	ND	288	ND	ND	ND
GW-PW03-Q191	ND	238	ND	ND	ND
GW-PW04-Q191	ND	253	ND	ND	ND
GW-PW05-Q191	ND	300	ND	ND	0.33
GW-PW06-Q191	ND	304	ND	2.9	ND
GW-PW07-Q191	ND	478	ND	ND	ND
GW-PW08-Q191	4.2	385	ND	ND	0.26
GW-PW09-	NOT ON LINE QUARTER ONE				

ND Not Detected
NS Not Sampled

3 SURFACE WATER MONITORING

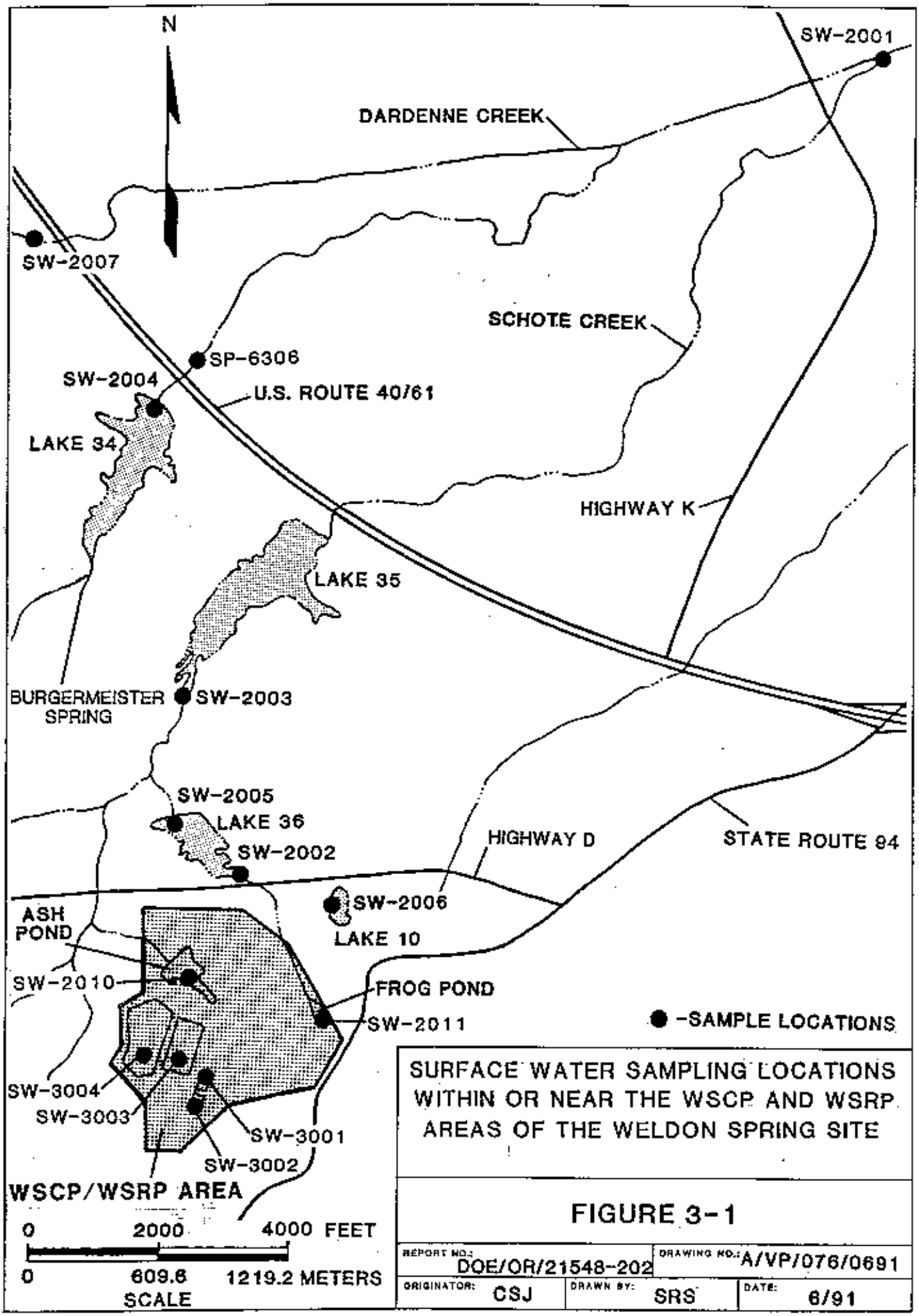
Routine samples were collected during the first quarter of 1991 from both on-site and off-site surface water and spring locations. All surface water samples were analyzed without filtering, unless a specific comparison of dissolved versus total contaminant concentrations was desired. Some analytical results are not available at this time; however, they will be presented in the 1991 ASER.

3.1 Chemical Plant/Raffinate Pits/Vicinity Properties

During the first quarter, surface water samples were collected from the 13 surface water sampling locations shown in Figure 3-1 and analyzed for uranium. The available results, presented in Table 3-1, indicate that conditions remain similar with values within the range measured historically with the highest level (197.2 pCi/l) detected at Frog Pond. All other values at off-site locations remain relatively low and consistent with historical values.

3.2 Weldon Spring Quarry

Surface water samples were collected from the 10 locations shown in Figure 3-2 and three locations in Figure 3-3. Samples were analyzed for uranium, arsenic, and barium and the results are presented in Tables 3-2 and 3-3. The results of all samples indicate no apparent changes in environmental conditions, although as seen in previous first quarters, the uranium levels within the slough were higher than in previous quarters. The highest measured level was 326.4 pCi/l detected at sampling location SW-1004. However, elevated levels of uranium in the slough have been observed in previous years during March, April, and May. This phenomenon is thought to be the result of the annual spring thaw. As the ground thaws, usually during February and March, an increase in groundwater movement transports uranium to the slough. The effect may be enhanced by the fact that more uranium is dissolved from the soil during the freeze/thaw process due to longer soil/water contact times. The elevated levels in the slough are not detected until March, April, or May because of the time required for uranium to reach the slough via groundwater transport. To better understand uranium concentrations in the slough, the frequency of sampling and analysis is being increased from quarterly to monthly.



SURFACE WATER SAMPLING LOCATIONS WITHIN OR NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

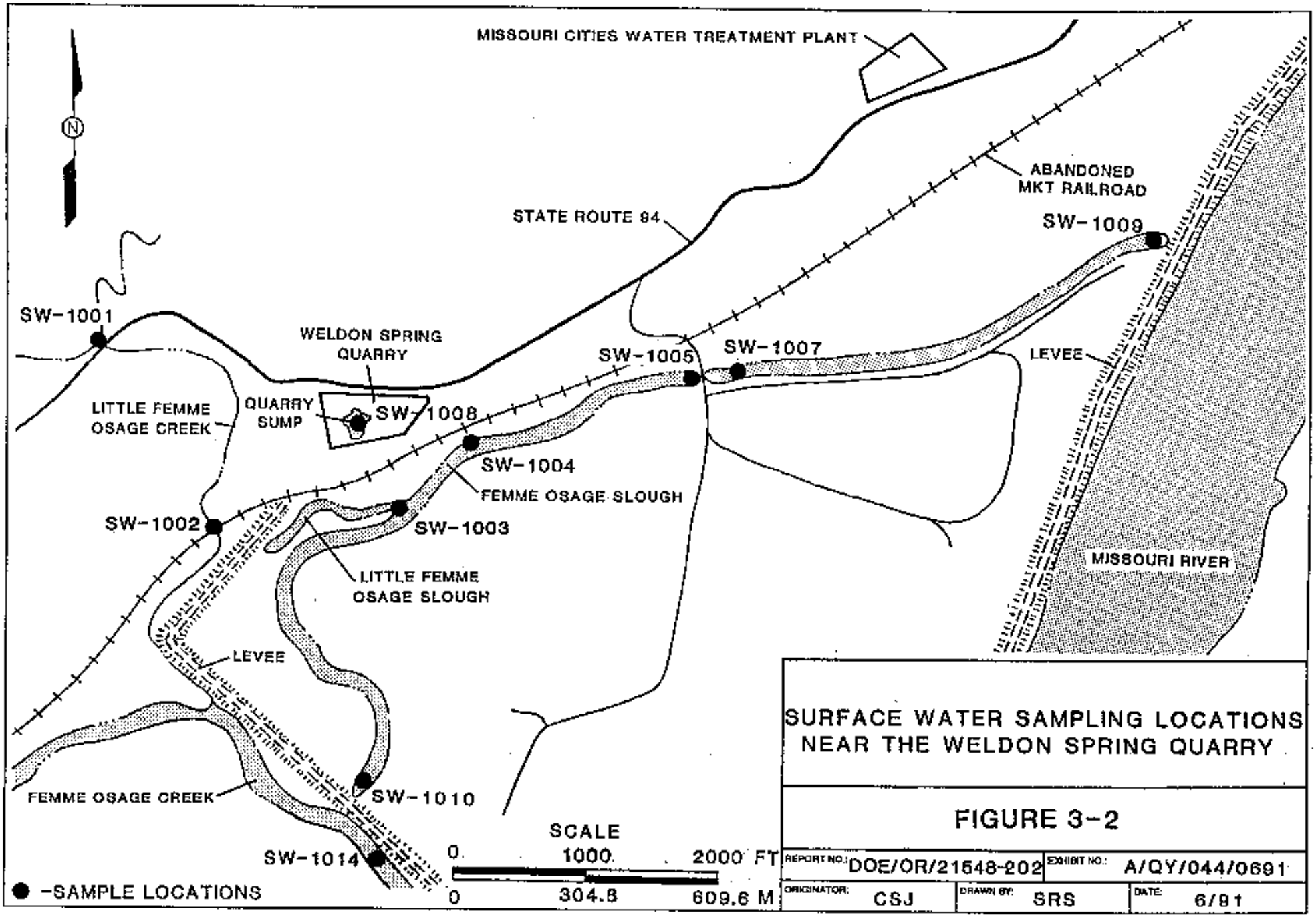
FIGURE 3-1

REPORT NO.: DOE/OR/21548-202	DRAWING NO.: A/VP/076/0691	
ORIGINATOR: CSJ	DRAWN BY: SRS	DATE: 6/91

TABLE 3-1 First Quarter Uranium Results in Surface water at the WSCP/RP/VP

SITE ID	URANIUM, TOTAL (pCi/l)
SW-2001	2.0
SW-2002	43.5
SW-2003	7.5
SW-2004	16.3
SW-2005	2.7
SW-2007	2.0
SW-2010	106.8
SW-2011	197.2
SW-3001	NA
SW-3002	NA
SW-3003	NA
SW-3004	NA

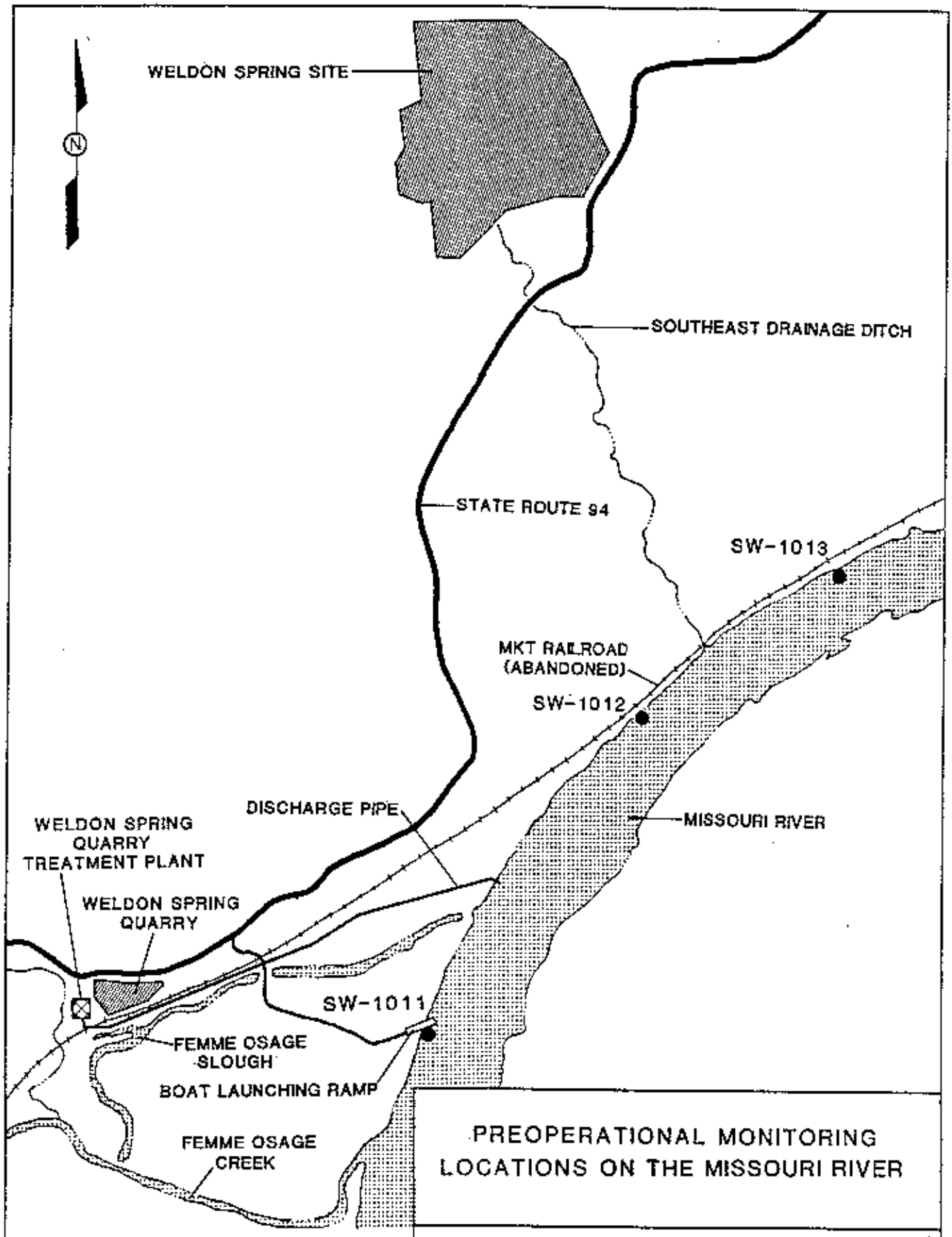
NA Not Available



SURFACE WATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 3-2

REPORT NO.: DOE/OR/21548-202	EXHIBIT NO.: A/QY/044/0691	
ORIGINATOR: CSJ	DRAWN BY: SRS	DATE: 6/91



PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

FIGURE 3-3

REPORT NO: DOE/OR/21548-202		EXHIBIT NO: A/VP/077/0691			
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 6/91			

TABLE 3-2 First Quarter Results for Uranium in Surface Water at the WSQ

SITE ID	URANIUM (pCi/l)
SW-1001	0.68
SW-1002	6.8
SW-1003	156.4
SW-1004	326.4
SW-1005	81.6
SW-1007	11.6
SW-1008	NA
SW-1009	28.6
SW-1010	74.8
SW-1011	4.8
SW-1012	4.8
SW-1013	3.4

NA Not Available

TABLE 3-3 First Quarter Metal Results in Surface Water At the WSQ (µg/l)

SITE ID	ARSENIC	BARIUM
SW-1001	ND	54.1
SW-1002	ND	56.1
SW-1003	ND	123.0
SW-1004	NA	NA
SW-1005	NA	NA
SW-1007	NA	NA
SW-1008	NA	NA
SW-1009	ND	ND
SW-1010	ND	126.0
SW-1011	3.7	143.0
SW-1012	3.0	137.0
SW-1013	3.3	139.0
SW-1014	ND	61.7

ND Not Detected
NA Not Available

The first quarter uranium values measured in the Missouri River were lower than the values detected during the previous quarter. Historically, the levels of uranium at these locations have fluctuated (due to either natural fluctuations or analytical variability) such that uranium concentrations have been higher at upstream locations than downstream, and vice versa. The U.S. Department of Energy (DOE) has increased monitoring of the Missouri River prior to the operation of the Weldon Spring Site Remedial Action Project (WSSRAP) quarry water treatment plant to ascertain the preoperational (background) levels in the river. In addition, the National Pollution Discharge Elimination System (NPDES) permit for the quarry water treatment plant requires additional monitoring of the river. This monitoring increases the DOEs capability to ensure the safety of the public and the environment.

Arsenic and barium results indicate that arsenic within the Missouri River is at levels well below the National Primary Drinking Water Standards (slightly above the detection limit) and barium found in all samples is within the background range and well below the National Primary Drinking Water Standard.

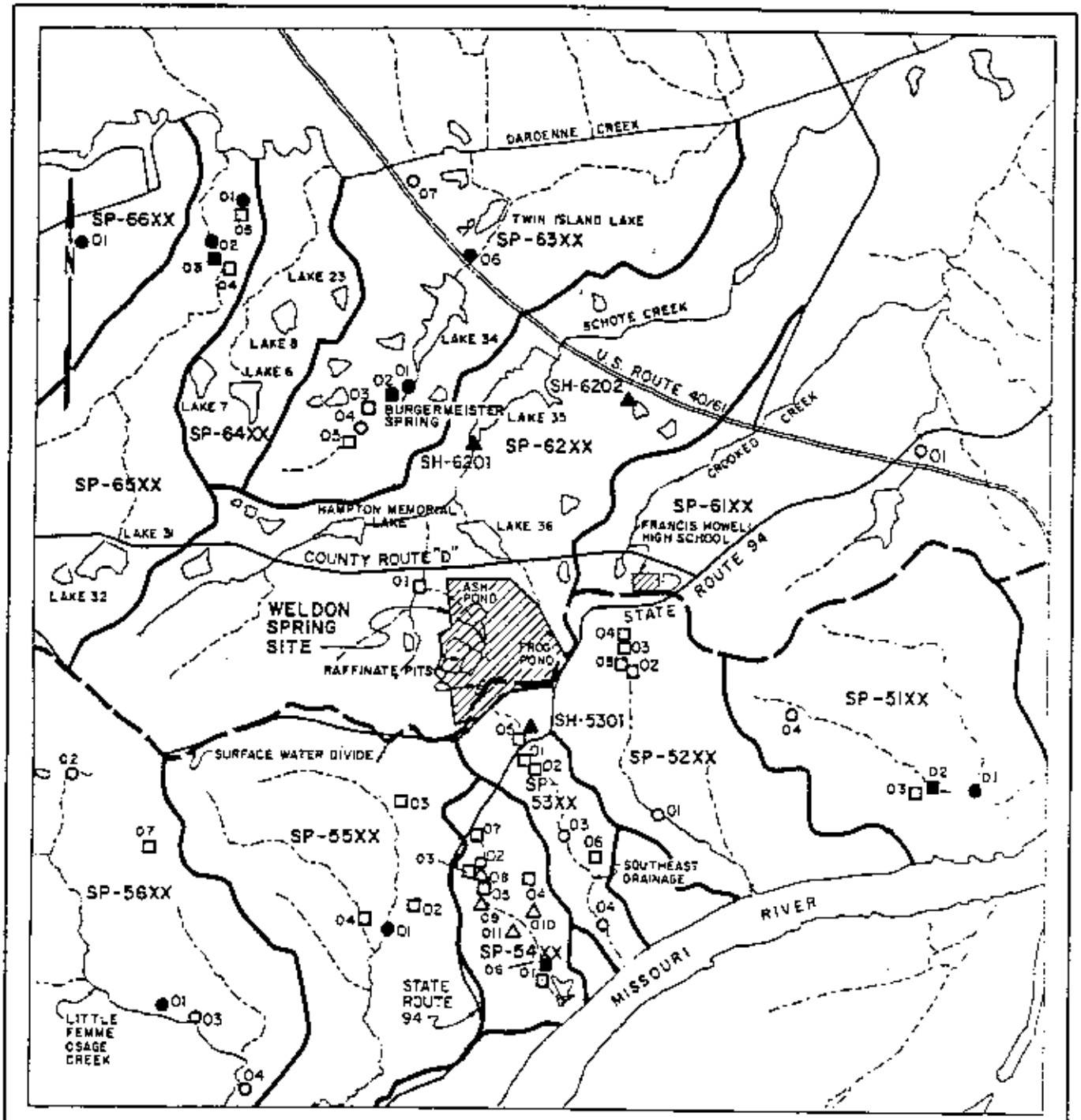
The analytical results for the six nitroaromatic compounds within the quarry slump were not available at the time of this report. The ponded water is to be treated for nitroaromatic compounds and other organics upon completion of the quarry water treatment plant.

3.3 Springs

Eleven springs around the Weldon Spring site (WSS) are sampled quarterly (see Figure 3-4 for spring locations). Previous spring monitoring indicated that waters from six perennial springs and one wet-weather spring are measurably influenced by site-related contaminants. These springs are SP-6301, SP-6302, SP-6306, and SP-5301 through SP-5304. All spring samples are analyzed for uranium with a select few analyzed for nitroaromatics, inorganics and metals. Analytical results for these parameters are listed in Tables 3-4, 3-5, 3-6, and 3-7. Values for these parameters remain consistent with their historical values.

3.4 National Pollutant Discharge Elimination System Data Review

Surface water and effluent samples were collected and analyzed in compliance with the Weldon Spring Site National Pollutant Discharge Elimination System (NPDES) permit.



SOURCE: MDNR, 1989

LEGEND:

- SURFACE WATER DIVIDE BETWEEN MISSISSIPPI RIVER AND MISSOURI RIVER
- DRAINAGE BOUNDARY
- CREEK OR SURFACE DRAINAGE
- POND OR LAKE
- PERENNIAL SPRING WITH LARGE MAXIMUM FLOW
- PERENNIAL SPRING WITH SMALL MAXIMUM FLOW
- WET WEATHER SPRING WITH LARGE MAXIMUM FLOW
- WET WEATHER SPRING WITH SMALL MAXIMUM FLOW
- SHALLOW HOLE (SH)
- SEEP
- SP-63XX: SPRING OR SEEP IN DESIGNATED DRAINAGE AREA NUMBER 63. XX REPRESENTS THE DESIGNATED SPRING NUMBER IN DRAINAGE 63.

SCALE 0 3200 6400 FT
0 975.4 1950.7 M

SPRINGS AND SEEPS IN THE VICINITY OF THE WSS

FIGURE 3-4

REPORT NO: DOE/OR/21548-202	EXHIBIT NO.: A/VP/078/0691	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 6/91

TABLE 3-4 First Quarter Uranium Results in Springs Near the WSS

Site ID	Uranium (pCi/l)
SP-5201	NA
SP-5203	NA
SP-5301	176.8
SP-5302	156.4
SP-5303	NA
SP-5304	NA
SP-6301	49.0
SP-6303	2.0
SP-6306	6.1
SP-5503	NA
SP-6302	63.2

NA Not Available

TABLE 3-5 First Quarter Nitroaromatic Results in Springs Near the WSS (µg/l)

SITE ID	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NITROBENZENE
SP-6301	ND	ND	0.052	ND	0.19	ND
SP-6303	0.053	ND	0.36	0.05	0.83	ND
SP-6306	ND	ND	ND	ND	ND	ND
SP-6302	ND	ND	ND	ND	0.021	ND

ND Not Detected

TABLE 3-6 First Quarter Inorganic Anion Results in Springs Near the WSS

Site ID	Nitrate (mg/l)	Sulfate (mg/l)
SP-6301	8.7	31.8

TABLE 3-7 First Quarter Metals Results in Springs Near the WSS (µg/l)

METAL	SP-6301	SP-6306
LITHIUM	ND	15.6
MOLYBDENUM	ND	ND
ALUMINUM	143	153.0
ANTIMONY	ND	ND
BARIUM	76.8	308.0
BERYLLIUM	ND	ND
CADMIUM	ND	ND
CALCIUM	43100	33600
CHROMIUM	ND	ND
COBALT	ND	ND
COPPER	ND	ND
IRON	156.0	4150
MAGNESIUM	9290	7870
MANGANESE	4.8	6710.0
NICKEL	ND	ND
POTASSIUM	1570	1710.0
SILVER	ND	ND
SODIUM	14700	10200
VANADIUM	ND	ND
ZINC	8.5	ND
ARSENIC	ND	6.7
LEAD	ND	ND
SELENIUM	ND	ND
THALLIUM	ND	ND
MERCURY	ND	ND

ND Not Detected

This permit (Number MO-0107701) was issued in November 1988 and addresses storm water and wastewater discharges. The six discharge points or outfalls included in this permit are shown in Figure 3-5. Outfalls NP-0001 through NP-0005 represent storm water discharge and NP-0006 represents the treated effluent discharge associated with the administration building sanitary wastewater treatment plant. Currently NP-0006 is the only outfall with effluent limitations. The five surface water outfalls have monitoring requirements only. First quarter 1991 analytical data for each outfall is presented in Table 3-8.

Radiological Analysis

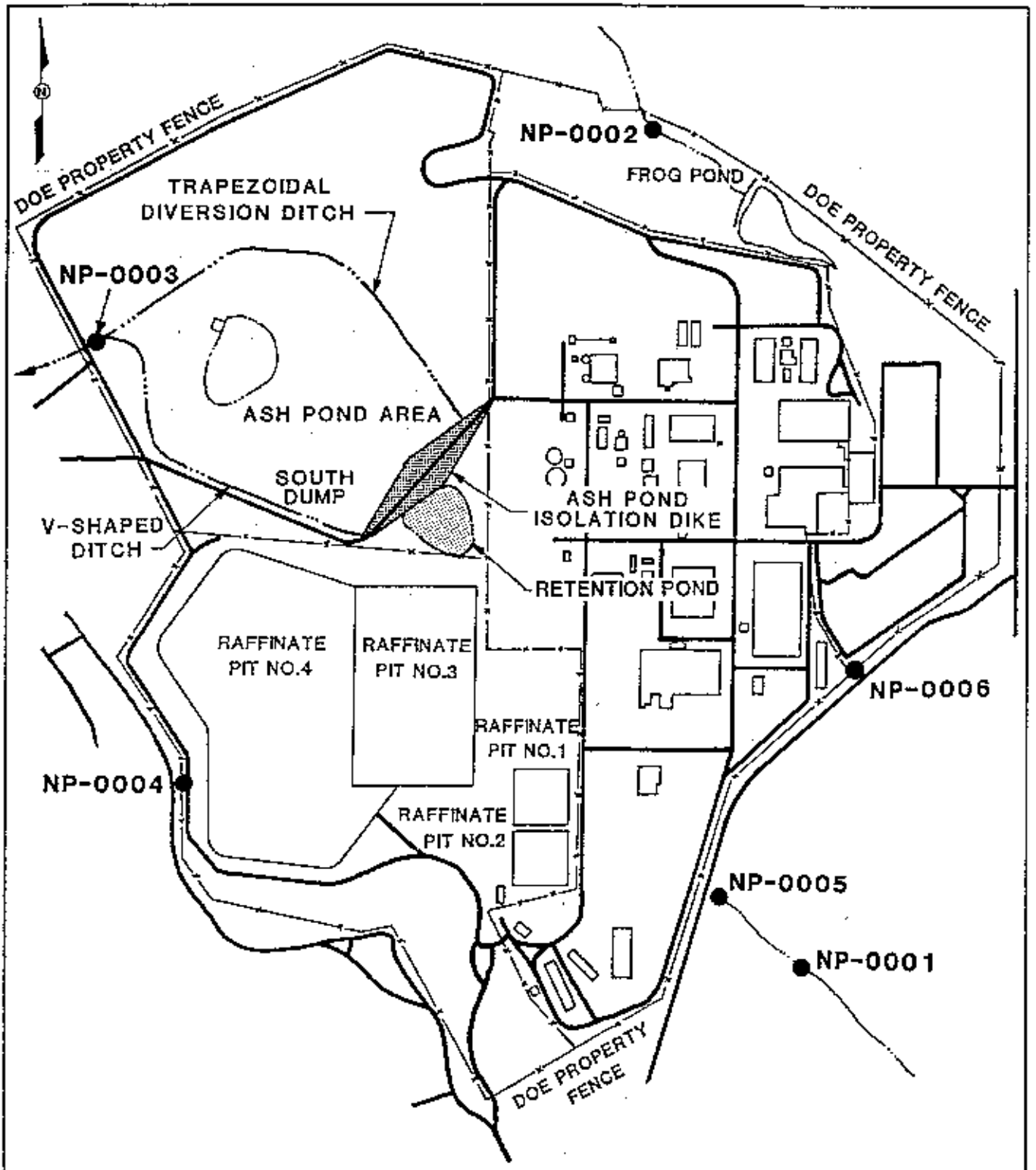
Gross Alpha and Total Uranium analyses correspond reasonably well with past data. The highest uranium levels were present in surface flow from the southeast portion of the site (NP-0005) and surface flow for the northwest area of the site (NP-0003). The peaks for these points were 2244 pCi/l and 3400 pCi/l, respectively.

Other outfalls exhibited the following range of uranium concentrations. NP-0002, the drainage from the Frog Pond area, ranged from 97 pCi/l to 197 pCi/l. NP-0001, (process sewer) was measured at 816 pCi/l. A uranium concentration of 9.5 pCi/l was present in the sample collected from NP-0004, behind raffinate pit No. 4.

Other Analysis

Other analyses include physical analysis (settleable solids and suspended solids) and chemical analysis (nitrate, pH, and lithium). First quarter 1991 values generally correspond to past values for the majority of parameters.

The discharge from the administration building treatment plant, NP-0006, has effluent limitations for quarterly samples. In addition to this quarterly monitoring, the subcontractor monitors the same parameters monthly, to assess plant performance. The NPDES permit contains effluent limitations on biochemical oxygen demand (BOD), total suspended solids (TSS), and fecal coliform at this outfall. These limits are 15 mg/l (BOD), and 20 mg/l (TSS), for weekly averages with maximum daily fecal coliform of 1000 colonies 1100 ml. NPDES permit limits were exceeded in the first quarter 1991 at this outfall. The BOD standard was exceeded in February. The cold months showed higher values due to upsets intensified by weather.



NPDES MONITORING LOCATIONS

FIGURE 3-5

SCALE 0 500 1000 FT
0 152.4 304.8 M

REPORT NO: DOE/OR/21548-202	EXHIBIT NO.: A/CP/128/0691	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 6/91

TABLE 3-8 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006

Outfall NP-0001 NPDES data for Q1 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	mg/l	pCi/l
Jan. 3	1440	2.0	<0.1	1.56	7.14	0.0078	560	1.20	816

Outfall NP-0002 NPDES data for Q1 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	mg/l	pCi/l
Jan. 3	5109	3.0	<0.1	1.68	6.1	<0.004	180	0.29	197
Feb. 5	56736	8.0	<0.1	2.31	6.1	0.0127	94	0.14	97
Mar. 1	1440	13.0	<0.1	4.72	6.25	ND	120	0.20	136

Outfall NP-003 NPDES data for Q1 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	mg/l	pCi/l
Jan. 3	50490	5.0	<0.1	2.04	6.09	0.0084	2300	5.00	3400
Feb. 5	50500	4.0	<0.1	10.5	6.27	ND	210	0.28	192
Mar. 1	36700	13.0	<0.1	13.5	6.24	ND	1100	1.90	1292

TABLE 3-8 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006 (Continued)

Outfall NP-0004 NPDES data for Q1 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	mg/l	pCi/l
Mar. 11	Not Flowing	11.0	<0.1	2.0	6.76	ND	15	0.01	9.5

Outfall NP-0005 NPDES data for Q1 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	mg/l	pCi/l
Jan. 3	250	13.0	<0.1	29.6	6.66	<0.004	1600	3.30	2244
Feb. 5	9360	5.0	<0.1	ND	5.95*	0.062	510	0.79	537
Mar. 1	11800	5.0	<0.1	29.4	6.51	ND	550	1.10	748

* Indicates value which exceeded effluent limitation

Outfall NP-0006 NPDES data for Q1 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	BOD	FECAL COLIFORMS	pH
UNITS	GPD	mg/l	mg/l	No./100 ml	
Jan. 30	1690	13	<2.0	<10	7.0
Feb. 13	2475	16	18.1*	77	6.3
Mar. 11	2385	1.0	<3.0	<1.0	7.0

* Indicates value which exceeded effluent limitation

4 AIR MONITORING

4.1 Radon Gas

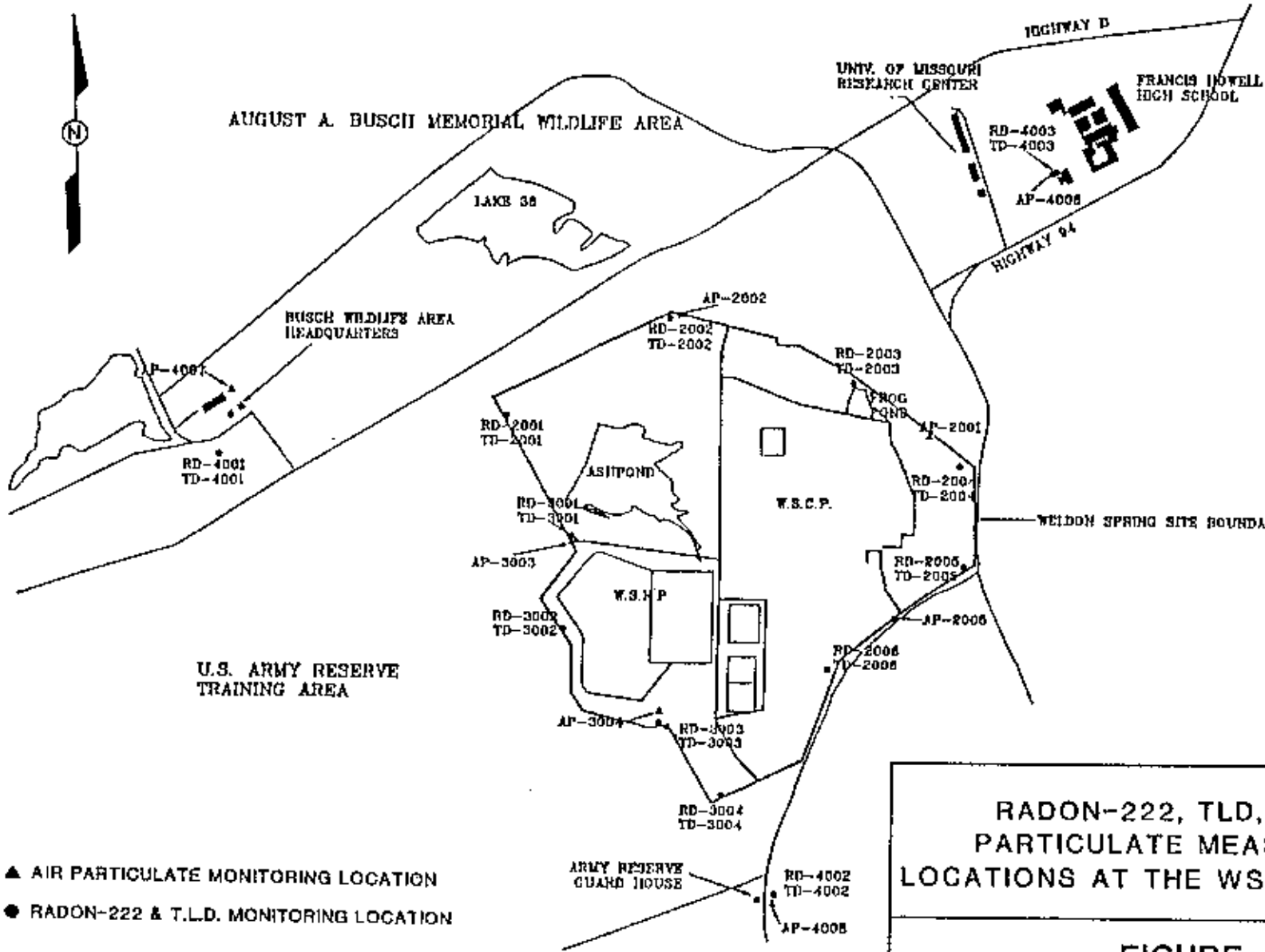
The radon gas monitoring program utilizes a pair of radon detectors at each of 22 permanent locations; each detector is exchanged quarterly. These detectors are deployed at six locations at the Weldon Spring Chemical Plant, six locations at the Weldon Spring quarry, four locations at the Weldon Spring raffinate pits, and six off-site locations. Radon monitoring locations are shown in Figures 4-1, 4-2, and 4-3. On-site detectors are distributed around the perimeter fences to ensure adequate detection of radon dispersing from the properties under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005, and RD-4006 were used to monitor background levels near the site.

Table 4-1 summarizes the first quarter 1991 radon concentrations detected at all site perimeter and off-site monitoring locations. Also contained in Table 4-1 is a comparison of the measured concentration with the Federally permitted radon concentration (for unrestricted areas) of 3 pCi/l (110 Bq/m^3) above background as authorized by U.S. Department of Energy (DOE) Order 5400.5.

An average ambient background concentration was determined by calculating the arithmetic average for the four background locations. This data yielded an average ambient background radon concentration of less than 0.1 pCi/l for the first quarter of 1991. This concentration was then subtracted from the concentration for each monitoring station, and compared to the DOE guideline of 3 pCi/l above background.

Radon concentrations at the site and quarry perimeters and at off-site locations for the first quarter of 1991 were within the typical range expected during years of normal precipitation. The quarterly radon concentrations (background included) ranged from less than 0.1 pCi/l at 10 locations to 0.9 pCi/l at monitoring location RD-1002.

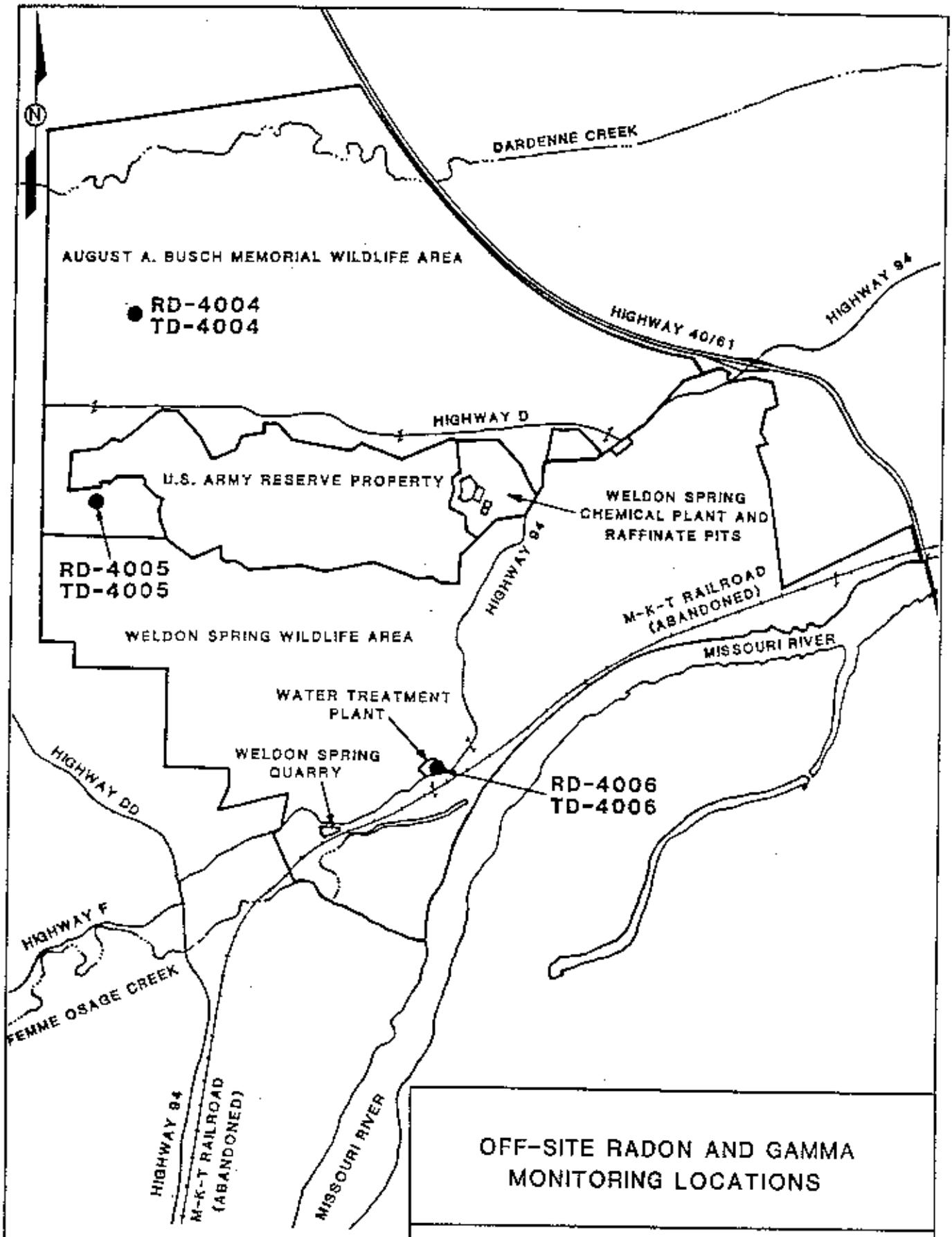
Radon concentrations found in the quarry are higher than concentrations measured at other locations because the radium concentrations in quarry wastes are typically much higher than other areas, and because the quarry is a large depression with side walls ranging from 3 m to 15 m (10 ft to 50 ft) high. In conjunction with stable meteorological



RADON-222, TLD, AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 4-1

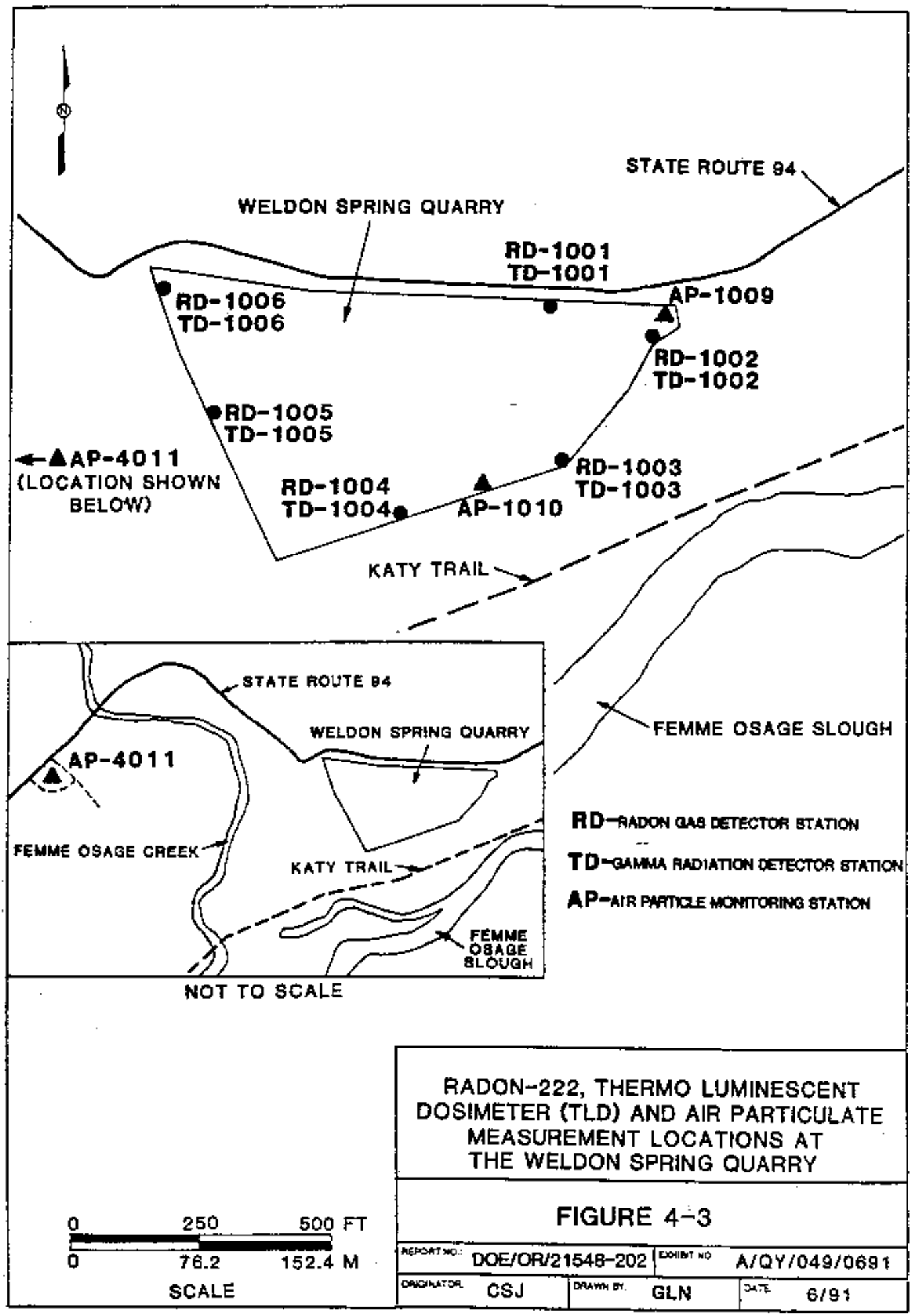
REPORT NO.: DOE/OR/21548-202		EXHIBIT NO.: A/VP/079/0691	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 6/91	



OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

FIGURE 4-2

REPORT NO:	DOE/OR/21548-202	EXHIBIT NO.:	A/VP/080/0691		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	6/91



RADON-222, THERMO LUMINESCENT DOSIMETER (TLD) AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 4-3

REPORT NO.: DOE/OR/21548-202	EXHIBIT NO: A/QY/049/0691	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 6/91

TABLE 4-1 1991 Track Etch Radon Results[a]

Location I.D.	1st quarter pCi/l	Percent of Guidance [b]
WSQ		
RD-1001	0.4	10
RD-1002	0.9	30
RD-1003	0.7	20
RD-1004	<0.1	0
RD-1005	0.5	13
RD-1006	0.2	3
WSCP		
RD-2001	<0.5	13
RD-2002	0.1	0
RD-2003	<0.1	0
RD-2004	<0.1	0
RD-2005	<0.1	0
RD-2006	<0.1	0
WSRP		
RD-3001	<0.1	0
RD-3002	<0.1	0
RD-3003	<0.2	3
RD-3004	0.1	0
OFF-SITE		
RD-4001*	<0.1	0
RD-4002	0.2	3
RD-4003	<0.2	3
RD-4004*	0.1	0
RD-4005*	<0.1	0
RD-4006*	<0.1	0

(a) Results include natural background.
(b) Percent of guideline calculated by taking the year-to-date average minus the average of the background stations divided by the DOE concentration guideline for RN-222 which is 3 pCi/l (100 Bq/m ^ 3)(Annual average above background) for uncontrolled areas.
* Denotes Background Station

conditions, this configuration tends to trap emanating radon within the quarry and raise the concentrations along the quarry perimeter.

4.2 Gamma Radiation Exposure

To monitor exposure from gamma radiation, spherical environmental thermoluminescent dosimeters (TLDs) were deployed at 22 locations. The gamma monitoring station locations are the same as the ambient radon monitoring locations (see Section 4.1).

Table 4-2 summarizes the quarterly and year-to-date results of total gamma radiation monitoring at the 16 Weldon Spring site (WSS) perimeter monitoring stations, Francis Howell High School, the Weldon Spring Army Reserve Training Area, and at the four background monitoring stations.

The annual average background gamma exposures measured with TLDs in 1989 and 1990 were 68 mR/year and 62 mR/year, respectively. The gamma exposures measured with TLDs in the first quarter of 1991 were consistent with 1989 and 1990 data. This was expected because no significant changes in the configuration or location of the wastes have occurred.

4.3 Radioactive Air Particulates

Eleven air particulate samplers monitor the Weldon Spring site. Five of these (AP-2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the Weldon Spring Chemical Plant (WSCP) perimeter and two are located around the quarry perimeter as shown in Figure 4-3. Three monitoring stations (AP-4006, AP-4008, and AP-4011) are located off site at sensitive receptor locations; including Francis Howell High School, the Army Reserve property, and near a residential site west of the quarry. The monitoring station at the August A. Busch Wildlife Area (AP-4007) is used to monitor background levels in the vicinity of the WSCP. The off-site monitoring stations are also shown in Figure 4-2.

TABLE 4-2 1991 Environmental TLD Results[a]

Location I.D.	1st Quarter mrem
WSQ	
TD-1001	24
TD-1002	20
TD-1003	20
TD-1004	19
TD-1005	20
TD-1006	19
WSCP	
TD-2001	18
TD-2002	17
TD-2003	18
TD-2004	19
TD-2005	18
TD-2006	17
WSRP	
TD-3001	22
TD-3002	17
TD-3003	19
TD-3004	16
OFF-SITE	
TD-4001*	18
TD-4002	16
TD-4003	16
TD-4004*	19
TD-4005*	16
TD-4006*	17

(a) Results include natural background.
- Denotes loss of TLD.
* Denotes background station.

The sampling station near the August A. Busch Wildlife Area (ABWA) headquarters is used as a background air monitoring station. This station is approximately 0.8 km (0.5 mile) from the WSCP perimeter in a northwestern direction. The terrain between the WSCP and this sampling station is hilly and forested, providing a significant physical barrier to airborne particulates originating from the WSCP/ Weldon Spring raffinate pits (WSRP). In addition, winds from the southeast are relatively rare at the WSCP.

Table 4-3 summarizes the quarterly average concentrations and the standard deviations for the 11 air monitoring locations. The quarterly average concentration for each monitoring location was calculated by averaging either the weekly air particulate analysis results or the counting instrument's lower limit of detection (LLD), whichever was greater. The "<" sign in Table 4-3 appears when the actual average is less than the calculated average due to the use of LLD values in the calculation. The standard deviation for each of the monitoring locations was calculated using only results that were above the LLD. Locations AP-2005 and AP-4011 were not in operation for one and two weeks respectively, due to maintenance.

The first quarter net alpha concentrations ranged from 1.24×10^{-15} μCi/ml to 1.98×10^{-15} μCi/ml with $< 1.50 \times 10^{-15}$ μCi/ml detected at the background station.

4.4 Asbestos

Air sampling for asbestos has been performed on a routine basis for three years. The monitoring data indicate no elevated levels of airborne asbestos during both asbestos abatement operations and during periods when no asbestos activities were in progress at the site. Since asbestos removal and handling operations were in progress during the first quarter 1991, perimeter asbestos sampling was performed. The results of asbestos analyses during the first quarter of 1991 were below the standard of 0.01 f/cc. Asbestos Analyses results are shown in Table 4-4.

TABLE 4-3 Radiological Air Particulate First Quarter 1991

MONITOR IDENTIFICATION NUMBER	QUARTERLY AVG. CONCENTRATION (1E-15 µCi/ml)	STANDARD DEVIATION	NUMBER OF WEEKS COLLECTED	NUMBER OF VALUES ABOVE LLD
AP-2001	1.62E-15	5.47E-16	13	12
AP-2002	1.45E-15	3.40E-16	13	13
AP-3003	1.50E-15	5.75E-16	13	13
AP-3004	<1.83E-15	6.57E-16	13	12
AP-2005	<1.75E-15	6.05E-16	12	10
AP-4006	<1.56E-15	4.17E-16	13	12
AP-4007*	<1.50E-15	3.30E-16	13	12
AP-4008	1.98E-15	7.08E-16	13	13
AP-1009	<1.60E-15	5.18E-16	13	12
AP1010	1.70E-15	4.80E-16	13	13
AP-4011	1.24E-15	5.29E-16	11	11

* Indicates background monitor station.
To convert µCi/ml to Bq/M^3, multiply by 3.7E10.

Table 4-4 Asbestos Analyses Results

Record #	Sample ID	Date	Location	Sample Time	Sample Volume	Fiberconc
SITE PERIMETER						
1	AA-2010-021591	02/15/91	AP-2001 DOWNWIND	305	4431.8	<0.001 LOD
2	AA-2011-021591	02/15/91	AP-3004 UPWIND	350	5075	<0.001 LOD
3	AA-2024-022291	02/22/91	AP-2005 DOWNWIND	490	4936	<0.001 LOD
4	AA-2025-022291	02/22/91	AP-3003 UPWIND	505	5085	<0.001 LOD
5	AA-2002-030191	03/01/91	AP-2005 UPWIND	480	4835	<0.001 LOD
6	AA-2003-030191	03/01/91	AP-3003 DOWNWIND	475	4785	<0.001 LOD
7	AA-2010-030891	03/08/91	AP-2005 UPWIND	590	5900	NONE DETECTED
8	AA-2011-030891	03/08/91	AP-3003 DOWNWIND	520	5200	NONE DETECTED
9	AA-2022-031591	03/15/91	AP-2005 UPWIND	410	4130	<0.001 LOD
10	AA-2023-031591	03/15/91	AP-3003 DOWNWIND	410	4141	<0.001 LOD

Table 4-4 Asbestos Analyses Results (Continued) 061491

FRANCIS HOWELL HIGH SCHOOL						
1*	AA-2001-021191	02/11/91	AP-4006	454		OVERLOADED
2*	AA-2003-021291	02/12/91	AP-4006	585		OVERLOADED
3	AA-2006-021491	02/14/91	AP-4006	379	5620.8	<0.0005 LOD
4	AA-2009-021591	02/15/91	AP-4006	440	6525.5	<0.0005 LOD
5**	AA-2012-021991	02/19/91	AP-4006	570	5742.2	0.165
6	AA-2015-022091	02/20/91	AP-4006	570	5742.2	<0.0005 LOD
7	AA-2018-022191	02/21/91	AP-4006	743	7485	<0.0005 LOD
8	AA-2023-022291	02/22/91	AP-4006	542	5420	<0.0002
9	AA-2026-022591	02/25/91	AP-4006	500	5035	<0.001 LOD
10	AA-2029-022691	02/26/91	AP-4006	740	7460	0.0001
11	AA-2032-022691	02/28/91	AP-4006	440	4432.5	0.003
12	AA-2001-030191	03/01/91	AP-4006	545	5490	0.0003
13	AA-2005-030491	03/04/91	AP-4006	495	4999.5	<0.001 LOD
14	AA-2007-030591	03/05/91	AP-4006	468	4714.6	<0.001 LOD
15	AA-2007-030591	03/05/91	AP-4006	468	4714.6	<0.001 LOD
16	AA-2009-030891	03/08/91	AP-4006	510	5151	<0.001 LOD
17	AA-2006-030591	03/06/91	AP-4006	558	5635.8	<0.001 LOD
18	AA-2012-031291	03/12/91	AP-4006	470	4747	<0.001 LOD
19	AA-2026-032591	03/25/91	AP-4006	470	4703.66	<0.001 LOD

* Probably due to windy conditions over dusty gravel road.
** Transmission Electron microscopy analysis indicates 0.165 f/cc to be non-asbestos.

LOD - Limit of detection
f/cc - fibers per cubic cm of air

(Asbestos abatement project commenced on 2/11/91 — 3/26/91 Building 302 and south corridor of Building 407)

CHEMICAL PLANT
202-1.08

DOE/OR/21548-193
CONTRACT NO. DE-AC05-86OR21548

ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

SEPTEMBER 1991 **REV. 1**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

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Environmental Protection Manager — Date: 8/22/91

Environmental, Safety & Health Department Manager — Date: 8/22/91

Quality Assurance Manager — Date: 8/22/91

Deputy Project Director — Date: 8-22-91

Project Director — Date: 8/22/91

Weldon Spring Site Remedial Action Project

EXECUTIVE SUMMARY
for the
Annual Site Environmental Report
for Calendar Year 1990

Revision 1

September 1991

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63303

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

EXECUTIVE SUMMARY

The Weldon Spring Site Remedial Action Project (WSSRAP) Annual Site Environmental Report for 1990 is the fifth in a series of annual reports produced by the WSSRAP since 1986. It reports the results of a comprehensive, year-round program to monitor the impact of the Weldon Spring site (WSS) on the surrounding region's groundwater, surface waters, and air quality through multiple pathways as well as monitoring for potential exposure to receptor human populations. Information is also presented on the environmental monitoring quality assurance program, waste management activities, audits and reviews, and special environmental studies.

Data are included for both the Weldon Spring Chemical Plant and raffinate pits areas and the Weldon Spring quarry area. Based upon the WSSRAP's consistent exercise of quality assurance measures, in the form of both standard operating procedures and quality control sample collection, the WSSRAP asserts that the data presented in the WSSRAP Annual Site Environmental Report for 1990 (ASER) accurately reflect the environmental conditions monitored at the WSS. This ASER presents narratives, summaries, and conclusions on environmental monitoring at the subject areas and surrounding vicinity properties for the entire 1990 monitoring year. The WSSRAP also initiated a quarterly data reporting mechanism in 1990. All routine monitoring data are tabulated and presented in quarterly reports, which allows for timely public review and avoids the delays associated with final issuance of the annual report.

SCOPE AND PURPOSE

While the annual report documents environmental conditions, effluents, emissions, and monitoring results; its ultimate concern is with potential impacts to human health and the environment. To this end, contaminant levels are reported both in absolute terms and in relation to discharge limits established by State and Federal regulatory bodies according to existing national and international guidelines and standards designed to protect human health and the environment.

The WSSRAP monitoring program provides a thorough and systematic ongoing assessment to ensure compliance with State and Federal regulations. The environmental

data also provide a yardstick for measuring improvement in environmental conditions resulting from remedial actions.

The environmental management programs at the WSSRAP ensure that environmental releases from the site are at levels demonstrably and consistently "as low as reasonably achievable". This is being done concurrently with site remediation and contaminant clean-up through the course of the U.S. Environmental Protection Agency's (EPA) environmental documentation process under the Comprehensive Environmental Response Compensation, and Liability Act (CERCLA).

Therefore, the effluent and environmental monitoring program must (1) serve as an effective early indicator that detects and provides the data required to assess potentially adverse discharges and impacts, and (2) provide for continuing, regular verification of compliance with applicable State and Federal permits and regulations.

Routine monitoring for radiation, radioactive materials, and chemical substances on and off the WSS is an important tool to document compliance with appropriate standards, and to identify undesirable trends. Additionally, the monitoring programs provide information to the public in the St. Charles and St. Louis, Missouri areas, and contribute to the general scientific database of knowledge on the environmental effects of radiological and chemical substances.

MONITORING NETWORKS

The data reported in the ASER have been collected from a growing complex of monitoring stations and a routine sampling program supplemented by the following:

- An air monitoring network of 22 stations located within and on the perimeters of the two operable remedial units of the site, and at critical receptor locations around the WSS.

- Six National Pollutant Discharge Elimination System (NPDES) locations and over 25 surface water sampling locations.

- Twenty-two locations for measuring external gamma radiation.

- Groundwater monitoring networks consisting of nearly 100 groundwater monitoring wells and piezometers.

- Dozens of soil and ground surface scanning locations for potential direct contact exposure.

- An on-site meteorological monitoring station.

STATE AND FEDERAL REGULATIONS

The WSSRAP regulatory environment is multifaceted and complex. Therefore, the U.S. Department of Energy (DOE) and its Project Management Contractor (PMC), MK-Ferguson Company, have established complementary monitoring and reporting systems for responding to all applicable regulatory requirements. Modifications to improve these systems continue. The systems ensure compliance with legislation, regulations, and standards associated with the Clean Air Act; the Clean Water Act; the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA); the Resource Conservation and Recovery Act (RCRA); Superfund Amendments Reauthorization Act (SARA); and the Atomic Energy Act. These regulations and standards are enforced by the Environmental Protection Agency (EPA), the Missouri Department of Natural Resources (MDNR), and other Federal, State and local agencies.

SUMMARY AND CONCLUSIONS:

In 1990, the WSSRAP continued to adhere to its mission of environmental protection and site remediation. The DOE is pursuing the Weldon Spring Site Remedial Action Project as a coordinated effort among the DOE, the EPA, the MDNR, and others.

Comprehensive environmental monitoring data for 1990 show that emissions of radiological contamination from the WSS continue to decrease, and contaminant migration pathways and environmental variability are better understood.

The calculated total radiation dose to a hypothetical maximally exposed individual from the WSCP/WSRP was less than 1 mrem (0.01 mSv). The calculated total radiation dose from the WSQ to a maximally exposed individual was 3.9 mrem (0.055 Msv). The

calculated total radiation dose to a hypothetical maximally exposed individual for the vicinity properties was less than 1 mrem.

The collective dose equivalent estimate for 1990 is less than 0.018 person-rem for an estimated exposed population of 72,000 persons. Section 4.1.8 of the report describes the assessment of collective population dose.

Additional investigations are underway to further characterize environmental conditions and contaminant distributions; these investigations will support planning for the next stage of remedial action. Waste consolidation and water treatment plant construction are examples of the efforts undertaken.

Total costs associated with the environmental and remedial activities at the WSS for 1990 were approximately $16.1 million. Remedial action at the WSS is presently slated to continue through the year 2000.

The 1990 environmental report pays particular attention to the following areas of health and environmental concern: Airborne discharges of radionuclides and air particulates; waterborne discharges and surface water monitoring; external gamma exposure levels; meteorological measurements and potential chemical and radiation exposures to the surrounding public and public-use areas. Key results by sampling program are highlighted below.

GROUNDWATER

Groundwater at the WSSRAP is monitored at least semiannually for total natural uranium, nitroaromatic compounds, and inorganic anions in all monitoring wells at the Weldon Spring Chemical Plant/raffinate pits/vicinity properties (WSCP/RP/VP) and at the Weldon Spring quarry (WSQ). The groundwater monitoring network for the WSCP/RP/VP area consists of 59 monitoring wells. The monitoring network at the WSQ consists of 26 DOE monitoring wells, four St. Charles County monitoring wells, eight St. Charles County production wells, and the St. Charles County Water Treatment Plant.

Overall, the 1990 groundwater analytical results for samples at the WSCP/RP/VP and the WSQ are consistent with previous monitoring. The analytical results for 1990 did

indicate uranium concentrations slightly above background levels over a larger area than indicated in previous years. Although these slightly higher levels are believed to be due in part to laboratory contamination, as evidenced by contamination of water blanks collected during the monitoring year, the WSSRAP will focus attention on the situation during the 1991 monitoring year.

SURFACE WATER

During 1990, surface water and spring monitoring involved the collection of samples for radiological and chemical parameters from a total of 35 locations. Radiological parameters included uranium, thorium, and radium. Chemical parameters included chloride, fluoride nitrate, sulfate and nitroaromatic compounds. All results were near or within their historical range of values. However, results also indicate that uranium continues to migrate from the site at relatively low levels in surface water and springs along known discharge pathways. Concentrations for both chemical and radiological parameters at the monitoring locations fluctuated due to seasonal and climatic effects.

An analysis for trends of uranium concentrations in surface water was performed for the site and the quarry area to compare with previous years' monitoring results. No trends were evident at the site other than fluctuations due to seasonal effects. The quarry area (Femme Osage Slough) indicated a possible trend; as uranium increased from 1987 to 1989, but then decreased during 1990 at most of the surface water locations. This is believed due to the effects of drought conditions on the concentrations in the slough during the 1988-89 period, followed by normal precipitation levels during 1990 which affected dilution.

EFFLUENT MONITORING (NPDES)

Surface water effluents from the WSS during 1990 were primarily due to precipitation runoff. The WSSRAP maintains discharge permits under the National Pollutant Discharge Elimination System (NPDES). During 1990, the permit at the WSCP applied to one sanitary discharge point and five stormwater discharge points or outfalls. The five monitored outfalls that discharge precipitation runoff are subject to monitoring requirements only under the permit. The sixth outfall (administration building's treated sanitary effluent) is subject to specific discharge limits.

During 1990, the five storm water outfalls maintained levels that corresponded with prior year values. Sampling was performed on three occasions when flows were not representative of normal storm water flows. These three sampling events were performed during water release which was not associated with precipitation. Some abnormal levels of monitored constituents were detected in the discharge associated with these events. Section 4.2.4 further explains the 1990 discharge history.

The sanitary wastewater outfall was monitored for comparison to effluent limitations for biochemical oxygen demand (BOD), total suspended solids (TSS), and fecal coliform. NPDES permit levels were exceeded twice in 1990 at this outfall. Operational adjustments and repairs to the treatment plant were performed by the operating subcontractor and levels returned to within the range of the compliance limits.

GAMMA RADIATION MONITORING

To monitor exposure from gamma radiation, 22 permanent monitoring stations using spherical environmental thermoluminescent dosimeters (TLDs) were utilized. Monitoring stations are located at the WSCP, WSRP, WSQ and at off-site locations. None of the monitoring stations around the WSCP, the WSRP, or at the off-site locations detected gamma radiation levels above background, at a 95% confidence level. Two of the six stations around the quarry were statistically greater than background levels, although the measured exposure rate was less than the DOE guideline of 100 mrem/yr above background levels.

RADON GAS MONITORING

The radon gas monitoring program at the WSSRAP utilizes two radon gas detectors (track etch cups) at each of 22 permanent locations. These detectors are situated at the same locations as the above referenced gamma TLDs. The WSSRAP has concluded that none of the stations at the WSCP, the WSRP, or at off-site areas measured levels above background.

The results for the WSQ did indicate measurable levels above background. These measurable levels are due to the higher radium concentrations within the quarry; the contours of the terrain within and around the quarry; and the effects of those contours on

wind direction within the quarry. The concentrations released were below the DOE guidelines of 3 pCi/l annual average above background.

RADIOACTIVE AIR PARTICULATES

Eleven samplers are utilized to monitor the gross alpha concentrations of radioactive air particulates at the WSCP, the WSRP, the WSQ, and at off site locations. The WSSRAP has concluded that no measurable levels of radioactive air particulates were detected above background levels at any stations around the WSCP, the WSRP, or at off-site stations.

The results from one station at the WSQ were statistically greater than background levels. During 1990, remediation activities at the quarry were in progress and engineering controls were in place to control dust. The calculated effective dose equivalent as a result of the above background results to a hypothetical maximally exposed individual was <1 mrem.

Weldon Spring Site Remedial Action Project

Annual Site Environmental Report for Calendar Year 1990

Revision 1

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- Twenty-two locations for measuring external gamma radiation.
- Over 100 groundwater monitoring wells and piezometers.
- Dozens of soil and ground surface scanning locations for potential direct contact exposure.
- An on-site meteorological monitoring station.

Comprehensive environmental monitoring data for 1990 show that emissions of radiological contamination from the WSS continue to decrease, and contaminant migration pathways and environmental variability are better understood.

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1 INTRODUCTION

This report presents the findings of the environmental monitoring program conducted at the Weldon Spring site (WSS) in 1990. The report presents summary environmental data, discusses compliance with environmental standards, and highlights significant programs and efforts undertaken at the WSS. Annual environmental monitoring reports have been prepared for this site (or portions thereof) since 1981. The WSS is part of the U.S. Department of Energy (DOE) Surplus Facilities Management Program (SFMP), one of the remedial action programs under the direction of the Office of Environmental Restoration and Waste Management. The WSS is comprised of the Weldon Spring raffinate pits (WSRP), the Weldon Spring Chemical Plant (WSCP), and the Weldon Spring quarry (WSQ). These areas encompass 20.7, 67.2 and 3.6 ha (51, 166, and 9 acres), respectively. The WSRP and WSCP areas are contiguous. The WSQ is approximately 6.4 km (4 mi) to the south-southwest of the site.

When custody of the WSCP was transferred in 1985 from the U.S. Department of the Army (DA) to the DOE, the WSCP became part of the WSS. In conjunction with this transfer, the Weldon Spring Site Remedial Action Project (WSSRAP) was created as DOE Major Project Number 182 (DOE Order 4240.1E - 05/14/85). Consistent with the DOE environmental restoration mission, the WSSRAP will eliminate potential hazards to the public and the environment and make surplus real property available for other uses.

DOE Order 5400.1, *General Environmental Protection Program* requires that an environmental radioactivity monitoring program be maintained at existing sites and, as determined on a case-by-case basis, at certain former sites to determine:

- Background levels and site contribution of radioactivity and other pollutants from DOE operations to the site environs.

- Compliance with applicable and appropriate environmental standards for radioactivity and other pollutants specified by the DOE and the U.S. Environmental Protection Agency (EPA).

- Compliance with environmental commitments in official documents such as environmental impact statements and Federal Facility Agreements (FFA).

This DOE Order also requires a listing of environmental permits. Existing permits and compliance with those permits is discussed in Section 2 of this report.

This *Annual Site Environmental Report* is the DOE's vehicle for documenting the results of its extensive monitoring program at the WSSRAP. The report provides the public and concerned regulatory agencies with summary level discussions regarding the routine environmental monitoring program. It explains how the WSSRAP effluent monitoring program meets the requirements of the National Pollution Discharge Elimination System (NPDES) program and compares the measured contaminant levels to applicable standards. Further, the report indicates whether changes are occurring in contaminant distribution or contaminant source conditions on and around the site--changes which might equate to variations in potential exposure scenarios to the public or environmental receptors.

Environmental monitoring is the WSSRAP's most effective means by which to assess the impacts from the site. The data and evaluations contained in the report provide the summary of that monitoring for 1990. Section 4 reports results of the contaminant level measurements and compares the environmental levels of radioactivity and chemical contaminants released from the site with applicable standards. Quarterly data are presented in Appendix A.

In addition to the routine environmental monitoring conducted in 1990, a number of related activities and special studies were performed. These activities and studies are directly applicable to the assessment of the overall impact of site operations on the environment. Therefore, these activities are described and the results are discussed in Section 7.

Section 4 presents the results of calculations, based on the 1990 sampling results, of the maximum radiation dose to a hypothetical maximally exposed individual at the WSCP/WSRP and WSQ areas. Calculations of the doses to the general population in the vicinity of the WSS are also reported.

Appendix B contains trend analyses figures for groundwater wells. For definitions of selected terms used in this report, the reader may consult Appendix C. Although each acronym used in this report is defined when it is first used in each main section, a list of all abbreviations used is provided in Appendix D. Appendix E presents a discussion of the

environmental guidelines that apply to the monitoring program. Appendix F provides a useful conversion table, Appendix G is Dose Assessment Calculations and Appendix H is the distribution list for this report.

1.1 Location and Description

The WSS is located in St. Charles County, Missouri, about 48 km (30 mi) west of St. Louis. The WSRP and WSCP areas are reached from Missouri State Route 94, 3.2 km (2 mi) southwest of the junction of Route 94 and U.S. Route 40/61. The WSQ is also reached from Route 94, 6.4 km (4 mi) south-southwest of the WSRP and WSCP areas. The Missouri River is located approximately 2.4 km (1.5 mi) southeast of the WSRP and WSCP areas and 1.6 km (1 mi) east of the WSQ. The Mississippi River lies approximately 22 km (14 mi) northeast of the WSRP and WSCP areas and roughly 29 km (18 mi) northeast of the WSQ. The general locations of these properties are illustrated in Figure 1-1.

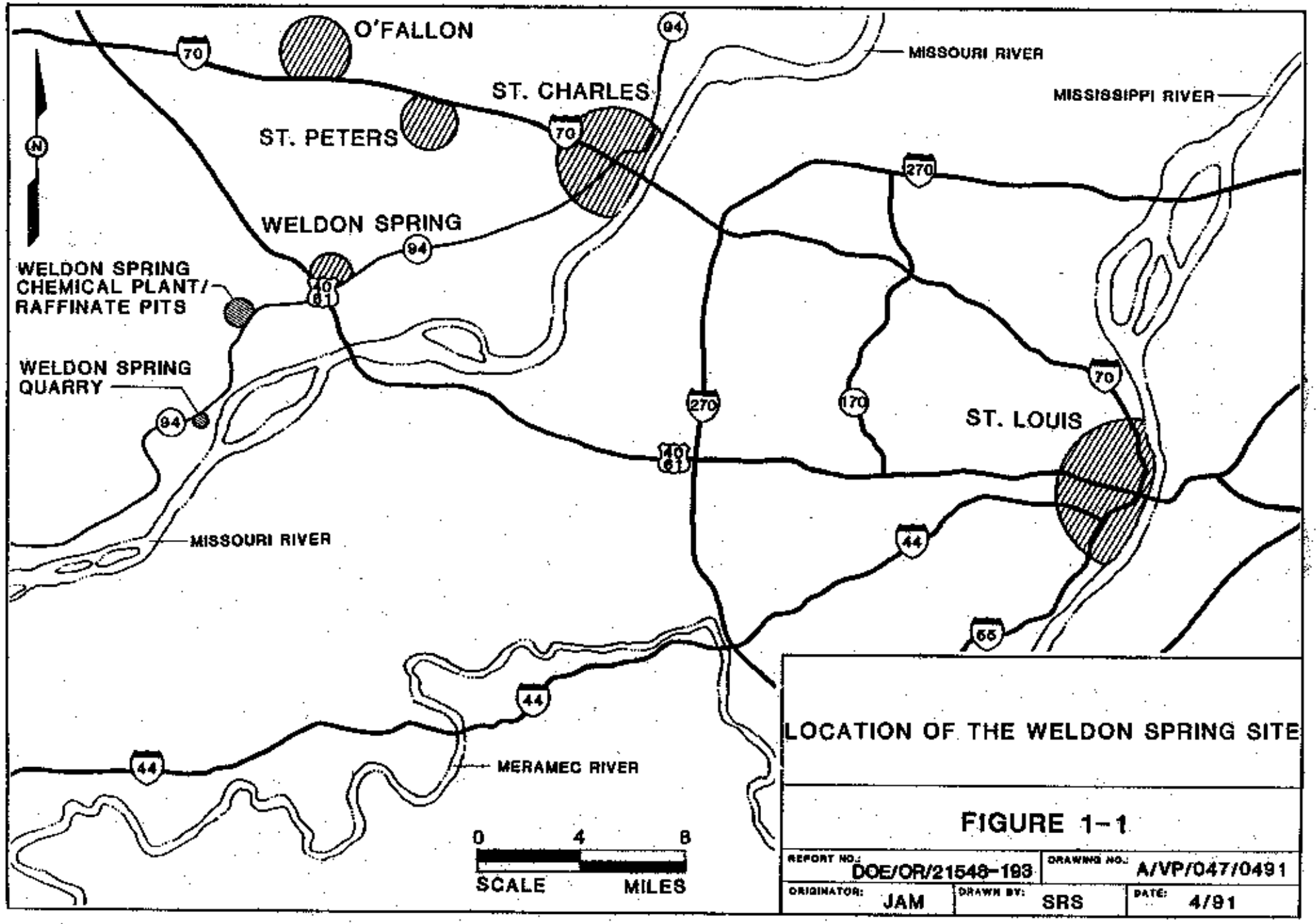
Uranium and thorium residues, waste materials, and contaminated rubble are stored at the WSS. In addition to environmental monitoring, engineering activities are being conducted to minimize the migration of contaminants from these facilities into surface water and groundwater.

Additional characterization activities have been conducted at the WSCP and WSRP during 1990. These activities provide information on the types and magnitudes of the contamination. The complete picture of characterization information has been presented in the Draft WSSRAP Remedial Investigation (RI) report issued to EPA in 1990 and scheduled for completion in 1991. This information will be used to evaluate the course of remedial actions.

Brief descriptions of each major area of the site are given below.

Weldon Spring Raffinate Pits

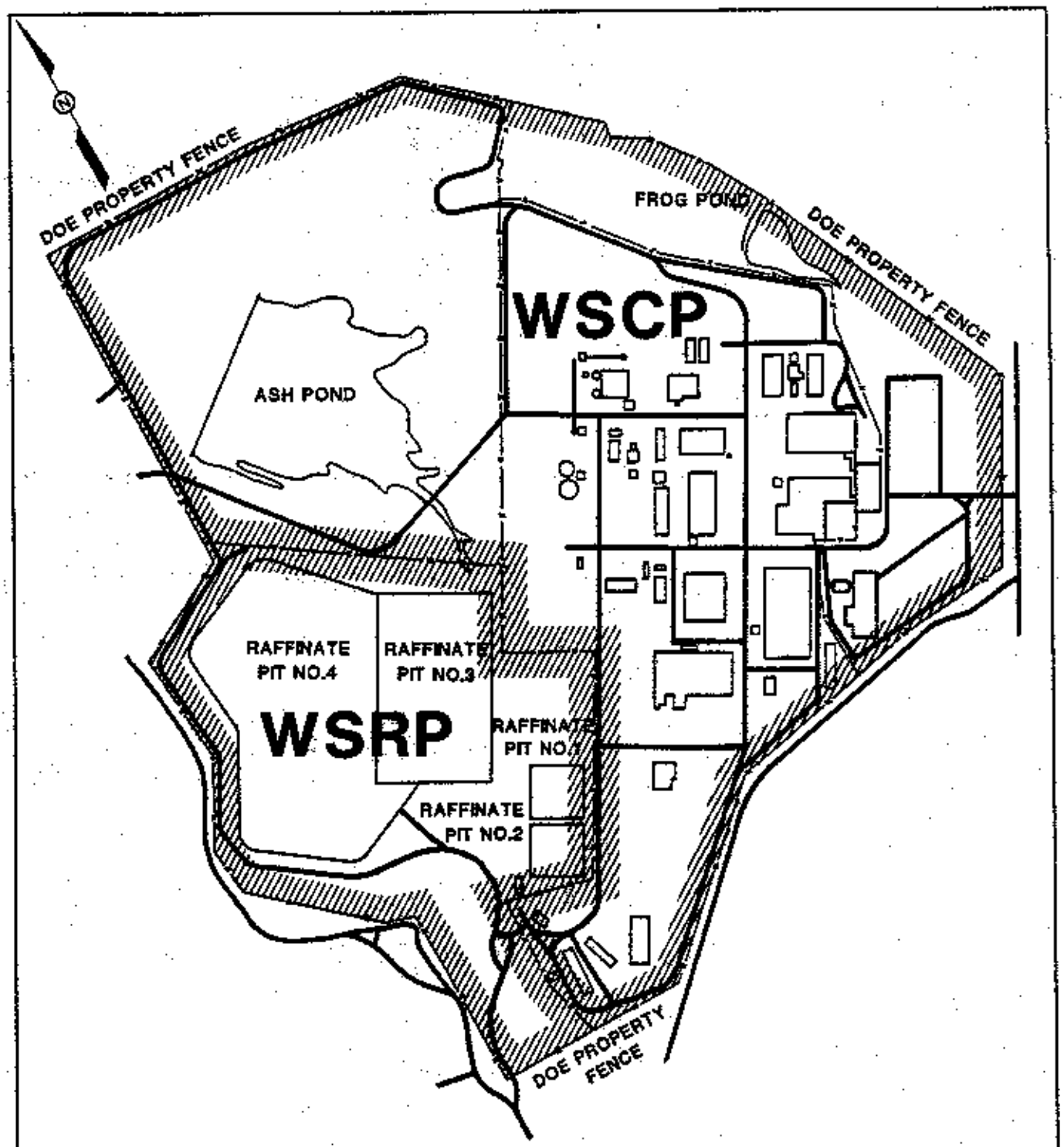
Figure 1-2 is map of the WSCP/WSRP area. The 20.7-ha (51-acre) area includes four pits that cover approximately 10.5 ha (26 acres). The raffinate pits were constructed by excavating into the existing clay soils and using the removed clay for construction of dikes. These pits contain radioactive residues (raffinates) from uranium and thorium processing



LOCATION OF THE WELDON SPRING SITE

FIGURE 1-1

REPORT NO.: DOE/OR/21548-193	DRAWING NO.: A/VP/047/0491	
ORIGINATOR: JAM	DRAWN BY: SRS	DATE: 4/91



SCALE 0 500 1000 FT
0 152.4 304.8 M

MAP OF THE
WELDON SPRING CHEMICAL PLANT AND
WELDON SPRING RAFFINATE PIT AREA

FIGURE 1-2

REPORT NO.: DOE/OR/21548-193	EXHIBIT NO.: A/CP/113/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91

operations at the former Weldon Spring Uranium Feed Materials Plant (WSUFMP) which is now the WSCP.

Access to the area is controlled by a 2.1-m (7-ft) high fence that encloses the DOE property. In addition, each pit is enclosed by a fence at least 1.3 m (4 ft) high. All drains and transfer lines from the pits to the WSCP process sewer have been sealed (Ficker 1981). During the 1990 monitoring year, surface water covered the vast majority of the residues in the pits.

Weldon Spring Chemical Plant

The 67.2-ha (166-acres) WSCP is located to the north and east of the WSRP area (Figure 1-2). The WSCP, which operated as the WSUFMP until 1966, comprises 13 major buildings and 27 smaller buildings. Of the former, five were used as process buildings, and eight were major support buildings. The entire site is fenced. Access is controlled at a manned gate-house and site security continues to be maintained by guards periodically patrolling the site 24 hr/day.

The interiors of the eight major support buildings are heavily contaminated with uranium that is mostly "fixed" on surfaces. The rest of the buildings contain only small quantities of uranium contamination.

Surface water runoff from the WSCP drains primarily along three corridors. These include the natural drainageways leading to Ash Pond and Frog Pond, and the complex of tributaries which exits the site to the southeast. Surface water drains into these ponds and drainageways where it transports uranium off-site.

Chemically hazardous substances are also present both in the buildings and as contamination in the soil in several areas of the site. These substances include asbestos, polychlorinated biphenyls (PCBs), nitroaromatic compounds, ammonia, hydrofluoric acid, sulfuric acid, and nitric acid. The data on these substances and their impacts to the environment will be detailed in the previously mentioned Remedial Investigation (RI) report.

Weldon Spring Quarry

The WSQ, an abandoned 3.6-ha (9-acres) limestone quarry, is located approximately 6.4 km (4 mi) south-southwest of the WSRP/WSCP area. As shown in Figure 1-3, the WSQ is accessible at both the upper and lower levels from Missouri State Route 94. The WSQ is essentially a closed basin; surface water within the rim flows to the quarry floor and into a pond which covers approximately 0.2 ha (0.5 acres). The pond contains approximately 12 million liters (3 million gal) of water and is 6.1 m (20 ft) deep at its deepest point. The amount of water in the pond varies according to seasonal variations in precipitation and evaporation.

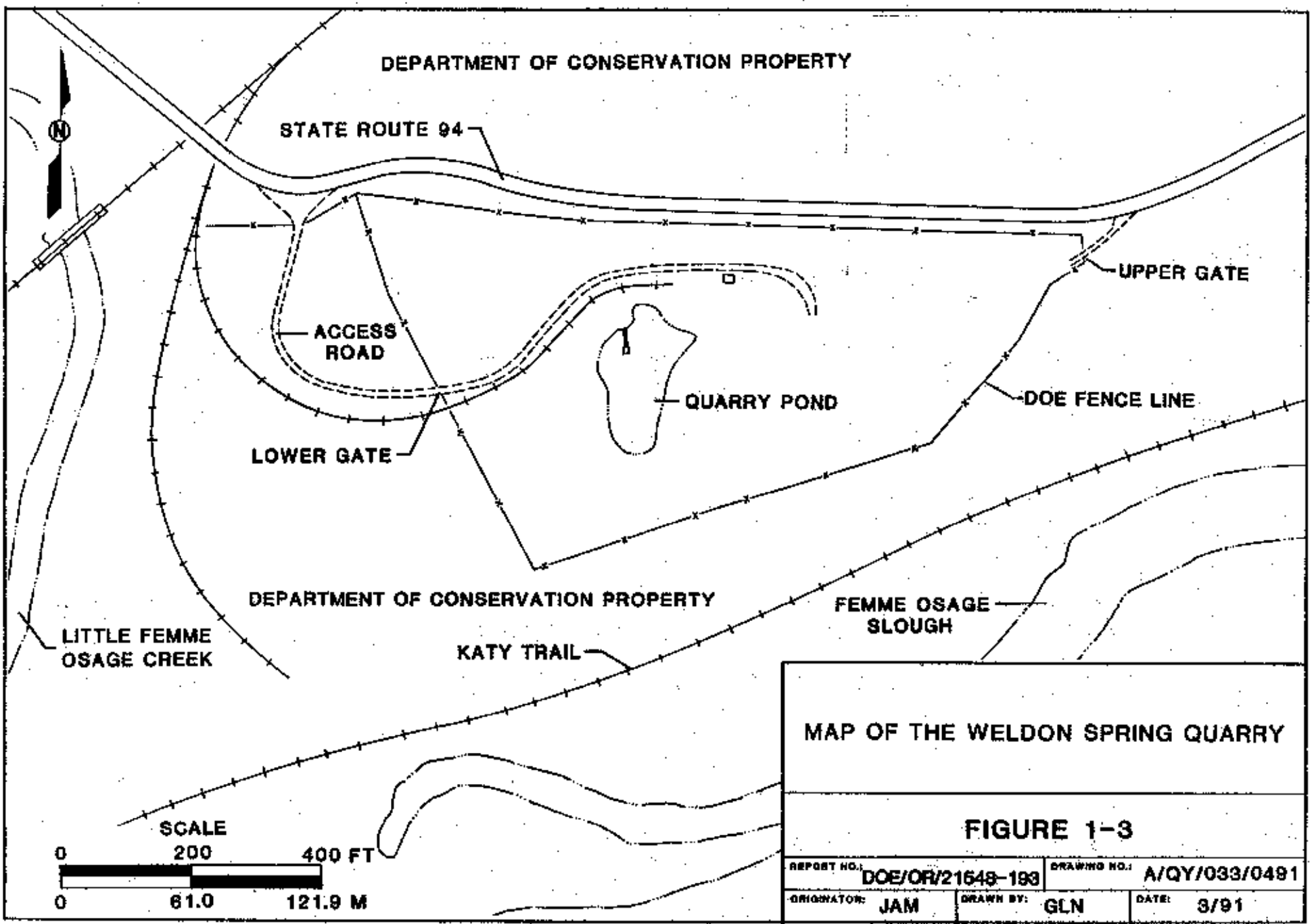
The only structures at the WSQ site are a small storage shed and a sampling platform in the pond area. Access to the site is restricted by a locked, 2.1-m (7-ft) high chain link fence. The amounts and types of wastes in the WSQ are summarized in the *Remedial Investigation Report for Quarry Bulk Wastes* (MKF and JEG 1989a).

1.2 Site History

The WSS has a complex history of production processes within its boundaries. Between 1941 and 1944, the U.S. Department of Army (DA) occupied the property (Weldon Spring Ordnance Works--WSOW) and located four of its 20 explosives production lines across the WSS area (the remaining 16 production lines were distributed across an adjacent property which is now referred to as the U.S. Army's Reserve Training Area, Weldon Spring, Missouri). The WSOW produced dinitrotoluene and trinitrotoluene (DNT and TNT) for the Allied Forces during World War II.

In 1955, 83 ha (205 acres) of the former ordnance works property was transferred to the U.S. Atomic Energy Commission (AEC) for construction of the WSUFMP. Until 1966, the AEC operated an integrated facility for the conversion of processed uranium ore concentrates to pure uranium trioxide, intermediate compounds, and uranium metal. A small amount of thorium was also processed. The wastes generated from these operations were stored in four raffinate pits on the site property.

In 1958, the AEC acquired title to the WSQ from the DA. The WSQ had been used earlier by the DA for disposal of TNT-contaminated rubble during the operation of the


DEPARTMENT OF CONSERVATION PROPERTY
STATE ROUTE 94
UPPER GATE
ACCESS ROAD
QUARRY POND
DOE FENCE LINE
LOWER GATE
DEPARTMENT OF CONSERVATION PROPERTY
FEMME OSAGE SLOUGH
LITTLE FEMME OSAGE CREEK
KATY TRAIL
SCALE
0 200 400 FT
0 61.0 121.9 M
MAP OF THE WELDON SPRING QUARRY
FIGURE 1-3
REPORT NO.: DOE/OR/21548-193
DRAWING NO.: A/QY/033/0491
ORIGINATOR: JAM
DRAWN BY: GLN
DATE: 3/91

WSOW. The AEC used the WSQ as a disposal area for a small amount of thorium residue, but most of the material disposed of there consisted of uranium- and radium-contaminated building rubble and soils from the demolition of a uranium ore processing facility in St. Louis.

In February 1985, the DOE proposed designating the control and decontamination of the WSRP, WSCP, and WSQ as a major project. Designation was effected by DOE Order 4240.1E dated May 14, 1985. A Project Management Contractor (PMC) for the WSSRAP was selected in February 1986. In July 1986, a DOE project office was established on site. The PMC, MK-Ferguson Company, assumed control of the WSS on October 1, 1986. The WSQ was placed on the Environmental Protection Agency's National Priorities List (NPL) in July 1987. The WSCP/WSRP was added to the NPL in March 1989.

Remedial investigations were conducted at the WSCP/WSRP area in 1988 and 1989. The investigations included characterization of the groundwater, on-site soil contamination, contaminated sediments in off-site surface drainages and lakes, surface water, and springs; the chemical and radiological characteristics of the raffinate wastes; and other smaller scale efforts. The results of each of these investigations are presented in stand-alone documents on the respective efforts and are brought together and summarized in the RI report for the WSCP/WSRP, which is in the final stage of production following agency review.

Several small-scale actions have been conducted to mitigate or eliminate conditions that pose immediate or potential threats to worker safety, public health or the environment. These have included removal of exposed friable asbestos and overhead piping, PCB electrical equipment removal, power pole and wire removal, nonprocess-building demolition, Ash Pond isolation, and containerized chemical consolidation. Section 7.2 of this report details the interim response actions (IRAs) in process or completed during 1990.

The WSSRAP evolved from a National Environmental Policy Act (NEPA) authority decommissioning and cleanup project in 1986 into a remedial action project under combined NEPA-Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) authority requiring a Remedial Investigation/Feasibility Study (RI/FS) and complete environmental documentation in July of 1987. The environmental documentation process necessary to begin the excavation of the bulk waste from the WSQ is completed.

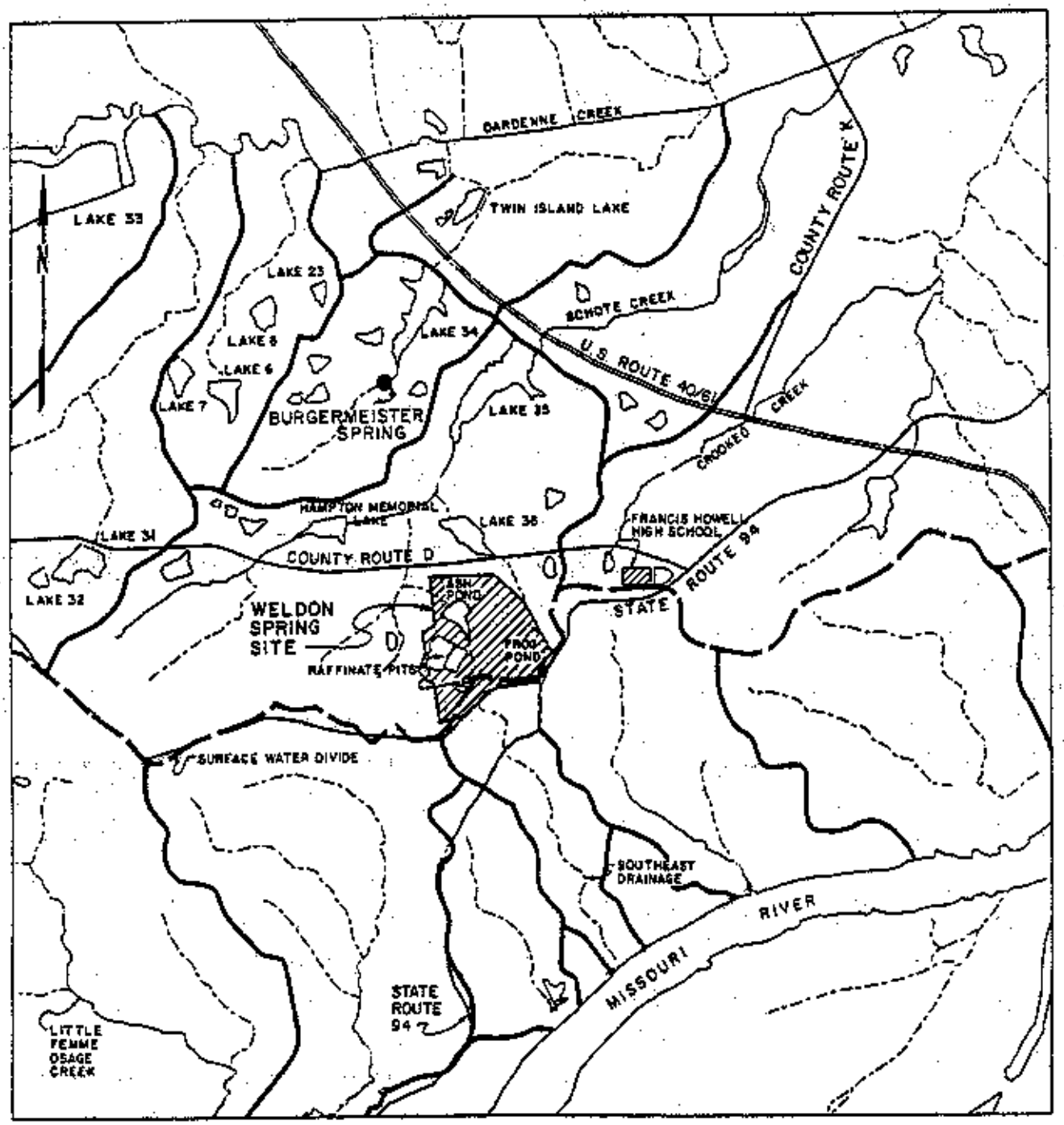
The residual contamination within the quarry confines can be characterized when the excavation is completed.

A more detailed presentation of the production, ownership and waste history of the WSS is available in the RI reports for the WSQ and the draft WSCP/WSRP reports prepared by the DOE Project Office.

1.3 Environmental Setting

The environmental setting of the WSCP/WSRP and the WSQ are described briefly below. A more detailed description is provided in the *Work Plan for the Remedial Investigation/Feasibility Study-Environmental Impact Statement for the Weldon Spring Site, Weldon Spring, Missouri* (Peterson et al. 1988). The WSRP/WSCP area is located on the Missouri-Mississippi River surface-drainage divide. The topography is gently undulating and generally slopes northward toward the Mississippi River. To the southeast are bluffs that overlook the Missouri River floodplain. Though the bedrock under the site is fractured, it is overlain by low permeability clays ranging from 1 m to 9 m (3 ft to 30 ft) thick.

Most surface water runoff from the WSCP/WSRP area discharges either through an intermittent stream in the Army Reserve Training Area or through the Ash Pond diversion structure on the WSCP property to Schote Creek. An additional surface drainage system reaching Schote Creek exits the WSCP area along the Frog Pond drainage. That drainageway carries storm water from most of the plant area where concrete surfaces drain into a storm water sewer system. The Frog Pond drainageway also carries runoff from the northeastern portion of the WSCP. Drainage from the southern portion of the WSCP property travels southeast to the Missouri River. Schote Creek joins with Dardenne Creek and flows northeast to the Mississippi River. Schote Creek and several of its tributaries are impounded on the August A. Busch Memorial Wildlife Area (ABWA). Dardenne Creek, portions of Schote Creek, and lakes on the ABWA support aquatic life and are accessible to the public for recreational activities, such as fishing. The WSQ is located on the northern bluff of the Missouri River valley. The unconsolidated upland material overlying bedrock consists of up to 10 m (30 ft) of silty clay soil developed from loess deposits. A residual soil is present in some areas between the silty clay and bedrock. Figure 1-4 shows the environmental setting of the Weldon Spring site.



LEGEND:

- SURFACE WATER DIVIDE BETWEEN MISSISSIPPI RIVER AND MISSOURI RIVER
- DRAINAGE BOUNDARY
- CREEK OR SURFACE DRAINAGE
- POND OR LAKE

0 3200 6400 FT

0 975.4 1950.7 M

SCALE

ENVIRONMENTAL SETTING OF THE WELDON SPRING SITE

FIGURE 1-4

REPORT NO: DOE/OR/21548-193	EXHIBIT NO.: A/VP/066/0591	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 5/91

2 COMPLIANCE SUMMARY

2.1 Compliance Status for 1990

The Department of Energy's Weldon Spring Site Remedial Action Project (WSSRAP) is subject to meeting or exceeding the regulatory requirements of Federal, State, and local laws and statutes. The WSSRAP maintains a permanent staff of compliance experts who monitor the progress and status of the project relative to the environmental laws. The following is a summary of applicable regulations and the WSSRAPs current compliance status.

2.1.1 Compliance Status

National Environmental Policy Act

The WSSRAP has successfully integrated the procedural and documentation requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the National Environmental Policy Act (NEPA), as required by the policy stated in DOE Order 5400.4. Site documents are published as integrated documents, such as the sites' Remedial Investigation/Feasibility Study-Environmental Impact Statement (RI/FS-EIS). For example, Engineering Evaluation/Cost Analysis (EE/CA) and Remedial Investigation/ Feasibility Study (RI/FS) documents are adopted by the U.S. Department of Energy (DOE) as Environmental Assessments (EAs) and Environmental Impact Statements (EISs) and contain the required NEPA information. Proposed plans and actions are evaluated in terms of both NEPA and CERCLA. Actions falling under the categorical exclusion (CX) classification are submitted as such for approval. The WSSRAP submitted six categorical exclusions in 1990; four have been approved. The CX actions approved are: (1) the off-site removal of tributyl phosphate (TBP) to the Oak Ridge incinerator for destruction, (2) removal and disposal of transformers and equipment contaminated with polychlorinated biphenyls (PCBs) from an out-of-service electrical substation, (3) site characterization and environmental monitoring activities, and (4) a variety of general plant projects, e.g., repaving the administration building parking lot. A memorandum-to-file was approved in September for a material staging area which will serve as a temporary storage area for debris resulting from building dismantlement at the chemical plant.

Comprehensive Environmental Response, Compensation, and Liability Act

The WSSRAP removal and remedial actions are performed under CERCLA (as amended by Superfund Amendments and Reauthorization Act [SARA]). The requirements of the following acts, laws, regulations, etc. may have Applicable or Relevant and Appropriate Requirements (ARARs) for the site.

Resource Conservation and Recovery Act

Hazardous waste at the Weldon Spring site (WSS) is managed as required by Resource Conservation Recovery Act (RCRA) (and substantive ARARs) and includes the characterization, consolidation, inventory, storage, transportation, and disposal of hazardous and other wastes that remained on-site after closure of the Weldon Spring Uranium Feed Materials Plant (WSUFMP) and for wastes generated during remedial activities. Phase II of the chemical consolidation is discussed in more detail in the Issues and Action Section. RCRA permits are not required at the WSS since the remediation is being performed in accordance with decisions reached under CERCLA. Section 121(e) of CERCLA states that no Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely on site.

Toxic Substances Control Act

PCBs are managed at the WSS under the requirements of the Toxic Substances Control Act (TSCA). Non-radiologically contaminated PCBs are scheduled for off-site disposal in 1991. More information is offered in the Issues and Actions Section.

Clean Air Act

The portion of the Clean Air Act (CAA) that pertains to the WSSRAP is the National Emission Standards for Hazardous Air Pollutants (NESHAPs). The standards contain maximum levels for radionuclides and asbestos. The WSSRAP plan for monitoring radionuclide emissions was approved by the Environmental Protection Agency (EPA), and is explained in more detail in the Issues and Actions Section.

Clean Water Act

Compliance under the Clean Water Act (CWA) consists of the two National Pollution Discharge Elimination System (NPDES) permits. Both effluent and erosion control monitoring is performed. NPDES permit limits were exceeded twice in 1990 at the administration building sanitary wastewater plant. Operational adjustments to the plant were made by the subcontractor, bringing levels to below permit limits.

Archaeological and Historical Preservation Act

In 1986, the Missouri Department of Natural Resources determined that any archaeological resources present in the chemical plant area would have been so severely damaged or destroyed during plant construction that further investigation would not be warranted. A competent archaeologist was consulted for the quarry and the quarry haul road. The archaeologist found six sites in the quarry vicinity, that unless disturbed by newly planned activity, will need no mitigation. A preliminary investigation and surveillance was performed by the archaeologist on the haul road in 1990. The investigation will continue in 1991 before construction begins.

Endangered Species Act

The U.S. Fish and Wildlife Service (USFWS) has been consulted under Section 7(a) of the Endangered Species Act. An ecological assessment is being performed in conjunction with the Baseline Assessment. The Baseline Assessment will evaluate risks to human health and the environment in support of overall site waste management decisions. The ecological evaluation includes a review of threatened and endangered species present, or potentially present, in the area of the Weldon Spring site.

Consultation with USFWS regarding endangered species continued in 1990. The USFWS will be contacted in 1991 concerning the biological assessment requirement for the quarry haul road and the chemical plant. The Missouri Department of Conservation lists numerous threatened or endangered species for the county in which the WSS is located and will be consulted concerning the state's requirement for a biological assessment.

Executive Order 11988 Floodplain Management

The Engineering Evaluation/Cost Analysis Environmental Assessment (EE/CA-EA) for the proposed management of contaminated water at the Weldon Spring quarry contains a floodplain assessment that describes the impact of the floodplain as a result of construction activities at the quarry. The structure to be located in the floodplain is the effluent pond associated with the quarry water treatment plant. The floodplain assessment was written in accordance with 10 CFR 1022.12 of the DOE Floodplains/Wetlands Environmental Review Requirements which establishes policy and procedures for discharging the DOEs compliance responsibilities for EO 11988.

2.1.2 Issues and Actions

2.1.2.1 Ongoing Issues. An amended Federal Facilities Agreement (FFA) is being negotiated between the DOE and the EPA. The EPA transmitted the final draft of the FFA to DOE-Headquarters for approval. Any final issues will be negotiated during DOE review and the signature process.

In June 1988, electrical equipment was discovered on a concrete pad (Substation 411) outside of the WSS property boundaries. The equipment consisted of three transformers, a circuit breaker, three pole-mounted units and other electrical equipment that had remained in place since the closure of the chemical plant. One of the transformers contained 1,637 liters (360 gal) of oil contaminated with approximately 150 parts per million (ppm) of PCBs. One of the pole-mounted units contained 55 liters (12 gal) of oil contaminated with 1,100 ppm of PCBs. More discussion on Substation 411 is included in Section 7 of this report.

In August 1990, eight drums of PCB contaminated oil were generated by draining the transformers containing greater than 50 ppm of PCB. Two pole-mounted transformer units were placed in overpack containers. The containers have been stored in the RCRA/TSCA regulated building (Building 434) awaiting disposal. The containers will be disposed off site before August 1991.

Three compliance issues that were identified in 1990 still remain unresolved. They are described below.

Issue No. 1: Storage of PCB wastes beyond allowable time limits (40 CFR 761.65(a)).

Approximately 28,120 liters (7,400 gal) of tributyl phosphate (TBP) contaminated with radionuclides and with PCBs in excess of 50 ppm are on the Weldon Spring site. In addition, preliminary analyses indicate the TBP is also contaminated with mercury exceeding the regulatory level for Toxicity Characteristic, thereby making it a RCRA hazardous waste. On the site, there are also small amounts of radiologically contaminated PCB waste within electrical capacitors, and eight drums of PCB-contaminated soil suspected of radiological contamination.

All PCB wastes identified to date by investigative and remedial activities have been present since the plant was operational in the 1950s and 1960s. The WSSRAP continues to locate and identify all PCB-containing material and to place it in proper storage.

Corrective Action for Issue No. 1: In December 1989, the WSSRAP-DOE sent a letter to the EPA (Region VII) notifying them that the one-year storage limitations had been exceeded.

Efforts to send the TBP to the Oak Ridge Gaseous Diffusion Plant Incinerator for destruction continued during 1990. The incinerator was not operational during 1990.

An attempt by the WSSRAP to decontaminate the radiologically contaminated PCB capacitors failed. Therefore, the capacitors will remain on site and eventually be disposed with other radiologically contaminated material when a viable disposal option is identified.

Issue No. 2: Unknown abandoned wastes at the processing plant have not been chemically analyzed or placed in proper storage (40 CFR 264).

When the uranium processing plant was shut down in 1966, large quantities of organic and inorganic chemicals were abandoned in both process and non-process buildings. Phase I characterization activities included an initial effort to identify and containerize these chemicals. As Phase I progressed, more chemicals were discovered; these are being addressed by Phase II. Chemicals were found during both phases in tanks, sumps, process vessels, and in abandoned buildings. Phase I was completed in January 1989.

Corrective Action for Issue No. 2: After the containers which were accumulated and consolidated during Phase I were moved to the new RCRA storage area in Building 434, emphasis was directed to identifying, characterizing, and containerizing the remaining chemicals in accordance with the appropriate regulations. Activities included moving unknown chemicals to the site staging areas; and sampling, testing, and repackaging as necessary to meet the requirements of 40 CFR 264. As chemicals are properly packaged, they are placed in the RCRA storage facility in Building 434 pending final disposition.

Issue No. 3: Surpassing the Missouri State maximum permissible exposure limit for radon at the quarry (19 CSR 20 - 10.040)

Missouri Code of State Regulations limits quarterly-averaged radon concentrations outside controlled areas to 1 pCi/l. This concentration is regularly exceeded at one quarry perimeter monitoring station and occasionally exceeded at other quarry perimeter monitoring stations.

Corrective Action for Issue No. 3: The long term solution is the excavation and final disposal of the bulk waste (which is the primary radon source). This is addressed in the quarry Record of Decision (ROD).

2.1.2.2 Significant Accomplishments. In March 1990, Building 434 remodeling was completed for the storage of TSCA and RCRA wastes. The building meets storage requirements for RCRA and TSCA wastes and is inspected on a weekly basis.

The WSSRAP NEPA Compliance Officer (NCO) position was created in 1990 to review and ensure compliance with the requirements of NEPA. A procedure for ensuring early review of proposed activities was developed and has been implemented. Categorical exclusion determinations are being made for relevant subcontracts and projects to ensure compliance. NEPA EA and EIS documents are integrated with CERCLA EE/CA and RI/FS documents.

2.1.2.3 NESHAPs Compliance. The WSSRAP has developed an alternate method for NESHAP compliance as provided in 40 CFR 61.93 paragraph (b)(5) whereby air concentrations are monitored at five designated critical receptor locations on and around the Weldon Spring site. The WSSRAP plan is contained in the report *Plan for Monitoring*

Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors, (MKF and JEG 1990a) which has been approved by the EPA. The EPA has also approved the WSSRAP plan to report annual monitoring results and effective dose equivalents at critical receptor locations via the *Annual Site Environmental Report*.

The air at each critical receptor location is continuously sampled for radionuclides. The air sampling filters from each critical receptor location are separately composited and analyzed annually for the radionuclides that are major contributors to the effective dose equivalent, i.e., U-234, U-238, Th-228, Th-230, Th-232, Ra-226 and Ra-228. Air sampling filter collection, handling, and analysis methods are regimented such that radionuclide concentrations that would cause an effective dose equivalent of 10% of the standard (i.e., 1 mrem) are readily detectable and distinguishable from background. Radionuclide detection levels and sampled air volumes are sufficient to meet the sensitivity requirements of Table 2, Appendix E of 40 CFR 61 which determine compliance with the standard. The quality assurance program described in Section 5 of the WSSRAP NESHAPs compliance plan (MKF and JEG 1990a) meets the requirements of 40 CFR 61 Appendix B. Detailed information, including calculations on radiation monitoring and dose calculations are found in Sections 4.1.6 and Appendix G. During calendar year 1990, no significant asbestos abatement activities were performed at the site.

2.1.2.4 Satisfaction of Reporting Requirements

2.1.2.4.1 Continuous Release Reporting. There have been no reportable quantity releases from the WSS not exempted as a Federally permitted release. Consequently, no continuous release reports have been submitted.

2.1.2.4.2 SARA Title III Report. For the 1990 calendar year, WSSRAP reported the following hazardous chemicals in the SARA Title III Annual Chemical Inventory Report: 15 drums of polychlorinated biphenyls (PCBs); two process tanks containing a solution of tributyl phosphate (TBP)/uranyl nitrate; four raffinate pits containing sludge and water contaminated with uranium, thorium, radium, lead, arsenic, and other inorganic contaminants; approximately 1,011 cu m (1,330 cu yd) of bagged asbestos; and 16 drums of elemental magnesium and magnesium oxide. WSSRAP is not a facility in the standard industrial classification and is therefore not required to submit the annual Toxic Release Inventory under Section 313 of SARA.

2.1.2.5 Audit Summary. The DOE from Oak Ridge National Laboratory (ORNL) conducted an environmental compliance audit at the Weldon Spring site in October 1990. Draft findings were subsequently submitted to the WSSRAP. In December 1990, a Corrective Action plan responding to the findings was submitted to ORNL.

Oak Ridge Operations (ORO) also conducted an appraisal of the environmental safety and health and quality assurance procedures at the site in October 1990. Findings were transmitted to the WSSRAP in December 1990. A response to the findings was submitted to ORO in January 1991.

The audits identified Major (Priority II) and Minor (Priority III) findings. The attached matrix gives the status of the Major findings. The Minor findings are addressed in the corrective action plan for each audit. No Significant (Priority I) findings are known and none were determined by audit.

2.1.3 Summary of Permits for 1990

The WSSRAP maintains the following permits:

2 NPDES permits (quarry and chemical plant).

1 Construction permit from the Missouri Department of Natural Resources (MDNR) for the quarry water treatment plant.

1 Driveway permit from the Missouri Highway and Transportation Department for the entrance at the quarry.

1 Floodplain Development permit from St. Charles County Planning and Zoning Commission.

TABLE 2-1 ORNL Audit October 1, 2, 3, 1990

REGULATION	ISSUE	CORRECTIVE ACTION	DATE IN COMPLIANCE
40 CFR 264.194	TBP tanks spill/overflow controls are inadequate.	No material has been added or taken from the tanks in 20 years. Openings and valves are closed and the tanks are less than 75% full to allow expansion. Tanks are inspected daily. Letter transmitted to MDNR 10/16/90 seeking concurrence.	OPEN
40 CFR 761.65(b)(i)ii	TBP tanks require roof and walls to prevent rain contact with PCB materials.	On 10/11/90 the TSCA branch of EPA Region VII was consulted. It was determined that roof and walls were not needed.	OPEN

TABLE 2-2 ORO Audit October 15-19, 1990

REGULATION	ISSUE	CORRECTIVE ACTION (From Corrective Action Plan dated 1/91)	DATE IN COMPLIANCE
40 CFR 268.50	Land ban wastes stored beyond time limits.	WSSRAP does not concur because WSSRAP waste was stored prior to land ban (51 FR 40577).	OPEN
40 CFR 265.194	TBP tanks spill/overflow controls are inadequate.	See ORNL corrective action above.	OPEN
40 CFR 61, Subpart M	Areas of uncontained, possibly friable, asbestos materials were observed.	The major portion of uncontained asbestos from outdoor locations has been abated. The current schedule for remediation of uncontained ACM is appropriate for site remedial action priorities.	OPEN
29 CFR 1910.1001 29 CFR 1926.58 40 CFR 763.121	Asbestos containing materials not properly labelled.	Areas of ACM that cannot be labeled are posted with signs. Safety and health training and controlled access to the restricted areas meets the intent of the OSHA regulations.	OPEN
DOE Order 5400.1 40 CFR 262.41(a)(6)	Asbestos waste is not segregated by radiological contamination and non-radiological contamination.	WSSRAP does not concur. Regulation and order do not provide criteria for differentiating rad and non-rad contaminated asbestos	OPEN
40 CFR 262.41(a)6	Proper documentation for asbestos abatement action and waste disposal receipts is not being maintained.	WSSRAP will ensure documentation is provided in the future.	OPEN

Archaeological and Historic Preservation Act

In March 1991, the WSSRAP consulting archaeologist further investigated the potential sites along the quarry haul road to determine whether mitigation will be necessary before construction of the road begins.

2.2 Compliance Status for the Period January 1 - April 15, 1991

Status remains unchanged under CERCLA, RCRA, TSCA, CWA, the Endangered Species Act, and Executive Order 11988.

NEPA

Approval of two categorical exclusions is anticipated in April 1991. The approval will allow construction of an annex to the administration building and construction of a composite building to house the new access control, warehouse, and lab space.

Clean Air Act (CAA)

Removal of asbestos from buildings and tanks at the chemical plant was initiated in February 1991. Under this activity, asbestos, and asbestos-containing material will be removed according to the NESHAP and OSHA regulations.

Archaeological and Historic Preservation Act

In March 1991, the WSSRAP consulting archaeologist further investigated the potential sites along the quarry haul road to determine whether mitigation will be necessary before construction of the road begins.

2.2.1 Current Issues and Actions

Beginning in February 1991, an asbestos abatement action was initiated. This project involved removal of friable and nonfriable asbestos materials from six non-process buildings, three outside insulated storage tanks, and several asbestos items stored in outside debris storage areas. The revised asbestos NESHAPs regulations, including the amended

notification requirements, were incorporated into the abatement project specifications. Friable asbestos wastes were containerized and transferred to Building 103 for interim on-site storage.

No other new issues or actions were initiated from January 1 to April 15, 1991.

2.2.2 Summary of Permits for 1991

The WSSRAP currently maintains the following permits:

2 NPDES permits (quarry and chemical plant).

1 Construction permit from Missouri Department of Natural Resources for the quarry water treatment plant (QWTP).

1 Application of renewal of construction permit for the QWTP.

1 Driveway permit from the Missouri Highway and Transportation Department for the entrance at the quarry.

1 Floodplain Development permit from St. Charles County Planning and Zoning Commission for construction of a portion of the equalization basins at the quarry.

3 ENVIRONMENTAL PROTECTION PROGRAM

3.1 Environmental Program Overview

The U.S. Department of Energy (DOE) has implemented a multifaceted environmental management approach at the Weldon Spring site (WSS) to meet the requirements of the National Environmental Policy Act (NEPA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The project is designed to reduce the health or safety threats to on-site workers and the public, mitigate actual or potential uncontrolled contaminant releases, provide for public participation through an active community relations program, and lead to timely initiation of remedial actions. The DOE approach for implementing remedial action at the Weldon Spring site consists of the following major elements:

- Site characterization.
- Risk evaluation.
- Preparation of Remedial Investigation/Feasibility Study (RI/FS) Environmental Impact Statement (EIS) consistent with both NEPA and CERCLA.
- Initiation and completion of interim response actions.
- Removal of quarry bulk wastes as a separate operable unit.
- Preparation of a separate RI/FS and baseline assessment for the quarry as a separate operable unit.
- Site remediation.

The difficulty in characterizing the wastes and environmental media at the quarry has led to the identification of the quarry as a separate operable unit. Quarry bulk waste will be removed and transported to the chemical plant site for temporary storage. This remedial action is addressed under a separate RI for quarry bulk wastes (MKF and JEG 1989a). The

quarry bulk waste will ultimately be disposed of with wastes from the chemical plant and the raffinate pits. Subsequent to the removal of the bulk wastes from the quarry, an RI/FS and baseline assessment for the quarry environs will be conducted. The results will be presented in separate documents which are consistent with the overall Weldon Spring Site Remedial Action Project (WSSRAP) objectives and CERCLA and NEPA requirements.

While the environmental documentation process and remedial action is ongoing, environmental monitoring has been and will continued to be performed to assess the impacts of remedial action on all affected media. Over the long term, this monitoring will document the effectiveness of remedial action. Environmental monitoring will also demonstrate, in the near term, the effectiveness of engineering controls on minimizing releases and exposures during remedial action. Currently, routine monitoring at the WSS provides baseline data prior to remedial action and documents releases and exposures to the public and the environment.

3.2 Site Programs to Ensure Quality

The WSSRAP maintains numerous on-site programs to ensure the quality of the work performed. These programs continually stress the project priorities of quality and environmental safety and health. Two programs include self-assessment and training maintenance and tracking. The following is a summary description of those programs exercised in 1990.

3.2.1 Self-Assessment Program

During 1990, development of a formal self-assessment program was initiated. Although a formal self-assessment program did not exist during 1990, project quality assurance personnel performed audits and surveillances covering essentially all quality-affecting aspects of the environmental monitoring program. Specifically, environmental protection, radiation protection, industrial hygiene, and environmental compliance activities were reviewed to assess procedural compliance. Environmental protection activities associated with sample collection and integrity were reviewed. Radiation protection procedures regarding worker protection and environmental monitoring activities and shipping of radioactive materials were evaluated. Asbestos and worker protection monitoring procedures were reviewed within the Industrial Hygiene group. Environmental Compliance

activities regarding the storage of hazardous waste, the shipping of regulated materials, and the NPDES program were reviewed.

Corrective action plans have been formulated for discrepancies identified in audits and are currently being implemented. Progress in the implementation of corrective actions is verified and tracked through the site-wide audit tracking system.

3.2.2 Training

Training is a key element of the environmental protection program. Through training, each employee is instructed in the policies and procedures related to environmental protection. On-going training sessions also continually reinforce the objectives of the program.

The training program can essentially be broken into four main areas; (1) documents, (2) procedures, (3) special courses taught on-site to convey specific policies or issues and, (4) off-site courses designed to provide instruction for specific areas. Each new employee at WSSRAP is evaluated and assigned training requirements based on job assignment. The department manager establishes a unique training matrix for each employee that includes documents, procedures, and on and off site training courses.

Course selection for each employee is specifically designed to ensure a comprehensive understanding of position requirements and overall policies and program requirements. The need for off-site training to augment site training is evaluated annually and included in the FY budget. Courses specific to waste management are reviewed and planned throughout the year for general employee training. Other off-site courses are mandated for key individuals as a part of on-going training or certification requirements.

The status of employee training is reported to the various departmental managers and the individual employees on a monthly basis. Monthly reports include status of documents and procedures reviewed, as well as training programs and off site courses taken during the current year.

3.3 Waste Minimization/Pollution Prevention Program

The waste minimization/pollution prevention activities at the WSS have been combined and are described in the *Waste Minimization/Pollution Awareness Plan* (MKF and JEG 1990b). The waste minimization program's key elements include:

- Chemical Control - To minimize the generation of hazardous waste, a review and approval mechanism has been developed for chemical control. New purchase orders initiated by site personnel for chemically related materials are reviewed, evaluated, and approved by qualified personnel prior to purchase.

- Training and Awareness - Personnel at the WSSRAP maintain awareness of waste minimization concepts and on-site policy through periodic presentations, seminars, and other training.

- Work Activity Review - The site has developed and implemented a subcontractor work package review system that allows each affected site organization to review and comment on all proposed subcontracted work. Each package is reviewed to ensure that proper measures have been incorporated into the subcontractors requirements in support of waste minimization and pollution prevention.

- Recycling Program - A small, but successful, office recycling program was initiated by the WSSRAP in 1990. Conceived by the employees and endorsed by project management, the site presently reuses office materials and recycles office paper to the extent practical. It is also standard practice to purchase recycled paper products in an effort to increase the markets for recyclable materials. The program exemplifies the effectiveness of the sites employee participation program.

3.4 Waste Management

Consolidation of containerized wastes at the WSS was completed in a two-phase effort in January 1991. Over 1000 containers (varying in size from 209 liters [55 gal] drums to small vials) were collected, field analyzed, consolidated and placed in interim storage pending final disposition. The field analysis provided qualitative data to support the consolidation effort. Treatment and disposal options are being supported by a

comprehensive off-site analysis program. This detailed characterization program is guided by the *Weldon Spring Site Waste Analysis Plan* (MKF and JEG 1991a). The wastes will be stored in the on-site Resource Conservation Recovery Act (RCRA) storage facility, Building 434, until a final treatment or disposal option is available.

The on-site RCRA storage facility, Building 434, provides approximately 1,767 sq m (19,000 sq ft) of storage area. The building, originally a warehouse, was renovated to meet the RCRA standards for containerized storage areas. The majority of wastes are contained in U.S. Department of Transportation (DOT) approved 209 liters (55 gal) drums and overpacks. The current containerized inventory includes 486 drums of hazardous material, 187 drums of asbestos containing material, 138 drums of RCRA regulated material, 43 drums of the Missouri Department of Natural Resources (MDNR) regulated material, 31 drums of Toxic Substance Control Act (TSCA) regulated material, 87 drums of other DOT hazardous material, and 550 drums of non-hazardous material. These drums are stored according to RCRA standards.

All wastes at the WSS are tracked using the Waste Inventory/Tracking System (WITS), a computer oriented inventory database which facilitates tracking of bulk and containerized waste data. The WITS has four functions: inventory, tracking, disposal, and report generation. The inventory function consists of original material inventory. The tracking function is capable of tracking material from its original location, a temporary location, or tracking a specific container. The disposal function is capable of providing information on the disposal of material from its original location, disposal from a temporary location, or disposal of a specific container. The report generation function is capable of producing reports based on the original inventory, remaining inventory, transferred inventory, disposed inventory, reportable quantities, and the tracking of a specific container, or type of waste.

3.5 Unusual Occurrence Reporting for Environmental Incidents

On September 20, 1990 an incident occurred within the chemical plant area in Building 406. During containerized chemical consolidation activities, incompatible substances, i.e., sodium metal bars and an aqueous caustic solution, were combined. The ensuing reaction resulted in the release of approximately 95 liters (25 gal) of caustic liquid

which was confined to the interior bermed portion of the building. Therefore, the release was not reportable under CERCLA and RCRA.

The released material was subsequently neutralized and recontainerized. No radioactive material was involved in the incident and only minor chemical burns were sustained by three employees working in the area. Corrective actions involved the implementation of a new safety oversight/management procedure that is designed to ensure communication of safety and health hazards and preventative measures at the working level. The incident was reported as an unusual occurrence under DOE Order 5000.3A.

3.6 Dam Safety Inspections

In early 1990, the PMC evaluated the dam safety requirements applicable to the WSSRAP. The PMC evaluated the raffinate pits, the Ash Pond dam, and the Ash Pond diversion structure against State and Federal regulations. It was determined that State requirements do not apply to Federally-owned structures or properties regulated by a dam safety program. Under Federal regulations, a dam or berm is regulated if it has a height of 7.6 m (25 ft) or greater as measured from the downstream toe to the maximum water storage elevation, and also if failure of the dam creates a significant downstream hazard.

It was determined that all four raffinate pits fall under Federal regulations. The berms of pits 3 and 4 meet the slope length regulations and the contamination in the pits poses a significant potential downstream hazard. Pits 1 and 2 also pose a significant potential downstream hazard. The PMC determined that the Ash Pond structures do not qualify as regulated dams.

Federal regulations require that all regulated structures be subjected to a standard inspection program. This program consists of surveillance on a regular basis, intermediate inspections on a yearly basis, and a formal inspection once every five years. An emergency inspection may also be performed if some significant damage occurs to the structure. An informal surveillance of the raffinate pit berms was performed on a monthly basis beginning in June of 1990. This schedule will continue through mid-1991 so that the baseline condition of the berms can be established. After this time, the informal surveillances will be performed on a quarterly basis.

4 ENVIRONMENTAL MONITORING PROGRAM INFORMATION

4.1 Radiological Monitoring Program Information

The Weldon Spring Site Remedial Action Project (WSSRAP) operates its environmental monitoring and surveillance program in accordance with the DOE Order 5400 series. The substances present as wastes on the site require monitoring for both radiological and non-radiological species. Although the programs are described separately in this report for information utility, the sampling and analysis programs for each are conducted simultaneously. The environmental monitoring programs and the analytical results, which represent the status of environmental impacts from site related contaminants, are described below.

4.1.1 Surface Water And Spring Monitoring

Surface water samples were collected and analyzed for radiological parameters from a total of 25 locations; 13 within or near the Weldon Spring Chemical Plant/Weldon Spring raffinate pits (WSCP/WSRP) and 12 near the quarry. A total of 10 springs were monitored both north and south of the WSCP/WSRP for radiological parameters. All samples were analyzed for uranium and selected sites were analyzed for Ra-226, Th-230, and Th-232. Radium and thorium isotopes have been analyzed in water samples from surface water runoff from the WSS in past years. The analyses of those samples indicate that radium and thorium do not constitute a radiological contaminant in surface water leaving the site perimeter. Because the water solubility of those radionuclides in the environment is low, and because there was not significant disturbance in radium or thorium contaminated soil materials during 1990, it is not expected that the discharge of those nuclides in surface water would differ significantly from previous years. Many of these locations have been sampled by the WSSRAP for four consecutive monitoring years and are considered to be the most representative for monitoring contaminants that may pose a risk to the public health or the environment.

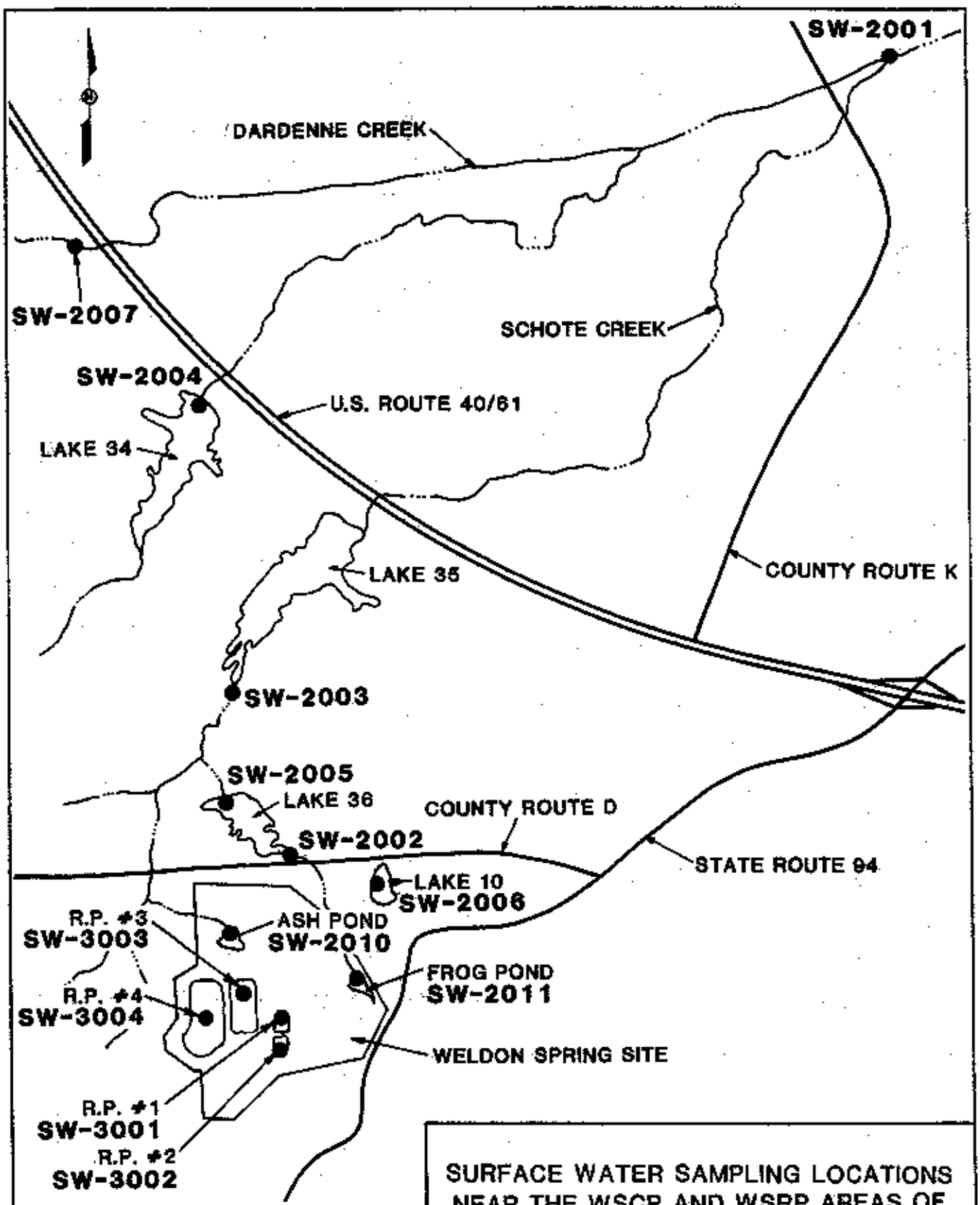
In an effort to maintain a current understanding of site-related contaminant concentrations in potentially affected surface water features, surface water samples were collected from five on-site and seven off-site locations. Locations SW-2007 and SW-2001 are upstream and downstream, respectively, of the surface water migration pathway from the

site. Locations SW-2002, SW-2003, SW-2004, SW-2005 and SW-2006 are located within or near August A. Busch Wildlife Area (ABWA) lakes while SW-2010 (Ash Pond), SW-2011 (Frog Pond), and SW-3001 through SW-3004 (raffinate pits) are located onsite. These locations are shown on Figure 4-1.

Springs SP-5201, SP-5203 and SP-5301 through SP-5304 (southeast drainage) are located south of the site while springs SP-6301 (Burgermeister Spring), SP-6302, SP-6303, and SP-6306 are located north of the site as shown on Figure 4-2.

The 12 surface water locations in Figures 4-3 and 4-4 were selected for routine monitoring to evaluate and document the possibility that surface waters near the Weldon Spring quarry (WSQ) might pose a risk to human health or the environment. Locations SW-1001 and SW-1002 monitor the Little Femme Osage Creek at points upstream and downstream of the WSQ, respectively. Six sampling locations, SW-1003 through SW-1005, SW-1007, SW-1009, and SW-1010 are distributed along the Femme Osage Slough. Location SW-1006 was renamed during the 1990 monitoring year as a groundwater monitoring location - GW-RAWW. Location SW-1008 monitors the ponded water within the WSQ. The samples from this location permit a rough determination of the concentrations of the various contaminants in the ponded surface water (in contact with the quarry wastes) that may migrate to groundwater. Locations SW-1011, SW-1012, and SW-1013 were added to the monitoring program in 1989 to provide baseline water quality data from the Missouri River. SW-1011 is the upstream Missouri River location above potential influences from Weldon Spring site (WSS) contamination, while SW-1013 is furthest downstream below the outfall point of the southeast drainage easement.

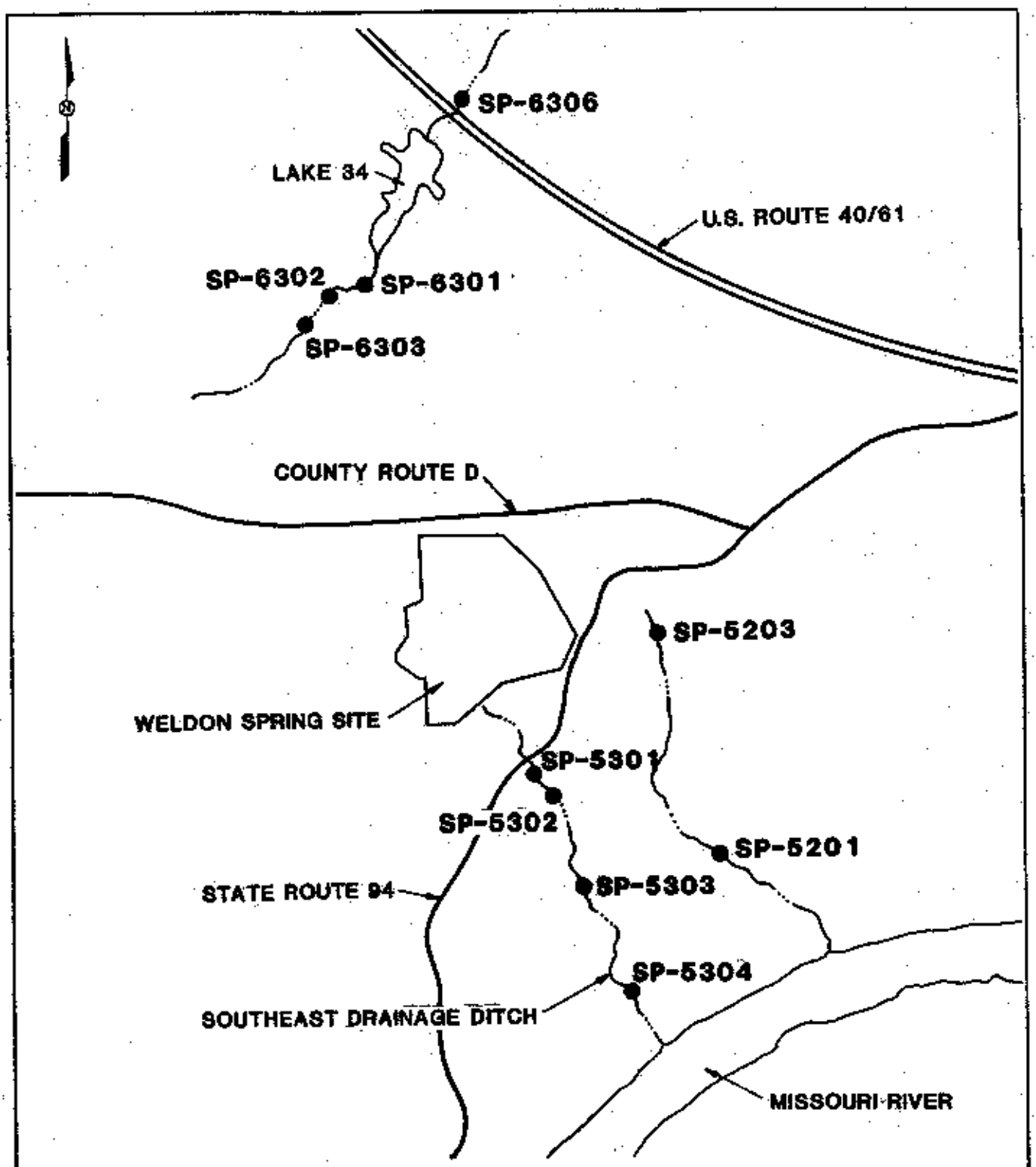
4.1.1.1 Weldon Spring Chemical Plant/Raffinate Pits. The average total uranium activities at off-site locations SW-2001, SW-2006, SW-2007, SP-5203, and SP-6303 were at background levels of less than 5 pCi/l (0.185 Bq/l) (see Tables 4-1 and 4-2 for annual averages). Off-site locations SW-2002, SW-2003, SW-2004, and SW-2005 ranged from a low of 7.34 pCi/l (0.27 Bq/l), or 1% of the derived concentration guideline (DCG) to a high of 190 pCi/l (7.03 Bq/l), or 32% of the DCG. These values were within their historical ranges as were all other off-site locations SP-5301, SP-5302, SP-5303, SP-5304, SP-5503, SP-6301, SP-6302, and SP-6306 which ranged from a low of 6.80 pCi/l (0.25 Bq/l), or 1% of the DCG, to a high of 592 pCi/l (21.9 Bq/l), or 99% of the DCG. The six on-site surface water



SURFACE WATER SAMPLING LOCATIONS NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

FIGURE 4-1

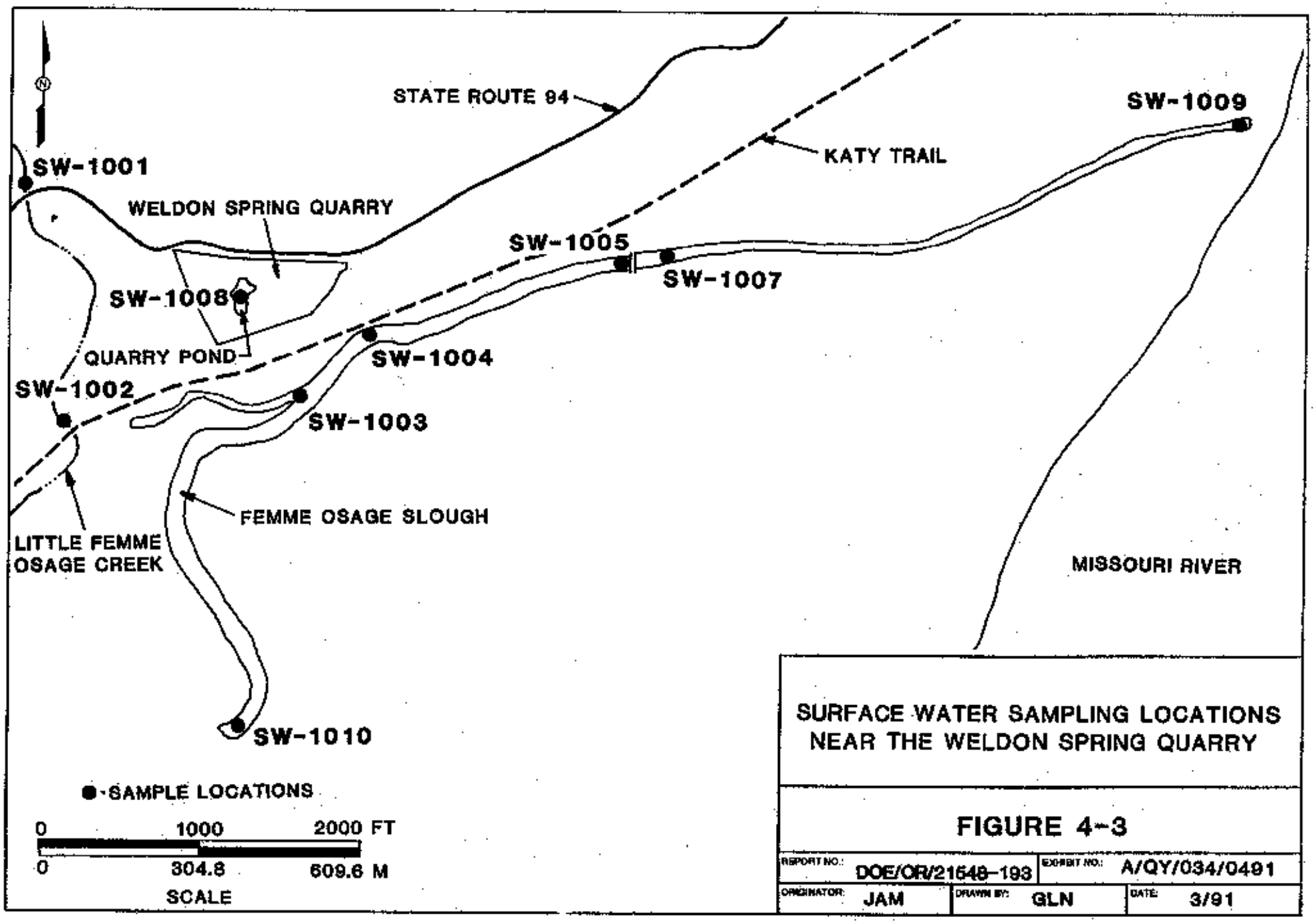
REPORT NO.: DOE/OR/21548-193	EXHIBIT NO.: A/VP/048/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91



SPRINGS AND SEEPS SAMPLED IN THE VICINITY OF THE WELDON SPRING SITE

FIGURE 4-2

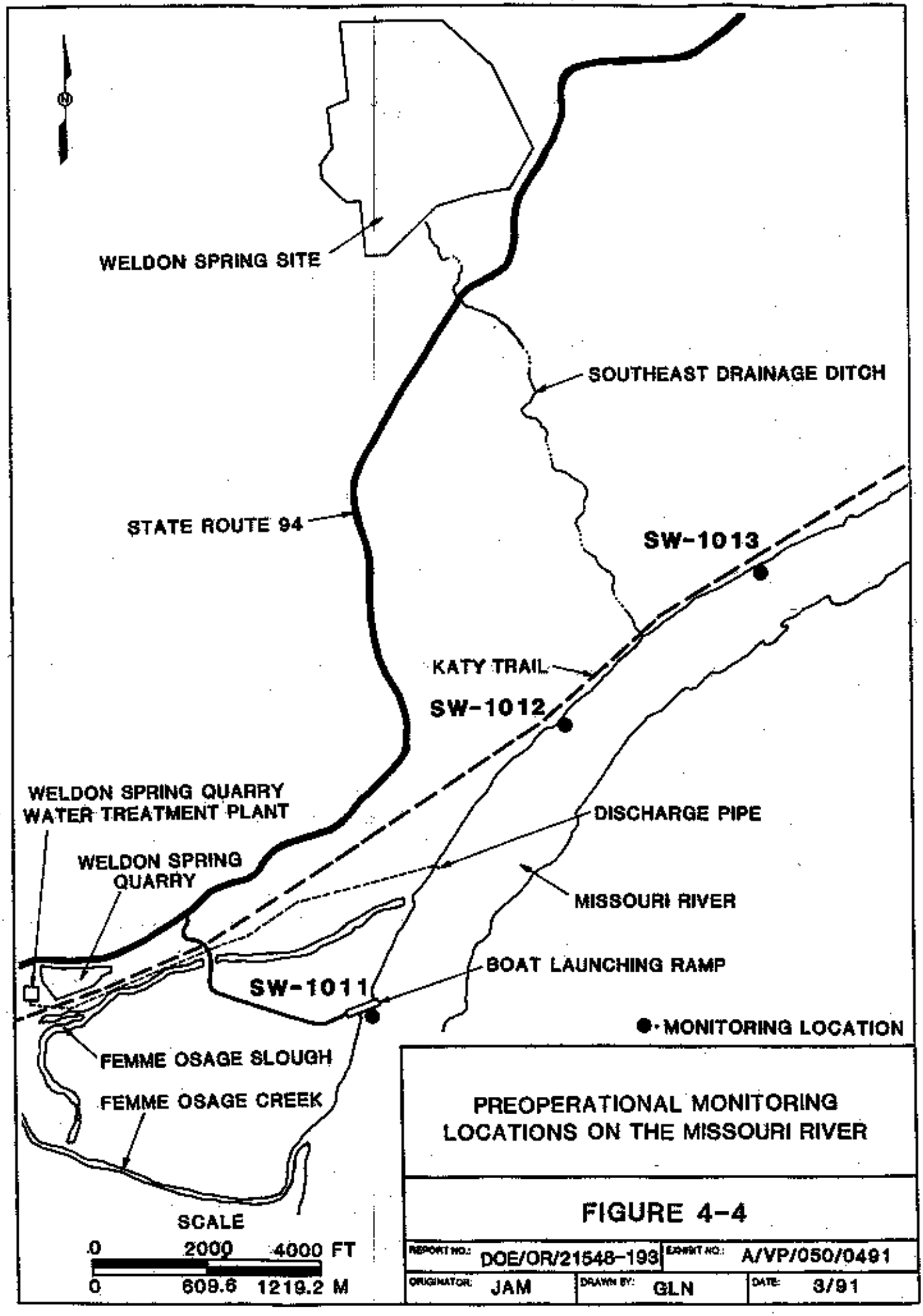
REPORT NO.: DOE/OR/21548-193	EXHIBIT NO.: A/VP/049/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91



SURFACE WATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 4-3

REPORT NO.: DOE/OR/21548-193	EXHIBIT NO.: A/QY/034/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91



PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

FIGURE 4-4

REPORT NO.: DOE/OR/21548-193	EXHIBIT NO.: A/VP/050/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91

TABLE 4-1 1990 Annual Average Uranium and Inorganic Anion Concentrations for Surface Water Near the WSCP/RP Area

WSSRAP ID	URANIUM (pCi/l) (0.68)*	@	CHLORIDE (mg/l) (0.25)*	@	FLUORIDE (mg/l) (0.25)*	@	NITRATE as N (mg/l) (0.1)*	@	SULFATE (mg/l) (1.0)*	@
SW-2001	4.9	(3/4)	NSF		NSF		NSF		NSF	
SW-2002	85.7	(4/4)	NSF		NSF		NSF		NSF	
SW-2003	14.7	(4/4)	NSF		NSF		NSF		NSF	
SW-2004	19.8	(4/4)	NSF		NSF		NSF		NSF	
SW-2005	16.5	(4/4)	NSF		NSF		NSF		NSF	
SW-2006	4.9	(3/4)	NSF		NSF		NSF		NSF	
SW-2007	4.5	(3/4)	NSF		NSF		NSF		NSF	
SW-2010	1792.0	(3/3)	NSF		NSF		NSF		NSF	
SW-2011	237.8	(4/4)	NSF		NSF		NSF		NSF	
SW-3001	282.4	(1/1)	27.9	(1/1)	0.3	(1/1)	464.0	(1/1)	318.0	(1/1)
SW-3002	1700.0	(1/1)	9.6	(1/1)	0.3	(1/1)	ND	(1/1)	415.0	(1/1)
SW-3003	1424.6	(2/2)	30.3	(1/1)	0.7	(1/1)	1900.0	(1/1)	695.0	(1/1)
SW-3004	1700.0	(1/1)	7.83	(1/1)	0.9	(1/1)	0.3	(1/1)	87.5	(1/1)

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

ND - Not Detected

NSF - Not Scheduled for Sampling

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.

* Detection limit

TABLE 4-2 1990 Annual Average Uranium and Inorganic Anion Results at Springs Near the WSCP/RP Area

WSSRAP ID	URANIUM (pCi/l) (0.68)*	@	CHLORIDE (mg/l) (0.25)*	@	FLUORIDE (mg/l) (0.25)*	@	NITRATE as N (mg/l) (0.1)*	@	SULFATE (mg/l) (1.0)*	@
SP-5203	1.7	(2/3)	NSF		NSF		NSF		NSF	
SP-5301	397.7	(4/4)	NSF		NSF		NSF		NSF	
SP-5302	368.9	(4/4)	NSF		NSF		NSF		NSF	
SP-5303	270.3	(4/4)	NSF		NSF		NSF		NSF	
SP-5304	119.3	(4/4)	NSF		NSF		NSF		NSF	
SP-5503	6.80	(1/1)	NSF		NSF		NSF		NSF	
SP-6301	56.6	(4/4)	32.0	(1/1)	ND	(0/1)	42.0	(1/1)	54.0	(1/1)
SP-6302	30.9	(2/2)	NSF		NSF		NSF		NSF	
SP-6303	4.1	(3/4)	NSF		NSF		NSF		NSF	
SP-6306	10.4	(3/3)	7.4	(1/1)	0.2	(1/1)	2.7	(1/1)	13.5	(1/1)

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

ND - Not Detected

NSF - Not Scheduled for Sampling

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.

* Detection limit

impoundments, the four raffinate pits, Ash Pond, and Frog Pond indicated a low of 170 pCi/l (6.29 Bq/l), or 28% of the DCG, to a high of 2,584 pCi/l (95.6 Bq/l), or 430% of the DCG. These levels are within their historical ranges.

No significant changes were observed between the average values measured in 1990 and 1989 at any of the 13 surface water or the 10 spring locations within or near the site. At the furthest downstream location, SW-2001 (the confluence of Schote and Dardenne creeks), the average of the quarterly measurements remained at background levels as in 1989, while the maximum value increased only slightly. No seasonal pattern was observed in the values.

The sampling results indicate that uranium continues to migrate from the site at relatively low levels in surface water and springs along known discharge pathways. The concentrations (activity) of the total uranium is reduced by dilution and natural processes to the point that the level falls to within the range of natural background at the farthest downstream measurement location, SW-2001.

Other radiological species (radium and thorium) were monitored in 1990 at the raffinate pits only (see Table 4-3). Historically, no other monitoring locations have detected elevated levels of those species. The raffinate pits were sampled once in 1990 to maintain a baseline on the radioisotope levels. The radium and thorium values within the pits for 1990 were very similar to those of 1989.

4.1.1.2 Weldon Spring Quarry. The primary radionuclide of concern at the WSQ and surrounding area is total uranium, which was detected at levels ranging from 2.7 pCi/l (0.10 Bq/l) or less than 1% of the DCG within the Missouri River to a quarterly high of 3130 pCi/l (115.8 Bq/l) or 522% of the DCG in the quarry pond water within the access-controlled area. Refer to Table 4-4 for annual averages of uranium for sample locations near the quarry.

The quarry pond water was once again sampled quarterly for uranium. The average measured value was 2400.7 pCi/l (88.8 Bq/l) which is similar to but slightly higher than the average measured value of 1827 pCi/l (76.6 Bq/l) during 1989. The quarry pond poses little direct threat to the public health.

TABLE 4-3 1990 Radiological Results For Raffinate Pits (pCi/l)

WSSRAP ID	RADIUM-226	@	THORIUM-230	@	THORIUM-232	@
SW-3001	130.0	(1/1)	100.0	(1/1)	0.2	(1/1)
SW-3002	95.0	(1/1)	90.0	(1/1)	0.3	(1/1)
SW-3003	7.0	(1/1)	3.8	(1/1)	1.2	(1/1)
SW-3004	98.0	(1/1)	92.0	(1/1)	2.8	(1/1)

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were taken in 1990, two of which average 2.00 and the other two samples were ND.

Locations SW-1011 to SW-1013 are distributed along the north bank of the Missouri River to provide samples of river water for water quality testing in preparation for effluent discharge from the WSQ water treatment plant (WTP). The results of the measurements yielded annual average uranium activities for 1990 of 5.9 pCi/l (0.22 Bq/l) at SW-1013 (downstream), 5.7 pCi/l (0.21 Bq/l) at SW-1012, and 4.3 pCi/l 4.3 Bq/l) at SW-1011 (upstream). The error is $\pm$1.0 pCi/l (0.037 Bq/l). The highest quarterly measured uranium activity in the Missouri River was detected during the fourth quarter of 1990 at 9.52 pCi/l (0.35 Bq/l) or 2% of the DCG at SW-1013. These values fluctuate due to natural variations in the river water.

Uranium activities slightly above background were detected in the waters of the Little Femme Osage Creek both up and downstream of the quarry during the first quarter of 1990. Upstream (SW-1001) indicated 8.16 pCi/l and downstream (SW-1002) indicated 11.5 pCi/l. However, the later quarters for both locations were at background or non-detect. The higher uranium values for the first quarter were probably due to laboratory error as sampling blanks also contained uranium. The two locations will continue to be monitored.

The Femme Osage Slough, which is the former channel of the Femme Osage Creek prior to rerouting that stream course, is a nearly stagnant water body. The slough has been known to receive uranium contamination from the contaminated groundwater in the bedrock

TABLE 4-4 1990 Annual Average Uranium and Inorganic Anion Concentrations For Surface Water Near the WSQ

WSSRAP ID	URANIUM (pCi/l) (0.68)*	@	CHLORIDE (mg/l) (0.25)*	@	FLUORIDE (mg/l) (0.25)*	@	NITRATE (mg/l) (0.1)*	@	SULFATE (mg/l) (1.0)*	@
SW-1001	4.5	(3/4)	NSF		NSF		NSF		NSF	
SW-1002	6.6	(2/4)	NSF		NSF		NSF		NSF	
SW-1003	45.7	(4/4)	NSF		NSF		NSF		NSF	
SW-1004	47.6	(4/4)	NSF		NSF		NSF		NSF	
SW-1005	19.9	(4/4)	NSF		NSF		NSF		NSF	
SW-1007	17.2	(4/4)	NSF		NSF		NSF		NSF	
SW-1008	2400.7	(3/3)	12.1	(2/2)	0.9	(2/2)	ND	(2/2)	139.5	(2/2)
SW-1009	15.9	(3/3)	NSF		NSF		NSF		NSF	
SW-1010	34.4	(3/3)	NSF		NSF		NSF		NSF	
SW-1011	4.3	(3/3)	NSF		NSF		NSF		NSF	
SW-1012	5.7	(3/3)	NSF		NSF		NSF		NSF	
SW-1013	5.9	(3/3)	NSF		NSF		NSF		NSF	

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

ND - Not Detected

NSF - Not Scheduled For Sampling

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4)Indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.

* Detection limit

and alluvium to the north. In 1990, the uranium activities within the Slough ranged from a low of 8.84 pCi/l (0.33 Bq/l) or 1% of the DCG at SW-1009 to a high of 57.1 pCi/l (2.11 Bq/l) or 10% of the DCG at SW-1004. This is attributed to uranium contaminated groundwater discharging to the slough from the north side. The water level in the slough is managed by the Missouri Department of Conservation, whereby water is allowed to fill the slough during high river stage. The valve is closed at high stage and the water is retained in the slough. These fluctuating water levels are a mechanism for migration. All average uranium levels for the slough remained within their historical ranges.

According to the 1990 measurements, the quarry pond water did not contained Ra-226 or Ra-228 above the detection limit of 2 pCi/l (0.074 Bq/l), and Th-230 activities were measurable near the detection limit of 0.5 pCi/l (0.018 Bq/l) while Th-232 remained undetected. See Table 4-5. These values remain within their historical ranges.

4.1.2 Four Year Trend Analysis for Uranium in Surface Water

4.1.2.1 Weldon Spring Chemical Plant/Raffinate Pits. A four year trend analysis for uranium in surface water near the site was performed using surface water sampling locations SW-2001 through SW-2005 and SW-2007. Annual averages were used for the years 1987 through 1990. Refer to Figure 4-4A for a representation of this data.

The trend analysis does not portray an increase or decrease in uranium over a four-year period, but indicates fluctuations in concentrations that can be accounted for by natural dilution effects.

4.1.2.2 Weldon Spring Quarry. A four-year trend analysis for uranium in surface water near the quarry was performed using surface water sampling locations SW-1001 through SW-1005. Annual averages were once again used for the years 1987 through 1990 due to availability. Refer to Figure 4-4B for a representation of this data.

The trend analysis indicates fluctuations in uranium concentrations over a four-year period that can also be accounted for by natural dilution effects. However, it should be noted that surface water locations SW-1003 and SW-1004 do indicate a consistent trend of increasing from 1987 to 1989 and then decreasing during 1990. This pattern could be a

TABLE 4-5 1990 Annual Average Radiological Results For Surface Water in the WSQ (pCi/l)

WSSRAP ID	RADIUM-226	@	RADIUM-228	@	THORIUM-230	@	THORIUM-232	@
SW-1008	1.8	(3/3)	1.8	(1/1)	0.5	(2/3)	ND	(3/3)

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

ND - Not Detected

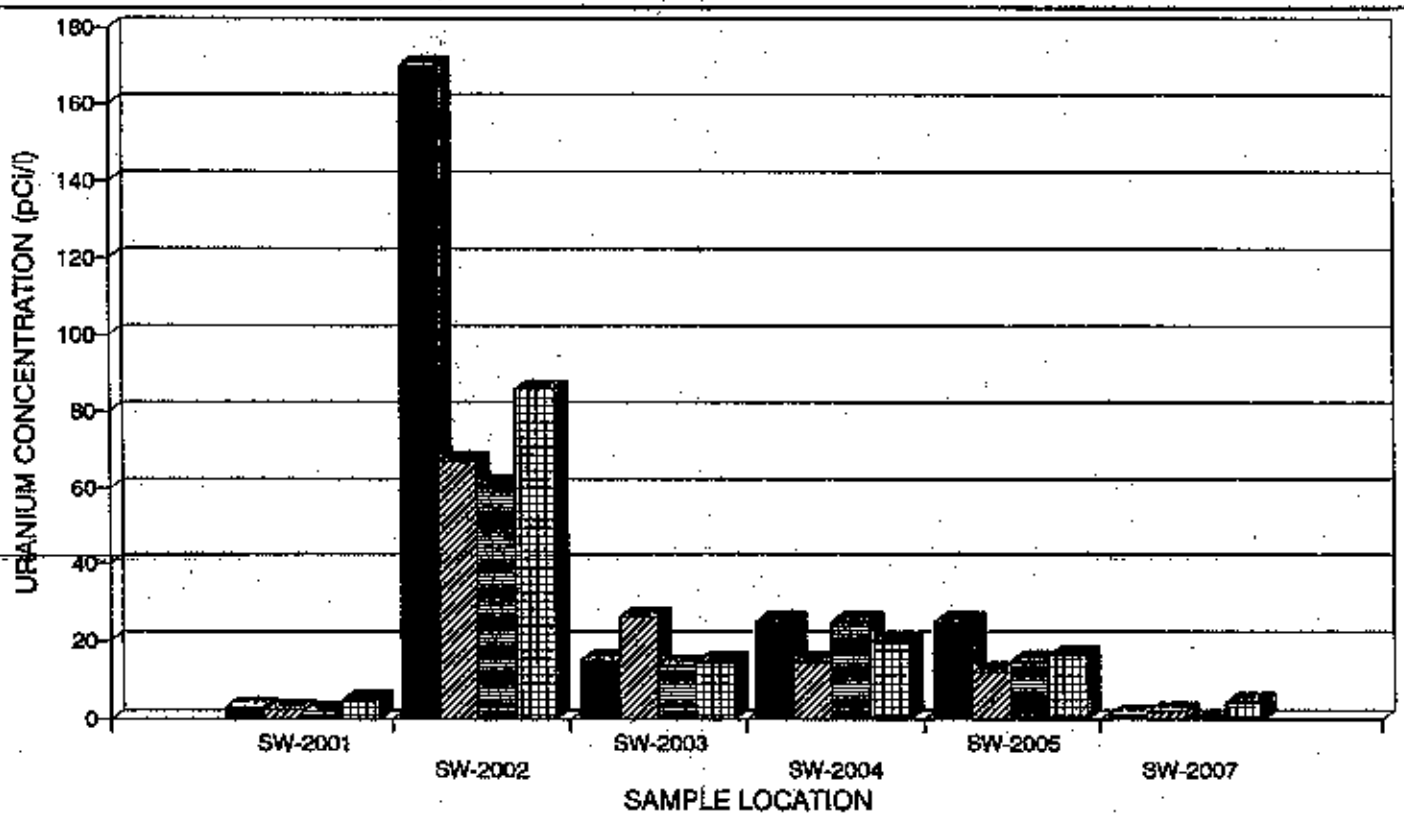
@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.

result of the drought conditions that existed during 1988-1989 followed by an above normal amount of precipitation during 1990.

4.1.3 Groundwater Monitoring Radiological Results

All Weldon Spring Chemical Plant/raffinate pits/vicinity properties (WSCP/RP/VP) and WSQ monitoring wells were sampled during 1990 for radiological parameters. An understanding of groundwater quality and hydrogeology has been established over the past four years through routine monitoring and investigations at the site. Therefore, the groundwater monitoring program has been modified each year to include areas where more information is needed, and to be more efficient by avoiding unnecessary or redundant sampling and analysis. Through these modifications, a high quality program to effectively assess the groundwater quality has been maintained.

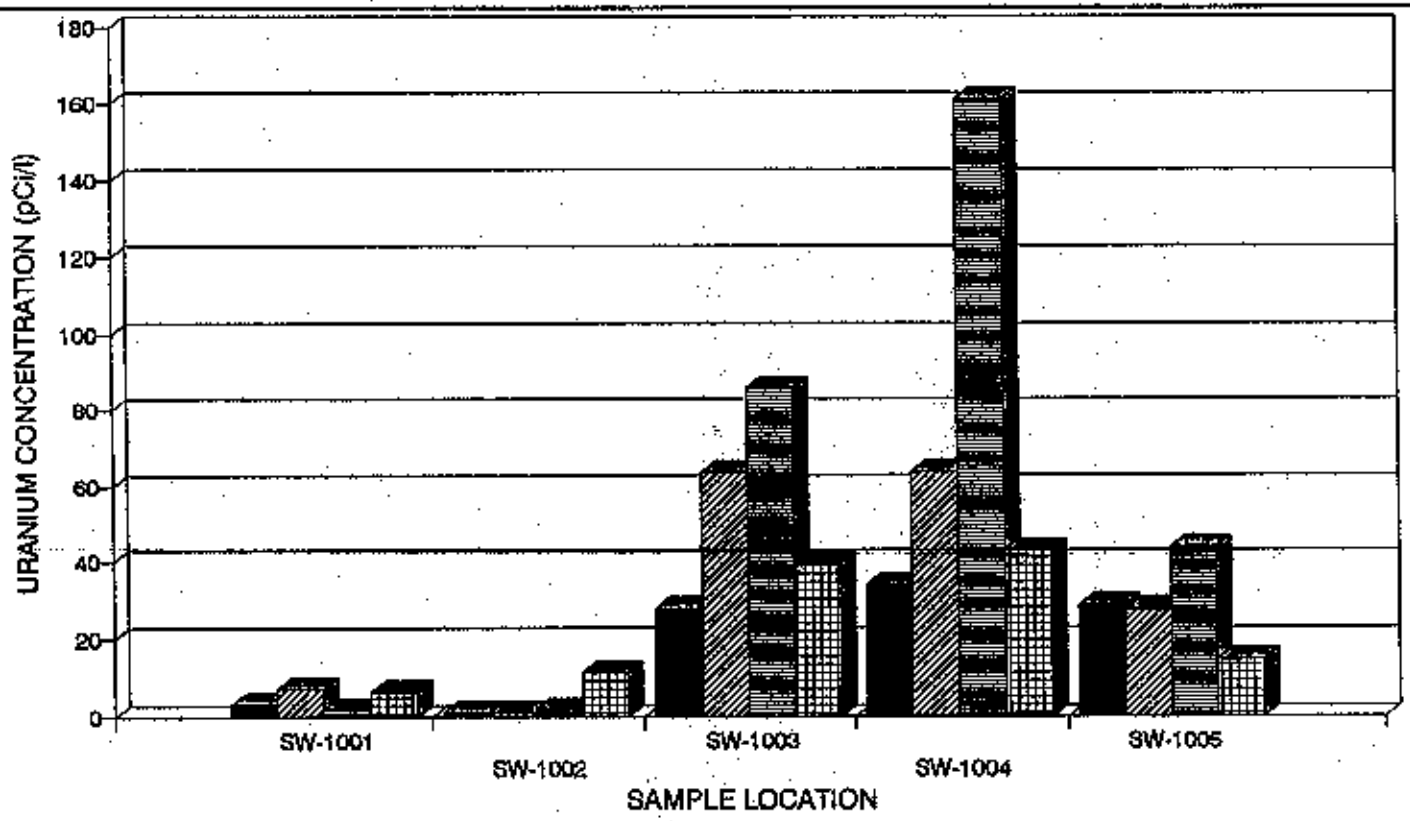
All wells sampled at the WSCP/RP/VPs and the WSQ were monitored at least semi-annually for total natural uranium. The St. Charles County pumping wells, the treated and untreated water from the St. Charles County Water Treatment Plant, and a select group of monitoring wells in the county wellfield were monitored for total natural uranium and gross alpha on a quarterly basis. These same locations were also monitored on an annual basis for Th-230, Th-232, Ra-226, Ra-228 and gross beta. This quarterly and annual sampling was performed to ensure the safety of the St. Charles County water supply from contaminant



FOUR YEAR TREND ANALYSIS FOR URANIUM IN SURFACE WATER NEAR THE SITE

FIGURE 4-4A

REPORT NO.: DOE/OR/21548-193	EXHIBIT NO.: A/PI/097/0591	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 5/91



FOUR YEAR TREND ANALYSIS FOR URANIUM IN SURFACE WATER NEAR THE QUARRY

FIGURE 4-4B

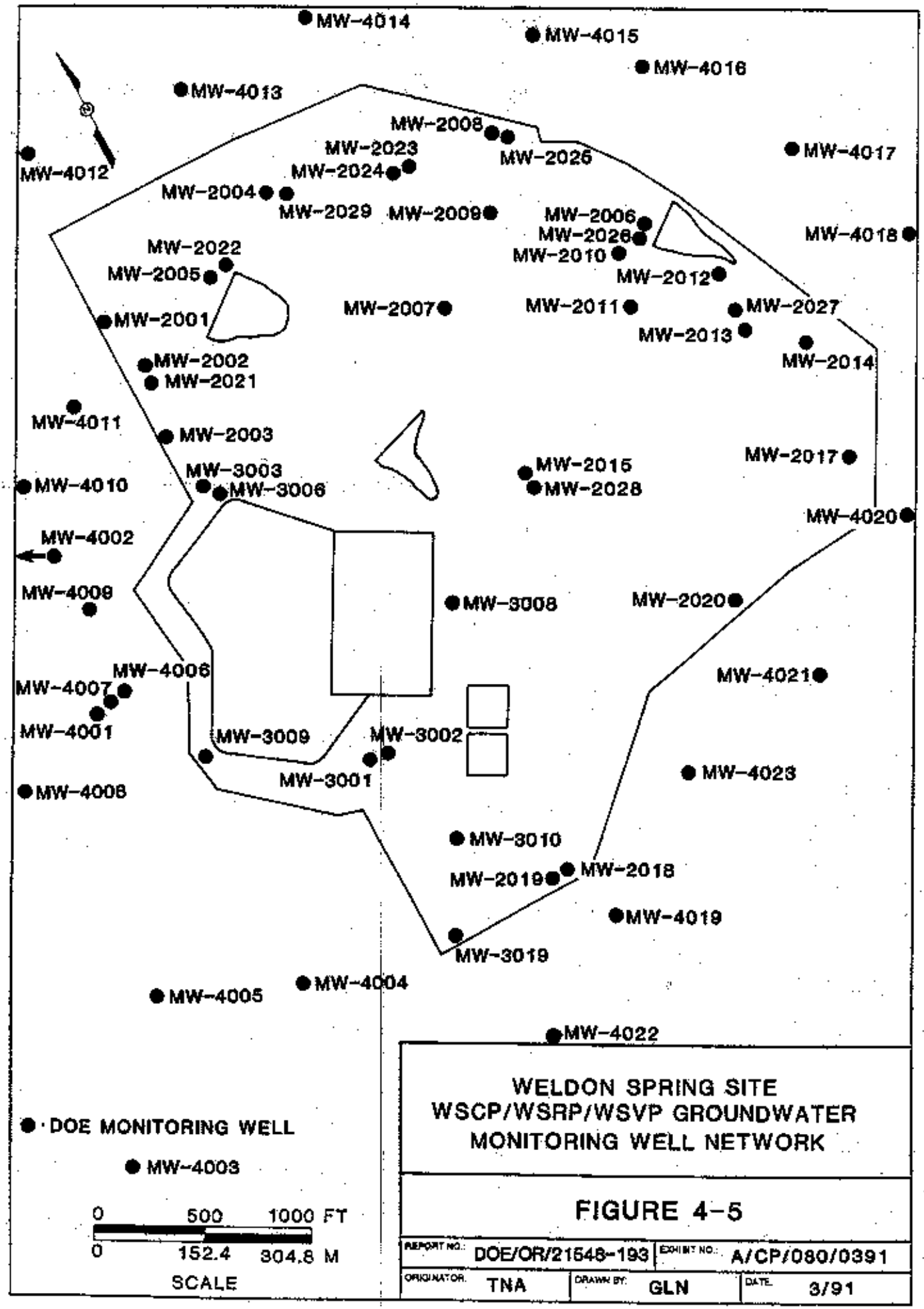
REPORT NO.:	DOE/OR/21548-193	EXHIBIT NO.:	A/PI/098/0591		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	5/91

migration originating from the WSQ. The protection of the wellfield is an issue of great sensitivity to the public, the U.S. Department of Energy (DOE), and other regulatory agencies.

Data tables for all laboratory analytical results of uranium analysis presented in this section contain annual average concentrations calculated from data generated during 1990 where more than one analysis was conducted. The values from the tables are compared to background concentrations and/or to Environmental Protection Agency (EPA) guidelines. The annual average concentration is stated in each column with a fraction in parentheses adjacent to that value. The numerator represents the number of samples used to calculate the annual concentration. The denominator represents the number of times that particular well was sampled during 1990. An "ND" indicates "Not Detected" and appears only if a particular parameter was not measurable above the detection limit in any analyses performed on samples obtained from that well during 1990. If the analytical laboratory reported an "ND" for a particular parameter for a particular sampling event, the ND was not used to calculate the annual concentration. Quarterly results are presented in data tables in Appendix A. Where quarterly data points were not received from the analytical laboratory in time for inclusion in this report, the annual average was calculated based on available data. Where semi-annual data points might have been absent for calculation of annual average, sufficient historical data exists to verify the 1990 measured values.

4.1.3.1 Chemical Plant/Raffinate Pits. Groundwater at the WSCP/RP area became radiologically contaminated as a result of operations at the Weldon Spring Uranium Feed Materials Plant (WSUFMP) during the 1950s and 1960s. The *Water Quality Phase I Assessment Report* (MKF and JEG 1987) reported that: "groundwater near the raffinate pits contains elevated amounts of uranium and is a result of leaking raffinate pits and other sources." The Phase II Groundwater Quality Assessment Report (MKF and JEG 1989b), an expanded, comprehensive evaluation of groundwater quality at the WSCP/RP/VP area during the third quarter of 1988, is essentially in agreement with the Phase I report for radiological parameters.

The groundwater monitoring network consists of 59 wells; 28 at the WSCP, eight at the WSRP, and 23 at the WSVP. Figure 4-5 shows the locations of individual wells in the WSCP/RP/VP monitoring well network. All of these wells are screened in the uppermost unconfined aquifer. The wells are completed at a range of depths so that the entire



WELDON SPRING SITE
WSCP/WSRP/WSVP GROUNDWATER MONITORING WELL NETWORK

FIGURE 4-5

REPORT NO.: DOE/OR/21548-193	EXHIBIT NO.: A/CP/080/0391	
ORIGINATOR: TNA	DRAWN BY: GLN	DATE: 3/91

uppermost aquifer is monitored. Detailed well construction information for individual wells is available in the 1990 *Environmental Monitoring Plan* (MKF and JEG 1990c). The upper bound for total natural uranium background concentrations in groundwater at the WSCP/RP/VP has been determined to be 3.4 pCi/l (0.125 Bq/l) (MKF and JEG 1989b). the EPA has not yet established drinking water standards for uranium; however studies leading to proposed rulemaking are using uranium concentration in the 10 pCi/l to 40 pCi/l (0.37 Bq/l to 1.48 Bq/l) range (MKF and JEG 1989b).

Each groundwater monitoring well was sampled and analyzed for total natural uranium during 1990. Table 4-6 provides the annual concentrations.

Twenty-seven of the 59 groundwater monitoring wells have average total natural uranium concentrations below the upper bound for natural background. As Table 4-6 shows, 27 monitoring wells have annual average concentrations above background but below 10 pCi/l. Three wells, MW-3003, MW-4005 and MW-4020 have annual average concentrations in the 10 pCi/l to 40 pCi/l range. Monitoring wells MW-3008 and MW-3009 have the highest annual average concentrations, 231.2 pCi/l and 52.36 pCi/l (8.55 Bq/l and 1.94 Bq/l) respectively. Figure 4-6 highlights those wells with annual average total natural uranium concentrations above 10 pCi/l (the lowest proposed drinking water standard). These results show a larger area of groundwater uranium contamination than previous studies have indicated. This is believed to be due in part to the laboratory contamination discussed in Section 6.3.2.

4.1.3.2 Quarry. Groundwater near the WSQ has become radiologically contaminated as a result of contact with or migration from the radioactive substances present in the WSQ. Twenty-six DOE groundwater monitoring wells located at or near the WSQ were sampled and analyzed during 1990 to monitor for the presence of WSQ related contaminants. The St. Charles County production wells and the treated and untreated water from the St. Charles County Water Treatment Plant were also monitored for the presence of these contaminants. Figures 4-7 and 4-8 show the locations of the monitoring wells, pumping wells, and the St. Charles County Water Treatment Plant. The groundwater monitoring wells are screened in a range of geologic formations from the Ordovician-aged Plattin Limestone, upsection to and including the unconsolidated Quaternary-aged Missouri River alluvium. Samples from four monitoring wells (RMW series) screened in the Missouri River alluvium and owned by St. Charles County were also analyzed during 1990. During

TABLE 4-6 Summary of Averages for Inorganic Anions and Total Uranium in Groundwater Around the WSCP/RP Area

WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCi/l (0.68)*	@
MW-2001	57.0	(2/2)	4.71	(2/2)	6.3	(2/2)	1.27	(1/2)	ND	(0/2)
MW-2002	408.5	(2/2)	145.0	(2/2)	9.74	(2/2)	ND	(0/2)	3.4	(1/2)
MW-2003	266.00	(1/1)	232.00	(1/1)	12	(1/1)	0.09	(1/1)	1.17	(2/2)
MW-2004	0.74	(2/2)	5.13	(1/2)	1	(1/2)	0.16	(1/2)	2.31	(2/2)
MW-2005	240	(1/1)	19.34	(2/2)	3.3	(2/2)	0.19	(1/2)	4.05	(2/2)
MW-2006	5.99	(2/2)	34.95	(2/2)	176	(2/2)	ND	(0/2)	2.66	(2/2)
MW-2007	ND	(0/2)	14.55	(2/2)	ND	(0/2)	0.10	(1/2)	5.57	(2/2)
MW-2008	5.08	(2/2)	25.9	(2/2)	73.65	(2/2)	0.8	(1/2)	7.46	(2/2)
MW-2009	1.62	(2/2)	86.5	(2/2)	11.65	(2/2)	0.06	(1/2)	1.56	(2/2)
MW-2010	0.83	(2/2)	35.4	(2/2)	58.5	(2/2)	0.08	(1/2)	9.2	(2/2)
MW-2011	2.78	(1/1)	13	(1/1)	2.1	(1/1)	0.09	(1/1)	ND	(1/1)
MW-2012	0.38	(2/2)	65.9	(2/2)	37	(2/2)	0.05	(1/2)	ND	(1/2)
MW-2013	0.80	(3/3)	17.83	(3/3)	4.78	(3/3)	ND	(0/3)	2.47	(2/2)
MW-2014	1.66	(2/2)	84.6	(2/2)	26.4	(2/2)	0.07	(1/2)	2.04	(1/1)
MW-2015	0.28	(1/1)	104	(1/2)	1	(1/2)	0.15	(1/2)	4.66	(2/2)
MW-2017	2.92	(2/2)	426.5	(2/2)	7.95	(2/2)	0.19	(1/2)	3.98	(2/2)
MW-2018	0.52	(2/2)	17.26	(2/2)	12.63	(2/2)	0.27	(1/2)	5.76	(2/2)
MW-2019	2.41	(1/2)	33.1	(1/1)	2.38	(1/1)	0.2	(1/1)	4.08	(2/2)

TABLE 4-6 Summary of Data Averages for Inorganic Anions and Total Uranium in 1990 (Continued)

WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCi/l (0.68)*	@
MW-2020	0.69	(2/2)	155.5	(2/2)	16.9	(2/2)	0.24	(2/2)	7.48	(2/2)
MW-2021	ND	(0/2)	15.5	(2/2)	1.24	(2/2)	0.14	(2/2)	1.7	(2/2)
MW-2022	ND	(0/2)	14.8	(2/2)	1.74	(2/2)	0.16	(2/2)	1.36	(1/2)
MW-2023	0.08	(1/2)	21.45	(2/2)	1.62	(2/2)	0.24	(1/2)	7.15	(2/2)
MW-2024	ND	(0/2)	58.85	(2/2)	1.93	(2/2)	0.19	(2/2)	1.36	(1/2)
MW-2025	ND	(0/2)	19.35	(2/2)	1.73	(2/2)	0.19	(2/2)	0.7	(1/2)
MW-2026	ND	(0/2)	19.5	(2/2)	1.88	(2/2)	0.18	(1/2)	2.4	(2/2)
MW-2027	ND	(0/2)	12.9	(2/2)	3.11	(2/2)	0.22	(2/2)	2.04	(2/2)
MW-2028	ND	(0/2)	143.0	(2/2)	2.07	(2/2)	0.19	(2/2)	1.7	(2/2)
MW-2029	ND	(0/2)	27.95	(2/2)	2	(1/2)	0.17	(1/2)	3.48	(2/2)
MW-3001	537	(2/2)	24.5	(2/2)	12.25	(2/2)	0.16	(2/2)	1.03	(2/2)
MW-3002	ND	(0/2)	19.5	(2/2)	1.17	(2/2)	0.28	(2/2)	2.72	(2/2)
MW-3003	1260	(2/2)	86.6	(2/2)	6.9	(2/2)	0.18	(1/2)	15.5	(2/2)
MW-3006	ND	(0/2)	22.4	(2/2)	0.68	(1/2)	0.18	(1/2)	1.1	(2/2)
MW-3008	646	(1/1)	42.1	(1/1)	13.5	(1/1)	0.16	(1/1)	231.2	(1/1)
MW-3009	671	(2/2)	27.3	(1/1)	5.8	(1/1)	0.11	(1/1)	52.36	(2/2)
MW-3010	1.14	(2/2)	6.71	(2/2)	1.75	(2/2)	0.26	(2/2)	2.72	(1/2)
MW-3019	ND	(0/2)	26.74	(2/2)	2.95	(2/2)	0.31	(1/2)	9.5	(2/2)
MW-4001	30.15	(2/2)	62	(1/1)	3.91	(1/1)	0.11	(1/1)	0.84	(2/2)

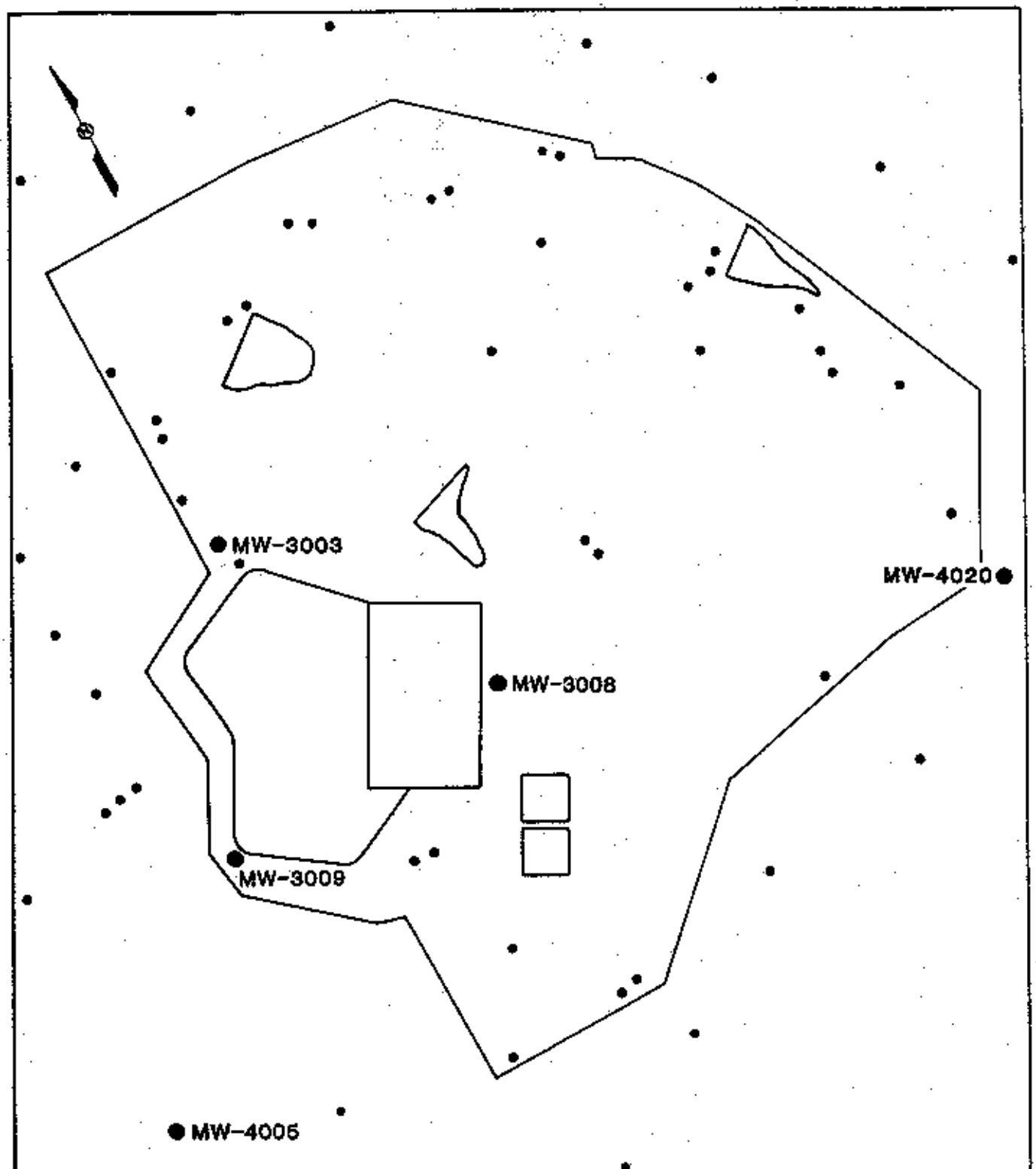
TABLE 4-6 Summary of Data Averages for Inorganic Anions and Total Uranium in 1990 (Continued)

WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCi/l (0.66)*	@
MW-4002	3.01	(2/2)	27.4	(2/2)	11.9	(2/2)	0.11	(2/2)	0.7	(1/2)
MW-4003	0.66	(2/2)	32.2	(1/1)	5.7	(1/2)	0.17	(1/2)	8.4	(1/2)
MW-4004	0.70	(2/2)	25.95	(2/2)	2.97	(2/2)	0.33	(2/2)	8.16	(2/2)
MW-4005	1.27	(2/2)	23.25	(2/2)	5.11	(2/2)	0.32	(2/2)	15.64	(2/2)
MW-4006	14.1	(1/1)	29.45	(2/2)	1.8	(2/2)	0.15	(1/2)	1.34	(1/2)
MW-4007	0.14	(1/2)	18.25	(2/2)	1.43	(2/2)	0.46	(2/2)	3.74	(2/2)
MW-4008	ND	(0/2)	14.8	(2/2)	4.2	(1/2)	0.26	(2/2)	2.04	(2/2)
MW-4009	ND	(0/2)	17.45	(2/2)	1.1	(1/2)	0.33	(1/2)	6.93	(2/2)
MW-4010	0.12	(1/2)	24.85	(2/2)	2.56	(2/2)	0.26	(2/2)	4.76	(2/2)
MW-4011	16.8	(1/2)	37.2	(2/2)	5.75	(2/2)	0.29	(2/2)	6.46	(2/2)
MW-4012	0.13	(1/1)	30.7	(2/2)	2.5	(1/2)	0.32	(1/2)	4.13	(2/2)
MW-4013	51.4	(2/2)	44.4	(2/2)	6.14	(2/2)	ND	(0/2)	8.17	(2/2)
MW-4014	3.93	(2/2)	30.85	(2/2)	3.37	(2/2)	0.68	(2/2)	1.36	(2/2)
MW-4015	2.39	(2/2)	18.45	(2/2)	2.77	(2/2)	0.19	(2/2)	3.4	(2/2)
MW-4016	ND	(0/2)	7.15	(2/2)	1.5	(1/2)	0.21	(1/2)	3.7	(2/2)
MW-4017	0.43	(1/2)	8.65	(2/2)	1.4	(2/2)	0.15	(1/2)	1.59	(2/2)
MW-4018	0.94	(2/2)	8.25	(2/2)	6.2	(2/2)	0.11	(1/2)	2.4	(1/2)
MW-4019	0.23	(2/2)	7.85	(2/2)	1.3	(2/2)	0.4	(2/2)	4.8	(1/1)
MW-4020	0.05	(1/2)	105.7	(2/2)	5.8	(2/2)	0.19	(1/2)	16.66	(2/2)

TABLE 4-6 Summary of Data Averages for Inorganic Anions and Total Uranium in 1990 (Continued)

WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCi/l (0.68)*	@
MW-4021	0.12	(1/2)	265.0	(2/2)	1.55	(2/2)	0.17	(1/2)	6.56	(2/2)
MW-4022	0.05	(1/2)	29.55	(2/2)	4.45	(2/2)	0.39	(1/2)	6.61	(2/2)
MW-4023	6.07	(2/2)	90.5	(2/2)	14.15	(2/2)	0.25	(1/2)	4.415	(2/2)

Average is calculated using non-ND results. An ND is reported in this table only if all all samples from that location had ND reported.
ND - Not Detected
* - Detection limit
@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.



● WELLS WITH CONCENTRATIONS >10pCi/l

• DOE MONITORING WELL

0 500 1000 FT
0 152.4 304.8 M
SCALE

WELDON SPRING CHEMICAL PLANT/
RAFFINATE PITS/VICINITY PROPERTIES
WELLS WITH ANNUAL AVERAGE
URANIUM CONCENTRATIONS
> 10 pCi/L

FIGURE 4-6

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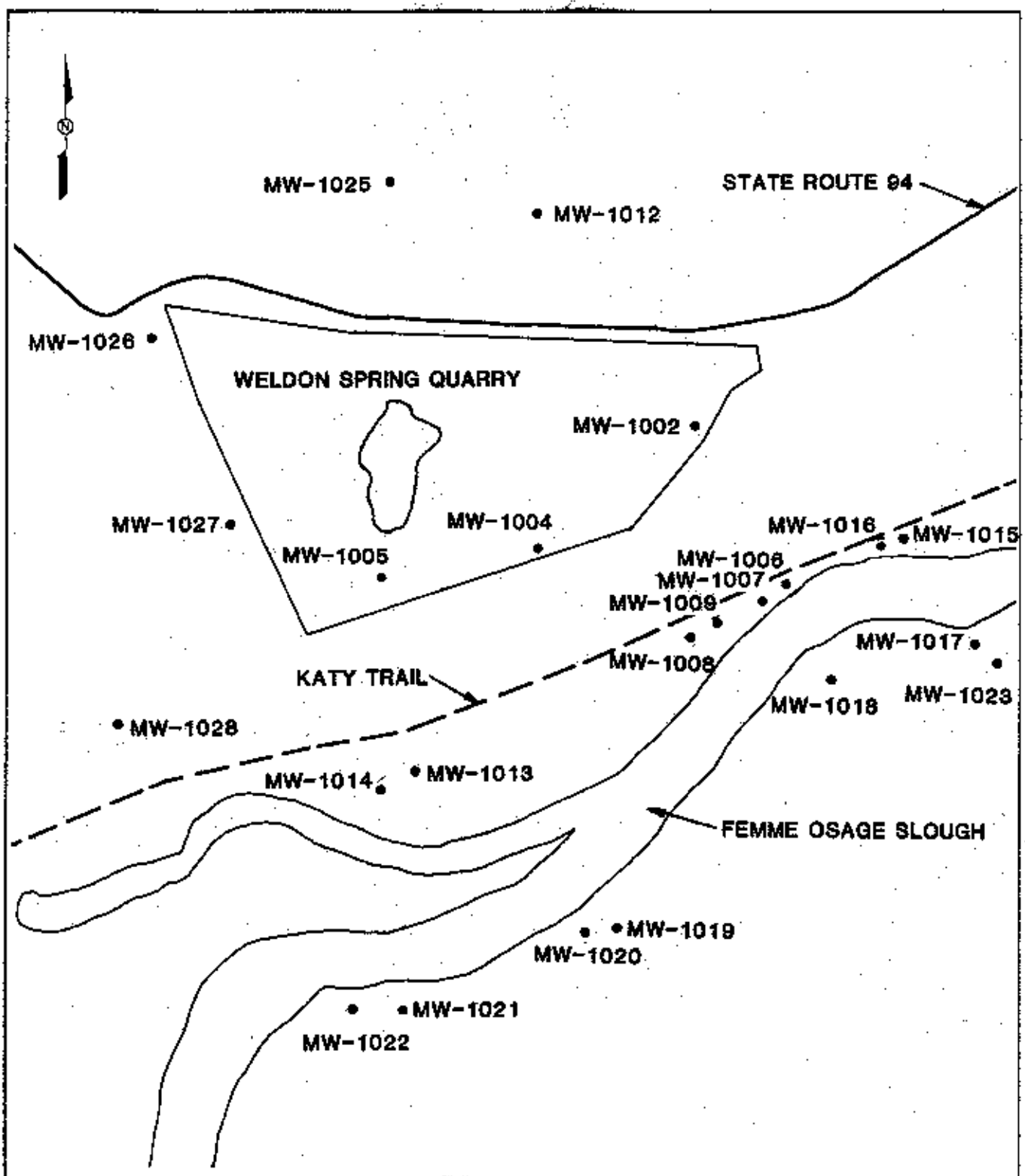
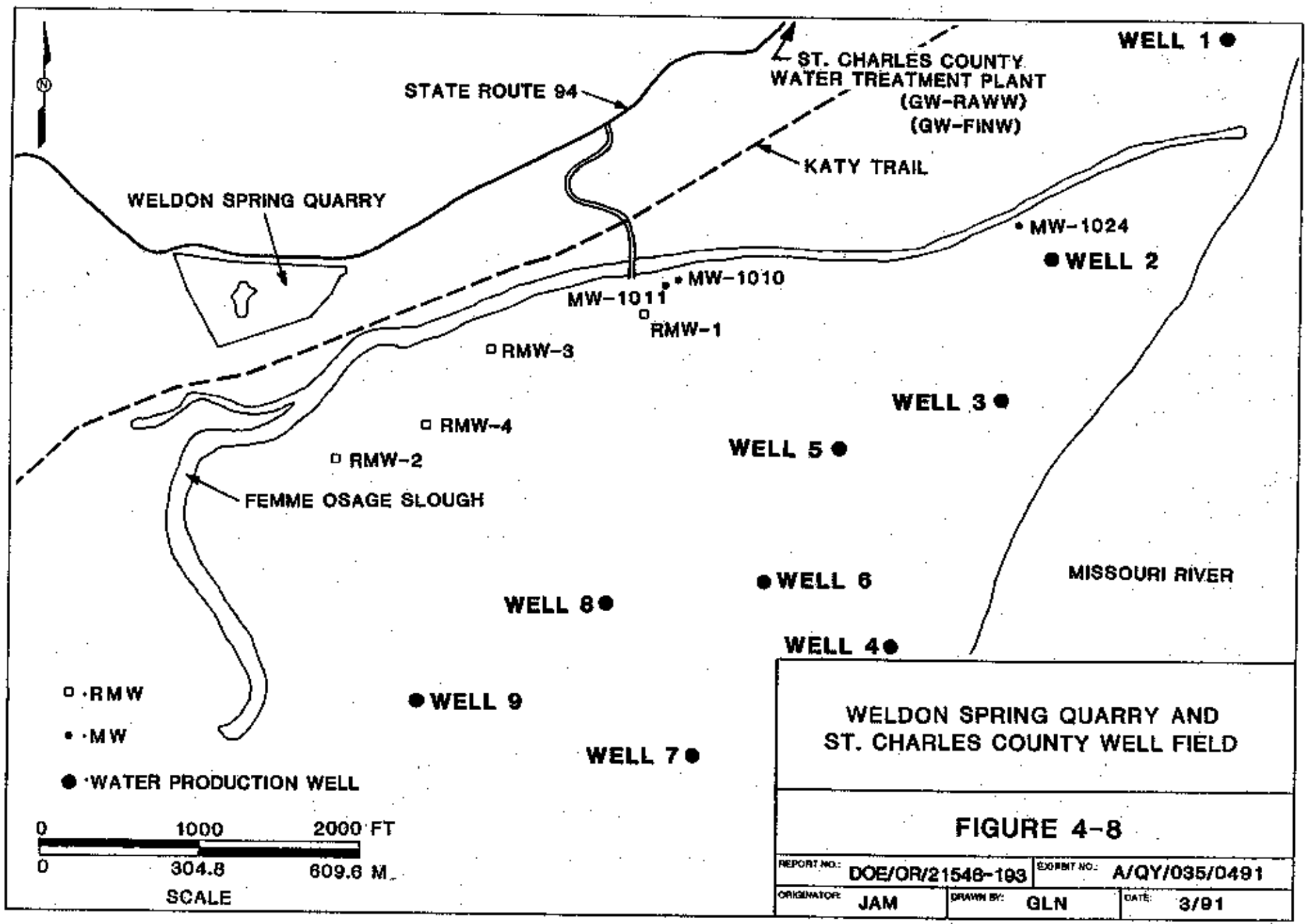


WELDON SPRING QUARRY AND FEMME OSAGE SLOUGH MONITORING WELL LOCATIONS

FIGURE 4-7

REPORT NO.: DOE/OR/21548-193	EXHIBIT NO.: A/QY/018/0391	
ORIGINATOR: TNA	DRAWN BY: GLN	DATE: 3/91



WELDON SPRING QUARRY AND
ST. CHARLES COUNTY WELL FIELD

FIGURE 4-8

REPORT NO.:	DOE/OR/21548-193	EXHIBIT NO.:	A/QY/035/0491		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	3/91

1988 and 1989, samples of groundwater were taken from a private water well which produces from the Missouri River alluvium and is located several miles upstream of the WSQ and St. Charles County wellfield. These samples were analyzed for a suite of parameters including total natural uranium. Four separate total natural uranium analyses were run on samples from this background well and the results ranged from 4.8 pCi/l to 9.0 pCi/l (0.18 Bq/l to 0.33 Bq/l) with an average value of 6.8 pCi/l (0.25 Bq/l). Although not a comprehensive study, results of the monitoring suggest that the lower range for background in the Missouri River alluvium is approximately 4.2 pCi/l (0.19 Bq/l).

All groundwater sampling locations at the WSQ were sampled for total natural uranium during 1990. Table 4-7 presents the results of analyses performed on these samples. The average 1990 uranium results continue to show elevated levels in the bedrock adjacent to the quarry and the alluvium on the north side of the Femme Osage Slough. Figure 4-9 highlights the wells with concentrations above the lowest proposed drinking water standard of 10 pCi/l. One of the four samples collected from MW-1022 indicated a detectable level of uranium of 10.2 pCi/l. This measured value is attributed in part to be the result of the laboratory error discussed in Section 6.3.2 of this report. Two wells, RMW-2 and MW-1011, south of the slough exhibited annual uranium averages above background. However, the average concentrations from these wells, were still below the most restrictive proposed drinking water standard of 10 pCi/l.

Fifteen locations from the St. Charles county wellfield were sampled for gross alpha in 1990. Table 4-8 presents the results of analyses performed on these samples. These results are within a range that corresponds to the uranium values discussed earlier. These locations were also sampled once in 1990 for Th-230/Th-232, Ra-226/Ra-228 and gross beta. The results of these sample analyses are shown in Appendix A. The gross beta results are within the expected range to correspond with uranium and gross alpha values. No elevated values of thorium or radium were detected.

4.1.4 Radon Gas Monitoring

Radon is a naturally occurring radioactive gas in the uranium and thorium decay series. Rn-222 is formed by the natural radioactive decay of Ra-226 which is a decay product of U-238 found in soil and rock. Rn-220 (also referred to historically as thoron) is formed by the natural radioactive decay of Ra-224 which is a decay product of Th-232.

TABLE 4-7 Summary of Averages for Inorganic Anions and Total Uranium in Groundwater Around the WSQ

WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCi/l (0.68)*	@
MW-1002	0.62	(2/2)	52.75	(2/2)	8.57	(2/2)	0.44	(2/2)	2.38	(2/2)
MW-1004	0.36	(2/2)	260.5	(2/2)	23.4	(2/2)	1.21	(2/2)	5167	(2/2)
MW-1005	ND	(0/2)	227.0	(2/2)	19.5	(2/2)	1.06	(2/2)	2481	(2/2)
MW-1006	0.76	(2/2)	529.0	(2/2)	32.55	(2/2)	0.32	(2/2)	3226	(2/2)
MW-1007	ND	(0/2)	31.75	(2/2)	72.15	(2/2)	0.44	(1/2)	100.3	(2/2)
MW-1008	0.12	(1/2)	308.5	(2/2)	24.4	(2/2)	0.38	(2/2)	5134	(2/2)
MW-1009	ND	(0/2)	308.0	(2/2)	25.5	(2/2)	0.27	(2/2)	5.44	(2/2)
MW-1010	ND	(0/2)	6.88	(1/2)	7.45	(2/2)	0.21	(1/2)	2.13	(2/2)
MW-1011	ND	(0/2)	18.83	(2/2)	11.55	(2/2)	0.28	(1/2)	9.57	(2/2)
MW-1012	1.44	(2/2)	54.35	(2/2)	7.03	(2/2)	0.46	(2/2)	2.04	(2/2)
MW-1013	ND	(0/2)	119.5	(2/2)	21.35	(2/2)	0.5	(2/2)	918	(2/2)
MW-1014	ND	(0/2)	113.25	(2/2)	24.2	(2/2)	0.46	(2/2)	816	(2/2)
MW-1015	1.14	(2/2)	333.0	(2/2)	27.2	(2/2)	0.35	(2/2)	574.6	(2/2)
MW-1016	0.68	(2/2)	212.5	(2/2)	16.65	(2/2)	0.31	(2/2)	173.2	(2/2)
MW-1017	ND	(0/4)	17.47	(4/4)	22.05	(4/4)	0.17	(2/4)	1.36	(2/4)
MW-1018	ND	(0/4)	59.55	(4/4)	19.2	(4/4)	0.23	(3/4)	6.12	(1/4)

TABLE 4-7 Summary of Data Averages for Inorganic Anions and Total Uranium in 1990 (Continued)

WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCi/l (0.68)*	@
MW-1019	ND	(0/4)	5.70	(2/4)	6.2	(4/4)	0.22	(3/4)	4.76	(2/3)
MW-1020	ND	(0/4)	23.5	(3/4)	10.91	(4/4)	0.3	(3/4)	3.27	(3/4)
MW-1021	ND	(0/4)	1.35	(2/4)	8.86	(4/4)	0.18	(3/4)	6.6	(1/4)
MW-1022	ND	(0/4)	3.93	(2/4)	8.56	(4/4)	0.21	(3/4)	10.2	(1/4)
MW-1023	ND	(0/3)	3.69	(2/3)	4.41	(4/4)	0.22	(2/3)	1.36	(1/4)
MW-1024	ND	(0/4)	5.46	(4/4)	10.3	(4/4)	0.28	(3/4)	1.36	(1/3)
MW-1025	ND	(0/2)	132.5	(2/2)	5.49	(2/2)	0.17	(1/2)	3.06	(2/2)
MW-1026	ND	(0/2)	1.81	(1/2)	2.98	(2/2)	0.19	(1/2)	ND	(0/2)
MW-1027	ND	(0/2)	135.0	(2/2)	14.4	(2/2)	0.26	(2/2)	616.9	(2/2)
MW-1028	0.06	(1/2)	58.6	(2/2)	10.24	(2/2)	0.28	(1/2)	6.46	(2/2)
MW-RMW1	ND	(0/4)	21.48	(4/4)	7.1	(4/4)	0.19	(2/4)	3.77	(3/4)
MW-RMW2	0.20	(1/4)	25.53	(4/4)	4.35	(4/4)	0.29	(3/4)	7.36	(4/4)
MW-RMW3	0.20	(1/4)	31.56	(4/4)	12.93	(4/4)	0.19	(2/4)	9.53	(2/4)
MW-RMW4	ND	(0/4)	16.45	(4/4)	7.58	(4/4)	0.24	(2/4)	3.46	(4/4)
MW-RAWW	ND	(0/1)	NSF		NSF		NSF		2.04	(2/4)
MW-FINW	ND	(0/1)	NSF		NSF		NSF		1.36	(1/4)

TABLE 4-7 Summary of Data Averages for Inorganic Anions and Total Uranium in 1990 (Continued)

WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCi/l (0.68)*	@
MW-PW02	ND	(0/2)	NSF		NSF		NSF		1.85	(2/4)
MW-PW03	ND	(0/1)	NSF		NSF		NSF		2.12	(2/3)
MW-PW04	ND	(0/2)	NSF		NSF		NSF		2.49	(3/4)
MW-PW05	ND	(0/1)	NSF		NSF		NSF		4.08	(1/3)
MW-PW06	ND	(0/2)	NSF		NSF		NSF		2.72	(2/4)
MW-PW07	ND	(0/2)	NSF		NSF		NSF		6.12	(2/4)
MW-PW08	ND	(0/2)	NSF		NSF		NSF		1.36	(1/4)
MW-PW09	ND	(0/2)	NSF		NSF		NSF		3.06	(2/4)

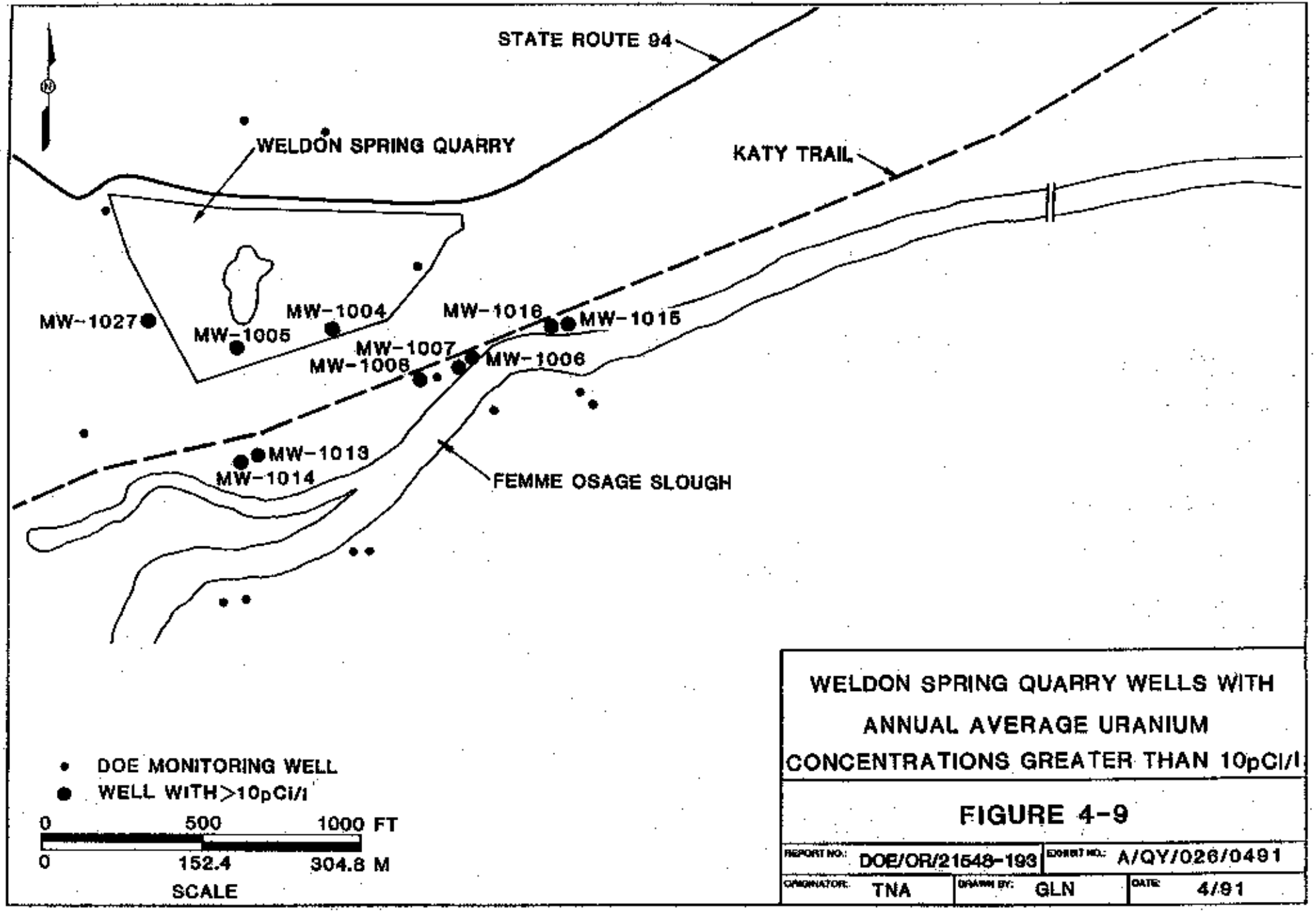
Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

ND - Not Detected

* - Detection limit

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.

NSF - Not Scheduled For Sampling



WELDON SPRING QUARRY WELLS WITH ANNUAL AVERAGE URANIUM CONCENTRATIONS GREATER THAN 10pCi/l

FIGURE 4-9

REPORT NO: DOE/OR/21548-193	EXHIBIT NO: A/QY/026/0491	
ORIGINATOR: TNA	DRAWN BY: GLN	DATE: 4/91

Table 4-8. Gross Alpha Data From St. Charles County Wellfield, 1990

WSSRAP LOCATION	Q190 pCi/l	Q290 pCi/l	Q390 pCi/l	Q490 pCi/l
MW-PWO2	2 +/- 5	2 +/- 3	< 4.9	0 +/- 3
MW-PWO3	NOL	3 +/- 3	< 4.5	2 +/- 3
MW-PWO4	4 +/- 6	0 +/- 3	< 4.8	1 +/- 3
MW-PWO5	6 +/- 6	2 +/- 3	NOL	0 +/- 3
MW-PWO6	2 +/- 6	3 +/- 4	< 5.5	1 +/- 4
MW-PWO7	1 +/- 7	-1 +/- 5	< 6.1	0 +/- 4
MW-PWO8	1 +/- 7	0 +/- 4	< 6.1	0 +/- 4
MW-PWO9	3 +/- 7	1 +/- 3	< 5.6	3 +/- 4
MW-RMW1	1 +/- 10	3 +/- 6	< 12.0	2 +/- 5
MW-RMW2	4 +/- 7	0 +/- 6	13.1 +/- 6	10 +/- 6
MW-RMW3	9 +/- 11	0 +/- 10	< 16.0	0 +/- 6
MW-RMW4	-3 +/- 8	2 +/- 4	< 14.0	4 +/- 6
MW-RAWW	4 +/- 4	2 +/- 3	< 8.4	2 +/- 3
MW-FINW	-1 +/- 2	0 +/- 2	< 3.7	1 +/- 2
MW-1024	6 +/- 6	-2 +/- 4	< 6.3	1 +/- 5

NOL - Not on Line on Sample Date
MW-RAWW - Untreated Water From St. Charles County Water Treatment Plant
MW-FINW - Treated Water From St. Charles County Water Treatment Plant

found in soil and rock. A fraction of the radon diffuses into the atmosphere and accounts for natural background radon concentrations. Radon is also produced at the WSS as the Ra-226 and Ra-224 contained in the waste materials undergo decay.

Radon concentrations fluctuate with both soil conditions and meteorological dispersion conditions. This is because the amount of radon that actually enters the atmosphere varies depending on the following parameters: radium concentrations, moisture content, soil porosity, soil density, emanating fraction, and atmospheric pressure.

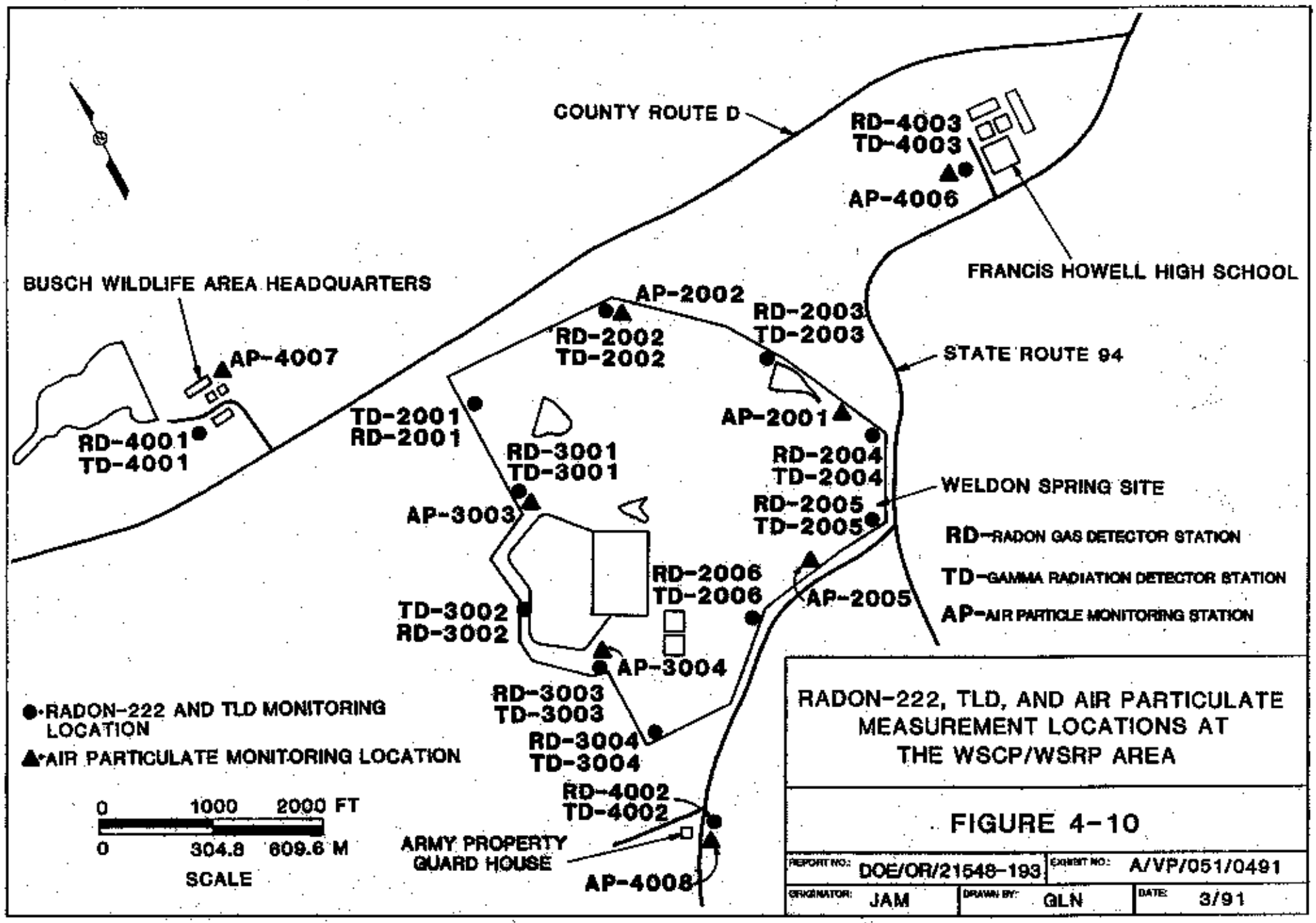
The emanating fraction is the portion of radon that escapes from soil particles into the pore spaces, which are the voids found in all soils regardless of density. Only the radon entering these pore spaces is available for release to the atmosphere.

Porosity is a measure of the amount of pore space or fraction of total volume occupied by the pore spaces. The higher the porosity the more pore spaces for the radon to move through.

Some fraction of the total pore space volume is typically filled with water, and soil moisture content provides a measure of this fraction. Radon diffuses easier through air-filled pore spaces than water-filled ones, so the higher the soil moisture content, the lower the radon emanation from the exposed surface. The moisture content of the soil is the most variable of these parameters and is primarily responsible for quarterly and annual changes in radon concentrations.

The radon gas monitoring program uses a pair of radon detectors at each of 22 permanent monitoring locations; six locations are at the WSCP, six locations are at the WSQ, four locations are at the WSRP, and there are six off-site locations. Radon monitoring locations are identified with an "RD" prefix and are shown in Figures 4-10, 4-11, and 4-11A. On-site monitoring locations are spaced around the perimeter fences to ensure adequate detection of radon dissipating from the properties under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005 and RD-4006 were used to monitor background radon concentrations near the Weldon Spring site (WSS).

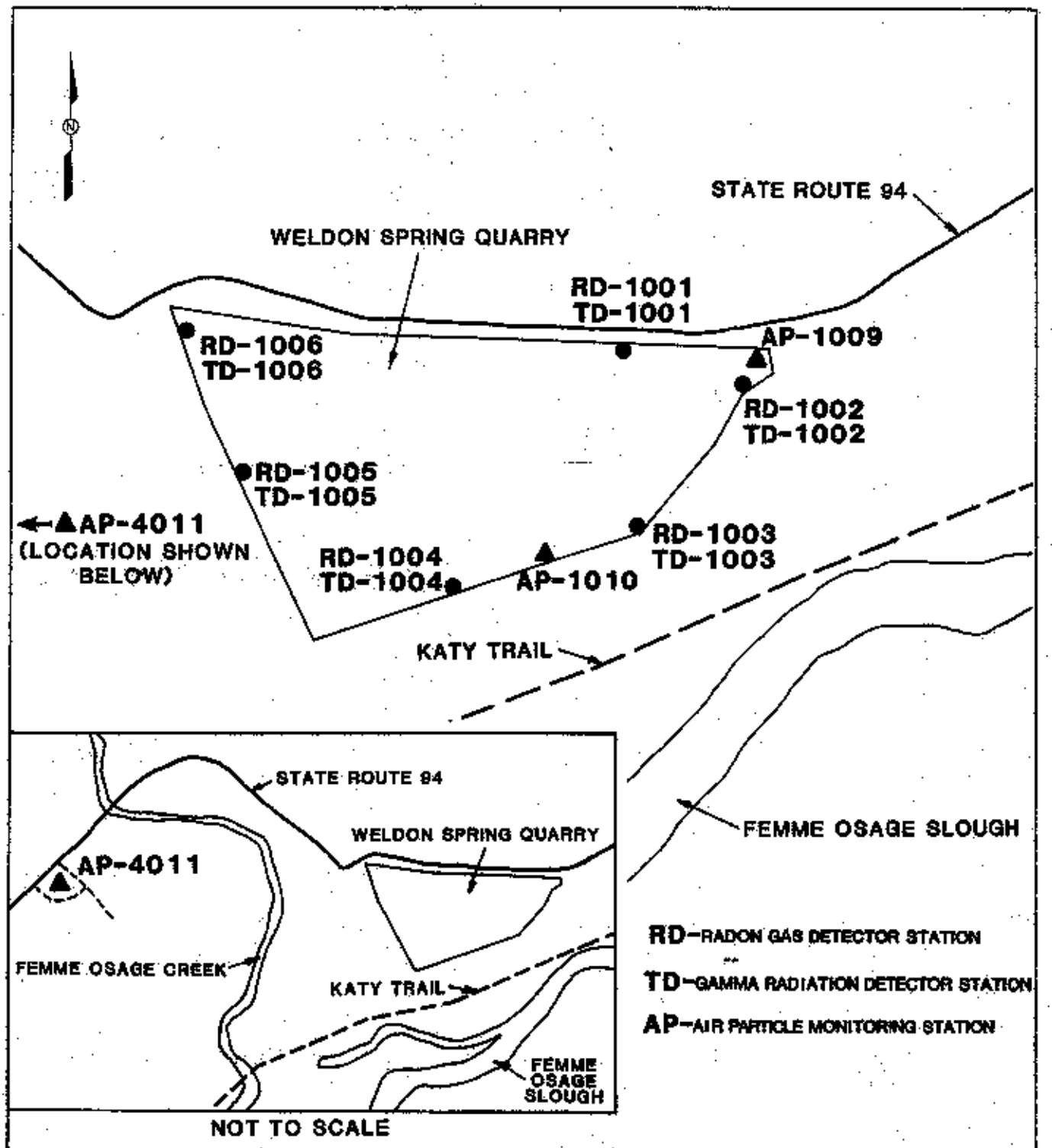
The radon detectors used in this program are Terradex Track Etch Type F. Type F detectors are sensitive to all isotopes of radon. These detectors are housed in protective



RADON-222, TLD, AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 4-10

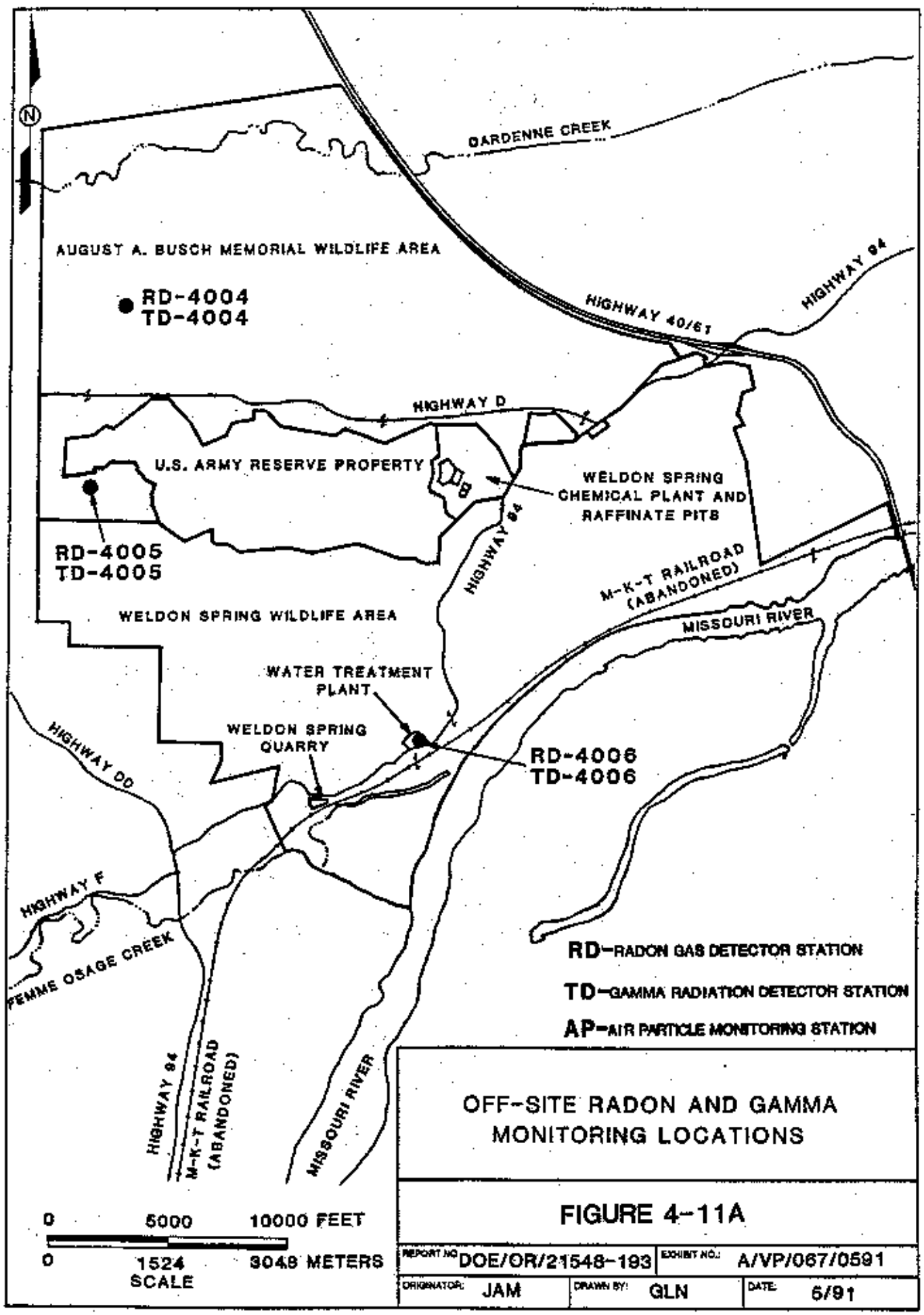
REPORT NO:	DOE/OR/21548-193	EXHIBIT NO:	A/VP/051/0491		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	3/91



RADON-222, THERMO LUMINESCENT DOSIMETER (TLD) AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 4-11

REPORT NO.: DOE/OR/21548-193	EXHIBIT NO.: A/QY/036/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91



OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

FIGURE 4-11A

REPORT NO. DOE/OR/21548-193	EXHIBIT NO.: A/VP/067/0591	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 5/91

plastic cups and are mounted in an inverted fashion on posts. The detectors are exchanged at the beginning of each calendar quarter and are sent to a subcontract laboratory for analysis. The detectors were deployed in pairs to evaluate and reduce the natural uncertainties associated with this type of measurement.

Table 4-9 summarizes the quarterly and annual average radon concentrations detected at all WSS perimeter and off-site monitoring locations. Also contained in Table 4-9 is a comparison of the measured annual average concentration to the Derived Concentration Guideline for unrestricted areas of 3 pCi/l (111 Bq/m^3) as authorized by DOE Order 5400.5.

For each monitoring station, annual averages in Table 4-9 were calculated by finding the arithmetic average of the four quarterly values. The annual standard deviation was calculated by taking the square root of the sum of the squared quarterly standard deviations.

Ambient background concentrations were determined by calculating the arithmetic average of concentrations for the four background monitoring locations. These four locations are: RD-4001, RD-4004, RD-4005, and RD-4006. These data yielded an annual average background radon concentration (Rn-222 plus Rn-220) in 1990 of 0.3 pCi/l (11.1 Bq/m^3).

The quarterly radon concentrations at each monitoring location were compared statistically at the 95% confidence level, to the quarterly concentrations of the four background locations. Only those monitoring locations that were statistically greater than background were compared to the Derived Concentration Guideline.

4.1.4.1 Chemical Plant/Raffinate Pits. Radon concentrations at the WSS perimeter and at the raffinate pit locations were lower in 1990 than in 1989. Abnormally high values were recorded in 1988 because of a regional drought. The 1988 drought reduced the moisture content of soils and radium-containing wastes, thus allowing a greater fraction of radon in the soil and waste voids to diffuse into the atmosphere. Lower radon concentrations were measured in 1989 and continued to decrease in 1990. The concentrations measured in 1990 are typical of values expected during years with normal precipitation levels.

TABLE 4-9 1990 Track Etch Radon Results for the WSCP/RP and WSQ Areas(a)

LOCATION I.D.	1st QUARTER pCi/l	2nd QUARTER pCi/l	3rd QUARTER pCi/l	4th QUARTER pCi/l	ANNUAL AVERAGE (b) pCi/l	STD. DEV.	PERCENT OF DCG (b)(c)
WSQ							
RD-1001	1.1	1.4	2.4	1.1	1.5	0.3	40
RD-1002	1.4	2.1	3.1	1.7	2.1	0.4	60
RD-1003	1.0	0.5	1.0	1.0	0.9	0.3	20
RD-1004	0.3	0.4	0.8	0.4	0.5	0.2	
RD-1005	0.6	0.5	0.6	0.6	0.7	0.2	18
RD-1006	0.5	0.3	0.5	0.2	0.4	0.2	
WSCP							
RD-2001	0.4	0.3	0.5	0.2	0.4	0.2	
RD-2002	0.4	0.1	0.4	0.2	0.3	0.1	
RD-2003	0.4	0.1	0.7	0.3	0.4	0.2	
RD-2004	0.3	0.1	0.4	0.2	0.3	0.1	
RD-2005	0.5	0.1	0.4	0.2	0.3	0.1	
RD-2006	0.4	0.2	0.4	0.2	0.3	0.1	
WSRP							
RD-3001	0.3	0.1	0.5	0.1	0.3	0.1	
RD-3002	0.3	0.1	0.4	0.1	0.2	0.1	
RD-3003	0.5	0.1	0.5	0.1	0.3	0.1	
RD-3004	0.3	0.1	0.5	0.1	0.3	0.1	

TABLE 4-9 1990 Track Etch Radon Results for the WSCP/RP and WSQ Areas(a) (Continued)

LOCATION I.D.	1st QUARTER pCi/l	2nd QUARTER pCi/l	3rd QUARTER pCi/l	4th QUARTER pCi/l	ANNUAL AVERAGE (b) pCi/l	STD. DEV.	PERCENT OF DCG (b)(c)
OFF SITE							
RD-4001*	0.3	0.1	0.7	0.1	0.3	0.1	
RD-4002	0.3	0.1	0.3	0.2	0.2	0.1	
RD-4003	0.3	0.1	0.3	0.2	0.2	0.1	
RD-4004*	0.3	0.1	0.7	0.3	0.4	0.2	
RD-4005*	0.5	0.1	0.3	-	0.3	0.1	
RD-4006*	0.3	0.1	0.5	0.1	0.3	0.1	

(a) Results include natural background.
(b) Percent of Derived Concentration Guideline (DCG) calculated by taking the annual average minus the average of the background stations divided by the DOE DCG for Rn-222 -3 pCi/l (100 Bq/M^3) (for annual average above background).
(c) Percent of guideline calculated only for stations that are statistically different from background.
* Denotes background station.
\- Denotes missing detector (vandalism).

4.1.4.2 Quarry. Only at the quarry were measured radon concentrations found to be statistically greater, at the 95% confidence level, than background radon concentrations. Radon concentrations found at the quarry are much greater than in concentrations measured at other WSS properties because the radium concentrations in quarry wastes are typically much greater than in other contaminated areas, and because the quarry is a large depression in the terrain with side walls ranging from 3 m to 15 m high (10 ft to 50 ft). In conjunction with stable meteorological conditions, this tends to trap emanating radon within the quarry and raises the concentrations along the quarry perimeter. However, none of the locations at the quarry showed annual average radon concentrations above the DOE DCG annual average radon concentration of 3 pCi/l (111 Bq/m^3). Third quarter results for station RD-1002 were above 3 pCi/l (111 Bq/m^3), but when averaged with the other three quarters the annual average concentration was less than 3 pCi/l. The concentrations at the quarry in 1990 were typical of years with normal precipitation.

4.1.4.3 Off-Site. Radon concentrations found at the off-site locations were lower in 1990 than in 1989. The concentration levels measured in 1990 were typical of years with normal precipitation.

4.1.5 Gamma Radiation Exposure Rate Monitoring Program and Results

Gamma rays are electromagnetic radiation emitted from the nucleus of atoms. The environment naturally contains radioactive substances which emit gamma radiation. Terrestrial radiation sources are natural radioactive elements in the environment found in soil and water. Cosmic radiation is high-energy radiation that originates in outer space and filters through the atmosphere reaching the earth's surface. Together, these two sources account for natural background gamma radiation. Terrestrial and cosmic radiation fluctuates depending on the soil composition and elevation above sea level.

Gamma radiation is emitted by many radionuclides in the U-238 and Th-232 decay series. These radionuclides are found in above-background concentrations at the WSS properties. Therefore, gamma radiation is monitored at the WSS.

Spherical environmental thermoluminescent dosimeters (TLDs) were deployed at 22 monitoring stations to monitor exposure from gamma radiation at the WSS. The monitoring station locations are the same as the ambient radon monitoring locations.

Ten monitoring stations are located at the WSCP/WSRP along the perimeter fence (Figure 4-10), six monitoring stations are located along the WSQ perimeter fence (Figure 4-11) and six monitoring stations are located off-site (Figures 4-10 and 4-11). Monitoring stations TD-4001, TD-4004, TD-4005, and TD-4006 measure natural background at locations unaffected by the site.

The TLDs are composed of five lithium fluoride chips in a durable spherical polyethylene holder. The TLDs are exchanged quarterly.

To determine background levels of gamma radiation as measured with the TLDs, the gamma exposures at the four background monitoring stations were averaged. This yielded an average of 62 mrem/year (0.62 mSv/yr) with two standard deviations of 16.3 mrem/yr (0.163 mSv/yr).

Table 4-10 summarizes the quarterly and annual total gamma radiation monitoring results at the 16 WSS perimeter monitoring stations, Francis Howell High School, the Weldon Spring Army Reserve Training Area (WSTA), and at the four background monitoring stations. The results reported in the table include two standard deviations. The United Nations (UNSCEAR 1982) estimates the external annual effective dose equivalent from all naturally occurring radiation in "normal" parts of the world to be 30 mrem/yr (0.3 mSv/yr) from cosmic sources and 35 mrem/yr (0.35 mSv/yr) from terrestrial radiation for a total of 65 mrem/yr (0.65 mSv/yr). This correlates well with the results from the WSS background monitoring stations.

TLDs were missing at various monitoring stations during all four quarters. In order to calculate an annual total gamma exposure rate, the missing data were replaced with the average of the remaining quarterly TLD results for those monitoring stations. Missing TLDs are indicated in Table 4-10 by a dash (-).

TABLE 4-10 Gamma Radiation Exposure Rate Monitoring Results for the WSCP/RP and WSQ Areas(a) (mrem/year)

LOCATION I.D.	FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER	ANNUAL TOTAL	2 ST DEV
QUARRY						
TD-1001	21	21	26	24	92	4
TD-1002	17	17	22	20	76	5
TD-1003	20	16	24	15	76	7
TD-1004	18	15	21	19	73	1
TD-1005[b]	18	17	–	21	75	4
TD-1006	15	14	21	19	69	5
CHEMICAL PLANT						
TD-2001	16	16	18	16	66	2
TD-2002	15	14	22	17	68	6
TD-2003	15	15	18	17	66	3
TD-2004	16	17	18	16	68	2
TD-2005	–	14	17	17	64	3
TD-2006	17	15	19	17	67	3
RAFFINATE PITS						
TD-3001[b]	–	16	20	19	73	4
TD-3002[b]	13	12	–	14	53	2
TD-3003	17	17	20	16	71	3
TD-3004[b]	12	13	18	–	57	5
OFF SITE						
TD-4001*	15	16	–	18	66	2
TD-4002	14	13	15	14	57	1
TD-4003	12	11	13	13	51	2
TD-4004*	14	16	20	18	69	4

TABLE 4-10 Gamma Radiation Exposure Rate Monitoring Results for the WSCP/RP and WSQ Areas(a) (mrem/year) (Continued)

LOCATION I.D.	FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER	ANNUAL TOTAL	2 ST DEV
TD-4005*(b)	12	–	–	–	48	0
TD-4006*	13	13	19	18	64	6

(a) Results include natural background.
(b) Year-to-date totals for locations where some quarterly data are unavailable were calculated using the average of the existing Quarterly data in place of the unavailable data.
* Denotes background station.
– Denotes a missing TLD.
To convert to mSv/yr, Divide by 100.

4.1.5.1 **Chemical Plant/Raffinate Pits.** At the WSCP/WSRP site perimeters, the annual exposures ranged from 53 mrem to 73 mrem (0.53 mSv to 0.73 mSv). There was no reason to suspect at the 95% confidence level, that any of the stations were greater than the background level.

4.1.5.2 **Quarry.** Two of the six monitoring stations at the quarry, TD-1001 and TD-1002 located on the north and east perimeter respectively, were statistically greater than background at the 95% confidence level. Station TD-1003 had the same annual total as TD-1002, but because it had a larger standard deviation it did not meet the statistically significant at 95% confidence level criteria. Permissible exposure level of 100 mrem (1.0 mSv) above background in unrestricted areas was not exceeded. Table 4-11 presents a comparison of the annual effective dose equivalent from external gamma radiation measured at TD-1001 and TD-1002, to the DOE 100 mrem/yr standard for all exposure modes as cited in DOE 5400.5. The percent of the DOE standard was calculated by subtracting the annual average background dose equivalent rate (62 mrem/year ± 16.3 mrem/year [0.62 ± 0.163 mSv/yr]) from the annual dose equivalent rate measured at stations TD-1001 and TD-1002 and then dividing by the 100 mrem/year (1.0 mSv/yr) DOE standard.

TABLE 4-11 Summary of TLD Monitoring Results of Stations That Exceeded Natural Background

STATION NUMBER	LOCATION	ANNUAL EXPOSURE (mrem/yr)	PERCENT OF DOE GUIDELINE[a]
TD-1001	WSQ North Perimeter	92	30
TD-1002	WSQ East Perimeter	76	8

(a) Percent of the DOE guideline is calculated by taking the annual exposure results minus the average background results divided by the DOE guideline of 100 mrem.

4.1.5.3 Off-Site. At the off-site locations the annual exposures ranged from 48 mrem to 69 mrem. Annual exposure at the Francis Howell High School was 51 mrem (0.51 mSv). At the U.S. Army Weldon Spring Training Area (WSTA) area the annual exposure was 57 mrem (0.57 mSv). At these two locations, the only off-site locations that are not background stations; there was no reason to suspect at the 95% confidence level, that the measured exposure levels were greater than background.

4.1.6 Radioactive Air Particulate Monitoring and Results

Radioactive air particulates are dust particles that carry radioactive contaminants. The main contributors to long-lived natural background radioactivity on dust particles are Po-210 and Pb-210 which are naturally occurring Rn-222 decay products. Surface soils also naturally contain radioactivity that becomes airborne and accounts, to a much lesser extent, for natural background concentrations of radioactive air particulates. Background concentrations of radioactive air particulates vary depending on soil moisture, wind, and geological conditions.

Many areas of the WSS properties contain elevated concentrations of radionuclides in the soil which could result in increased radioactive air particulate concentrations. Increased airborne radioactive particulate emissions from the WSS could result from work activities such as movement of equipment or vehicles in contaminated areas or from wind erosion.

Eleven air particulate samplers are used to monitor the WSS properties. Five of these (AP-2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the WSCP

perimeter as shown on Figure 4-10. Two monitoring stations (AP-4006 and AP-4008) are located off-site at sensitive receptor locations, which are Francis Howell High School and the WSTA. The monitoring station (AP-4007), at the August A. Busch Wildlife Area (ABWA), is used to monitor background levels in the vicinity of the WSCP. The off-site monitoring stations are also shown on Figure 4-11A. Two monitors (AP-1009 and AP-1010) located at the quarry, and one monitor (AP-4011) located approximately 0.7 km (0.4 mi) west of the quarry are used to monitor levels in the vicinity of the quarry. The quarry monitoring stations are shown on Figure 4-11.

The sampling station near the ABWA headquarters is used as a WSCP/WSRP and WSQ background air monitoring station. This station is approximately 0.8 km (0.5 mi) from the WSCP perimeter in a northwestern direction. The terrain between the WSCP and this sampling station is hilly and forested, providing a significant physical barrier to airborne particulates originating from the WSCP/WSRP. In addition, winds from the southeast are relatively rare in this region.

The five air particulate samplers used at the WSCP, the two nearby off-site samplers, the background samplers at ABWA headquarters, and the three air particulate samplers used in and near the quarry are constant flow dual diaphragm units operating at a continuous total flow of 2.4 cu m/hr (85 ft^3/hour). These monitors use open-face sampling heads and do not segregate the air flow according to particle size. This results in the collection of respirable and non-respirable particles. Since respirable particles pose the most significant detrimental human health impacts, the analysis of both respirable and non-respirable radioactive air particulates will overestimate the respirable radioactive air particulate concentrations as well as the associated potential health hazard. Radioactive air particulate samples are collected on 47-mm (1.88 in.) diameter membrane filters with an effective pore size of 0.45 μm and filters are exchanged weekly.

The majority of the radionuclides present at the WSS and in the quarry waste are from the natural U-238 and Th-232 decay chains. Many of these radionuclides emit alpha particles during decay which pose the greatest hazard when deposited internally in the respiratory tract and lung. Therefore air particulate samples were analyzed for long-lived gross alpha activity. The long-lived gross alpha method of analysis sums the alpha activity from all of the long-lived alpha-emitting radionuclides.

The long-lived gross alpha measurements were made with a standard zinc-sulfide alpha scintillation detector. The alpha counts per filter were converted to radioactivity per volume of air for that filter and reported in μCi/ml (Bq/m^3).

The annual average long-lived concentrations and the calculated standard deviations for the 11 air monitoring locations are summarized in Table 4-12. The annual average long-lived alpha concentration for each monitoring location was calculated by averaging the weekly air particulate analysis results, or the counting instrument's lower limit of detection (LLD), whichever was greater.

All of the monitoring stations exhibited some long-lived alpha weekly concentrations less than the LLD. The "<" sign in Table 4-12 indicates that the actual average is less than the calculated average. The cause for this was the use of LLD values in calculation of the annual average concentration. When a value was reported as less than the LLD, the LLD value was used in the calculation. The standard deviation for each of the monitoring locations was calculated using only analysis results that were above the LLD, because the weekly LLD values were nearly the same, and to have used them would have resulted in a low bias in the annual standard deviation.

The typical LLD at the WSCP/WSRP monitoring locations was approximately 7.5×10^{-16} μCi/ml (.03 mBq/m^3). The WSQ monitoring locations typically achieved an LLD of approximately 7.7×10^{-16} μCi/ml (.03 mBq/m^3). These LLDs are low enough to allow detection of Th-232, the radionuclide with the lowest derived concentration guideline (DCG) found at the WSS. The DCG for Th-232 is 7×10^{-15} μCi/ml (.26 mBq/m^3). The DOE provides DCGs for airborne contaminants which, if inhaled by a member of the public continuously for one year, would result in a committed effective dose equivalent of 100 mrem (1 mSv).

4.1.6.1 Chemical Plant/Raffinate Pits. There was no reason to suspect at the 95% confidence level, that the annual average long-lived gross alpha concentrations measured at WSCP/WSRP monitoring stations were greater than background station (AP-4007). This means that there were no statistically significant above background radioactive air particulates concentrations measured at the WSCP/WSRP perimeter during 1990.

TABLE 4-12: 1990 Radioactive Air Particulate Results for the WSCP/RP and WSQ Areas

MONITOR IDENTIFICATION NUMBER	ANNUAL AVG. LONG-LIVED GROSS ALPHA CONCENTRATION ($X\ 10^{-15}$ µCi/ml)[b]	STANDARD DEVIATION	NUMBER OF VALUES ABOVE LLD[c]
AP-2001	<2.1	2.0	42
AP-2002	<2.5	8.6	45
AP-3003	<2.2	1.0	41
AP-3004	<2.9	1.2	48
AP-2005	<2.4	1.4	48
AP-4006	<2.2	1.0	39
AP-4007 (a)	<2.2	7.5	49
AP-4008	<2.4	1.5	47
AP-1009	<2.4	7.4	46
AP-1010	<2.7	8.0	43
AP-4011	<2.1	1.3	46

(a) Indicates background monitoring station.
(b) The lower limits of detection (LLD) range from 5.10E-16 µCi/ml to 1.09E-15 µCi/ml.
(c) LLD = Lower limit of detection.
< Indicates that LLD values were used to calculate the averages when reported values were less than the LLD.
To Convert µCi/ml To Bq/M^3 multiply by 3.7E10

4.1.6.2 Quarry. There are two airborne radioactive particulate monitoring stations along the WSQ perimeter. The long lived gross alpha activity measured at station AP-1009, located on the northeastern perimeter, was not statistically different at the 95% confidence level than the long lived gross alpha activity measured at the background station. The long lived gross alpha activity measured at Station AP-1010, located on the southern perimeter, was statistically different at the 95% confidence level than the long lived alpha activity measured at the background station. This is the first time that an annual average gross alpha concentration measured at any of the WSS air particulate monitoring stations has ever been statistically different at the 95% confidence level than the measured background concentration. During 1990, remediation activities at the quarry were in progress. Although engineering controls were in place to control dust, these activities could have resulted in the statistically significant above-background gross alpha activity measured at Station AP-1010. Although this was a statistically significant event, it would result in an effective dose

equivalent of less than 1 mrem to a hypothetical maximally exposed individual as is discussed in Section 4.1.8.2.

4.1.6.3 Off-Site. The annual average long-lived gross alpha concentrations at all off-site monitoring stations were not significantly different at the 95% confidence level than the long-lived background alpha activity measured at the background station during 1990. This is significant because it indicates that there are no releases from the WSQ or chemical plant that can be distinguished from background levels at these locations.

4.1.6.4 NESHAPs Annual Report. In 1990, the WSS initiated an environmental airborne particulate monitoring and quality assurance program sensitive enough to detect airborne radionuclide concentrations (other than radon) at the levels specified in the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR 61 Subpart H). Subpart H of 40 CFR 61 requires that radionuclide emissions other than radon be determined and effective dose equivalents to members of the public be calculated using EPA approved procedures and computer models, or other procedures for which EPA has granted prior approval. The WSS has chosen to meet the NESHAPs emission monitoring and dose assessment requirements by measuring airborne radionuclide concentrations at designated critical receptor locations rather than through the use of computer modeling using the CAP-88, AIRDOS-PC, or EPA COMPLY computer models for determining dose. The WSS monitoring plan is contained in the report *Plan For Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (MKF and JEG 1990a) which has been approved by the EPA Region VII.

Airborne emissions at the WSS result from wind dispersal of surface soils, dust and dirt within the deteriorating buildings, and fugitive dust generated during remedial actions. Accurate monitoring of these emission sources is not practical because of uncertainties associated with the emissions inventory, dust particle entrainment, and micro-meteorology associated with these emission sources. The most accurate method of dose estimation at receptor locations near the WSS is via measurement of airborne concentrations at these locations, which are designated as critical receptor locations. Critical receptors are locations where members of the public abide or reside, and where the highest potential off-site concentrations of radionuclide other than radon are likely to occur during remediation of the WSS.

Tables 4-13 through 4-17 present the estimated effective dose equivalents (EDE) at each of the five designated critical receptor locations. The estimated EDEs at all critical receptor locations are less than 1 mrem (0.01 mSv). In order to determine EDEs, both the net airborne radionuclide concentrations (i.e., the airborne concentration at the critical receptor location less the background concentration) and the amount of time members of the public reside or abide at the critical receptor location must be known.

As outlined in the *Plan For Monitoring Radionuclides Other Than Radon at Weldon Spring Site Critical Receptor Locations* (MKF and JEG 1990a), air at critical receptor locations is sampled continuously and the air sample filters are collected weekly. All filters collected weekly in 1990 were composited separately for each critical receptor location, and the composited samples were sent to a subcontract laboratory for radiochemical analysis. The subcontract laboratory separated each composite sample into three aliquots to allow for a determination of analytical precision. Each aliquot was analyzed for isotopic uranium, isotopic thorium, Ra-226, and Ra-228. The gross radionuclide concentrations reported in Tables 4-13 through 4-17 are the averages of the results for the three aliquots. The net radionuclide concentrations equal the gross results minus the results reported for the WSS background monitoring station at the ABWA, which is designated as station AP–4007. The estimated EDE is then calculated by multiplying the net radionuclide concentrations in μCi/ml by an assumed breathing rate of 1.25 m^3/hr (44.14 ft^3/hr), the dose conversion factor in mrem/μCi as reported in *EPA Federal Guidance Report No. 11* (Eckerman et al. 1988) and the assumed exposure time at the specific critical receptor location. If the net concentration (gross minus background) was zero, or less than zero, then the net airborne concentration and the effective dose equivalent in Tables 4-13 through 4-17 was recorded as zero.

An EDE was calculated for each designated critical receptor monitoring location as is required by the EPA-approved NESHAPs compliance monitoring program for the WSS (MKF and JEG 1990a). Effective dose equivalents were calculated using net measured airborne radionuclide concentrations, the exposure time stated in the NESHAPs compliance monitoring program, a breathing rate of 1.25 m^3/hr, and the radionuclide-specific dose conversions factors provided in EPA Federal Guidance Report No. 11 (Eckerman, et al. 1988). The EDEs calculated for all critical receptor locations are all less than 0.3 mrem as is shown in Tables 4-13 through 4-17. It is likely, however, that the airborne radionuclide concentrations measured at all critical receptor locations are all measurements

TABLE 4-13: Effective Dose Equivalent at Critical Receptor Location AP-2001

RADIONUCLIDE	GROSS ANALYSIS RESULTS (a) (pCi)	NET RESULTS(b) (GROSS -BKG.) (pCi)	NET AIRBORNE CONCENTRATION ($\mu Ci/m^3$)	DCF (c) (mrem/μCi)	EDE[d] (mrem)
U-238	0.8	0.0	0	1.2E+05	0
U-234	0.7	-0.1	0	1.3E+05	0
U-235	<0.1	<0.0	0	0.2E+05	0
Ra-226	<0.7	<0.0	0	8.6E+03	0
Ra-228	5.3	-0.5	0	4.8E+03	0
Th-228	2.6	1.2	1.9E-10	3.4E+05	1.7E-01
Th-230	<1.5	<0.8	1.3E-10	3.3E+05	1.1E-01
Th-232	<0.4	<0.0	0	1.8E+06	0
				TOTAL EDE[d] =	1.1E-01

(a) Reported results are the average of three separate analysis on three sample aliquots.

(b) Net results obtained by subtracting results from the background station AP-4007.

(c) Dose conversion factors (DCF) were taken from the EPA Federal Guidance Report No. 11 (Eckerman et al. 1988).

(d) Effective Dose Equivalents (EDE). Exposure time assumed for this critical receptor location was 2,000 hours.

< Indicates that lower limit detection (LLD) values were used to calculate the average when reported values were less than the LLD.

TABLE 4-14 Effective Dose Equivalent at Critical Receptor Location AP-2005

RADIONUCLIDE	GROSS ANALYSIS RESULTS (a) (pCi)	NET RESULTS (b) (GROSS -BKG.) (pCi)	NET AIRBORNE CONCENTRATION ($\mu Ci/m^3$)	DCF (c) (mrem/μCi)	EDE (d) (mrem)
U-238	0.7	-0.1	0	1.2E+05	0
U-234	1.0	0.2	3.2E-11	1.3E+05	1.3E-02
U-235	<0.1	<0.0	0	1.2E+05	0
Ra-226	<0.5	<-0.2	0	8.6E+03	0
Ra-228	<9.3	<3.5	5.6E-10	4.8E+03	8.3E-03
Th-228	3.4	2.0	3.2E-10	3.4E+05	3.4E-01
Th-230	<0.8	<0.1	0	3.3E+06	0
Th-232	<0.6	<0.2	3.2E-11	1.6E+06	1.6E-01
				TOTAL EDE =	0.16

(a) Reported results are the average of three separate analysis performed on three sample aliquots.

(b) Net results obtained by subtracting results from the background station AP-4007.

(c) Dose conversion factors (DCF) were taken from the EPA Federal Guidance Report No. 11 (Eckerman et al. 1988)

(d) Effective Dose Equivalent (EDE). Exposure time assumed for the critical receptor location was 2,500 hours.

TABLE 4-15 Effective Dose Equivalent at Critical Receptor Location AP-4006

RADIONUCLIDE	GROSS ANALYSIS RESULTS(a) (pCi)	NET RESULTS(b) (GROSS -BKG.) (pCi)	NET AIRBORNE CONCENTRATION ($\mu Ci/m^3$)	DCF (c) (mrem/μCi)	EDE (d) (mrem)
U-238	0.5	-0.3	0	1.2E+05	0
U-234	0.7	-0.1	0	1.3E+05	0
U-235	<0.1	<0.0	0	1.2E+05	0
Ra-226	<0.6	<-0.1	0	8.6E+03	0
Ra-226	6.6	0.6	1.3E-10	4.6E+03	1.8E-03
Th-228	1.1	-0.3	0	3.4E+05	0
Th-230	<0.3	<-0.4	0	0.0E+00	0
Th-232	<0.3	<-0.1	0	1.6E+05	0
				TOTAL EDE =	1.8E-03

(a) Reported results are the average of three separate analysis performed on three sample aliquots.

(b) Net results obtained by subtracting results from the background station AP-4007.

(c) Dose conversion factors (DCF) were taken from the EPA Federal Guidance Report No. 11 (Eckerman et al. 1988).

(d) Effective Dose Equivalent (EDE). Exposure time assumed for this critical receptor location was 2,250 hours.

TABLE 4-16 Effective Dose Equivalent at Critical Receptor Location AP-4008

RADIONUCLIDE	GROSS ANALYSIS RESULTS (a) (pCi)	NET RESULTS (b) (GROSS - BKG.) (pCi)	NET AIRBORNE CONCENTRATION ($\mu Ci/m^3$)	DCF (c) (mrem/μCi)	EDE (d) (mrem)
U-238	0.5	-0.3	0	1.2E+05	0
U-234	0.5	-0.3	0	1.3E+05	0
U-235	<0.1	<0.0	0	1.2E+05	0
Ra-226	<0.6	<-0.1	0	8.6E+03	0
Ra-228	<4.1	<-1.7	0	4.6E+03	0
Th-228	<1.3	-0.1	0	3.4E+03	0
Th-230	<0.3	<-0.4	0	8.3E+05	0
Th-232	<0.3	<-0.1	0	1.6E+06	0
				TOTAL EDE =	0

(a) Reported results are the average of three separate analysis performed on three sample aliquots.
(b) Net results obtained by subtracting results from the background station AP-4007.
(c) Dose conversion factors (DCF) were taken from the EPA Federal Guidance Report No. 11 (Eckerman et al. 1988).
(d) Effective Dose Equivalents (EDE). Exposure time assumed for the critical receptor location was 2,000 hours.

TABLE 4-17 Effective Dose Equivalent at Critical Receptor Location AP-4011

RADIONUCLIDE	GROSS ANALYSIS RESULTS (a) (pCi)	NET RESULTS (b) (GROSS-BKG.) (pCi)	NET AIRBORNE CONCENTRATION ($\mu Ci/m^3$)	DCF (c) (mrem/μCi)	EDE (d) (mrem)
U-238	0.6	-0.2	0	1.2E+05	0
U-234	0.6	-0.2	0	1.3E+05	0
U-235	<0.1	<0.0	0	1.2E+05	0
Ra-226	<0.5	<-0.2	0	6.8E+03	0
Ra-228	5.0	-0.8	0	4.6E+03	0
Th-230	<0.5	<-0.2	0	3.3E+05	0
Th-232	<0.5	<0.1	1.6E-11	1.6E+06	2.6E-01
				TOTAL EDE =	2.6E-01

(a) Reported results are the average of three separate analysis performed on three sample aliquots.
(b) Net results obtained by subtracting results from the background station AP-4007.
(c) Dose conversion factors (DCF) were taken from the EPA Federal Guidance Report No. 11 (Eckerman et al. 1988).
(d) Effective Dose Equivalent (EDE). Exposure time assumed for this critical receptor location was 8,736 hours.

of background concentrations. This is because, based on a T-test statistical comparison of airborne radionculide concentrations measured at the critical receptor locations versus concentrations measured at the background station, there is no reason to suspect, at the 95% confidence level, that there is a difference between the average of the concentration results measured at the background monitoring station and the average of the concentration results measured at any of the critical receptor locations other than at location AP-2005. The comparison of Th-228 analyses from stations AP-2005 and AP-4007 (background station) did not pass the statistical test at the 95% confidence level. The analysis results from station AP-2005 for Th-228 are probably an anomily because they are not supported by characterization data collected at the WSSRAP.

When Th-228 is detected uranium should also be detected. All site characterization data have indicated that whenever Ra-228 activity is present there are at least the same or greater U-238 activity concentrations. Th-228, a radioactive daughter product of Ra-228, has

a half-life of 1.9 years. At least 20 years have passed since the shutdown of the chemical plant, which is more than ample time for Th-228 to attain secular equilibrium with Ra-228. Therefore, whenever Ra-228 is present at the site, Th-228 should also be present at approximately the same activity level; and the U-238 activity should be equal to or greater than both Ra-228 and Th-228. However, analyses from station AP-2005 show that average gross Th-228 activity was almost five times higher than average gross U-238 activity. In addition, all uranium analyses from station AP-2005 passed the statistical test at the 95% confidence level. There is also no reason to suspect, at the 95% confidence level, that there is a difference between the long-lived gross alpha concentrations measured at the background monitoring station and the concentrations measured at any of the critical receptor locations.

There are five critical receptor locations surrounding the WSS. These locations are designated with the following identification numbers: AP-2001, AP-2005, AP-4006, AP-4008, and AP-4011. Critical receptor AP-2001 is the common boundary of the WSCP and the Missouri Highway Maintenance Facility. There are nine workers at the highway maintenance facility. The exposure time at this critical receptor location is 40 hr/wk for 50 wk/yr, or 2,000 hr/yr. Critical receptor AP-2005 is located near the WSSRAP administration building. There are approximately 150 workers at the administration building. The exposure time at this critical receptor location is 50 hr/wk, for 50 wk/yr, or 2,500 hr/yr. Critical receptor AP-4006 is located at the Francis Howell High School. There are approximately 1,800 students, faculty, and staff members at the high school. Faculty and staff generally spend more time at the school than do students. The exposure time for students, faculty and staff members at the high school is 45 hr/wk for 50 wk/yr at the school or 2,250 hr/yr. In addition, there is one employee who lives on the high school grounds; therefore, his exposure time is assumed to be continuous. This employee's exposure time is 24 hr/day, 365 day/yr or 8,760 hr/yr. Critical receptor AP-4008 is located on the WSTA. A remedial investigation is being conducted at the WSTA where Subcontract workers intermittently perform site characterization tasks. One employee of the Department of the Army works 40 hr/wk, 50 wk/yr which yields an exposure time of 2,000 hr/yr. Critical receptor AP-4011 is located approximately 0.7 km (0.4 mi) west of the quarry. There is a residence within 150 m (165 yd) of the critical receptor and directly in line with the quarry and critical receptor. The exposure time at the residence is continuous i.e., 8,760 hr/yr. Based on this exposure time and the radionuclide concentrations shown in Table 4-17, an effective dose equivalent of less than 1 mrem would be calculated for the residence.

In order to meet the detection limits specified in 40 CFR 61 Subpart H a strict quality control program must be maintained. The quality control program for the critical receptor includes spikes, blanks, duplicates, and control charts. In addition, analytical data quality objectives have been established for precision and accuracy. Precision is determined by averaging the results of the three duplicate analyses. The results of the precision samples are considered acceptable if the standard deviation of duplicate analysis is within ±50% of the average for 85% of the duplicate data sets. Analytical precision is also calculated for U-238/U-234 for each composite sample. Precision results are acceptable if the standard deviation of U-238 and U-234 results for each composite sample falls within ±50% of the average for 85% of all samples analyzed. Accuracy objectives are that 85% of the results for spiked samples are within ±50% of the known values.

Except for spiked samples, data quality objectives were met in all cases. Two samples were spiked with different concentrations of both U-238 and Th-230. Each spiked sample contained 13 filters; these were divided into thirds and each composite third was analyzed separately. All six composite thirds from the two U-238 spikes met the established criteria previously mentioned. However, four of the six Th-230 composite thirds did not meet established criteria for accuracy, so only 67% of all the spiked samples met accuracy criteria. Although accuracy for thorium spikes was not met, five of the six results were greater than the actual concentration and four of those were almost twice the actual concentration. This would indicate a probable high bias for Th-230 results. If Th-230 results are biased high, the effective dose equivalent calculation for Th-230 would also be high.

The Ra-228 analyses for the five critical receptor locations have gross radionuclide concentrations higher than those for the other isotopes of radium, thorium, and uranium. The higher Ra-228 results were consistent for all samples including blanks and spikes. The Ra-228 results are higher because the procedure for extracting Ra-228 also extracts other beta emitters into the analyte. This high bias for the method used is noted in the EPA document *Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA 1980).

The procedure for measurement of Ra-228 in drinking water is applicable to the analysis of air filters because the same radiochemistry procedure is applicable for both matrixes.

4.1.7 Unrestricted-Area Radiological Contamination Monitoring and Results

The WSS contains many areas of radiological contamination due to waste deposition and spillage during former uranium and thorium refining operations. Also, due to atmospheric releases of radioactivity during operations at the WSS, all structures and roads may have surficial contamination. The majority of the processing involved refining uranium, and thus uranium is the primary contaminant at the site.

Since 1986, the WSSRAP has employed an unrestricted-area monitoring program to ensure that radioactive materials are not migrating from the site (as a result of the remedial construction) to areas used by the general public.

This program includes radiological surveys of the WSSRAP administration building, laboratory, access control point for the site controlled area, WSSRAP trailers, subcontractor trailers, vehicles, site roadways, and a portion of the Katy Trail. Radiological surveys are usually performed monthly or at least quarterly. The surveys involve performing in situ measurements and collecting swipe samples.

In situ measurements are taken with a beta-gamma detector. Measurements are collected over a one-minute counting interval and then converted to disintegrations per minute per 100 cm^2 (dpm/100 cm^2) (dpm/15.5 $in.^2$). These measurements determine the total radioactivity; fixed plus removable.

Measurements of removable surficial contamination levels are made at each beta-gamma measurement location using a dry cloth or paper swipe. The swipes are wiped (smeared) over a surface area of approximately 100 cm^2 (15.5 $in.^2$). Swipes are analyzed for one minute using an alpha scintillation detector. The count rate results are corrected for detector efficiency to yield measurement results in dpm/100 cm^2 (dpm/15.5 $in.^2$).

For the purpose of this report, only the monitoring results for the WSSRAP roadways outside the controlled area and the Katy Trail are presented. These areas are discussed because they represent areas accessible to the public. All other monitoring results are on file at the WSSRAP. Performance of these surveys to date confirms that contaminated materials are not being carried into unrestricted areas.

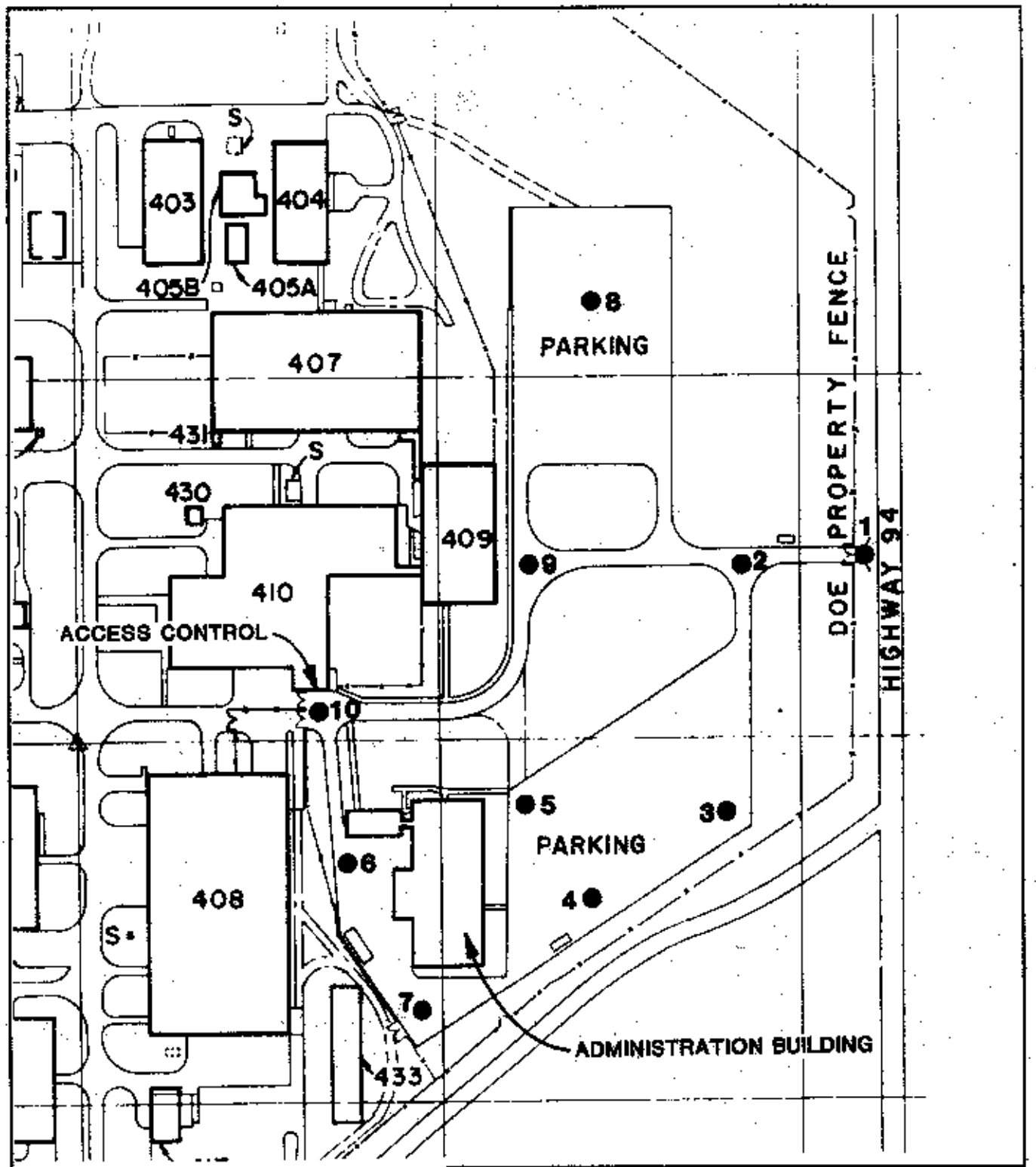
Figure 4-12 shows the monitoring locations for the roadways outside the controlled area. Table 4-18 lists the annual average beta-gamma and alpha monitoring results at each location. The "<" signs in the table indicate that some of the measurements at that location were less than the minimum detectable activity (MDA) of the instruments used. In such cases, the MDA of the instrument was used to calculate the annual average. Also included in the table are the associated standard deviations of the beta-gamma and alpha results. The standard deviation for each of the monitoring locations was calculated using only analysis results that were above the MDA, because the weekly MDS values were nearly the same, and to have used them would have resulted in a low basis in the standard deviation.

The results of the monitoring show that fixed contamination is present at a few locations, but only at levels well below the DOE uranium surface contamination guidelines for unrestricted use of 5,000 dpm/100 cm^2 (5,000 dpm/15.5 $in.^2$). The probable cause of the contamination is the deposition of atmospheric releases of uranium during the operation of the Weldon Spring Uranium Feed Materials Plant (WSUFMP). Since monitoring began, there has been no increase in the removable contamination levels on the uncontrolled area roadways at the WSS.

The Katy Trail is shown on Figure 4-13. An approximate 1,130-m (1,243 yd) stretch of the trail is monitored due to its proximity to the WSQ and Femme Osage Slough. Beta/gamma measurements are taken at 10 locations along the trail. The section that is monitored is shaded in Figure 4-13. The 10 locations are varied each time so as to check for any mobile contamination over the entire length of the monitored portion of the trail.

Table 4-19 lists the average beta-gamma and alpha monitoring results for each location. The "<" signs in the table indicate that some of the measurements at that location were less than the MDA of the instrument used. In such cases, the MDAs of the instruments were used to calculate the annual average. The table also includes associated standard deviations of the beta-gamma and alpha results.

The results from all monitoring locations along the Katy Trail indicate background radionuclide concentration levels. A soil sample was taken at location No. 1 because this location had the highest average beta-gamma monitoring results. The analysis of this soil sample showed concentrations within the typical background concentrations ranges of U-238, Ra-226, Ra-228, and K-40. There is no evidence of radioactive material migrating from the



ROAD SURVEY LOCATIONS

FIGURE 4-12

REPORT NO. DOE/OR/21548-193	EXHIBIT NO.: A/CP/121/0591	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 5/91

TABLE 4-18 1990 Site Roads Periodic Survey Results

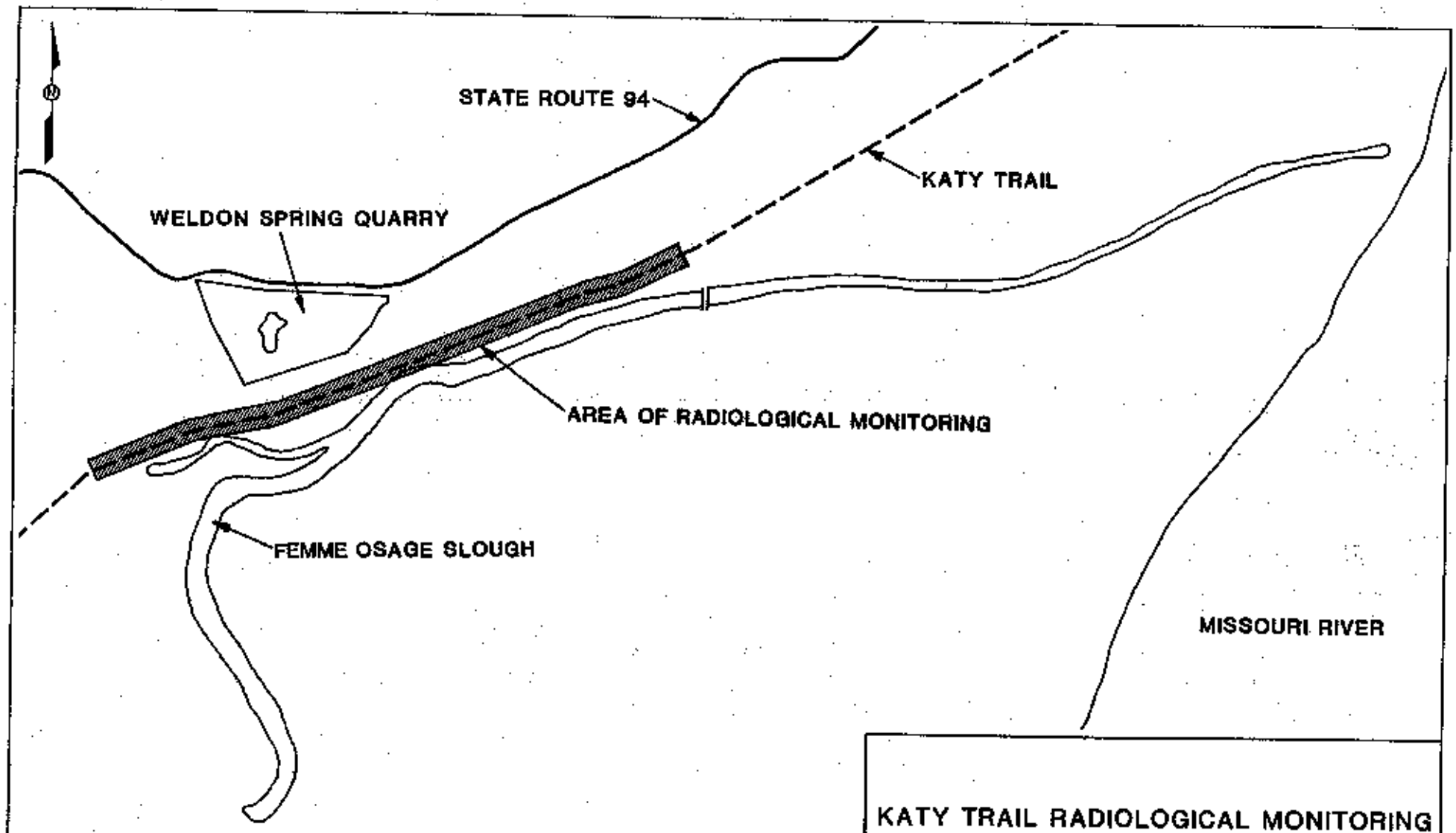
LOCATION I.D.	TOTAL BETA-GAMMA RESULTS ANNUAL AVERAGE[a] [b] (dpm/100 cm^2) [b]	STANDARD DEVIATION	REMOVABLE ALPHA RESULTS ANNUAL AVERAGE[a] [c] (dpm/100 cm^2)	STANDARD DEVIATION
1	752	356	<6	3.5
2	<621	161	<6	1.5
3	<650	390	<6	1.4
4	1333	474	<6	1.4
5	881	201	<6	3.2
6	<944	594	<6	4.2
7	2338	505	<6	1.4
8	2039	791	<6	2.1
9	1460	278	<6	2.5
10	610	201	<6	2.5

(a) Minimum detectable activities (MDA) ranged from 381 to 315 dpm/100 cm^2.
(b) Results given in disintegrations per minute per 100 square centimeter area.
(c) MDA ranged from 4 to 7 dpm/100 cm^2.
< Indicates that some of the values used to calculate the annual average were the instruments minimum detectable activities, and that the actual averages would be lower than what is shown.

WSQ or the Femme Osage Slough area on to the Katy Trail, and thus, there is no identifiable probability of radiological contamination to users of the Katy Trail.

4.1.8 Radiological Exposure Assessments

In assessing the health effects of the radioactive materials present at the WSCP/WSRP, WSQ, and WSVP as required by DOE Order 5484.1; radiological exposure was evaluated for a maximally exposed individual at the WSCP/WSRP, the WSQ, the WSVP, and for the general population within 80 km (50 mi) of the WSS. The scenarios and models used to evaluate radiological exposures are conservative and simplistic, but are realistic in the attempt to estimate exposures attributable to the WSSRAP. This is appropriate since the above-background airborne radioactive particulate concentrations, radon concentrations, and external gamma radiation measured during 1990 result in an estimated effective dose



KATY TRAIL RADIOLOGICAL MONITORING

FIGURE 4-13

REPORT NO.:	DOE/OR/21548-193	EXHIBIT NO.:	A/VP/052/0491		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	3/91

TABLE 4-19 1990 Katy Trail Periodic Radiological Survey Results

LOCATION I.D.	BETA-GAMMA RESULTS		ALPHA RESULTS	
	ANNUAL AVERAGE (DPM/100 CM^2) (a) (b)	STANDARD DEVIATION	ANNUAL AVERAGE (DPM/100 CM^2) (a) (c)	STANDARD DEVIATION
1	<780	336	<6	2.4
2	601	294	<6	1.2
3	562	214	<6	3.0
4	589	365	<6	3.5
5	<552	294	<6	2.7
6	<527	180	<6	1.3
7	652	319	<6	1.7
8	<674	336	<6	2.7
9	<525	174	<6	1.6
10	<493	106	<6	1.3

(a) Minimum detectable activities (MDA) ranged from 361 to 315 dpm/100 cm^2.
(b) Results given in disintegrations per minute per 100 square centimeter area.
(c) MDA ranged from 4 to 7 dpm/100 cm^2.
< Indicates that some of the values used to calculate the annual average were the instruments minimum detectable activities, and that the actual averages would be lower than what is shown.

equivalent of less than 3.9 mrem to a hypothetical maximally exposed individual as shown in Table 4-20 and discussed in this section.

Many of the parameter values and assumptions used in the calculation of effective dose equivalents to hypothetical maximally exposed individuals and to the potentially exposed population are provided in subsections 4.1.8.1 through 4.1.8.4. A more detailed account of assumptions, parameters valves, and equations used to calculate effective dose equivalents is provided in Appendix G, Dose Assessment Calculations.

Individuals could be exposed to radioactivity from the WSS via five principal pathways: (1) direct external gamma radiation, (2) inhalation of radon, (3) inhalation of airborne radioactive dust particles, (4) ingestion of fish from nearby lakes that receive runoff from the WSS, and (5) ingestion of drinking water from sources contaminated with

TABLE 4-20 Estimated Effective Dose Equivalent to a Maximally Exposed Individual and Estimated Collective Population Dose for the Weldon Spring Site

	AIRBORNE PARTICULATES EDE	GAMMA EDE	RADON EDE	TOTAL EDE	PERCENT OF EPA[a] STANDARD	PERCENT OF DOE[b] GUIDELINE
Radiation dose to a maximally exposed individual	0.006 mrem	0.55 mrem	3.3 mrem	3.9 mrem	0.06	3.9
Radiation collective population dose	0.0002 person-rem	0.004 person-rem	0.055 person-rem	0.059 person-rem	N/A	N/A

(a) The EPA standard limits effective dose equivalents (EDE) from airborne emissions other than radon to 10 mrem annually. The WSSRAPs effective dose equivalent from airborne particulates was compared to the EPA standard.

(b) The DOE guideline limits effective dose equivalents from plant emissions to 100 mrem annually. The WSSRAPs total effective dose equivalent was compared to the DOE guideline.

radionuclides from the WSS. All five pathways were included for the hypothetical maximally exposed individual. Pathway 4 was not considered in the population dose assessments because it is not reasonable or realistic to expect all members of a population to eat fish from bodies of water that receive runoff from the WSS. Pathway 5 was not considered in the population dose estimate because none of the surface water or groundwater voids that receive runoff or recharge from the WSS are used as drinking water sources. An evaluation of radiological exposures from these lakes when they are used for recreational purposes was included to ensure that the assessment would be thorough.

Although radiation doses can be calculated or measured for individuals, it is not practical to predict the health risk to a single individual. Estimates of health risks related to radiation doses are based on statistical data collected from large groups of people exposed to radiation under various circumstances. Statistical models are not applicable to a single individual. Therefore, dose equivalents to a single individual are estimated by hypothesizing a maximally exposed individual and placing this individual in a reasonable, but very conservative scenario.

Exposures of maximally exposed individuals and individuals near the off-site water bodies are given in terms of an effective dose equivalent (EDE). Exposures of people in neighboring facilities and populations within 80 km (50 mi) of the WSS are expressed in

terms of collective effective dose equivalent (CEDE) in units of person-rems (person-sieverts). Table 4-20 reports the estimated effective dose equivalents to the hypothetical maximally exposed individual and the estimated collective population dose. The effective dose equivalents to the hypothetical maximally exposed individual near the WSCP/WSRP, WSQ,
and WSVP are <1 mrem, 3.8 mrem, and <1 mrem (<0.01 mSv, 0.038 mSv, and <0.01 mSv) respectively. The highest of these three results was included in Table 4-20. All calculations were performed using the methodology described in International Commission on Radiation Protection (ICRP) reports 26 and 30 for a 50-yr committed effective dose equivalent (ICRP 1977; 1979). Fifty-year committed effective dose equivalent conversion factors were obtained from the EPA Federal Guidance Report No. 11 (Eckerman 1988).

In Table 4-20, the estimated effective dose equivalent for the hypothetical maximally exposed individual due to airborne radioactive particulates is compared to the EPA standard of 10 mrem annually for airborne emissions other than radon. It is not clear whether the emission standards in 40 CFR 61 subpart H are meant to apply to fugitive emissions from a site being remediated according to CERCLA. DOE is attempting to clarify this through a draft Memorandum of Understanding (MOU) with EPA. Until this issue is resolved, exposures due to fugitive emissions from area sources will be compared to the standards in 40 CFR 61 subpart H.

4.1.8.1 Radiation Dose From the WSCP/WSRP to a Hypothetical Maximally Exposed Individual. This section provides an estimated committed effective dose equivalent to a hypothetical individual assumed to frequent the perimeter of the WSCP/WSRP and to receive a radiation dose by the five pathways identified above. No private residences are adjacent to the WSCP/WSRP sites; therefore, all calculations of dose equivalent due to direct gamma exposure, airborne radioactive particle inhalation, and radon daughter inhalation assume a realistic less than 100% residence time. The amount of fish obtained and ingested from lakes receiving effluent from the WSCP/WSRP is assumed to be the average consumption rate per year according to U.S. Environmental Protection Agency statistics (Eckerman et al. 1988). None of these bodies of water are used as sources of drinking water. However, an evaluation of this pathway is included on the assumption that people could conceivably drink from them.

Direct gamma exposure rates were determined by means of TLD monitoring stations at the WSTA, the Missouri State Highway Department facility, and the ABWA. Continuous air samplers measured airborne radioactive particulates at these three locations, and radon exposures were measured via alpha track-etch detectors. There is no reason to suspect (with 95% confidence) that gamma exposure rates, airborne radioactive particulate concentrations, and radon gas concentrations exceed natural background; therefore, the effective dose equivalent to a hypothetical individual receiving the maximum reasonable exposure from these three pathways is not measurable above normal background exposure.

Three off-site bodies of water (Busch Lakes 34, 35, and 36) receive runoff from drainage originating at the WSCP/WSRP site. All three lakes are used for fishing and boating. In 1990, a bio-uptake investigation was conducted in order to determine the possible exposure of humans to chemical and radioactive contamination from ingestion of fish and game affected by previous operations at the WSS. This investigation included collecting fish samples from the three Busch lakes.

A variety of fish were collected from the lakes which included bass, catfish, sunfish, and crappie. Fillets representing the edible portion of the fish were sent for analysis. The fish were analyzed for uranium only because radium and thorium concentrations in lake sediments and water were not above normal background levels.

The analysis results for the various fish were combined and averaged. The average U-238 concentrations in the fish collected from Lakes 34, 35, and 36 were 0.001 pCi/g, 0.005 pCi/g, and 0.018 pCi/g, respectively. Using an average consumption rate of 6.5 g/day (0.23 oz/day) for fresh-water fish (EPA 1988) and EPA dose conversion factors (Eckerman et al. 1988) the highest calculated annual dose from ingestion of fish living in these lakes would be less than 1 mrem (0.01 mSv).

None of these lakes are presently used for drinking or irrigation. Swimming is not permitted in these lakes; however, it is realistic to assume the hypothetical maximally exposed individual would swim in the lakes despite the rules. Swimming can result in the ingestion of 0.05 liters/hr (0.05 qt/hr) on average (EPA 1988). Assuming that the individual swims in Lake 36, which has the highest average surface water concentration (51 pCi/l, or 1,887 Bq/m^3) for 12 hr/yr based on swimming 1 hr/wk during the summer or approximately

three months and using EPA dose conversion factors (Eckerman et al. 1988), the calculated dose would be less than 1 mrem (0.01 mSv).

It is also possible for an individual to ingest lake sediments during visits to the lakes. It is assumed the hypothetical individual would spend an average of approximately 2 day/yr at the lakes consuming 200 mg/day. Using the average uranium concentration of surface sediments for Lake 34 which has the highest value of 46.8 pCi/g (1.7 Bq/g) and EPA dose conversion factors, the calculated effective dose equivalent would be below 1 mrem (0.01 mSv).

A maximally exposed individual would therefore receive a total effective dose equivalent of less than 1 mrem (0.01 mSv) from direct gamma exposure, inhalation of airborne dust particles, inhalation of radon daughters, ingestion of water and sediment, and ingestion of fish from contaminated waters.

4.1.8.2 Radiation Dose From the WSQ to a Hypothetical Maximally Exposed Individual. This section discusses the estimated committed effective dose equivalent of a hypothetical individual assumed to frequent the perimeter of the WSQ and receive a radiation dose by three of the five pathways identified above. No private residences are adjacent to the WSQ site; therefore, all calculations of direct gamma exposure, airborne radioactive particulate concentrations, and radon daughter inhalation assume a realistic less than 100% residence time. Access to the quarry is controlled by a barbed wire fence; thus fishing, swimming, and drinking water from the quarry pond need not be evaluated.

In order to estimate the effective dose equivalent received via the inhalation pathway, a breathing rate must be assumed. The breathing rate assumed for all inhalation pathway calculations is 1.25 m^3/hr (Cember 1983). All effective dose equivalent conversion factors were determined from the EPA Federal Guidance Report No. 11 (Eckerman et al. 1988).

The exposure scenario consists of a hypothetical individual who routinely walks along the northern boundary of the quarry on State Route 94. The individual is assumed to make this trip twice per day, 250 day/yr. Average residence time per day is estimated to be 12 min (ANL 1989), resulting in an annual exposure time of 50 hr/yr. An individual driving by the site twice per day, could receive an exposure; but it would be insignificant relative to the walking scenario and, therefore, was not considered in the calculation.

Data from three environmental TLD monitoring stations were used to evaluate the dose by direct gamma exposure of the hypothetical individual. The dose from external gamma radiation was calculated by multiplying the length of time the individual would be exposed by the radiation field strength. Using these conservative assumptions and the highest measured gamma exposure rate (30 μrem/hr at TD-1001), the calculated dose equivalent would be less than 1 mrem (0.01 mSv).

Analysis of long-lived gross alpha activity from airborne radioactive particulate data from 1990 indicated that results from monitoring station AP-1010 on the quarry southern perimeter were significantly different than background at the 95% confidence level. The net average airborne long-lived gross alpha concentration at station AP–1010 (i.e., the concentration measured at AP-1010 less the background concentration measured at the Busch Wildlife Area) was 4.6 E–16 μCi/ml. This net airborne gross alpha concentration was proportioned among uranium, radium, and thorium isotopes according to the average radionuclide concentration results measured in the surface (0 m to 0.15 m) wastes within the WSQ and reported in the Remedial Investigation for the Quarry Bulk Waste (MKF and JEG 1989a). Using this assumption, the measured concentration would result in an estimated effective dose equivalent of less than 1 mrem (0.01 mSv).

The risk associated with Rn-222 is due primarily to inhalation of its short-lived daughter products. Data from the three alpha track-etch radon monitoring stations closest to State Route 94 were used to evaluate the dose by inhalation of radon daughters for the hypothetical individual. The highest average measured radon gas concentration at these monitoring stations was 1.8 pCi/l (67 Bq/m^3) above normal background. Assuming a 50% equilibrium between radon gas and its daughters and 1.25 rem/working level month (WLM) (12 mSv/WLM) effective dose equivalent conversion factor derived from EPA guidance (Eckerman et al. 1988), the estimated effective dose equivalent from inhalation of radon daughters is 3.3 mrem (0.033 mSv).

The dose to the hypothetical maximally exposed individual from the three pathways discussed above consists of a total of 3.8 mrem (0.038 mSv) from direct gamma exposure, inhalation of radon daughters and inhalation of radioactive air particulates.

4.1.8.3 Radiation Dose From WSVPs to a Hypothetical Maximally Exposed Individual. This section discusses the estimated effective dose equivalent to a hypothetical

individual assumed to frequent the largest vicinity property, the Femme Osage Slough, located south of the WSQ. This scenario provides a very conservative but plausible exposure assessment. No private residences are adjacent to the slough (it is on land that is currently managed by the Missouri Department of Conservation as part of the Weldon Spring Wildlife Refuge); therefore, all direct gamma exposure calculations assume a realistic less than 100% time of residence. The slough is not suspected of having airborne radioactive particulate concentrations and radon daughter concentrations above normal background because it is in a floodplain with saturated soil. The water in the soil minimizes airborne migration. In addition, the slough is contaminated only with uranium, implying that above-background concentrations of radon are not possible.

The amount of fish obtained and ingested from the Femme Osage Slough assumes the average consumption rate of 6.5 g/day (0.23 oz/day) according to EPA estimates (EPA 1988). Because of the stagnant water conditions, the slough is not a source of drinking water, nor is it a place for recreational swimming. Therefore, these pathways were not included in the dose calculations, and airborne radioactive particulates and radon daughter concentrations were not measured.

External gamma dose rate measurements were used to derive the effective dose equivalent by direct gamma exposure for the maximally exposed individual who is assumed to sit on the bank of the slough and fish 4 hr/wk, 50 wk/yr. The measurements were taken with a pressurized ion chamber (PIC) on the bank of the slough in an area of known radioactive soil contamination. Using the measured external gamma dose equivalent rate of 10.3 μrem/hr, which is 2.5 μrem/hr in excess of natural background, the calculated dose equivalent would be less than 1 mrem (0.01 mSv).

As part of the bio-uptake study, fish samples were collected and analyzed for total uranium, Th-230, Th-232, and Ra-226. All results were below detection limits. Uranium is the only radionuclide in the slough sediments and water that is elevated above background concentrations; therefore, uranium and its decay products are the only radionuclides that were considered for possible uptake. Assuming that the uranium concentration in fish is equal to the detection limit achieved during tissue analysis, the fish tissue concentration is 0.01 pCi/g (0.27 mBq/g). Using the average annual consumption rate of 6.5 g/day (0.23 oz/day) (EPA 1988), the calculated effective dose equivalent to the maximally exposed

individual from ingestion of fish living in contaminated waters would be less than 1 mrem (0.01 mSv).

The dose to the maximally exposed individual from the two pathways discussed above consists of a total of less than 1 mrem (0.01 mSv) from direct gamma exposure and consumption of fish tissue.

4.1.8.4 Collective Population Dose. The risk from radiation exposure to the general population is a function of the number of persons exposed, duration of exposure, and concentration or exposure rate to which the population is exposed. Below an absorbed dose of 10 rad (0.1 Gy) the projection of risk is uncertain. This is more than 30 times the typical yearly natural background exposure in the United States. In fact, no statistically significant adverse effects of radiation exposure have ever been proven at low doses of radiation. This is substantiated by studies of human populations exposed in regions of the world where natural background exposures are several times higher than those typically incurred in the United States. In these regions of higher background radiation exposures, the rate of adverse health effects has not been shown to increase above those which occur due to other factors (BEIR IV 1988).

The collective effective dose equivalent estimate is the product of the effective dose equivalent estimate at the exposure point and the number of persons exposed. Exposure points are locations where members of the public are potentially being exposed to airborne radioactive particulate concentrations, radon gas concentrations, external gamma radiation, or radionuclide concentration in water or food at above-background levels. The effective dose equivalent is calculated by estimating radionuclide concentrations in the air, water, food, and external gamma pathways at a given exposure point and developing reasonable exposure scenarios to estimate the amount of radioactivity ingested and inhaled and external gamma radiation received by the potentially exposed population.

The collective dose equivalent estimate for 1990 is less than 0.059 person-rem. The estimated exposed population is 72,000 persons. The following paragraphs discuss the exposure points, estimated radionuclide concentrations in the various pathways, and summaries of exposure scenarios used to develop the collective effective dose equivalent estimate.

The potential exposure point locations were chosen on the basis of analytical results from critical receptor monitoring stations and WSQ perimeter monitoring stations. None of the analytical results from critical receptor monitoring stations were significantly different than background concentrations at the 95% confidence level for long-lived gross alpha concentrations of airborne radioactive particulates, radon gas, and external gamma exposure. Since the results from all critical receptor monitoring locations were not significantly different than background concentrations, no collective effective dose equivalent estimate was made for populations at or beyond the critical receptor locations.

Analytical results from the WSQ perimeter monitoring stations were used to estimate airborne radioactive particulate and radon gas concentrations and the resulting collective effective dose equivalent estimate at the Katy Trail, which is a recreational trail located on state-owned land south of the quarry. The Katy Trail lies approximately 45 m (46 yd) south of the quarry at its closest point and about 25 m (27.5 yd) below the southern quarry rim. It parallels the southern rim for approximately 260 m (286 yd). The Katy Trail was chosen as the only potential exposure point location because only at the quarry were statistically significant above background radon and air particulate concentrations measured. The estimated number of people using the Katy Trail annually is 72,000, which was derived from an estimate provided by the Missouri State Parks Department in February 1991, (Maher 1991). Results from monitoring stations at other potentially affected populations near the WSQ (e.g., monitoring stations AP-4011 and RD-4006) are not significantly different than background levels. Figure 4-11 shows the locations of all WSQ perimeter monitoring stations as well as the Katy Trail.

The Katy Trail was chosen as the only potential exposure point location; because only at the WSQ were measured concentrations found to be statistically different at the 95% confidence level than the measured background concentrations for radon, external gamma radiation, and airborne radioactive particulates. Results at all non-WSQ monitoring locations, including the designated critical receptor locations, were not statistically different than the measured background concentrations at the 95% confidence level. Since measured concentrations at all monitoring locations other than the WSQ monitoring stations were not significantly different than background, and the monitoring network includes a monitoring station at every public receptor location within 2.5 km (1.5 mi) of the site, there were no other potential public exposure points during 1990.

The collective effective dose equivalent estimate was determined by calculation of conservatively-estimated airborne particulate and radon gas concentrations at the Katy Trail and an assumed exposure time of 5 min, which corresponds to a 3.2 km/hr (2 mi/hr) walking speed along the 260 m (286 yd) length of trail which parallels the WSQ. The breathing rate used in calculation of effective dose equivalent via the inhalation pathway was 1.25 m^3/hr (Cember 1983) and the dose equivalent conversion factors were obtained from EPA Federal Guidance Report No. 11 (Eckerman et al. 1988). Airborne radioactive particulate and radon concentrations at the WSQ were estimated using a Gaussian atmospheric dispersion model modified to predict concentrations close to an area source (DOE 1986). External gamma radiation is estimated using the inverse square law modified for an area source (Cember 1983). Details on calculations and assumptions used to calculate the effective dose equivalent are provided in Appendix G.

None of the surface water or groundwater bodies that receive runoff or recharge from the WSS are used as drinking water sources; therefore, this pathway was not included in the dose evaluation. It is not realistic to expect that a significant number of persons living within 80 km (50 mi) of the site consume fish or game affective by the WSS; hence this is not a significant exposure pathway (see Section 4.1.8.1).

The above-background airborne particulate and radon gas concentration estimates at the Katy Trail were 1.7E-16 µCi/ml and 0.26 pCi/l respectively. The above-background external gamma dose equivalent rate estimate is 7.7E-4 mrem/hr.

The resultant concentration estimates at the Katy Trail exposure point are conservative, because the model used to estimate concentrations at the trail assumes that the wind direction toward the trail remains continuous. Since the wind direction is variable, the true average concentrations of airborne particulates and radon gas at the exposure point would be lower than predicted by the model. More realistic wind direction estimates were not included in the model, because increasing the model complexity was not warranted based on the extremely low collective population dose estimate obtained by the conservative model used (DOE Order 5400.5).

4.1.8.5. Five Year Trend Analysis of Radon Gas. Track etch radon detector results from the last five years are represented graphically in Figure 4-14. The graph represents the

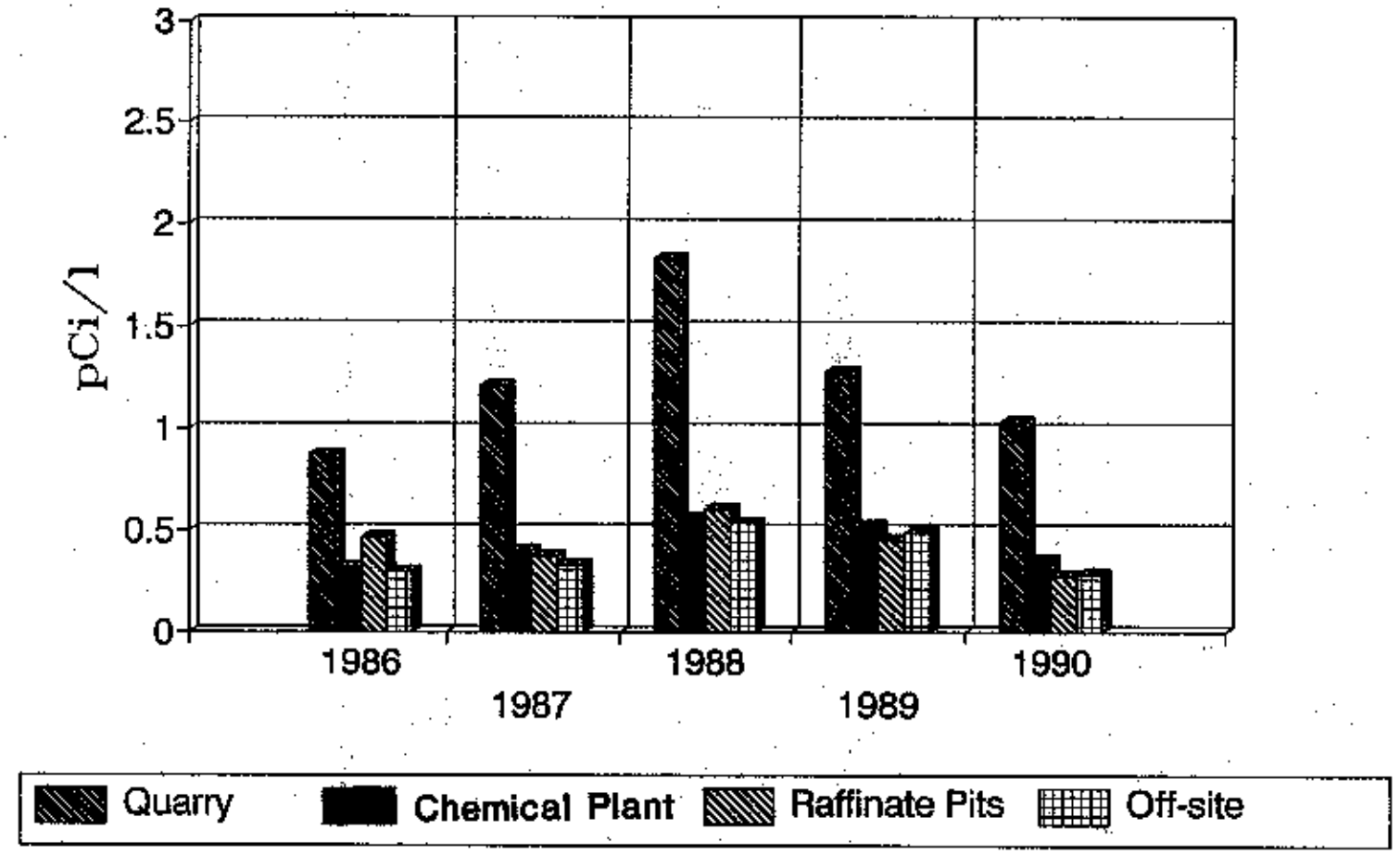
yearly averages of results from the monitoring stations at the quarry, chemical plant, raffinate pits, and off-site locations. The results shown include natural background.

The graph shows a definite increase and decrease in radon concentrations centered around 1988. This is due to the regional drought which occurred during this time period. The drought reduced the moisture content of the soil and the low moisture content allowed a greater fraction of the radon in the voids to diffuse into the atmosphere.

The quarry annual average concentrations, which are higher than other locations, also had greater increases in radon concentrations in proportion to the other locations. This is due to the higher concentrations of uranium and thorium at the quarry. Radon is a naturally occurring radionuclide in the uranium and thorium decay series.

4.1.8.6. Five Year Trend TLD. Gamma radiation exposure monitoring results from the last five years are represented graphically in Figure 4-15. the graph represents the yearly averages of results from monitoring stations at the quarry, chemical plants, raffinate pits, and off-site locations. The results shown include natural background.

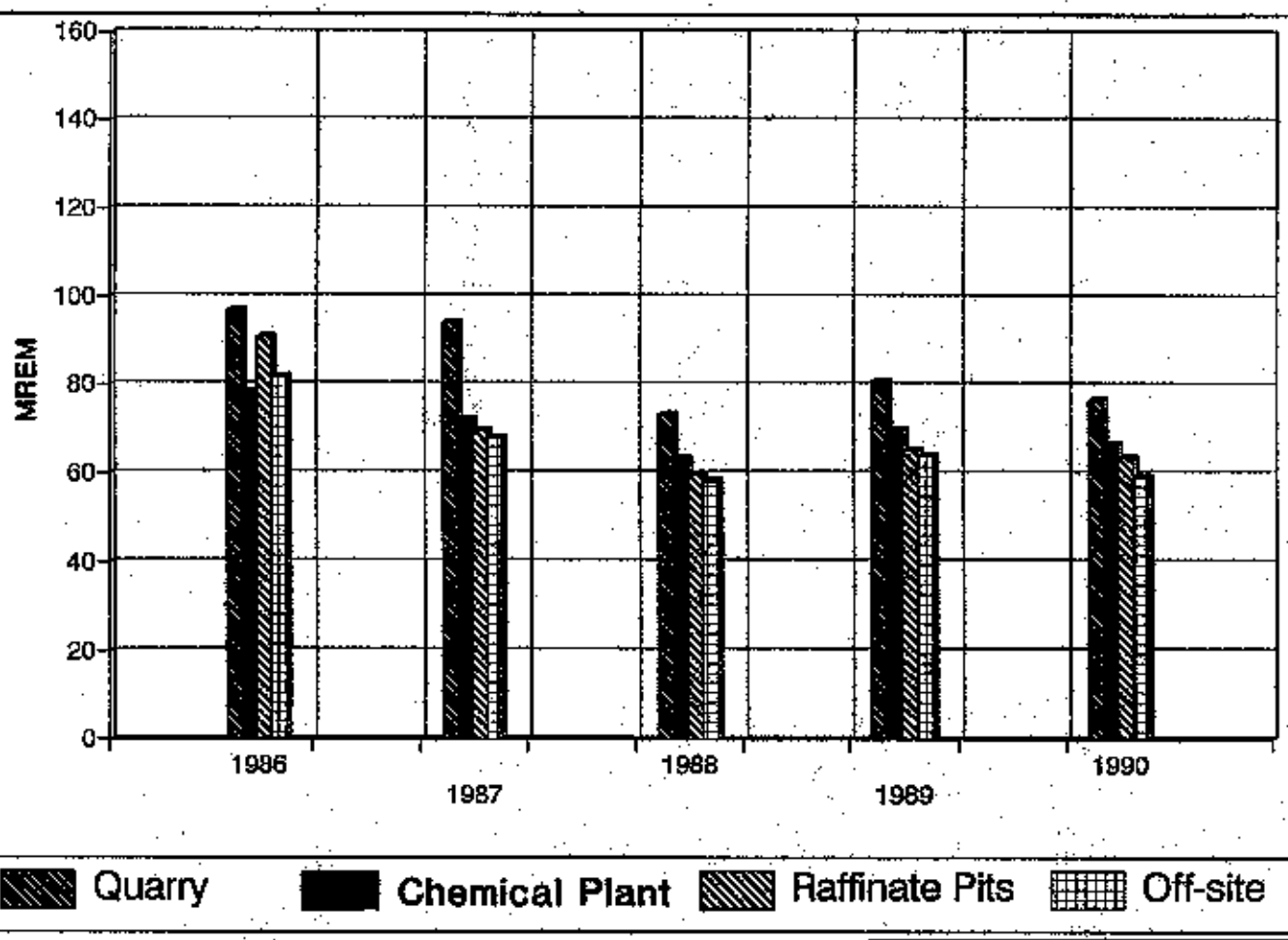
As shown in the graph, there is a difference of approximately 20 mrem between 1986 and 1987 data, and 1988-1990 data. The 20 mrem change between the two time periods can not be explained by changes in the radionuclide inventory, since the radionculide inventory at the WSSRAP has not significantly changed since 1986. The control thermoluminescent dosimeter (TLD) results reported in 1986 and 1987 were also approximately 20 mrem higher than the control TLD results reported in 1988 through 1990. Control TLDS are included in every quarterly shipment of environmental TLDs and are used as a quality control check to verify that the environmental TLDs were not exposed to a radioactive source during transportation from the WSSRAP to the subcontract laboratory. The subcontract laboratory that provides and analyzes the TLDs was contacted and indicated that a probable cause for the change between 1987 and 1988 could be due to improvements, based on additional testing and research, in the calculation of effective dose equivalents measured by the environmental TLDs. The graph shows that while there has been small variations in the effective dose equivalents measured with the environmental TLDs, during the period from 1988 to 1990, there is not an increasing trend in the effective dose equivalents resulting from gamma exposure.



TRACK ETCH RADON RESULTS

FIGURE 4-14

REPORT NO.: DOE/OR/21548-193	EXHIBIT NO.: A/PI/088/0591	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 5/91



ENVIRONMENTAL TLD RESULTS

FIGURE 4-15

REPORT NO.: DOE/OR/21548-193	EXHIBIT NO.: A/PI/089/0591	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 5/91

4.1.9 Radiological Release Estimates

During 1990 air particulate monitoring station AP-1010, located at the rim of the quarry, was the only location which had results that were statistically above background. An average of 4.6E-16 pCi/ml above background gross alpha results were obtained at station AP-1010. Using this concentration and a box model, calculations showed that 1.08E-5 Ci of gross alpha activity was released form the quarry perimeter. Assuming that the ratios of the various nuclides on filter are the same as those for surface soils reported in the remedial investigations for quarry bulk waste report (MKF and JEG 1989), the calculated amounts of the radionuclides range from 5.8 pCi to 0.3 pCi. Based on the reported activity of uranium that was released, and a specific activity of 3.3E-5 pCi/g, a total of 8.9 grams of uranium were released from the quarry perimeter. The results of the calculated quantities of radioactive materials are shown in Table 4-20A.

Intermittent surface water runoff also transported uranium (in the natural distribution) from the site area during 1990 through five major discharge routes. These routes are monitored through monthly sampling of the runoff water, as is required under the site's NPDES permit (see Section 4.2.4). Table 4-28 shows the discharge of natural uranium from the NPDES outfalls. Based upon those estimated total activities, and since the uranium on the site maintains a natural distribution of the isotopes, the estimated activity by isotope is calculated and is shown in Table 4-20A. Other radionuclides were not measured in surface water during 1990.

4.2 Non-Radiological Monitoring Program Information

4.2.1 Surface Water and Spring Monitoring

The environmental monitoring program for chemical constituents in surface water and springs for 1990 include 10 locations, nine of which were within or near the site and the other location was located within the quarry sump. The four surface water locations within the four on-site raffinate pits (SW-3001 through SW-3004), were monitored annually for inorganic anions. The five spring locations, SP-5201, SP-6301, SP–6302, SP-6303, and

TABLE 4-20A Radionuclide Emissions to the Environment

RADIONUCLIDE	ACTIVITY OF RADIONUCLIDE RELEASED TO AIR (Ci)	ACTIVITY OF RADIONUCLIDE RELEASED TO WATER	HALF-LIFE (yrs)
U-238	2.89E-6	1.8E-2	4.47E9
U-235	1.34E-7	8.0E-4	7.04E8
U-234	2.89E-6	1.8E-2	2.45E5
Th-232	3.24E-7	—	1.40E10
Th-230	2.49E-6	—	7.54E4
Ra-228	3.24E-7	—	5.76
Ra-226	1.76E-6	—	1,600
Rn-222	16.4	—	3.82 days

SP–6306 located off-site were monitored for nitroaromatics either semiannually or quarterly, and two of the same springs, SP-6301 and SP-6306, were monitored annually for inorganic anions. The surface water monitoring location within the quarry, the quarry pond (SW–1008), was sampled quarterly for inorganic anions and nitroaromatics.

4.2.1.1 Inorganic Anion Analyses in Surface Water at the WSCP. The inorganic anions of interest included chloride, fluoride, nitrate, and sulfate. The following text details the results and implications of the anion analyses. Annual averages of these analytical results are presented in Tables 4-1 and 4-2.

The average chloride levels measured in the two off-site surface water locations ranged from 7.4 mg/l at SP-6306 to 32.0 mg/l at SP-6301. These values are within their historical range. These results indicate that the chloride levels off-site do not pose a threat to public health or safety as the secondary standard for chloride is 250 mg/l. No standards exist for protection of aquatic life or biota. The average chloride levels located onsite ranged from 7.83 mg/l to 30.3 mg/l within the raffinate pits. These values are also within their historical ranges.

The measured average fluoride concentrations at the off-site sampling locations remained below 0.2 mg/l. The highest concentration measured in the raffinate pits was 0.9 mg/l which remains well within the EPA's maximum contaminant level (MCL) of 4 mg/l

for fluoride. Fluoride does not constitute a major contamination problem at the WSCP/WSRP.

Off-site concentrations of nitrate (as N) ranged from 2.7 mg/l at SP-6306 to 42.0 mg/l at SP-6301, (Burgermeister Spring). The level at Burgermeister Spring is below its historical range. However, the nitrate levels reinforce the conclusion that contaminated groundwater is apparently contributing to the elevated nitrate levels in the Burgermeister Spring. The levels of nitrate (as N) that are present in Burgermeister Spring are above the drinking water standard of 10 mg/l; however, these nitrate levels constitute no particular threat to human health or the environment as the water is not used domestically, but they do provide valuable information on the mechanics of contaminant migration from the WSS. Nitrate levels within the raffinate pits remained within their historical ranges also. Nitrate values ranged from a low of ND in SW-3002 to a high of 1900 mg/l in SW-3003 (see Table 4-1).

The off-site sulfate measurements made as part of the surface water monitoring program yielded levels ranging between 13.5 mg/l at SP-6306 and 54.0 mg/l at SP-6301. The sulfate value of 54 mg/l at Burgermeister Spring remains within its historical range and possibly suggests a component of sulfate contaminated groundwater discharging at that point. The measured level is well below the EPA's secondary drinking water standard of 250 mg/l for sulfate.

Sulfate levels within the raffinate pits remained within their historical range with a low of 37.5 mg/l at SW-3004 and a high of 695.0 mg/l at SW-3003.

4.2.1.2 Nitroaromatic Compound Monitoring - WSCP/RP Surface Water. The monitoring program for nitroaromatic compounds in 1990 involved quarterly and semi-annual sampling at five off-site locations, SP-5201, SP-6301, SP-6302, SP-6303 and SP-6306. Table 4-21 shows the levels of nitroaromatic compounds detected in those springs. No routine monitoring for nitroaromatic compounds was performed during 1990 at the raffinate pit locations (SW-3001 through SW-3004).

The monitoring results confirm what has been detected historically at the off-site monitoring locations. Total nitroaromatics were detected at levels above the detection limits to a high of 0.8 µg/l at Burgermeister Spring. Positive results were also indicated at SP-5201,

TABLE 4-21 1990 Annual Average Nitroaromatic Concentrations (ug/l) in Springs

WSSRAP ID	1,3,5-TRINITROBENZENE	@	1,3-DINITROBENZENE	@	2,4,6-TNT	@	2,4-DNT	@	2,6-DNT	@	NITROBENZENE	@	NITROTOLUENE	@
SP-5201	1.1	(1/2)	ND	(0/2)	8.4	(2/2)	ND	(0/2)	0.4	(2/2)	ND	(0/2)	NSF	
SP-6301	0.02	(1/2)	ND	(0/2)	0.5	(2/2)	0.8	(2/2)	0.4	(2/2)	ND	(0/2)	ND	(0/1)
SP-6302	ND	(0/2)	ND	(0/2)	0.1	(2/2)	0.7	(2/2)	0.3	(2/2)	ND	(0/2)	NSF	
SP-6303	ND	(0/2)	ND	(0/2)	0.2	(1/2)	0.05	(1/2)	0.4	(2/2)	ND	(0/2)	NSF	
SP-6306	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	NSF	

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.
ND - Not Detected
NSF - Not Scheduled For Sampling
@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were taken in 1990, two of which average 2.00 and the other two samples were ND.

downstream of a known source of this contamination known as the Department of Army Burn Area No. 1.

4.2.2 Weldon Spring Quarry Surface Water Monitoring

4.2.2.1 Inorganic Anions Results. Inorganic anions were analyzed on a quarterly basis on samples from the quarry pond. The inorganic anions category includes chlorides, fluorides, nitrates, and sulfates. The results of the analyses are presented for each parameter below. Table 4-4 shows the annual averages for each parameter measured.

The highest measured chloride value detected in the quarry sump was 12.4 mg/l with an annual average of 12.1 mg/l. The levels measured in 1990 at SW-1008 have remained very nearly the same compared to historical values. The relatively slight variations can be accounted for by natural dilution effects.

Fluoride levels also remained within their historical range at SW-1008. The annual average for fluoride at SW-1008 was 0.9 mg/l.

The nitrate levels for SW-1008 remained below the detection limit for 1990.

The sulfate measurements ranged from 118 mg/l to 161 mg/l with an average value of 139.5 mg/l at SW-1008. This level is the same as historical values at this location. All measured levels remained well below the EPA's secondary drinking water standard for sulfate of 250 mg/l.

4.2.2.2 Results for Nitroaromatics Analyses in WSQ Surface Water. The quarry pond SW-1008 was sampled quarterly for nitroaromatic compounds. The total quantified concentrations of all six compounds ranged from 1.8 ug/l during the first quarter to 16.2 ug/l during the fourth quarter. Table 4-22 shows those measured values. Samples will continue to be collected from the quarry pond to maintain accurate information on the levels in the water. The ponded water will ultimately be treated for nitroaromatic compounds and other organics upon completion of the quarry water treatment plant.

TABLE 4-22 1990 Annual Average Nitroaromatic Concentrations (ug/l) For Surface Water Near the WSQ

WSSRAP ID	1,3,5-TRINITROBENZENE	@	1,3-DINITROBENZENE	@	2,4,6-TNT	@	2,4-DNT	@	2,6-DNT	@	NITROBENZENE	@
SW-1008	0.06	(1/3)	ND	(0/3)	4.73	(3/3)	1.71	(3/3)	0.46	(3/3)	ND	(0/3)

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

ND - Not Detected

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicated that four samples were taken in 1990, two of which average 2.00 and the other two samples were ND.

4.2.3 Groundwater Monitoring Non-Radiological Results

All WSCP/RP/VP and WSQ monitoring wells were sampled during 1990 for nitroaromatics, nitrate, sulfate, chloride, and fluoride. These parameters are sampled with the same frequency and same monitoring program as uranium described in Section 4.1.3 of this report. The St. Charles County pumping wells, treated and untreated water from the St. Charles County Water Treatment Plant, and a select group of monitoring wells in the county wellfield were monitored quarterly for arsenic and barium. These same locations at the wellfield were sampled once in 1990 for volatile and semi-volatile organics, pesticides\polychlorinated biphenyls (PCBs), mercury, lead, and cadmium.

Data tables for all laboratory analytical results presented in this section contain annual concentrations calculated in the same format as the uranium table of Section 4.1.3.1 of this report.

4.2.3.1 Chemical Plant/Raffinate Pits. Groundwater at the WSCP/RP area became contaminated as a result of the Weldon Spring Ordnance Works (WSOW) operations during World War II and operations at the WSUFMP during the 1950s and 1960s. The *Phase I Water Quality Assessment Report* (MKF and JEG 1987) reported: "nitroaromatic compounds are present at low to high levels over much of the site; and relatively widespread nitrate and sulfate contamination problems are the result of leaking raffinate pits and other sources." The *Phase II Groundwater Quality Assessment Report* (MKF and JEG 1989b), an expanded comprehensive evaluation of groundwater quality at the WSCP/RP/VP area during the third quarter of 1988, is essentially in agreement with the Phase I report. Two notable exceptions are that the nitrate plume has been more clearly defined and that the original sulfate plume reported in the *Phase I Water Quality Assessment* is actually several isolated plumes, and its source is not exclusively the raffinate pits. These exceptions were detected as a result of additional monitoring well installations.

The groundwater monitoring network is described in Section 4.1.3.1 of this report. Figure 4-5 shows the location of individual wells at the WSCP/RP/VP area.

4.2.3.1.1 Analytical Results for Nitroaromatic Compounds - WSCP/RP Groundwater. No primary or secondary drinking water standards have been promulgated for any of the six nitroaromatic compounds of interest at the WSCP/RP/VP area. However, standards set by

the Clean Water Act-Federal Ambient Water Quality Criteria may be utilized as a reference for discussion. The criteria for 2,4-DNT is 0.11 µg/l based on a lifetime 10^{-6} cancer risk. For nitrobenzene, the criteria is 30 µg/l based on toxicity. Both 2,4-DNT and 2,6-DNT are suspected carcinogens. Nitroaromatic compounds are not naturally occurring; therefore any concentration detected indicates contamination of the groundwater system.

Each groundwater monitoring well was sampled and analyzed for nitroaromatic compounds during 1990. Table 4-23 summarizes the results of these analyses. Nitroaromatic compounds were not detected in 34 monitoring wells. Eighteen wells exhibited cumulative annual average concentrations of nitroaromatic compounds above detection limits, but below 10 µg/l. Seven wells exhibited annual average concentrations greater than 10 µg/l. They are MW-2006, MW-2011, MW-2012, MW-2013, MW-4001, MW-4006 and MW-4013. Figure 4-16 highlights wells with detected annual concentrations.

All 25 of the wells with detected concentrations of nitroaromatics exhibited concentrations of one or both of the suspected carcinogens 2,4-DNT and 2,6-DNT. Ten groundwater monitoring wells--MW-2009, MW-2010, MW-2011, MW-2012, MW-2013, MW-2014, MW-3001, MW-3009, MW-4001 and MW-4013--exhibited annual concentrations of 2,4-DNT above the ambient water quality criteria (0.11 µg/l). No detectable concentrations of nitrobenzene were observed in 1990. Overall the nitroaromatic results are consistent with past environmental monitoring and characterization studies.

4.2.3.1.2 Analytical Results for Inorganic Anions - WSCP/RP Groundwater. All groundwater monitoring wells at the WSCP/RP/VP were sampled for nitrate, sulfate, chloride, and fluoride in 1990. Table 4-6 shows the annual average concentrations of these inorganic anions.

The standard issued in the Safe Drinking Water Act for nitrate (as nitrogen) is 10 mg/l. Background concentrations are below 3.26 mg/l (MKF and JEG 1989a). During 1990, concentrations exceeding background occurred in 16 groundwater monitoring wells. The range of values for these wells is 3.93 mg/l in MW-4014 to 1280 mg/l in MW-3003. Figure 4-17 highlights wells with nitrate values above the EPAs drinking water standard of 10 mg/l. Although values from individual wells have fluctuated somewhat from previous

TABLE 4-23 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Chemical Plant/Raffinate Pits

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-2001	0.032	(1/2)@	ND	(0/2)	ND	(0/2)	0.106	(2/2)	0.054	(2/2)	ND	(0/2)	0.192
MW-2002	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.077	(2/2)	0.415	(2/2)	ND	(0/2)	0.492
MW-2003	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.029	(2/2)	1.4	(2/2)	ND	(0/2)	1.429
MW-2004	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2005	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.06	(2/2)	0.06	(2/2)	ND	(0/2)	0.140
MW-2006	11.5	(2/2)	0.14	(1/2)	0.039	(1/2)	0.06	(1/2)	1.5	(2/2)	ND	(0/2)	13.239
MW-2007	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2008	6.455	(2/2)	0.14	(1/2)	0.036	(1/2)	ND	(0/2)	1.16	(2/2)	ND	(0/2)	7.791
MW-2009	ND	(0/2)	0.5	(1/2)	ND	(0/2)	0.74	(1/2)	0.425	(2/2)	ND	(0/2)	1.665
MW-2010	0.25	(2/2)	0.155	(2/2)	0.455	(2/2)	0.491	(2/2)	0.875	(2/2)	ND	(0/2)	2.226
MW-2011	0.19	(1/1)	0.48	(1/1)	0.06	(1/1)	14	(1/1)	2.2	(1/1)	ND	(0/1)	16.930
MW-2012	4.35	(2/2)	0.29	(1/2)	1.17	(2/2)	4.3	(1/2)	1.65	(2/2)	ND	(0/2)	11.760
MW-2013	6.7	(2/3)	ND	(3/3)	1.9	(2/3)	2.97	(2/3)	21	(2/3)	ND	(0/3)	32.570
MW-2014	4	(1/2)	0.14	(1/2)	0.03	(0/2)	2.2	(1/2)	1.2	(1/2)	ND	(0/2)	7.570
MW-2015	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2017	0.074	(1/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	1.2	(1/2)	ND	(0/2)	1.274
MW-2018	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2019	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND

TABLE 4-23 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Chemical Plant/Raffinate Pits (Continued)

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-2020	ND	(0/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)	ND
MW-2021	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2022	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2023	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2024	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2025	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2026	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2027	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2028	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2029	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(2/2)	ND
MW-3001	0.115	(2/3)	ND	(0/3)	ND	(0/3)	0.52	(2/3)	0.185	(2/3)	ND	(0/2)	0.820
MW-3002	ND	(0/1)	ND	(0/2)	ND	(0/2)	ND	(0/1)	ND	(0/1)	ND	(0/2)	ND
MW-3003	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.034	(1/2)	0.073	(1/2)	ND	(0/2)	0.107
MW-3006	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.06	(1/2)	0.11	(1/2)	ND	(0/2)	0.170
MW-3008	ND	(0/1)	ND	(0/1)	ND	(0/1)	0.06	(1/1)	0.04	(1/1)	ND	(0/1)	0.120
MW-3009	0.235	(2/2)	ND	(0/2)	ND	(0/2)	0.14	(2/2)	0.1	(2/2)	ND	(0/2)	0.475

TABLE 4-23 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Chemical Plant/Raffinate Pits (Continued)

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-3010	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-3019	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4001	59	(2/2)	ND	(0/2)	1.95	(2/2)	3.05	(2/2)	3.15	(2/2)	ND	(0/2)	67.150
MW-4002	0.235	(2/2)	ND	(0/2)	1.06	(2/2)	ND	(0/2)	0.345	(0/2)	ND	(0/2)	1.630
MW-4003	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4004	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4005	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4006	19.5	(2/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	4.05	(2/2)	ND	(0/2)	23.550
MW-4007	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4008	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4009	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4010	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4011	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4012	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4013	38.5	(2/2)	ND	(0/2)	0.075	(2/2)	0.22	(2/2)	1.4	(2/2)	ND	(0/2)	40.195
MW-4014	0.465	(2/2)	ND	(0/2)	0.06	(0/2)	ND	(0/2)	0.085	(2/2)	ND	(0/2)	0.610

TABLE 4-23 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Chemical Plant/Raffinate Pits (Continued)

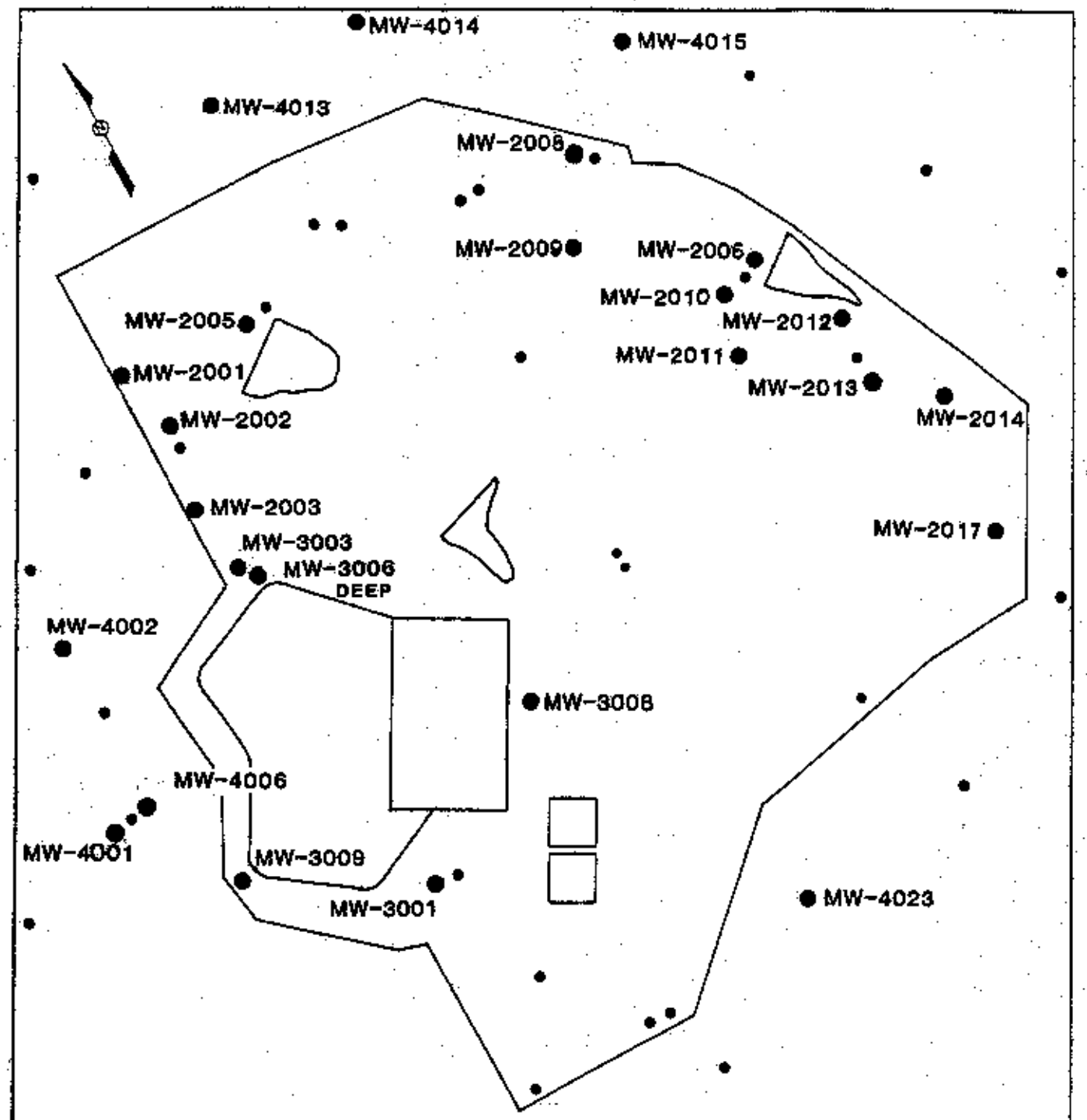
WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-4015	0.32	(2/2)	ND	(0/2)	ND	(0/2)	0.05	(1/2)	2	(2/2)	ND	(0/2)	2.370
MW-4016	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4017	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4018	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4019	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4020	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4021	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4022	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4023	0.09	(2/2)	ND	(0/2)	ND	(0/2)	0.068	(2/2)	0.024	(2/2)	ND	(0/2)	0.182

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

ND - Not Detected

* - Detection limit

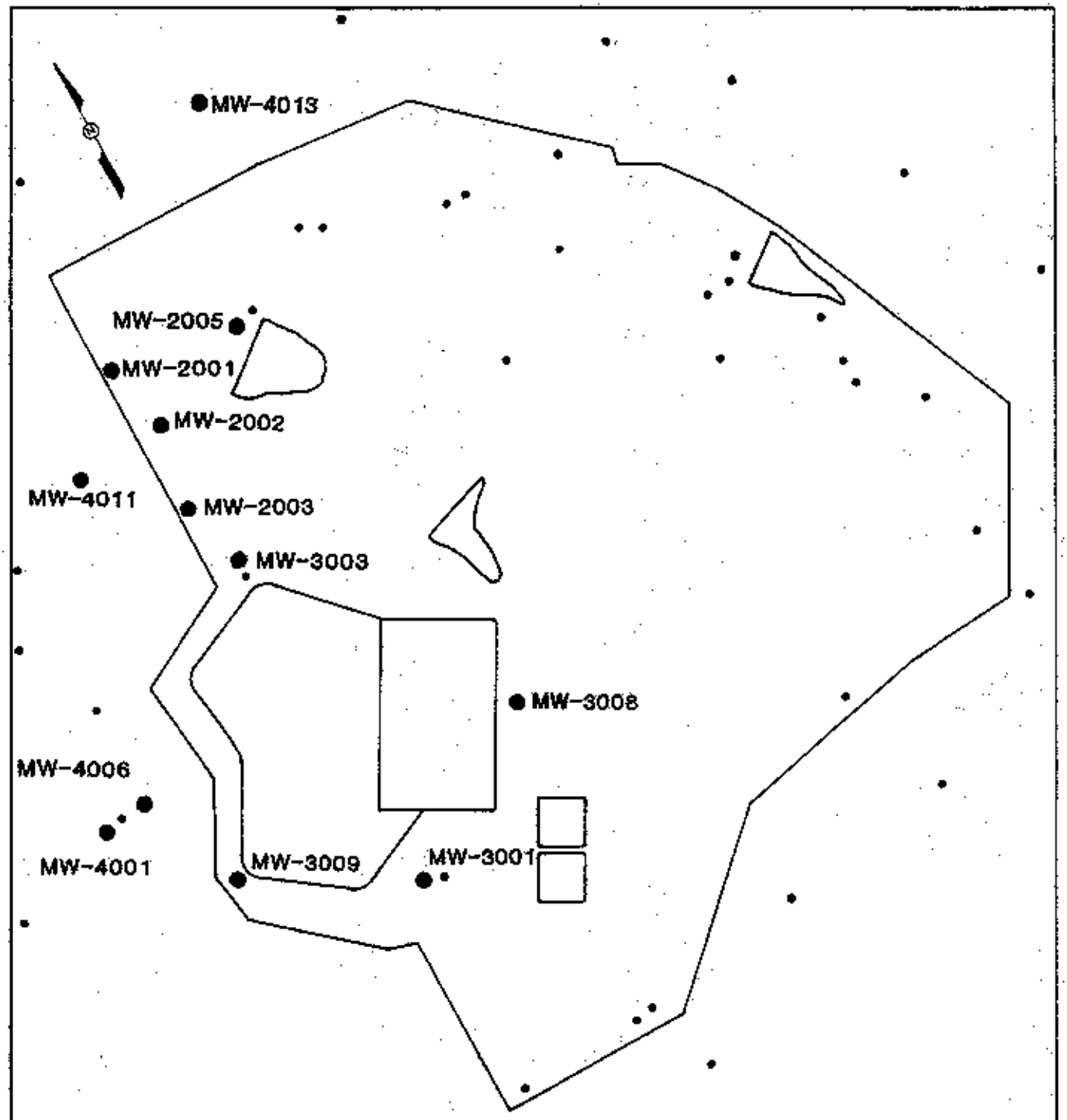
@ - The numerator is number of samples with detectable concentrations upon which the average is based and the denominator is the number of times the location was sampled during 1990. For example, 2.00 2/4) indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.



TOTAL NITROAROMATIC COMPOUNDS ABOVE DETECTION LIMITS

FIGURE 4-16

REPORT NO.	DOE/OR/21548-193	EXHIBIT NO	A/CP/076/0391
ORIGINATOR	TNA	DRAWN BY	GLN	DATE	3/91



● WELLS WITH CONCENTRATIONS >10mg/l

• DOE MONITORING WELL

0 500 1000 FT

0 152.4 304.8 M

SCALE

ANNUAL AVERAGE NITRATE CONCENTRATIONS ABOVE 10mg/L

FIGURE 4-17

REPORT NO.: DOE/OR/21548-193	EXHIBIT NO.: A/CP/104/0491	
ORIGINATOR: TNA	DRAWN BY: GLN	DATE: 4/91

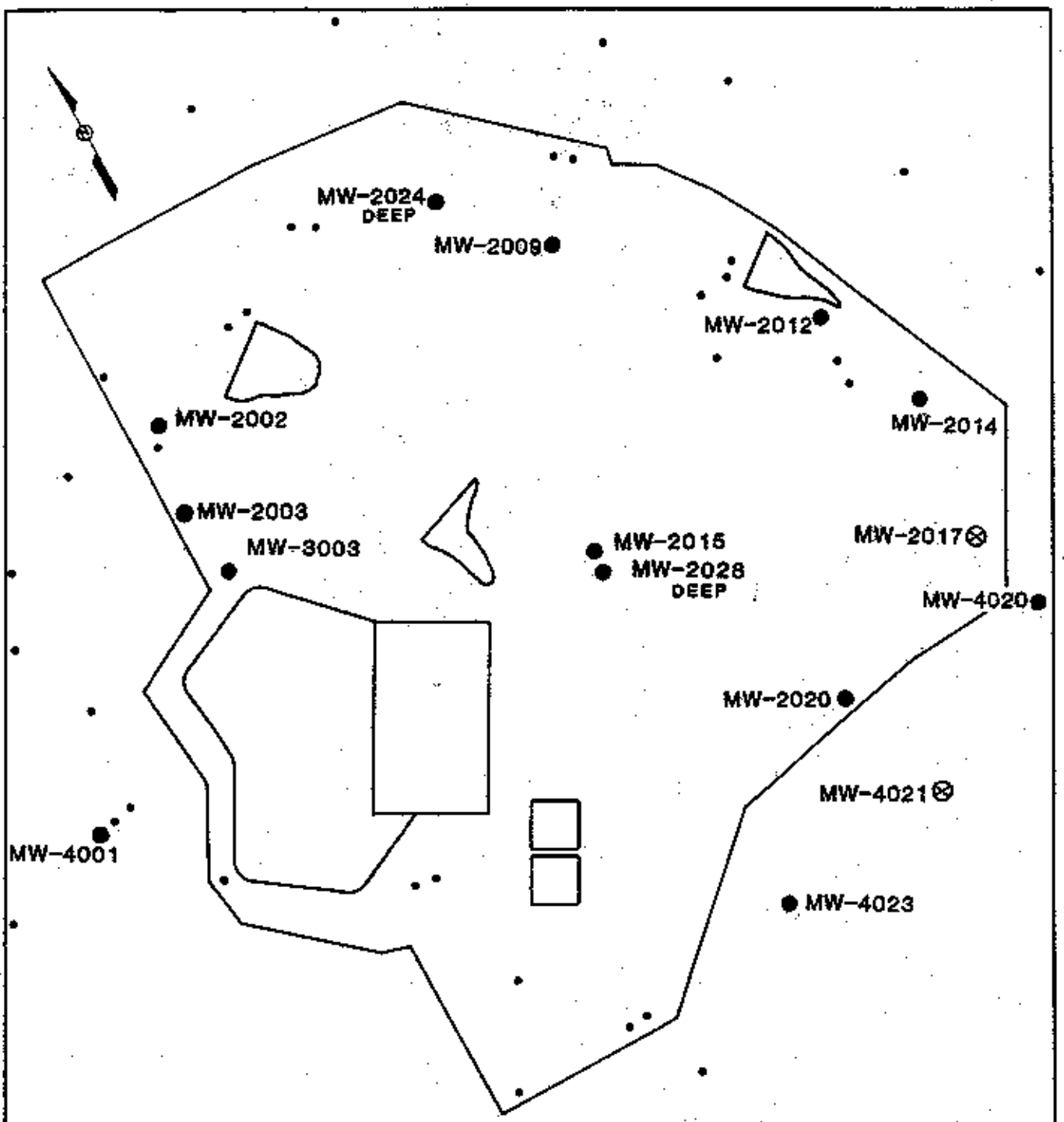
monitoring and characterizations, the groundwater scenario for nitrate contamination at the WSCP/RP/VP remains unchanged.

The upper bound of natural background sulfate concentrations in the aquifer at the WSCP/RP/VP was determined to be 50 mg/l (MKF and JEG 1989b). The EPA secondary drinking water standard for sulfate is 250 mg/l. Monitoring wells MW-2017 and MW-4021 exhibited average sulfate concentrations above the drinking water standard in 1990. Thirteen monitoring wells exhibited average sulfate concentrations between the upper bound of background and the drinking water standard. Figure 4-18 highlights monitoring wells with average sulfate concentrations above the upper bound of background. The *Phase II Groundwater Quality Assessment* (MKF and JEG 1989b) established that former WSOW processes were the primary source of these areas of sulfate contamination.

The upper limit of background for chloride in groundwater at the WSCP/RP/VP area is 22 mg/l (MKF and JEG 1989b). The EPA secondary drinking water standard for chloride is 250 mg/l. Five wells--MW-2006, MW-2008, MW-2010, MW-2012 and MW-2014--exhibited annual average chloride concentrations above the upper bound of background, but below the secondary drinking water standard in 1990. All five of these wells are located adjacent to a surface water drainage that drains a salt (sodium chloride) depot of the Missouri Highway Department off Highway 94. All of these wells have exhibited elevated chloride concentrations in the past.

Background concentrations for fluoride in groundwater are below 1 mg/l. The maximum contaminant level (MCL) for fluoride is 4.0 mg/l. One groundwater monitoring well, MW-2001 exhibited a fluoride concentration of 1.27 mg/l for the first sample of 1990 and was not detected in the second sample. No other monitoring wells exceeded background concentrations in 1990. This is consistent with previous monitoring results.

4.2.3.2 Non-Radiological Monitoring Results for WSQ Groundwater. Groundwater near the WSQ has become contaminated as a result of contact with or migration from the hazardous substances present in the WSQ. The monitoring well network for the WSQ is described in Section 4.1.3.2 of this report. The analytical results for non-radiological substances in groundwater at the WSQ are discussed in the following sections.



● - > 50 mg/L < 250 mg/L

⊗ - > 250 mg/L

● - DOE MONITORING WELL

0 500 1000 FT

0 152.4 304.8 M

SCALE

ANNUAL AVERAGE SULFATE CONCENTRATIONS ABOVE 50mg/L

FIGURE 4-18

REPORT NO: DOE/OR/21548-193	EXHIBIT NO: A/CP/103/0491	
ORIGINATOR: TNA	DRAWN BY: GLN	DATE: 4/91

4.2.3.2.1 Analytical Results for Nitroaromatic Compounds - WSQ Groundwater. During 1990, samples from all WSQ wells were analyzed for nitroaromatic compounds. Ten monitoring wells yielded detectable concentrations of at least one of the six nitroaromatic compounds analyzed. The analytical results are presented in Table 4-24. The 10 wells yielding detectable concentrations are all north of the Femme Osage Slough. No groundwater samples taken south of the Femme Osage Slough exhibited detectable concentrations of nitroaromatic compounds. Overall the nitroaromatic results are consistent with past environmental monitoring and characterization. The one exception is MW-1002 which indicated no detectable levels of nitroaromatic compounds in 1989 (MKF and JEG 1989b), but did average 47.97 µg/l total nitroaromatics in 1990. This well has, however, indicated detectable concentrations of nitroaromatics before 1989.

4.2.3.2.2 Analytical Results for Inorganic Anions - WSQ Groundwater. All monitoring wells in the WSQ area were sampled for nitrate, sulfate, chloride and fluoride in 1990. Table 4-7 displays the annual averages for these inorganic anions.

Groundwater samples collected at the WSQ area in 1990 continued to indicate no notable groundwater contamination by nitrate. The highest annual average observed was at MW-1012, which is adjacent to the WSQ. This level was 1.44 mg/l. Nitrate does not constitute a particular threat to the groundwater system near the WSQ.

The quarry bulk waste is a source of sulfate contamination to the surface water in the WSQ pond and subsequently to the groundwater surrounding the quarry. Sulfate levels in most of the wells adjacent to the quarry and in the alluvium north of the Femme Osage Slough appear to be elevated as a result of migration from the quarry. The highest 1990 sulfate average value of 529 mg/l was measured in MW-1006. Wells to the south of the slough continue to remain at background concentration levels. Groundwater samples collected in 1988 and 1989 from the upgradient background well referenced in Section 4.1.3.2 indicate a background level of 95 mg/l for sulfate in the alluvial groundwater.

Groundwater samples collected for chloride analysis in 1990 continue to agree with previous environmental monitoring and characterizations. The upper limit for background chloride levels in the bedrock aquifer near the WSCP/RP/VP was established at 22 mg/l in the WSSRAP's *1988 Environmental Monitoring Report* (MKF and JEG 1988). Data from the Missouri River alluvial water samples indicate that the background for the alluvium is

TABLE 4-24 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Quarry

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-1002	36	(2/2)@	0.27	(1/2)	6.2	(2/2)	ND	(0/2)	3.5	(2/2)	ND	(0/2)	47.97
MW-1004	0.5	(2/2)	ND	(0/2)	3.05	(2/2)	0.84	(2/2)	2.8	(2/2)	ND	(0/2)	7.19
MW-1005	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.16	(1/2)	0.071	(2/2)	ND	(0/2)	0.231
MW-1006	62.6	(2/2)	0.19	(1/2)	13.45	(2/2)	0.16	(1/2)	6	(2/2)	ND	(0/2)	82.60
MW-1007	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1008	ND	(0/2)	0.14	(1/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.14
MW-1009	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1010	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1011	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1012	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1013	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.038	(1/2)	ND	(0/2)	ND	(0/2)	0.038
MW-1014	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.066	(2/2)	0.02	(1/2)	ND	(0/2)	0.086
MW-1015	14.45	(2/2)	0.22	(1/2)	6.515	(2/2)	0.36	(1/2)	0.465	(2/2)	ND	(0/2)	22.010

TABLE 4-24 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Quarry (Continued)

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-1016	0.37	(2/2)	0.43	(2/2)	0.425	(2/2)	ND	(0/2)	0.07	(1/2)	ND	(0/2)	1.295
MW-1017	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1018	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1019	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1020	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1021	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1022	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1023	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND
MW-1024	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1025	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1026	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1027	0.13	(1/2)	ND	(0/2)	15.2	(2/2)	25	(2/2)	11.85	(2/2)	ND	(0/2)	52.180
MW-1028	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND

TABLE 4-24 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Quarry (Continued)

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-RMW1	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-RMW2	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-RMW3	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-RMW4	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-RAWW	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-FINW	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-PW02	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-PW03	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND
MW-PW04	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-PW05	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND
MW-PW06	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-PW07	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-PW08	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND

TABLE 4-24 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Quarry (Continued)

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-PW09	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

ND - Not Detected

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were taken in 1990, two of which average 2.00 and the other two samples were ND.

* - Detection limit

similar. The quarry sump shows an annual average concentration of 12.1 mg/l chloride. Based upon the comparison with background, chloride levels appear to be slightly elevated north of the Femme Osage Slough. The elevated chloride levels remain well below the EPA secondary drinking water standard of 250 mg/l. The highest level of chloride measured south of the Femme Osage Slough was 22.05 mg/l. Chloride does not constitute a threat to the groundwater system near the WSQ.

Fluoride levels ranged from 0.17 mg/l to 1.21 mg/l in the groundwater near the WSQ. These levels do not exceed the EPA's maximum contaminant level of 4.0 mg/l.

4.2.3.2.3 Analytical Results for Metals - WSQ Groundwater. Samples were collected for arsenic, barium, cadmium, lead, and mercury in 1990 at the St. Charles County pumping wells and the treated and untreated water from the St. Charles County Water Treatment Plant. These metals have been detected in previous samples of the quarry bulk waste. Arsenic and barium samples were also retrieved from the St. Charles County RMW series monitoring wells and monitoring well MW-1024. The results of analyses for these samples are shown in Table 4-25. The WSQ does not appear to influence metals concentrations in the well field area. Uranium is the primary indicator for WSQ contaminant migration.

4.2.3.2.4 Analytical Results for Organics - WSQ Groundwater. The St. Charles County pumping wells; treated and untreated water from the St. Charles County Water Treatment Plant; the St. Charles County RMW series monitoring wells; and monitoring well MW-1024 were sampled once in 1990 for PCBs, pesticides, and volatile and semi-volatile organics. No PCBs, pesticides, or semi-volatiles were detected in sample analyses. Low levels of acetone were detected in two samples and a low level of xylene was detected in one sample. Low levels of these compounds were also detected in quality control laboratory blanks. Due to this, the levels are believed to be a result of lab contamination. Laboratory analysis also indicated low levels of three trihalomethanes (chloroform, bromodichloromethane and dibromochloromethane) in the treated water from the water treatment plant. However, the summed concentrations of the three compounds are less than 100 ug/l, which is the maximum contaminant level from the Safe Drinking Water Act for the sum of all four trihalomethanes that may occur in drinking water. The compounds are believed to be a result of the natural organics in the groundwater reacting with the chlorine in the water treatment process.

Table 4-25 Metals Data Averages From St. Charles County Wellfield, 1990

WSSRAP ID	ARSENIC µg/l (10.0)*	@	BARIUM µg/l (200)*	@	CADMIUM µg/l (5.0)*	@	LEAD µg/l (5.0)*	@	MERCURY µg/l (0.2)*	@
MW-PW02	ND	(0/1)	287	(1/1)	ND	(0/1)	6.1	(1/1)	ND	(0/1)
MW-PW03	NOL		NOL		NOL		NOL		NOL	
MW-PW04	ND	(0/1)	266	(1/1)	ND	(0/1)	4.4	(1/1)	ND	(0/1)
MW-PW05	ND	(0/1)	275	(1/1)	ND	(0/1)	5	(1/1)	ND	(0/1)
MW-PW06	ND	(0/1)	310	(1/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)
MW-PW07	ND	(0/1)	397	(1/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)
MW-PW08	ND	(0/1)	362	(1/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)
MW-PW09	ND	(0/1)	389	(1/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)
MW-RMW1	6.6	(2/4)	427	(4/4)	NSF		NSF		NSF	
MW-RMW2	21.3	(4/4)	202	(4/4)	NSF		NSF		NSF	
MW-RMW3	41.3	(4/4)	498	(4/4)	NSF		NSF		NSF	
MW-RMW4	40	(3/4)	194	(4/4)	NSF		NSF		NSF	
MW-RAWW	6.4	(1/4)	387	(4/4)	ND	(0/1)	ND	(0/1)	ND	(0/1)
MW-FINW	ND	(0/4)	266	(4/4)	ND	(0/1)	5.4	(1/1)	ND	(0/1)
MW-1024	8	(1/4)	316	(4/4)	NSF		NSF		NSF	

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

ND - Not Detected
NOL - Well Not on Line or Sample Date
NSF - Not Scheduled For Sampling
* - Detection limit
@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were taken in 1990, two of which average 2.00 and the other two samples were ND.

4.2.4 Effluent Monitoring Results

Surface water and effluent samples were collected and analyzed in compliance with the Weldon Spring Site National Pollutant Discharge Elimination System (NPDES) permit. This permit (Number MO-0107701) was issued in November 1988, and addresses storm water and wastewater discharges. Six discharge points or outfalls are included in this permit and are shown on Figure 4-19. Outfalls NP-0001 through NP-0005 represent surface water discharge and NP-0006 represents the treated effluent discharge associated with the administration building sanitary wastewater treatment plant. Currently, NP-0006 is the only outfall with effluent limitations. The five surface water outfalls have monitoring requirements only. A summary of permit requirements including monitoring parameters and frequencies is shown in Table 4-26.

Annual averages of analytical results for the storm water locations are presented in Table 4-27. This table presents an annual summary of the individual sampling events. Tables indicating analytical results for the individual NPDES sampling events may be found in Appendix A.

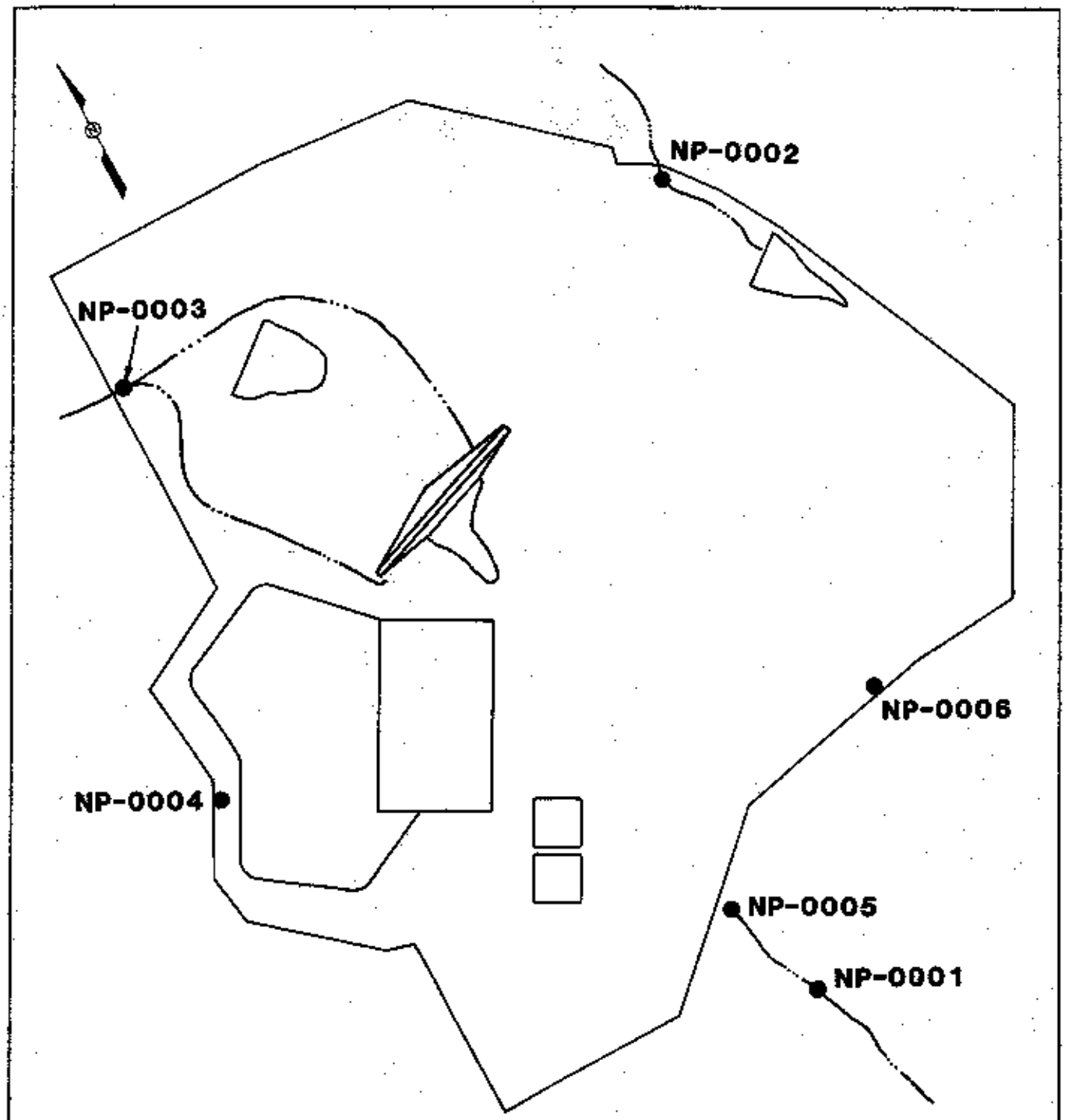
In general, all values correspond well with prior year values. On three occasions sampling was performed when flows were not representative of normal storm water flows. These three sampling events were performed during water release which was not associated with precipitation:

March 1: Samples collected at NP-0003 in conjunction with a release of water from Ash Pond retention basin.

May 8: Samples collected at NP-0003 in conjunction with a release of water from the Ash Pond retention basin.

September 27: Samples collected at NP-0001, NP-0002, and NP-0005 in conjunction with flow testing in the Frog Pond and Southeast drainages.

During the March 1 release, above average concentrations of gross alpha, uranium, settleable solids and nitrate were observed. These values are within the expected range with the exception of nitrate. An intermittent nitrate source has been observed in this drainage



NPDES MONITORING LOCATIONS

● MONITORING LOCATION

0 500 1000 FT
0 152.4 304.8 M
SCALE

FIGURE 4-19

REPORT NO. DOE/OR/21548-193	EXHIBIT NO.: A/CP/115/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91

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TABLE 4-26 National Pollutant Discharge Elimination System Permit Monitoring Requirements

	OUTFALL					
PARAMETERS	0001	0002	0003	0004	0005	0006
Flow*	Q	M	M	Q	M	M
Settleable Solids*	Q	M	M	Q	M	-
Total Suspended Solids*F	Q	M	M	Q	M	Q
Nitrate *	Q	M	M	Q	M	-
Uranium*	Q	M	M	Q	M	-
Lithium*	Q	M	M	Q	M	-
Gross Alpha*	Q	M	M	Q	M	-
pH*	Q	M	M	Q	M	Q
BOD F	-	-	-	-	-	Q
Fecal Coliforms F	-	-	-	-	-	Q

* - Monitoring requirements only; no discharge limits
F - Limits set for Outfall NP-0006
Q - Quarterly sampling
M - Monthly sampling

TABLE 4-27 1990 Annual Average NPDES Results for WSS Outfalls

LOCATION	NO. OF SAMPLES	pH	TOTAL URANIUM pCi/l	GROSS ALPHA pCi/l	NITRATE mg/l	LITHIUM mg/l	SUSPENDED SOLIDS mg/l	SETTLEABLE SOLIDS ml/l	FLOW GPD
NP-0001	6	6.98	413.4	396.6	1.290	0.0139	4.6	<0.1	98,880
NP-0002	12	6.84	139.47	147.24	0.678	0.0100	91.42	<0.1	393,053
NP-0003	13	6.77	89.45	81.95	95.310	ND	33.46	<0.1	296,494
NP-0004	4	6.91	7.59	6.35	0.290	ND	22.75	<0.1	2,550
NP-0005	12	6.76	364.45	373.68	3.350	*0.0256	12.36	<0.1	158,172

* This was the only sample above detection limits out of 12 total samples.

in the past. Values from the May 8 discharge were within expected ranges. Values from the September 27 sampling were slightly lower than normal, with the exception of lithium at NP-0005. This was the only sampling event in 1990 when lithium was detected at NP-0005 and the lithium levels at NP-0001 and NP-0002 were highest in samples obtained on this date.

4.2.4.1 Radiological Analysis. Annual average uranium levels ranged from 7.59 pCi/l (0.281 Bq/l), about 1% of the DCG at the minimum concentration discharge point (NP-0004) to 413.4 pCi/l (15.3 Bq/l), about 75% of the DCG at the maximum concentration discharge point (NP-0001) (Table 4-27). The highest average uranium concentration was measured at the off-site discharge of the abandoned sanitary and process sewer outfall (NP-0001). Uranium concentrations measured at NP-0001 ranged from 197 to 952 pCi/l (7.29 to 35.22 Bq/l) during 1990. Flows from the process and sanitary sewer outfall (NP-0001) combine with surface runoff from the southeast drainage easement. Uranium concentrations measured at NP-0005 exhibited similar levels with an annual average of 364.45 pCi/l (13.48 Bq/l), 66% of the DCG, and a range of 17.7 to 1020 pCi/l (0.65 to 37.74 Bq/l).

Frog Pond's off-site discharge (NP-0002) exhibited an annual average uranium concentration of 139.47 pCi/l (5.16 Bq/l), 25% of the DCG. Individual monthly measurements ranged from 10.2 to 367.2 pCi/l (0.38 to 13.59 Bq/l).

Off-site runoff from the area of raffinate pit No. 4 (NP-0004) exhibited an annual average uranium concentration of 7.59 pCi/l (0.281 Bq/l), 1 % of the DCG with a range of individual measurements from 4.2 to 10.9 pCi/l (0.16 to 0.40 Bq/l).

Runoff from the Ash Pond drainage (NP-0003) exhibited an annual average uranium concentration of 89.45 pCi/l (3.31 Bq/l). This continues a downward trend in uranium concentration at this outfall. The 1988 annual average at NP-0003 was 1178 pCi/l (43.59 Bq/l). The 1989 annual average of 280 pCi/l (10.36 Bq/l) signaled the start of the downward trend in uranium concentrations, primarily due to the completion of the Ash Pond diversion project. This project provided for diversion of surface water around the south dump and the Ash Pond areas.

Annual average gross alpha levels generally followed the same pattern as the natural uranium results. This correlation between the average uranium and gross alpha values indicates that the majority of all off-site radionuclide release in surface water is in the form of soluble uranium.

Estimated quantities of total uranium released off site through surface water are presented in Table 4-28. If it is assumed that the entire annual precipitation runoff is discharged from these points and the discharge from each point is proportional to the site drainage area for each point, an upper bound estimate of the total uranium released can be calculated. These results are consistent with values from 1989 with the exception of NP-0003 which was lower in 1990.

4.2.4.2 Physical/Chemical Analysis. Physical analysis (settleable solids and suspended solids) and chemical analysis (nitrate, pH, and lithium) were also performed on NPDES samples in 1990. The 1990 values generally correspond to 1989 values for the majority of parameters.

Settleable solids analyses of all outfalls averaged <0.1 ml/l in 1990. All outfalls exhibited at least one sample equal to 0.1 ml/l, with the following exceptions: all samples from NP-0004 were <0.1 ml/l and two samples from NP-0003 were equal to 0.1 ml/l.

Suspended solids analyses were comparable to prior data. Annual average values ranged from 4.6 mg/l at NP-0001 to 91.42 mg/l at NP-0002. Higher values of suspended solids were present at NP-0002 in July and August due to an accumulation of silt immediately above the outfall structure. Following removal of this sediment, measured values dropped and remained much lower.

Nitrate values were lower in 1990 compared to 1989 in all outfalls except NP-0003. Annual average values ranged from 0.290 mg/l at NP-0004 to 95.31 at NP-0003. The higher values at NP-0003 were present due to the single high value reported for March 1 during release from the Ash Pond retention basin, as mentioned previously.

Lithium values were slightly higher in 1990 compared to 1989. Annual average values ranged from ND (not detected) at NP-0003 and NP-0004 to 0.0256 mg/l at NP-0005. A

TABLE 4-28 1990 Estimated Annual Release of Natural Uranium from NPDES Outfalls

OUTFALL LOCATION*	DRAINAGE AREA (ACRES)	PERCENT OF PRECIPITATION AS RUNOFF**	AVERAGE CONCENTRATION (pCi/l)	UPPER BOUND TOTAL VOLUME (Mgal/yr)	UPPER BOUND TOTAL URANIUM (Ci/yr)	UPPER BOUND TOTAL URANIUM (kg/yr)
NP-0001 & NP-0005	20.2	60%	388.93	12.8	0.019	27.78
NP-0002	39.1	65%	139.47	26.9	0.014	20.87
NP-0003	60.1	20%	89.45	12.7	0.004	6.32
NP-0004	5.6	50%	7.59	3.0	0.00009	0.13
TOTALS =					0.0371	55.10

* See Figure 4-19 for Outfall Locations

** Estimated

limited number of samples from NP-0001 and NP-0002 contained lithium values slightly above the detection limit. The highest lithium value (at NP-0005) was present in a sample obtained during flow testing on September 27. As discussed previously, this flow was not representative of normal storm water flows.

4.2.4.3 Sanitary Wastewater. Outfall NP-0006 is the discharge for the site administration building wastewater treatment facility. The NPDES permit contains effluent limitations on biochemical oxygen demand (BOD), total suspended solids (TSS), and fecal coliform at this outfall. These limits are 10 mg/l BOD, 15 mg/l TSS, and 400 colonies/100 ml (fecal coliform). Samples were analyzed quarterly for these parameters by the Subcontractor operating this facility. A table illustrating all of these results is presented in Appendix A. NPDES permit limits were exceeded twice in 1990 at this outfall. The BOD value of April 12 was 13.8 mg/l. Operational adjustments to the plant were performed by the Subcontractor, and BOD levels returned to below permit limits. The fecal coliform value for December 5 was 7000 colonies/100 ml. This was due to removal of additional chlorine in the chlorine contact chamber by the Subcontractor. This was done at the direction of Missouri Department of Natural Resources (MDNR), due to a concern that excess residual chlorine might be present in the effluent. The Subcontractor has since replaced this additional chlorine in a more acceptable location resulting in a return to compliance for fecal coliform levels, while maintaining a minimal level of residual chlorine.

4.2.4.4 Erosion Control Monitoring. Sampling was conducted in the Little Femme Osage Creek, near the Weldon Spring quarry to assess erosion control measures associated with construction of the quarry staging area and water treatment plant facilities. Although the treatment plant has not yet been constructed, the NPDES permit for this discharge (MO-0108987), requires that all runoff from construction and material storage areas remain within the following limits.

Total Suspended Solids: Less than 50.0 mg/l (standard units)
pH: greater than 6.0 and less than 9.0

Samples were collected from SW-1001 and SW-1002 during rainfall events (see Figure 4-3). SW-1001 is located upstream of the quarry staging area and represents normally occurring concentrations in this drainage. SW-1002 is located immediately downstream of the quarry staging area. Water quality impacts from quarry staging area

construction are assessed by comparing values from these two locations. Results from these samples were as follows:

DATE	SW-1001		SW-1002	
	TOTAL SUSPENDED SOLIDS	pH	TOTAL SUSPENDED SOLIDS	pH
08/29/90	1.6	6.90	<0.1	7.17
10/10/90	6.0	7.32	7.0	7.32
11/05/90	7.0	6.74	7.0	6.66

These results indicate compliance with permit requirements.

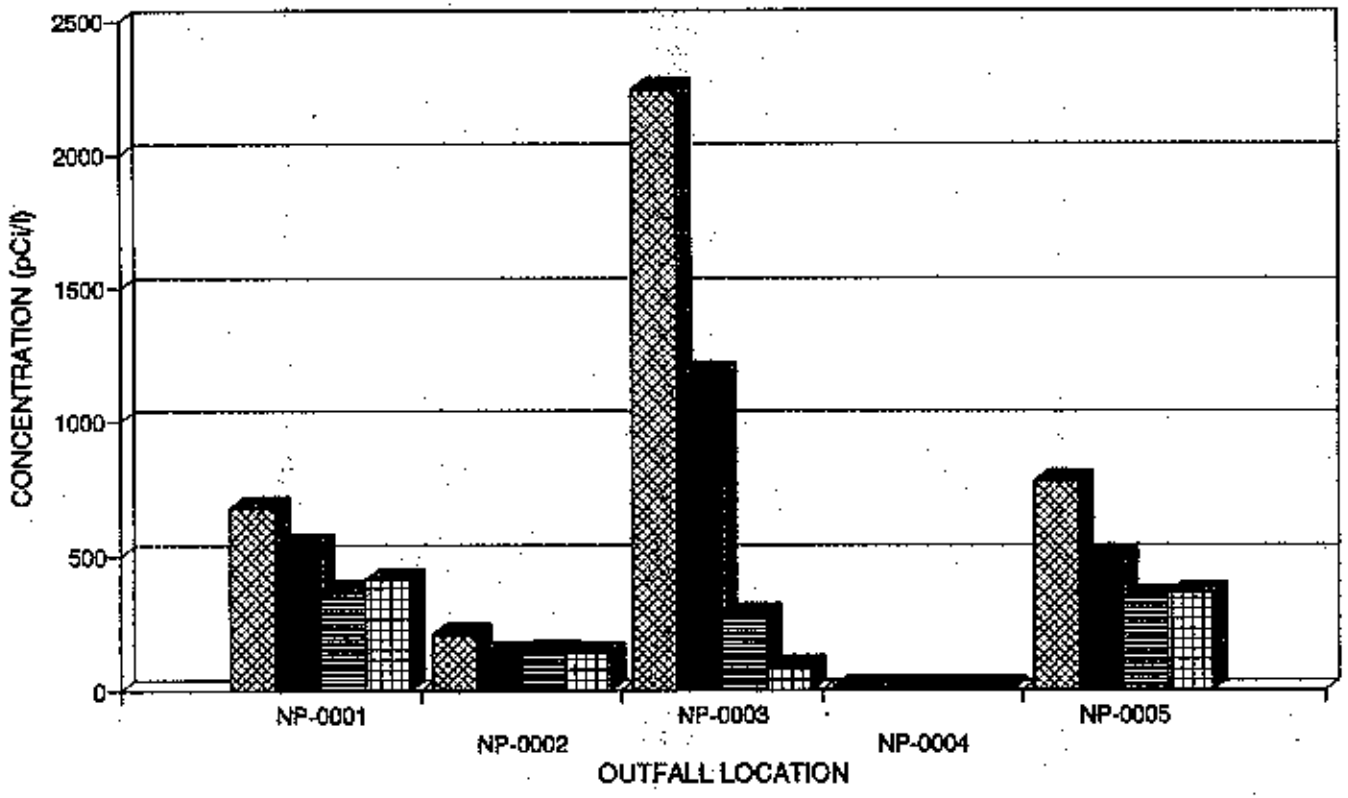
4.2.4.5 Uranium Trend Analysis. Annual average uranium concentrations in NPDES Outfalls from 1987 through 1990 are presented in Table 4-29. Uranium trends in NPDES Outfalls are shown in Figure 4-20. Uranium concentrations show an overall decline for the past four years with the exceptions of NP-0001 and NP-0005 which show a slight increase in 1990. All average values for both 1989 and 1990 are below the DCG of 600 pCi/l (22.2 Bq/l). The most dramatic decrease during this period was at NP-0003, the Ash Pond outfall. The Ash Pond diversion project is an interim response action that was completed in early 1989. This project provided surface water diversion around the south dump and Ash Pond areas and resulted in a subsequent decrease in uranium levels.

Comparison of values between Outfall locations indicates the following:

Uranium concentrations at NP-0004 remain extremely low indicating no significant contaminant migration in this area.

Uranium concentrations at NP-0002 do not indicate any significant fluctuation. This is expected since very little excavation or disruption has occurred within this watershed.

Outfall NP-0003 has shown a dramatic decrease in uranium concentrations due to effective surface water management.



TRENDS OF ANNUAL AVERAGE
URANIUM VALUES
FOR NPDES OUTFALLS

FIGURE 4-20

REPORT NO.:	DOE/OR/21548-193	EXHIBIT NO.:	A/PI/090/0591		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	5/91

TABLE 4-29 Annual Average Uranium Values at NPDES Outfalls 1987-1990

URANIUM VALUES pCi/l				
OUTFALL LOCATION	1987	1988	1989	1990
NP-0001	660	539	366	413
NP-0002	210	141	145	139
NP-0003	2240	1178	280	89
NP-0004	9.5	6.2	6.5	7.6
NP-0005	780	497	347	384

Currently, the highest values of uranium release in surface water occur in the southeast drainage (from Outfalls NP-0001 and NP-0005).

4.2.5 Airborne Asbestos Monitoring

During the first and second quarters of 1990, asbestos was monitored at five site perimeter stations and at the off-site monitoring station located at Francis Howell High School (FHHS) (Figure 4-10). Samples were typically collected once per week. Each sample was collected over a 7 hr to 8 hr sampling period, during normal site working hours. During the subject period, no asbestos abatement operations were conducted at the site. On the basis of the air monitoring results obtained from the site perimeter and off-site asbestos monitoring stations for the period from April 1988 through May 1990, in which no significant trends or findings were observed, site perimeter and off-site asbestos monitoring for the third and fourth quarters was discontinued. Routine asbestos monitoring at the FHHS and site perimeter stations will resume whenever on-site asbestos abatement operations are underway.

All samples were analyzed by Phase Contrast Microscopy (PCM). This method provides a measurement of total airborne concentration for fibers having size and shape characteristics typical of asbestos fibers. PCM methodology does not distinguish between airborne asbestos fibers and non-asbestos fibers having similar morphology. One sample, collected at the FHHS on May 18, was analyzed by Transmission Electron Microscopy

(TEM) which is capable of positively identifying asbestos fibers. No asbestos fibers were detected in the TEM sample.

The results of the PCM analyses for the air samples collected at the site perimeter and off-site monitoring stations are provided in Table 4-30. The average fiber concentration for the 28 site perimeter samples was 0.002 f/cc. The average concentration for the 18 FHHS samples was < 0.001 f/cc.

Table 4-30 Asbestos Monitoring Summary Calendar Quarter 1 and 2, 1990

SAMPLING LOCATIONS[a]	CONCENTRATION RANGE MIN. (FIBERS/CC)	CONCENTRATION RANGE MAX. (FIBERS/CC)	AVERAGE (FIBERS/CC)[b]	NO. OF SAMPLES REPORTED AS BELOW DETECTION LIMIT	TOTAL NUMBER OF SAMPLES COLLECTED
AP-2001	<0.001	<0.001	<0.001	4	5
AP-2002	<0.001	0.007	0.003	3	4
AP-2005	<0.001	0.002	0.001	9	11
AP-3003	<0.001	0.009	0.002	5	6
AP-3004	<0.001	<0.001	<0.001	2	2
AP-4006	<0.001	<0.001	<0.001	18	18

(a) See Figure 2-7 for monitoring station locations.
(b) For those samples with fiber concentrations less than the limit of detection, the limit of detection was used to calculate the overall average fiber concentration for each sampling location.

Routine area and employee exposure monitoring were conducted throughout 1990. This monitoring was conducted in the vicinity or in the breathing zones of site personnel engaged in asbestos related activities or other activities for which there were potential asbestos exposures. The results of the PCM analysis for the area and employee exposure monitoring are provided in Table 4-31. The average fiber concentration for the seven area

TABLE 4-31 Area and Worker Asbestos Exposure Monitoring Summary Calendar Year 1990

SAMPLE TYPE	CONCENTRATION RANGE (fibers/cc)	AVERAGE (fibers/cc) [a]	NO. OF SAMPLES REPORTED AS BELOW DETECTION LIMIT	TOTAL NO. OF SAMPLES COLLECTED
Area	<0.002 - 0.006	.009	4	7
Worker Exposure	<0.003 - 0.069[b]	.013	4	9

(a) For those samples with fiber concentrations less than the limit of detection, the limit of detection was used to calculate the overall average fiber concentration for each sample type.

(b) Concentrations represent 8-hr time weighted average exposures.

samples was 0.009 f/cc. The air sample results for the employee exposure monitoring indicate that worker exposures were less than the Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELS). OSHA's PEL for an 8-hr time weighted average (TWA) is 0.2 f/cc and for a 30-min excursion limit is 1 f/cc.

4.2.6 Meteorological Monitoring

In 1990, the WSSRAP installed a new meteorological tower and associated equipment capable of monitoring current weather data and recording the data for later use. Located near the main entrance to the chemical plant site, the meteorological station monitors the following parameters: wind speed, wind direction, temperature, barometric pressure, and precipitation. The intended uses of the meteorological system include:

1. Correlation with background fluctuations of naturally occurring radionuclides in ambient air measured at nearby locations.

2. Real time data read out of the meteorological variables influencing the dispersion of potentially released airborne materials.

3. Post incident data review to potentially explain source and receptor results.

The WSSRAP meteorological monitoring system produces data that can be used in routine dispersion modeling to predict impacts from site operations and as input to emergency response atmospheric models used in the event of accidental releases from the site.

5 GROUNDWATER PROTECTION PROGRAM

5.1 Groundwater Protection Program Management Plan

The Weldon Spring Site Remedial Action Project (WSSRAP) Groundwater Protection Program (GWPP) began in 1981 when the U.S. Department of Energy (DOE) appointed Bechtel National, Inc. (BNI) as the custodial contractor, responsible for installing the first groundwater monitoring wells and investigating water quality beneath the Weldon Spring site (WSS). Since the establishment of the WSSRAP in 1986, the current Project Management Contractor (PMC) has had an informal organization in place devoted to the protection, investigation, and remediation of the groundwater system at the WSS. The purpose of the WSSRAP GWPP Management Plan is to formalize and structure the program both for internal consistency and ease of external review. The formal plan developed in 1990 meets the requirements for a Groundwater Protection Management Program and Groundwater Monitoring Plans as described in DOE Order 5400.1. The scope of the plan is as follows:

- To define the purpose, policies, and objectives of the WSSRAP GWPP.
- To define the interfaces between the GWPP and other programs.
- To define the methods, procedures, and schedules to be utilized in meeting the GWPP objectives.
- To provide effective quality maintenance for the GWPP. (A separate quality assurance [QA] plan that meets Nuclear Quality Assurance (NQA-1) requirements has been developed for the project.)
- To provide the most effective overall management possible for the GWPP.

5.1.1 History of Groundwater Protection Program Activities

A large number of wells, piezometers, and borings have been installed at the WSS for groundwater monitoring, aquifer testing, geologic characterization, and geotechnical studies. The current monitoring well network includes wells constructed to support the

current Remedial Investigation/Feasibility Study-Environmental Impact Statement (RI/FS-EIS) studies and wells installed for routine monitoring.

The following well designations are currently used at the WSS. Monitoring wells with 1000 series numbers are located at or near the WSQ; wells with 2000 series numbers are located within the chemical plant area; wells with 3000 series numbers are located in the raffinate pit area; and wells with 4000 series numbers are located outside the site boundaries near the WSCP/WSRP.

Monitoring wells constructed at the WSS have been drilled, installed, and developed generally in accordance with accepted procedures as discussed in the U.S. Environmental Protection Agency (EPA) Resource Conservation and Recovery Act (RCRA) *Groundwater Monitoring Technical Enforcement Guidance Document* (EPA 1986). Standard operating procedures have been developed for WSSRAP based on these EPA guidelines.

5.1.2 Application of the GWPP Management Plan

The WSSRAP GWPP Management Plan is a management tool for the formalization of the DOE groundwater protection and management policies at the WSS. The Management Plan establishes criteria for the performance of groundwater management practices at the WSSRAP. Functionally, it serves the DOE, the PMC, and the public by establishing the groundwater protection and management criteria for the project. Annual review and appropriate updates to the plan also ensure that the plan remains up to date.

5.1.3 Plugging and Abandonment Requirements

The proper plugging of a groundwater monitoring device that is being removed from service is essential to maintaining the integrity of the associated aquifer or aquifers. For this reason, the WSSRAP has established requirements for plugging wells at the WSS. The lines of authority, procedures, and plugging criteria are established by the Groundwater Protection Program Management Plan (GWPPMP).

Project Structure and Lines of Authority

Since all monitoring wells are used by, and are under the authority of, the PMC Environmental Safety and Health (ES&H) Department, this department will approve the plugging and abandonment (P&A) process. The process will proceed as follows:

- The ES&H Department will authorize removing a well from service. The ES&H Department will notify the Construction Management and Operations (CM&O) and Engineering departments to begin their respective tasks.

- The Engineering Department will prepare a specification, subject to approval by the ES&H Department, and a request for bids to subcontract for the work will be issued by the Procurement Department.

- The CM&O and ES&H departments will oversee the Subcontractor's work.

- The ES&H and QA Departments may also choose to perform quality-related supervision of the P&A activities.

Well Plugging Criteria

The WSSRAP has developed a standard operating procedure (SOP) for the ES&H Department (ES&H Procedure 4.4.4s) for the abandonment of all subsurface monitoring devices, including wells. Wells will be plugged in accordance with all applicable State and Federal regulations and requirements. Currently, the State of Missouri has some formal requirements for P&A; however, the regulations do not specify how technical specifications should be written. The Missouri Code of State Regulations (10 CSR 23-3.02) requires that wells be plugged to prevent the vertical migration of pollutants. These regulations will be reviewed prior to the preparation of each P&A specification to ensure, at a minimum, that the State regulations and reporting requirements are met.

The WSSRAP will take greater precautions than required by the State regulations when plugging wells. As a standard practice, the WSSRAP will remove the well casing, filter pack, and drilling debris from the borehole and grout the hole using a tremie method.

5.2 Groundwater Contaminant Trend Analysis

Appendix B presents graphs of annual average concentrations of total nitroaromatics, total natural uranium, nitrate (as N) and sulfate for the years 1987 through 1990. Some of the monitoring wells were installed during this time. Accordingly, not all of the locations list four years of data. The monitoring wells are grouped primarily by concentration, due to the wide range of concentrations. The annual average concentrations are calculated in the same format as described in Sections 4.1.2 and 4.2.2.

Overall, the data for nitroaromatics show consistency with the exception of 1988 when a problem with laboratory contamination and error biased some results. The largest discrepancy evident is a reduction by one order of magnitude at location MW-2013.

As the graphs illustrate, (see Figure 4-20) the uranium concentrations show an overall increase in 1990. As discussed in Section 6.3, many distilled water blanks showed detectable levels of uranium in 1990, indicating laboratory contamination.

There appears to be a gradual increase in nitrate concentrations for certain wells adjacent to the raffinate pits. The nitrate levels for monitoring wells MW-1002, MW-1004, MW-1005, and MW-1014 show consistency for the years 1988 through 1990. The 1987 concentrations for these wells are believed to be in error due to laboratory contamination or sample handling.

Due to the widespread areas of sulfate contamination at the Weldon Spring Chemical Plant/raffinate pits/vicinity property (WSCP/RP/VP) and the WSQ, the graphs illustrate some fluctuations for the four years in certain monitoring wells. There appears to be some concentration error involved for certain wells in 1987. This is believed to be related to the nitrate concentration errors from the same year.

6 QUALITY ASSURANCE PROGRAM INFORMATION

The Weldon Spring Site Remedial Action Project (WSSRAP) Quality Assurance Program Plan (QAPP) establishes the quality program for those activities performed by the Project Management Contractor (PMC) during the WSSRAP. The QAPP requires compliance with the criteria of ANSI/ASME NQA-1 1986; the U.S. Department of Energy (DOE) Order 5700.6B, as required by the PMC; the DOE contract document DE-AC05-86OR21548; and the MK-Environmental Services NQA-1 Quality Assurance Manual. The purpose of the QAPP is to assure compliance with these documents.

All criteria of NQA-1 are applicable to the WSSRAP. The MK-Environmental Services NQA-1 Quality Assurance program provides guidance for the development of requisites to implement quality at the WSSRAP. The QAPP, however, does not address all criteria. Only criteria that describe quality assurance departmental actions are described. QA Audits, QA Surveillances, and the WSSRAP Self-Assessment program ensure compliance with criteria not addressed in the QAPP.

Certain environmental compliance issues are addressed in the WSSRAP Remedial Investigation Quality Assurance Program Plan (RIQAPP). The RIQAPP addresses the specific EPA/QAMS 005-80 Quality Assurance requirements for the characterization of the WSSRAP. The RIQAPP does not supersede the project QAPP, but rather it expands on specific requirements.

This chapter includes a discussion of the data administration and validation program in Section 6.1, the external audits and audit tracking system in Section 6.2, and the quality assurance sample results in Section 6.3.

6.1 Data Administration and Data Quality

The WSSRAP quality assurance (QA) program for environmental data has numerous initiatives within each aspect of data collection, evaluation, and reporting. The *Environmental Data Administration Plan* (EDAP), (MKF and JEG 1991b) a specific program-level plan, provides the foundation for collecting, verifying, validating, and interpreting data. The EDAP provides site-specific guidance for managing data and associated documentation, and establishes general data quality goals. This plan also includes

guidance on sampling plan preparation, data verification, validation requirements, database administration, and data archival.

All WSSRAP environmental surveillance and effluent monitoring activities required by permits and DOE Orders are performed as detailed in the *Environmental Monitoring Plan* (MKF and JEG 1990c) which describes sampling methods, locations, rationale, and quality control measures.

Site specific procedures have been developed for all aspects of sample collection and handling. These procedures were developed from EPA and other relevant guidance documents. They are reviewed annually and revised as necessary. Sampling personnel are trained in appropriate procedures prior to sample collection. All procedure training is documented and tracked so that personnel are retrained as procedures are revised. Variances or field modifications to procedures are noted in field notebooks and on sampling forms.

Quality control samples are collected to assess location variability, the effects of sample matrix on analytical procedures, laboratory precision, and the effects of sampling methods and shipping on analytical results. Chain of custody documentation is maintained for all samples from sample collection through shipment to the analytical laboratory. Completed chain of custody records are maintained at the WSSRAP as QA records.

Laboratories analyzing the WSSRAP samples are required to use standard methods and to have a quality assurance program. These quality assurance programs are reviewed and approved by the project's Quality Assurance Department prior to commencement of analyses. Laboratories are also required to comply with standardized reporting requirements, thus simplifying data verification, validation, and interpretation. Laboratories are routinely audited to assure compliance with their QA programs and appropriate analytical procedures.

All data received from analytical laboratories are subjected to data verification. The data verification process is detailed in ES&H Procedure 4.9.1 and consists of a preliminary review of the quality-impacting aspects of sampling, analysis, and reporting. Data verification includes reviewing field sampling documentation, sample preservation, chain of custody, analytical holding times, and a comparison of electronic versus hard copy reporting.

Data verification assures that all data are received for every sample submitted for analyses and includes a preliminary review by the data users. The verification process also ensures that any discrepancies noted have been addressed and that the resultant changes are documented.

Data validation is performed independent of the analytical laboratory. Data validation consists of two primary functions. First, the analytical process is reviewed and the quality of the data is documented. This consists of reviewing all records related to sample integrity, sample preparation, and the analytical measurement systems. Second, the data are compared to the method-specific criteria and site-specific data quality requirements. This ensures that data quality is evaluated based on the end use of the data. At the WSSRAP, approximately 10% of all analytical data is validated according to site-specific procedures. Approximately 5% is evaluated on a random basis to provide coverage across all data sets. The other 5% is selected from critical data. The 10% validation actually reviews a large portion of the analytical lots, effectively validating a much larger percentage of the data base. This is accomplished by reviewing information affecting data quality, such as instrument calibration, which is the same for all samples in an analytical lot.

The useability of the data is established by data validation. The final step involves comparing results to the method criteria and data quality requirements. Qualifiers are attached to data records that have been validated. This allows data users to assess the quality of the data being used without requiring a detailed knowledge of the analytical processes. The data validation process is detailed in Engineering Procedure ENG-9.

The result of these programs and procedures is that analytical data quality is known and documented. The data presented in this report have been verified and a percentage have been validated. Additional information regarding data quality is available in the *Chemical Plant Site Remedial Investigation/Feasibility Study Data Validation Report* (MKF and JEG 1991c).

6.2 Quality Assurance Audits and Audit Tracking System

In 1990, WSS operations were reviewed during seven audits by outside entities. Four of these audits directly evaluated environmental aspects of the project. These audits evaluated the topics, and were performed by the organizations listed below.

Scope of Audit	Auditing Organization
Management Appraisal of ES&H and Quality Assurance	DOE - Oak Ridge Operations
Waste Management and Regulatory Compliance	Oak Ridge National Laboratories
ES&H and QA Appraisal	DOE - Oak Ridge Operations
Quality Assurance Project Plan Compliance	M-K Environmental Services Quality Assurance

Each audit resulted in an audit report which detailed findings and proficiencies. A response was prepared and corrective actions were defined and scheduled. All audit-related information is entered into a site-wide audit tracking system (SWATS) which tracks findings from initiation through corrective action and verification by both internal and external entities. The majority of findings in these audits relate to problems that only remedial action can solve (such as storage of polychlorinated biphenyls (PCBs) beyond the one-year limit), or relate to best management practices (which can be resolved through upgrading existing systems or by developing or revising procedures). The status of all audits is routinely reviewed by project management and QA personnel to ensure that progress is being made and that adequate resources are applied to correcting problems.

6.3 Quality Control Data Summary

Quality control samples were collected during all phases of the routine environmental monitoring program at the WSS. In some programs such as the external gamma and radon monitoring, the results are directly incorporated into the discussion of the data.

Groundwater, surface water, spring and National Pollution Discharge Elimination System (NPDES) monitoring, quality control sample results are discussed in this chapter. These samples include trip blanks, water and bottle blanks, field blanks, and duplicates. The results from these quality control samples are discussed in the following sections. Quality control data has been reviewed to evaluate impacts on the conclusions and interpretations presented in this report. The detection of uranium in water and bottle blanks, and field blanks has not impacted the dose calculations discussed in this report.

The WSSRAP did not participate in the DOE interlab comparison program in 1990. Participation will be implemented during 1991 for subcontract laboratory samples that were analyzed. The WSSRAP did collect quality control samples that were analyzed by numerous laboratories. The results of this program are discussed in Section 6.3.4.

6.3.1 Trip Blanks

Trip blank samples were collected to assess the impacts of sample shipping on analytical results. Trip blanks are sent with each shipment of samples to be analyzed for volatile organic compounds. During 1990, six trip blank samples were analyzed for volatile organic compounds. Analysis of these samples detected only low concentrations of acetone, methylene chloride, and toluene. These compounds were also detected in laboratory blanks, indicating that lab contamination is the source of these compounds.

6.3.2 Water and Bottle Blanks

Water and bottle blank samples are collected to evaluate the cleanliness of sampling containers and the purity of distilled water used to decontaminate nondedicated sampling equipment. These samples also serve as additional laboratory blanks. Eleven water and bottle blank samples were collected during 1990. These samples were analyzed for combinations of the following parameters: inorganic anions, uranium, gross alpha, and nitroaromatic compounds. These samples detected low concentrations (near the detection limit) for chloride (1 of 5 samples), fluoride (1 of 5 samples), sulfate (3 of 5 samples) and uranium (6 of 6 samples). The detection of uranium is particularly significant due to the concentrations detected. Uranium concentrations in these samples ranged from less than 1 pCi/l to 4.8 pCi/l (0.037 Bq/l to 0.177 Bq/l). As a result of these analyses, the uranium results (in water samples) presented in Section 4 are likely biased high, up to approximately

.5 pCi/l (0.185 Bq/l). In many areas, this slight bias may not be significant. However, in surface water and groundwater at the Weldon Spring Chemical Plant/raffinate pits (WSCP/WSRP), this bias may have artificially increased concerns regarding elevated uranium levels.

6.3.3 Field Blanks

Field blank samples are collected by filling sample containers with distilled water at an actual sampling location. These samples evaluate potential contamination resulting from actual sample collection activities. Seven field blank samples were collected during 1990. Field blank results must be used in conjunction with water and bottle blank sample results to accurately assess any impacts associated with actual sample collection. Field blank sample results correlated with water and bottle blanks sample results, indicating either bottle or laboratory contamination as the source for biased results for uranium and sulfate analyses. Uranium concentrations in field blanks ranged from less than 1 pCi/l to 5.4 pCi/l (0.037 Bq/l to 0.199 Bq/l), supporting the conclusions reached in Section 6.3.2.

6.3.4 Duplicate Sample Results

Two types of duplicate samples were collected and analyzed during 1990 for groundwater, surface water, spring, and NPDES samples. The first duplicate type is blind duplicate samples which were collected at the same time and in the same manner as regular samples, given a unique sample number, and analyzed by the laboratory analyzing the regular sample. The second duplicate type is replicate samples which are collected at the same time and in the same manner as the original sample and analyzed by a different laboratory.

Duplicate samples were analyzed for the same parameters as the original samples at the rate of approximately one per 20 samples. Therefore, duplicate samples were most frequently analyzed for uranium, nitroaromatic compounds, and inorganic anions. The number of duplicate samples analyzed by analytical parameter is presented in Table 6-1. Overall, the duplicate and replicate analyses indicated good agreement between the original and duplicate samples.

TABLE 6-1 Duplicate Sample Summary for Water Samples

PARAMETER	NUMBER OF DUPLICATE SAMPLES
1,3,5-Trinitrobenzene	25
1,3-Dinitrobenzene	25
Nitrobenzene	25
2,4,6-Trinitrotoluene	25
2,4-Dinitrotoluene	25
2,6-Dinitrotoluene	25
Nitrate	26
Sulfate	24
Fluoride	25
Chloride	25
Uranium	26

7 SPECIAL STUDIES AND REMEDIAL ACTIVITIES

7.1 Characterization Special Studies

7.1.1 Haul Route Characterization

A haul road is planned for transportation of quarry bulk wastes from the Weldon Spring quarry (WSQ) to the Weldon Spring Chemical Plant (WSCP). This road will traverse an abandoned railroad grade and parallel Highway 94 when deviating from the railroad grade. The majority of this route crosses portions of the Weldon Spring Wildlife Area (owned by the Missouri Department of Conservation [MDOC]). Chemical and radiological characterization efforts were performed along this route in 1990 to assess waste management requirements for excavated materials and personnel exposure during construction of the road.

Chemical sampling included soil sampling in the marshalling yard (near the WSCP) and soil sampling near two abandoned drum locations adjacent to the railroad grade. The most intensive sampling was performed in the marshalling yard since this area presented the highest potential for contamination due to additional railcar operations and documentation of potential contaminant sources in this area. Soil samples were analyzed for volatile organics, semi-volatile organics, pesticides and polychlorinated biphenyls (PCBs), hazardous substance list metals, and nitroaromatic compounds. Samples from the marshalling yard indicated detectable levels of nitroaromatics in one grab sample and in one composite sample. PCBs were found at levels just above the detection limit near an abandoned transformer station. Metals concentrations were at or near background levels. No contaminants were found above background levels near the two abandoned drum locations. Chemical characterization did not indicate any contaminant levels which would require the use of special personnel protection equipment or present waste management concerns during construction of the haul road. The chemical results on wastes in the marshalling yard area will be given to the Department of the Army to support their remedial action decision on the Weldon Spring Training Area (WSTA).

Radiological characterization was performed along the entire railroad grade from the WSQ up to and including the marshalling yard. The characterization included: total beta-gamma radiation measurement and loose alpha contamination measurement surveys, and collection of physical samples from railroad ties, soil, and rail. Total beta-gamma

measurements and loose alpha contamination measurement surveys were performed to determine the levels of contamination present. Physical samples were collected to determine which radionuclides were present. Radiological characterization results indicated that all materials surveyed were within the release criteria established in the *Radiological Survey and Release Plan for the Quarry Haul Road* (MKF and JEG 1990e). Additional surveying of areas on the rails and ties that are inaccessible at this time (e.g., bottoms of rails), will be completed before any materials can be released for unrestricted use.

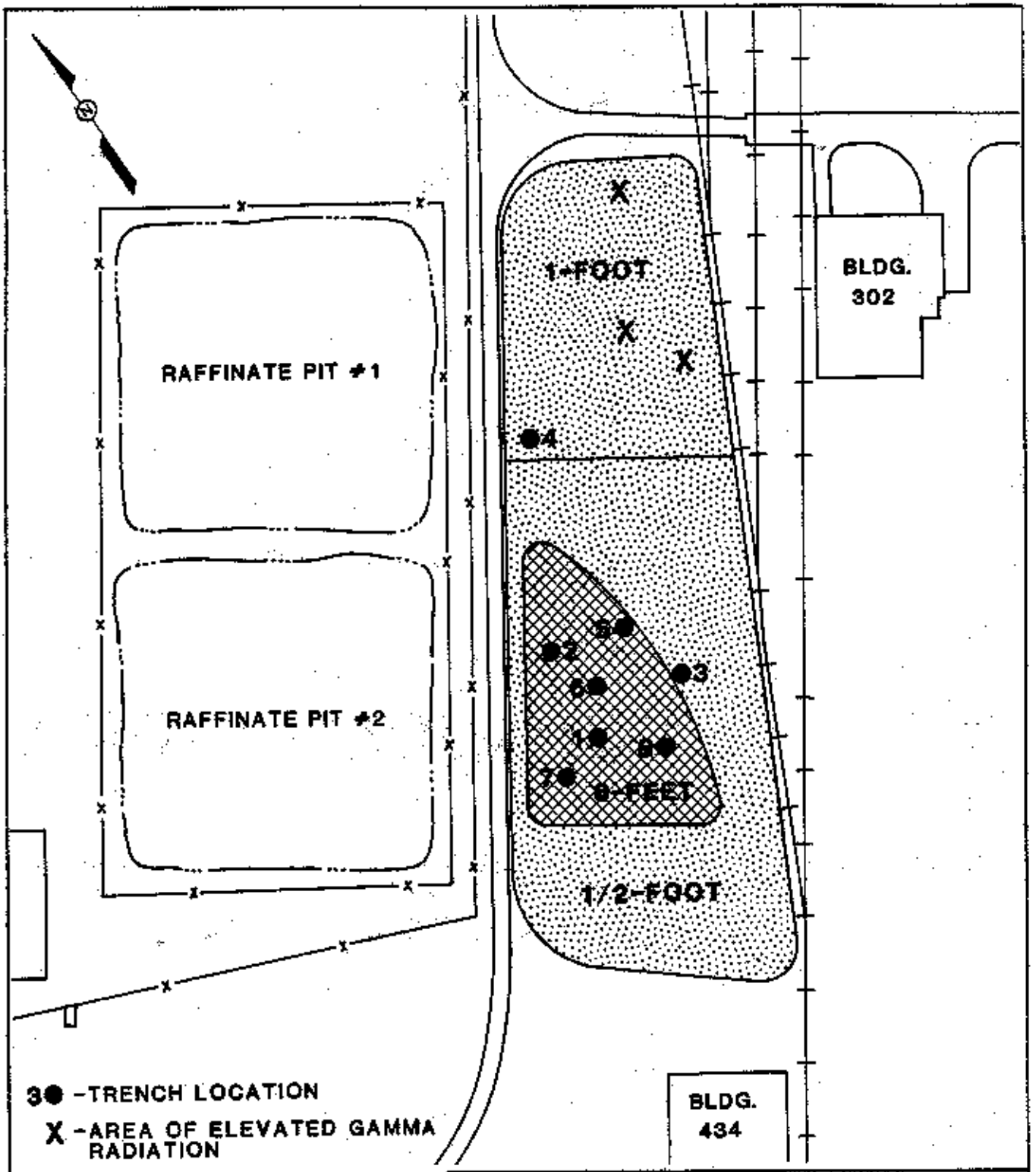
7.1.2 Aquatic Sampling

Fish and turtle specimens were collected during the 1990 calendar year to assess bio-uptake in aquatic habitats. In May 1990, a fish survey was performed in conjunction with MDOC in the Busch Wildlife area. Lakes 34 and 35 were sampled using electroshocking methods. Channel and bullhead catfish, sunfish (redear, green and bluegill) and largemouth bass were collected from Lake 34. The same three species were also collected in Lake 35, along with black crappie and white crappie. Fish samples which included (fillets, cakes, and the entire fish) were analyzed for isotopic uranium. The data results showed a range of concentrations from below the detection limit of .001 pCi/g to 0.349 pCi/g (0.000037 Bq/g to 0.0129 Bq/g). The whole fish samples from Lakes 34 and 35 showed the highest uranium concentrations.

On May 16, 1990, a snapping turtle was captured from the raffinate pit area. The turtle was analyzed to determine bioaccumulation of U-238, isotopic thorium, and isotopic radium. Four samples; skin, muscle tissue, bones, and internal organs were analyzed separately for each of the isotopes. Data results ranged from <.001 pCi/g (<0.000037 Bq/g) for Th–232 in muscle tissues and organs to 7.17 pCi/g (0.265 Bq/g) for Th-228 in the bone sample. A report is being prepared that will present the data and further discuss the findings of this study.

7.1.3 Southeast Drainage Sampling

The Southeast Drainage Flow Study was initiated during 1990 as a three-step investigation to determine the impacts of contaminated sediments on relatively uncontaminated stream flow. Steps one and two were performed in the autumn of 1990 at flow rates of 100 gal/min (gpm) (378.5 liters/min) and 200 gpm (757 liters/min). Step three



BURIED BRICK TRENCHING AREA

FIGURE 7-1

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ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 4/91

is consistent with site characterization results for this area. The average U-238 concentration in this area, based on site characterization performed in 1987, is approximately 20 pCi/g (0.74 Bq/g). Trench No. 4 exhibited unexpected results. This trench was out of the suspected debris area, and no debris other than gravel was encountered. However, the composite soil sample collected from this location contained 125 pCi/g (4.625 Bq/g) of U-238. This is much higher than the 20 pCi/g (0.74 Bq/g) average found during site characterization. A more thorough discussion and presentation of the data are included in the completion report being prepared by the Project Management Contractor (PMC).

7.1.6 Transformer 411 Characterization

Number 411 Electrical Substation is located on Department of Conservation property south of the Weldon Spring Chemical Plant (WSCP). The objective of the characterization effort was to supply the data necessary to prepare a subcontract package for the removal of all transformers and dielectric fluids contained at Substation 411.

Actual sampling of Substation 411 was performed on April 23 and 24, 1990. This included soil sampling throughout the area and collection of dielectric fluid (oil) samples from each transformer. A sampling plan was developed prior to sampling which contained detailed information on sampling locations, equipment, techniques, and personal protective equipment to be used during the sampling effort.

Two pole mounted transformers located within Substation 411 could not be sampled in April due to safety concerns. On June 14, 1990, a subcontractor was employed to disconnect and remove the transformers from their respective poles and place them on the substation concrete pad. The transformers were sampled on June 20, 1990, using the prescribed sampling techniques.

The results of the sampling were as follows: the oils in the transformers were determined to contain background levels of uranium; the oils contained varying levels of PCBs ranging from 6.1 ppm to 1,100 ppm of PCB (Arochlor 1260); the transformers were drained and rinsed as required by 40 CFR 761.60(b)(1)(i)B.

The soils surrounding the substation were sampled for Hazardous Substance List (HSL) metals, nitroaromatics, and PCBs. Metal levels were within the range of background.

Two soil samples showed low levels of nitrobenzene. Two samples showed detectable levels of PCBs, although both were below the 10 ppm clean-up criteria in 40 CFR 761.125(c)(4). Further detail on this investigation is available in the completion report for this effort (MKF and JEG 1990d).

7.2 Interim Response Actions

7.2.1 Quarry Water Treatment Plant Soil Remediation

The quarry construction staging area (QCSA) is an area adjacent to the WSQ to be used for placement of a quarry water treatment system to support the treatment of contaminated water from the quarry pond and subsequent removal of bulk wastes from the quarry.

The planned QCSA is to include an equalization basin, two effluent ponds, roads, parking areas, and infrastructure along with a water treatment plant. Before work could begin on the QCSA, contamination due to spills from haul trucks and railroad cars bringing wastes into quarry during past disposal operations had to be characterized.

Prior to radiological characterization, background gamma radiation levels and soil radionuclide concentrations were measured in the vicinity of the WSQ. The background locations were selected in areas unaffected by previous operations at the Weldon Spring site. Soil samples were collected in these background areas to a depth of 15.24 cm (6 in). All soil samples were analyzed for U-238, Ra-226 and Th-232 via high-purity germanium (HpGe) gamma spectroscopy.

Using background gamma radiation levels and soil radionuclide concentrations as a guide, initial characterization of the QCSA was performed. Systematic soil sampling was performed within the QCSA. Sample locations were established approximately every 68 m (200 ft) along the Little Femme Osage Creek, the quarry access road, and the abandoned railroad tracks and spurs. Seventeen sample locations were established and 20 soil samples were collected. These soil samples were taken to determine whether radioactive contamination occurs in these areas and, if necessary, to guide further sampling. Further information concerning the QCSA initial characterization may be found in the *Radiological*

and Chemical Characterization Report For The Planned Quarry Construction Staging Area and Water Treatment Plant, (MKF and JEG 1989d).

The areal extent of contamination was determined after the initial characterization was performed and contaminated areas were identified. This was done to determine explicit perimeter boundaries (depth and area) of the contaminated zones determined in the initial characterization. Previously determined background radiation and background radionuclide concentrations were used in this phase of characterization.

Thirty-four sample grids bordering the perimeters of the contaminated Zones 1, 2, and 3, previously identified in the initial characterization were established, and total of 36 composite soil samples were collected. Figure 7-2 displays these zones.

As a result of this characterization, the perimeters of the extent of contamination were unchanged from those previously determined by initial characterization. The single exception was one sample grid which had results for Th-230 of 6.9 pCi/g (0.255 Bq/g). This area was added to those which required remediation.

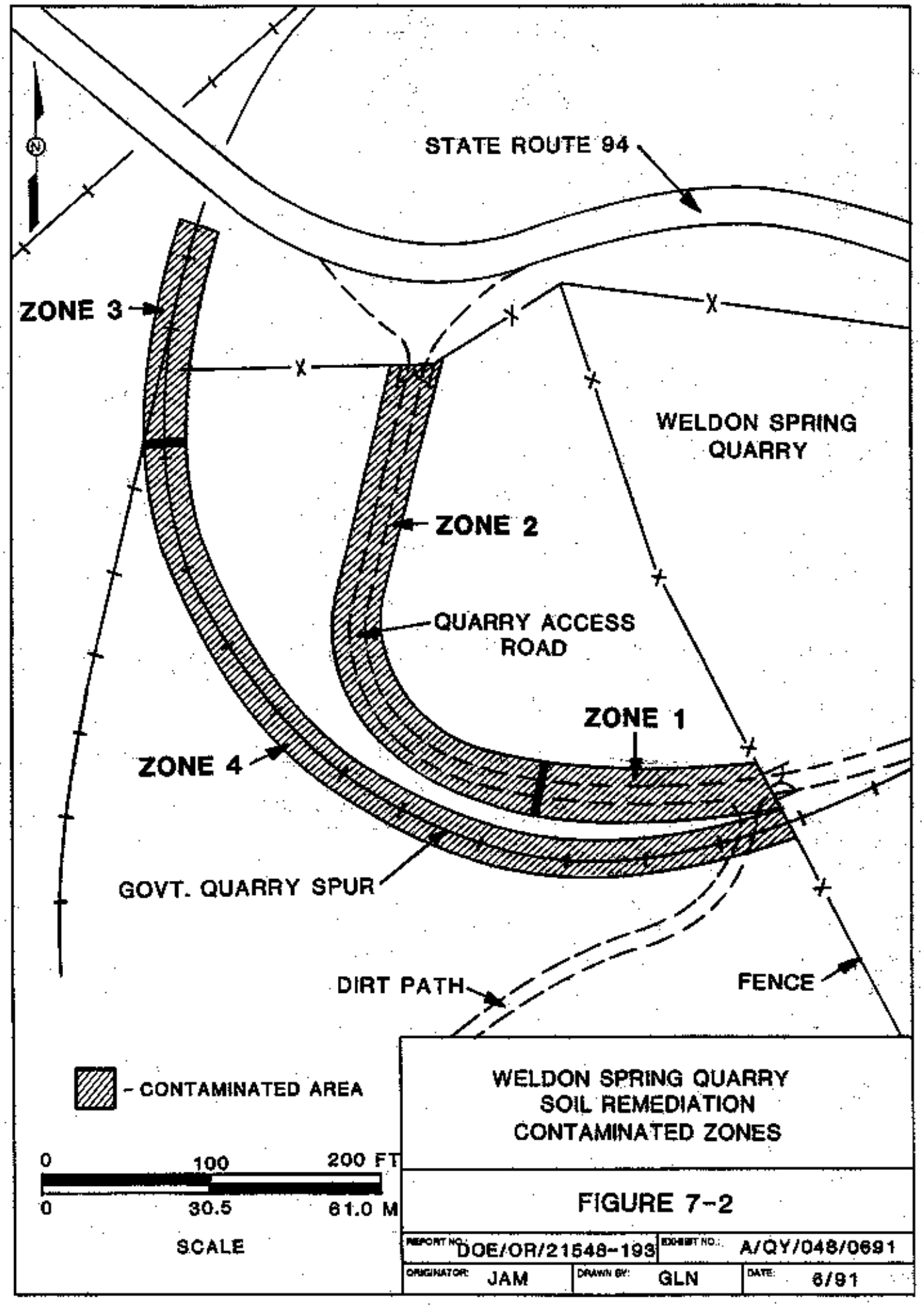
After contaminated zone perimeters were established through initial and areal extent characterization, remediation was performed by excavating with a backhoe and dumptruck. The excavated soil was placed in a soils staging area within the fenced inner quarry area.

Characterization to confirm the completion of remediation was performed immediately following excavation of each area. After each area was remediated, a walk-over scan of the exposed surface was performed. Walk-over scans after remediation revealed background levels of contamination.

Soil was sampled in each area after the walk-over scans were performed. All verification samples taken after remediation revealed concentrations of Th-230, U-238, Ra-226, and Ra-228 below criteria established for this project.

7.2.2 Containerized Chemical Consolidation

As reported in the 1989 *Annual Site Environmental Report* (MKF and JEG 1989c) the containerized chemical consolidation program continued to identify, characterize, consolidate,



WELDON SPRING QUARRY
SOIL REMEDIATION
CONTAMINATED ZONES

FIGURE 7-2

REPORT NO: DOE/OR/21548-193	EXHIBIT NO.: A/QY/048/0691	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 6/91

repackage and temporarily store chemical wastes which were located throughout the chemical plant. Approximately 6,000 containers (bottles, jars, barrels, etc.) have been repackaged and placed into storage. Work has begun on characterizing the process piping, sumps, tanks, and vessels which occur throughout the site. Upon completion, the results of this program will be described in a characterization report.

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40 CFR 61 Subpart H - National Emission Standards for Hazardous Air Pollutants

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40 CFR 264 - Code of Federal Regulations Part 264 Standards for Owners and Operators and Disposal Facilities, July 1, 1990.

19 CSR 20-10.040 - Maximum Permissible Exposure Limits

APPENDIX A
QUARTERLY MONITORING DATA FOR WATER MEDIA

Appendix A contains all of the measured valves that were used to calculate the annual averages reported in the preceding text. Although the quarterly and annual sampling schedules varied by media and location, all data in the appendix are tabulated by the quarter during which they were collected.

Consequently, this format represents differing numbers of data points per location based on the sampling schedule of each location.

The data are organized by media beginning with groundwater, followed by springs, and then surface water. Data within each section are arranged by analytical category as follows: nitraromatics, inorganic anions, and radiological species.

1,3,5-TRINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	20.0			52.0	µg/l
GW-1004	0.21			0.79	µg/l
GW-1005	ND			ND	µg/l
GW-1006	5.60			120	µg/l
GW-1007	ND			ND	µg/l
GW-1008		ND		ND	µg/l
GW-1009	ND			ND	µg/l
GW-1010	ND		ND		µg/l
GW-1011	ND		ND		µg/l
GW-1012	ND			ND	µg/l
GW-1013	ND			ND	µg/l
GW-1014	ND			ND	µg/l
GW-1015	17.9			11.0	µg/l
GW-1016	0.26			0.48	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	0.00	ND	µg/l
GW-1020	ND	ND	ND	ND	µg/l
GW-1021	ND	ND	ND	ND	µg/l
GW-1022	ND	ND	ND	ND	µg/l
GW-1023		ND	ND	ND	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-1025		ND		ND	µg/l
GW-1026		ND		ND	µg/l
GW-1027	ND			0.13	µg/l
GW-1028	ND			ND	µg/l
GW-2001		ND	.032		µg/l
GW-2002		ND		ND	µg/l
GW-2003		ND	ND		µg/l
GW-2004		ND	ND		µg/l
GW-2005		ND	ND		µg/l
GW-2006		12.0	11.0		µg/l
GW-2007		ND	ND		µg/l
GW-2008		12.0	0.91		µg/l
GW-2009		ND	ND		µg/l
GW-2010		0.26	0.24		µg/l
GW-2011		0.19			µg/l
GW-2012		5.20	3.50		µg/l
GW-2013	7.50		5.90	ND	µg/l
GW-2014		4.00		ND	µg/l
GW-2015		ND	ND		µg/l
GW-2017		ND	.074		µg/l
GW-2018		ND		ND	µg/l
GW-2019		ND		ND	µg/l
GW-2020		ND			µg/l

1,3,5-TRINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2021		ND		ND	µg/l
GW-2022		ND		ND	µg/l
GW-2023		ND		ND	µg/l
GW-2024		ND		ND	µg/l
GW-2025		ND		ND	µg/l
GW-2026		ND		ND	µg/l
GW-2027		ND		ND	µg/l
GW-2028		ND		ND	µg/l
GW-2029		ND	ND		µg/l
GW-3001		0.09	0.14	ND	µg/l
GW-3002		ND			µg/l
GW-3003		ND	ND		µg/l
GW-3006		ND	ND		µg/l
GW-3008		ND			µg/l
GW-3009		0.36		0.11	µg/l
GW-3010		ND		ND	µg/l
GW-3019		ND	ND		µg/l
GW-4001		60.0	58.000		µg/l
GW-4002		0.20	0.27		µg/l
GW-4003		ND	ND		µg/l
GW-4004	ND			ND	µg/l
GW-4005	ND			ND	µg/l
GW-4006		22.0	17.000		µg/l
GW-4007		ND		ND	µg/l
GW-4008		ND		ND	µg/l
GW-4009	ND		ND		µg/l
GW-4010	ND			ND	µg/l
GW-4011		ND		ND	µg/l
GW-4012	ND		ND		µg/l
GW-4013		43.0		34.0	µg/l
GW-4014		0.45		0.48	µg/l
GW-4015		0.48		0.16	µg/l
GW-4016		ND	ND		µg/l
GW-4017		ND	ND		µg/l
GW-4018		ND	ND		µg/l
GW-4019	ND			ND	µg/l
GW-4020		ND		ND	µg/l
GW-4021	ND		ND		µg/l
GW-4022	ND		ND		µg/l
GW-4023	0.08		0.100		µg/l
GW-FINN		ND			µg/l
GW-FINW	ND		ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03		ND	ND	ND	µg/l

1,3,5-TRINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND		ND	µg/l
GW-PW06	ND	ND	ND	ND	µg/l
GW-PW07	ND	ND	ND	ND	µg/l
GW-PW08	ND	ND	ND	ND	µg/l
GW-PW09	ND	ND	ND	ND	µg/l
GW-RAWW	ND	ND	ND	ND	µg/l
GW-RMW1	ND	ND	ND	ND	µg/l
GW-RMW2	ND	ND	ND	ND	µg/l
GW-RMW3	ND	ND	ND	ND	µg/l
GW-RMW4	ND	ND	ND	ND	µg/l

1,3-DINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	ND			0.27	µg/l
GW-1004	ND			ND	µg/l
GW-1005	ND			ND	µg/l
GW-1006	ND			0.19	µg/l
GW-1007	ND			ND	µg/l
GW-1008		ND		0.14	µg/l
GW-1009	ND			ND	µg/l
GW-1010	ND		ND		µg/l
GW-1011	ND		ND		µg/l
GW-1012	ND			ND	µg/l
GW-1013	ND			ND	µg/l
GW-1014	ND			ND	µg/l
GW-1015	ND			0.22	µg/l
GW-1016	0.66			0.20	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	0.00	ND	µg/l
GW-1020	ND	ND	ND	ND	µg/l
GW-1021	ND	ND	ND	ND	µg/l
GW-1022	ND	ND	ND	ND	µg/l
GW-1023		ND	ND	ND	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-1025		ND		ND	µg/l
GW-1026		ND		ND	µg/l
GW-1027	ND			ND	µg/l
GW-1028	ND			ND	µg/l
GW-2001		ND	ND		µg/l
GW-2002		ND		ND	µg/l
GW-2003		ND	ND		µg/l
GW-2004		ND	ND		µg/l
GW-2005		ND	ND		µg/l
GW-2006		0.14	ND		µg/l
GW-2007		ND	ND		µg/l
GW-2008		0.14	ND		µg/l
GW-2009		0.50	ND		µg/l
GW-2010		0.11	0.20		µg/l
GW-2011		0.48			µg/l
GW-2012		0.29	ND		µg/l
GW-2013	ND		ND	ND	µg/l
GW-2014		0.14		ND	µg/l
GW-2015		ND	ND		µg/l
GW-2017		ND	ND		µg/l
GW-2018		ND		ND	µg/l
GW-2019		ND		ND	µg/l
GW-2020		ND			µg/l
GW-2021		ND		ND	µg/l

1,3-DINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2022		ND		ND	µg/l
GW-2023		ND		ND	µg/l
GW-2024		ND		ND	µg/l
GW-2025		ND		ND	µg/l
GW-2026		ND		ND	µg/l
GW-2027		ND		ND	µg/l
GW-2028		ND		ND	µg/l
GW-2029		ND	ND		µg/l
GW-3001		ND	ND	ND	µg/l
GW-3002		ND			µg/l
GW-3003		ND	ND		µg/l
GW-3006		ND	ND		µg/l
GW-3008		ND			µg/l
GW-3009		ND		ND	µg/l
GW-3010		ND		ND	µg/l
GW-3019		ND	ND		µg/l
GW-4001		ND	ND		µg/l
GW-4002		ND	ND		µg/l
GW-4003		ND	ND		µg/l
GW-4004	ND			ND	µg/l
GW-4005	ND			ND	µg/l
GW-4006		ND	ND		µg/l
GW-4007		ND		ND	µg/l
GW-4008		ND		ND	µg/l
GW-4009	ND		ND		µg/l
GW-4010	ND			ND	µg/l
GW-4011		ND		ND	µg/l
GW-4012	ND		ND		µg/l
GW-4013		ND		ND	µg/l
GW-4014		ND		ND	µg/l
GW-4015		ND		ND	µg/l
GW-4016		ND	ND		µg/l
GW-4017		ND	ND		µg/l
GW-4018		ND	ND		µg/l
GW-4019	ND			ND	µg/l
GW-4020		ND		ND	µg/l
GW-4021	ND		ND		µg/l
GW-4022	ND		ND		µg/l
GW-4023	ND		ND		µg/l
GW-FINN		ND			µg/l
GW-FINW	ND		ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03		ND	ND	ND	µg/l

1,3-DINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND		ND	µg/l
GW-PW06	ND	ND	ND	ND	µg/l
GW-PW07	ND	ND	ND	ND	µg/l
GW-PW08	ND	ND	ND	ND	µg/l
GW-PW09	ND	ND	ND	ND	µg/l
GW-RAWW	ND	ND	ND	ND	µg/l
GW-RMW1	ND	ND	ND	ND	µg/l
GW-RMW2	ND	ND	ND	ND	µg/l
GW-RMW3	ND	ND	ND	ND	µg/l
GW-RMW4	ND	ND	ND	ND	µg/l

2,4,6-TNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	6.40			10.0	µg/l
GW-1004	1.90			4.20	µg/l
GW-1005	ND			ND	µg/l
GW-1006	8.90			18.0	µg/l
GW-1007	ND			ND	µg/l
GW-1008		ND		ND	µg/l
GW-1009	ND			ND	µg/l
GW-1010	ND		ND		µg/l
GW-1011	ND		ND		µg/l
GW-1012	ND			ND	µg/l
GW-1013	ND			ND	µg/l
GW-1014	ND			ND	µg/l
GW-1015	8.13			4.9	µg/l
GW-1016	0.57			0.28	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	0.00	ND	µg/l
GW-1020	ND	ND	ND	ND	µg/l
GW-1021	ND	ND	ND	ND	µg/l
GW-1022	ND	ND	ND	ND	µg/l
GW-1023		ND	ND	ND	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-1025		ND		ND	µg/l
GW-1026		ND		ND	µg/l
GW-1027	2.40			28.0	µg/l
GW-1028	ND			ND	µg/l
GW-2001		ND	ND		µg/l
GW-2002		ND		ND	µg/l
GW-2003		ND	ND		µg/l
GW-2004		ND	ND		µg/l
GW-2005		ND	ND		µg/l
GW-2006		ND	0.039		µg/l
GW-2007		ND	ND		µg/l
GW-2008		ND	0.036		µg/l
GW-2009		ND	ND		µg/l
GW-2010		0.36	0.55		µg/l
GW-2011		0.06			µg/l
GW-2012		1.60	0.74		µg/l
GW-2013	2.60		1.20	ND	µg/l
GW-2014		0.03		ND	µg/l
GW-2015		ND	ND		µg/l
GW-2017		ND	ND		µg/l
GW-2018		ND		ND	µg/l
GW-2019		ND		ND	µg/l
GW-2020		ND			µg/l
GW-2021		ND		ND	µg/l

2,4,6-TNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2022		ND		ND	µg/l
GW-2023		ND		ND	µg/l
GW-2024		ND		ND	µg/l
GW-2025		ND		ND	µg/l
GW-2026		ND		ND	µg/l
GW-2027		ND		ND	µg/l
GW-2028		ND		ND	µg/l
GW-2029		ND	ND		µg/l
GW-3001		ND	ND	ND	µg/l
GW-3002		ND			µg/l
GW-3003		ND	ND		µg/l
GW-3006		ND	ND		µg/l
GW-3008		ND			µg/l
GW-3009		ND		ND	µg/l
GW-3010		ND		ND	µg/l
GW-3019		ND	ND		µg/l
GW-4001		1.90	2.000		µg/l
GW-4002		1.90	0.20		µg/l
GW-4003		ND	ND		µg/l
GW-4004	ND			ND	µg/l
GW-4005	ND			ND	µg/l
GW-4006		ND	ND		µg/l
GW-4007		ND		ND	µg/l
GW-4008		ND		ND	µg/l
GW-4009	ND		ND		µg/l
GW-4010	ND			ND	µg/l
GW-4011		ND		ND	µg/l
GW-4012	ND		ND		µg/l
GW-4013		0.08		0.07	µg/l
GW-4014		0.06		0.06	µg/l
GW-4015		ND		ND	µg/l
GW-4016		ND	ND		µg/l
GW-4017		ND	ND		µg/l
GW-4018		ND	ND		µg/l
GW-4019	ND			ND	µg/l
GW-4020		ND		ND	µg/l
GW-4021	ND		ND		µg/l
GW-4022	ND		ND		µg/l
GW-4023	ND		ND		µg/l
GW-FINN		ND			µg/l
GW-FINW	ND		ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03		ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND		ND	µg/l

2,4,6-TNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW06	ND	ND	ND	ND	µg/l
GW-PW07	ND	ND	ND	ND	µg/l
GW-PW08	ND	ND	ND	ND	µg/l
GW-PW09	ND	ND	ND	ND	µg/l
GW-RAWW	ND	ND	ND	ND	µg/l
GW-RMW1	ND	ND	ND	ND	µg/l
GW-RMW2	ND	ND	ND	ND	µg/l
GW-RMW3	ND	ND	ND	ND	µg/l
GW-RMW4	ND	ND	ND	ND	µg/l

2,4-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	ND			ND	µg/l
GW-1004	0.08			1.60	µg/l
GW-1005	ND			0.16	µg/l
GW-1006	ND			0.16	µg/l
GW-1007	ND			ND	µg/l
GW-1008		ND		ND	µg/l
GW-1009	ND			ND	µg/l
GW-1010	ND		ND		µg/l
GW-1011	ND		ND		µg/l
GW-1012	ND			ND	µg/l
GW-1013	ND			0.038	µg/l
GW-1014	0.10			0.031	µg/l
GW-1015	0.36			ND	µg/l
GW-1016	ND			ND	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	0.00	ND	µg/l
GW-1020	ND	ND	ND	ND	µg/l
GW-1021	ND	ND	ND	ND	µg/l
GW-1022	ND	ND	ND	ND	µg/l
GW-1023		ND	ND	ND	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-1025		ND		ND	µg/l
GW-1026		ND		ND	µg/l
GW-1027	38.0			12.0	µg/l
GW-1028	ND			ND	µg/l
GW-2001		0.14	.071		µg/l
GW-2002		0.07		0.083	µg/l
GW-2003		0.30	0.28		µg/l
GW-2004		ND	ND		µg/l
GW-2005		0.08	.079		µg/l
GW-2006		0.06	ND		µg/l
GW-2007		ND	ND		µg/l
GW-2008		ND	ND		µg/l
GW-2009		0.74	ND		µg/l
GW-2010		0.95	0.032		µg/l
GW-2011		14.0			µg/l
GW-2012		4.30	ND		µg/l
GW-2013	5.40		0.54	ND	µg/l
GW-2014		2.20		ND	µg/l
GW-2015		ND	ND		µg/l
GW-2017		ND	ND		µg/l
GW-2018		ND		ND	µg/l
GW-2019		ND		ND	µg/l
GW-2020		ND			µg/l
GW-2021		ND		ND	µg/l

2,4-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2022		ND		ND	µg/l
GW-2023		ND		ND	µg/l
GW-2024		ND		ND	µg/l
GW-2025		ND		ND	µg/l
GW-2026		ND		ND	µg/l
GW-2027		ND		ND	µg/l
GW-2028		ND		ND	µg/l
GW-2029		ND	ND		µg/l
GW-3001		0.38	0.66	ND	µg/l
GW-3002		ND			µg/l
GW-3003		ND	.034		µg/l
GW-3006		0.06	ND		µg/l
GW-3008		0.08			µg/l
GW-3009		0.17		0.11	µg/l
GW-3010		ND		ND	µg/l
GW-3019		ND	ND		µg/l
GW-4001		3.00	3.100		µg/l
GW-4002		ND	ND		µg/l
GW-4003		ND	ND		µg/l
GW-4004	ND			ND	µg/l
GW-4005	ND			ND	µg/l
GW-4006		ND	ND		µg/l
GW-4007		ND		ND	µg/l
GW-4008		ND		ND	µg/l
GW-4009	ND		ND		µg/l
GW-4010	ND			ND	µg/l
GW-4011		ND		ND	µg/l
GW-4012	ND		ND		µg/l
GW-4013		0.40		0.04	µg/l
GW-4014		ND		ND	µg/l
GW-4015		ND		0.05	µg/l
GW-4016		ND	ND		µg/l
GW-4017		ND	ND		µg/l
GW-4018		ND	ND		µg/l
GW-4019	ND			ND	µg/l
GW-4020		ND		ND	µg/l
GW-4021	ND		ND		µg/l
GW-4022	ND		ND		µg/l
GW-4023	0.06		0.075		µg/l
GW-FINN		ND			µg/l
GW-FINW	ND		ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03		ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND		ND	µg/l

2,4-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW06	ND	ND	ND	ND	µg/l
GW-PW07	ND	ND	ND	ND	µg/l
GW-PW08	ND	ND	ND	ND	µg/l
GW-PW09	ND	ND	ND	ND	µg/l
GW-RAWW	ND	ND	ND	ND	µg/l
GW-RMW1	ND	ND	ND	ND	µg/l
GW-RMW2	ND	ND	ND	ND	µg/l
GW-RMW3	ND	ND	ND	ND	µg/l
GW-RMW4	ND	ND	ND	ND	µg/l

2,6-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	2.60			4.40	µg/l
GW-1004	1.80			3.80	µg/l
GW-1005	0.08			0.062	µg/l
GW-1006	4.60			7.40	µg/l
GW-1007	ND			ND	µg/l
GW-1008		ND		ND	µg/l
GW-1009	ND			ND	µg/l
GW-1010	ND		ND		µg/l
GW-1011	ND		ND		µg/l
GW-1012	ND			ND	µg/l
GW-1013	ND			ND	µg/l
GW-1014	0.02			ND	µg/l
GW-1015	0.37			0.56	µg/l
GW-1016	ND			0.070	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	0.00	ND	µg/l
GW-1020	ND	ND	ND	ND	µg/l
GW-1021	ND	ND	ND	ND	µg/l
GW-1022	ND	ND	ND	ND	µg/l
GW-1023		ND	ND	ND	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-1025		ND		ND	µg/l
GW-1026		ND		ND	µg/l
GW-1027	17.0			6.70	µg/l
GW-1028	ND			ND	µg/l
GW-2001		0.06	.048		µg/l
GW-2002		0.34		0.49	µg/l
GW-2003		1.60	1.20		µg/l
GW-2004		ND	ND		µg/l
GW-2005		0.07	.050		µg/l
GW-2006		1.40	1.60		µg/l
GW-2007		ND	ND		µg/l
GW-2008		1.60	0.72		µg/l
GW-2009		0.50	0.35		µg/l
GW-2010		1.00	0.75		µg/l
GW-2011		2.20			µg/l
GW-2012		1.90	1.40		µg/l
GW-2013	29.0		13.0	ND	µg/l
GW-2014		1.20		ND	µg/l
GW-2015		ND	ND		µg/l
GW-2017		ND	1.20		µg/l
GW-2018		ND		ND	µg/l
GW-2019		ND		ND	µg/l
GW-2020		ND			µg/l
GW-2021		ND		ND	µg/l

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2,6-DNT

1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2022		ND		ND	µg/l
GW-2023		ND		ND	µg/l
GW-2024		ND		ND	µg/l
GW-2025		ND		ND	µg/l
GW-2026		ND		ND	µg/l
GW-2027		ND		ND	µg/l
GW-2028		ND		ND	µg/l
GW-2029		ND	ND		µg/l
GW-3001		0.17	0.20	ND	µg/l
GW-3002		ND			µg/l
GW-3003		ND	.073		µg/l
GW-3006		0.11	ND		µg/l
GW-3008		0.04			µg/l
GW-3009		0.14		0.06	µg/l
GW-3010		ND		ND	µg/l
GW-3019		ND	ND		µg/l
GW-4001		3.20	3.100		µg/l
GW-4002		0.56	0.13		µg/l
GW-4003		ND	ND		µg/l
GW-4004	ND			ND	µg/l
GW-4005	ND			ND	µg/l
GW-4006		4.60	3.500		µg/l
GW-4007		ND		ND	µg/l
GW-4008		ND		ND	µg/l
GW-4009	ND		ND		µg/l
GW-4010	ND			ND	µg/l
GW-4011		ND		ND	µg/l
GW-4012	ND		ND		µg/l
GW-4013		1.50		1.30	µg/l
GW-4014		0.05		0.12	µg/l
GW-4015		1.80		2.20	µg/l
GW-4016		ND	ND		µg/l
GW-4017		ND	ND		µg/l
GW-4018		ND	ND		µg/l
GW-4019	ND			ND	µg/l
GW-4020		ND		ND	µg/l
GW-4021	ND		ND		µg/l
GW-4022	ND		ND		µg/l
GW-4023	0.02		0.028		µg/l
GW-FINN		ND			µg/l
GW-FINW	ND		ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03		ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND		ND	µg/l

2,6-DNT

1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW06	ND	ND	ND	ND	µg/l
GW-PW07	ND	ND	ND	ND	µg/l
GW-PW08	ND	ND	ND	ND	µg/l
GW-PW09	ND	ND	ND	ND	µg/l
GW-RAWW	ND	ND	ND	ND	µg/l
GW-RMW1	ND	ND	ND	ND	µg/l
GW-RMW2	ND	ND	ND	ND	µg/l
GW-RMW3	ND	ND	ND	ND	µg/l
GW-RMW4	ND	ND	ND	ND	µg/l

NITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	ND			ND	µg/l
GW-1004	ND			ND	µg/l
GW-1005	ND			ND	µg/l
GW-1006	ND			ND	µg/l
GW-1007	ND			ND	µg/l
GW-1008		ND		ND	µg/l
GW-1009	ND			ND	µg/l
GW-1010	ND		ND		µg/l
GW-1011	ND		ND		µg/l
GW-1012	ND			ND	µg/l
GW-1013	ND			ND	µg/l
GW-1014	ND			ND	µg/l
GW-1015	ND			ND	µg/l
GW-1016	ND			ND	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	ND	ND	µg/l
GW-1020	ND	ND	ND	ND	µg/l
GW-1021	ND	ND	ND	ND	µg/l
GW-1022	ND	ND	ND	ND	µg/l
GW-1023		ND	ND	ND	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-1025		ND		ND	µg/l
GW-1026		ND		ND	µg/l
GW-1027	ND			ND	µg/l
GW-1028	ND			ND	µg/l
GW-2001		ND	ND		µg/l
GW-2002		ND		ND	µg/l
GW-2003		ND	ND		µg/l
GW-2004		ND	ND		µg/l
GW-2005		ND	ND		µg/l
GW-2006		ND	ND		µg/l
GW-2007		ND	ND		µg/l
GW-2008		ND	ND		µg/l
GW-2009		ND	ND		µg/l
GW-2010		ND	ND		µg/l
GW-2011		ND			µg/l
GW-2012		ND	ND		µg/l
GW-2013	ND		ND	ND	µg/l
GW-2014		ND		ND	µg/l
GW-2015		ND	ND		µg/l
GW-2017		ND	ND		µg/l
GW-2018		ND		ND	µg/l
GW-2019		ND		ND	µg/l
GW-2020		ND			µg/l
GW-2021		ND		ND	µg/l

NITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2022		ND		ND	µg/l
GW-2023		ND		ND	µg/l
GW-2024		ND		ND	µg/l
GW-2025		ND		ND	µg/l
GW-2026		ND		ND	µg/l
GW-2027		ND		ND	µg/l
GW-2028		ND		ND	µg/l
GW-2029		ND	ND		µg/l
GW-3001		ND	ND	ND	µg/l
GW-3002		ND			µg/l
GW-3003		ND	ND		µg/l
GW-3006		ND	ND		µg/l
GW-3008		ND			µg/l
GW-3009		ND		ND	µg/l
GW-3010		ND		ND	µg/l
GW-3019		ND	ND		µg/l
GW-4001		ND	ND		µg/l
GW-4002		ND	ND		µg/l
GW-4003		ND	ND		µg/l
GW-4004	ND			ND	µg/l
GW-4005	ND			ND	µg/l
GW-4006		ND	ND		µg/l
GW-4007		ND		ND	µg/l
GW-4008		ND		ND	µg/l
GW-4009	ND		ND		µg/l
GW-4010	ND			ND	µg/l
GW-4011		ND		ND	µg/l
GW-4012	ND		ND		µg/l
GW-4013		ND		ND	µg/l
GW-4014		ND		ND	µg/l
GW-4015		ND		ND	µg/l
GW-4016		ND	ND		µg/l
GW-4017		ND	ND		µg/l
GW-4018		ND	ND		µg/l
GW-4019	ND			ND	µg/l
GW-4020		ND		ND	µg/l
GW-4021	ND		ND		µg/l
GW-4022	ND		ND		µg/l
GW-4023	ND		ND		µg/l
GW-FINN		ND			µg/l
GW-FINW	ND		ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03		ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND		ND	µg/l

NITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW06	ND	ND	ND	ND	µg/l
GW-PW07	ND	ND	ND	ND	µg/l
GW-PW08	ND	ND	ND	ND	µg/l
GW-PW09	ND	ND	ND	ND	µg/l
GW-RAWW	ND	ND	ND	ND	µg/l
GW-RMW1	ND	ND	ND	ND	µg/l
GW-RMW2	ND	ND	ND	ND	µg/l
GW-RMW3	ND	ND	ND	ND	µg/l
GW-RMW4	ND	ND	ND	ND	µg/l

CHLORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	7.70			9.44	mg/l
GW-1004	19.0			27.8	mg/l
GW-1005	13.8			25.2	mg/l
GW-1006	28.1			37.0	mg/l
GW-1007	79.8			64.5	mg/l
GW-1008		24.80		24.0	mg/l
GW-1009	25.5			25.5	mg/l
GW-1010	9.50		5.40		mg/l
GW-1011	13.7		9.40		mg/l
GW-1012	6.00			8.06	mg/l
GW-1013	22.2			20.5	mg/l
GW-1014	25.4			23.0	mg/l
GW-1015	25.4			29.0	mg/l
GW-1016	14.3			19.0	mg/l
GW-1017	27.3	23.0	19.0	18.9	mg/l
GW-1018	25.0	23.30	5.90	22.6	mg/l
GW-1019	5.50	6.90	6.10	6.30	mg/l
GW-1020	13.5	11.5	9.20	9.44	mg/l
GW-1021	3.00	11.00	12.0	9.44	mg/l
GW-1022	9.80	9.000	6.00	9.44	mg/l
GW-1023	2.50	5.50	4.40	5.25	mg/l
GW-1024	10.2	10.4	8.90	11.7	mg/l
GW-1025		5.500		5.48	mg/l
GW-1026		4.00		1.96	mg/l
GW-1027	14.000			14.8	mg/l
GW-1028	11.6			8.88	mg/l
GW-2001		9.00	3.60		mg/l
GW-2002		9.50		9.97	mg/l
GW-2003		12.0			mg/l
GW-2004		1.00	ND		mg/l
GW-2005		3.80	2.80		mg/l
GW-2006		279	73.0		mg/l
GW-2007		ND	ND		mg/l
GW-2008		93.3	54.0		mg/l
GW-2009		14.5	8.60		mg/l
GW-2010		49.0	68		mg/l
GW-2011		2.10			mg/l
GW-2012		62.0	12.0		mg/l
GW-2013	6.500		3.40	4.44	mg/l
GW-2014		26.5		26.3	mg/l
GW-2015		1.00	ND		mg/l
GW-2017		13.9	2.00		mg/l
GW-2018		17.9		7.35	mg/l
GW-2019		2.38			mg/l
GW-2020		16.6		17.2	mg/l
GW-2021		1.43		1.05	mg/l

CHLORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2022		1.90		1.57	mg/l
GW-2023		1.90		1.34	mg/l
GW-2024		2.00		1.86	mg/l
GW-2025		2.40		1.05	mg/l
GW-2026		2.00		1.76	mg/l
GW-2027		5.00		1.21	mg/l
GW-2028		2.48		1.65	mg/l
GW-2029		2.00	ND		mg/l
GW-3001		12.9	11.6		mg/l
GW-3002		1.43		0.91	mg/l
GW-3003		12.4	1.40		mg/l
GW-3006		ND	0.68		mg/l
GW-3008		13.5			mg/l
GW-3009		5.80			mg/l
GW-3010		1.50		2.00	mg/l
GW-3019		5.000	0.89		mg/l
GW-4001		3.910			mg/l
GW-4002		3.80	20.0		mg/l
GW-4003		5.70	ND		mg/l
GW-4004	2.32			3.62	mg/l
GW-4005	5.50			4.72	mg/l
GW-4006		2.00	1.60		mg/l
GW-4007		1.500		1.35	mg/l
GW-4008		ND		4.20	mg/l
GW-4009	ND		1.10		mg/l
GW-4010	2.50			2.62	mg/l
GW-4011		4.00		7.50	mg/l
GW-4012	2.500		ND		mg/l
GW-4013		6.50		5.78	mg/l
GW-4014		2.500		4.24	mg/l
GW-4015		2.85		2.69	mg/l
GW-4016		1.50	ND		mg/l
GW-4017		1.50	1.30		mg/l
GW-4018		5.50	6.90		mg/l
GW-4019	1.00			1.60	mg/l
GW-4020		5.70		5.89	mg/l
GW-4021	1.00		2.10		mg/l
GW-4022	6.500		2.40		mg/l
GW-4023	16.3		12.0		mg/l
GW-PW02			15.0		mg/l
GW-PW03			18.0		mg/l
GW-PW04			17.0		mg/l
GW-PW06			17.0		mg/l
GW-PW07			2.9		mg/l
GW-PW08			4.20		mg/l

CHLORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW09			4.80		mg/l
GW-RMW1	6.80	6.95	6.90	7.75	mg/l
GW-RMW2	7.20	3.86	2.1	4.24	mg/l
GW-RMW3	14.6	15.9	9.00	12.2	mg/l
GW-RMW4	11.2	3.50	5.40	10.2	mg/l

FLUORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	0.463			0.41	mg/l
GW-1004	1.18			1.23	mg/l
GW-1005	1.090			1.02	mg/l
GW-1006	0.273			0.36	mg/l
GW-1007	ND			0.44	mg/l
GW-1008		0.256		0.50	mg/l
GW-1009	0.189			0.35	mg/l
GW-1010	0.205		ND		mg/l
GW-1011	0.284		ND		mg/l
GW-1012	0.482			0.43	mg/l
GW-1013	0.482			0.51	mg/l
GW-1014	0.427			0.50	mg/l
GW-1015	0.321			0.38	mg/l
GW-1016	0.262			0.36	mg/l
GW-1017	ND	0.096	ND	0.24	mg/l
GW-1018	0.229	0.212	ND	0.25	mg/l
GW-1019	0.281	0.188	ND	0.20	mg/l
GW-1020	0.331	0.281	ND	0.28	mg/l
GW-1021	0.215	0.109	ND	0.23	mg/l
GW-1022	0.292	0.137	ND	0.20	mg/l
GW-1023		0.171	ND	0.27	mg/l
GW-1024	0.229	0.250	ND	0.35	mg/l
GW-1025		0.168		ND	mg/l
GW-1026		0.191		ND	mg/l
GW-1027	0.200			0.36	mg/l
GW-1028	0.282			ND	mg/l
GW-2001		1.270	ND		mg/l
GW-2002		ND		ND	mg/l
GW-2003		0.086			mg/l
GW-2004		0.160	ND		mg/l
GW-2005		0.190	ND		mg/l
GW-2006		ND	ND		mg/l
GW-2007		0.098	ND		mg/l
GW-2008		0.080	ND		mg/l
GW-2009		0.056	ND		mg/l
GW-2010		0.083	ND		mg/l
GW-2011		0.090			mg/l
GW-2012		0.051	ND		mg/l
GW-2013	ND		ND	ND	mg/l
GW-2014		0.070		ND	mg/l
GW-2015		0.150	ND		mg/l
GW-2017		0.191	ND		mg/l
GW-2018		0.230		0.31	mg/l
GW-2019		0.201			mg/l
GW-2020		0.186		0.30	mg/l
GW-2021		0.146		0.13	mg/l

FLUORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2022		0.178		0.14	mg/l
GW-2023		0.236		ND	mg/l
GW-2024		0.222		0.15	mg/l
GW-2025		0.191		0.18	mg/l
GW-2026		0.180		ND	mg/l
GW-2027		0.138		0.31	mg/l
GW-2028		0.158		0.22	mg/l
GW-2029		0.173	ND		mg/l
GW-3001		0.152	0.167		mg/l
GW-3002		0.186		0.37	mg/l
GW-3003		0.180	ND		mg/l
GW-3006		0.180	ND		mg/l
GW-3008		0.169			mg/l
GW-3009		0.105			mg/l
GW-3010		0.209		0.32	mg/l
GW-3019		0.314	ND		mg/l
GW-4001		0.111			mg/l
GW-4002		0.098	.121		mg/l
GW-4003		0.173	ND		mg/l
GW-4004	0.215			0.45	mg/l
GW-4005	0.327			0.32	mg/l
GW-4006		0.148	ND		mg/l
GW-4007		0.495		0.42	mg/l
GW-4008		0.275		0.28	mg/l
GW-4009	0.327		ND		mg/l
GW-4010	0.241			0.27	mg/l
GW-4011		0.231		0.35	mg/l
GW-4012	0.321		ND		mg/l
GW-4013		ND		ND	mg/l
GW-4014		0.191		1.17	mg/l
GW-4015		0.110		0.26	mg/l
GW-4016		0.212	ND		mg/l
GW-4017		0.148	ND		mg/l
GW-4018		0.105	ND		mg/l
GW-4019	0.444			0.35	mg/l
GW-4020		0.186		ND	mg/l
GW-4021	0.167		ND		mg/l
GW-4022	0.393		ND		mg/l
GW-4023	0.250		ND		mg/l
GW-PW02			ND		mg/l
GW-PW03			ND		mg/l
GW-PW04			ND		mg/l
GW-PW06			ND		mg/l
GW-PW07			ND		mg/l
GW-PW08			ND		mg/l

FLUORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW09			ND		mg/l
GW-RMW1	0.195	0.180	ND	ND	mg/l
GW-RMW2	0.259	0.246	ND	0.35	mg/l
GW-RMW3	0.195	0.186	ND	ND	mg/l
GW-RMW4	ND	0.200	ND	0.27	mg/l

NITRATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	0.557			0.68	mg/l
GW-1004	0.093			0.629	mg/l
GW-1005	ND			ND	mg/l
GW-1006	0.197			1.33	mg/l
GW-1007	ND			ND	mg/l
GW-1008		0.116		ND	mg/l
GW-1009	ND			ND	mg/l
GW-1010	ND		ND		mg/l
GW-1011	ND		ND		mg/l
GW-1012	1.58			1.29	mg/l
GW-1013	ND			ND	mg/l
GW-1014	ND			ND	mg/l
GW-1015	0.349			1.93	mg/l
GW-1016	0.071			1.29	mg/l
GW-1017	ND	ND	ND	ND	mg/l
GW-1018	ND	ND	ND	ND	mg/l
GW-1019	ND	ND	ND	ND	mg/l
GW-1020	ND	ND	ND	ND	mg/l
GW-1021	ND	ND	ND	ND	mg/l
GW-1022	ND	ND	ND	ND	mg/l
GW-1023		ND	ND	ND	mg/l
GW-1024	ND	ND	ND	ND	mg/l
GW-1025		ND		ND	mg/l
GW-1026		ND		ND	mg/l
GW-1027	ND			ND	mg/l
GW-1028	0.06			ND	mg/l
GW-2001		100	14.0		mg/l
GW-2002		493		324	mg/l
GW-2003		266			mg/l
GW-2004		0.61	0.86		mg/l
GW-2005		11900	240		mg/l
GW-2006		5.79	6.20		mg/l
GW-2007		ND	ND		mg/l
GW-2008		2.76	7.40		mg/l
GW-2009		1.73	1.50		mg/l
GW-2010		0.797	0.86		mg/l
GW-2011		2.780			mg/l
GW-2012		0.38	0.38		mg/l
GW-2013	0.954		0.70	0.74	mg/l
GW-2014		1.320		1.99	mg/l
GW-2015		0.28			mg/l
GW-2017		1.23	4.60		mg/l
GW-2018		0.48		0.56	mg/l
GW-2019		ND		2.41	mg/l
GW-2020		0.67		1.11	mg/l
GW-2021		ND		ND	mg/l

NITRATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2022		ND		ND	mg/l
GW-2023		0.08		ND	mg/l
GW-2024		ND		ND	mg/l
GW-2025		ND		ND	mg/l
GW-2026		ND		ND	mg/l
GW-2027		ND		ND	mg/l
GW-2028		ND		ND	mg/l
GW-2029		ND	ND		mg/l
GW-3001		670	404		mg/l
GW-3002		ND		ND	mg/l
GW-3003		2200	360		mg/l
GW-3006		ND	ND		mg/l
GW-3008		646			mg/l
GW-3009		1340		2.09	mg/l
GW-3010		1.08		1.19	mg/l
GW-3019		ND	ND		mg/l
GW-4001		32.300	28.0		mg/l
GW-4002		2.70	3.32		mg/l
GW-4003		0.59	0.76		mg/l
GW-4004	0.72			0.67	mg/l
GW-4005	0.98			1.55	mg/l
GW-4006		14.1			mg/l
GW-4007		0.140		ND	mg/l
GW-4008		ND		ND	mg/l
GW-4009	ND		ND		mg/l
GW-4010	0.12			ND	mg/l
GW-4011		ND		16.8	mg/l
GW-4012	0.130				mg/l
GW-4013		11.8		91.0	mg/l
GW-4014		7.70		0.15	mg/l
GW-4015		2.04		2.74	mg/l
GW-4016		ND	ND		mg/l
GW-4017		ND	0.43		mg/l
GW-4018		0.081	1.80		mg/l
GW-4019	0.177			0.28	mg/l
GW-4020		0.05		ND	mg/l
GW-4021	ND		0.12		mg/l
GW-4022	0.054		ND		mg/l
GW-4023	7.33		4.80		mg/l
GW-FIMW	ND				mg/l
GW-PW02	ND		ND		mg/l
GW-PW03			ND		mg/l
GW-PW04	ND		ND		mg/l
GW-PW05	ND				mg/l
GW-PW06	ND		ND		mg/l

NITRATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW07	ND		ND		mg/l
GW-PW08	ND		ND		mg/l
GW-PW09	ND		ND		mg/l
GW-RAWW	ND				mg/l
GW-RMW1	ND	ND	ND	ND	mg/l
GW-RMW2	0.20	ND	ND	ND	mg/l
GW-RMW3	0.20	ND	ND	ND	mg/l
GW-RMW4	ND	ND	ND	ND	mg/l

SULFATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	50.5			55.0	mg/l
GW-1004	231			330	mg/l
GW-1005	186			268	mg/l
GW-1006	383			675	mg/l
GW-1007	34.7			28.8	mg/l
GW-1008		266		351	mg/l
GW-1009	348			268	mg/l
GW-1010	6.88		ND		mg/l
GW-1011	3.66		34.0		mg/l
GW-1012	72.5			96.2	mg/l
GW-1013	119			120	mg/l
GW-1014	92.5			134	mg/l
GW-1015	192			474	mg/l
GW-1016	196			229	mg/l
GW-1017	14.0	39.2	14.0	2.68	mg/l
GW-1018	71.0	41.2	21.0	105	mg/l
GW-1019	6.90	ND	ND	4.50	mg/l
GW-1020	ND	25.3	20.0	25.2	mg/l
GW-1021	1.10	ND	1.60	ND	mg/l
GW-1022	5.90	ND	ND	1.95	mg/l
GW-1023		ND	4.00	3.77	mg/l
GW-1024	1.70	3.64	5.50	11.0	mg/l
GW-1025		131		134	mg/l
GW-1026		1.81		ND	mg/l
GW-1027	114			156	mg/l
GW-1028	67.5			50.1	mg/l
GW-2001		4.72	4.70		mg/l
GW-2002		147		143	mg/l
GW-2003		232			mg/l
GW-2004		5.13	ND		mg/l
GW-2005		8.68	30.0		mg/l
GW-2006		36.9	33.0		mg/l
GW-2007		15.1	14.0		mg/l
GW-2008		34.8	17.0		mg/l
GW-2009		128	45.0		mg/l
GW-2010		29.8	41.0		mg/l
GW-2011		13.0			mg/l
GW-2012		86.8	45.0		mg/l
GW-2013	22.7		16.0	14.2	mg/l
GW-2014		130		39.2	mg/l
GW-2015		104	ND		mg/l
GW-2017		840	13.0		mg/l
GW-2018		25.3		9.22	mg/l
GW-2019		33.1			mg/l
GW-2020		168		143	mg/l
GW-2021		17.1		13.9	mg/l

SULFATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2022		14.9		14.7	mg/l
GW-2023		24.5		18.4	mg/l
GW-2024		88.0		29.7	mg/l
GW-2025		22.9		15.8	mg/l
GW-2026		23.8		15.2	mg/l
GW-2027		12.6		13.2	mg/l
GW-2028		143		143	mg/l
GW-2029		30.9	25.0		mg/l
GW-3001		24.2	24.8		mg/l
GW-3002		21.1		17.9	mg/l
GW-3003		174	3.20		mg/l
GW-3006		23.8	21.0		mg/l
GW-3008		42.1			mg/l
GW-3009		27.3			mg/l
GW-3010		7.35		6.07	mg/l
GW-3019		6.47	47.0		mg/l
GW-4001		62.0			mg/l
GW-4002		37.2		17.6	mg/l
GW-4003		32.2	350		mg/l
GW-4004	25.1			26.8	mg/l
GW-4005	20.9			25.6	mg/l
GW-4006		31.9	27.0		mg/l
GW-4007		22.4		14.1	mg/l
GW-4008		13.8		15.8	mg/l
GW-4009	17.9		17.0		mg/l
GW-4010	25.9			23.8	mg/l
GW-4011		36.2		38.2	mg/l
GW-4012	57.5		3.90		mg/l
GW-4013		44.400		44.4	mg/l
GW-4014		31.900		29.8	mg/l
GW-4015		15.2		11.7	mg/l
GW-4016		11.8	2.50		mg/l
GW-4017		10.5	6.80		mg/l
GW-4018		9.70	6.80		mg/l
GW-4019	8.02			6.68	mg/l
GW-4020		126		85.4	mg/l
GW-4021	270		260		mg/l
GW-4022	57.5		1.60		mg/l
GW-4023	103		78.0		mg/l
GW-PW02			94.0		mg/l
GW-PW03			130		mg/l
GW-PW04			110		mg/l
GW-PW06			110		mg/l
GW-PW07			22.0		mg/l
GW-PW08			40.0		mg/l

SULFATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW09			53.0		mg/l
GW-RMW1	12.6	20.8	29.0	23.5	mg/l
GW-RMW2	18.7	25.0	32.0	26.8	mg/l
GW-RMW3	16.7	12.0	36.0	61.6	mg/l
GW-RMW4	7.50	29.8	10.0	18.5	mg/l

GROSS ALPHA
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1024	6.00		ND	1.00	pCi/l
GW-FINN		ND			pCi/l
GW-FINW	1.00		ND	1.00	pCi/l
GW-PW02	2.00	2.00	ND	ND	pCi/l
GW-PW03		3.00	ND	2.00	pCi/l
GW-PW04	4.00	ND	ND	1.00	pCi/l
GW-PW05	6.00	2.00		ND	pCi/l
GW-PW06	2.00	3.00	ND	1.00	pCi/l
GW-PW07	1.00	ND	ND	ND	pCi/l
GW-PW08	1.00	ND	ND	ND	pCi/l
GW-PW09	3.00	1.00	ND	3.00	pCi/l
GW-RAWW	4.00	2.00	ND	2.00	pCi/l
GW-RMW1	1.00		ND	2.00	pCi/l
GW-RMW2	4.90	ND	13.1	10.0	pCi/l
GW-RMW3	9.00	ND	ND	ND	pCi/l
GW-RMW4	ND		ND	4.00	pCi/l

GROSS BETA
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1024	1.00				pCi/l
GW-FINW	4.00				pCi/l
GW-PW02	6.00		5.38		pCi/l
GW-PW03			5.52		pCi/l
GW-PW04	5.00		4.64		pCi/l
GW-PW05	2.00				pCi/l
GW-PW06	2.00		5.71		pCi/l
GW-PW07	1.00		5.53		pCi/l
GW-PW08	3.00		7.43		pCi/l
GW-PW09	ND		6.50		pCi/l
GW-RAWW	7.00				pCi/l
GW-RMW1	7.00				pCi/l
GW-RMW2	2.00		7.63		pCi/l
GW-RMW3	ND				pCi/l
GW-RMW4	ND				pCi/l

RADIUM-226
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1024	0.30				pCi/l
GW-4015		0.10			pCi/l
GW-4020		ND			pCi/l
GW-FINW	ND				pCi/l
GW-PW02	0.40				pCi/l
GW-PW04	0.30				pCi/l
GW-PW05	0.60				pCi/l
GW-PW06	0.40				pCi/l
GW-PW07	4.00				pCi/l
GW-PW08	0.60				pCi/l
GW-PW09	0.40				pCi/l
GW-RAWW	0.50				pCi/l
GW-RMW1	0.20				pCi/l
GW-RMW2	0.60				pCi/l
GW-RMW3	0.40				pCi/l
GW-RMW4	0.10				pCi/l

RADIUM-228
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1024	ND				pCi/l
GW-4015		ND			pCi/l
GW-4020		0.70			pCi/l
GW-FINW	0.90				pCi/l
GW-PW02	0.40				pCi/l
GW-PW04	ND				pCi/l
GW-PW05	0.10				pCi/l
GW-PW06	0.90				pCi/l
GW-PW07	0.30				pCi/l
GW-PW08	1.60				pCi/l
GW-PW09	1.30				pCi/l
GW-RAWW	0.70				pCi/l
GW-RMW1	1.20				pCi/l
GW-RMW2	ND				pCi/l
GW-RMW3	0.90				pCi/l
GW-RMW4	ND				pCi/l

THORIUM-230
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1024	ND				pCi/l
GW-4015		ND			pCi/l
GW-4020		0.70			pCi/l
GW-FINW	ND				pCi/l
GW-PW02	ND				pCi/l
GW-PW04	0.30				pCi/l
GW-PW05	ND				pCi/l
GW-PW06	ND				pCi/l
GW-PW07	ND				pCi/l
GW-PW08	0.80				pCi/l
GW-PW09	0.50				pCi/l
GW-RAWW	0.10				pCi/l
GW-RMW1	ND				pCi/l
GW-RMW2	ND				pCi/l
GW-RMW3	0.50				pCi/l
GW-RMW4	0.40				pCi/l

THORIUM-232
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1024	ND				pCi/l
GW-4015		ND			pCi/l
GW-4020		ND			pCi/l
GW-FINW	ND				pCi/l
GW-PW02	0.10				pCi/l
GW-PW04	ND				pCi/l
GW-PW05	ND				pCi/l
GW-PW06	ND				pCi/l
GW-PW07	ND				pCi/l
GW-PW08	0.20				pCi/l
GW-PW09	0.10				pCi/l
GW-RAWW	ND				pCi/l
GW-RMW1	ND				pCi/l
GW-RMW2	ND				pCi/l
GW-RMW3	0.10				pCi/l
GW-RMW4	0.10				pCi/l

URANIUM, TOTAL
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	4.08			0.68	pCi/l
GW-1004	4350			5984	pCi/l
GW-1005	1970			2992	pCi/l
GW-1006	3120			3332	pCi/l
GW-1007	23.8			176.8	pCi/l
GW-1008		6732		3536	pCi/l
GW-1009	2.72			8.16	pCi/l
GW-1010	4.08		0.17		pCi/l
GW-1011	12.2		6.94		pCi/l
GW-1012	2.04			2.04	pCi/l
GW-1013	884			952	pCi/l
GW-1014	680			952	pCi/l
GW-1015	510			639.2	pCi/l
GW-1016	156			190.4	pCi/l
GW-1017	ND		ND	1.36	pCi/l
GW-1018	6.12	ND	ND	ND	pCi/l
GW-1019	4.08			ND	pCi/l
GW-1020	6.12		0.28	3.40	pCi/l
GW-1021			ND	ND	pCi/l
GW-1022			ND	ND	pCi/l
GW-1023	ND		ND	1.36	pCi/l
GW-1024	1.36		ND	ND	pCi/l
GW-1025				1.36	pCi/l
GW-1026				ND	pCi/l
GW-1027				652.8	pCi/l
GW-1028	5.44			7.48	pCi/l
GW-2001			ND		pCi/l
GW-2002		3.40		ND	pCi/l
GW-2003		0.68	1.65		pCi/l
GW-2004			1.87		pCi/l
GW-2006			2.96		pCi/l
GW-2007		4.76	6.37		pCi/l
GW-2008			12.2		pCi/l
GW-2009		2.04	1.07		pCi/l
GW-2010		1.70			pCi/l
GW-2011		ND			pCi/l
GW-2012		ND	ND		pCi/l
GW-2013			0.85	ND	pCi/l
GW-2014		2.04		ND	pCi/l
GW-2015		6.80	2.51		pCi/l
GW-2017			0.48		pCi/l
GW-2018				2.72	pCi/l
GW-2019		3.40		4.76	pCi/l
GW-2020		9.52		5.44	pCi/l
GW-2021		2.04		1.36	pCi/l
GW-2022		ND		1.36	pCi/l

URANIUM, TOTAL
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2023		3.40		10.9	pCi/l
GW-2024		ND		1.36	pCi/l
GW-2025				ND	pCi/l
GW-2026				0.68	pCi/l
GW-2027		2.72		1.36	pCi/l
GW-2028		1.36		2.04	pCi/l
GW-2029			5.58		pCi/l
GW-3001		1.36	0.68		pCi/l
GW-3002		2.04		3.40	pCi/l
GW-3003			20.1		pCi/l
GW-3006			0.42		pCi/l
GW-3008		231.2			pCi/l
GW-3009		29.92		74.8	pCi/l
GW-3010		2.722		ND	pCi/l
GW-3019			6.67		pCi/l
GW-4001		0.68	0.99		pCi/l
GW-4002			ND		pCi/l
GW-4003			ND		pCi/l
GW-4004				2.72	pCi/l
GW-4005				24.48	pCi/l
GW-4006		ND	1.34		pCi/l
GW-4007		2.04		5.44	pCi/l
GW-4008		2.72		1.36	pCi/l
GW-4009			3.65		pCi/l
GW-4010	1.36			8.16	pCi/l
GW-4011		9.52		3.40	pCi/l
GW-4012			3.50		pCi/l
GW-4013				14.3	pCi/l
GW-4014				1.36	pCi/l
GW-4015		3.40		3.40	pCi/l
GW-4016			5.372		pCi/l
GW-4017			1.135		pCi/l
GW-4018			0.69		pCi/l
GW-4020		13.6		19.72	pCi/l
GW-4021			7.68		pCi/l
GW-4022			4.42		pCi/l
GW-4023			2.03		pCi/l
GW-FINN		1.36			pCi/l
GW-FINW	ND		ND	ND	pCi/l
GW-PW02	2.72	ND	0.97	ND	pCi/l
GW-PW03		ND	0.84	3.40	pCi/l
GW-PW04	4.08	1.36	ND	2.04	pCi/l
GW-PW05	4.08	ND		ND	pCi/l
GW-PW06	3.40	2.04	ND	ND	pCi/l
GW-PW07	8.16	4.08	ND	ND	pCi/l

URANIUM, TOTAL
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW08	1.36	ND	ND	ND	pCi/l
GW-PW09	4.76	1.36	ND	ND	pCi/l
GW-RAWW	1.36	ND	ND	2.72	pCi/l
GW-RMW1	8.84		1.14	1.36	pCi/l
GW-RMW2	10.2	7.48	7.07	4.76	pCi/l
GW-RMW3	8.16	10.88	ND	ND	pCi/l
GW-RMW4	6.12		2.29	3.40	pCi/l

URANIUM-234
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2005			2.27		pCi/l
GW-2010			13.0		pCi/l

URANIUM-235
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2005			ND		pCi/l
GW-2010			1.09		pCi/l

URANIUM-238
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2005			3.71		pCi/l
GW-2010			10.4		pCi/l

1,3,5-TRINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5201	1.10		ND		µg/l
SP-5304				ND	µg/l
SP-6301	ND		0.02		µg/l
SP-6302	ND	ND			µg/l
SP-6303	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l

1,3-DINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5201	ND		ND		µg/l
SP-5304				ND	µg/l
SP-6301	ND		0.00		µg/l
SP-6302	ND	ND			µg/l
SP-6303	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l

2,4,6-TNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5201	15.0		1.80		µg/l
SP-5304				0.44	µg/l
SP-6301	0.05		0.97		µg/l
SP-6302	0.11	0.04			µg/l
SP-6303	ND		0.24		µg/l
SP-6306	ND	ND	ND	ND	µg/l

2,4-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5201	ND		ND		µg/l
SP-5304				0.098	µg/l
SP-6301	1.44		0.22		µg/l
SP-6302	1.42	0.03			µg/l
SP-6303	ND		0.056		µg/l
SP-6306	ND	ND	ND	ND	µg/l

2,6-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5201	0.34		0.49		µg/l
SP-5304				0.14	µg/l
SP-6301	0.58		0.24		µg/l
SP-6302	0.53	0.13			µg/l
SP-6303	0.21		0.66		µg/l
SP-6306	ND	ND	ND	ND	µg/l

NITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5201	ND		ND		µg/l
SP-5302	ND				µg/l
SP-5304				ND	µg/l
SP-6301	ND		0.00		µg/l
SP-6302	ND	ND			µg/l
SP-6303	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l

CHLORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-6301			32.0		mg/l
SP-6306	7.40				mg/l

FLUORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-6301			ND		mg/l
SP-6306	231				µg/l

NITRATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-6301			42.0		mg/l
SP-6306	2.70				mg/l

SULFATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-6301			54.0		mg/l
SP-6306	13.5				mg/l

URANIUM, TOTAL
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5203	2.04	ND		1.36	pCi/l
SP-5301	503	285	211	592	pCi/l
SP-5302	435	238	258	544	pCi/l
SP-5303	265	170	272	374	pCi/l
SP-5304	142	39.4	74.8	221.00	pCi/l
SP-5503	6.80				pCi/l
SP-6301	55.0	13.6	55.8	102	pCi/l
SP-6302	51.6	10.2			pCi/l
SP-6303	5.44	2.72	4.08	ND	pCi/l
SP-6306	12.9	10.2		8.16	pCi/l

1,3,5-TRINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	ND	0.08		ND	µg/l
SW-3201				ND	µg/l
SW-3301				ND	µg/l
SW-3302				ND	µg/l
SW-3401				ND	µg/l
SW-3402				ND	µg/l
SW-5311				ND	µg/l

1,3-DINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	ND	ND		ND	µg/l
SW-3201				ND	µg/l
SW-3301				ND	µg/l
SW-3302				ND	µg/l
SW-3401				ND	µg/l
SW-3402				ND	µg/l
SW-5311				ND	µg/l

2,4,6-TNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	0.18	2.00		12.0	µg/l
SW-3201				ND	µg/l
SW-3301				ND	µg/l
SW-3302				ND	µg/l
SW-3401				ND	µg/l
SW-3402				ND	µg/l
SW-5311				ND	µg/l

2,4-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	1.50	0.63		3.00	µg/l
SW-3201				ND	µg/l
SW-3301				ND	µg/l
SW-3302				ND	µg/l
SW-3401				ND	µg/l
SW-3402				ND	µg/l
SW-5311				ND	µg/l

2,6-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	0.12	0.12		1.20	µg/l
SW-3201				ND	µg/l
SW-3301				ND	µg/l
SW-3302				ND	µg/l
SW-3401				ND	µg/l
SW-3402				ND	µg/l
SW-5311				0.057	µg/l

NITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	ND	ND		ND	µg/l
SW-3201				ND	µg/l
SW-3301				ND	µg/l
SW-3302				ND	µg/l
SW-3401				ND	µg/l
SW-3402				ND	µg/l
SW-5311				ND	µg/l

CHLORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	12.4	11.7			mg/l
SW-3001		27.9			mg/l
SW-3002		9.80			mg/l
SW-3003		30.3			mg/l
SW-3004		7.83			mg/l
SW-3101				44.6	mg/l
SW-3201				10.1	mg/l
SW-3301				29.8	mg/l
SW-3302				29.1	mg/l
SW-3401				7.50	mg/l
SW-3402				10.0	mg/l

FLUORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	0.79	0.97			mg/l
SW-3001		0.30			mg/l
SW-3002		0.31			mg/l
SW-3003		0.66			mg/l
SW-3004		0.87			mg/l
SW-3101				4.65	mg/l
SW-3201				3.63	mg/l
SW-3301				8.75	mg/l
SW-3302				ND	mg/l
SW-3401				10.2	mg/l
SW-3402				13.7	mg/l

NITRATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	ND	ND			mg/l
SW-3001		464			mg/l
SW-3002		ND			mg/l
SW-3003		1900			mg/l
SW-3004		0.28			mg/l
SW-3201				ND	mg/l
SW-3301				1000	mg/l
SW-3302				1100	mg/l
SW-3401				ND	mg/l
SW-3402				ND	mg/l

SULFATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	118	161			mg/l
SW-3001		318			mg/l
SW-3002		415			mg/l
SW-3003		695			mg/l
SW-3004		37.5			mg/l
SW-3101				333	mg/l
SW-3201				978	mg/l
SW-3301				735	mg/l
SW-3302				765	mg/l
SW-3401				76.0	mg/l
SW-3402				79.1	mg/l

GROSS ALPHA
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-3401				2900	pCi/l
SW-3402				3000	pCi/l

GROSS BETA
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-3401				950	pCi/l
SW-3402				990	pCi/l

RADIUM-226
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	1.20	2.9		1.30	pCi/l
SW-3001		130.000			pCi/l
SW-3002		95.000			pCi/l
SW-3003		7.000			pCi/l
SW-3004		98.000			pCi/l
SW-3401				5.60	pCi/l
SW-3402				6.00	pCi/l
SW-5305				0.50	pCi/l
SW-5311				1.1	pCi/l

RADIUM-228
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008				1.60	pCi/l
SW-3401				15.0	pCi/l
SW-3402				15.0	pCi/l
SW-5305				0.30	pCi/l
SW-5311				ND	pCi/l

THORIUM-228
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-3401				1.20	pCi/l
SW-3402				1.30	pCi/l

THORIUM-230
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	ND	0.20		0.70	pCi/l
SW-3001		100.000			pCi/l
SW-3002		90.000			pCi/l
SW-3003		3.800			pCi/l
SW-3004		92.000			pCi/l
SW-3401				2.00	pCi/l
SW-3402				3.30	pCi/l
SW-5305				0.05	pCi/l
SW-5311				ND	pCi/l

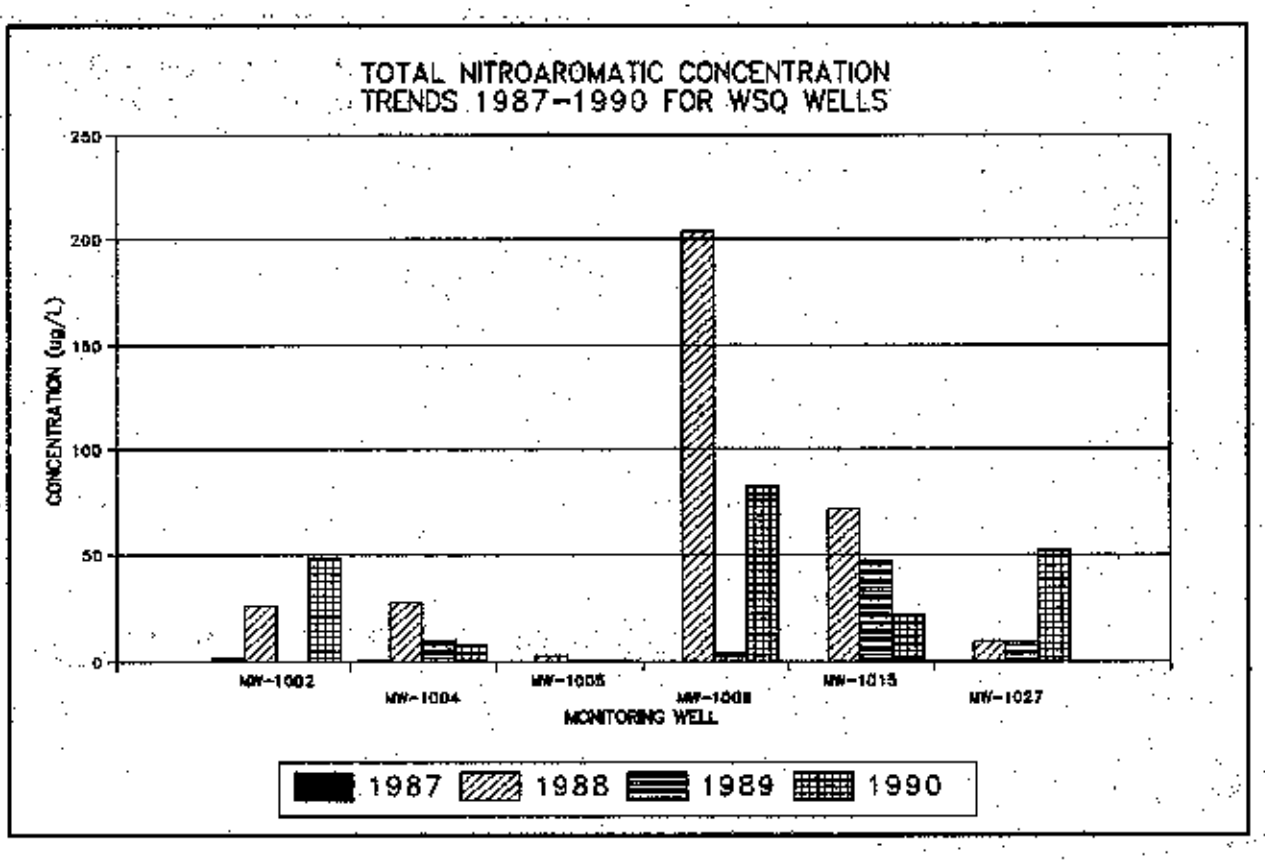
THORIUM-232
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

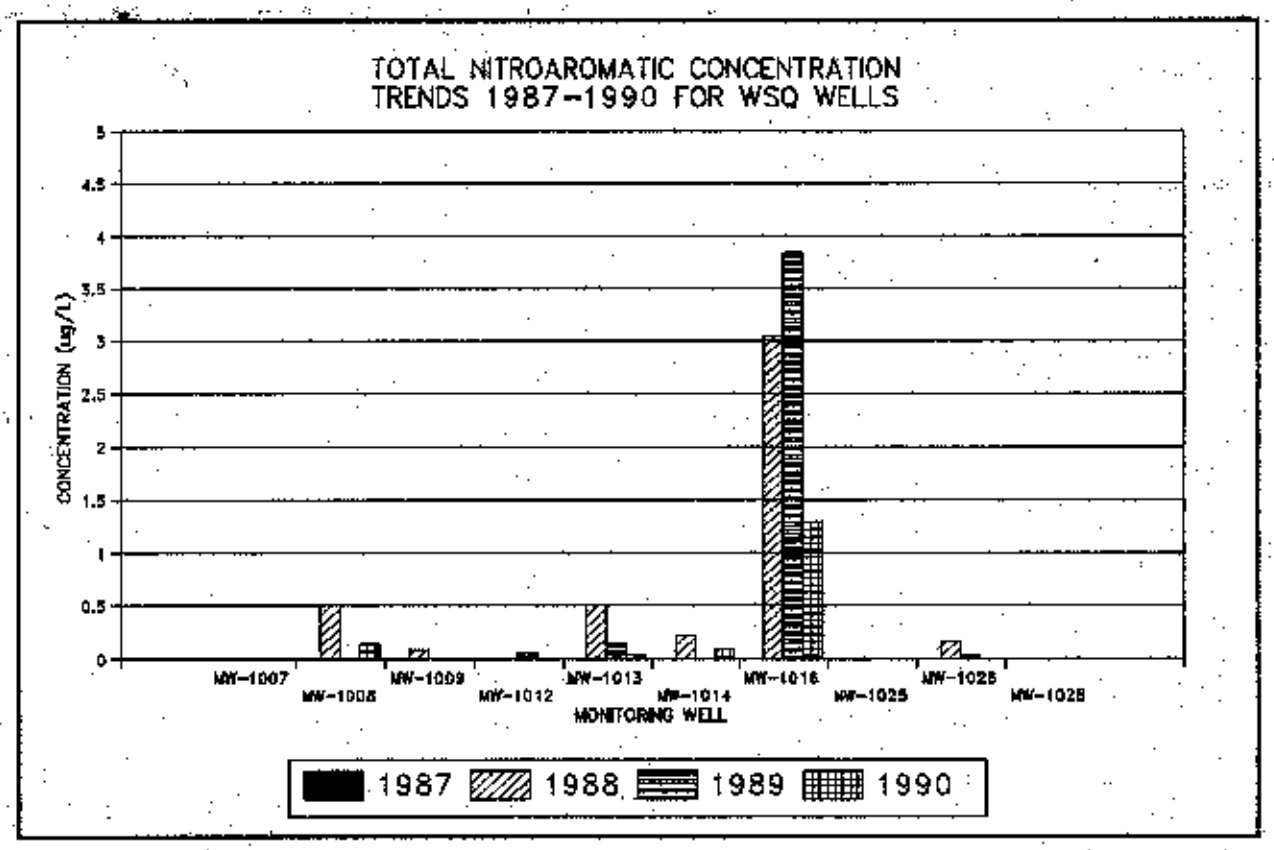
WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	ND	ND		ND	pCi/l
SW-3001		0.200			pCi/l
SW-3002		0.300			pCi/l
SW-3003		1.200			pCi/l
SW-3004		2.900			pCi/l
SW-3401				0.20	pCi/l
SW-3402				0.50	pCi/l
SW-5305				0.00	pCi/l
SW-5311				ND	pCi/l

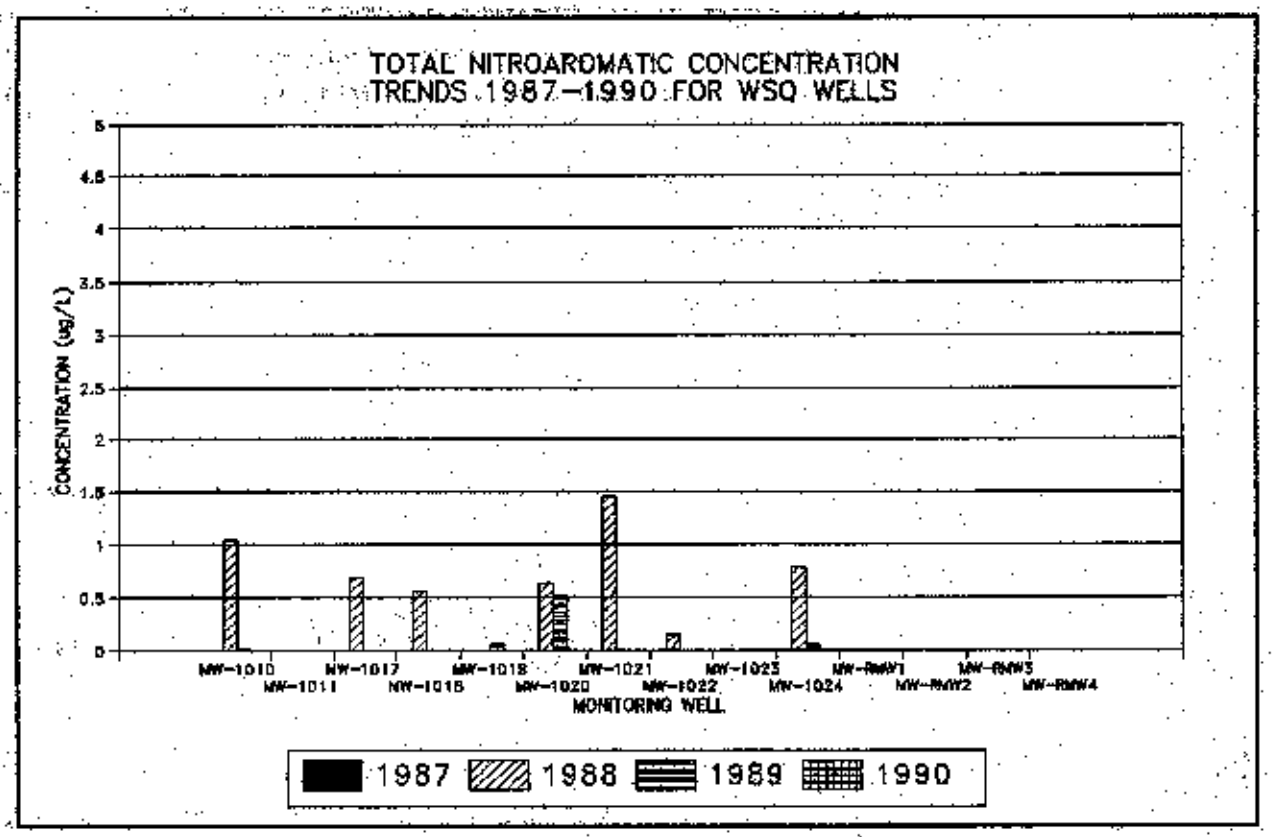
URANIUM, TOTAL
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

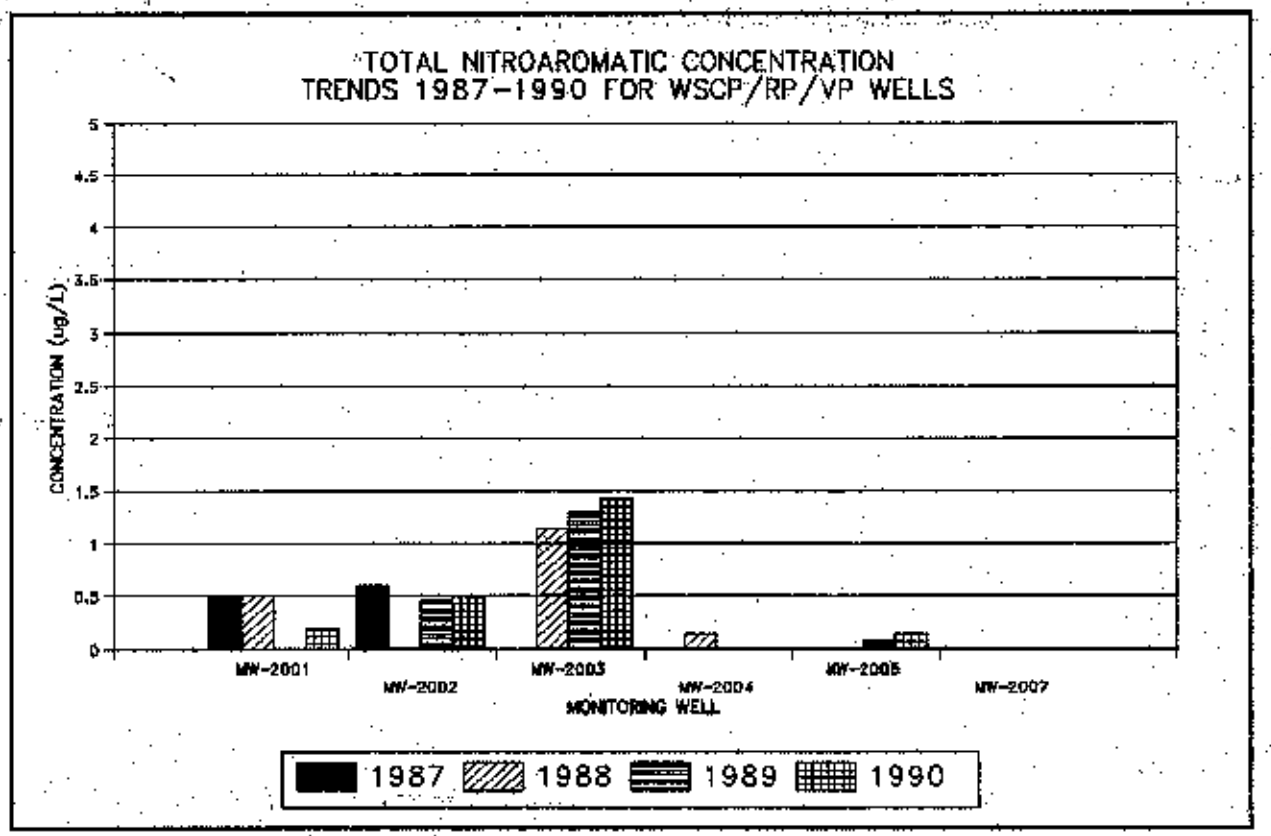
WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1001	8.16	4.76		ND	pCi/l
SW-1002	11.5	ND		ND	pCi/l
SW-1003	38.1	22.4		58.5	pCi/l
SW-1004	34.6	37.4		57.1	pCi/l
SW-1005	18.3	12.2		13.6	pCi/l
SW-1007	17.0	10.2		19.0	pCi/l
SW-1008	1770	2312		3130	pCi/l
SW-1009	17.7	8.84		21.1	pCi/l
SW-1010	41.4	20.4		41.5	pCi/l
SW-1011	6.12	2.72		4.08	pCi/l
SW-1012	4.08	5.44		7.48	pCi/l
SW-1013	5.40	2.72		9.52	pCi/l
SW-2001	8.16	4.76	1.90	ND	pCi/l
SW-2002	190	39.4	11.3	102	pCi/l
SW-2003	24.4	14.9	7.34	12.24	pCi/l
SW-2004	29.2	23.8	12.7	13.6	pCi/l
SW-2005	18.3	18.3	13.0	16.32	pCi/l
SW-2006	12.9	1.36	0.37	ND	pCi/l
SW-2007	8.20	ND	0.55	4.76	pCi/l
SW-2010	2510	1156	1710		pCi/l
SW-2011	258	299.2	224	170	pCi/l
SW-2013			ND		pCi/l
SW-3001		292			pCi/l
SW-3002		1700			pCi/l
SW-3003		2584		265.20	pCi/l
SW-3004		1700			pCi/l
SW-3401				2180	pCi/l
SW-3402				2180	pCi/l
SW-4019				4.76	pCi/l

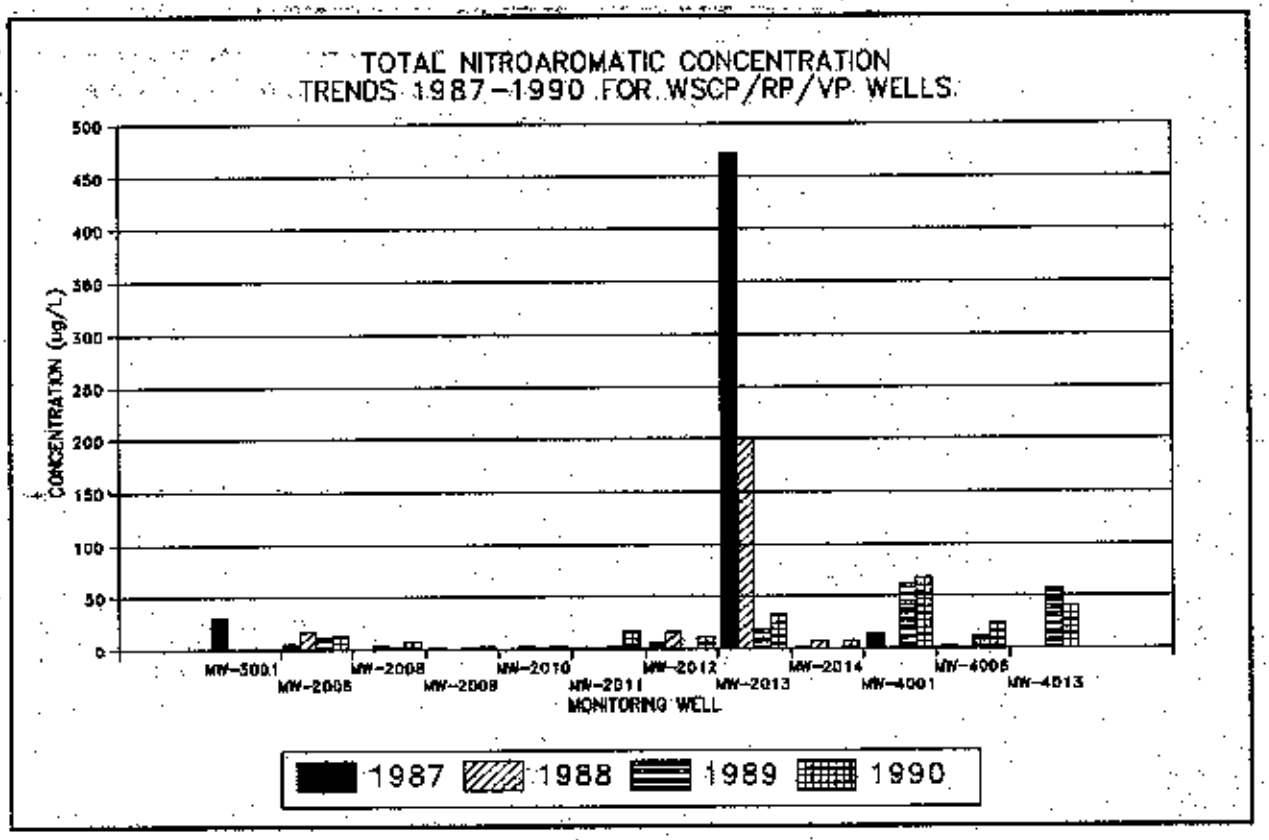
APPENDIX B
TREND ANALYSIS FIGURES

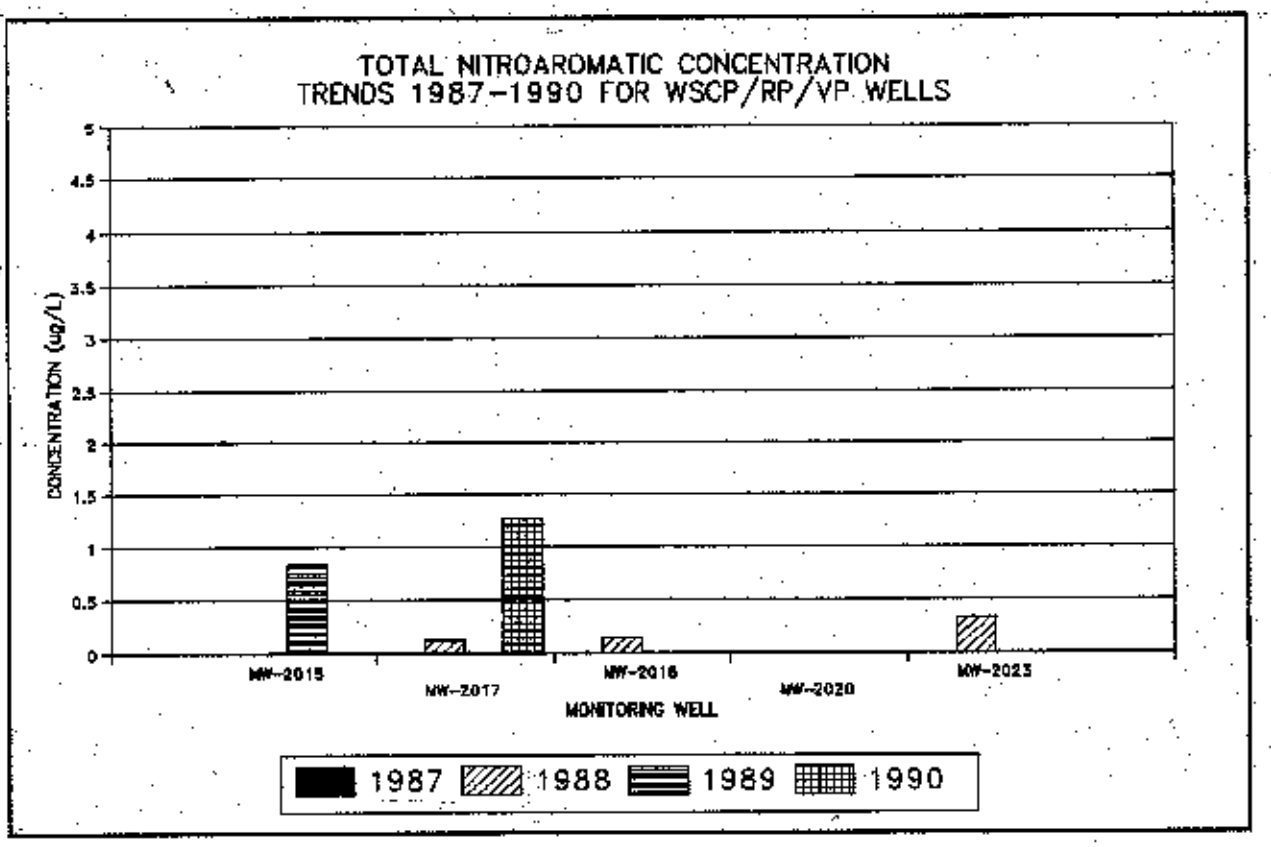

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSQ WELLS
CONCENTRATION (ug/L)
250
200
150
100
50
0
MW-1002
MW-1004
MW-1005
MW-1008
MW-1015
MW-1027
MONITORING WELL
1987
1988
1989
1990

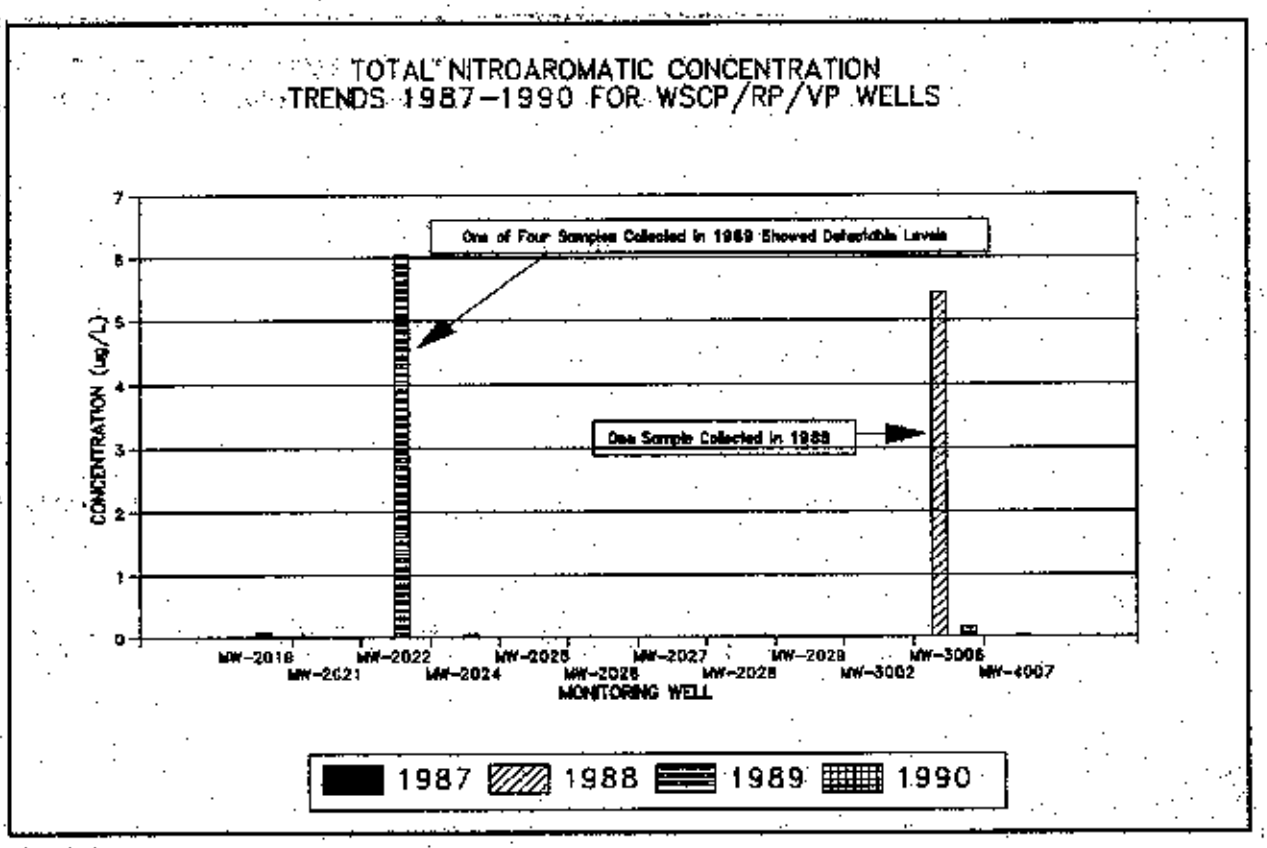

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSQ WELLS
CONCENTRATION (ug/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
MW-1007
MW-1008
MW-1009
MW-1012
MW-1013
MW-1014
MW-1016
MW-1025
MW-1026
MW-1028
MONITORING WELL
1987
1988
1989
1990

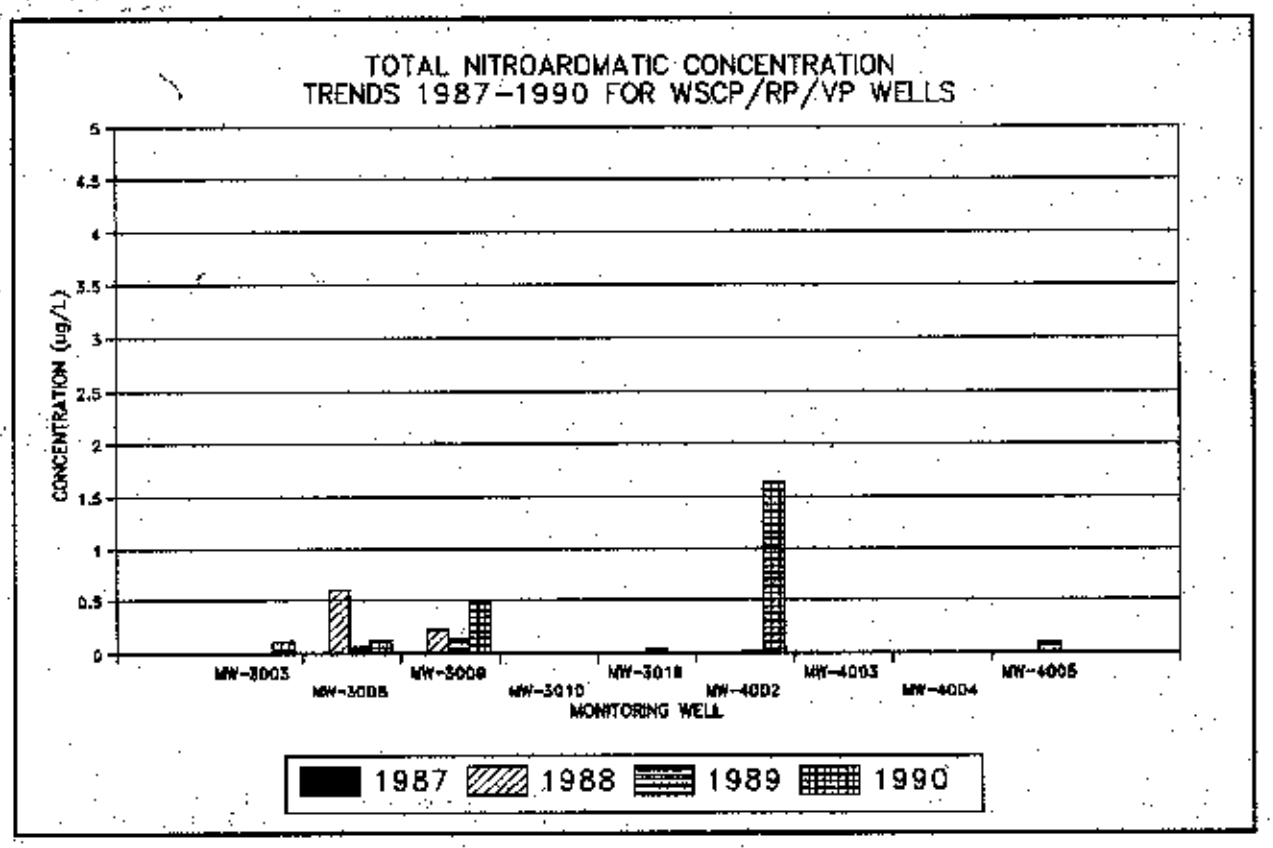

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987–1990 FOR WSQ WELLS
CONCENTRATION (ug/L)
MW-1010
MW-1011
MW-1017
MW-1018
MW-1021
MW-1023
MW-RMW1
MW-RMW3
MW-1016
MW-1020
MW-1022
MW-1024
MW-RMW2
MW-RMW4
MONITORING WELL
1987
1988
1989
1990

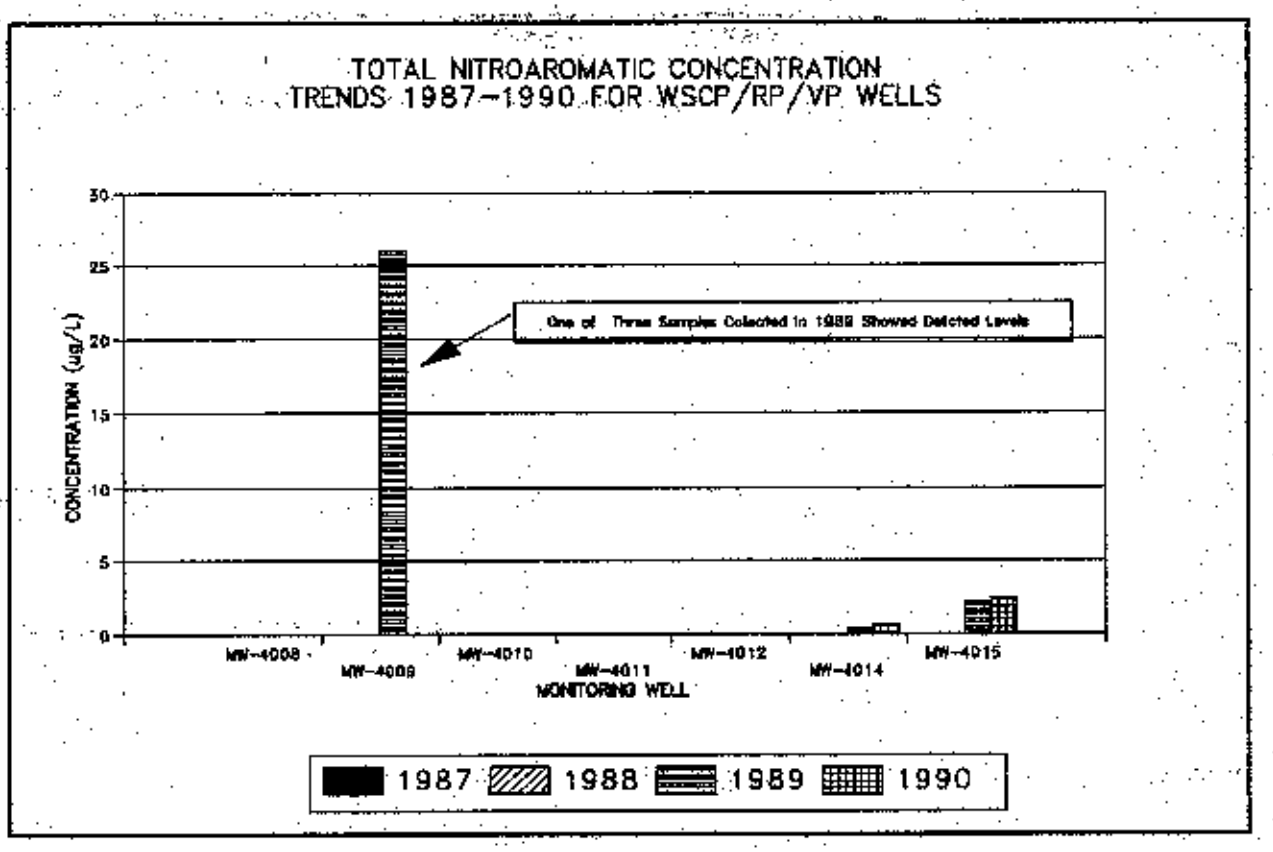

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987–1990 FOR WSCP/RP/VP WELLS
CONCENTRATION (ug/L)
MW-2001
MW-2002
MW-2003
MW-2004
MW-2005
MW-2007
MONITORING WELL
1987
1988
1989
1990

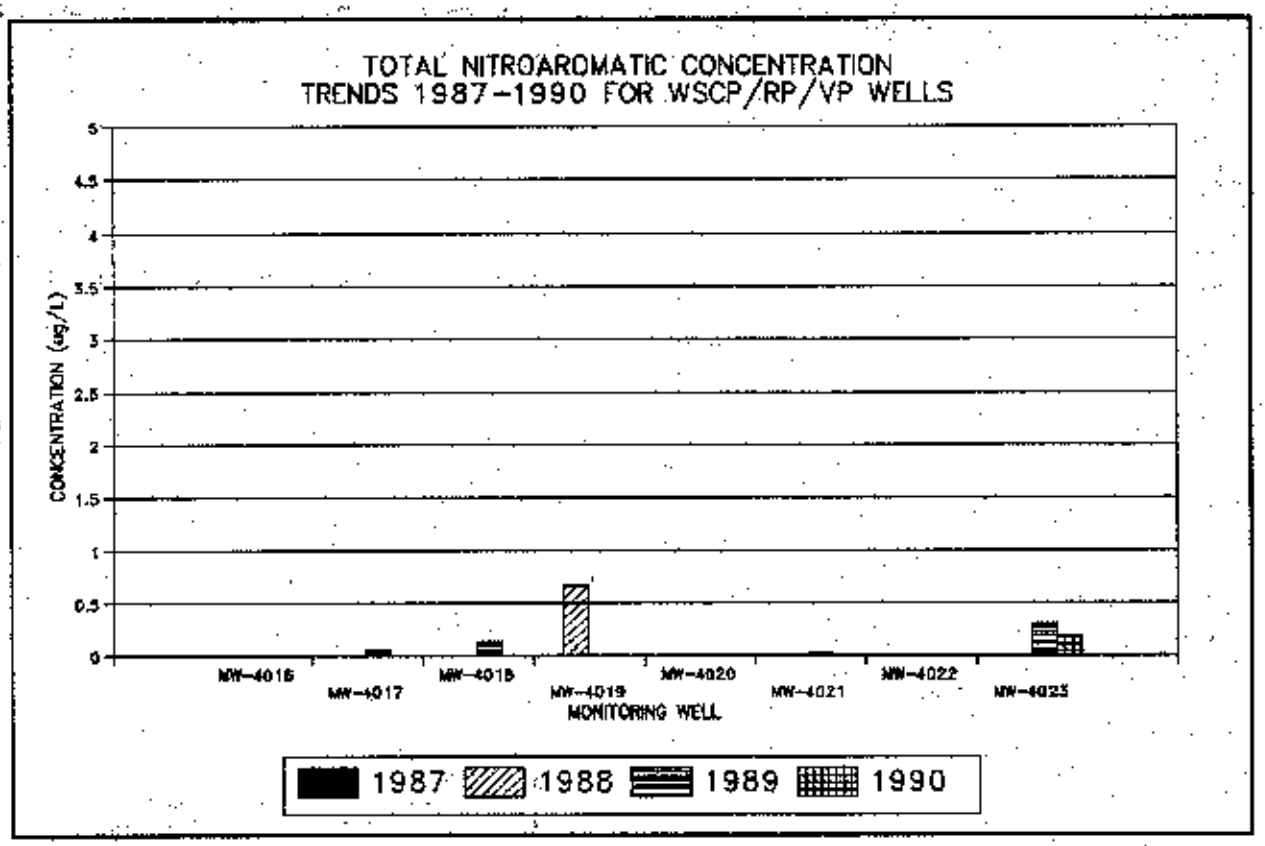

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSCP/RP/VP WELLS
CONCENTRATION (ug/L)
500
450
400
350
300
250
200
150
100
50
0
MW-3001
MW-2005
MW-2008
MW-2009
MW-2010
MW-2011
MW-2012
MW-2013
MW-2014
MW-4001
MW-4005
MW-4013
MONITORING WELL
1987
1988
1989
1990

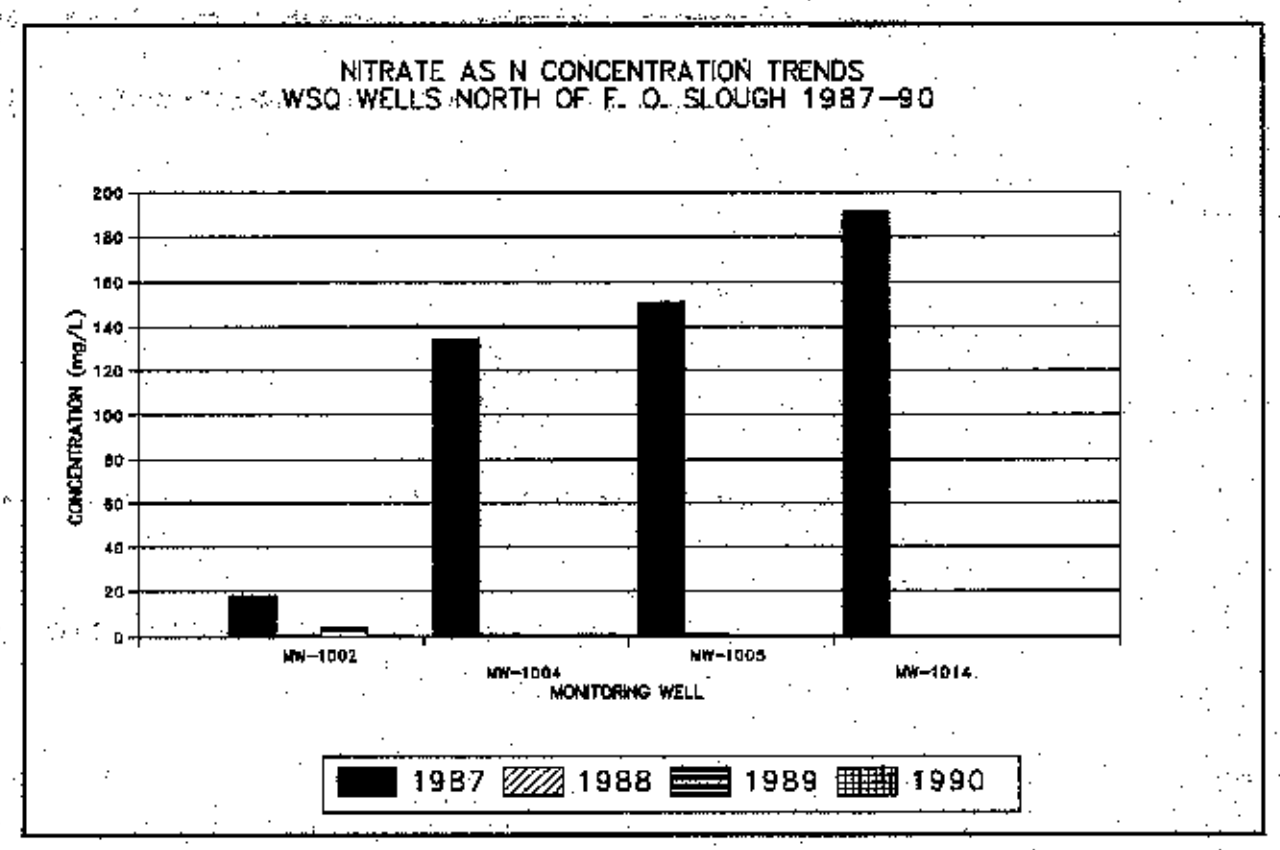

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSCP/RP/VP WELLS
CONCENTRATION (ug/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
MW-2015
MW-2017
MW-2018
MW-2020
MW-2023
MONITORING WELL
1987
1988
1989
1990

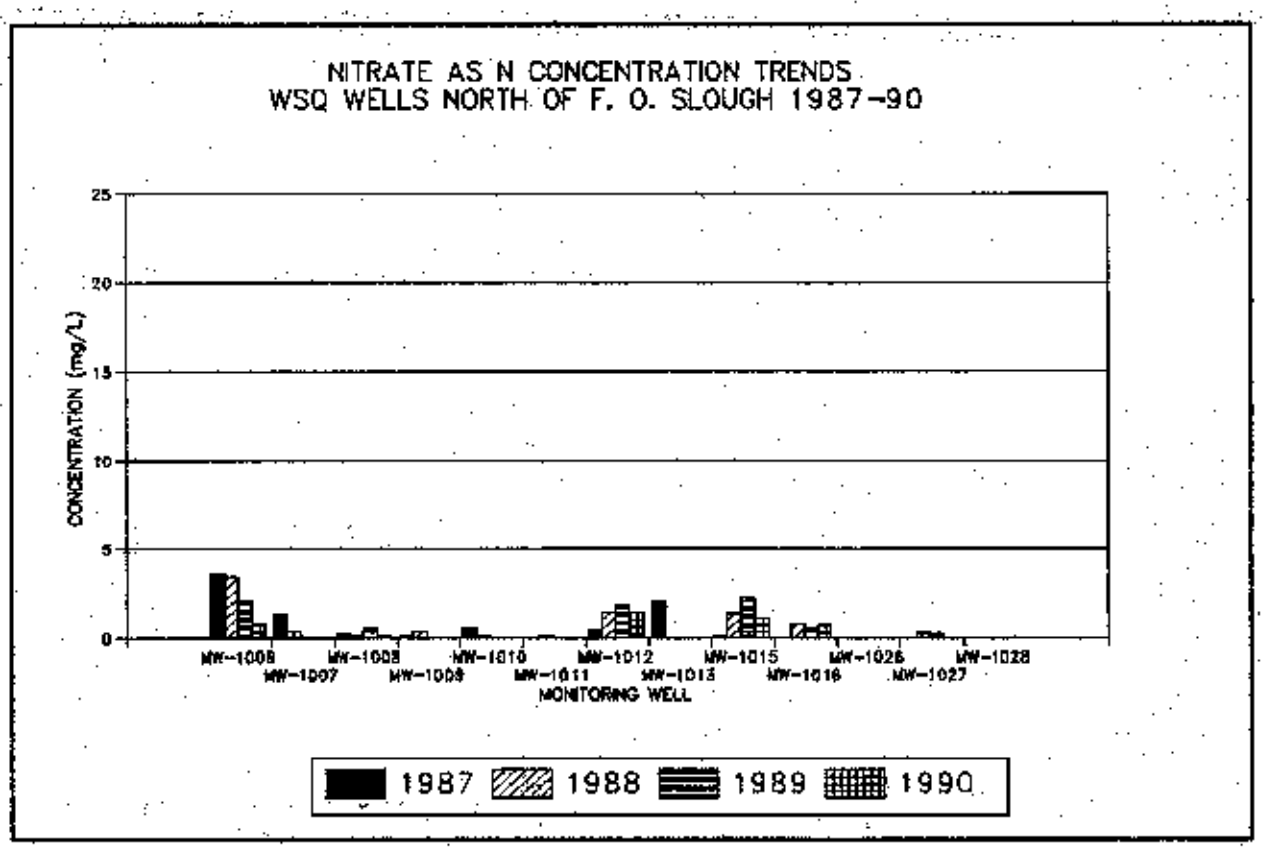

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSCP/RP/VP WELLS
One of Four Samples Collected in 1989 Showed Detectable Levels
One Sample Collected in 1988
CONCENTRATION (ug/L)
MW-2016
MW-2021
MW-2022
MW-2024
MW-2025
MW-2026
MW-2027
MW-2028
MW-3002
MW-3006
MW-4007
MONITORING WELL
1987
1988
1989
1990

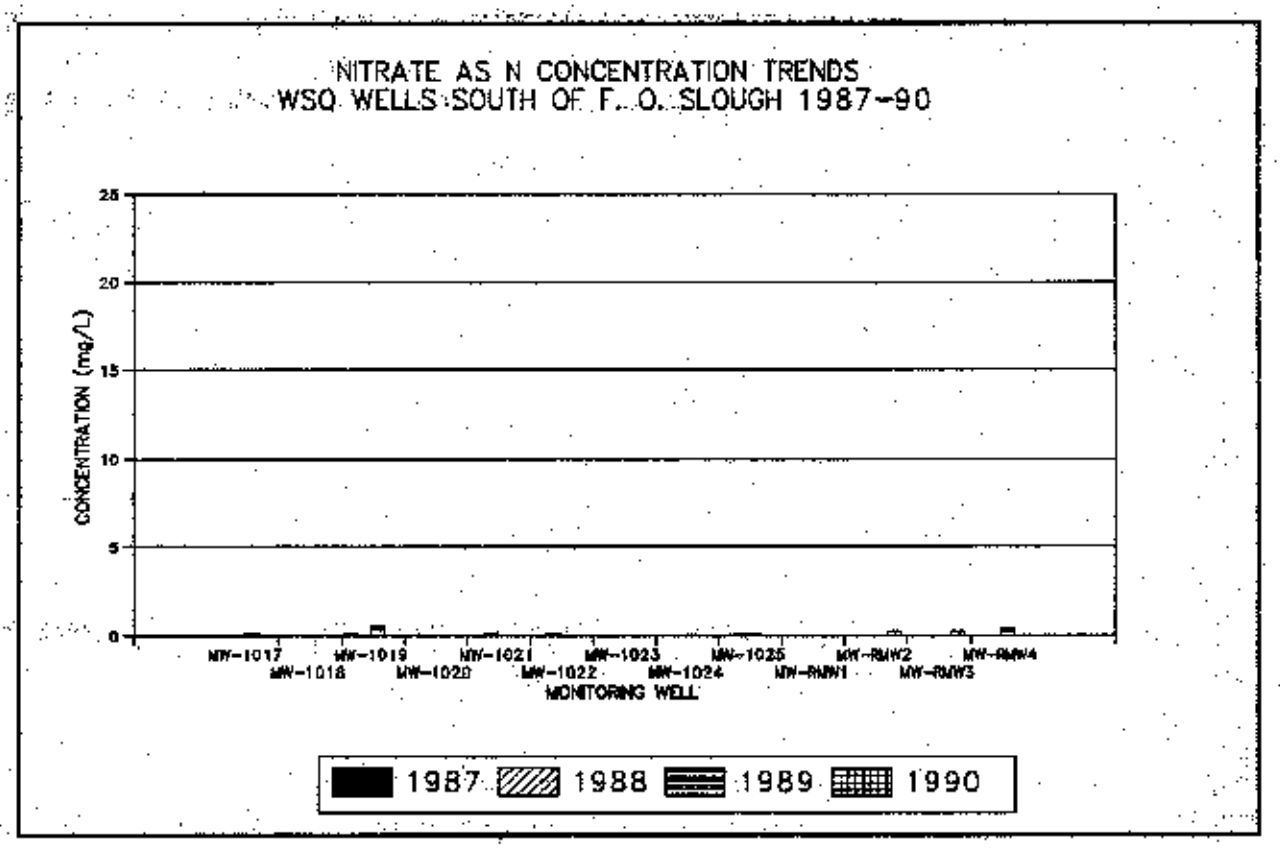

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSCP/RP/VP WELLS
CONCENTRATION (ug/L)
MW-3003
MW-3005
MW-3009
MW-3010
MW-3018
MW-4002
MW-4003
MW-4004
MW-4005
MONITORING WELL
1987
1988
1989
1990

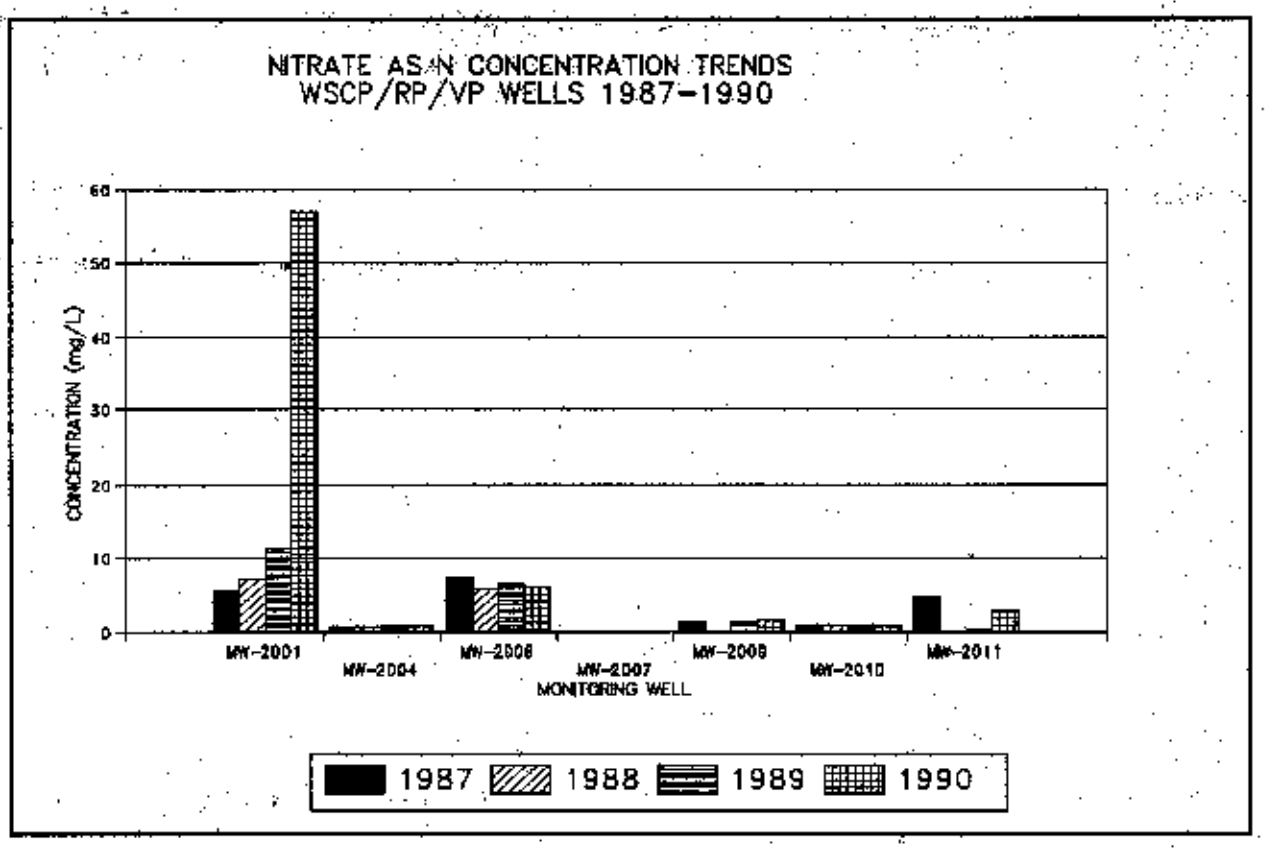

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSCP/RP/VP WELLS
CONCENTRATION (ug/L)
30
25
20
15
10
5
0
One of Three Samples Collected in 1988 Showed Detected Levels
MW-4008
MW-4009
MW-4010
MW-4011
MW-4012
MW-4014
MW-4015
MONITORING WELL
1987
1988
1989
1990

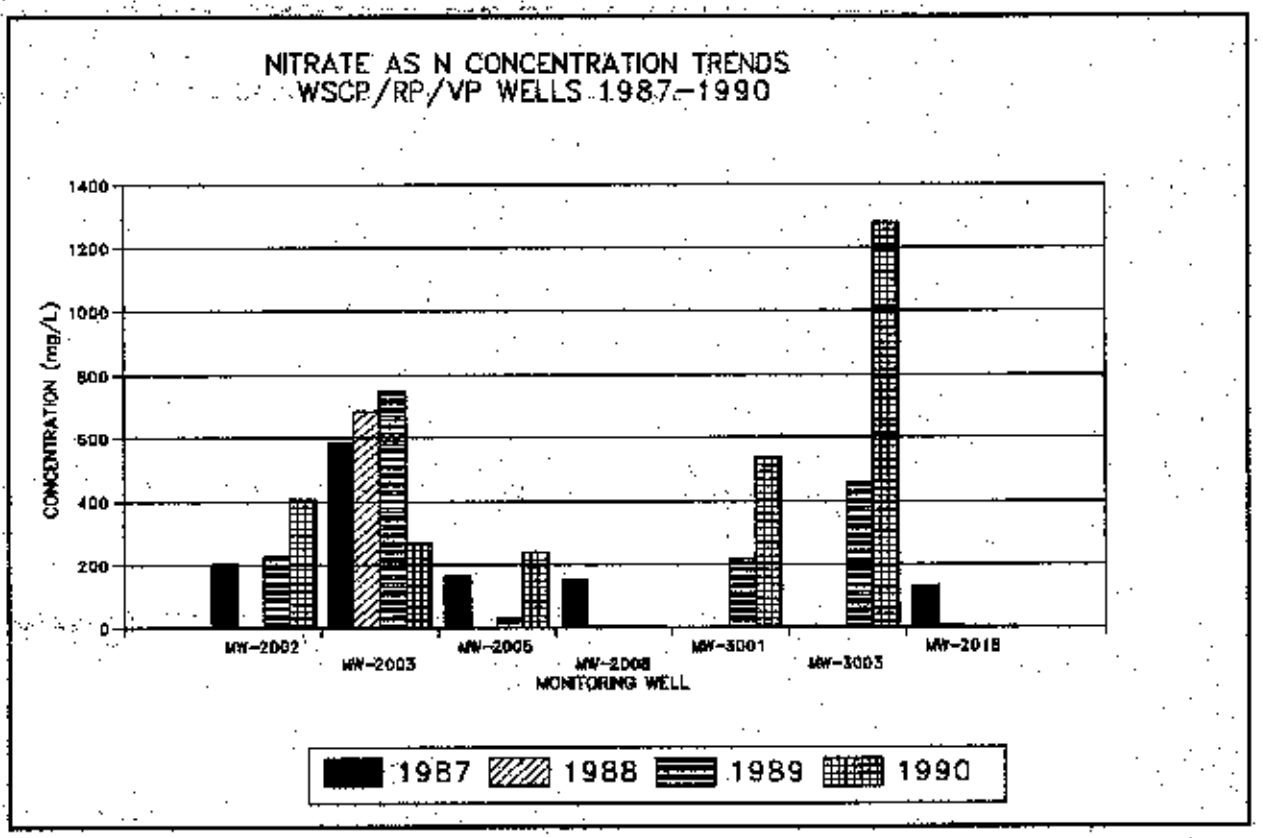

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSCP/RP/VP WELLS
CONCENTRATION (ug/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
MW-4016
MW-4017
MW-4018
MW-4019
MW-4020
MW-4021
MW-4022
MW-4023
MONITORING WELL
1987
1988
1989
1990

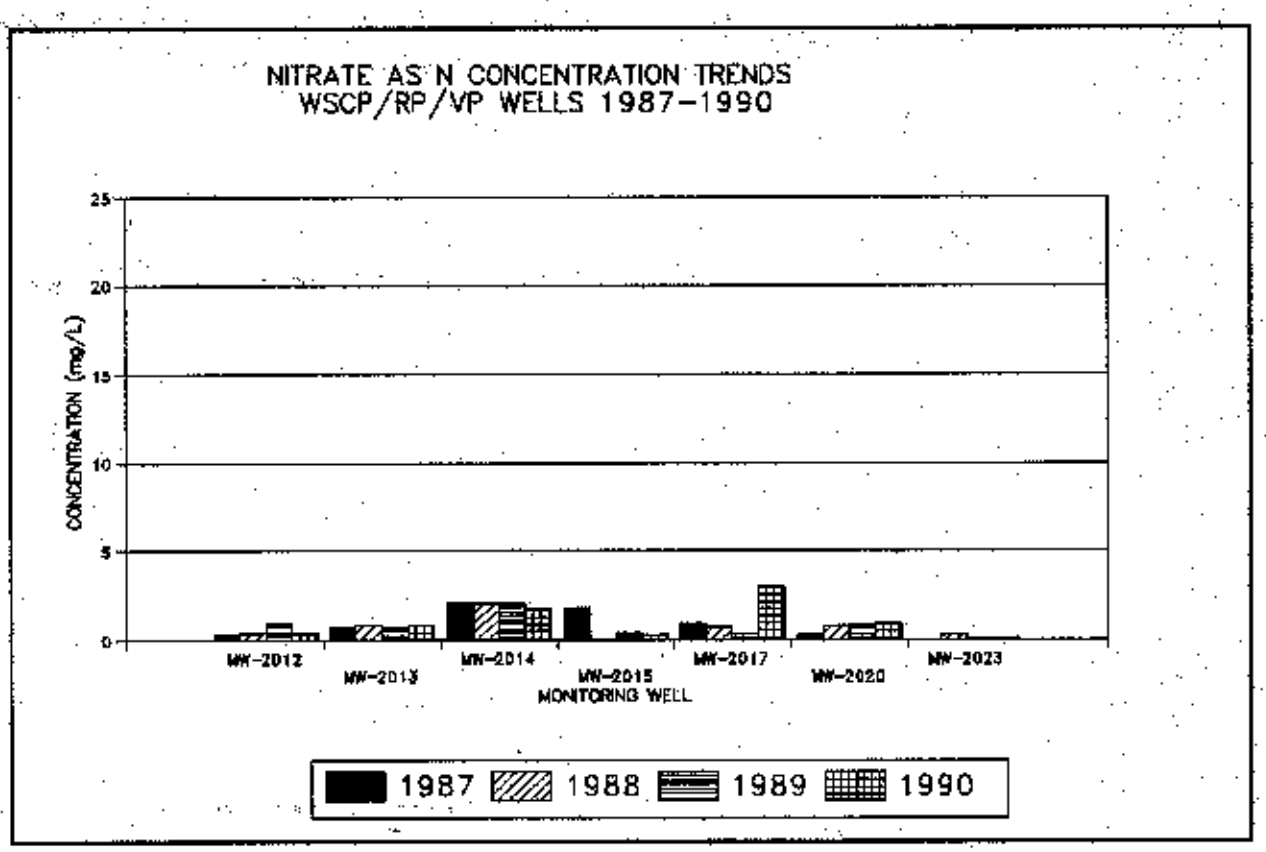

NITRATE AS N CONCENTRATION TRENDS
WSQ WELLS NORTH OF F. O. SLOUGH 1987-90
CONCENTRATION (mg/L)
200
180
160
140
120
100
80
60
40
20
0
MW-1002
MW-1004
MW-1005
MW-1014
MONITORING WELL
1987
1988
1989
1990

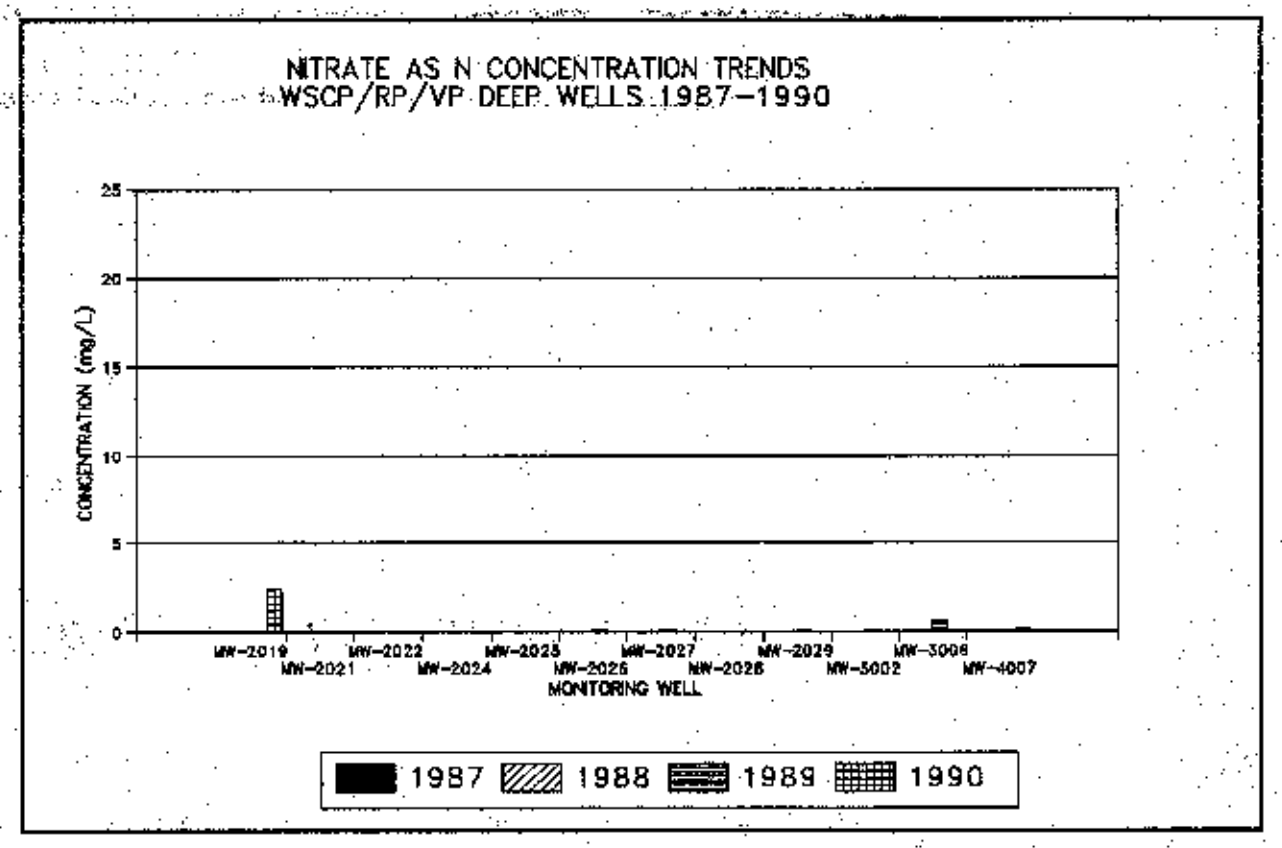

NITRATE AS N CONCENTRATION TRENDS
WSQ WELLS NORTH OF F. O. SLOUGH 1987-90
CONCENTRATION (mg/L)
25
20
15
10
5
0
MW-1006
MW-1007
MW-1008
MW-1009
MW-1010
MW-1011
MW-1012
MW-1013
MW-1015
MW-1016
MW-1026
MW-1027
MW-1028
MONITORING WELL
1987
1988
1989
1990

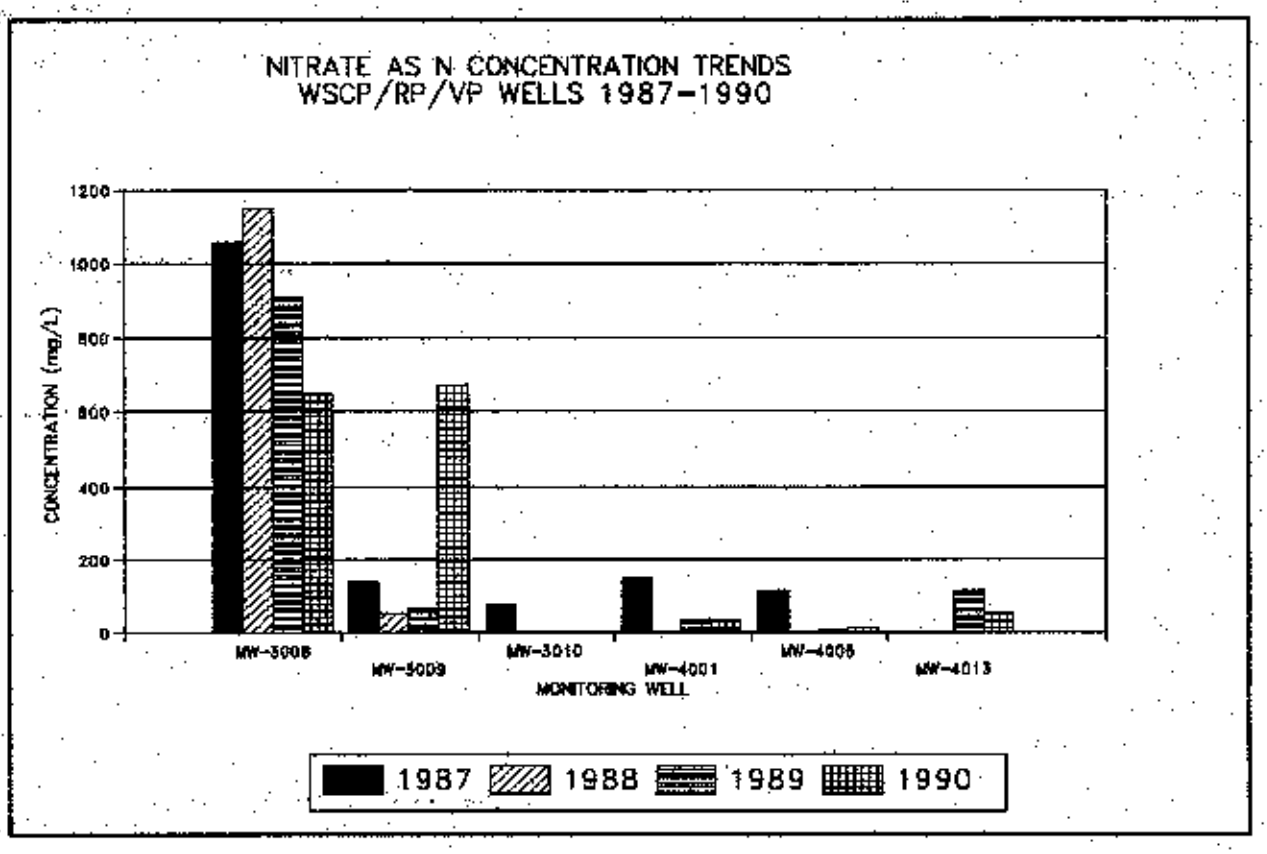

NITRATE AS N CONCENTRATION TRENDS
WSQ WELLS SOUTH OF F..O..SLOUGH 1987-90
CONCENTRATION (mg/L)
25
20
15
10
5
0
MW-1017
MW-1018
MW-1019
MW-1020
MW-1021
MW-1022
MW-1023
MW-1024
MW-1025
MW-RMW1
MW-RMW2
MW-RMW3
MW-RMW4
MONITORING WELL
1987
1988
1989
1990

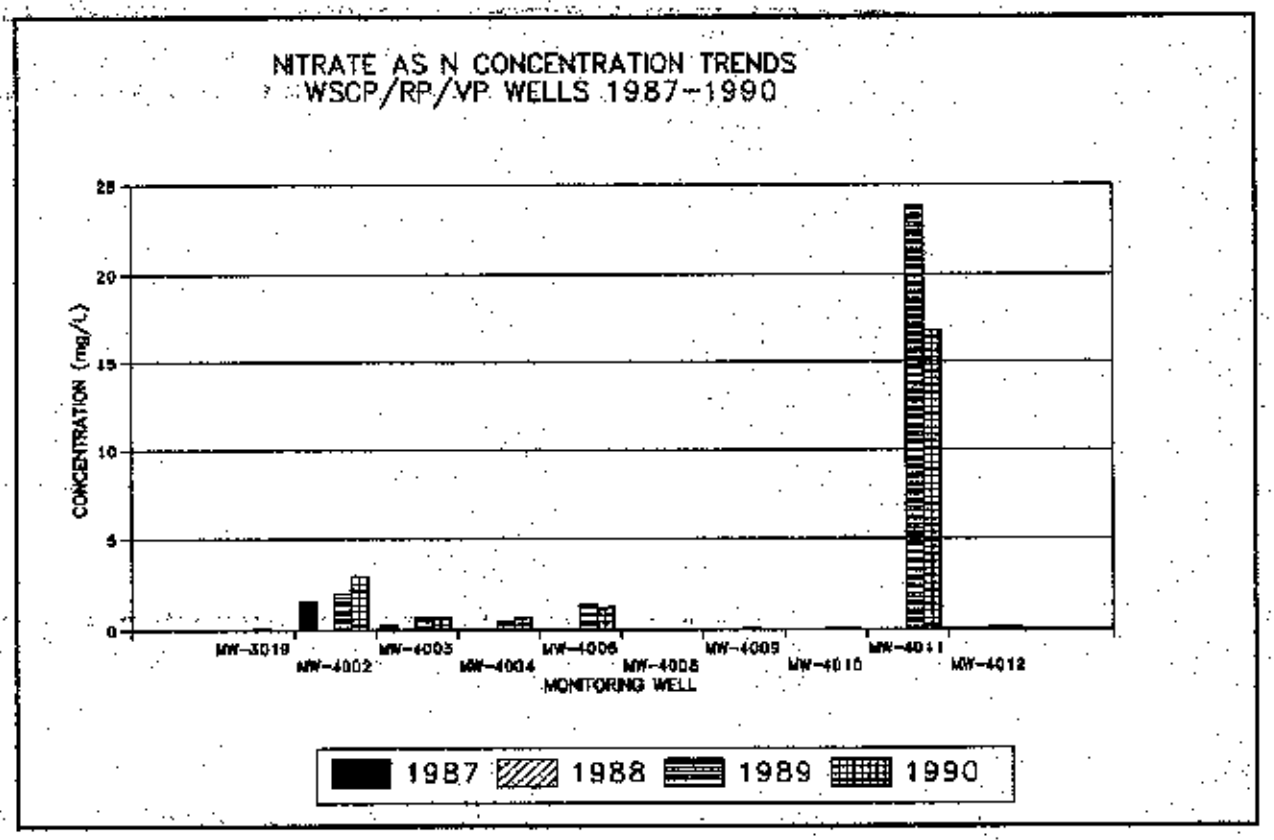

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP WELLS 1987-1990
CONCENTRATION (mg/L)
60
50
40
30
20
10
0
MW-2001
MW-2004
MW-2006
MW-2007
MW-2009
MW-2010
MW-2011
MONITORING WELL
1987
1988
1989
1990

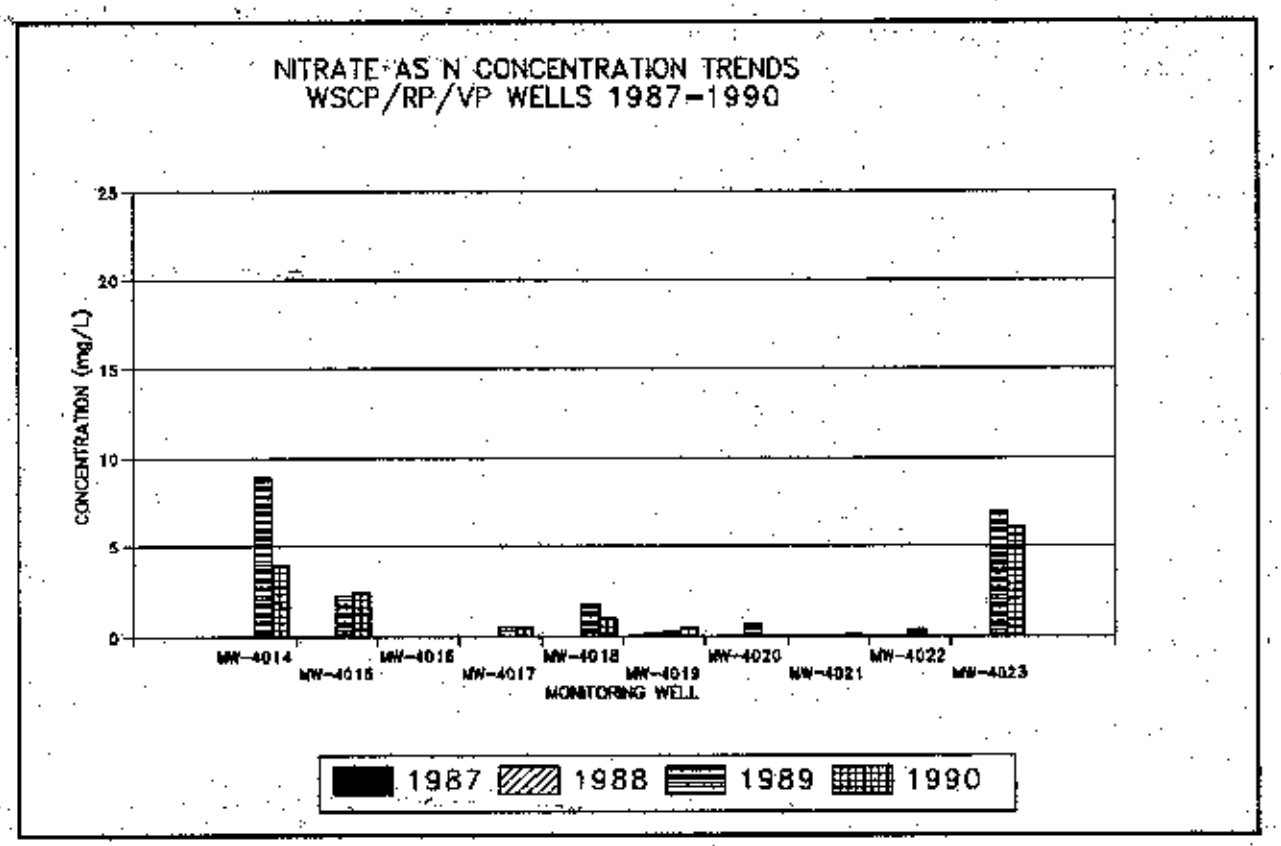

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP WELLS 1987-1990
CONCENTRATION (mg/L)
1400
1200
1000
800
600
400
200
0
MW-2002
MW-2003
MW-2005
MW-2008
MW-3001
MW-3003
MW-2018
MONITORING WELL
1987
1988
1989
1990

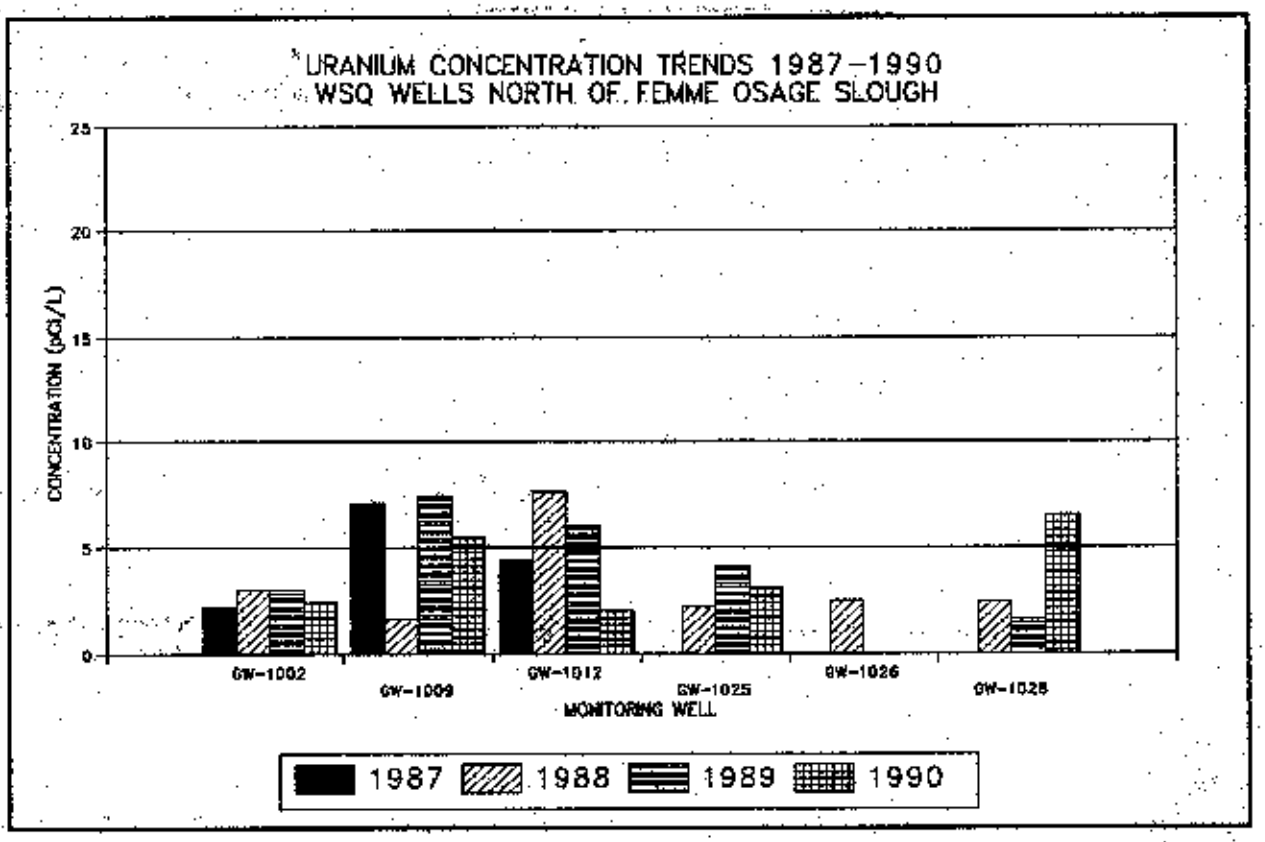

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP WELLS 1987-1990
CONCENTRATION (mg/L)
25
20
15
10
5
0
MW-2012
MW-2013
MW-2014
MW-2015
MW-2017
MW-2020
MW-2023
MONITORING WELL
1987
1988
1989
1990

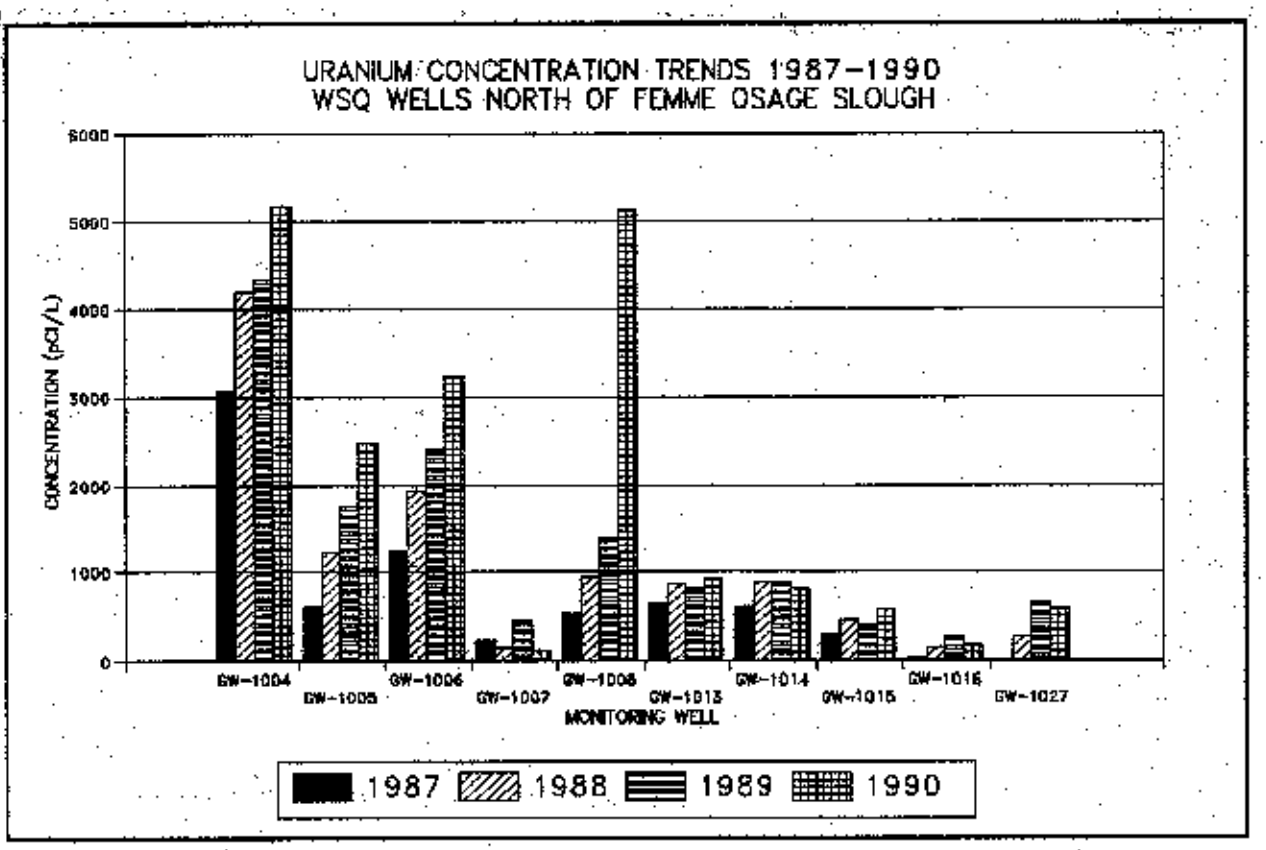

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP DEEP WELLS 1987-1990
CONCENTRATION (mg/L)
25
20
15
10
5
0
MW-2019
MW-2021
MW-2022
MW-2024
MW-2025
MW-2026
MW-2027
MW-2028
MW-2029
MW-5002
MW-5006
MW-4007
MONITORING WELL
1987
1988
1989
1990

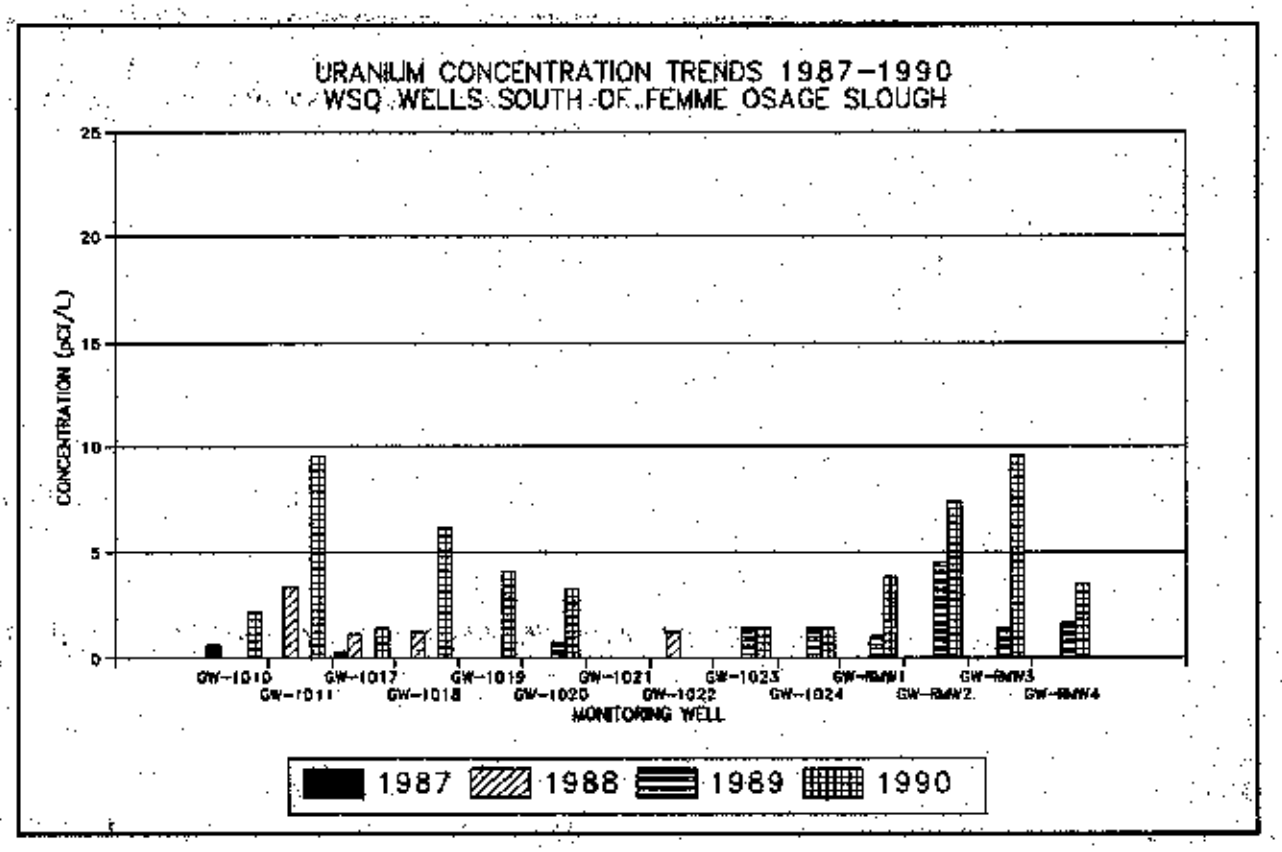

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP WELLS 1987-1990
CONCENTRATION (mg/L)
1200
1000
800
600
400
200
0
MW-5008
MW-5009
MW-3010
MW-4001
MW-4005
MW-4013
MONITORING WELL
1987
1988
1989
1990

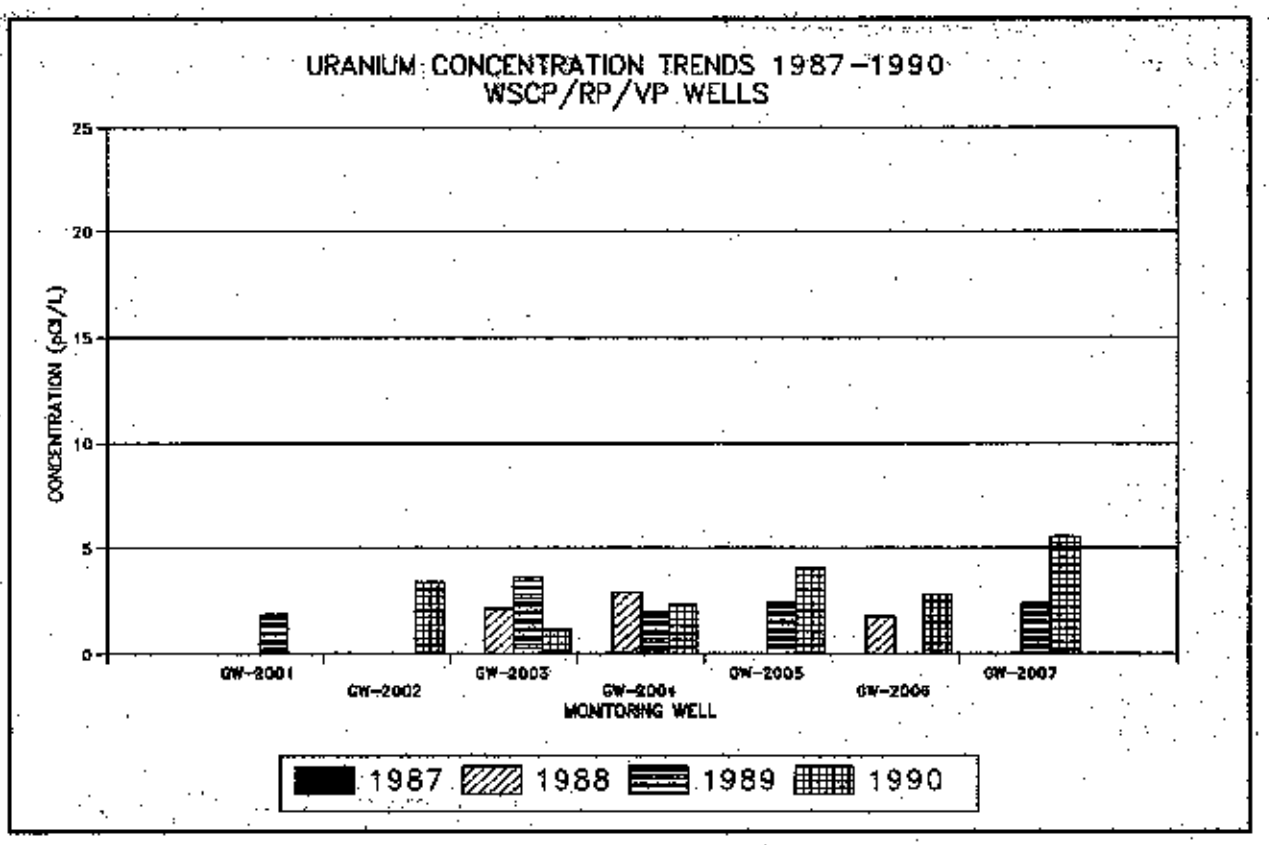

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP WELLS 1987-1990
CONCENTRATION (mg/L)
0
5
10
15
20
25
MW-3019
MW-4002
MW-4003
MW-4004
MW-4006
MW-4008
MW-4009
MW-4010
MW-4011
MW-4012
MONITORING WELL
1987
1988
1989
1990

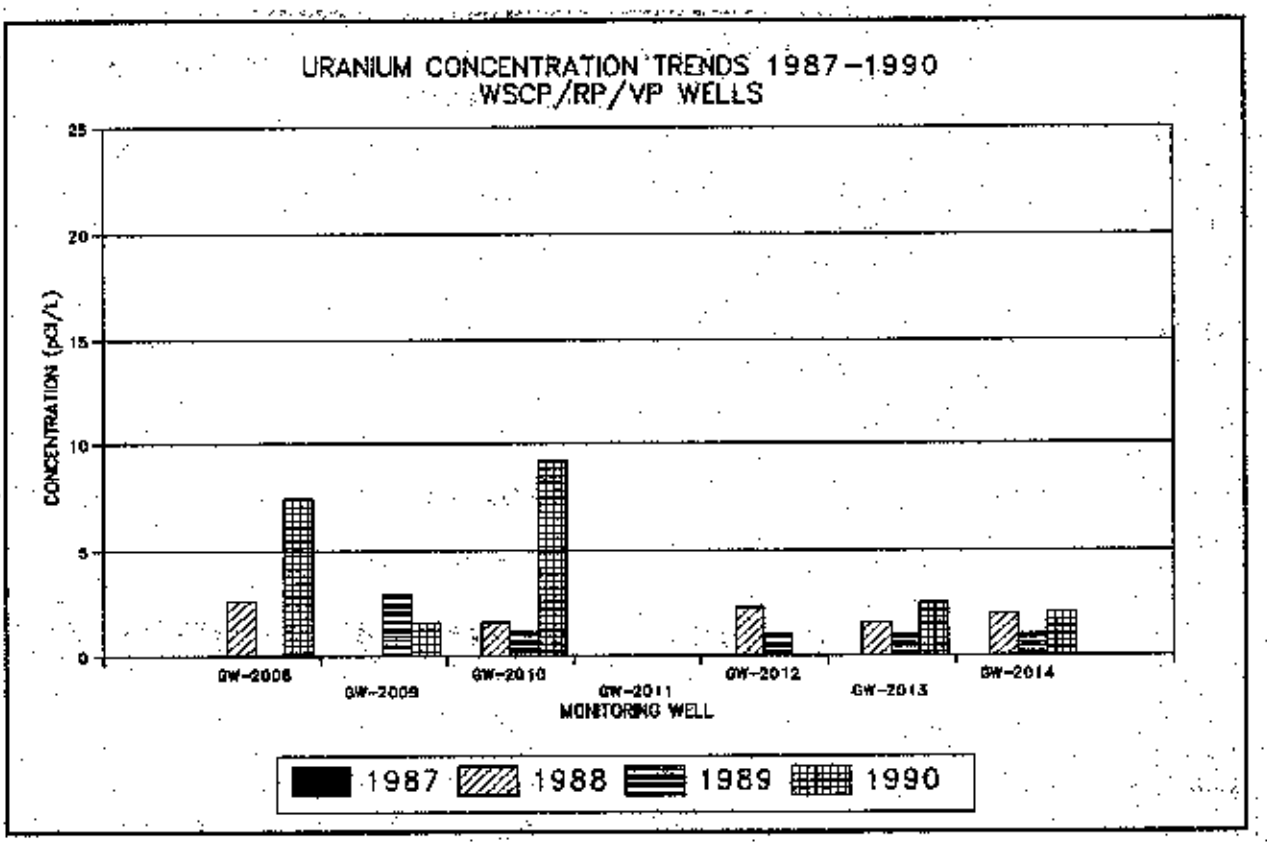

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP WELLS 1987-1990
CONCENTRATION (mg/L)
0
5
10
15
20
25
MW-4014
MW-4015
MW-4016
MW-4017
MW-4018
MW-4019
MW-4020
MW-4021
MW-4022
MW-4023
MONITORING WELL
1987
1988
1989
1990

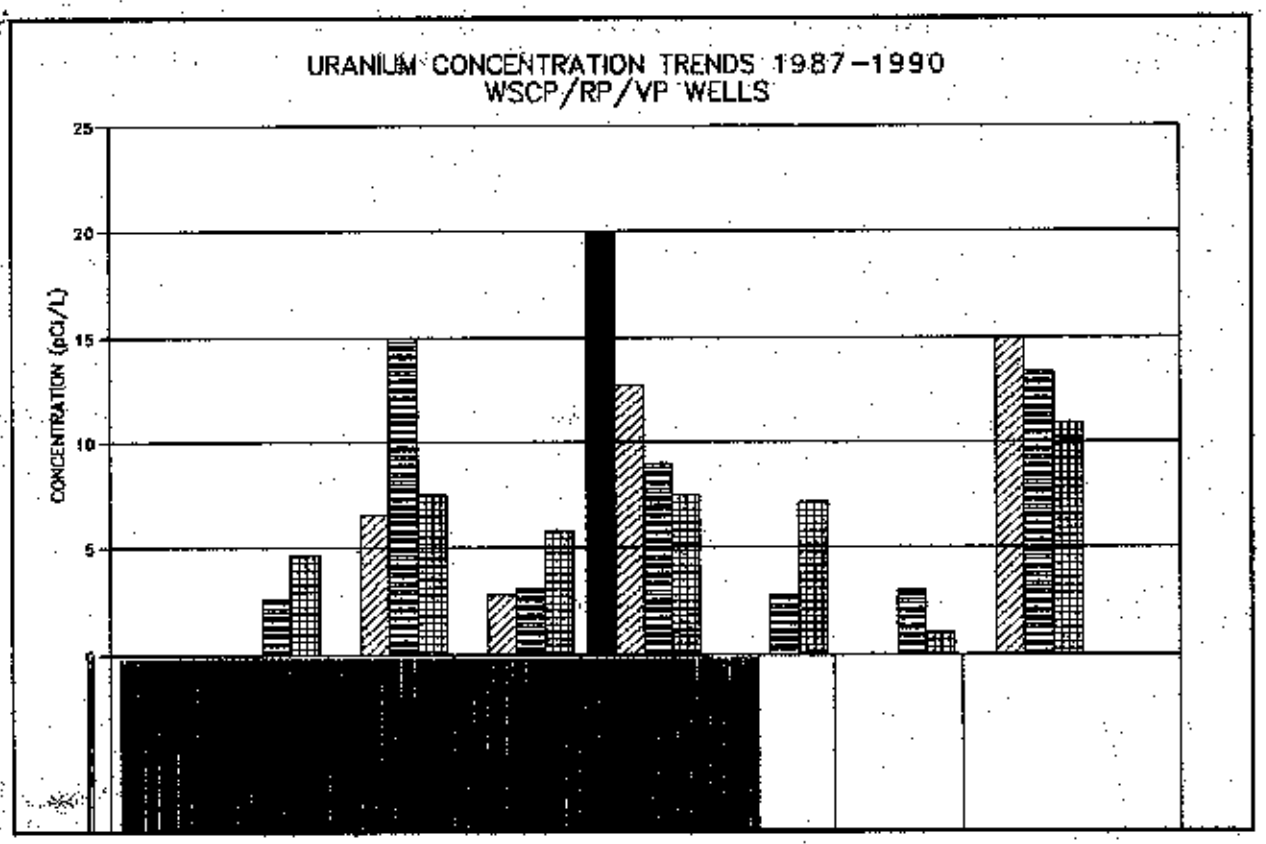

URANIUM CONCENTRATION TRENDS 1987–1990
WSQ WELLS NORTH OF FEMME OSAGE SLOUGH
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-1002
GW-1009
GW-1012
GW-1025
GW-1026
GW-1028
MONITORING WELL
1987
1988
1989
1990

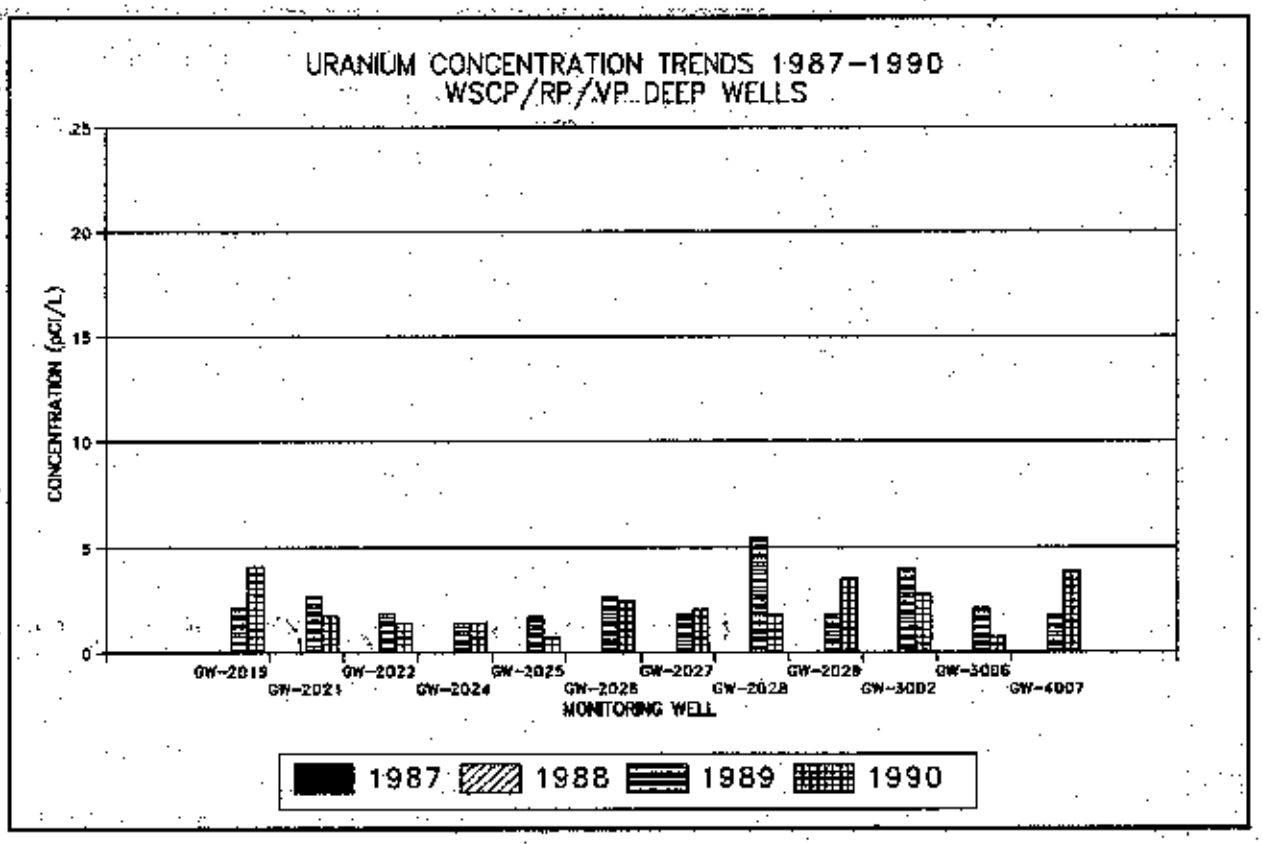

URANIUM CONCENTRATION TRENDS 1987–1990
WSQ WELLS NORTH OF FEMME OSAGE SLOUGH
CONCENTRATION (pCi/L)
6000
5000
4000
3000
2000
1000
0
GW-1004
GW-1005
GW-1006
GW-1007
GW-1008
GW-1013
GW-1014
GW-1015
GW-1016
GW-1027
MONITORING WELL
1987
1988
1989
1990

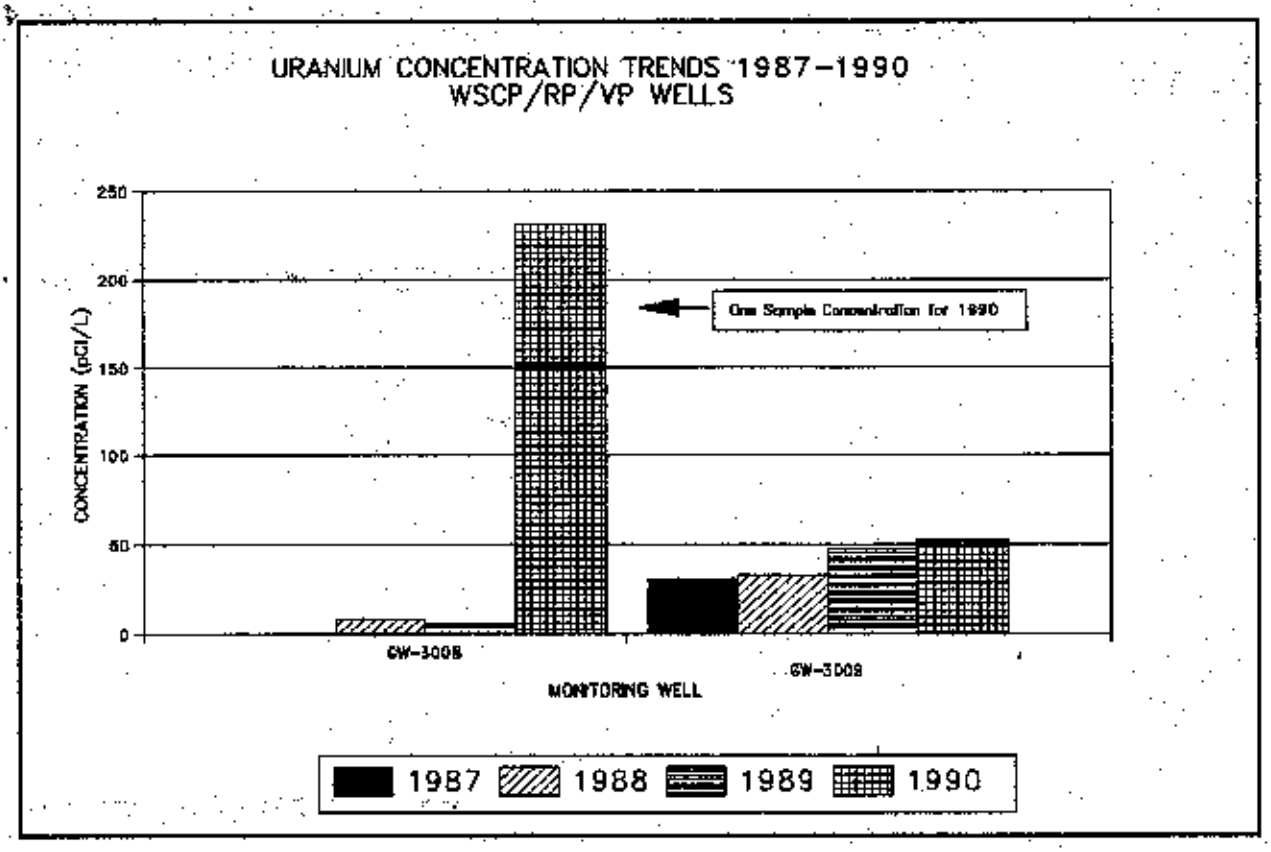

URANIUM CONCENTRATION TRENDS 1987–1990
WSQ WELLS SOUTH OF FEMME OSAGE SLOUGH
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-1010
GW-1011
GW-1017
GW-1018
GW-1019
GW-1020
GW-1021
GW-1022
GW-1023
GW-1024
GW-RMW1
GW-RMW2
GW-RMW3
GW-RMW4
MONITORING WELL
1987
1988
1989
1990

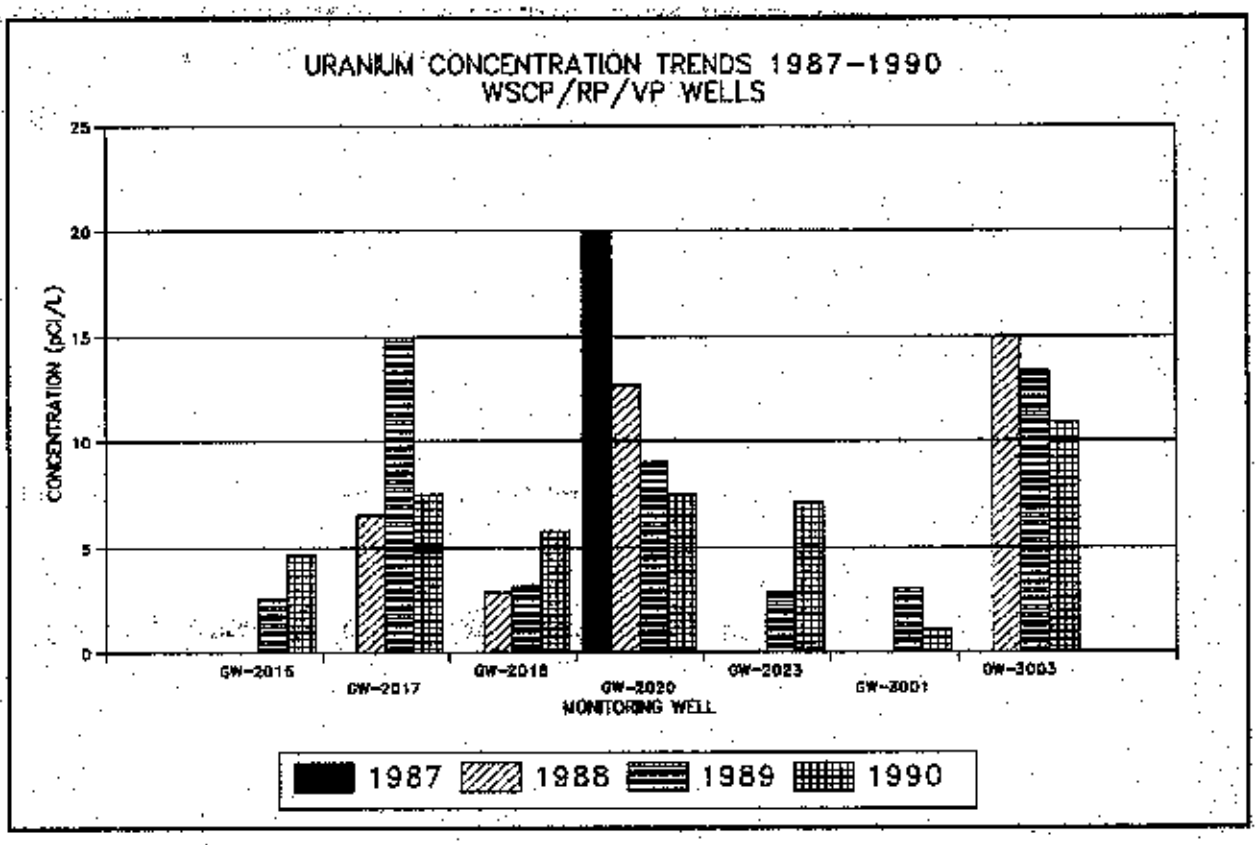

URANIUM CONCENTRATION TRENDS 1987–1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-2001
GW-2002
GW-2003
GW-2004
GW-2005
GW-2006
GW-2007
MONITORING WELL
1987
1988
1989
1990

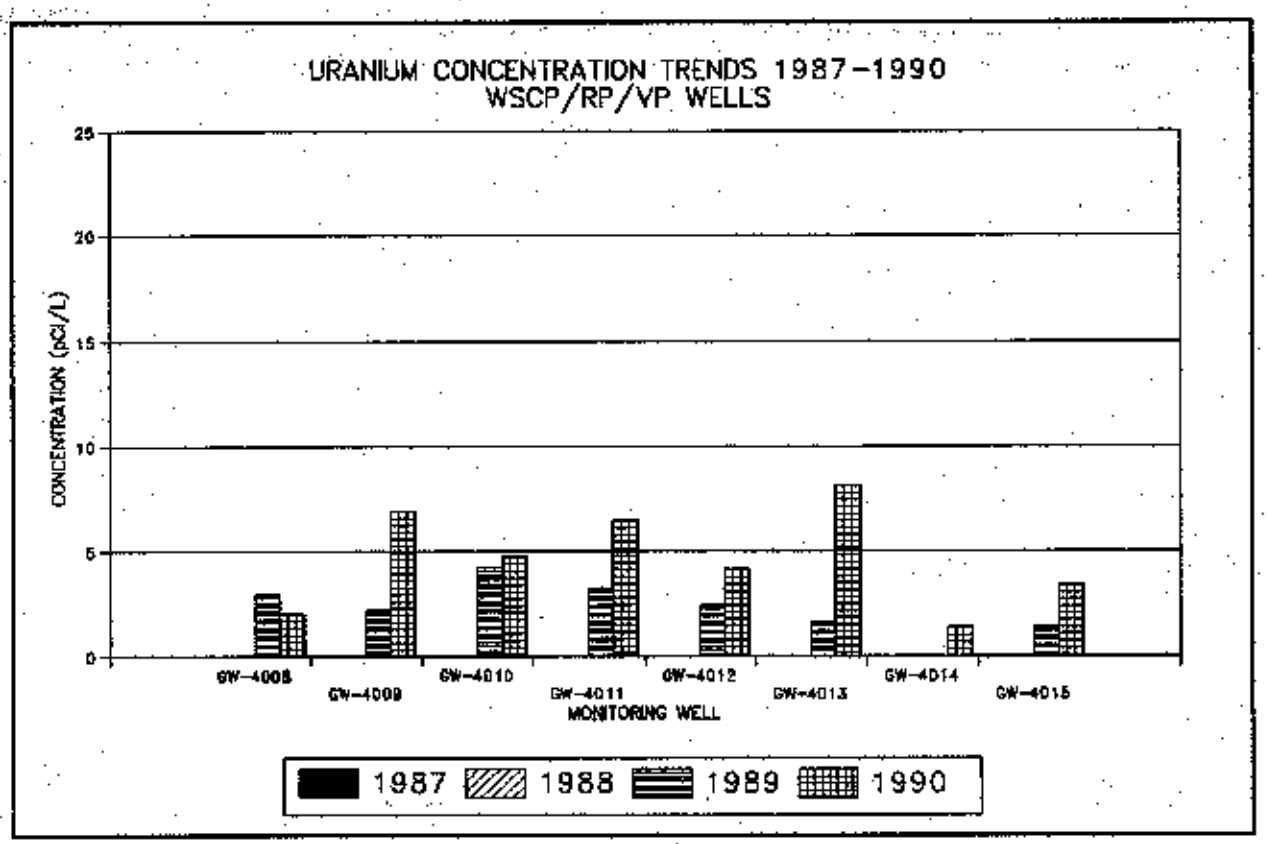

URANIUM CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-2008
GW-2009
GW-2010
GW-2011
GW-2012
GW-2013
GW-2014
MONITORING WELL
1987
1988
1989
1990

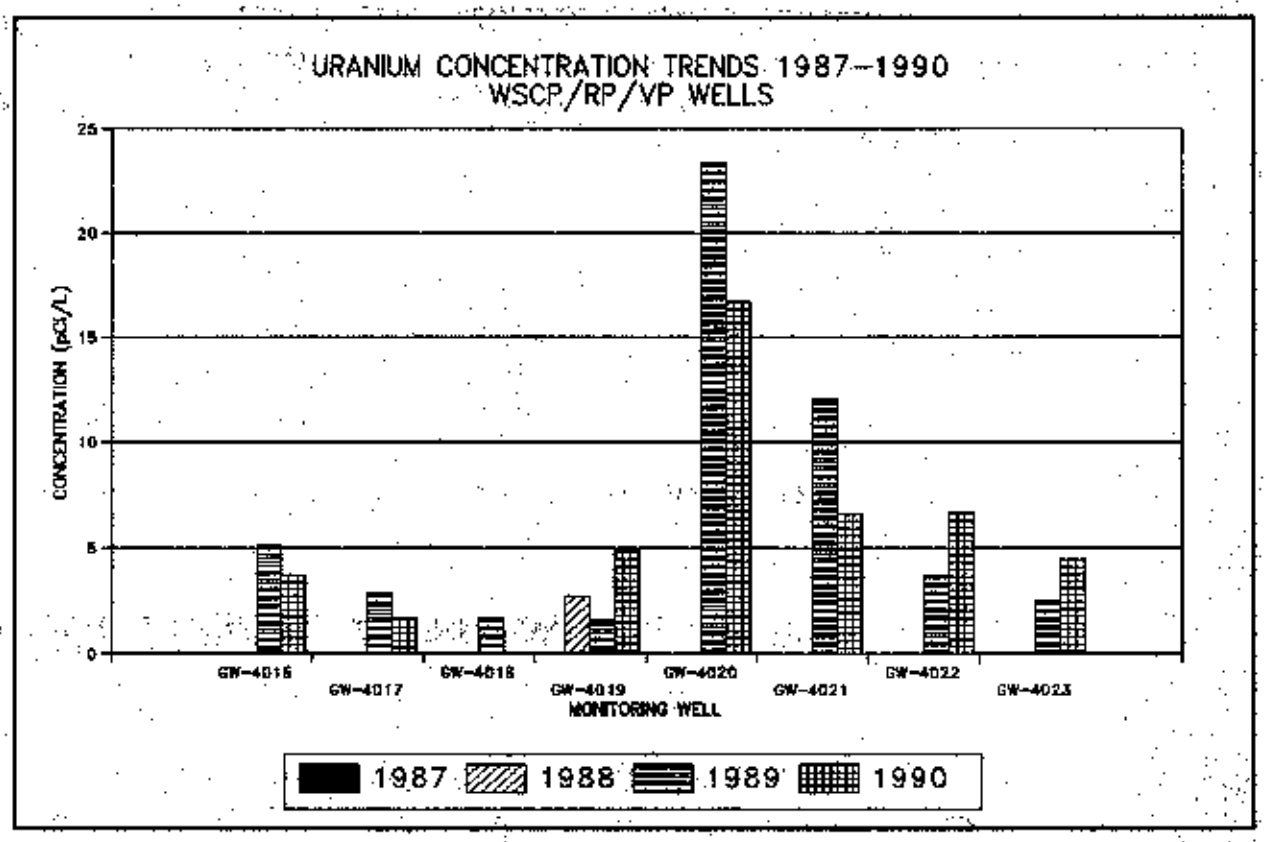

URANIUM CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
25
20
15
10
5
0

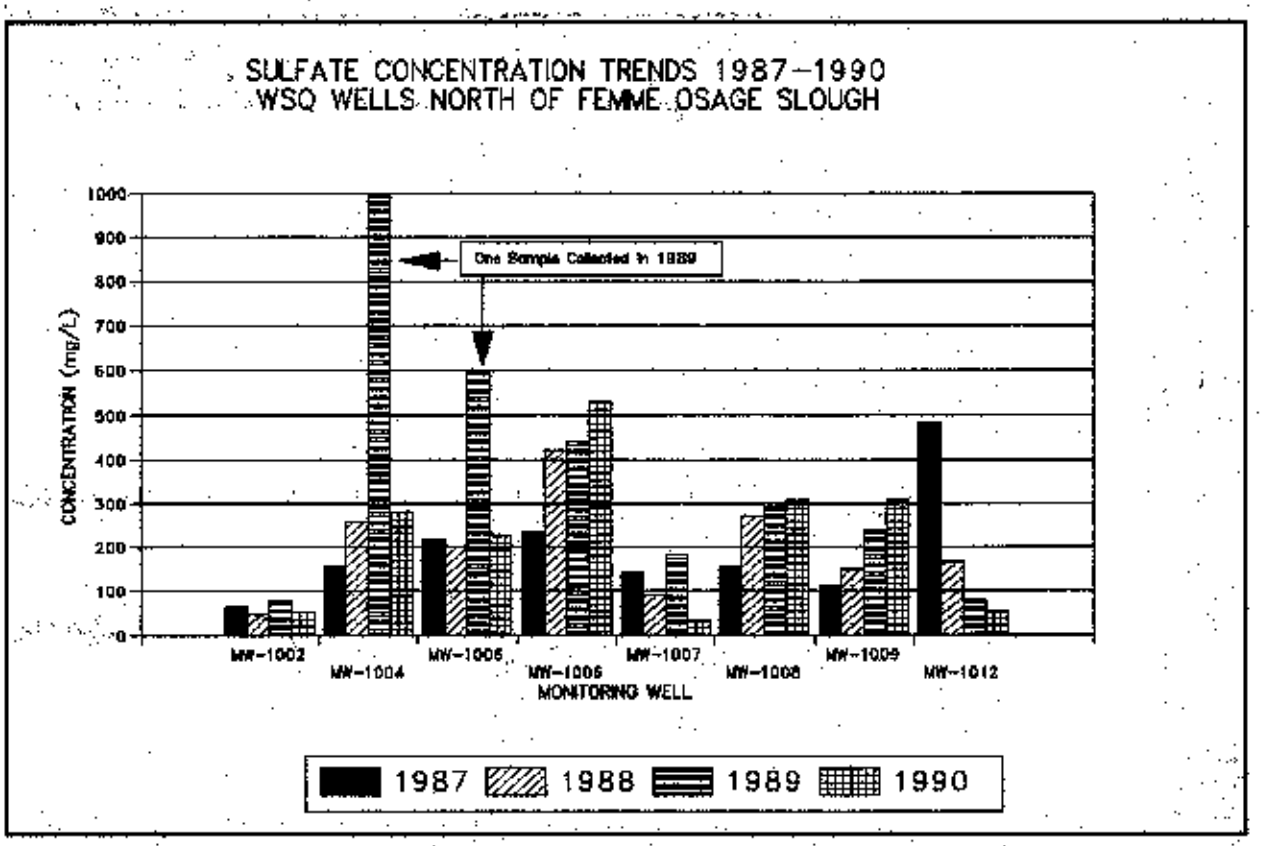

URANIUM CONCENTRATION TRENDS 1987–1990
WSCP/RP/VP DEEP WELLS
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-2019
GW-2021
GW-2022
GW-2024
GW-2025
GW-2026
GW-2027
GW-2028
GW-2029
GW-3002
GW-3006
GW-4007
MONITORING WELL
1987
1988
1989
1990

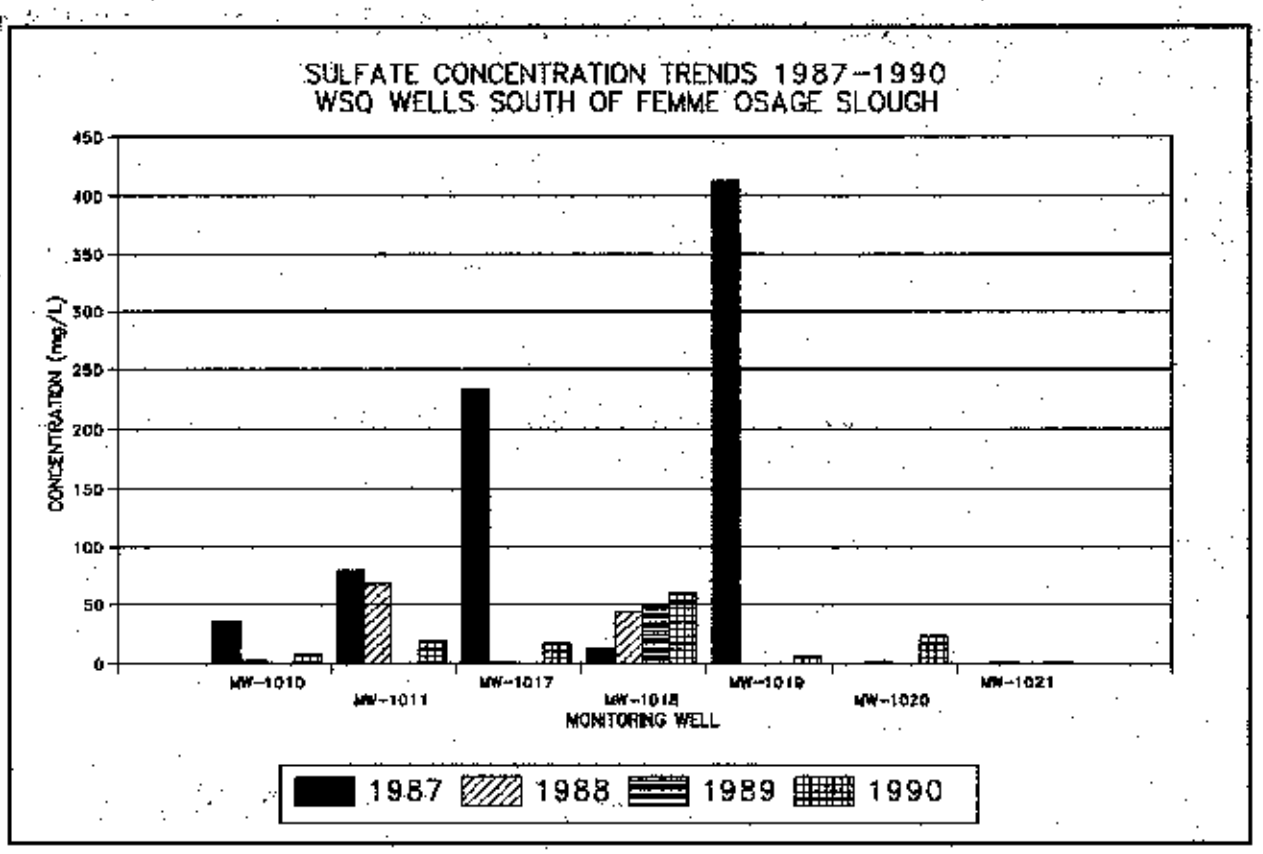

URANIUM CONCENTRATION TRENDS 1987–1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
250
200
150
100
50
0
One Sample Concentration for 1990
GW-3005
GW-3009
MONITORING WELL
1987
1988
1989
1990

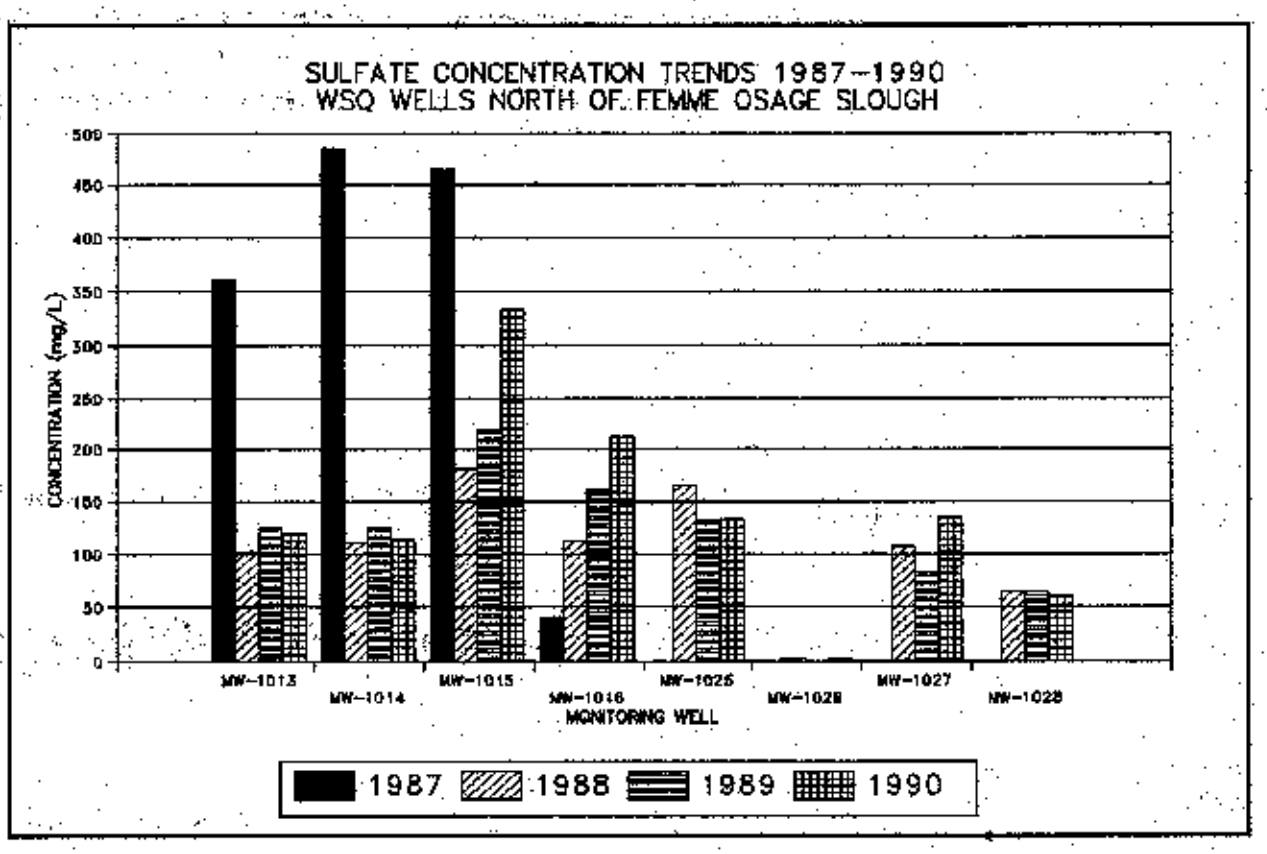

URANIUM CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
0
5
10
15
20
25
GW-2015
GW-2017
GW-2018
GW-2020
GW-2023
GW-3001
GW-3003
MONITORING WELL
1987
1988
1989
1990

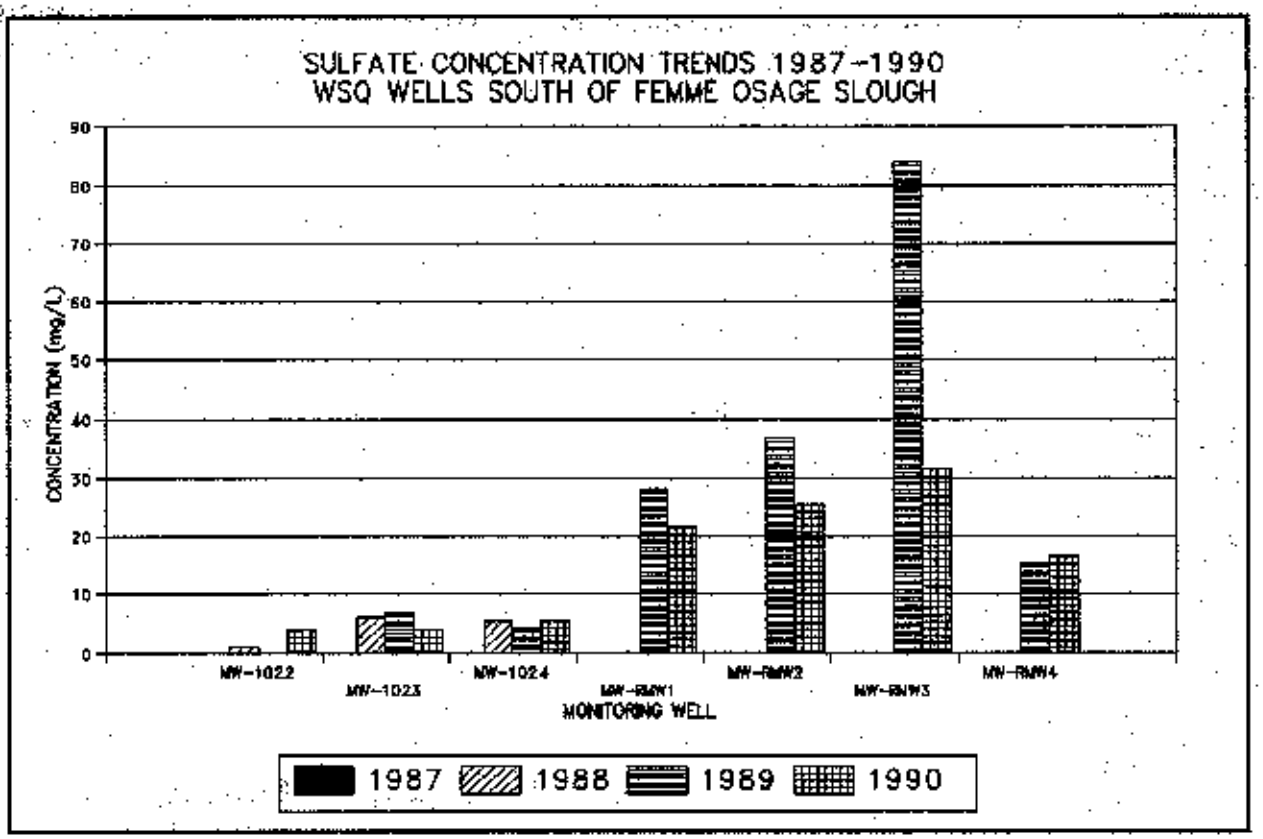

URANIUM CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
0
5
10
15
20
25
GW-4008
GW-4009
GW-4010
GW-4011
GW-4012
GW-4013
GW-4014
GW-4015
MONITORING WELL
1987
1988
1989
1990

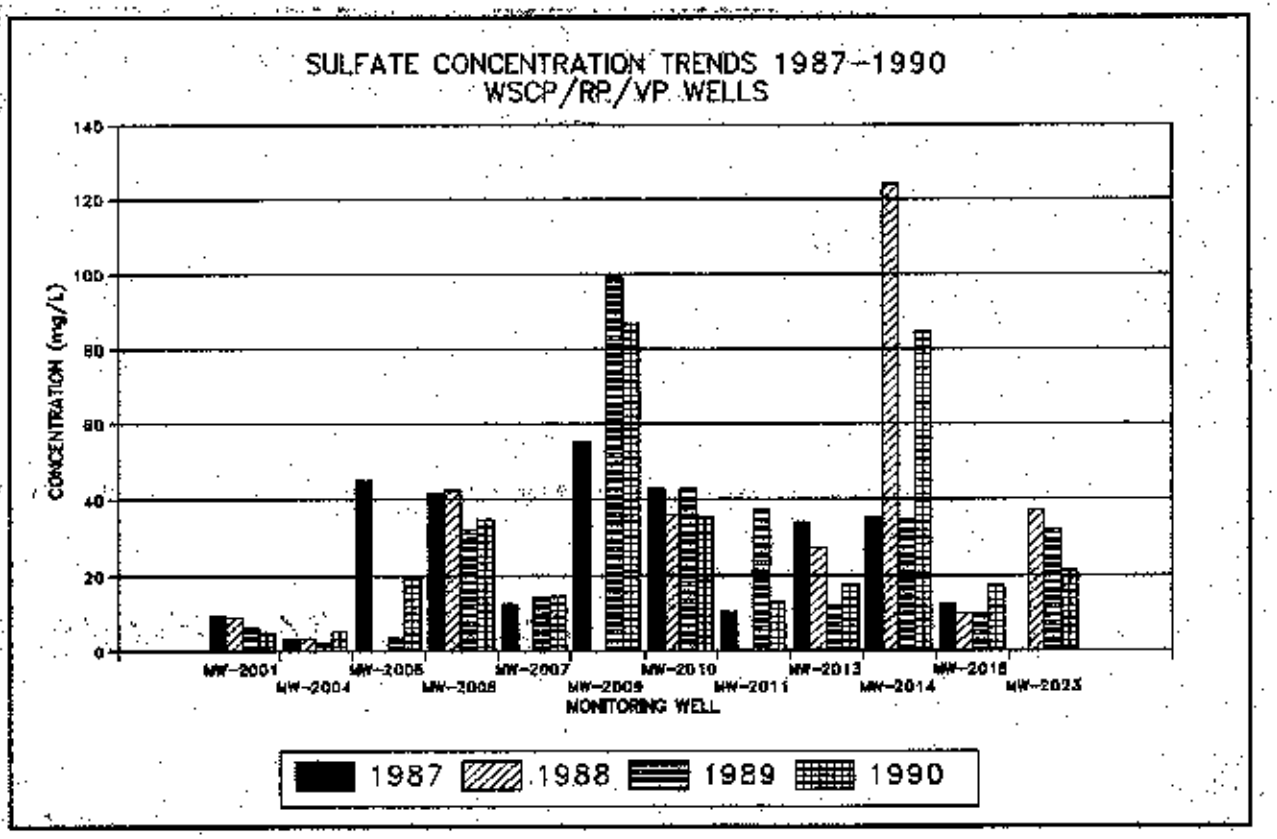

URANIUM CONCENTRATION TRENDS 1987–1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-4016
GW-4017
GW-4018
GW-4019
GW-4020
GW-4021
GW-4022
GW-4023
MONITORING WELL
1987
1988
1989
1990

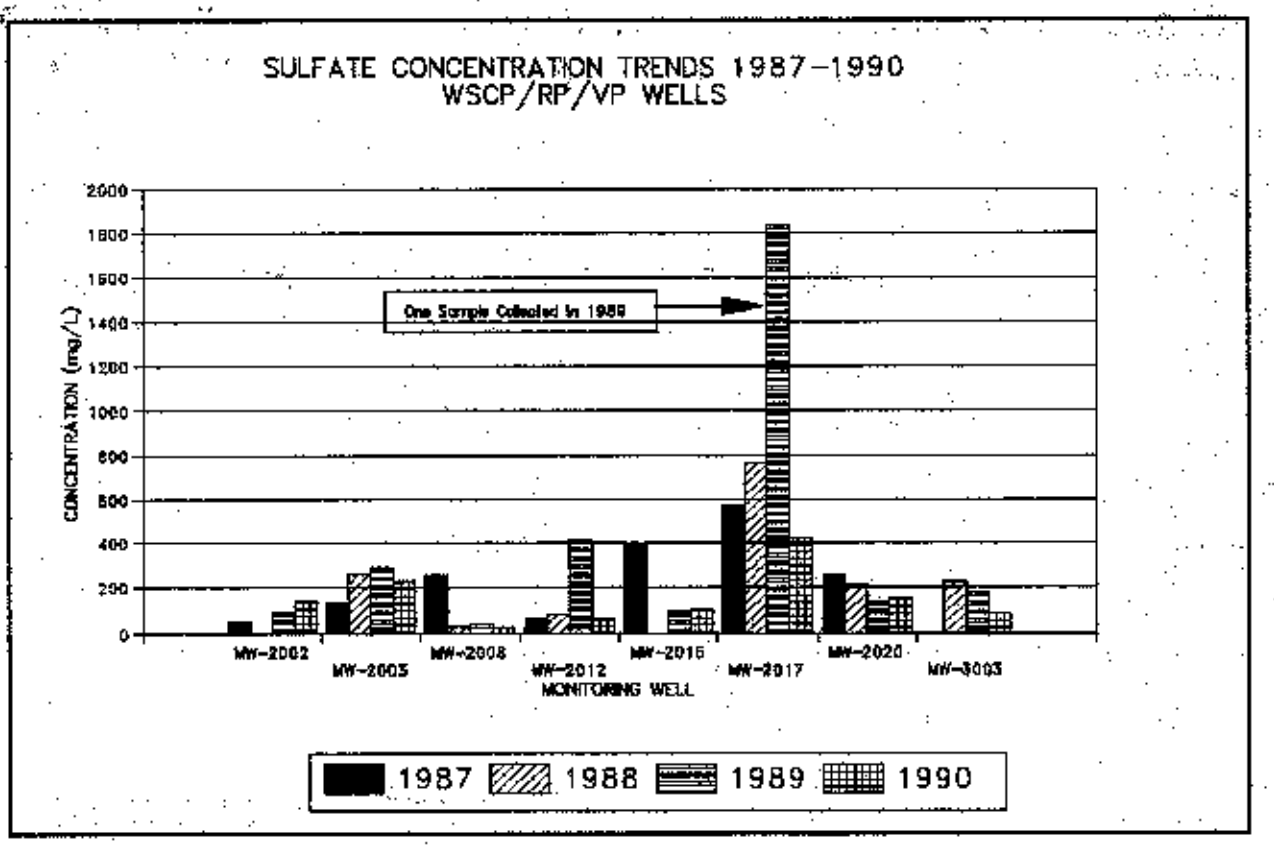

SULFATE CONCENTRATION TRENDS 1987–1990
WSQ WELLS NORTH OF FEMME OSAGE SLOUGH
CONCENTRATION (mg/L)
1000
900
800
700
600
500
400
300
200
100
0
One Sample Collected in 1989
MW-1002
MW-1004
MW-1005
MW-1006
MW-1007
MW-1008
MW-1009
MW-1012
MONITORING WELL
1987
1988
1989
1990

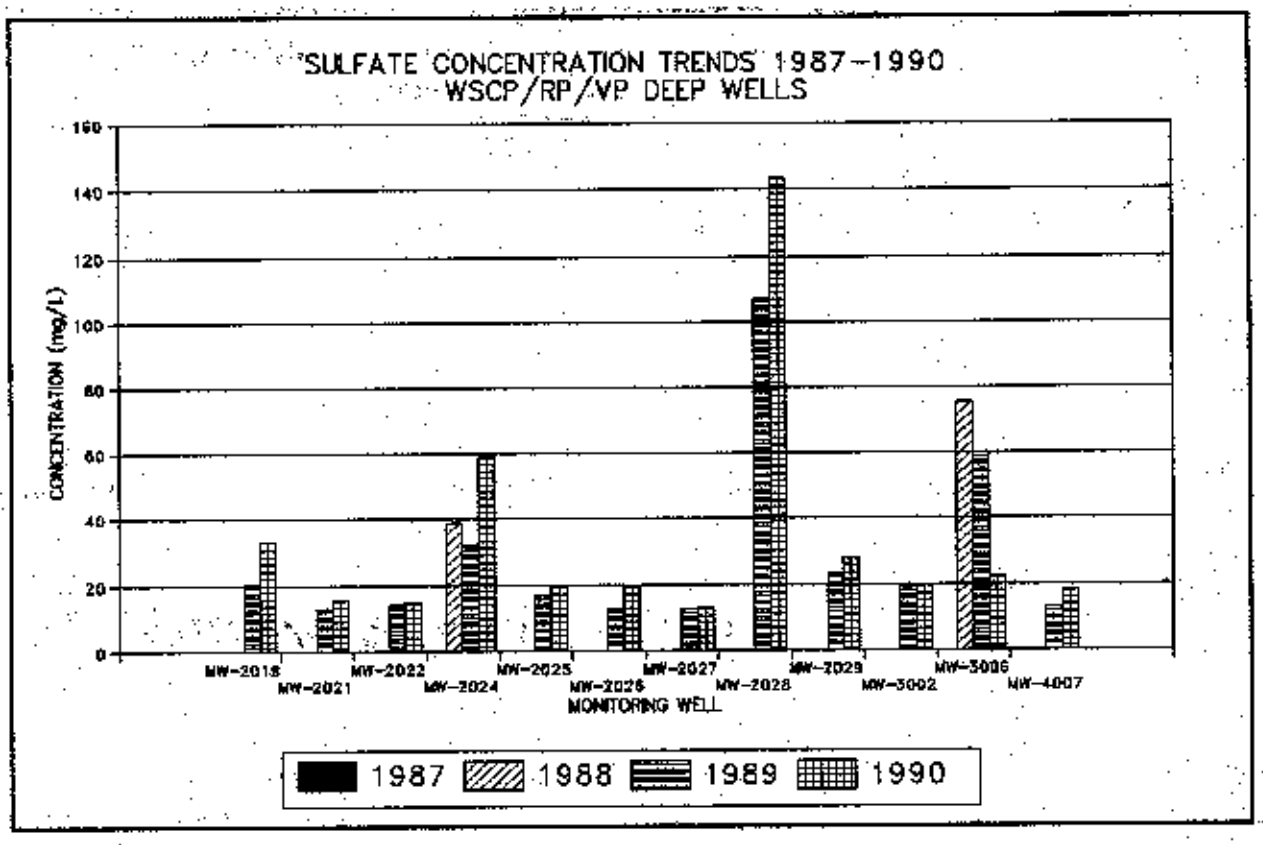

SULFATE CONCENTRATION TRENDS 1987–1990
WSQ WELLS SOUTH OF FEMME OSAGE SLOUGH
CONCENTRATION (mg/L)
450
400
350
300
250
200
150
100
50
0
MW-1010
MW-1011
MW-1017
MW-1018
MW-1019
MW-1020
MW-1021
MONITORING WELL
1987
1988
1989
1990

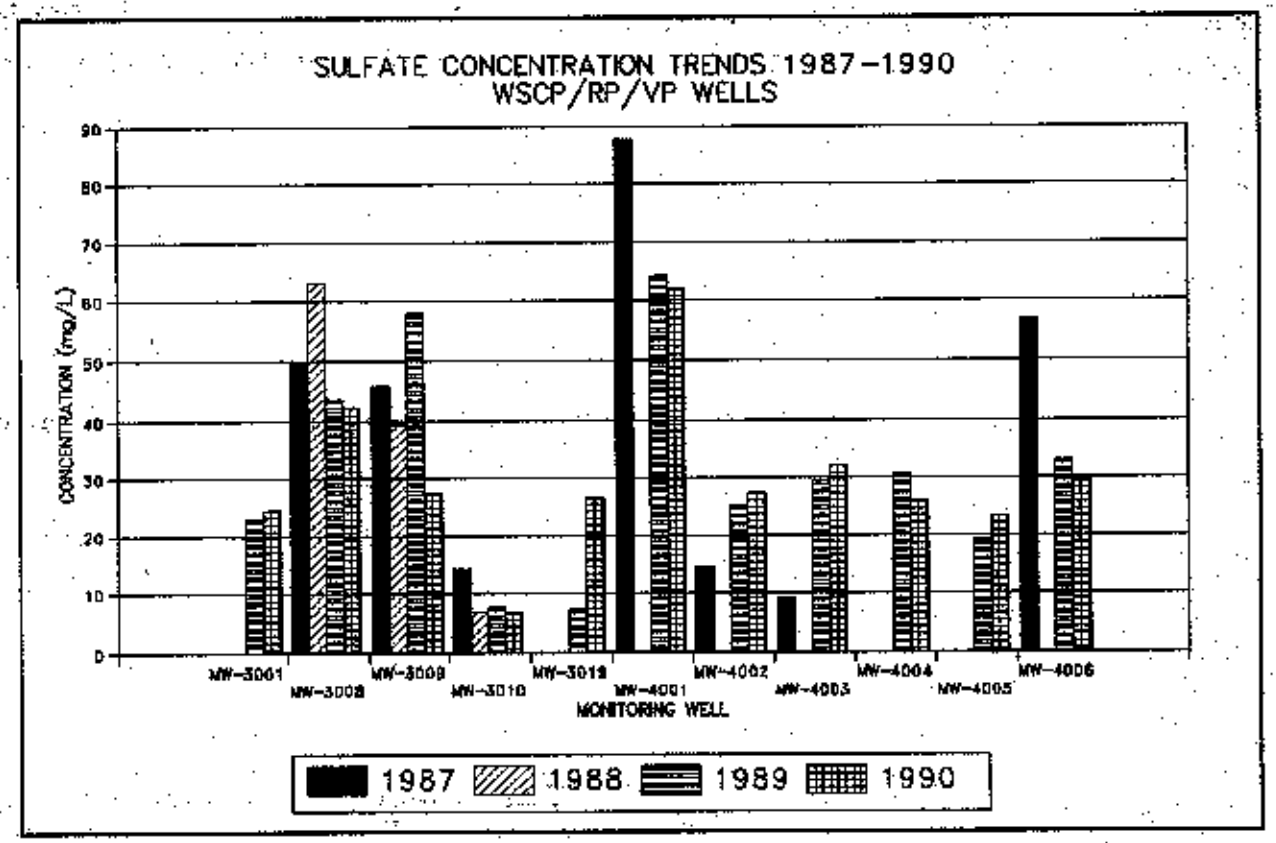

SULFATE CONCENTRATION TRENDS 1987-1990
WSQ WELLS NORTH OF FEMME OSAGE SLOUGH
CONCENTRATION (mg/L)
500
450
400
350
300
250
200
150
100
50
0
MW-1013
MW-1014
MW-1015
MW-1016
MW-1025
MW-1026
MW-1027
MW-1028
MONITORING WELL
1987
1988
1989
1990

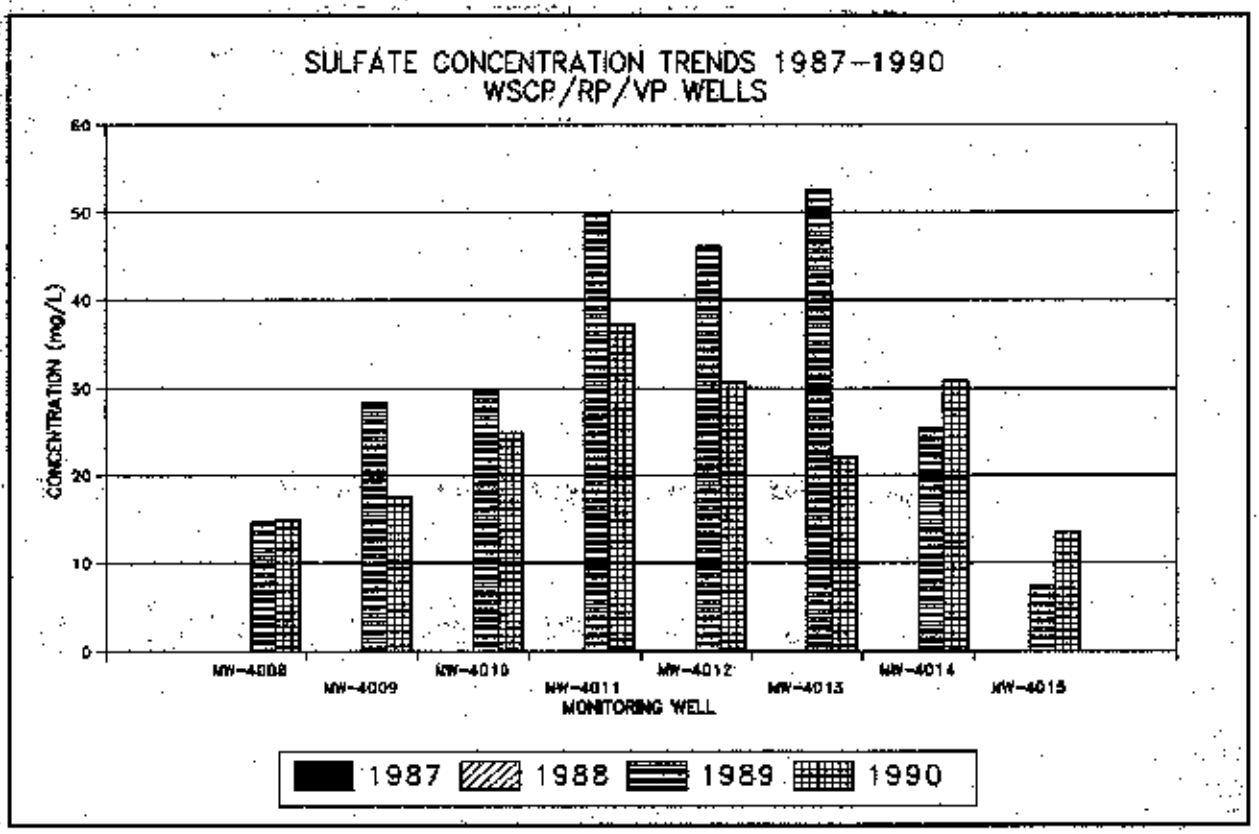

SULFATE CONCENTRATION TRENDS 1987-1990
WSQ WELLS SOUTH OF FEMME OSAGE SLOUGH
CONCENTRATION (mg/L)
90
80
70
60
50
40
30
20
10
0
MW-1022
MW-1023
MW-1024
MW-RMW1
MW-RMW2
MW-RMW3
MW-RMW4
MONITORING WELL
1987
1988
1989
1990

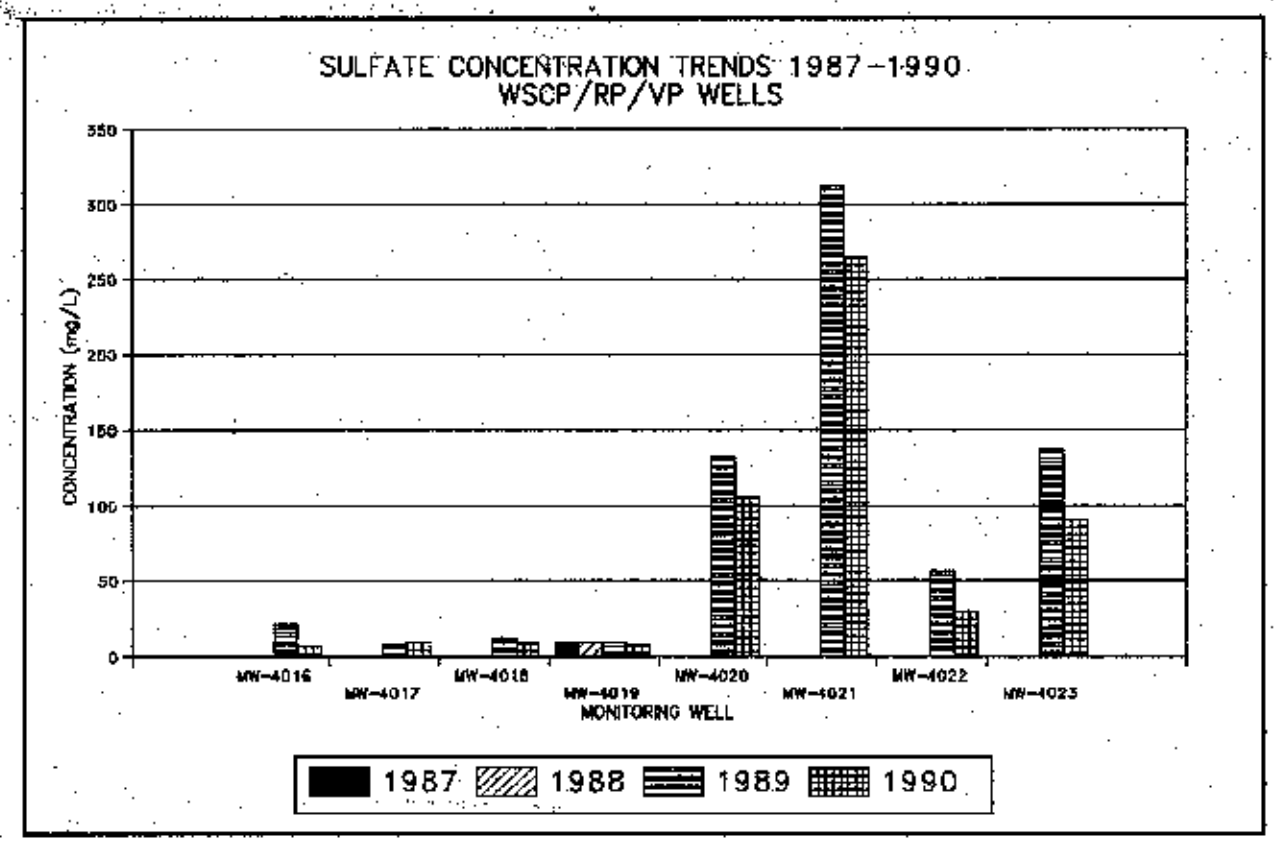

SULFATE CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (mg/L)
0
20
40
60
80
100
120
140
MW-2001
MW-2004
MW-2005
MW-2006
MW-2007
MW-2009
MW-2010
MW-2011
MW-2013
MW-2014
MW-2016
MW-2023
MONITORING WELL
1987
1988
1989
1990


SULFATE CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (mg/L)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
One Sample Collected in 1989
MW-2002
MW-2005
MW-2008
MW-2012
MW-2015
MW-2017
MW-2020
MW-3003
MONITORING WELL
1987
1988
1989
1990


SULFATE CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP DEEP WELLS
CONCENTRATION (mg/L)
0
20
40
60
80
100
120
140
160
MW-2018
MW-2021
MW-2022
MW-2024
MW-2025
MW-2026
MW-2027
MW-2028
MW-2029
MW-3002
MW-3006
MW-4007
MONITORING WELL
1987
1988
1989
1990


SULFATE CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (mg/L)
0
10
20
30
40
50
60
70
80
90
MW-3001
MW-3002
MW-3009
MW-3010
MW-3012
MW-4001
MW-4002
MW-4003
MW-4004
MW-4005
MW-4006
MONITORING WELL
1987
1988
1989
1990


SULFATE CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (mg/L)
0
10
20
30
40
50
60
MW-4008
MW-4009
MW-4010
MW-4011
MW-4012
MW-4013
MW-4014
MW-4015
MONITORING WELL
1987
1988
1989
1990


SULFATE CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (mg/L)
0
50
100
150
200
250
300
350
MW-4016
MW-4017
MW-4018
MW-4019
MW-4020
MW-4021
MW-4022
MW-4023
MONITORING WELL
1987
1988
1989
1990

APPENDIX C
GLOSSARY OF TECHNICAL TERMS

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APPENDIX C
GLOSSARY OF TECHNICAL TERMS

ABSORBED DOSE: The amount of energy absorbed in any material from incident radiation. Measured in rads, where 1 rad equals 100 ergs of energy absorbed in 1 gram of matter.

ACTIVITY: A measure of the rate at which radioactive material is undergoing radioactive decay; usually given in terms of the number of nuclear disintegrations occurring in a given quantity of material over a unit of time. The unit of activity is the Curie (Ci) (see also Bequerel and Curie).

ALARA: An acronym for "As Low as Reasonably Achievable." This refers to the U.S. Department of Energy goal of keeping releases of radioactive substances to the environment and exposures of humans to radiation as far below regulatory limits as "reasonably achievable."

ALLUVIAL AQUIFER: A subsurface zone, formed by the deposition of sediments by running water, capable of yielding usable quantities of groundwater to wells.

ALPHA PARTICLE: A positively charged particle emitted from the nucleus during the radioactive decay of certain radionuclides. It consists of two protons and two neutrons bound together; it is identical to the nucleus of a helium-4 atom.

BACKGROUND RADIATION: Radiation due to cosmic rays and radiation from the naturally radioactive elements in the surface of earth.

BEDROCK: A rock formation usually underlying one or more unconsolidated formations.

BEQUEREL: SI unit for activity. 1 bequerel (Bq) = 1 disintegration/second = 2.703×10^{-11} Ci (curie).

BETA PARTICLE: Charged particle emitted from the nucleus of an atom, with a mass and charge equal in magnitude to that of the electron.

CHAIN OF CUSTODY: Standardized form tracing the possession and handling of individual samples from the time of field collection through laboratory analysis.

COMMITTED DOSE EQUIVALENT: The total dose equivalent averaged throughout a tissue in the 50 years after intake of a radionuclide into the body.

CONTAMINATION: A foreign substance in or on the surfaces of soils, structures, areas, objects, or personnel.

COUNTING STATISTICS: Statistical analysis required to process the results of nuclear counting experiments and to make predictions about the expected precision of quantities derived from these measurements.

CURIE: A measure of the rate of radioactive decay. One Curie (Ci) is equal to 37 billion disintegrations per second (3.7×10^{10} dps), which is equal to the decay rate of one gram of radium-226.

DAUGHTER: An element that results immediately from the disintegration of a radioactive element.

DECAY PRODUCTS: Isotopes that are formed by the radioactive decay of some other isotope. In the case of radium-226, for example, there are 10 successive decay products, ending in the stable isotope Lead-206.

DERIVED CONCENTRATION GUIDE (DCG): Concentrations of radionuclides in water and air that could be continuously consumed or inhaled and not exceed an effective dose equivalent of 100 mrem/year.

DISCHARGE: In groundwater hydrology, the rate of flow (usually from a well or spring) at a given instant in terms of volume per unit of time.

DOSE: Total radiation delivered to a specific part of the body, or to the body as a whole; also called dose equivalent.

DOSE RATE: Dose or dose equivalent per unit of time (i.e., millirem per year) as it is being delivered to the body.

DOSIMETER: A device used in measuring radiation dose, such as a lithium fluoride (LiF) thermoluminescent detector (TLD).

EFFECTIVE DOSE EQUIVALENT: The proportion of the stochastic risk resulting from irradiation of a tissue to the total risk when the whole body is irradiated uniformly. A term used to express the amount of effective radiation when modifying factors have been considered, it is the product of absorbed dose (rads) multiplied by a quality factor and any other modifying factors. It is measured in rem (Roentgen Equivalent Man).

ERG: 1 ERG = 2.8×10^{-14} KWH

EXPOSURE PATHWAY: The route by which a contaminant/health hazard may enter and move through the environment or individual.

EXPOSURE RADIATION: The amount of ionization produced in air by X-rays or gamma rays, measured in Roentgens (R).

GAMMA RADIATION: Penetrating high energy, short wave-length, electromagnetic radiation (similar to x-rays) emitted during radioactive decay. Gamma rays are very penetrating and can be attenuated only by dense materials such as lead.

GROSS ALPHA: Measurement of all alpha-emitting radionuclides in a sample.

GROSS BETA: Measurement of all beta-emitting radionuclides in a sample. Gross alpha and beta are useful analyses for screening to determine whether further analyses for specific radionuclides are merited.

HALF LIFE: The time it takes for half the atoms of a quantity of a particular radioactive element to decay into another form. Half-lives of different isotopes vary from millionths of a second or less to billions of years.

HECTARE: A unit of area in the metric system equal to 10,000 square meters. It is approximately 2.5 acres.

HYDROLOGIC: Pertaining to study of the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

ISOTOPE: Nuclides having the same atomic number but different mass numbers.

MDA/LLD: The minimum amount of a material or characteristic property being measured that can be detected with reasonable certainty by the analytical procedure being used.

NATURAL URANIUM: A naturally occurring radioactive element that consists of 99.2830% by weight uranium-238, 0.7110% uranium-235 and 0.0054% uranium-234.

NUCLIDE: A general term referring to isotopes, both stable (279) and unstable (about 500), of the chemical elements.

PERCHED LENSES: A small, localized water-saturated zone of subsurface material surrounded by unsaturated material.

RAD: Unit of absorbed dose; acronym for radiation absorbed dose.

RADIATION: A very general term that covers many forms of particles and energy, from sunlight and radiowaves to the energy that is released from inside an atom. Radiation can be in the form of electromagnetic waves (gamma rays, x-rays) or particles (alpha particles, beta particles, protons, neutrons).

RADIONUCLIDE: An unstable nuclide that undergoes radioactive decay.

RAFFINATE: A waste product from a refining process, i.e., that portion of a treated liquid mixture that is not dissolved and not removed by a selective solvent.

REM (Roentgen Equivalent Man): A quantity used in radiation protection to express the effective dose equivalent for all forms of ionizing radiation. A rem is the product of the absorbed dose in rads and factors related to relative biological effectiveness.

SI: International System of Units.

SIEVERT: SI unit used to express the effective dose equivalent for all forms of ionizing radiation. 1 Sv = 100 rem

STOCHASTIC: "Stochastic" effects are those for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose, without a threshold.

WORKING LEVEL: Any combination of radon-222 decay products in 1 liter of air that will result in the ultimate emission of 0.21 erg of alpha energy is defined as 1 WL. It is based on the 0.21 erg of alpha energy that would be emitted by the decay products of 100 pCi of radon-222 in 1 liter of air, where the decay products are in radioactive equilibrium with the parent.

WORKING LEVEL MONTH: The product of WL and duration of exposure, normalized to a 1-month exposure period.

X-RAYS: Penetrating electromagnetic radiation having a wave length that is much shorter than that of visible light. It is customary to refer to rays originating in the nucleus as gamma rays and to those originating in the electron field of the atom as x-rays.

APPENDIX D
ACRONYMS AND ABREVIATIONS

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APPENDIX D
ACRONYMS AND ABBREVIATIONS

ABWA	August A. Busch Memorial Wildlife Area
AEC	Atomic Energy Commission
ARAR	applicable and/or relevant and appropriate requirements
BNI	Bechtel National Inc.
BOD	Biochemical Oxygen Demand
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CM&O	Construction Management and Operations
CWA	Clean Water Act
CX	categorical exclusion
DA	Department of the Army
DCG	Derived Concentration Guideline
DNT	dinitrotoluene
DOE	U.S. Department of Energy
DOT	Department of Transportation
DQO	data quality objectives
EA	Environmental Assessment
EDAP	Environmental Data Administration Plan
EDE	effective dose equivalent
EE/CA	engineering evaluation/cost analysis
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ES&H	Environmental Safety and Health
FFA	Federal Facility Agreement
FHHS	Francis Howell High School
GWPP	Groundwater Protection Program
HpGe	high purity germanium
IRA	interim response action
LLD	lower limit of detection
MDA	minimum detectable activity
MDNR	Missouri Department of Natural Resources
MDOC	Missouri Department of Conservation
NCO	NEPA Compliance Officer
ND	non detect
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
OSHA	Occupational Safety & Health Administration

PCB	polychlorinated biphenyl
PCM	phase contrast microscopy
PEL	permissible exposure limit
PIC	pressurized ionization chamber
PIP	Productivity Improvement Program
PMC	Project Management Contractor
QA/QC	Quality Assurance/Quality Control
QCSA	quarry construction staging area
QWTP	quarry water treatment plant
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SFMP	Surplus Facilities Management Program
SWATS	Site Wide Audit Tracking System
SWTP	site water treatment plant
SOP	Standard Operating Procedures
TBP	tributyl phosphate
TCLP	toxicity characteristic leaching procedure
TEM	transmission electron microscopy
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TSCA	Toxic Substance Control Act
TSS	total suspended solid
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
WITS	Waste Inventory Tracking System
WLM	Working Level Monitor
WSCP	Weldon Spring Chemical Plant
WSCP/RP/VP	Weldon Spring Chemical Plant/raffinate pits/vicinity properties
WSOW	Weldon Spring Ordnance Works
WSQ	Weldon Spring quarry
WSRP	Weldon Spring raffinate pits
WSS	Weldon Spring site
WSSRAP	Weldon Spring Site Remedial Action Project
WSUFMP	Weldon Spring Uranium Feed Materials Plant
WTP	water treatment plant

APPENDIX E
ENVIRONMENTAL GUIDELINES

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APPENDIX E
ENVIRONMENTAL GUIDELINES

This Appendix contains standards and guidelines that are either applicable to the WSS or are presented to provide a frame of reference for discussion.

RADIATION STANDARDS (DOE Order 5400.5, *Radiation Protection of the Public and the Environment*)

A. DOSE LIMITS

1. All Pathways
The effective dose equivalent for any member of the public from all routine DOE operations[1] (natural background and medical exposures excluded) shall not exceed the values given below:

	Effective dose equivalents[2] mrem/year	(mSv/year)
Occasional annual exposures	100	(1)

2. Air Pathway Only (Limits of 40 CFR 61, Subpart H)

Effective Dose Equivalent 10 mrem/year or 0.1 mSv/year

1. Routine DOE operations means normal planned operations and does not include actual or potential accidental or unplanned releases.

2. Effective dose equivalent will be expressed in rem (or millirem) with the corresponding value in sievert (or millisievert) in parenthesis. As used in this standard, effective dose equivalent includes both the effective dose equivalent from external radiation and the committed effective dose equivalent to individual tissues from ingestion and inhalation during the calendar year.

B. DERIVED CONCENTRATION GUIDES (DCG)

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1 Routine DOE operations mean normal planned operations and does not include actual or potential accidental or unplanned releases.

2 Effective dose equivalent will be expressed in rem (or millirem) with the corresponding value in sievert (or millisievert) in parenthesis. As used in this standard, effective dose equivalent includes both the effective dose equivalent from external radiation and the committed effective dose equivalent to individual tissues from ingestion and inhalation during the calendar year.

The following table contains a listing of the DCG values for the ingestion of drinking water and inhalation of air for members of the public. The values are based on a committed dose equivalent rate of 100 mrem/yr. Five columns of information are shown in the table: 1) radionuclide; 2) drinking water ingestion DCG in units of μCi/ml; 3) drinking water DCG in units of Bq/ml; 4) inhalation DCG in units of μCi/ml; 5) inhalation DCG in units of Bq/mL.

Only a single mode of exposure was considered--either ingestion or inhalation.

The DCG values are given for individual radionuclides. For known mixtures of radionuclides, the sum of the ratio of the observed concentration of a particular radionuclide and its corresponding DCG for all radionuclides in the mixture must not exceed 1.0.

It should be noted that the values given in the table only account for drinking water and inhaling air, and do not include other potentially significant environmental pathways. A more complete pathway analysis is required for calculating public radiation dose equivalent resulting from the operation of DOE facilities when more complex environmental pathways are involved.

	Drinking Water		Inhaled Air	
Radionuclide	μCi/mL	Bq/mL	μCi/mL	Bq/mL
Natural Uranium	6.0E-07	2.2E-02		
Uranium-238	6.0E-07	2.2E-02	1.0E-13	3.07-09
Uranium-235	6.0E-07	2.2E-02	1.0E-13	3.7E-09
Uranium-234	5.0E-07	1.9E-02	9.0E-14	3.3E-09
Thorium-232	5.0E-08	1.9E-03	7.0E-15	2.6E-10
Thorium-230	3.0E-07	1.1E-02	4.0E-14	1.5E-09
Radium-228	1.0E-07	3.7E-03	3.0E-12	1.1E-07
Radium-226	1.0E-07	3.7E-03	1.0E-12	3.7E-08

C. RADON

DCGs for radon (Rn-220) are being assessed by DOE. Until the review has been completed and new valves issued, the valve of 3.E-09 μCi/ml stated in DOE Order 5400.5 shall be used from radon releases from DOE facilities. In addition, interim storage facilities will not exceed an annual average concentration of 3 pCi/l at or above any location outside the facility site.

CHEMICAL STANDARDS

U.S. EPA Drinking Water Standards (mg/l) as noted in 40 CFR Parts 141 and 143

Drinking water standards are presented only for comparison purposes. These should not necessarily be construed as relevant cleanup standards.

A. HSL-Metals

Aluminum	NS	Lthium	NS
Antimony	NS	Magnesium	NS
Arsenic	0.05*	Manganese	0.05**
Barium	1.0*	Mercury	0.002
Beryllium	NS	Nickel	NS
Cadmium	0.01*	Potassium	NS
Calcium	NS	Selenium	0.01
Chromium	0.05*	Silver	0.05
Cobalt	NS	Sodium	NS
Copper	1.0**	Thallium	NS
Iron	0.3**	Vanadium	NS
Lead	0.05	Zinc	5.0**

B. Inorganic Anion and Water Quality

Nitrate (as N)	10*
Sulfate	250**
Chloride	250**
Fluoride	4*2**
Hardness	NS
TDS	500**
TOC	NS

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* Primary maximum contaminant level
** Secondary maximum contaminant level
NS - No Drinking Water Standard

APPENDIX F
CONVERSION FACTORS

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CONVERSION FACTORS

1 millisievert (mSv)	=	100 mrem
1 milliroentgen (mR)	=	1 mrem (for gamma radiation)
1 Curie (Ci)	=	3.7×10^{10} dps (disintegrations/sec)
1 Bequerel (Bq)	=	1 disintegration per second
1 M^3	=	1000 litres
1 Bq/M^3	=	3.7×10^{-2} pCi/M^3
1 Bq/l	=	3.7×10^{-2} pCi/l
1 Bq/kg	=	3.7×10^{-2} pCi/kg
1 km	=	.62 miles
1 m	=	3.28 ft
1 m^3	=	1.31 cu yd
1 mm	=	.039 inches
1 ha	=	2.47 acres
1 Gy	=	100 RAD

APPENDIX G
DOSE ASSESSMENT CALCULATIONS

A. Dose from the WSCP/WSRP to a maximally exposed individual.

1. Inhalation and external gamma pathways: not applicable since there is no reason to suspect at the 95% confidence level that airborne radioactive particulate, radon gas, and external gamma radiation data are greater than the respective background concentrations.

2. Ingestion pathway:

   a. fish - assume a 6.5 g/d fresh water fish consumption rate (EPA 1988) from Lake 36 (highest average uranium concentration in fish of all lakes receiving runoff from the WSS).

   b. water - assume a 0.05 liter/hr swimming ingestion rate (EPA 1988) for 1hr/wk for 12 wks, total of 0.6 liters. Assume water has uranium concentrations as detected in Lake 36 (highest uranium in water concentrations of all lakes receiving runoff from the WSS).

   c. sediment - assume a 200 mg/day ingestion rate for 2 days/yr for a total of 400 mg of sediment. Assume sediment has uranium concentrations as detected in Lake 34 (highest uranium concentration of all lakes receiving runoff from the WSS).

EDE (ingestion) = annual fish consumption x isotopic uranium concentration x isotopic DCF(1) + annual water consumption x uranium concentration x uranium DCF(2) + annual sediment concentration x uranium concentration x uranium DCF(2)

EDE (ingestion) = 0.0246 mrem

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(1) Isotopic Dose Conversion Factor (DCF) was the greater of the two DCFs reported for each uranium isotope as reported in Table 2.2 of Eckerman et al. (1988).

(2) Uranium DCF was obtained from DOE (1988). DOE DCF guidance was used for water and sediment consumption to be consistent with the exposure scenario used in the 1989 Annual Site Environmental Report.

B. Dose from the WSQ to a maximally exposed individual.

1. Inhalation pathway:

a. Airborne radioactive particulate - assume that the net concentration measured at AP-1010 (4.6E-16 μCi/ml) had the same ratio of radionuclides in the radionuclide inventory of the quarry surface soils, as reported in the quarry remedial investigation report (MKF and JEG 1989b) Activity ratios are given in Section D of this appendix. Assume an annual residence time of 50 hrs (Section 4.1.8.2). Assume a breathing rate of 1.25 m^3/hr (Cember 1983).

b. Radon gas - assume the concentration at State Route 94 is equal to the measured net concentration RD-1002 1.8 pCi/l. Assume an annual residence time of 50 hrs (Section 4.1.8.2). Assume that the working level ratio for Rn-222 was 50%.

EDE (inhalation) = net radon concentration x breathing rate x exposure time x dose conversion factor + net isotopic airborne particulate concentration x breathing rate x exposure time x isotopic DCF(1).

EDE (inhalation) = 3.306 mrem

2. External gamma radiation pathway: assume that the net gamma exposure at State Route 94 was the same as measured at monitoring station TD-1001 (0.003 mrem/hr), (the highest rate measured at the quarry). Assumed that the annual residence time was 50 hrs (Section 4.1.8.2).

EDE = Exposure rate x exposure time
EDE (gamma) = 0.15 mrem

(1) Dose Conversion Factors (DCF) were obtained from the EPA (Eckerman et al. 1988).

3. Ingestion pathway: because the quarry is controlled by an 2.4 m (8 ft) high barbed wire fence; fishing, swimming, and drinking water at the quarry does not constitute a realistic scenario.

C. Dose from the WSVPs to a maximally exposed individual.

1. Inhalation pathway: the Femme Osage Slough, that the hypothetical individual is assumed to frequent, is not suspected of having airborne radioactive particulate concentrations or radon daughter concentrations above normal background levels (Section 4.1.8.3), and thus there should be no effective dose exposed individual via this pathway.

2. External gamma pathway: assumed that the hypothetical individual sat on the bank of the slough a total of 200 hr/yr (Section 4.1.8.3). In addition the measured net gama exposure rate of 2.5 μR/hr was used to calculate the effective dose equivalent.

EDE = Exposure time x exposure rate
EDE = 0.5 mrem

3. Ingestion pathway:

Fish - assume a 6.5 g/day fresh water fish consumption rate (EPA 1988) from the slough. Assumed that the uranium concentration in fish is equal to the detection limit achieved during analysis (Section 4.1.8.3).

EDE = Fish consumption x uranium concentration x DCF[(1)]
EDE = 0.006 mrem

(1) Dose Conversion Factor (DCF) is from DOE guidance to be consistent with the exposure scenario used in the 1989 Annual Site Environmental Report.

D. Collective Population Dose Estimate

Exposure Points - Exposure points are locations where members of the public are potentially being exposed to above-background concentrations of: (1) airborne radioactive particulates; (2) radon gas concentrations; (3) external gamma radiation; or (4) radionuclides in food or water. The first three pathways will be addressed for the collective population dose estimate. Exposure to above-background radionuclide concentrations in food or water will not be addressed since it is not reasonable to assume that a majority of the population eats fish from bodies of water that receive runoff from the WSS, and because no surface water or groundwater bodies that receive runoff or recharge from the WSS are used as drinking water sources.

Exposure points, by definition, must be located where there is potential for public exposure as a result of activities performed at the WSS or from materials stored at the WSS. If there is no reason to suspect that environmental monitoring results are different than the appropriate background monitoring results, then the area surrounding the environmental monitoring station cannot be considered an exposure point; therefore, the population near the station as well as the population beyond the station is not included in the collective population dose estimate.

The only area where there was reason to suspect that environmental monitoring results could be different than the appropriate background monitoring results was at the WSQ perimeter. This was true for airborne radioactive particulate concentrations, radon concentrations, and external gamma radiation. The only potential receptors near the WSQ perimeter are people using the Katy Trail, a recreational hiking and biking trail located on state-owned land south of the quarry. The Katy Trail lies approximately 45 m (49 yd) south of the quarry at its closest point and about 25 m (28 yd) below the southern quarry rim. It parallels the southern rim for approximately 260 m (286 yd). The estimated annual population using the trail is 72,000 persons, which is derived from a one-calendar-quarter estimate made by the Missouri State Parks Department (Maher 1991). The exposure time estimate is approximately 5 min, which corresponds to a 3.2 km/hr (2 mi/hr) walking speed along the 260 m (286 yd) length of trail paralleling the quarry.

The Katy Trail was chosen as the only public exposure point near the quarry because there currently are no environmental monitoring stations near the trail, and therefore, it could not be concluded with confidence that an above-background concentration

could be measured there. At all environmental monitoring locations near the WSQ (i.e., AP-4011, RD-4006, and TD-4006), there was no reason to suspect at the 95% confidence level that the monitoring results were different than the background monitoring results. Since there was no reason to suspect that environmental monitoring results at all WSCP/WSRP perimeter stations and at all off-site stations were different than the background monitoring results, no exposure points other than the Katy Trail were included in the population dose estimate.

Although the Katy Trail was chosen as an exposure point, and a collective population dose estimate was calculated for persons using the trail, this does not mean that measurable exposures did in fact occur there. Implicit in the following radioactive air particulate and radon gas concentration calculations is the conservative assumption that the wind is blowing from the WSQ towards the Katy Trail 100% of the time. This is definitely not the case; therefore, these calculations overestimate the maximum above-background average airborne radioactive particulate and radon concentrations which could have occurred at the trail.

Models

In order to estimate airborne radioactive particulate and radon concentrations at the Katy Trail, the above-background results measured at the WSQ perimeter were incorporated into a box model. A box model predicts a radon or airborne radioactive particulate release rate in pCi/s by multiplying the measured net airborne radioactive particulate or radon concentration by the assumed box model parameters for length, height, and average annual wind speed. The box model assumes that airborne contaminants are dispersed homogeneously within the modeled volume of air. The selected value for model length is 122 m (134 yd); for height it is 3 m (3.3 yd); and the value for average annual wind speed is 2 m/s (4.4 mi/hr). The model length value corresponds to the length of the major contaminated area within the quarry. A simplified box model is justified for calculating the airborne radioactive particulate and radon release rates because: (1) in the case of airborne radioactive particulates the net measured gross alpha concentration (i.e., the concentration measured at quarry monitoring station AP-1010 less the background concentration measured at station AP-4007) is an extremely small 4.6E-16 μCi/ml, and (2) in the case of both the airborne particulate and radon concentrations, the effective dose equivalent and population doses are low as indicated by the calculation results.

Once airborne radioactive particulate and radon release rates are obtained using the box model, fluxes are calculated by dividing the release rates by the surface area of the quarry. Once estimated airborne radioactive particulate and radon fluxes are calculated, estimated concentrations at the Katy Trail are calculated using the Gaussian atmospheric dispersion model modified to predict concentrations close to an area source (DOE 1986).

The modified Gaussian dispersion model can predict airborne concentrations at distances as close as 50 m (55 yd) from the edge of the area source, therfore this minimum distance was chosen as the distance between the quarry rim and the Katy Trail for the purposes of the model. This 50 m (55 yd) distance is comparable to the 45 m (50 yd) minimum distance between the quarry rim and the trail.

The net annual average radon concentration at the WSQ is 0.7 pCi/l and is calculated by averaging the results from stations RD-1001 through RD-1006 less the average background result of 0.3 pCi/l.

1. Box Model: length = 122 m (134 yd), height = 3 m (3.3 yd), average wind speed (μ) = 2 m/s (4.4 mi/hr)

   a. Release rate = length x height x μ x net annual average radon concentration

   b. Flux (Ø) = Release rate; where quarry floor area = 3.6 ha (9 acre) quarry floor area (MKF and JEG 1989b)

      = 14 pCi/m^2/s

2. Modified Gaussin Dispersion Model (DOE 1986)

   Model inputs include source diameter (D), distance from source edge to receptor (d), and atmospheric stability class. Given 3.6 ha (9-acre) quarry floor area and using $A = \pi r^2$, effective diameter of quarry is D = 215 m (237 yd). Assume d = 50 m (55 yd) (minimum distance for input into model) and atmospheric stability Class D.

Given the input parameters, the model predicts values for $(X\mu/\phi)$[1]

$(X\mu/\phi)$ for D = 215 m (237 yd) is found by interpolation to be 36.63

$$\frac{X\mu}{\phi} = 36.63$$

$$X = 36.63 \times \frac{\phi}{\mu} = 0.26 pCi/l$$

3. Estimated Effective Dose Equivalent (EDE) = radon concentration x working level ratio x exposure time x DCF[2]

   EDE (from radon) = 7.6E-7 rem

4. Population Dose Estimate from radon = 72,000 persons x 7.6E-7 mrem = 0.055 person rem

5. Population dose estimate due to airborne radioactive particulates

   The same box model and modified Gaussion dispersion model are applicable to predict the airborne radioactive particulate concentration. The difference is that the net measured annual average long-lived gross alpha concentration of 4.6E-16 μCi/ml (Section 4.1.8.2) is substituted for the net annual average radon concentration.

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(1) X = predicted concentration at receptor location. For atmospheric stability Class D and d = 50 m (55 yd) the following $X\mu/\phi$ values are predicated:

Source Diameter(m)	$(X\mu/\phi)$
200 (220 yd)	35.39
300 (330 yd)	43.66

(2) Radon concentration = 0.26 pCi/l
Working level ratio = 0.50 (assumed)
Exposure time = 0.06 hr = 5 min
Dose conversion factor = 1.25 rem/working level month (Eckerman et al. 1988)

Using the same calculation and parameter values used to estimate the radon concentration:

Release Rate = 3.4E-7 μCi/s

Flux (ϕ) = 9.3E-12 μCi/m^2/s

$$\frac{X\mu}{\phi} = 36.63$$

$$X = 36.63 \times \frac{\phi}{\mu}$$

$$= 36.63 \times \frac{9.3E\text{-}12\ \mu Ci/m^2 \cdot s}{2\ m/s}$$

X = 1.7E-16 μCi/ml

To estimate radionuclide concentrations contributing to the long-lived gross alpha concentration, 1.7E-16 μCi/ml is proportioned among radium, thorium, and uranium isotopes according to average radionuclide concentrations in quarry surface (0 to 0.15 m) soils as reported in Table 4.6 of MKF and JEG 1989b. Additionally, U-238, U-234 and U-235 isotopes were assumed to be in their natural equilibrium state as were Ra-228 and Th-232. This results in the following percent of total activity and estimated airborne radionuclide concentrations:

RADIONUCLIDE	PERCENT OF TOTAL ACTIVITY	RADIONUCLIDE AIRBORNE CONCENTRATION µCi/ml
U-234	28.8	4.6E-17
U-235	1.2	2.0E-18
U-238	28.8	4.6E-17
Ra-226	16.1	2.7E-17
Ra-228	3.0	5.1E-18
Th-230	23.1	3.9E-17
Th-232	3.0	5.1E-18

EDE = airborne radionuclide concentration x breathing rate x exposure time x radionuclide DCF(1)

EDE (airborne radioactive particulates) = 3.3E-6 mrem

$$\textit{Population dose estimate airborne particulates} = 72{,}000\ \textit{persons} \times 3.3E\text{-}6\ \textit{mrem} \times \left(\frac{\textit{rem}}{10^3 \textit{mrem}}\right)$$

= 0.0002 person rem

6. Population dose estimate due to external gamma radiation

Model the quarry as a circular area source of diameter D = 215 m (same as for previous estimates) and use the following formula for ratio of external gamma dose equivalent rates at two points near a circular planar source.

(1) Breathing rate = 1.25 m^3/h (Gamber 1983)
Exposure time = 0.06 h
Radionuclide DCFs are as reported in Table 4-13

$$\frac{H_1}{H_2} = \frac{\ln[(R^2+h_1^2)/h_1^2]}{\ln[(R^2+h_2^2)/h_2^2]} \qquad \textit{(Cember 1983)}$$

H_1 = Average above-background dose equivalent rate at the quarry rim = 14.8 mrem/yr

H_2 = Estimated dose equivalent rate at Katy Trail

R = D/2 = 108 m

h_1 = Distance from quarry center to southern rim = 58 m (64 yd)

h_2 = h_1 + distance from quarry's southern rim to Katy Trail = 109 m (120 yd)

H_2 = 7.7E-4 mrem/hr

$$\textit{Population Dose Estimate} = 72{,}000 \textit{ persons} \times 7.74E{-}4 \frac{mrem}{h} \times 0.08h \times \left(\frac{rem}{10^3 \ mrem}\right)$$

= 0.004 person rem

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CHEMICAL PLANT ADMINISTRATIVE RECORD FILE

ARFS FILE # C-202-3

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200	REMEDIAL INVESTIGATION (RI)
202	Sampling and Analysis Data - Chain of Custody Forms

DOCUMENT NUMBERS	DOCUMENT TITLE
C-200-202-1.09	QUARTERLY ENVIRONMENTLA DATA SUMMARY 2ND QTR. 1991
C-200-202-1.10	QUARTERLY ENVIRONMENTAL DATA SUMMARY 3RD QTR. 1991
C-200-202-1.11	CHEMICAL PLANT SITE REMEDIAL INVESTIGATION/FEASIBILITY STUDY DATA VALIDATION REPORT
C-200-202-1.12	QUARTERLY ENVIRONMENTAL DATA SUMMARY 4TH QUARTER 1991
C-200-202-1.13	QUARTERLY ENVIRONMENTAL DATA SUMMARY 1ST QUARTER 1992

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

CHEMICAL PLANT
202-1.09

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
7295 Highway 94 South
St. Charles, Missouri 63304

September 24, 1991

ADDRESSEES:

QUARTERLY ENVIRONMENTAL DATA SUMMARY FOR THE SECOND QUARTER, 1991 FOR THE WELDON SPRING SITE REMEDIAL ACTION PROJECT

Enclosed for your information and use is a copy of the Quarterly Environmental Data Summary Report. The document summarizes the environmental monitoring data for the second quarter, highlights any potentially significant findings, and offers preliminary interpretations. Final interpretations will appear in the 1991 Annual Site Environmental Report.

The report concludes that no significant differences or changes in off-site exposures resulting from Weldon Spring Site contaminates have occurred during this reporting period.

If you have any questions please call Ken Lawver at (314)441-8978.

Sincerely,

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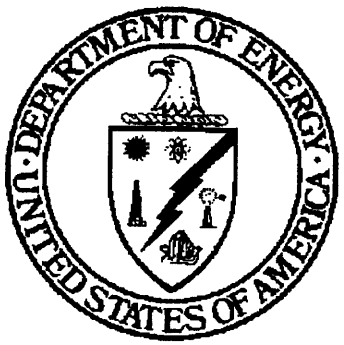
DOE/OR/21548-226
CONTRACT NO. DE-AC05-86OR21548

QUARTERLY ENVIRONMENTAL DATA SUMMARY SECOND QUARTER 1991

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

SEPTEMBER 1991 **REV. 0**



U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

091291

MK-FERGUSON A MORRISON KNUDSEN COMPANY	Issue Date:
Weldon Spring Site Remedial Action Project Contract No. DE-AC05-86OR21548	Rev. No. 0
PLAN TITLE: Quarterly Environmental Data Summary - Second Quarter 1991	

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James R. Powers — Project Director — Date 9/17/91

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091391

DOE/OR/21548-226

Weldon Spring Site Remedial Action Project

Quarterly Environmental Data Summary Second Quarter 1991

Revision 0

September 1991

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
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for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

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ABSTRACT AND WELDON SPRING SITE QUARTERLY SELF ASSESSMENT SECOND QUARTER 1991

The purpose of this Quarterly Environmental Data Summary is to provide preliminary data acquired as part of the Weldon Spring Site Remedial Action Project (WSSRAP) environmental monitoring program. The document summarizes the environmental data, highlights any potentially significant findings, and offers tentative interpretations. Validated data and final interpretations will appear in the 1991 Annual Site Environmental Report.

This report includes data from environmental monitoring activities at the Weldon Spring site (WSS) during the second quarter of 1991. Groundwater, surface water, and air were sampled in order to monitor potential exposure pathways. Analytical parameters included radionuclides, nitroaromatic compounds, inorganic anions, and direct gamma exposure. The results are used to calculate exposure doses (where applicable) and assess the impact of the contaminants at the site on potentially exposed populations.

In summary, no significant differences were observed in off-site exposures during the second quarter of 1991 relative to exposures calculated in previous quarters. Contaminated groundwater did not affect private water supplies or the St. Charles County well field. Surface water containing elevated uranium activity continued to impact the Femme Osage Slough. Off-site gamma, radon and air particulate exposures remained indistinguishable from background. Off-site monitoring demonstrated that exposure levels at the Francis Howell High School, the Busch Wildlife Area Headquarters, and the Weldon Spring Training Area remain indistinguishable from background levels.

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1 INTRODUCTION

This document is the fifth in a series of documents designed to provide a summary of the findings from the routine environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). These documents supplement the *Annual Site Environmental Report* (ASER) by providing interested outside agencies and organizations with more frequent access to WSSRAP data. They provide data resulting from routine environmental sampling as described in the WSSRAP Environmental Monitoring Plan and a brief interpretation of that data.

It is the goal of this document to summarize and briefly discuss the data, highlighting data that differ significantly from observations made in previous reports. The full interpretation of these data (as well as data in other quarterly summaries) will be undertaken in the 1991 ASER. It is recommended that interested readers refer to previous Environmental Monitoring Plans (EMPs), ASERs, and project documents for more information on existing site conditions, site history, transport mechanisms, and quantified contaminant levels. The monitoring scheme for every calendar year is established prior to that year in the annual EMP. Each sampling location to be monitored during the upcoming year is identified in the EMP and the schedule of analytical parameters are tabulated for easy reference. These reports may be obtained by visiting the WSSRAP reading room or contacting the WSSRAP Community Relations Manager at 314–441–8086.

These quarterly reports are intended to include data from all quarterly environmental monitoring programs conducted at the WSSRAP including groundwater, surface water, National Pollutant Discharge Elimination System (NPDES), radon gas, gamma radiation, and air particulates (including asbestos and radioactive particulates). However, because of delays in data delivery from the analytical laboratories, some of the data that was expected to be included in this report are not yet available for reporting. The unavailability of data is due to a nationwide shortage in analytical services. The WSSRAP is taking corrective action to ensure more timely availability of data in the future. These data will be reported in the 1991 ASER. Sludges, soils, and biological specimens are not sampled on a routine basis; therefore, analytical results for these parameters are not included in this report. Trend analyses are being prepared from historical data for surface water, groundwater and air pathways. These analyses will be presented in the 1991 ASER. Included for the first time are QC data for the second quarter which are presented in tables throughout this document.

This information provides insight as to the performance of the laboratory and the quality of the data. This QC data is provided for information only. Final interpretation will be presented in the 1991 Annual Site Environmental Report (ASER).

2 GROUNDWATER MONITORING

The groundwater is sampled regularly at both the Weldon Spring Chemical Plant/raffinate pits/vicinity properties (WSCP/RP/VP) and the Weldon Spring quarry (WSQ). Due to differences in the environmental settings and sources of contaminants, separate monitoring schedules are followed. Therefore, results of groundwater monitoring at the WSCP/RP/VP and WSQ will be discussed separately.

2.1 Chemical Plant/Raffinate Pits/Vicinity Properties

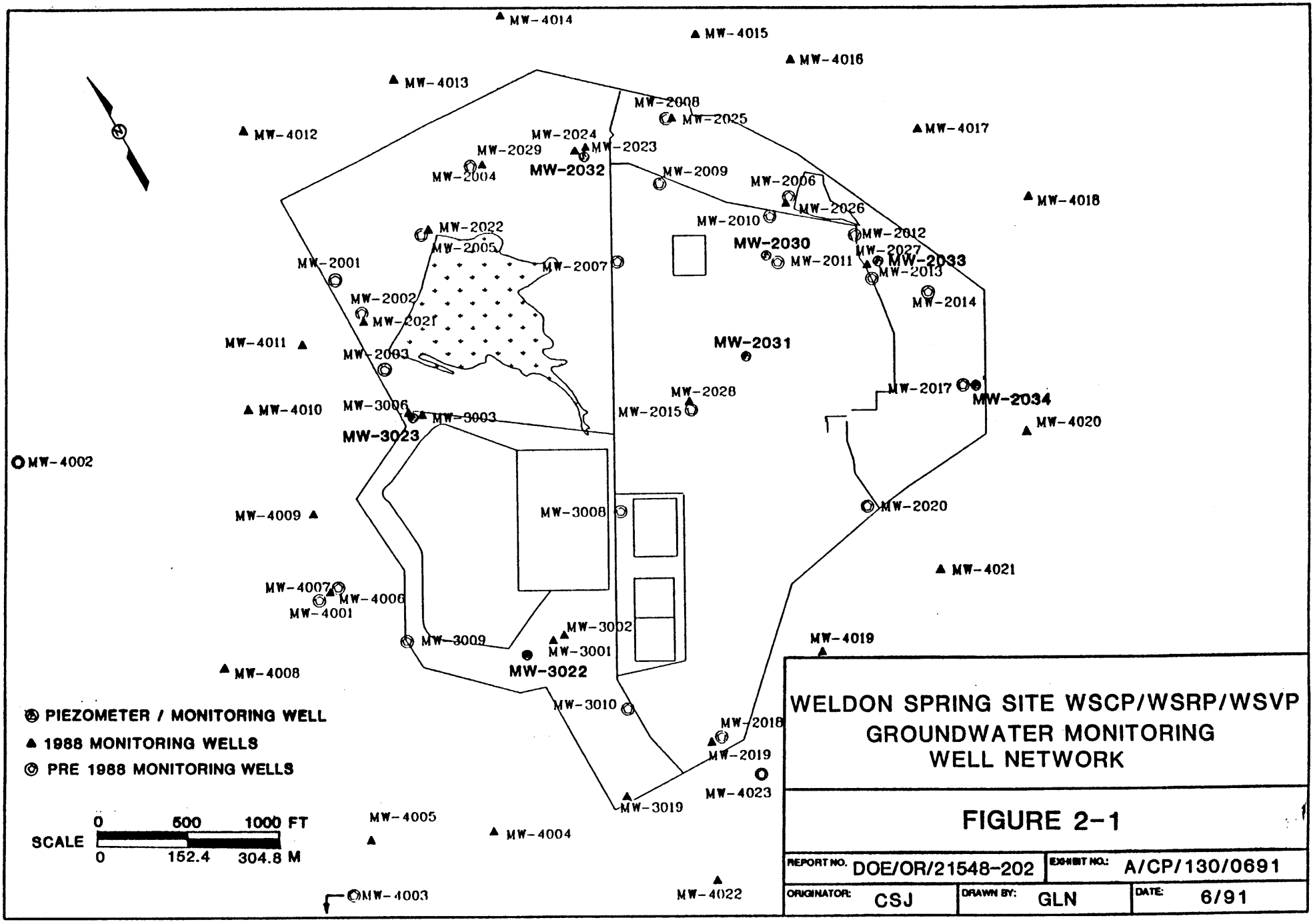
The groundwater at the chemical plant/raffinate pits/vicinity properties area is monitored on a semi-annual basis with the exception of MW-2001, MW-2002, MW-2003, MW-3003, MW-3006, MW-3008, MW-3009, MW-3023, MW-4012 and MW-4013 which are monitored quarterly. Monitoring well locations are shown in Figure 2-1. Data from the semiannual groundwater monitoring for the first half of 1991 are presented in this quarterly data summary, however, data from the quarterly monitored wells are presented in each QEDS.

2.1.1 Nitroaromatic Results

Table 2-1 contains nitroaromatic data from samples collected from the quarterly and semi-annual monitored groundwater wells at the CP/RP/VP area. Nitroaromatic compounds were detected in 22 samples. However, the data continue to reflect levels historically found and documented in previous environmental reports.

2.1.2 Radiological Results

The radiological results for samples from quarterly monitored wells at the WSCP/RP/VP are presented in Table 2-2. The upper bound for natural uranium background concentrations in groundwater at the WSCP/RP/VP has been determined to be 3.4 pCi/l. The EPA has not yet established drinking water standards for uranium; however, studies leading to proposed rulemaking are using uranium in the 10 pCi/l to 40 pCi/l range. The U.S. Department of Energy (DOE) has a health based derived concentration guideline (DCG) of 600 pCi/l in surface water effluent.



WELDON SPRING SITE WSCP/WSRP/WSVP GROUNDWATER MONITORING WELL NETWORK

FIGURE 2-1

REPORT NO.	DOE/OR/21548-202	EXHIBIT NO.:	A/CP/130/0691		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	6/91

TABLE 2-1 Second Quarter Nitroaromatic Data for Groundwater at the WSCP/RP/VP

SAMPLE ID	NB (µg/l) DL=0.03	1,3-DNB (µg/l) DL=0.09	2,4-DNT (µg/l) DL=0.03	2,6-DNT (µg/l) DL=0.01	2,4,6-TNT (µg/l) DL=0.03	1,3,5-TNB (µg/l) DL=0.03
GW-2001-Q191	ND	ND	0.073	0.049	ND	ND
GW-2002-Q191	ND	ND	0.063	0.34	ND	ND
GW-2003-Q191	ND	ND	0.15	0.65	ND	ND
GW-2004-040891	ND	ND	ND	ND	ND	ND
GW-2005-050791	ND	ND	0.066	0.11	ND	ND
GW-2006-040891	ND	ND	ND	2	ND	10
GW-2007-010991	ND	ND	ND	ND	ND	17.5
GW-2008-010791	ND	ND	0.05	0.89	ND	0.69
GW-2009-010891	ND	ND	ND	ND	ND	ND
GW-2010-010791	ND	0.14	0.6	0.93	0.44	0.19
GW-2011-010891	ND	ND	ND	ND	ND	ND
GW-2012-010891	ND	ND	ND	ND	ND	ND
GW-2013-030791	ND	0.18	0.7	15	0.85	5
GW-2014-022891	ND	ND	0.14	0.74	ND	2.8
GW-2015-010991	ND	ND	ND	ND	ND	ND
GW-2017-011591	ND	ND	ND	ND	ND	ND
GW-2018-011591	ND	ND	ND	ND	ND	ND
GW-2019-050991	ND	ND	ND	ND	ND	ND

TABLE 2-1 Second Quarter Nitroaromatic Data for Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	NB (µg/l) DL=0.03	1,3-DNB (µg/l) DL=0.09	2,4-DNT (µg/l) DL=0.03	2,6-DNT (µg/l) DL=0.01	2,4,6-TNT (µg/l) DL=0.03	1,3,5-TNB (µg/l) DL=0.03
GW-2020-052191	ND	ND	ND	ND	ND	ND
GW-2021-052191	ND	ND	ND	ND	ND	ND
GW-2022-050791	ND	ND	ND	ND	ND	ND
GW-2023-051491	ND	ND	ND	ND	ND	ND
GW-2024-052291	ND	ND	ND	ND	ND	ND
GW-2025-052291	ND	ND	ND	ND	ND	ND
GW-2026-052891	ND	ND	ND	ND	ND	ND
GW-2027-052891	ND	ND	ND	ND	ND	ND
GW-2028-050991	ND	ND	ND	ND	ND	ND
GW-2029-051391	ND	ND	ND	ND	ND	ND
GW-2030-050991	ND	ND	0.09	10	8.5	4.2
GW-2031-050291	ND	ND	ND	ND	ND	ND
GW-2032-053091	ND	ND	0.033	4.6	7.8	4
GW-2033-052991	ND	ND	0.09	9.3	1.1	2
GW-2034-060691	ND	ND	ND	ND	ND	ND
GW-3001-013191	ND	ND	0.44	0.25	ND	0.09
GW-3002-060491	ND	ND	ND	ND	ND	ND
GW-3003-031891	ND	ND	0.059	0.085	ND	ND

TABLE 2-1 Second Quarter Nitroaromatic Data for Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	NB (µg/l) DL=0.03	1,3-DNB (µg/l) DL=0.09	2,4-DNT (µg/l) DL=0.03	2,6-DNT (µg/l) DL=0.01	2,4,6-TNT (µg/l) DL=0.03	1,3,5-TNB (µg/l) DL=0.03
GW-3006-031991	ND	ND	ND	ND	ND	ND
GW-3008-Q191	ND	ND	0.08	0.16	ND	ND
GW-3009-Q191	ND	ND	ND	ND	ND	ND
GW-3010	ABANDONED 1991					
GW-3019-013091	ND	ND	ND	ND	ND	ND
GW-3022-060491	ND	ND	0.12	0.034	ND	ND
GW-3023-031991	ND	ND	2.6	4.5	ND	ND
GW-4001-010991	ND	ND	ND	ND	ND	43.3
GW-4002-011691	ND	ND	0.42	1.1	1.1	0.09
GW-4003-011691	ND	ND	ND	ND	ND	ND
GW-4004-021991	ND	ND	ND	ND	ND	ND
GW-4005-021991	ND	ND	ND	ND	ND	ND
GW-4005-050791	ND	ND	ND	ND	ND	ND
GW-4006-010991	ND	ND	ND	ND	ND	ND
GW-4007	NS	NS	NS	NS	NS	NS
GW-4008-011691	ND	ND	ND	ND	ND	ND
GW-4009-011791	ND	ND	ND	ND	ND	ND
GW-4010-050691	ND	ND	ND	ND	ND	ND

TABLE 2-1 Second Quarter Nitroaromatic Data for Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	NB (µg/l) DL=0.03	1,3-DNB (µg/l) DL=0.09	2,4-DNT (µg/l) DL=0.03	2,6-DNT (µg/l) DL=0.01	2,4,6-TNT (µg/l) DL=0.03	1,3,5-TNB (µg/l) DL=0.03
GW-4011-011791	ND	ND	ND	ND	ND	ND
GW-4012-Q191	ND	ND	ND	ND	ND	ND
GW-4013-Q191	ND	ND	0.049	1.1	0.55	34
GW-4014-061091	ND	ND	ND	0.028	ND	0.22
GW-4015-061791	ND	ND	0.031	1.3	ND	0.56
GW-4016-013191	ND	ND	ND	ND	ND	ND
GW-4017-013191	ND	ND	ND	ND	ND	ND
GW-4018-041791	ND	ND	ND	ND	ND	ND
GW-4019-041691	ND	ND	ND	ND	ND	ND
GW-4020-041691	ND	ND	ND	ND	ND	ND
GW-4021-041791	ND	ND	ND	ND	ND	ND
GW-4022-050791	ND	ND	ND	ND	ND	ND
GW-4023-041791	ND	ND	0.097	0.055	ND	0.13
GW-0000-060691	ND	ND	ND	ND	ND	ND
GW-2033-052991-BB	ND	ND	ND	ND	ND	ND
GW-2021-052191-FB	ND	ND	ND	ND	ND	ND

NS - NOT SAMPLED ND - NOT DETECTED
BB - BAILER BLANK FB - FIELD BLANK

TABLE 2-2 Second Quarter, Semiannaul Uranium and Inorganic Anion Data in Groundwater at the WSCP/RP/VP

SAMPLE ID	Nitrate (mg/l) DL=0.1	Sulfate (mg/l) DL=1.0	Uranium (pCi/l)
GW-2001-Q191	20.7	5.4	ND
GW-2001-Q291	19.6	5.8	NS
GW-2002-Q191	23	109	ND
GW-2002-Q291	18.9	122	NS
GW-2003-Q191	414	114	0.7
GW-2003-Q291	51.6	133	NS
GW-2004-040891	1	2.6	ND
GW-2005-050791	253	20.1	ND
GW-2006-040891	6	32.9	ND
GW-2007-010991	ND	11	2
GW-2008-010791	3.3	30.9	1.4
GW-2009-010891	5.5	10.6	1.4
GW-2010-010791	1.2	32.7	0.7
GW-2011-010891	2	107	4.8
GW-2012-010891	1.3	73.5	2
GW-2013-030791	1.2	18	2.7
GW-2014-022891	1.9	21	1.4
GW-2015-010991	0.3	102	4.1
GW-2017-011591	0.7	617	7.5
GW-2018-011591	0.6	6.5	1.4
GW-2019-050991	ND	30.7	1.4
GW-2020-052191	0.9	136.4	3.4
GW-2021-052191	ND	10.7	ND
GW-2022-050791	0.616	12.8	ND
GW-2023-051491	ND	16	ND
GW-2024-052291	ND	31.4	1.4
GW-2025-052291	ND	14.5	ND
GW-2026-052891	ND	14.5	0.7

TABLE 2-2 Second Quarter, Semiannual Uranium and Inorganic Anion Data in Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	Nitrate (mg/l) DL=0.1	Sulfate (mg/l) DL=1.0	Uranium (pCi/l)
GW-2027-052891	ND	10.5	ND
GW-2028-050991	ND	74.1	0.7
GW-2029-051391	ND	27.7	0.7
GW-2030-050991	1.3	28.5	12.2
GW-2031-050291	0.4	33.7	6.1
GW-2032-053091	79	10	2
GW-2033-052991	ND	0.9	ND
GW-2034-060691	ND	15.5	3.4
GW-3001-013191	336	20.9	4.1
GW-3002-060491	ND	636.7	1.4
GW-3003-Q191	4	149	19
GW-3003-Q291	806	255	NS
GW-3006-Q191	1	24.2	ND
GW-3006-Q291	ND	21.6	NS
GW-3008-Q191	1050	51.6	4.1
GW-3008-053091	1010	1030	NS
GW-3009-Q191	89	39.8	49.6
GW-3009-Q291	0.724	55.7	NS
GW-3010-	ABANDONED 1991		
GW-3019-013091	ND	4.7	8.2
GW-3022-060491	88	1.2	3.4
GW-3023-031991	275	558	7.5
GW-3023-Q291	389	268	NS
GW-4001-010991	43.3	62.5	3.4
GW-4002-011691	1.2	18.1	ND
GW-4003-011691	8.1	NA	ND
GW-4004-021991	0.8	20.2	ND

TABLE 2-2 Second Quarter, Semiannual Uranium and Inorganic Anion Data in Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	Nitrate (mg/l) DL=0.1	Sulfate (mg/l) DL=1.0	Uranium (pCi/l)
GW-4005-021991	1.9	17.9	6.8
GW-4005-050791	1.6	16.4	122.4
GW-4006-010991	5.3	25.5	1.2
GW-4007	NS	NS	NS
GW-4008-011691	ND	27.4	ND
GW-4009-011791	ND	20.9	2.7
GW-4010-050691	ND	24.9	0.7
GW-4010-070991	ND	25	NS
GW-4011-011791	23	45.4	4.8
GW-4012-Q191	ND	54	4.1
GW-4012-Q291	180	9140	NS
GW-4013-Q191	84.1	42	1.4
GW-4013-061091	75.8	35.2	NS
GW-4014-061091	1.55	25.9	ND
GW-4015-061791	2	7.3	NA
GW-4016-013191	ND	ND	5.4
GW-4017-013191	ND	9.83	2.7
GW-4018-041791	2.2	4.4	ND
GW-4019-041691	0.2	3.7	3.4
GW-4020-041691	ND	100	24.5
GW-4021-041791	ND	221	8.2
GW-4022-050791	0.1	43.7	ND
GW-4023-041791	0.2	46.4	ND
GW-0000-060691			ND
GW-4022-050791-DU			4.9
GW-2021-052191-FB	ND	ND	
GW-0000-053091-WB			ND

TABLE 2-2 Second Quarter, Semiannual Uranium and Inorganic Anion Data in Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	Nitrate (mg/l) DL=0.1	Sulfate (mg/l) DL=1.0	Uranium (pCi/l)
GW-2033-052991-BB			ND
GW-0000-052391-WB			2.04
GW-0000-061191			ND
GW-2033-052991-BB	ND	ND	
GW-0000-052891-WB			0.68

ND - NOT DETECTED
NS - NOT SAMPLED
NA - NOT AVAILABLE
DU - DUPLICATE
BB - BAILER BLANK
FB - FIELD BLANK
WB - WATER BLANK

The highest uranium level detected was 122.4 pCi/l from a sample obtained from Monitoring Well 4005. The other concentrations reported in Table 2-2 continue to indicate levels below the proposed drinking water standard for uranium.

2.1.3 Geochemical Results

Geochemical results for samples from quarterly monitored wells at the WSCP/RP/VP are presented in Table 2-3. Geochemical parameters were added to the *Environmental Monitoring Plan* for the 1991 monitoring year.

2.1.4 Inorganic Anion Results

Inorganic anion results for the quarterly monitored WSCP/RP/VP wells are shown in Table 2-2. The results reflect levels historically found in these wells.

2.2 Weldon Spring Quarry

Chemical and radiological wastes at the quarry are of particular concern because of their proximity to the St. Charles County well field. The well field is located approximately 0.8 km (0.5 mile) to the south of the Weldon Spring quarry. Monitoring of contaminants in groundwater and the protection of the well field is a top WSSRAP priority.

Groundwater is currently being monitored in 48 wells in and around the quarry. Thirty-six monitoring wells installed by the U.S. Department of Energy (DOE) currently exist in or near the quarry. Four monitoring wells were installed by St. Charles County in 1986 and are currently included in the DOE's monitoring program. Eight St. Charles County municipal wells are also included in the DOE's monitoring program. All monitoring well locations are shown in Figures 2-2 and 2-3. These wells draw water from both bedrock and alluvial aquifers.

Two separate groundwater monitoring programs have been developed for the quarry. The first program is a bimonthly sampling of all wells north of the Femme Osage Slough and MW-1010 and MW-1011. The second program is a quarterly sampling of all wells south of the Femme Osage Slough, excluding MW-1010 and -1011 but including the St. Charles

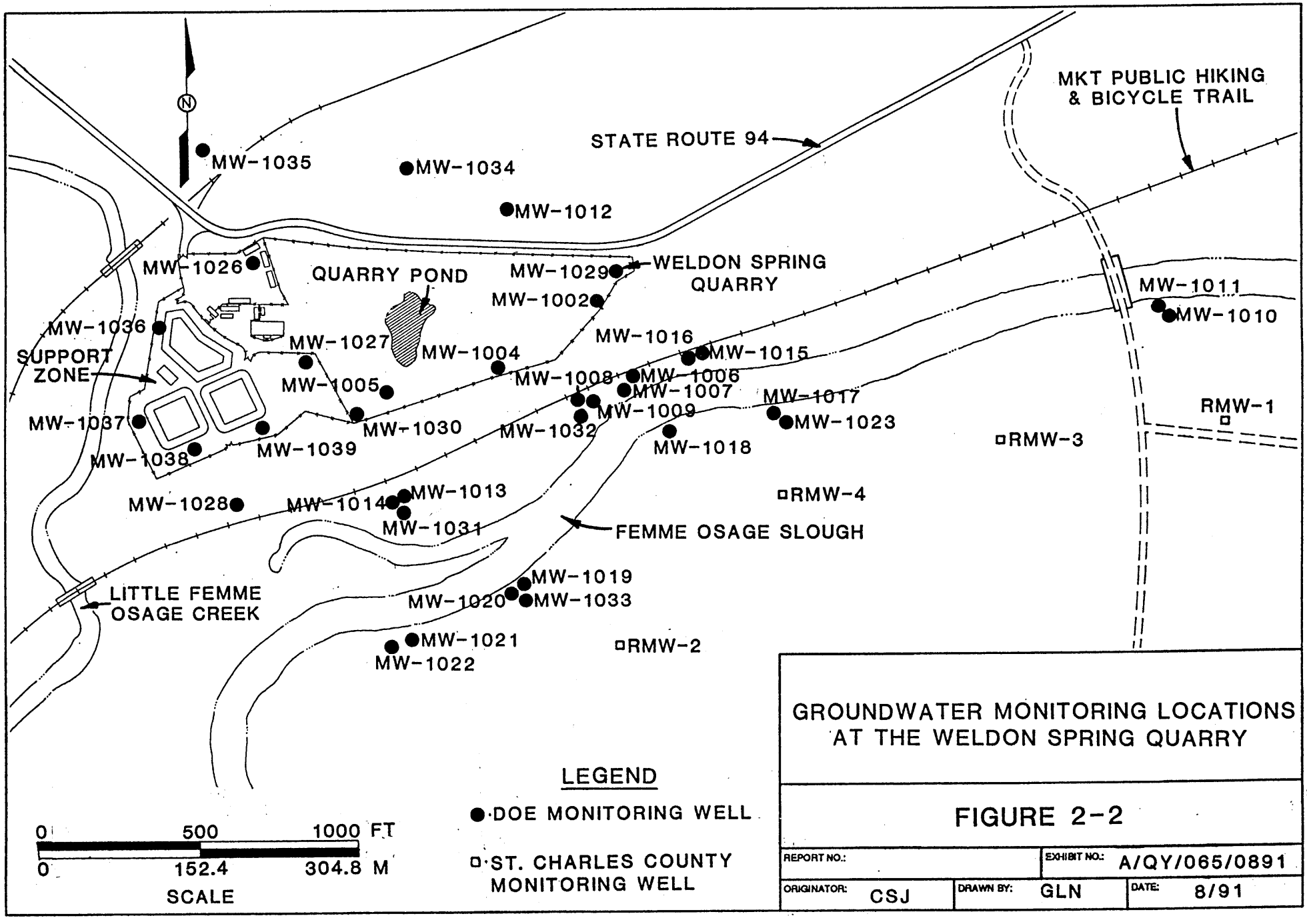
TABLE 2-3 Second Quarter Geochemical Data for Groundwater at the WSCP/RP/VP

	As (µg/l) DL=3.9	Ba (µg/l) DL=12.9	Ca (µg/l) DL=275.8	Cr (µg/l) DL=9.3	Co (µg/l)	Fe (µg/l) DL=37.2	Li (µg/l) DL=13	Mg (µg/l) DL=118.8	Mn (µg/l) DL=4.8	Ni (µg/l) DL=31.2
GW-2001-Q291	ND	189	NS	ND	ND	ND	ND	35700	ND	ND
GW-2002-Q291	ND	152	NS	ND	ND	ND	392	72100	ND	ND
GW-2003-Q291	ND	109	234000	ND	NA	41	405	85700	ND	ND
GW-3003-Q291	ND	157	231000	ND	NA	44	417	122000	85.6	ND
GW-3006-Q291	ND	133	50000	ND	NA	145	ND	40900	36.9	ND
GW-3008-Q291	ND	322	664000	ND	NA	ND	204	161000	ND	ND
GW-3009-Q291	ND	835	72100	ND	NA	ND	ND	43900	ND	52.4
GW-3023-Q291	ND	230	440000	55	NA	21700	729	108000	538	54.2
GW-4012-Q291	ND	77.1	47900	9.8	NA	115	ND	30300	9.1	ND
GW-4013-Q291	ND	148	123000	ND	NA	ND	58.1	45600	ND	99

TABLE 2-3 Second Quarter Geochemical Data for Groundwater at the WSCP/RP/VP (Continued)

	K (µg/l) DL=360	Na (µg/l) DL=240	Sr (µg/l) DL=1.5	Nitrite (µg/l) DL=100	Bromide (µg/l) DL=200	Chloride (µg/l) DL=.001	Phosphorus, Total (µg/l) DL=50	Silica, Dissolved (µg/l) DL=1000	Alkalinity (mg/l) DL=1
GW-2001-Q291	1300	8000	8.9	ND	ND	6600	41.3	9420	332
GW-2002-Q291	8100	87800	306	ND	NA	821	44.6	10500	291
GW-2003-Q291	6940	96600	344	ND	832	8680	37.9	8130	283
GW-3003-Q291	8830	135000	538	193	1006	10800	58.1	6270	288
GW-3006-Q291	1290	15500	196	ND	330	1510	22.7	6810	382
GW-3008-Q291	2450	213000	1300	ND	362	15100	22.9	10900	250
GW-3009-Q291	1530	17500	164	ND	271.1	3400	17.6	6270	165
GW-3023-Q291	4430	213000	683	1020	321.3	15900	1150	5360	295
GW-4012-Q291	11200	32300	169	180	262	2800	104	9500	329
GW-4013-Q291	ND	27300	147	ND	884	5670	126	9650	321

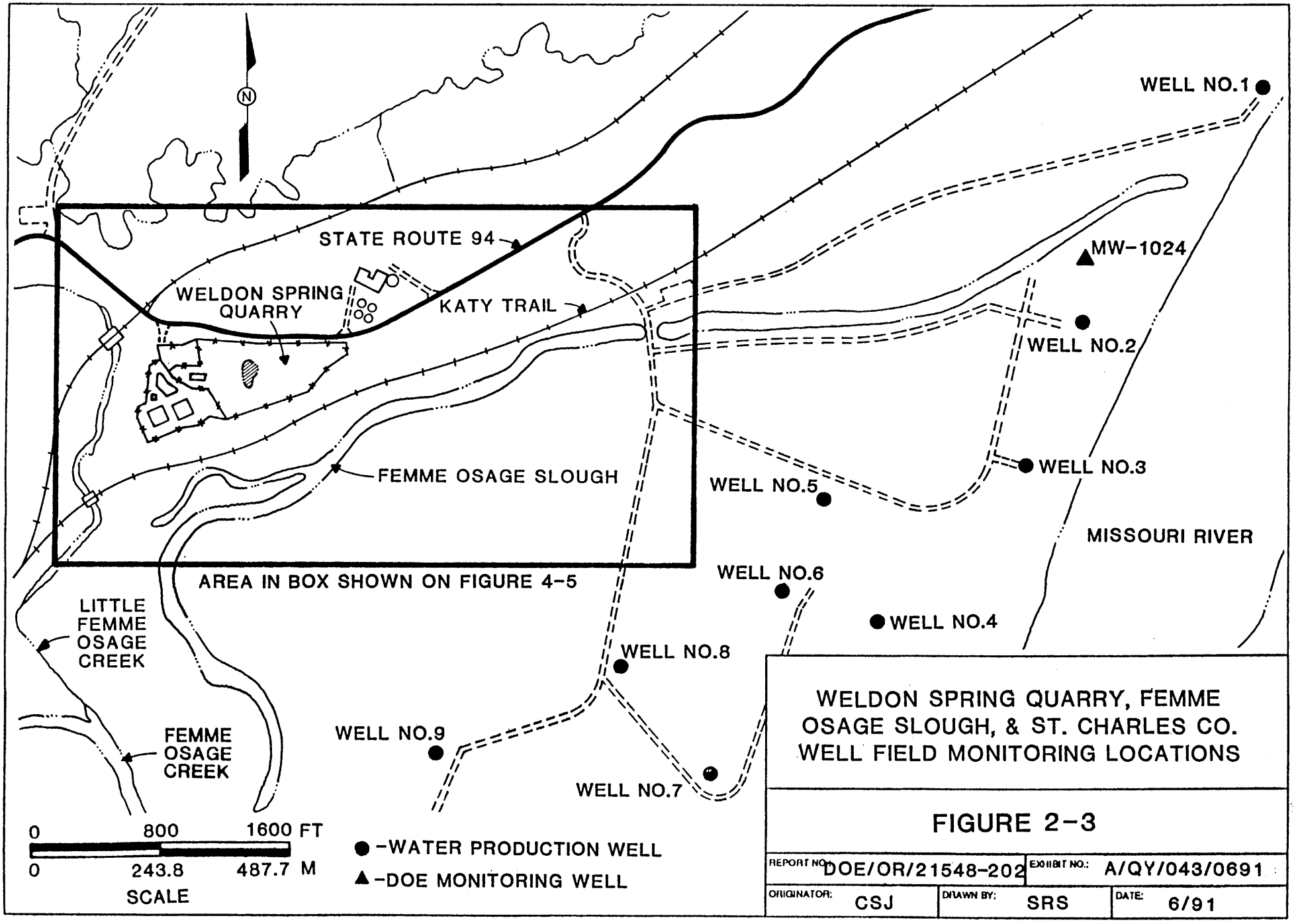
ND-Not Detected
NA-Not Available
NS-Not Sampled



GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 2-2

REPORT NO.:		EXHIBIT NO.: A/QY/065/0891
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 8/91


N
WELL NO.1
STATE ROUTE 94
MW-1024
WELDON SPRING QUARRY
KATY TRAIL
WELL NO.2
WELL NO.3
FEMME OSAGE SLOUGH
WELL NO.5
MISSOURI RIVER
AREA IN BOX SHOWN ON FIGURE 4-5
WELL NO.6
LITTLE FEMME OSAGE CREEK
WELL NO.4
WELL NO.8
FEMME OSAGE CREEK
WELL NO.9
WELL NO.7
0 800 1600 FT
0 243.8 487.7 M
SCALE
●-WATER PRODUCTION WELL
▲-DOE MONITORING WELL
WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, & ST. CHARLES CO. WELL FIELD MONITORING LOCATIONS
FIGURE 2-3
REPORT NO: DOE/OR/21548-202
EXHIBIT NO.: A/QY/043/0691
ORIGINATOR: CSJ
DRAWN BY: SRS
DATE: 6/91

County well field. Both the raw and treated waters from the St. Charles County water treatment plant are also sampled.

2.2.1 Radiological Results

Radiological data are presented in Tables 2-4, 2-5, and 2-6 for samples collected on a bimonthly and quarterly bases. The results show typical fluctuations near the average levels in the WSQ area with no dramatic increases evident except in MW-1015 and MW-1016. The increases in these two wells from the first bimonthly to the second and third bimonthly sampling events are on a magnitude of 2 to 5 times. The wells will continue to be monitored closely.

2.2.2 Nitroaromatic Compounds Results

Analytical results for nitroaromatic compounds are presented in Tables 2-7, 2-8, and 2-9. No monitoring wells south of the Femme Osage Slough showed detectable concentrations of nitroaromatic compounds during the second quarter 1991. The distribution and magnitude of nitroaromatic contamination near the quarry remains unchanged with slight increases of 2,4,6-TNT and 1,3,5-TNB found in MW-1002, MW-1004, MW-1006, MW-1015, and MW-1016.

2.2.3 Inorganic Anions Results

Two inorganic anions--nitrate and sulfate--were measured in quarry wells. Tables 2–4, 2-5, and 2-6 display the analytical results for the second quarter of 1991, which are consistent with data reported in the previous environmental monitoring reports. The WSQ groundwater samples continue to indicate no significant groundwater contamination by nitrate. The groundwater samples continue to indicate background concentrations of sulfate in wells south of the Femme Osage Slough.

2.2.4 Metals Results

A selected group of quarry wells located south of the Femme Osage Slough were sampled for cadmium, lead, and mercury in addition to arsenic and barium. Analytical results for these metals are presented in Tables 2-10, 2-11, and 2-12. Results from the

TABLE 2-4 Second Bimonthly (March/April) Inorganic Anions and Radiological Results in Groundwater for the Weldon Spring Quarry

SAMPLE ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-1002-050191	ND	38.7	NA
GW-1004-050191	0.15	68.1	NA
GW-1005-050191	ND	248.2	NA
GW-1006-043091	1.27	424	2992
GW-1007-043091	ND	26.6	312.8
GW-1008-043091	ND	243	3536
GW-1009-043091	ND	318.8	8.8
GW-1012-042991	1.5	60.7	NA
GW-1013-043091	ND	97.2	884
GW-1014-043091	ND	137.5	1224
GW-1015-050291	2.81	386	1088
GW-1016-050291	0.765	217	353.6
GW-1026-042591	ND	10.8	ND
GW-1027-042591	ND	112	605.2
GW-1028-043091	ND	58.4	ND
GW-1029-050191	1.02	183.8	NA
GW-1030-050691	0.104	91	ND
GW-1031-050291	ND	53.5	40.8
GW-1032-050891	ND	207.6	340
GW-0000-060691-WB	1.62	ND	
GW-0000-050791-WD-DU			ND

ND - NOT DETECTED
NA - NOT AVAILABLE
WB - WATER BLANK
DU - DUPLICATE

TABLE 2-5 Third Bimonthly (May/June) Inorganic Anions and Radiological Results in Groundwater for the Weldon Spring Quarry

SAMPLE ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-1002-060691	NS	NS	0.068
GW-1002-061091	1.29	52.8	NS
GW-1004-060391	0.12	261	4964.0
GW-1005-060391	ND	176	2108.0
GW-1006-060591	0.57	580.0	2516.0
GW-1007-060591	ND	ND	46.2
GW-1008-060591	ND	236.0	3604.0
GW-1009-060591	ND	208.0	ND
*GW-1010-061191	NS	NS	ND
*GW-1011-061191	NS	NS	13.6
GW-1012-061291	NA	NA	4.1
GW-1013-060591	ND	133.0	952.0
GW-1014-060591	ND	134.0	1224.0
GW-1015-061091	2.19	327	503.2
GW-1016-060691	NS	NS	1319.2
GW-1016-061091	0.295	259	NS
GW-1026-052391	NA	NA	ND
GW-1027-052391	NA	NA	408.0
GW-1028-052391	NA	NA	2.0
GW-1029-060391	ND	75.1	ND
GW-1030-061791	NA	NA	6.0
GW-1031-061191	NA	NA	32.6
GW-1032-050891	NA	NA	421.6
GW-1032-060691	NA	NA	414.8
GW-1032-061091	ND	208	NA
GW-1033-061291	NA	NA	2.0
GW-1034-062091	1.14	92.1	ND
GW-1035-062091	ND	44.8	ND

TABLE 2-5 Third Bimonthly (May/June) Inorganic Anions and Radiological Results in Groundwater for the Weldon Spring Quarry (Continued)

SAMPLE ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-1036-061391	ND	59.0	NA
GW-1037-062791	0.126	13.9	17.0
GW-1038-062691	ND	35.5	1.4
GW-1039-062691	ND	28.7	1.4

NA - NOT AVAILABLE
NS - NOT SAMPLED
ND - NOT DETECTED
* - SPECIAL SAMPLING EVENT

TABLE 2-6 Second Quarter Inorganic Anions and Radiological Results for the WSQ

SAMPLE ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)	Gross Alpha (pCi/l)
GW-1010-Q291	ND	ND	ND	NS
GW-1011-Q291	ND	15.6	2.7	NS
GW-1017-Q291	ND	10	ND	NS
GW-1018-Q291	ND	NA	ND	NS
GW-1019-Q291	ND	29	ND	NS
GW-1020-Q291	ND	50	1.36	NS
GW-1021-Q291	ND	20.8	ND	NS
GW-1022-Q291	ND	54.5	ND	NS
GW-1023-Q291	ND	1	ND	NS
GW-1024-Q291	ND	ND	ND	0 +/- 4
GW-RMW1-Q291	ND	22.8	ND	1 +/- 5
GW-RMW2-Q291	ND	31.7	4.8	5 +/- 5
GW-RMW3-Q291	ND	37.2	4.8	2 +/- 6
GW-RMW4-Q291	0.7	34.2	ND	3 +/- 5
GW-RAWW-Q291	NS	NS	ND	1 +/- 4
GW-FINW-Q291	NS	NS	ND	-1 +/- 2
GW-PW02-Q291	NS	NS	ND	0 +/- 4
GW-PW03-Q291	NS	NS	ND	0 +/- 4
GW-PW04-Q291	NS	NS	ND	-1 +/- 4
GW-PW05-Q291	NS	NS	ND	1 +/- 4
GW-PW06-Q291	NS	NS	ND	0 +/- 5
GW-PW07-Q291	NS	NS	ND	-3 +/- 5
GW-PW08-Q291	NS	NS	ND	-1 +/- 5

ND - NOT DETECTED
NS - NOT SAMPLED
NA - NOT AVAILABLE

TABLE 2-7 Second Bimonthly (March/April) Nitroaromatic Data for Groundwater at the Weldon Spring Quarry

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1002-050191*	ND	0.18	ND	11.0	27	160
GW-1004-050191*	ND	ND	2.8	7.3	19.0	8.0
GW-1005-050191*	ND	ND	0.14	0.059	ND	ND
GW-1006-043091	ND	ND	0.09	4.1	28.0	130.0
GW-1007-043091	ND	ND	ND	ND	ND	ND
GW-1008-043091	ND	ND	ND	0.092	0.16	ND
GW-1009-043091	ND	ND	ND	ND	ND	ND
GW-1012-042991	ND	ND	ND	ND	ND	ND
GW-1013-043091	ND	ND	0.17	0.047	ND	ND
GW-1014-043091	ND	ND	ND	ND	ND	ND
GW-1015-050291*	ND	ND	ND	0.75	18.0	160.0
GW-1016-050291*	ND	ND	ND	0.13	2.2	16.0
GW-1028-043091	ND	ND	ND	ND	ND	ND
GW-1029-050191*	ND	ND	ND	ND	ND	ND
GW-1030-050691*	ND	ND	0.046	0.012	ND	ND
GW-1031-050291*	ND	ND	ND	ND	ND	ND
GW-1032-Q291	ND	ND	0.060	0.049	ND	ND

* - Sampled in May NA - NOT ANALYZED ND - NOT DETECTED

TABLE 2-8 Third Bimonthly (May/June) Nitroaromatic Data for Groundwater at the Weldon Spring Quarry

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1002-061091	ND	0.16	ND	8.6	21.0	140.0
GW-1004-060391	ND	ND	2.6	5.8	14	5.4
GW-1005-060391	ND	ND	0.13	0.054	ND	ND
GW-1006-060591	ND	ND	ND	2.1	15.0	45.0
GW-1007-060591	ND	ND	ND	ND	ND	ND
GW-1008-060591	ND	ND	ND	0.088	0.094	ND
GW-1009-060591	ND	ND	ND	ND	ND	ND
GW-1010-061191	ND	ND	ND	ND	ND	ND
GW-1011-061191	ND	ND	ND	ND	ND	ND
GW-1012-061291	ND	ND	ND	ND	ND	ND
GW-1013-060591	ND	ND	0.066	0.019	ND	ND
GW-1014-060591	ND	ND	ND	ND	ND	ND
GW-1015-061091	ND	ND	ND	0.16	4.0	30.0
GW-1016-061091	ND	ND	ND	1.0	26.0	220.0
GW-1026-052391	ND	ND	ND	ND	ND	ND
GW-1027-052391	ND	ND	8.5	6.9	6.2	0.032
GW-1028-052391	ND	ND	ND	ND	ND	ND
GW-1029-060391	ND	ND	ND	ND	ND	ND
GW-1030-061791	ND	ND	0.038	ND	ND	ND

TABLE 2-8 Third Bimonthly (May/June) Nitroaromatic Data for Groundwater at the Weldon Spring Quarry (Continued)

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1031-061191	ND	ND	ND	ND	ND	ND
GW-1032-061091	ND	ND	0.52	0.27	0.48	0.053
GW-1033-061291	ND	ND	ND	ND	ND	ND
GW-1034-062091	ND	ND	ND	ND	ND	ND
GW-1035-062091	ND	ND	ND	ND	ND	ND
GW-1036-061391	ND	ND	ND	ND	ND	ND
GW-1037-062791	ND	ND	ND	ND	ND	ND
GW-1038-062691	ND	ND	ND	ND	ND	ND
GW-1039-062691	ND	ND	ND	ND	ND	ND

ND - NOT DETECTED

TABLE 2-9 Second Quarter Nitroaromatic Data for Groundwater at the Weldon Spring Quarry

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1010-Q291	ND	ND	ND	ND	ND	ND
GW-1011-Q291	ND	ND	ND	ND	ND	ND
GW-1017-Q291	ND	ND	ND	ND	ND	ND
GW-1018-Q291	ND	ND	ND	ND	ND	ND
GW-1019-Q291	ND	ND	ND	ND	ND	ND
GW-1020-Q291	ND	ND	ND	ND	ND	ND
GW-1021-Q291	ND	ND	ND	ND	ND	ND
GW-1022-Q291	ND	ND	ND	ND	ND	ND
GW-1023-Q291	ND	ND	ND	ND	ND	ND
GW-1024-Q291	ND	ND	ND	ND	ND	ND
GW-RMW1-Q291	*	*	*	*	*	*
GW-RMW2-Q291	ND	ND	ND	ND	ND	ND
GW-RMW3-Q291	ND	ND	ND	ND	ND	ND
GW-RMW4-Q291	ND	ND	ND	ND	ND	ND
GW-RAWW-Q291	ND	ND	ND	ND	ND	ND
GW-FINW-Q291	ND	ND	ND	ND	ND	ND
GW-PW02-Q291	ND	ND	ND	ND	ND	ND
GW-PW03-Q291	ND	ND	ND	ND	ND	ND
GW-PW04-Q291	ND	ND	ND	ND	ND	ND

TABLE 2-9 Second Quarter Nitroaromatic Data for Groundwater at the Weldon Spring Quarry (Continued)

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-PW05-Q291	ND	ND	ND	ND	ND	ND
GW-PW06-Q291	ND	ND	ND	ND	ND	ND
GW-PW07-Q291	ND	ND	ND	ND	ND	ND
GW-PW08-Q291	ND	ND	ND	ND	ND	ND
GW-PW09-Q291	ND	ND	ND	ND	ND	ND

ND - NOT DETECTED
* - NOT ANALYZED

TABLE 2-10 Second Bimonthly (March/April) Results for Metals in Groundwater at the Weldon Spring Quarry

	Arsenic (µg/l)	Barium (µg/l)
GW-1002-050191*	ND	42.9
GW-1004-050191*	ND	62.1
GW-1005-050191*	ND	96.1
GW-1006-043091	5.9	42.3
GW-1007-043091	9.1	408
GW-1008-043091	ND	31
GW-1009-043091	3.6	303
GW-1012-042991	ND	135
GW-1013-043091	2.6	119
GW-1014-043091	ND	94.5
GW-1015-050291*	ND	118
GW-1016-050291*	ND	135
GW-1026-042591	23.1	375
GW-1027-042591	ND	137
GW-1028-043091	3.8	282
GW-1029-050191*	ND	150
GW-1030-050691*	ND	134
GW-1031-050291*	ND	110
GW-1032-050891*	ND	126

ND - NOT DETECTED
* - May sampling event

TABLE 2-11 Third Bimonthly (May/June) Results for Metals in Groundwater at the Weldon Spring Quarry

	Arsenic (µg/l)	Barium (µg/l)
GW-1002-061091	ND	130
GW-1004-060391	ND	38.1
GW-1005-060391	ND	62.1
GW-1006-060591	ND	33.0
GW-1007-060591	17.6	435.0
GW-1008-060591	ND	40.7
GW-1009-060591	2.57	394.0
GW-1012	NA	NA
GW-1013-060591	ND	131.0
GW-1014-060591	ND	117.0
GW-1015-061091	ND	127
GW-1016-061091	ND	109
GW-1026	NA	NA
GW-1027	NA	NA
GW-1028	NA	NA
GW-1029-060391	ND	100
GW-1030	NA	NA
GW-1031	NA	NA
GW-1032-061091	6.7	133
GW-1033	NA	NA
GW-1034-062091	ND	106
GW-1035-062091	ND	198
GW-1036-061391	ND	315
GW-1037-062791	62.5	3130
GW-1038-062691	ND	230
GW-1039-062691	5.17	595

ND - NOT DETECTED
NA - NOT AVAILABLE

TABLE 2-12 Second Quarter Results for Metals in Groundwater at the Weldon Spring Quarry

	Arsenic (µg/l)	Barium (µg/l)	Cadmium (µg/l)	Lead (µg/l)	Mercury (µg/l)
GW-1010-Q291	84.9	331	NS	NS	NS
GW-1011-Q291	ND	263	NS	NS	NS
GW-1017-Q291	149	1030	NS	NS	NS
GW-1018-Q291	112	597	NS	NS	NS
GW-1019-Q291	71.4	710	NS	NS	NS
GW-1020-Q291	13.7	418	NS	NS	NS
GW-1021-Q291	72.3	745	NS	NS	NS
GW-1022-Q291	117	455	NS	NS	NS
GW-1023-Q291	3.7	320	NS	NS	NS
GW-1024-Q291	6.2	436	NS	NS	NS
GW-RMW1-Q291	6.4	510	NS	NS	NS
GW-RMW2-Q291	14.2	206	NS	NS	NS
GW-RMW3-Q291	34.5	505	NS	NS	NS
GW-RMW4-Q291	5.7	145	NS	NS	NS
GW-RAWW-Q291	ND	295	NS	NS	NS
GW-FINW-Q291	ND	71.4	NS	NS	NS
GW-PW02-Q291	ND	268	NS	NS	NS
GW-PW03-Q291	ND	239	NS	NS	NS
GW-PW04-Q291	ND	244	NS	NS	NS
GW-PW05-Q291	ND	334	NS	NS	NS
GW-PW06-Q291	4	376	NS	NS	NS
GW-PW07-Q291	ND	530	NS	NS	NS
GW-PW08-Q291	4.9	392	NS	NS	NS
GW-PW09-Q291	ND	297	ND	ND	ND

ND - NOT DETECTED
NS - NOT SAMPLED

second and third bimonthly and second quarter analyses of arsenic and barium continue to indicate elevated concentrations in selected wells. The highest levels reported are 149 µg/l for arsenic in MW-1017 and 1,030 µg/l for barium also detected in MW-1017.

3 SURFACE WATER MONITORING

Routine samples were collected during the second quarter of 1991 from both on-site and off-site surface water and spring locations. All surface water samples were analyzed without filtering, unless a specific comparison of dissolved versus total contaminant concentrations was desired. Some analytical results are not available at this time; however, they will be presented in the 1991 ASER.

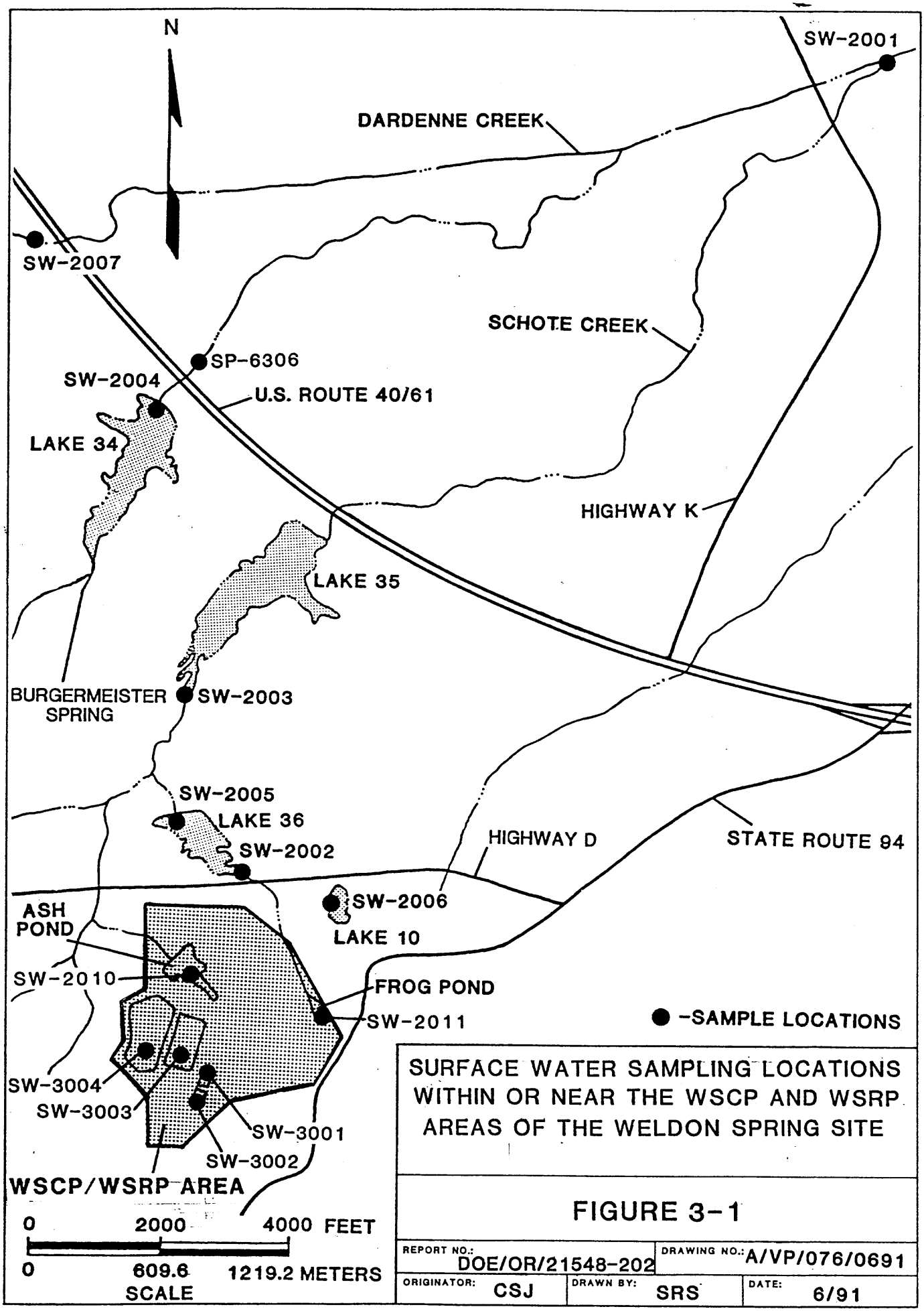
3.1 Chemical Plant/Raffinate Pits/Vicinity Properties

During the second quarter, surface water samples were collected from the 13 surface water sampling locations shown in Figure 3-1 and analyzed for uranium. The results, presented in Table 3-1, indicate that conditions remain similar to values measured historically.

3.2 Weldon Spring Quarry

Surface water samples were collected from the 10 locations shown in Figure 3-2 and three locations in Figure 3-3. Samples were analyzed for uranium, arsenic, and barium and the results are presented in Table 3-2. However, only the uranium results are available at this time. The results of all samples indicate no apparent changes in environmental conditions, although as seen in the previous first quarter, the uranium levels within the slough remain slightly elevated. The highest measured level was 312 pCi/l detected at sampling location SW-1004.

The second quarter uranium values measured in the Missouri River were almost the same as the values detected during the previous quarter. Historically, the levels of uranium at these locations have fluctuated (due to either natural fluctuations or analytical variability) such that uranium concentrations have been higher at upstream locations than downstream, and vice versa. The U.S. Department of Energy (DOE) has increased monitoring of the Missouri River prior to the operation of the Weldon Spring Site Remedial Action Project (WSSRAP) quarry water treatment plant to ascertain the preoperational (background) levels in the river. In addition, the National Pollution Discharge Elimination System (NPDES) permit for the quarry water treatment plant requires additional monitoring of the river. This



SURFACE WATER SAMPLING LOCATIONS WITHIN OR NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

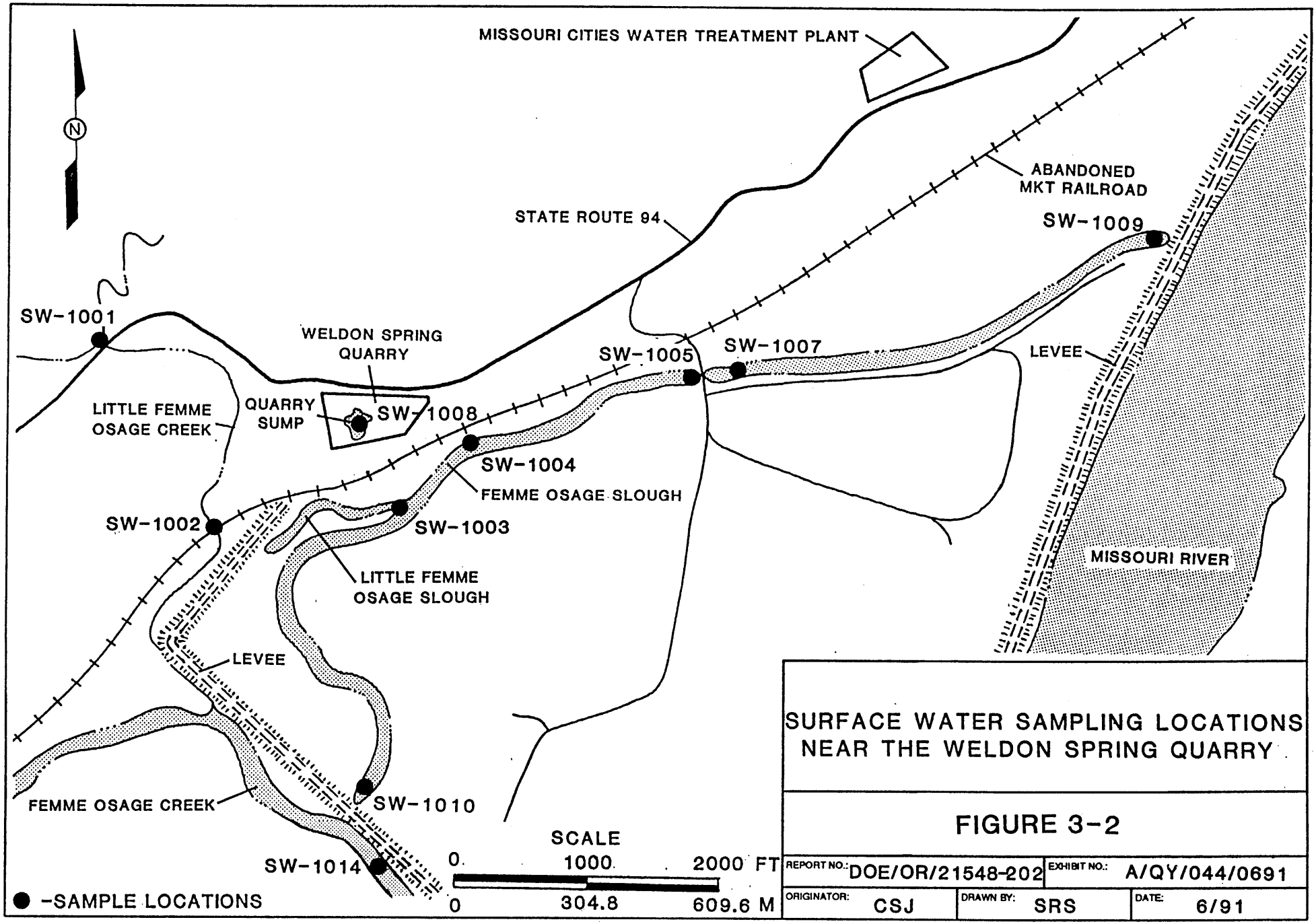
FIGURE 3-1

REPORT NO.: DOE/OR/21548-202	DRAWING NO.: A/VP/076/0691	
ORIGINATOR: CSJ	DRAWN BY: SRS	DATE: 6/91

TABLE 3-1 Second Quarter Uranium Results in Surface Water at the WSCP/RP/VP

WSSRAP_ID	TOTAL URANIUM (pCi/l)
SW-2001	4.0
SW-2002	16.0
SW-2003	8.0
SW-2004	19.0
SW-2005	18.0
SW-2007	ND
SW-2010	513
SW-2011	120
SW-3001	129
SW-3002	448
SW-3003	165
SW-3004	1770
SW-3002-Q291-DU	482.8

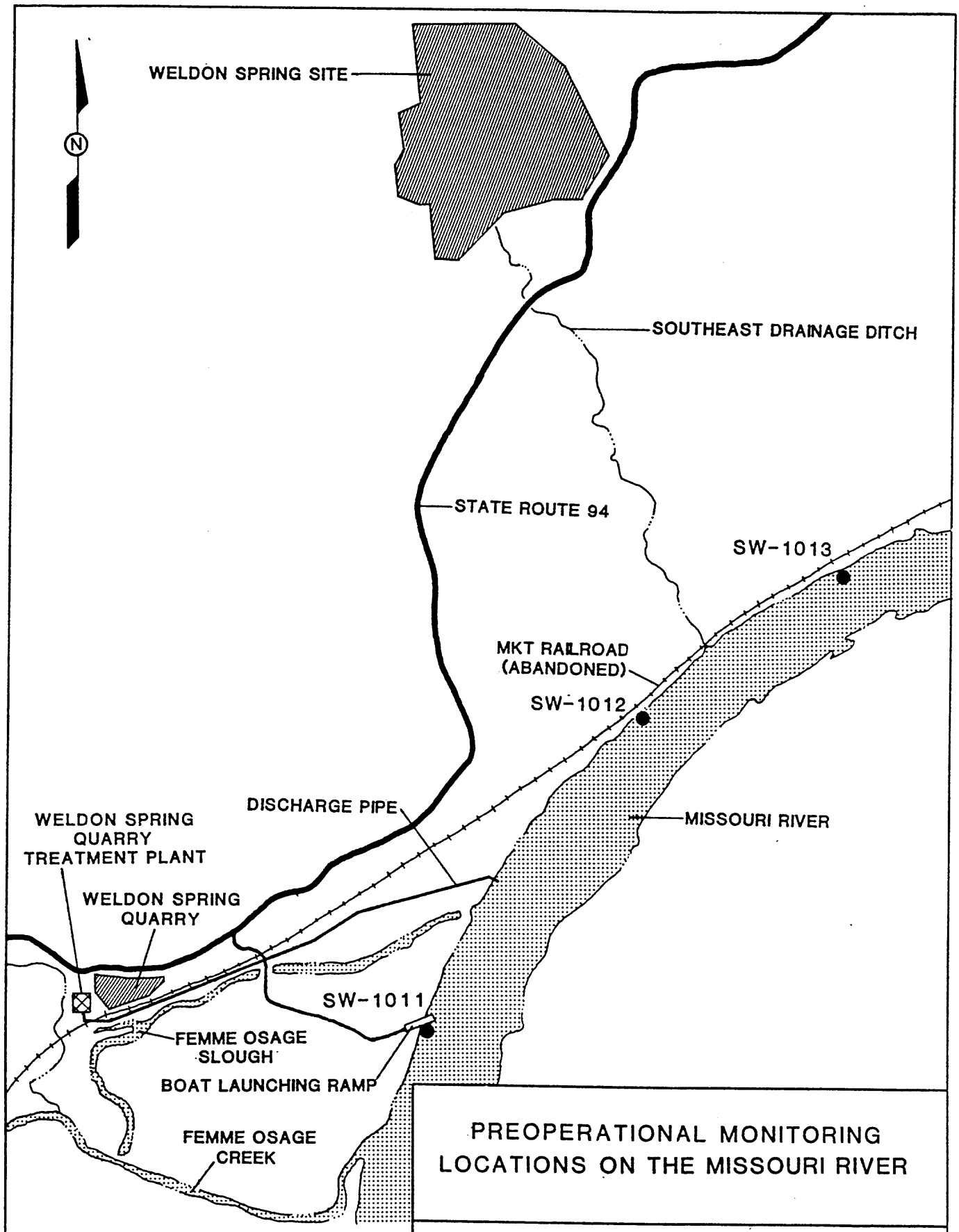
NA - NOT AVAILABLE AT THIS TIME
DU - DUPLICATE SAMPLE



SURFACE WATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 3-2

REPORT NO.: DOE/OR/21548-202		EXHIBIT NO.:	A/QY/044/0691
ORIGINATOR: CSJ	DRAWN BY: SRS	DATE:	6/91



PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

FIGURE 3-3

REPORT NO.: DOE/OR/21548-202		EXHIBIT NO.: A/VP/077/0691	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 6/91	

TABLE 3-2 Second Quarter Uranium Results in Surface Water at the Weldon Spring Quarry

WSSRAP ID	TOTAL URANIUM (pCi/l)
SW-1001	ND
SW-1002	ND
SW-1003	156.4
SW-1004	312.8
SW-1005	63.92
SW-1007	11.56
SW-1008	442
SW-1009	11.56
SW-1010	156.4
SW-1010-Q291-DU	361.8
SW-1011	2.04
SW-1012	ND
SW-1013	ND
SW-1014	0.68

ND - NOT DETECTED

monitoring increases the DOEs capability to ensure the safety of the public and the environment.

Arsenic and barium results in the second quarter for samples collected from the Missouri River were not available.

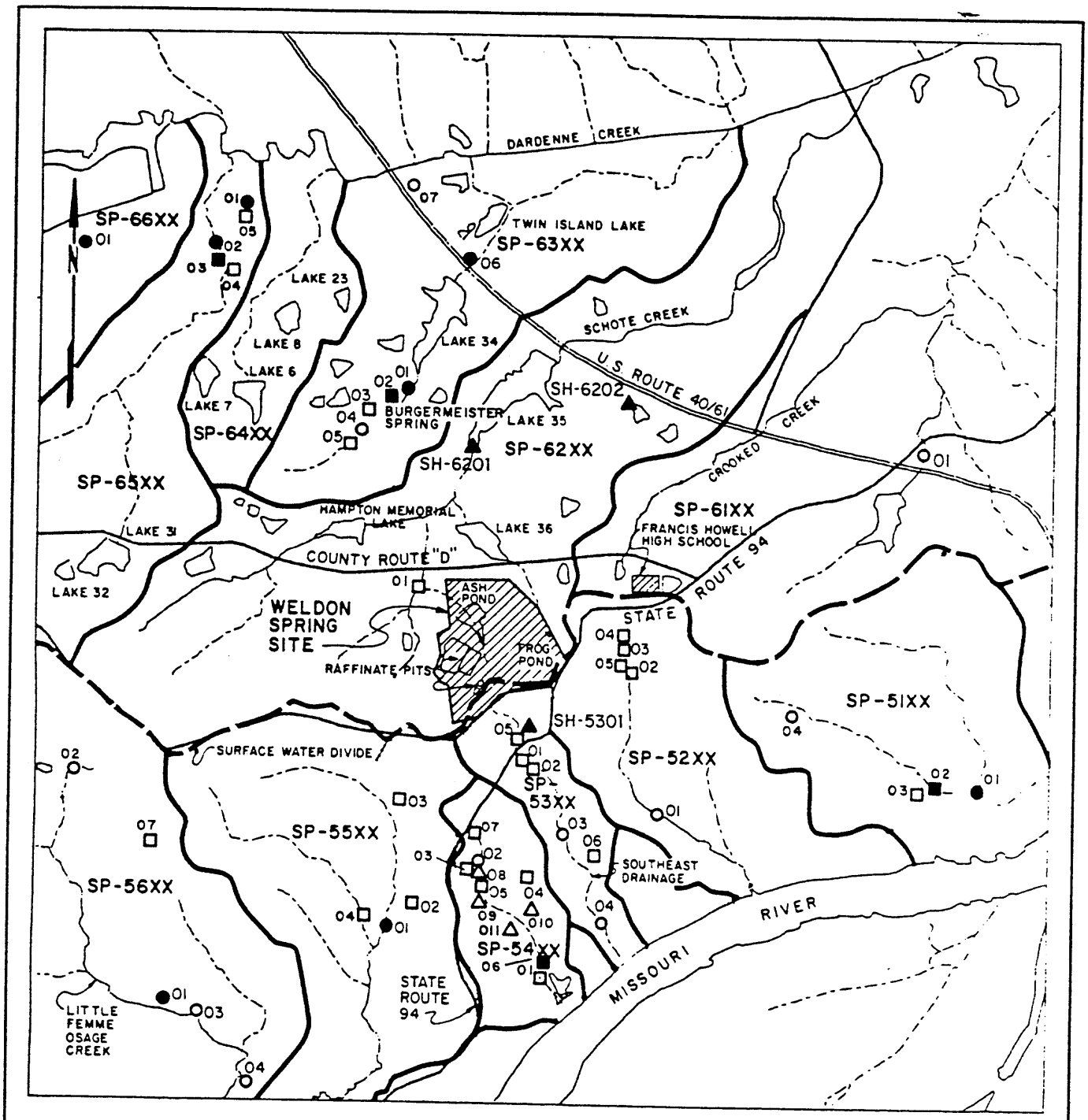
The analytical results for the six nitroaromatic compounds within the quarry sump were not available at the time of this report. The ponded water is to be treated for nitroaromatic compounds and other organics upon completion of the quarry water treatment plant.

3.3 Springs

Eleven springs around the Weldon Spring site (WSS) are sampled quarterly (see Figure 3-4 for spring locations). Previous spring monitoring indicated that waters from six perennial springs and one wet-weather spring are measurably influenced by site-related contaminants. These springs include SP-6301, SP-6302, SP-6306, and SP-5301 through SP-5304. All spring samples are analyzed for uranium with a select few analyzed for nitroaromatics, inorganics and metals. Available analytical results for these parameters are listed in Tables 3-3 and 3-4. Values for these parameters remain consistent with their historical values.

3.4 National Pollutant Discharge Elimination System Data Review

Surface water and effluent samples were collected and analyzed in compliance with the Weldon Spring Site National Pollutant Discharge Elimination System (NPDES) permit. This permit (Number MO-0107701) was issued in November 1988 and currently addresses these seven storm water and wastewater discharges shown in Figure 3-5. Outfalls NP-0001 through NP-0005 represent storm water discharge and NP-0006 represents the treated effluent discharge associated with the administration building sanitary wastewater treatment plant. Outfall NP-0007 represents the new site contaminated water treatment plant which is under contract but not yet constructed. Outfalls NP-0006 and NP-0007 have effluent limitations. The five surface water outfalls have monitoring requirements only. Second quarter 1991 analytical data for each outfall is presented in Table 3-5.



SOURCE: MDNR, 1989

LEGEND :

- SURFACE WATER DIVIDE BETWEEN MISSISSIPPI RIVER AND MISSOURI RIVER
- DRAINAGE BOUNDARY
- CREEK OR SURFACE DRAINAGE
- POND OR LAKE
- ● PERENNIAL SPRING WITH LARGE MAXIMUM FLOW
- ○ PERENNIAL SPRING WITH SMALL MAXIMUM FLOW
- ■ WET WEATHER SPRING WITH LARGE MAXIMUM FLOW
- □ WET WEATHER SPRING WITH SMALL MAXIMUM FLOW
- ▲ SHALLOW HOLE (SH)
- △ SEEP
- SP-63XX SPRING OR SEEP IN DESIGNATED DRAINAGE AREA NUMBER 63. XX REPRESENTS THE DESIGNATED SPRING NUMBER IN DRAINAGE 63.

SCALE 0 3200 6400 FT
0 975.4 1950.7 M

SPRINGS AND SEEPS IN THE VICINITY OF THE WSS

FIGURE 3-4

REPORT NO.: DOE/OR/21548-202		EXHIBIT NO.: A/VP/078/0691	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 6/91	

TABLE 3-3 Second Quarter Uranium Results in Springs Near the Weldon Spring Site

WSSRAP ID	TOTAL URANIUM (pCi/l)
SP-5201	NA
SP-5203	NA
SP-5301	NA
SP-5302	NA
SP-5303	129
SP-5304	163
SP-5503	NA
SP-5601	ND
SP-6301	NA
SP-6301-Q291-DU	136.0
SP-6302	NA
SP-6303	NA
SP-6306	16.32

NA - NOT AVAILABLE
ND - NOT DETECTED
DU - DUPLICATE SAMPLE

TABLE 3-4 Second Quarter Nitroaromatic Results in Springs Near the Weldon Spring Site

WSSRAP_ID	1,3,5-TRINITROBENZENE	1,3-DINITROBENZENE	2,4,6-TNT	2,4-DNT	2,6-DNT	NITROBENZENE
SP-5601	ND	ND	ND	ND	0.041	ND
SP-6301	NA	NA	NA	NA	NA	NA
SP-6302	NA	NA	NA	NA	NA	NA
SP-6303	NA	NA	NA	NA	NA	NA
SP-6306	ND	ND	ND	ND	ND	ND

ND - NOT DETECTED
NA - NOT AVAILABLE

3.4.1 Radiological Analysis

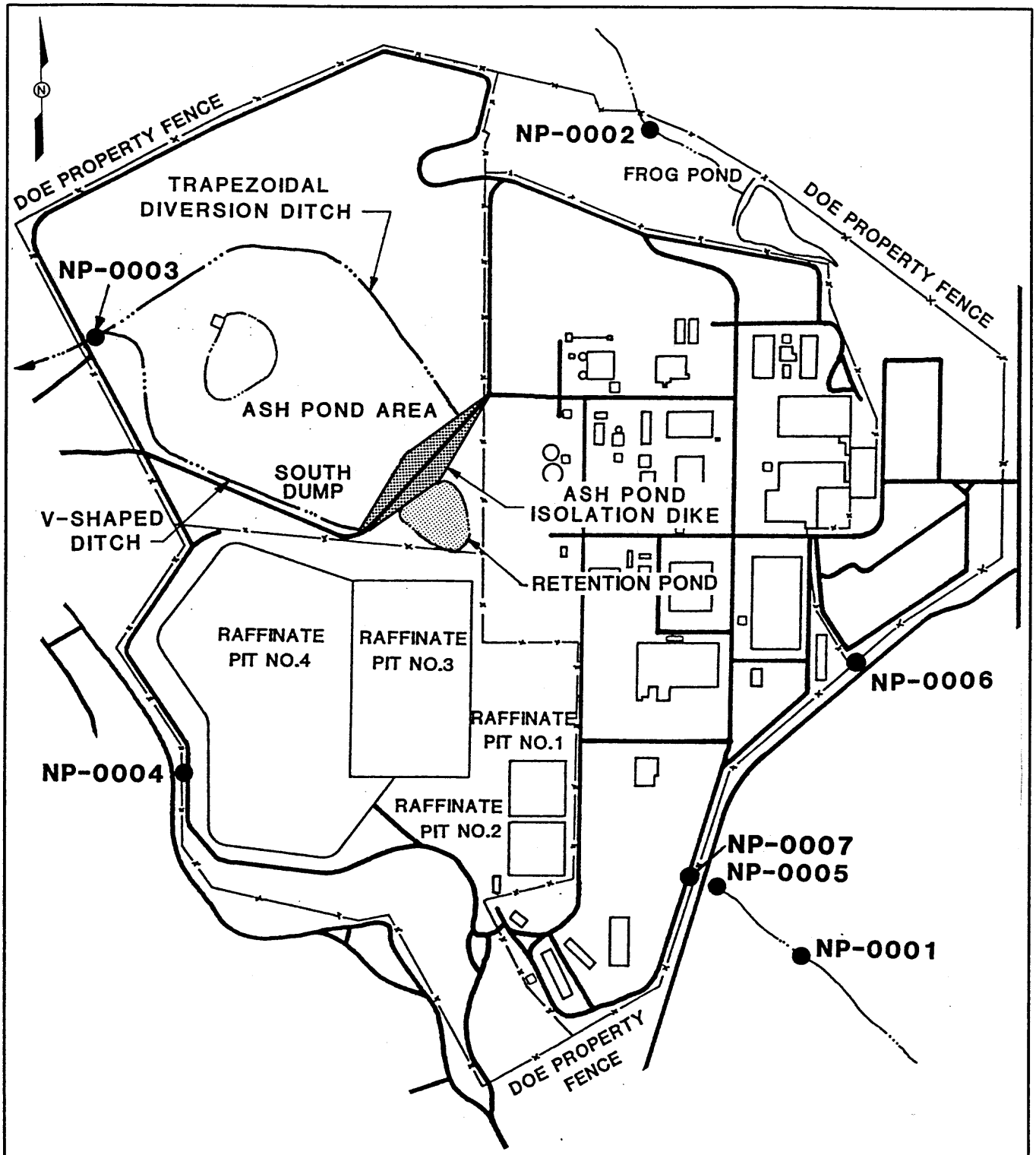
Gross Alpha and Total Uranium analyses correspond reasonably well with past data. The highest uranium levels were present in surface flow from the southeast portion of the site (NP-0001 and NP-0005). The peaks for these points were 666 pCi/l and 571 pCi/l, respectively.

Other outfalls exhibited the following peaks of uranium concentrations. NP-0002, the drainage from the Frog Pond area, was measured at 150 pCi/l. NP-0003, with drainage from the Ash Pond area, was measured at 156 pCi/l. A uranium concentration of 9.5 pCi/l was present in the sample collected from NP-0004, behind raffinate pit No. 4.

3.4.2 Other Analysis

Other analyses include physical analysis (settleable solids and suspended solids) and chemical analysis (nitrate, pH, and lithium). Second quarter 1991 values generally correspond to past values for the majority of parameters. The Ash Pond weir (NP-0003) discharged an excessive amount of solids because of erosion from a new construction activity on the day the samples were taken.

The discharge from the administration building treatment plant, NP-0006, has effluent limitations for quarterly samples. In addition to this quarterly monitoring, the subcontractor monitors the same parameters monthly, to assess plant performance. The NPDES permit contains effluent limitations on biochemical oxygen demand (BOD), total suspended solids (TSS), and fecal coliform at this outfall. These limits are 15 mg/l (BOD), and 20 mg/l (TSS), for weekly averages with maximum daily fecal coliform of 1,000 colonies per 100 ml. NPDES permit limits were not exceeded in the second of quarter 1991 at this outfall.



NPDES MONITORING LOCATIONS

FIGURE 3-5

SCALE 0 500 1000 FT
0 152.4 304.8 M

REPORT NO.: DOE/OR/21548-202	EXHIBIT NO.: A/CP/149/0991	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 9/91

TABLE 3-5 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006

Outfall NP-0001 NPDES data for Q2 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	mg/l	pCi/l
Apr. 15	22,000	4.0	<0.1	1.08	7.93	ND	480	0.98	666

Outfall NP-0002 NPDES data for Q2 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	mg/l	pCi/l
Apr. 15	637,000	26	<0.1	1.09	7.27	ND	110	0.2	136
May 16	82,000	9	<0.1	ND	6.01	ND	140	0.22	150
June	DRY								

Outfall NP-003 NPDES data for Q2 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	mg/l	pCi/l
Apr. 15	800,000	7,930	0.2	0.96	7.18	0.176	640	0.13	88
May 16	53,000	32	<0.1	0.89	5.92*	ND	120	0.23	156
June	No Discharge								

* Indicates value which exceeded effluent limitation

TABLE 3-5 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006 (Continued)

Outfall NP-0004 NPDES data for Q2 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	mg/l	pCi/l
June 13	Not Flowing	890	Not Obtained	48	7.35	0.038	ND	0.002	1.4

Outfall NP-0005 NPDES data for Q2 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD	mg/l	ml/l	mg/l		mg/l	pCi/l	mg/l	pCi/l
Apr. 15	164,000	7	<0.1	6.1	7.58	ND	440	0.84	571
May 16	11,000	16	<0.1	9.17	5.54*	ND	550	0.74	503
June	No Discharge								

* Indicates value which exceeded effluent limitation

Outfall NP-0006 NPDES data for Q2 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	BOD	FECAL COLIFORMS	pH
UNITS	GPD	mg/l	mg/l	No./100 ml	
Apr. 3	1,530	10	<3.0	<1	6.5
May 22	2,500	1	9.3	<1	6.6
June 5	1,620	5	<3.0	<1	6.25

4 AIR MONITORING

4.1 Radon Gas

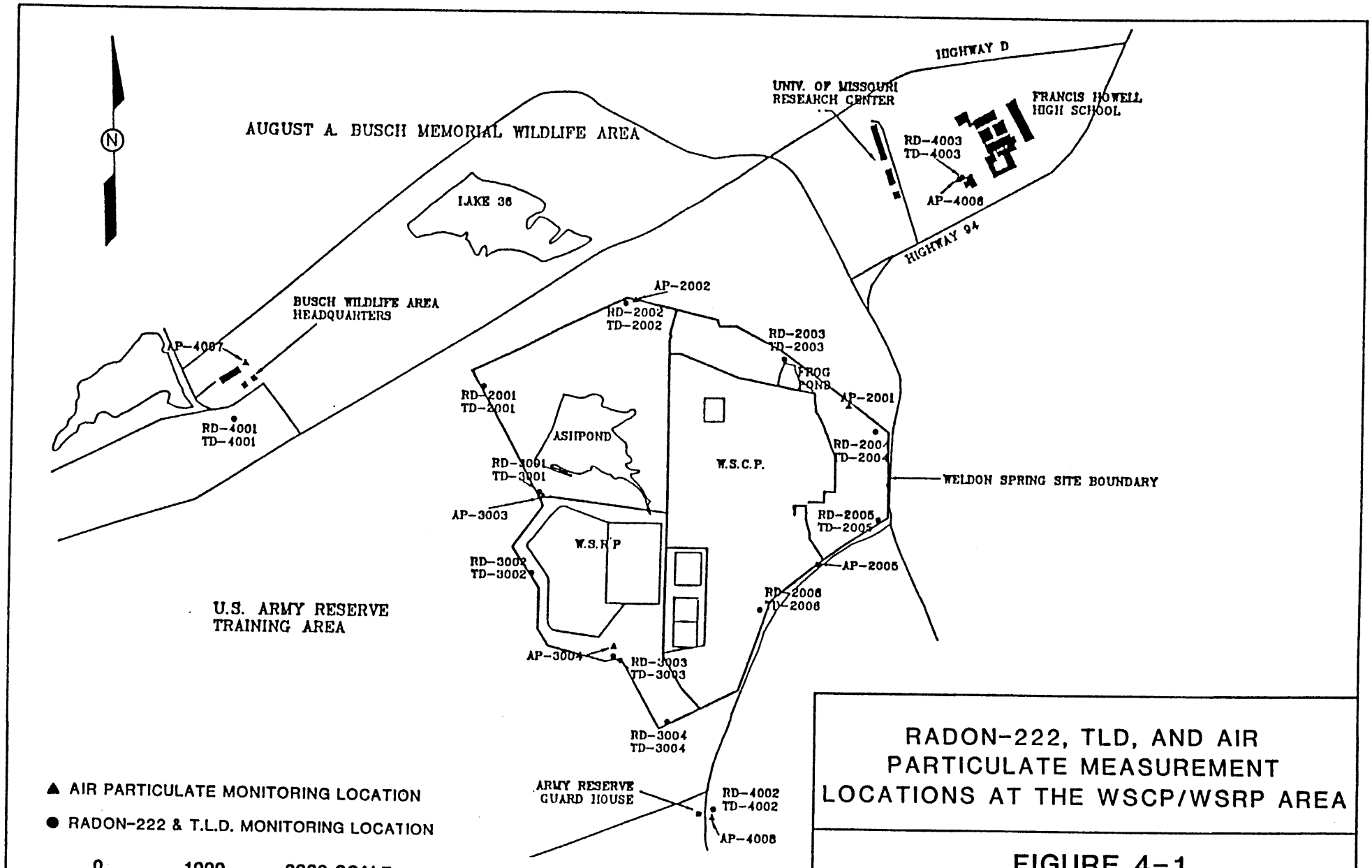
The radon gas monitoring program utilizes a pair of radon detectors at each of 22 permanent locations; each detector is exchanged quarterly. These detectors are deployed at six locations at the Weldon Spring Chemical Plant, six locations at the Weldon Spring quarry, four locations at the Weldon Spring raffinate pits, and six off-site locations. Radon monitoring locations are shown in Figures 4-1, 4-2, and 4-3. On-site detectors are distributed around the perimeter fences to ensure adequate detection of radon dispersing from the properties under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005, and RD-4006 were used to monitor background levels near the site.

Table 4-1 summarizes the second quarter 1991 radon concentrations detected at all site perimeter and off-site monitoring locations. Also contained in Table 4-1 is a comparison of the measured concentration with the Federally permitted radon concentration (for unrestricted areas) of 3 pCi/l (110 Bq/m^3) above background as authorized by U.S. Department of Energy (DOE) Order 5400.5.

An average ambient background concentration was determined by calculating the arithmetic average for the four background locations. This data yielded an average ambient background radon concentration of 0.3 pCi/l for the second quarter of 1991. This concentration was then subtracted from the concentration for each monitoring station, and compared to the DOE guideline of 3 pCi/l above background.

Radon concentrations at the site and quarry perimeters and at off-site locations for the second quarter of 1991 were within the typical range expected during years of normal precipitation. The quarterly radon concentrations (background included) ranged from 0.1 pCi/l at RD-2002 to 1.3 pCi/l at monitoring location RD-1001 and RD-1002.

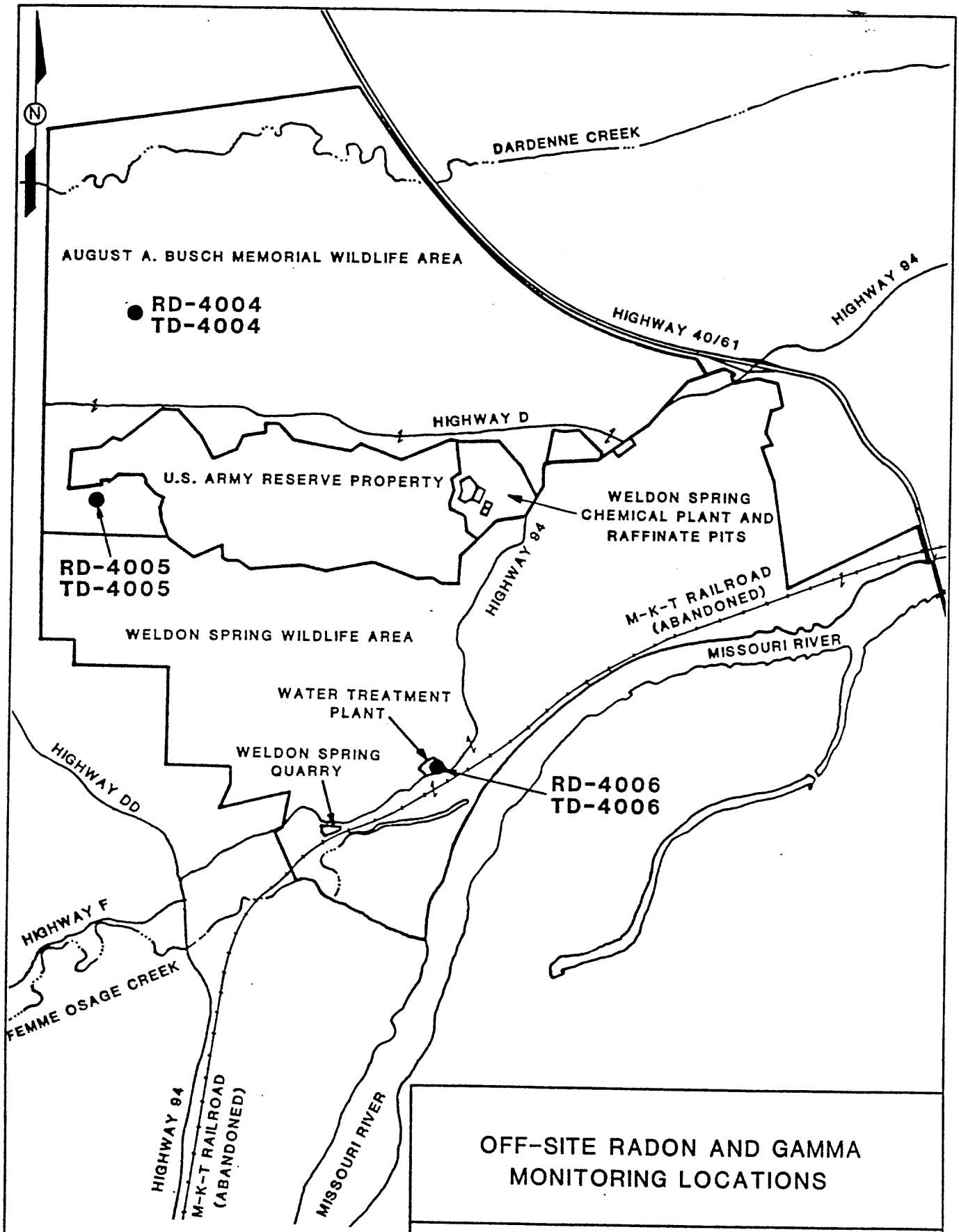
Radon concentrations found in the quarry are higher than concentrations measured at other locations because the radium concentrations in quarry wastes are typically much higher than other areas, and because the quarry is a large depression with side walls ranging from 3 m to 15 m (10 ft to 50 ft) high. In conjunction with stable meteorological conditions,



RADON-222, TLD, AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 4-1

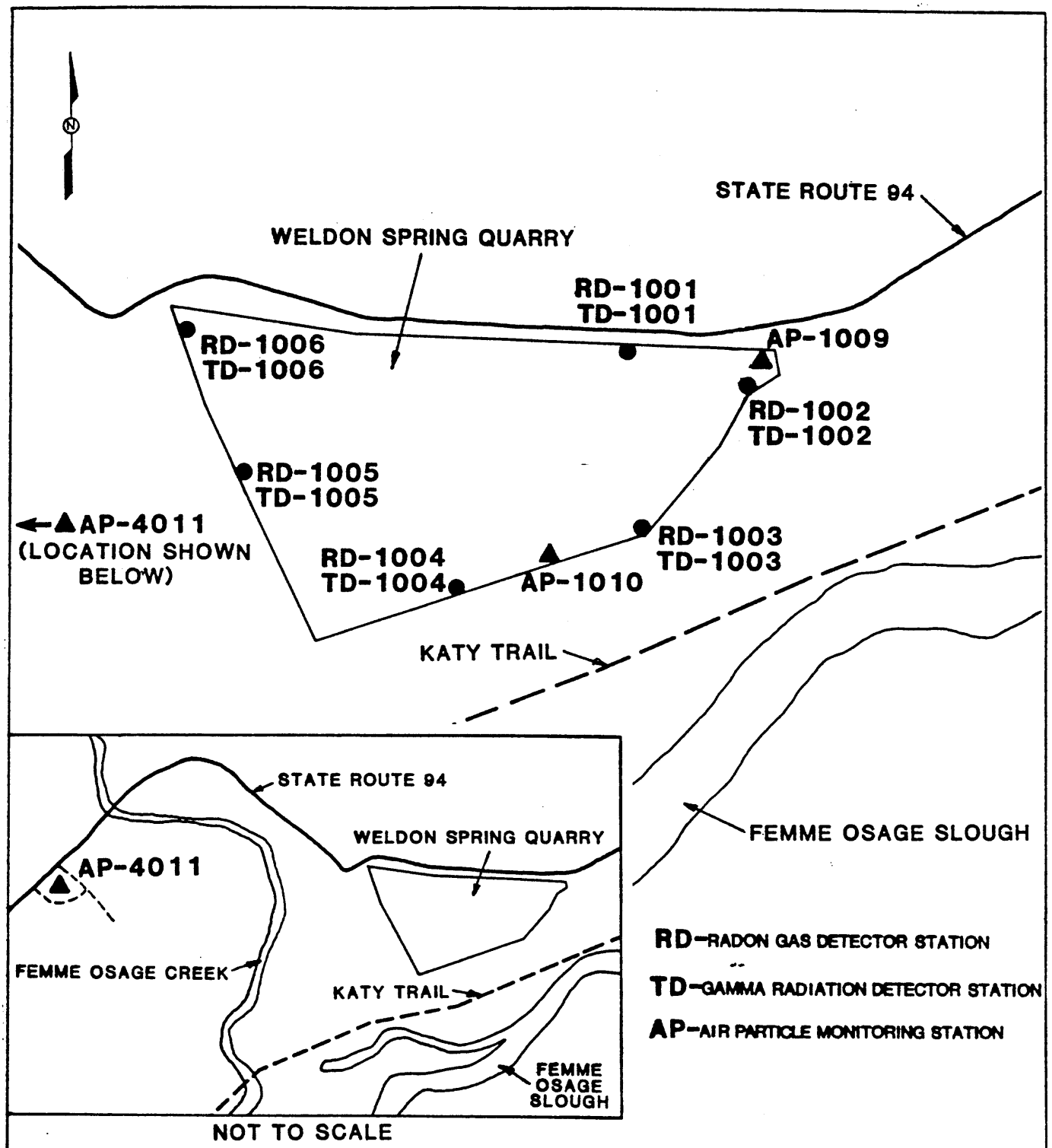
REPORT NO.:	DOE/OR/21548-202	EXHIBIT NO.:	A/VP/079/0691		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	6/91



OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

FIGURE 4-2

REPORT NO.: DOE/OR/21548-202		EXHIBIT NO.: A/VP/080/0691	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 6/91	



RADON-222, THERMO LUMINESCENT DOSIMETER (TLD) AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 4-3

REPORT NO.: DOE/OR/21548-202	EXHIBIT NO.: A/QY/049/0691	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 6/91

TABLE 4-1 1991 Track Etch Radon Results[a]

Location I.D.	2nd quarter pCi/l	Percent of Guidance [b]
WSQ		
RD-1001	1.3	33
RD-1002	1.3	33
RD-1003	0.5	7
RD-1004	0.4	3
RD-1005	0.4	3
RD-1006	0.4	3
WSCP		
RD-2001	0.3	0
RD-2002	0.1	0
RD-2003	0.3	0
RD-2004	0.3	0
RD-2005	0.2	0
RD-2006	0.2	0
WSRP		
RD-3001	0.2	0
RD-3002	0.3	0
RD-3003	0.3	0
RD-3004	0.3	0
OFF-SITE		
RD-4001*	0.3	0
RD-4002	0.2	0
RD-4003	0.2	0
RD-4004*	0.3	0
RD-4005*	0.2	0
RD-4006*	0.3	0

(a) Results include natural background.
(b) Percent of guideline calculated by taking the quarterly average minus the average of the background stations divided by the DOE concentration guideline for RN-222 which is 3 pCi/l (100 Bq/m^3)(Annual average above background) for uncontrolled areas.
* Denotes Background Station

this configuration tends to trap emanating radon within the quarry and raise the concentrations along the quarry perimeter.

4.2 Gamma Radiation Exposure

To monitor exposure from gamma radiation, spherical environmental thermoluminescent dosimeters (TLDs) were deployed at 22 locations. The gamma monitoring station locations are the same as the ambient radon monitoring locations (see Section 4.1).

Table 4-2 summarizes the first and second quarter results of total gamma radiation monitoring at the 16 Weldon Spring site (WSS) perimeter monitoring stations, the Francis Howell High School, the Weldon Spring Army Reserve Training Area, and at the four background monitoring stations.

The annual average background gamma exposures measured with TLDs in 1989 and 1990 were 68 mR/year and 62 mR/year, respectively. The gamma exposures measured with TLDs in the first and second quarter of 1991 were consistent with 1989 and 1990 data. This was expected because no significant changes in the configuration or location of the wastes have occurred.

4.3 Radioactive Air Particulates

Eleven low volume air particulate samplers monitor the Weldon Spring site continuously. Five of these (AP-2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the Weldon Spring Chemical Plant (WSCP) perimeter and two are located around the quarry perimeter as shown in Figure 4-3. Three monitoring stations (AP-4006, AP-4008, and AP-4011) are located off site at sensitive receptor locations; including Francis Howell High School, the Army Reserve property, and near a residential site west of the quarry. The monitoring station at the August A. Busch Wildlife Area (AP-4007) is used to monitor background levels in the vicinity of the WSCP. The off-site monitoring stations are also shown in Figure 4-2.

TABLE 4-2 1991 Environmental TLD Results[a]

Location I.D.	1st Quarter mrem	2nd Quarter mrem
WSQ		
TD-1001	24	17
TD-1002	20	15
TD-1003	20	20
TD-1004	19	17
TD-1005	20	17
TD-1006	19	18
WSCP		
TD-2001	18	16
TD-2002	17	16
TD-2003	18	17
TD-2004	19	17
TD-2005	18	14
TD-2006	17	15
WSRP		
TD-3001	22	14
TD-3002	17	13
TD-3003	19	17
TD-3004	16	14
OFF-SITE		
TD-4001*	18	16
TD-4002	16	13
TD-4003	16	12
TD-4004*	19	--
TD-4005*	16	13
TD-4006*	17	15

(a) Results include natural background.
\- Denotes loss of TLD.
* Denotes background station.

The sampling station near the August A. Busch Wildlife Area (ABWA) headquarters is used as a background air monitoring station. This station is approximately 0.8 km (0.5 mile) from the WSCP perimeter in a northwestern direction. The terrain between the WSCP and this sampling station is hilly and forested, providing a significant physical barrier to airborne particulates originating from the WSCP/ Weldon Spring raffinate pits (WSRP). In addition, winds from the southeast are relatively rare at the WSCP.

Table 4-3 summarizes the quarterly average concentrations and the standard deviations for the 11 air monitoring locations. The quarterly average concentration for each monitoring location was calculated by averaging either the weekly air particulate analysis results or the counting instrument's lower limit of detection (LLD), whichever was greater. The "<" sign in Table 4-3 appears when the actual average is less than the calculated average due to the use of LLD values in the calculation. The standard deviation for each of the monitoring locations was calculated using only results that were above the LLD. Due to maintenance, all monitors were not operating the entire 13 weeks as indicated in Table 4-3. However, the sensitive receptor monitoring stations (AP-4006, AP-4008, and AP-4011) were in operation the majority of the time and these stations are also equipped with high volume air monitoring. The high volume air monitors are part of the WSS radionuclide National Emissions Standards for Hazardous Air Pollutants (NESHAPs) requirements and were in operation the entire 13 weeks. The high volume monitoring results will be presented in the *Annual Site Environmental Report.*

The first quarter net alpha concentrations ranged from $< 9.19 \times 10^{-16}$ µCi/ml to $< 1.28 \times 10^{-15}$ µCi/ml with 1.12×10^{-15} µCi/ml detected at the background station.

4.4 Asbestos

No environmental asbestos monitoring was performed in the second quarter of 1991.

TABLE 4-3 Radiological Air Particulate Second Quarter 1991

MONITOR IDENTIFICATION NUMBER	QUARTERLY AVG. CONCENTRATION (1E-15 μCi/ml)	STANDARD DEVIATION	NUMBER OF WEEKS COLLECTED	NUMBER OF VALUES ABOVE LLD
AP-2001	<9.62E-16	2.83E-16	10	7
AP-2002	<1.06E-15	4.50E-16	10	5
AP-3003	<1.23E-15	5.11E-16	10	7
AP-3004	<9.19E-16	NA	4	1
AP-2005	<1.20E-15	6.26E-16	13	7
AP-4006	<9.49E-16	2.64E-16	13	8
AP-4007*	1.12E-15	3.72E-16	9	9
AP-4008	<1.08E-15	4.12E-16	12	6
AP-1009	<1.28E-15	3.67E-16	10	8
AP1010	<1.04E-15	4.53E-16	12	9
AP-4011	<1.19E-15	5.26E-16	12	8

* Indicates background monitor station.
To convert μCi/ml to Bq/M^3, multiply by 3.7E10.
NA Not available

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December 18, 1991

ADDRESSEES:

QUARTERLY ENVIRONMENTAL DATA SUMMARY FOR THE THIRD QUARTER, 1991 FOR THE WELDON SPRING SITE REMEDIAL ACTION PROJECT

Enclosed for your information and use is a copy of the Quarterly Environmental Data Summary Report. The document summarizes the environmental monitoring data for the third quarter, highlights any potentially significant findings, and offers preliminary interpretations. Final interpretations will appear in the 1991 Annual Site Environmental Report.

The report indicates the occurrence of slightly elevated levels of total suspended solids for Outfalls NP-0001 and NP-0005 resulting from construction activities and a 2.24 inch rainfall prior to sampling.

If you have any questions please call Alan D. Gibson at (314)441-8978.

Sincerely,

Stephen H. McCracken
Project Manager
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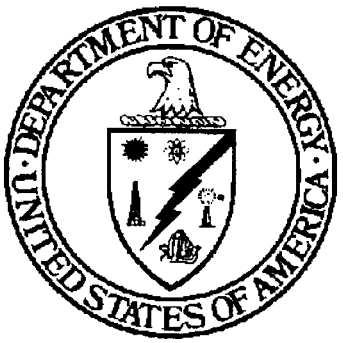
QUARTERLY ENVIRONMENTAL DATA SUMMARY THIRD QUARTER 1991

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

DECEMBER 1991 **REV. 0**



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Weldon Spring Site Remedial Action Project

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Weldon Spring Site Remedial Action Project

Quarterly Environmental Data Summary Third Quarter 1991

Revision 0

December 1991

Prepared by

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U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

ABSTRACT AND WELDON SPRING SITE QUARTERLY SELF ASSESSMENT THIRD QUARTER 1991

The purpose of this Quarterly Environmental Data Summary is to provide preliminary data acquired as part of the Weldon Spring Site Remedial Action Project (WSSRAP) environmental monitoring program. The document summarizes the environmental data, highlights any potentially significant findings, and offers tentative interpretations. Validated data and final interpretations will appear in the 1991 Annual Site Environmental Report.

This report includes data from environmental monitoring activities at the Weldon Spring site (WSS) during the third quarter of 1991. Groundwater, surface water, and air were sampled in order to monitor potential exposure pathways. Analytical parameters included radionuclides, nitroaromatic compounds, inorganic anions, and direct gamma exposure. The results are used to calculate exposure doses (where applicable) and assess the impact of the contaminants at the site on potentially exposed populations.

In summary, no significant differences were observed in off-site exposures during the third quarter of 1991 relative to exposures calculated in previous quarters. Contaminated groundwater did not affect private water supplies or the St. Charles County well field. Surface water containing elevated uranium activity continued to impact the Femme Osage Slough. Off-site gamma, radon, and air particulate exposures remained indistinguishable from background. Off-site monitoring demonstrated that exposure levels at the Francis Howell High School, the Busch Wildlife Area Headquarters, and the Weldon Spring Training Area remain indistinguishable from background levels.

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1 INTRODUCTION

This document is the sixth in a series of documents designed to provide a summary of the findings from the routine environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). These documents supplement the *Annual Site Environmental Report* (ASER) by providing interested outside agencies and organizations with more frequent access to WSSRAP data. They provide data resulting from routine environmental sampling as described in the WSSRAP Environmental Monitoring Plan and a brief interpretation of that data.

It is the goal of this document to summarize and briefly discuss the data, highlighting data that differ significantly from observations made in previous reports. The full interpretation of these data (as well as data in other quarterly summaries) will be undertaken in the 1991 ASER. It is recommended that interested readers refer to previous Environmental Monitoring Plans (EMPs), ASERs, and project documents for more information on existing site conditions, site history, transport mechanisms, and quantified contaminant levels. The monitoring scheme for every calendar year is established prior to that year in the annual EMP. Each sampling location to be monitored during the upcoming year is identified in the EMP and the schedule of analytical parameters are tabulated for easy reference. These reports may be obtained by visiting the WSSRAP reading room or contacting the WSSRAP Community Relations Manager at 314-441-8086.

These quarterly reports are intended to include data from all quarterly environmental monitoring programs conducted at the WSSRAP including groundwater, surface water, National Pollutant Discharge Elimination System (NPDES), radon gas, gamma radiation, and air particulates (including asbestos and radioactive particulates). However, because of delays in data delivery from the analytical laboratories, some of the data that was expected to be included in this report are not yet available for reporting. The unavailability of data is due to a nationwide shortage in analytical services. These data will be reported in the 1991 ASER. Sludges, soils, and biological specimens are not sampled on a routine basis; therefore, analytical results for these parameters are not included in this report. Trend analyses are being prepared from historical data for surface water, groundwater and air pathways. These analyses will be presented in the 1991 ASER. Quality control (QC) data for the third quarter are presented in tables throughout this document. This information provides insight as to the performance of the laboratory and the quality of the data. This

QC data is provided for information only. Final interpretation will be presented in the 1991 Annual Site Environmental Report (ASER).

2 GROUNDWATER MONITORING

The groundwater is sampled regularly at both the Weldon Spring Chemical Plant/raffinate pits/vicinity properties (WSCP/RP/VP) and the Weldon Spring Quarry (WSQ). Due to differences in the environmental settings and sources of contaminants, separate monitoring schedules are followed. Therefore, results of groundwater monitoring at the WSCP/RP/VP and WSQ will be discussed separately.

2.1 Chemical Plant/Raffinate Pits/Vicinity Properties

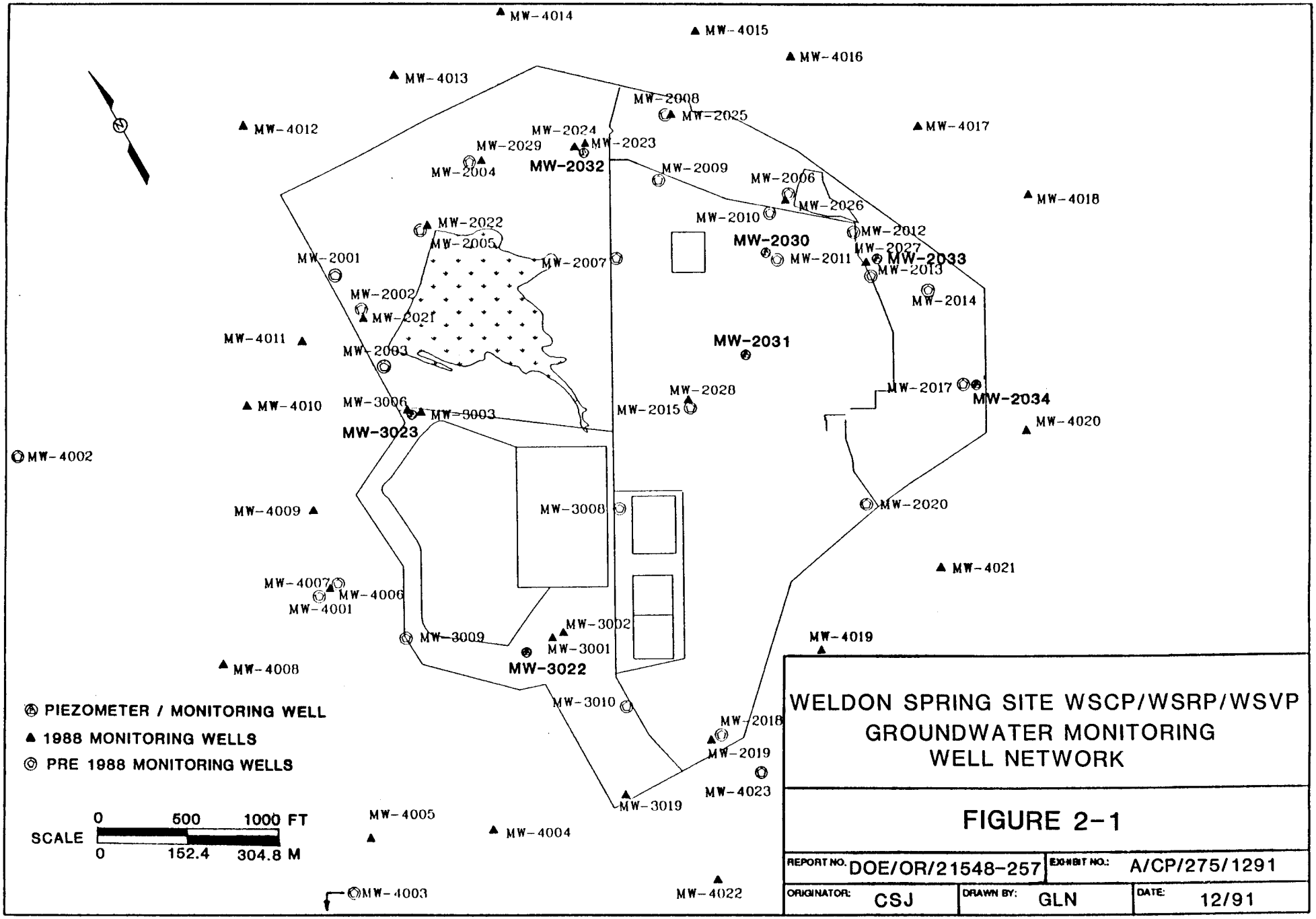
The groundwater at the chemical plant/raffinate pits/vicinity properties area is monitored on a semi-annual basis with the exception of MW-2001, MW-2002, MW-2003, MW-3003, MW-3006, MW-3008, MW-3009, MW-3023, MW-4012 and MW-4013 which are monitored quarterly. Monitoring well locations are shown in Figure 2-1. Data from the semiannual groundwater monitoring for the second half of 1991 will be presented in the fourth quarterly data summary, however, data from the quarterly monitored wells are presented in each Quarterly Environmental Data Summary (QEDS).

2.1.1 Nitroaromatic Results

Table 2-1 contains nitroaromatic data from samples collected from the quarterly monitored groundwater wells at the WSCP/RP/VP area. Nitroaromatic compounds were detected in 18 samples. However, not all the data are currently available. The data available continues to reflect levels historically found and documented in previous environmental reports.

2.1.2 Radiological Results

The radiological results for samples from quarterly monitored wells at the WSCP/RP/VP are presented in Table 2-2. The upper bound for natural uranium background concentrations in groundwater at the WSCP/RP/VP has been determined to be 3.4 pCi/l. The U.S. Environmental Protection Agency (EPA) has not yet established drinking water standards for uranium; however, studies leading to proposed rulemaking are using uranium in the 10 pCi/l to 40 pCi/l range. The U.S. Department of Energy (DOE) has a health based derived concentration guideline (DCG) of 600 pCi/l in surface water effluent.



WELDON SPRING SITE WSCP/WSRP/WSVP GROUNDWATER MONITORING WELL NETWORK

FIGURE 2-1

REPORT NO.	DOE/OR/21548-257	EXHIBIT NO.:	A/CP/275/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91

TABLE 2-1 Third Quarter Nitroaromatic Data for Groundwater at the WSCP/RP/VP

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-2001-Q391	ND	ND	0.073	0.061	ND	0.039
GW-2002-Q391	ND	ND	0.052	0.49	ND	0.037
GW-2003-080191	ND	ND	0.18	0.96	ND	ND
GW-2004-Q391	NA	NA	NA	NA	NA	NA
GW-2005-081491	ND	ND	0.089	0.14	ND	ND
GW-2006-Q391	NA	NA	NA	NA	NA	NA
GW-2007-Q391	NA	NA	NA	NA	NA	NA
GW-2008-071591	ND	ND	0.048	1.00	0.031	0.90
GW-2009-082291	ND	ND	0.074	0.33	ND	ND
GW-2010-091691	ND	ND	0.078	0.75	0.34	0.17
GW-2011-Q391	NA	NA	NA	NA	NA	NA
GW-2012-Q391	NA	NA	NA	NA	NA	NA
GW-2013-Q391	NA	NA	NA	NA	NA	NA
GW-2014-073091	ND	ND	0.12	0.86	ND	3.40
GW-2015-Q391	NA	NA	NA	NA	NA	NA
GW-2017-082291	ND	ND	ND	ND	ND	ND
GW-2018-082091	ND	ND	ND	ND	ND	ND
GW-2019-Q391	NA	NA	NA	NA	NA	NA
GW-2020-Q391	NA	NA	NA	NA	NA	NA
GW-2021-090391	ND	ND	ND	ND	ND	ND
GW-2022-081591	ND	ND	ND	ND	ND	ND
GW-2023-Q391	NA	NA	NA	NA	NA	NA
GW-2024-Q391	NA	NA	NA	NA	NA	NA
GW-2025-082691	ND	ND	ND	ND	ND	ND
GW-2026-081591	ND	ND	ND	ND	ND	ND
GW-2027-090391	ND	ND	ND	ND	ND	ND
GW-2028-Q391	NA	NA	NA	NA	NA	NA
GW-2029-Q391	NA	NA	NA	NA	NA	NA
GW-2030-Q391	NA	NA	NA	NA	NA	NA

TABLE 2-1 Third Quarter Nitroaromatic Data for Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-2031-Q391	NA	NA	NA	NA	NA	NA
GW-2032-Q391	NA	NA	NA	NA	NA	NA
GW-2033-Q391	NA	NA	NA	NA	NA	NA
GW-2034-Q391	NA	NA	NA	NA	NA	NA
GW-3001-Q391	NA	NA	NA	NA	NA	NA
GW-3002-Q391	NA	NA	NA	NA	NA	NA
GW-3003-091191	ND	ND	0.032	0.082	ND	ND
GW-3006-091191	ND	ND	ND	ND	ND	ND
GW-3008-091691	ND	ND	0.096	0.32	ND	ND
GW-3009-080191	ND	ND	0.16	0.11	ND	0.11
GW-3019-080891	ND	ND	ND	ND	ND	ND
GW-3022-Q391	NA	NA	NA	NA	NA	NA
GW-3023-091691	ND	ND	6.00	9.60	ND	ND
GW-4001-080691	ND	ND	7.40	6.80	1.60	64.0
GW-4002-080591	ND	ND	ND	0.069	0.093	0.10
GW-4003-080591	ND	ND	ND	ND	ND	ND
GW-4004-081991	ND	ND	ND	ND	ND	ND
GW-4005-081991	ND	ND	ND	ND	ND	ND
GW-4006-080891	ND	ND	0.19	6.40	ND	26.0
GW-4007-080691	ND	ND	ND	ND	ND	ND
GW-4008-080891	ND	ND	ND	ND	ND	ND
GW-4009-081391	ND	ND	ND	ND	ND	ND
GW-4010-070991	ND	ND	ND	ND	ND	ND
GW-4011-090991	ND	ND	ND	ND	ND	ND
GW-4012-091091	ND	ND	ND	ND	ND	ND
GW-4013-072391	ND	ND	0.086	1.90	0.066	86.0
GW-4014-072391	ND	ND	ND	0.053	ND	0.53
GW-4015-Q391	NA	NA	NA	NA	NA	NA

TABLE 2-1 Third Quarter Nitroaromatic Data for Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-4016-Q391	NA	NA	NA	NA	NA	NA
GW-4017-Q391	NA	NA	NA	NA	NA	NA
GW-4018-Q391	NA	NA	NA	NA	NA	NA
GW-4019-082091	ND	ND	ND	ND	ND	ND
GW-4020-Q391	NA	NA	NA	NA	NA	NA
GW-4021-090591	ND	ND	ND	ND	ND	ND
GW-4022-Q391	NA	NA	NA	NA	NA	NA
GW-4023-Q391	NA	NA	NA	NA	NA	NA
GW-0000-Q391	NA	NA	NA	NA	NA	NA

NA - Not Available
ND - Not Detected

TABLE 2-2 Third Quarter, Semiannual Uranium and Inorganic Anion Data in Groundwater at the WSCP/RP/VP

SAMPLE ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)
GW-2001-Q391	18.8	4.10	ND
GW-2002-Q391	232	97.5	ND
GW-2003-080191	223.0	121	0.60
GW-2004	NA	NA	NA
GW-2005-081491	70.6	21.2	2.00
GW-2006	NA	NA	NA
GW-2007-093091	NA	NA	0.87
GW-2008-071591	2.40	35.6	ND
GW-2009-082291	0.63	762	NA
GW-2010-091691	1.00	36.9	2.02
GW-2011-091991	4.18	11.8	NA
GW-2012-091991	0.40	62.9	NA
GW-2013-093091	NA	NA	ND
GW-2014-073091	1.86	42.6	ND
GW-2015	NA	NA	NA
GW-2017-082291	0.16	114	NA
GW-2018-082091	0.40	9.36	ND
GW-2019-091891	ND	49.5	NA
GW-2020	NA	NA	NA
GW-2021-090391	ND	16.3	NA
GW-2022-081591	ND	14.1	ND
GW-2023	NA	NA	NA
GW-2024-091891	ND	28.1	NA
GW-2025-082691	0.240	14.7	ND
GW-2026-081591	ND	18.0	NA
GW-2027-090391	ND	10.1	NA
GW-2028	NA	NA	ND
GW-2029	NA	NA	NA
GW-2030	NA	NA	NA

TABLE 2-2 Third Quarter, Semiannual Uranium and Inorganic Anion Data in Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)
GW-2031	NA	NA	NA
GW-2032	NA	NA	NA
GW-2033	NA	NA	NA
GW-2034	NA	NA	NA
GW-3001	NA	NA	NA
GW-3002-082691	0.320	17.3	1.14
GW-3003-091191	253	227	20.5
GW-3006-091191	ND	22.0	2.31
GW-3008-091691	667	59.0	4.04
GW-3009-080191	94.5	82.5	0.90
GW-3010	NA	NA	NA
GW-3019-080891	ND	5.20	1.70
GW-3022	NA	NA	NA
GW-3023-091691	290	432	6.63
GW-4001-080691	25.6	63.2	0.30
GW-4002-080591	1.48	17.8	1.20
GW-4003-080591	0.71	32.1	2.30
GW-4004-081991	0.56	20.6	NA
GW-4005-081991	1.51	21.5	NA
GW-4006-080891	4.17	29.8	ND
GW-4007-080691	0.12	16.1	ND
GW-4008-080891	0.21	14.1	ND
GW-4009-081391	0.95	21.9	1.40
GW-4010-070991	ND	25.0	1.36
GW-4011-090991	25.3	53.8	2.88
GW-4012-091091	ND	44.7	3.46
GW-4013-072391	83.1	43.0	NA
GW-4014-072391	2.86	26.5	NA

TABLE 2-2 Third Quarter, Semiannual Uranium and Inorganic Anion Data in Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)
GW-4015	NA	NA	NA
GW-4016	NA	NA	NA
GW-4017	NA	NA	NA
GW-4018-092491	11.0	7.10	0.87
GW-4019-082091	0.18	5.40	0.87
GW-4020	NA	NA	NA
GW-4021-090591	ND	320	NA
GW-4022	NA	NA	NA
GW-4023	NA	NA	NA

ND - Not Detected
NA - Not Available

The highest uranium level detected from the available data was 20.5 pCi/l from a sample obtained from Monitoring Well MW-3003. The concentrations reported in Table 2-2 continue to indicate levels below the proposed drinking water standard for uranium.

2.1.3 Geochemical Results

Geochemical results for samples from quarterly monitored wells at the WSCP/RP/VP are presented in Table 2-3. Geochemical parameters were added to the *Environmental Monitoring Plan* for the 1991 monitoring year.

2.1.4 Inorganic Anion Results

Inorganic anion results for the quarterly monitored WSCP/RP/VP wells are shown in Table 2-2. The results reflect levels historically found in these wells.

2.2 Weldon Spring Quarry

Chemical and radiological wastes at the quarry are of particular concern because of their proximity to the St. Charles County well field. The well field is located approximately 0.8 km (0.5 mile) to the south of the Weldon Spring quarry. Monitoring of contaminants in groundwater and the protection of the well field is a top Weldon Spring Site Remedial Action Project (WSSRAP) priority.

Groundwater is currently being monitored in 48 wells in and around the quarry. Thirty-six monitoring wells installed by the DOE currently exist in or near the quarry. Four monitoring wells were installed by St. Charles County in 1986 and are currently included in the DOE's monitoring program. Eight St. Charles County municipal wells are also included in the DOE's monitoring program. All monitoring well locations are shown in Figures 2-2 and 2-3. These wells draw water from both bedrock and alluvial aquifers.

Two separate groundwater monitoring programs have been developed for the quarry. The first program is a bimonthly sampling of all wells north of the Femme Osage Slough and MW-1010 and MW-1011. The second program is a quarterly sampling of all wells south of the Femme Osage Slough, excluding MW-1010 and MW-1011 but including the St. Charles

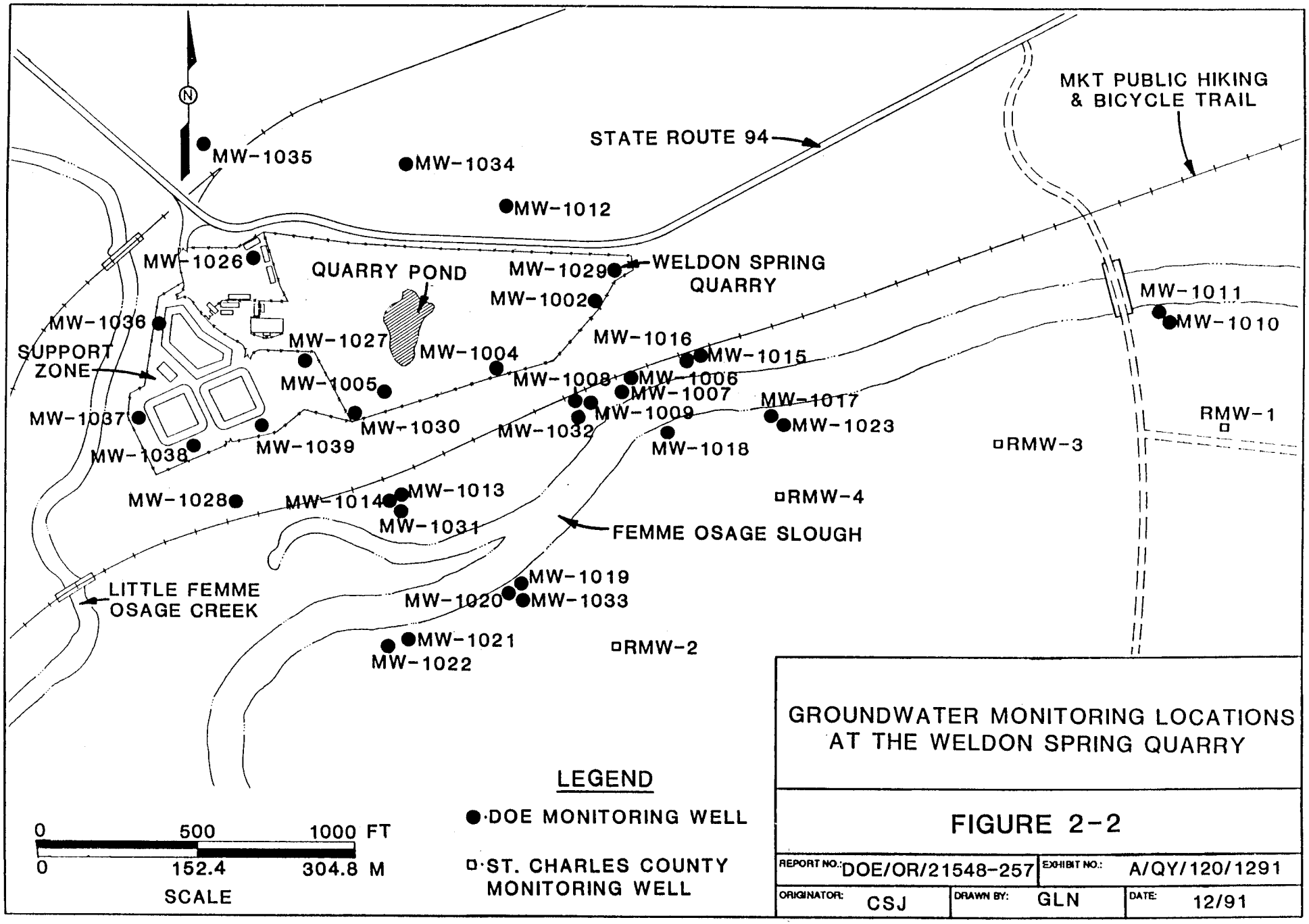
TABLE 2-3 Geochemical Results for Groundwater at the WSCP/RP/VP

SAMPLE ID	ARSENIC (µg/l)	BARIUM (µg/l)	CALCIUM (µg/l)	CHROMIUM (µg/l)	IRON (µg/l)	LITHIUM (µg/l)	MAGNESIUM (µg/l)	MANGANESE (µg/l)	NICKEL (µg/l)
GW-2001-Q391	ND	222	93600	ND	ND	ND	43300	ND	ND
GW-2002-Q391	ND	176	237000	ND	ND	404	91500	ND	146
GW-2003-080191	ND	140	244000	ND	ND	404	83400	ND	ND
GW-3003-091191	ND	109	202000	ND	ND	441	112000	27.9	27.2
GW-3006-091191	ND	110	53100	ND	100	ND	41600	77.5	ND
GW-3008-091691	ND	274	600000	ND	ND	228	156000	ND	97.1
GW-3009-080191	ND	1210	111000	ND	ND	ND	64100	8.40	78.6
GW-3023-091691	ND	179	409000	128	19000	813	92400	372	327
GW-4012-091091	ND	66.2	40100	34.0	ND	ND	29500	ND	ND
GW-4013-	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 2-3 Geochemical Results for Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	POTASSIUM (µg/l)	SODIUM (µg/l)	STRONTIUM (µg/l)	NITRITE (µg/l)	BROMIDE (µg/l)	CHLORIDE (µg/l)	PHOSPHORUS TOTAL (µg/l)	SILICA, DISSOLVED (µg/l)	ALKALINITY (mg/l)
GW-2001-Q391	1250	9050	101	ND	976	5060	700	8710	331
GW-2002-Q391	8590	117000	330	ND	1250	8700	100	12400	280
GW-2003-080191	6870	102000	415	ND	1110	7800	340	10000	321
GW-3003-091191	8580	100000	531	350	510	9200	200	9700	348
GW-3006-091191	ND	14500	197	ND	900	1400	100	10800	386
GW-3008-091691	1910	1960000	2620	ND	990	1590	80	12600	270
GW-3009-080191	2180	22900	225	185	470	3650	150	8480	161
GW-3023-091691	4160	1860000	670	1080	750	15800	10	11800	294
GW-4012-091091	27000	29000	152	ND	800	2600	100	11200	320
GW-4013-	NA	NA	NA	NA	NA	NA	NA	NA	322

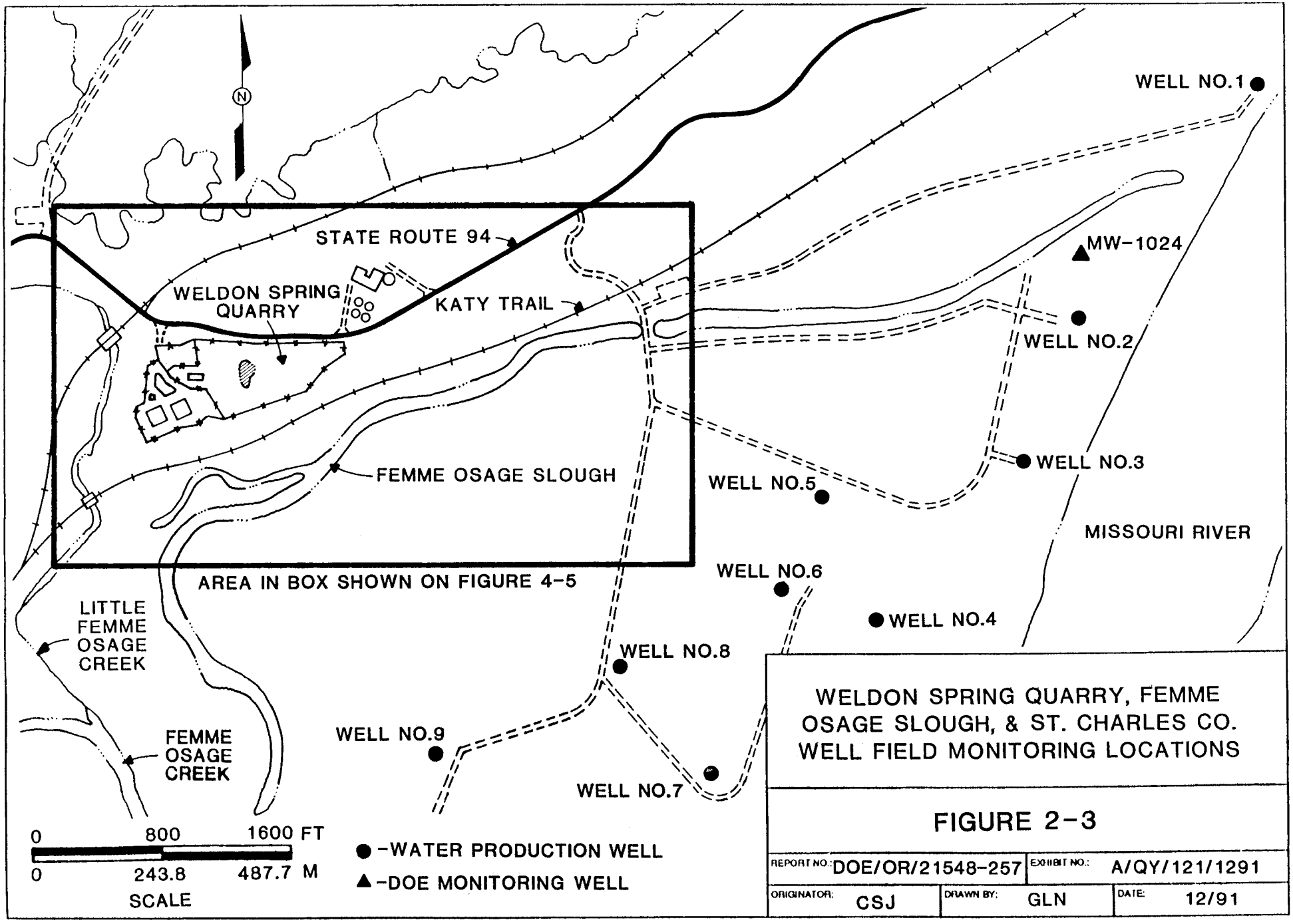
NA -Not Available
ND - Not Detected



GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 2-2

REPORT NO.: DOE/OR/21548-257	EXHIBIT NO.: A/QY/120/1291	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 12/91



WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, & ST. CHARLES CO. WELL FIELD MONITORING LOCATIONS

FIGURE 2-3

REPORT NO.:	DOE/OR/21548-257	EXHIBIT NO.:	A/QY/121/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91

County well field. Both the raw and treated waters from the St. Charles County water treatment plant are also sampled.

2.2.1 Radiological Results

Radiological data are presented in Tables 2-4 and 2-5 for samples collected on a bimonthly and quarterly bases. The results show typical fluctuations near the average levels in the WSQ area with no dramatic increases.

2.2.2 Nitroaromatic Compounds Results

Analytical results for nitroaromatic compounds are presented in Tables 2-6 and 2-7. No monitoring wells south of the Femme Osage Slough showed detectable concentrations of nitroaromatic compounds during the third quarter 1991. The distribution and magnitude of nitroaromatic contamination near the quarry remains unchanged.

2.2.3 Inorganic Anions Results

Two inorganic anions--nitrate and sulfate--were measured in quarry wells. Tables 2-4 and 2-5 display the analytical results for the fourth bimonthly sampling event and the third quarter of 1991, which are consistent with data reported in the previous environmental monitoring reports. The WSQ groundwater samples continue to indicate no significant groundwater contamination by nitrate. The groundwater samples continue to indicate background concentrations of sulfate in wells south of the Femme Osage Slough.

2.2.4 Metals Results

A selected group of quarry wells located south of the Femme Osage Slough were sampled for arsenic and barium. Analytical results for these metals are presented in Tables 2-8 and 2-9. Results from the fourth bimonthly and third quarter analyses of arsenic and barium continue to indicate elevated concentrations in selected wells. The highest levels reported are 146 µg/l for arsenic in MW-1022 and 5,380 µg/l for barium detected in RMW-3.

TABLE 2-4 Fourth Bimonthly (July/Aug) Inorganic Anions and Radiological Results in Groundwater at the Weldon Spring Quarry

SAMPLE ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)
GW-1002-071691	1.93	49.5	NA
GW-1004-072291	0.113	305	4870
GW-1005-071691	ND	201	NA
GW-1006-081291	1.27	418	2870
GW-1007-081291	0.24	12.7	18.7
GW-1008-081291	ND	245	3220
GW-1009-081291	ND	341	9.80
GW-1010-080291	NS	NS	ND
GW-1011-080291	NS	NS	20.5
GW-1012-072991	1.57	49.6	2.30
GW-1013-081391	ND	116	888
GW-1014-081391	ND	88.6	995
GW-1015-081391	5.50	306	1480
GW-1016-081391	2.95	341	660
GW-1026-070991	ND	ND	ND
GW-1027-071591	0.18	129	336
GW-1028-081991	ND	72.3	1.73
GW-1029-072291	ND	89.1	2.90
GW-1030-072291	0.13	58.5	11.0
GW-1031-073091	184	42.6	41.8
GW-1032-073091	ND	274	657
GW-1033-092691	NA	NA	NA
GW-1034-072991	0.27	104	2.30
GW-1035-072991	ND	33.0	ND
GW-1036-073191	ND	81.5	4.60
GW-1037-073191	ND	17.8	1.20
GW-1038-073191	ND	57.0	3.80
GW-1039-073191	ND	21.9	37.8
GW-0000-082291-WB	NS	NS	1.73

ND - Not Detected NA - Not Detected NS - Not Sampled WB - Water Blank

TABLE 2-5 Third Quarter Inorganic Anions and Radiological Results for the Weldon Spring Quarry

SAMPLE ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)	GROSS ALPHA (pCi/l)
GW-1010-Q391	ND	ND	ND	NA
GW-1011-Q391	ND	9.71	9.52	NA
GW-1017-Q391	ND	ND	ND	NA
GW-1018-071891	ND	ND	0.86	NA
GW-1019-071891	ND	ND	ND	NA
GW-1020-071891	ND	ND	ND	NA
GW-1021-081491	ND	3.00	2.90	NA
GW-1022-081491	ND	3.54	1.20	NA
GW-1023-Q391	ND	ND	ND	NA
GW-1024-Q391	ND	6.40	ND	7.90
GW-RMW1-Q391	ND	38.2	1.73	2.60
GW-RMW2-Q391	ND	28.9	5.77	10.2
GW-RMW3-Q391	ND	ND	2.59	ND
GW-RMW4-Q391	0.51	31.3	2.02	0.60
GW-RAWW-Q391	ND	71.5	ND	1.82
GW-FINW-Q391	ND	78.0	ND	0.48
GW-PW02	NS	NS	0.90	3.10
GW-PW03	NS	NS	0.60	4.50
GW-PW04	NS	NS	ND	3.00
GW-PW05	NS	NS	ND	4.60
GW-PW06	NS	NS	ND	1.30
GW-PW07	NS	NS	ND	1.80
GW-PW08	NS	NS	ND	2.90
GW-PW09-Q391	ND	36.6	0.58	ND
GW-RMWX-Q391	ND	28.6	NA	NA

ND - Not Detected
NA - Not Available
NS - Not Sampled
X - Laboratory Blind Duplicate

TABLE 2-6 Fourth Bimonthly (July/Aug) Nitroaromatic Data for Groundwater at the Weldon Spring Quarry

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1002-071691	ND	0.19	0.031	19.0	54.0	280
GW-1004-072291	ND	ND	4.00	6.00	13.0	7.20
GW-1005-071691	ND	ND	0.14	0.061	ND	ND
GW-1006-081291	ND	ND	0.21	6.10	32.0	220
GW-1007-081291	ND	ND	ND	ND	ND	ND
GW-1008-081291	ND	ND	ND	0.037	ND	ND
GW-1009-081291	ND	ND	ND	ND	ND	ND
GW-1010-Q391	ND	ND	ND	ND	ND	ND
GW-1011-Q391	ND	ND	ND	ND	ND	ND
GW-1012-072991	ND	ND	ND	ND	ND	ND
GW-1013-081391	ND	0.13	ND	0.040	ND	ND
GW-1014-081391	ND	ND	0.037	0.013	ND	ND
GW-1015-081391	ND	ND	0.065	1.00	34.0	300
GW-1016-081391	ND	ND	ND	0.30	9.50	75.0
GW-1026-070991	ND	ND	ND	ND	ND	ND
GW-1027-071591	ND	ND	0.10	3.60	68.0	0.12
GW-1028-081991	ND	ND	ND	ND	ND	ND
GW-1029-072291	ND	ND	ND	ND	ND	ND
GW-1030-072291	ND	ND	0.056	ND	ND	ND
GW-1031-073091	ND	ND	ND	ND	ND	ND
GW-1032-073091	ND	ND	0.040	0.36	0.12	ND
GW-1033-Q391	NA	NA	NA	NA	NA	NA
GW-1034-072991	ND	ND	ND	ND	ND	ND
GW-1035-072991	ND	ND	ND	ND	ND	ND
GW-1035-082191	ND	ND	ND	ND	ND	ND
GW-1036-073191	ND	ND	ND	ND	ND	ND
GW-1036-082191	ND	ND	ND	ND	ND	ND
GW-1037-073191	ND	ND	ND	ND	ND	ND
GW-1037-082191	ND	ND	ND	ND	ND	ND
GW-1038-073191	ND	ND	ND	ND	ND	ND

TABLE 2-6 Fourth Bimonthly (July/Aug) Nitroaromatic Data for Groundwater at the Weldon Spring Quarry (Continued)

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1038-082091	ND	ND	ND	ND	ND	ND
GW-1039-073191	ND	ND	ND	ND	ND	ND
GW-1039-082091	ND	ND	ND	ND	ND	ND

ND - Not Detected
NA - Not Available

TABLE 2-7 Third Quarter Nitroaromatic Data for Groundwater at the Weldon Spring Quarry

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1010-Q391	ND	ND	ND	ND	ND	ND
GW-1011-Q391	ND	ND	ND	ND	ND	ND
GW-1017-Q391	ND	ND	ND	ND	ND	ND
GW-1018-071891	ND	ND	ND	ND	ND	ND
GW-1019-071891	ND	ND	ND	ND	ND	ND
GW-1020-071891	ND	ND	ND	ND	ND	ND
GW-1021-081491	ND	ND	ND	ND	ND	ND
GW-1022-081491	ND	ND	ND	ND	ND	ND
GW-1023-Q391	ND	ND	ND	ND	ND	ND
GW-1024-071591	ND	ND	ND	ND	ND	ND
GW-RMW1-Q391	ND	ND	ND	ND	ND	ND
GW-RMW2-Q391	ND	ND	ND	ND	ND	ND
GW-RMW3-Q391	ND	ND	ND	ND	ND	ND
GW-RMW4-Q391	ND	ND	ND	ND	ND	ND
GW-RMWX-Q391	ND	ND	ND	ND	ND	ND
GW-RAWW-Q391	ND	ND	ND	ND	ND	ND
GW-FI NW-Q391	ND	ND	ND	ND	ND	ND
GW-PW02-Q391	ND	ND	ND	ND	ND	ND
GW-PW03-Q391	ND	ND	ND	ND	ND	ND
GW-PW04-Q391	ND	ND	ND	ND	ND	ND
GW-PW05-Q391	ND	ND	ND	ND	ND	ND
GW-PW06-Q391	ND	ND	ND	ND	ND	ND
GW-PW07-Q391	NA	NA	NA	NA	NA	NA
GW-PW08-Q391	NA	NA	NA	NA	NA	NA
GW-PW09-Q391	ND	ND	ND	ND	ND	ND

ND - Not Detected
NA - Not Available

TABLE 2-8 Fourth Bimonthly (July/Aug) Results for Metals in Groundwater at the Weldon Spring Quarry

SAMPLE ID	ARSENIC (µg/l)	BARIUM (µg/l)
GW-1002-071691	ND	116
GW-1004-072291	ND	32.4
GW-1005-071691	ND	50.0
GW-1006-081291	ND	31.4
GW-1007-081291	30.4	374
GW-1008-081291	ND	43.9
GW-1009-081291	5.88	311
GW-1012-072991	ND	125
GW-1013-081391	2.63	126
GW-1014-081391	ND	128
GW-1015-081391	ND	118
GW-1016-081391	ND	122
GW-1026-070991	25.8	357
GW-1027-071591	ND	86.7
GW-1028-081991	ND	283
GW-1029-072291	ND	96.6
GW-1030-072291	6.20	266
GW-1031-073091	ND	111
GW-1032-073091	ND	138
GW-1033	NA	NA
GW-1034-072991	ND	161
GW-1035-082191	ND	277
GW-1036-082191	ND	252
GW-1037-082191	ND	573
GW-1038-082091	ND	215
GW-1039-082091	ND	417

ND - Not Detected
NA - Not Available

TABLE 2-9 Third Quarter Results for Metals in Groundwater at the Weldon Spring Quarry

SAMPLE ID	ARSENIC (µg/l)	BARIUM (µg/l)
GW-1010-Q391	98.7	317
GW-1011-Q391	4.39	178
GW-1017-Q391	144	835
GW-1018-071891	110	533
GW-1019-071891	80.9	794
GW-1020-071891	21.5	357
GW-1021-081491	90.2	680
GW-1022-081491	146	429
GW-1023-Q391	67.0	275
GW-1024-Q391	5.87	412
GW-RMW1-Q391	4.06	516
GW-RMW2-Q391	6.82	218
GW-RMW3-Q391	10.3	5380
GW-RMW4-Q391	ND	166
GW-RAWW-Q391	ND	320
GW-FINW-Q391	ND	82.3
GW-PW02-Q391	ND	241
GW-PW03-Q391	ND	240
GW-PW04-Q391	ND	221
GW-PW05-Q391	ND	310
GW-PW06-Q391	ND	303
GW-PW07-Q391	ND	437
GW-PW08-Q391	4.35	423
GW-PW09-Q391	3.62	403

ND - Not Detected

3 SURFACE WATER MONITORING

Routine samples were collected during the third quarter of 1991 from both on-site and off-site surface water and spring locations. All surface water samples were analyzed without filtering, unless a specific comparison of dissolved versus total contaminant concentrations was desired. Some analytical results are not available at this time; however, they will be presented in the 1991 Annual Site Environmental Report (ASER).

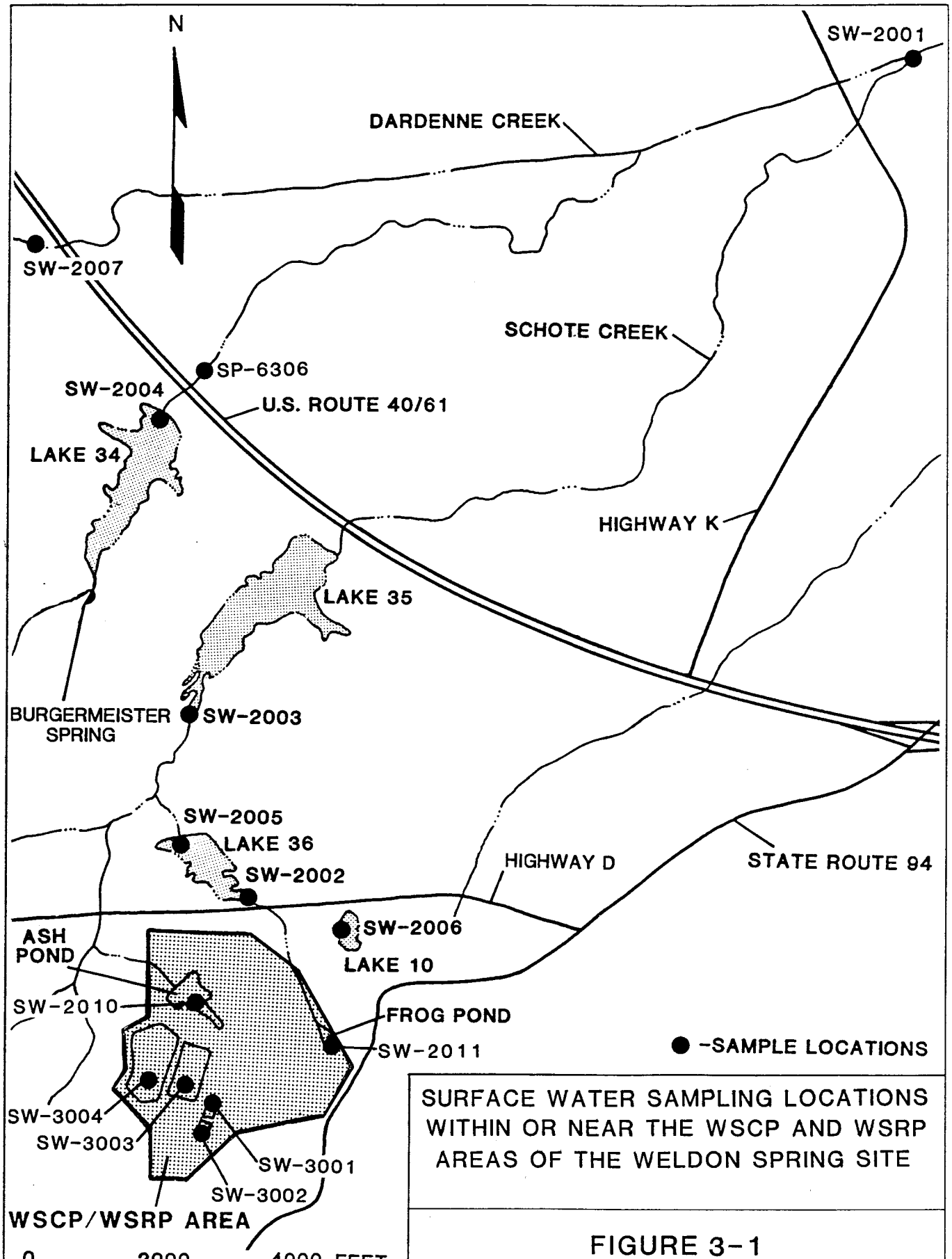
3.1 Chemical Plant/Raffinate Pits/Vicinity Properties

During the third quarter, surface water samples were collected from the 13 surface water sampling locations shown in Figure 3-1 and analyzed for uranium. The results, presented in Table 3-1, indicate that conditions remain similar to values measured historically.

3.2 Weldon Spring Quarry

Surface water samples were collected from the 10 locations shown in Figure 3-2 and three locations in Figure 3-3. Samples were analyzed for uranium, and the results are presented in Table 3-2. The results of all samples indicate no apparent changes in environmental conditions. The highest measured level was 667 pCi/l detected at sampling location SW-1008, the quarry sump.

The third quarter uranium values measured in the Missouri River that are available are nearly the same as were detected during the previous quarter. Historically, the levels of uranium at these locations have fluctuated (due to either natural fluctuations or analytical variability) such that uranium concentrations have been higher at upstream locations than downstream, and vice versa. The U.S. Department of Energy (DOE) has increased monitoring of the Missouri River prior to the operation of the Weldon Spring Site Remedial Action Project (WSSRAP) quarry water treatment plant to ascertain the preoperational (background) levels in the river. In addition, the National Pollution Discharge Elimination System (NPDES) permit for the quarry water treatment plant requires additional monitoring of the river. This monitoring increases the DOEs capability to ensure the safety of the public and the environment.



SURFACE WATER SAMPLING LOCATIONS WITHIN OR NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

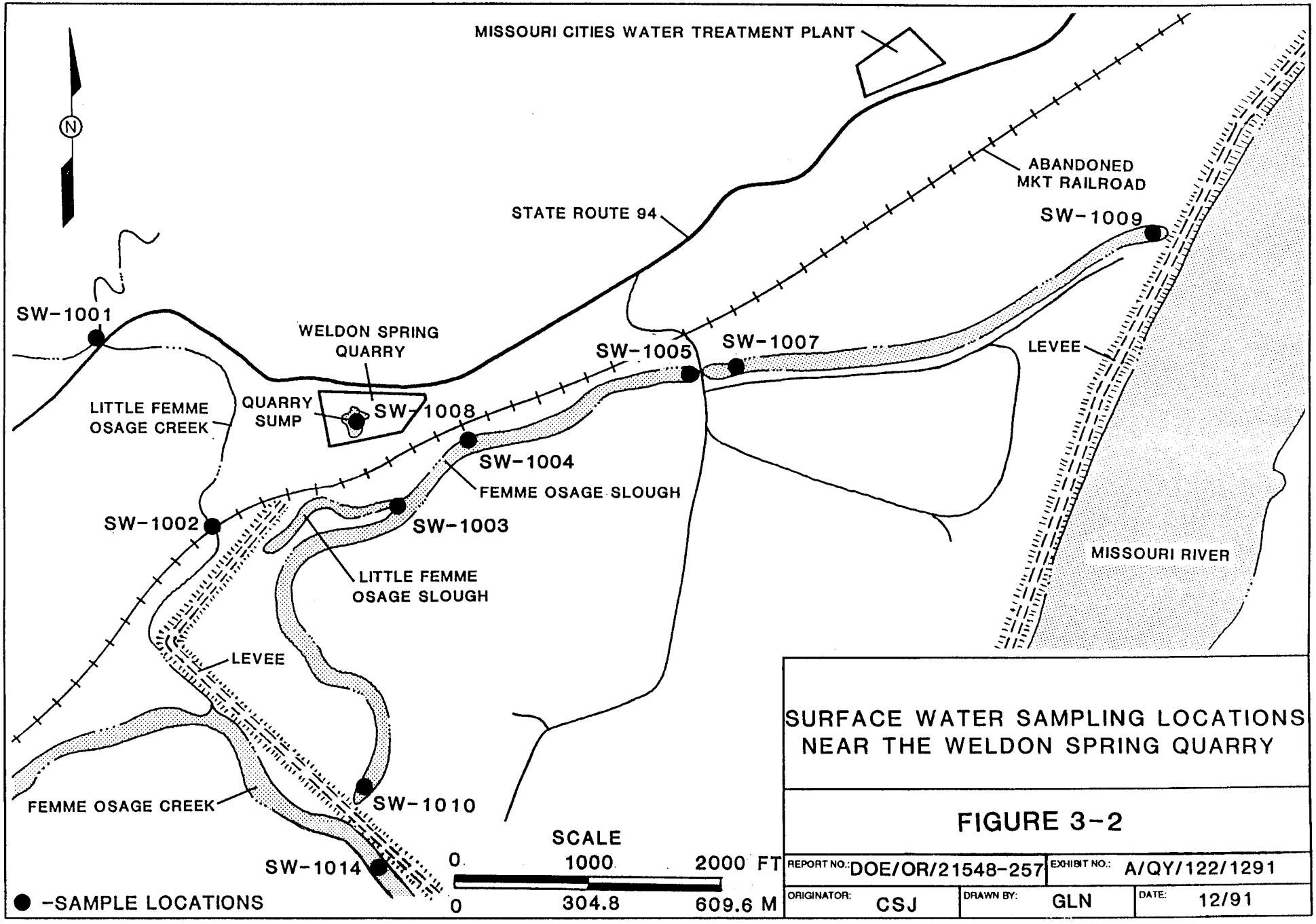
FIGURE 3-1

REPORT NO.: DOE/OR/21548-257	DRAWING NO.: A/VP/192/1291	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 12/91

TABLE 3-1 Third Quarter Uranium Results in Surface Water at the WSCP/RP/VP

SAMPLE ID	URANIUM, TOTAL (pCi/l)
SW-2001-Q391	ND
SW-2002-Q391	NA
SW-2003-Q391	2.72
SW-2004-Q391	6.12
SW-2005-Q391	4.76
SW-2007-Q391	ND
SW-2010-Q391	363
SW-2011-Q391	171
SW-2111-Q391	167
SW-3001-Q391	82.2
SW-3002-Q391	359
SW-3003-Q391	1590
SW-3004-Q391	213

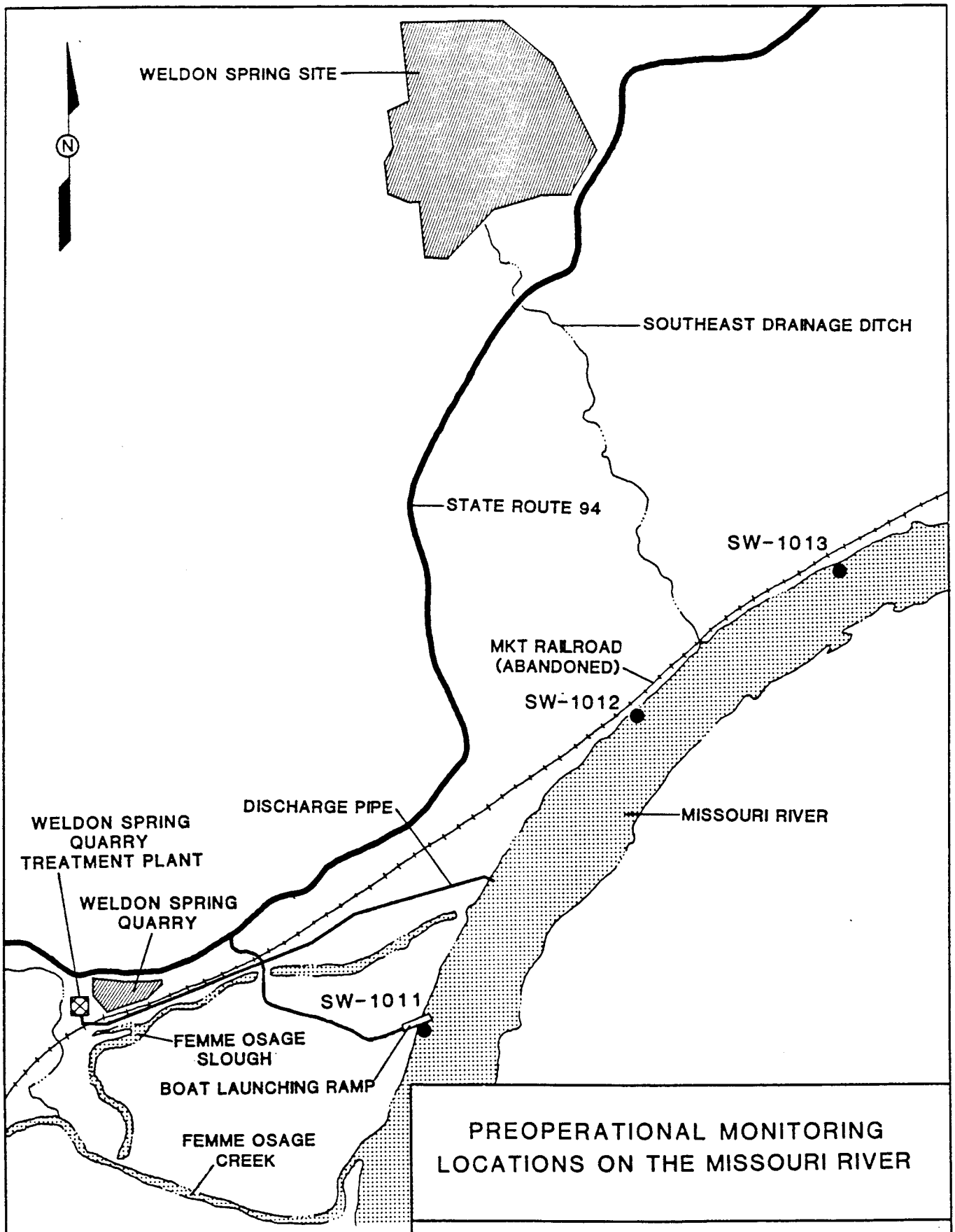
ND - Not Detected
NA - Not Available



SURFACE WATER SAMPLING LOCATIONS
NEAR THE WELDON SPRING QUARRY

FIGURE 3-2

REPORT NO.:	DOE/OR/21548-257	EXHIBIT NO.:	A/QY/122/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91



PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

FIGURE 3-3

REPORT NO.:	DOE/OR/21548-257	EXHIBIT NO.:	A/VP/193/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91

TABLE 3-2 Third Quarter Uranium Results in Surface Water at the Weldon Spring Quarry

SAMPLE ID	URANIUM, TOTAL (pCi/l)
SW-1001-Q391	6.00
SW-1002-Q391	3.00
SW-1003-Q391	46.0
SW-1004-Q391	71.0
SW-1005-Q391	31.0
SW-1007-Q391	14.0
SW-1008-Q391	667
SW-1009-Q391	10.0
SW-1010-Q391	61.0
SW-1011-Q391	4.00
SW-1012	NA
SW-1013	NA
'SW-1014-Q391	1.00
SW-1105-Q391	35.0
SW-1114-Q391	3.00

NA - Not Available

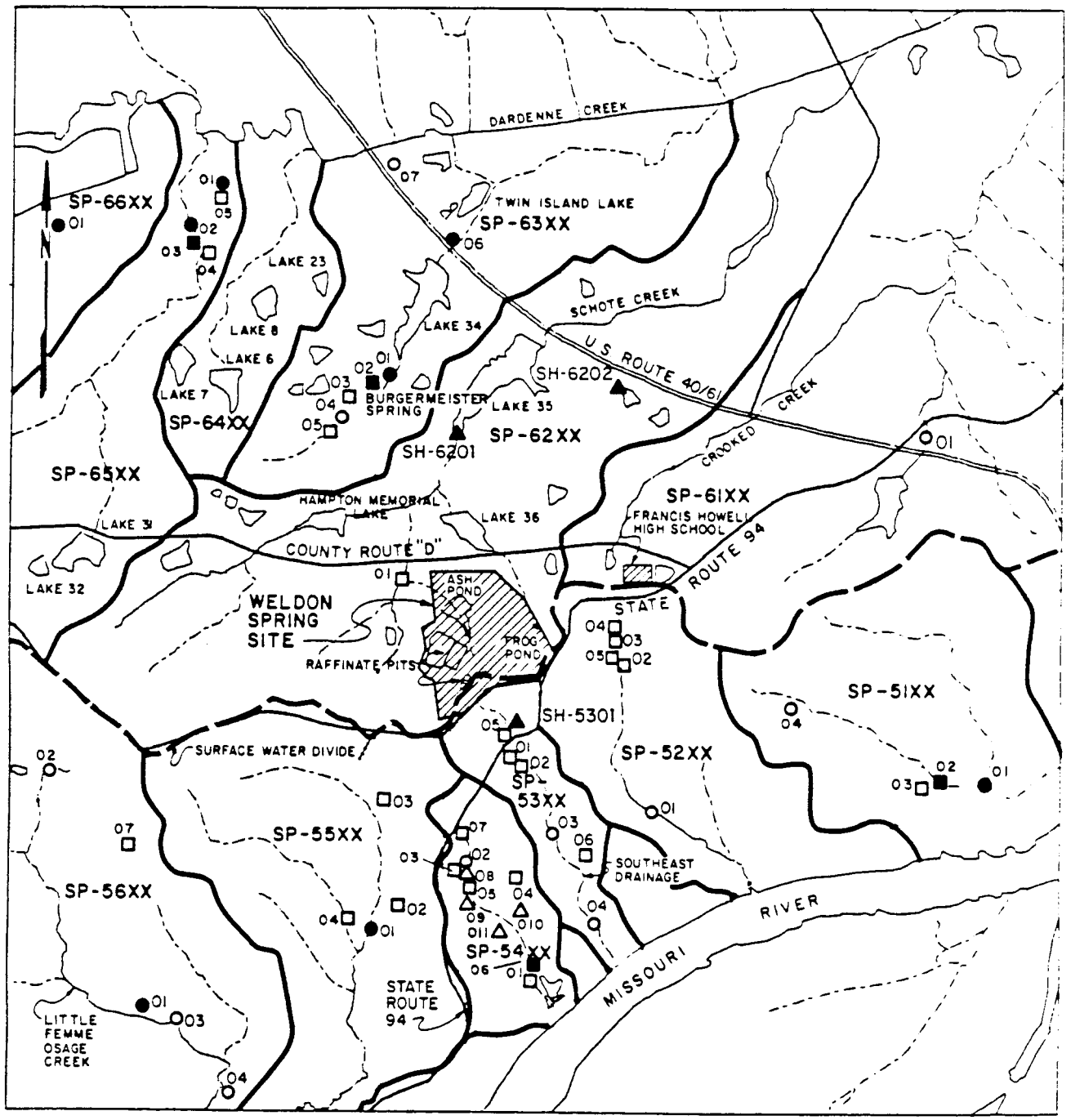
The analytical results for the six nitroaromatic compounds within the quarry sump were not available at the time of this report. The ponded water is to be treated for nitroaromatic compounds and other organics upon completion of the quarry water treatment plant.

3.3 Springs

Eleven springs around the Weldon Spring site (WSS) are sampled quarterly (see Figure 3-4 for spring locations). Previous spring monitoring indicated that waters from six perennial springs and one wet-weather spring are measurably influenced by site-related contaminants. These springs include SP-6301, SP-6302, SP-6306, and SP-5301 through SP-5304. All spring samples are analyzed for uranium with a select few analyzed for nitroaromatics, inorganics and metals. Available analytical results for these parameters are listed in Tables 3-3 and 3-4. Values for these parameters remain consistent with their historical values.

3.4 National Pollutant Discharge Elimination System Data Review

Surface water and effluent samples were collected and analyzed in compliance with the Weldon Spring site NPDES permits. Permit No. MO-0107701 was issued on October 1, 1990, and currently addresses the five storm water and two wastewater discharges shown in Figure 3-5. Outfalls NP-0001 through NP-0005 represent storm water discharges; Outfall NP–0006 represents the treated effluent discharge associated with the administration building sanitary wastewater treatment plant, and Outfall NP-0007 represents the contaminated site water treatment plant which is under contract but not yet constructed. Outfalls NP-0006 and NP-0007 have effluent limitations. The five storm water outfalls have monitoring requirements only. Third quarter 1991 analytical data for each outfall is presented in Table 3-5. Permit No. MO-0108987 was issued on May 5, 1989, for Outfall NP-1001 of the Weldon Spring Quarry contaminated water treatment plant. The plant is not completely constructed and no discharge took place during the third quarter of 1991.



SOURCE: MDNR, 1989

LEGEND:

- SURFACE WATER DIVIDE BETWEEN MISSISSIPPI RIVER AND MISSOURI RIVER
- DRAINAGE BOUNDARY
- CREEK OR SURFACE DRAINAGE
- POND OR LAKE
- ● PERENNIAL SPRING WITH LARGE MAXIMUM FLOW
- ○ PERENNIAL SPRING WITH SMALL MAXIMUM FLOW
- ■ WET WEATHER SPRING WITH LARGE MAXIMUM FLOW
- □ WET WEATHER SPRING WITH SMALL MAXIMUM FLOW
- ▲ SHALLOW HOLE (SH)
- △ SEEP
- SP-63XX SPRING OR SEEP IN DESIGNATED DRAINAGE AREA NUMBER 63. XX REPRESENTS THE DESIGNATED SPRING NUMBER IN DRAINAGE 63.

SCALE 0 3200 6400 FT
0 975.4 1950.7 M

SPRINGS AND SEEPS IN THE VICINITY OF THE WSS

FIGURE 3-4

REPORT NO.: DOE/OR/21548-257	EXHIBIT NO.: A/VP/194/1291	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 12/91

TABLE 3-3 Third Quarter Uranium Results in Springs Near the Weldon Spring Site

SAMPLE ID	TOTAL URANIUM (pCi/l)
SP-5201	ND
SP-5203	NA
SP-5301	314
SP-5302	365
SP-5302-Q391-DU	4010
SP-5303	300
SP-5304	172
SP-5503	0.58
SP-5601	ND
SP-6301	66.6
SP-6302	NA
SP-6303	2.31
SP-6303-Q391-DU	43.5
SP-6306	1.44

NA - Not Available
ND - Not Detected
DU - Duplicate Sample

TABLE 3-4 Third Quarter Nitroaromatic Results in Springs Near the Weldon Spring Site

SAMPLE ID	1,3,5-TRINITROBENZENE	1,3-DINITROBENZENE	2,4,6-TNT	2,4-DNT	2,6-DNT	NITROBENZENE
SP-6301-Q391	0.09	ND	0.29	0.04	0.46	ND
SP-6302	NA	NA	NA	NA	NA	NA
SP-6303-Q391	0.30	ND	0.51	0.09	0.86	ND
SP-6306-Q391	ND	ND	ND	ND	ND	ND
SP-6306-Q391-DU	0.86	ND	ND	ND	0.97	ND

ND - Not Detected
NA - Not Available

3.4.1 Radiological Analysis

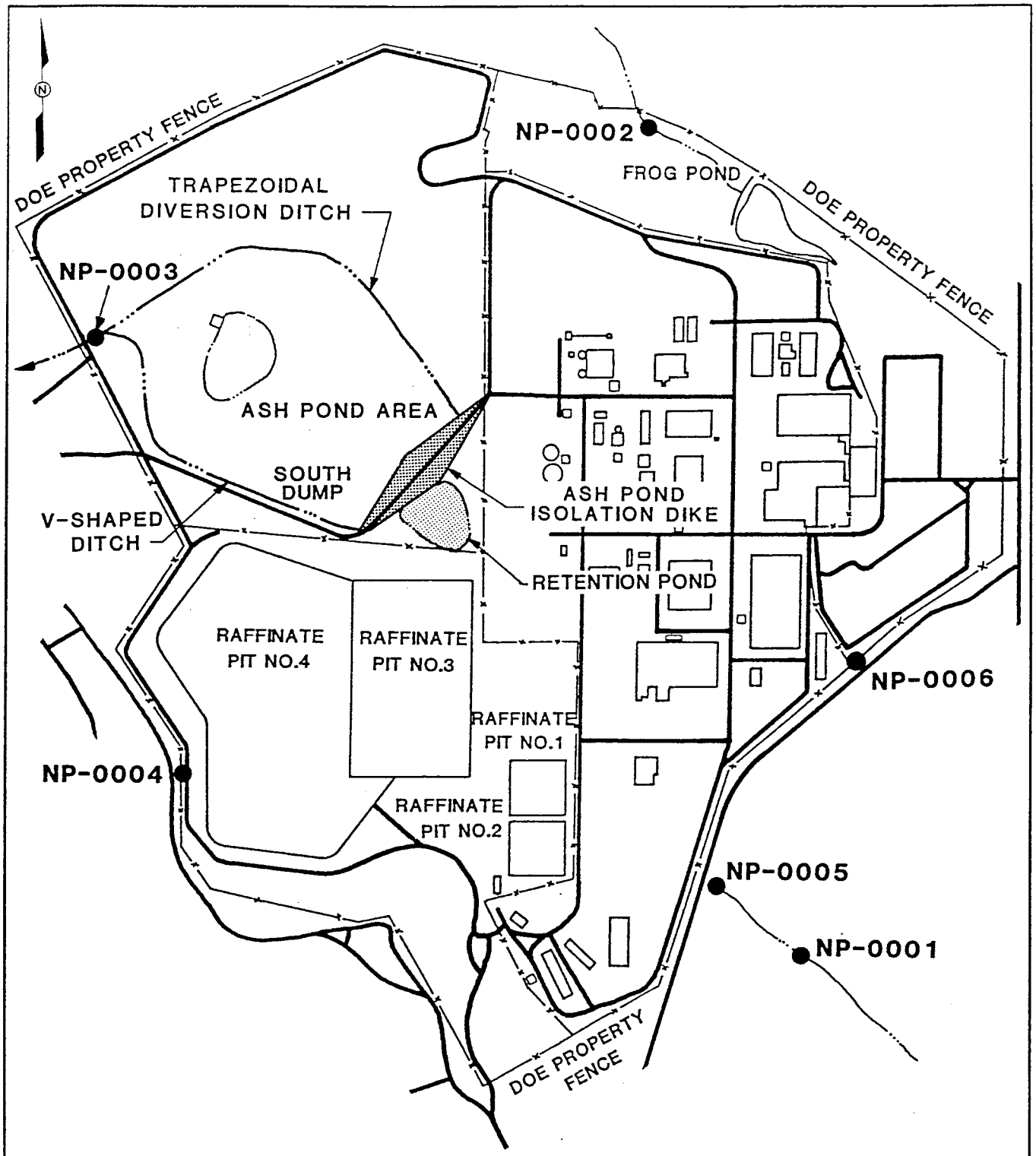
Gross alpha and total uranium analyses corresponded reasonably well with past data. The highest uranium levels were present in surface flow from Outfalls NP-0001, NP-0003, and NP-0005. The peaks for these points were 198, 253.6, and 282.7 pCi/l, respectively.

Other outfalls exhibited the following peaks of uranium concentrations. Outfall NP-0002 had a peak of 96.3 pCi/l and Outfall NP-0004 had a peak of 4.5 pCi/l. Although not required by the NPDES permit, the outfall from the administration building sanitary wastewater treatment plant (Outfall NP-0006) was also monitored for total uranium. No uranium was detected at this outfall.

3.4.2 Other Analysis

Other analyses for NP-0001 through NP-0005 included physical analysis (settleable solids and total suspended solids) and chemical analysis (nitrate, pH, and lithium). Third quarter 1991 values generally correspond to past values for the majority of parameters. Two exceptions were high total suspended solids (TSS) values for Outfalls NP-0005 and NP-0001. The TSS was higher than usual due to off-site construction activity and a 2.24 in. rainfall that ended two hours before sample collection. Settleable solids were not analyzed for Outfall NP-0004 since the sample was collected from a pooled area that was algae laden and the algae would have prevented proper settling.

The discharge from the administration building treatment plant, Outfall No. NP-0006, has effluent limitations and a requirement to monitor once per quarter. Flow must be measured once a month. The subcontractor monitors the effluent once a month to assess plant performance, thus generating two additional sample analyses a quarter. The NPDES permit specifies effluent limitations for biochemical oxygen demand (BOD), TSS, pH, and fecal coliform at this outfall. The limits for BOD are 10 mg/l monthly average and 15 mg/l weekly average; for TSS, 15 mg/l monthly average and 20 mg/l weekly average; for fecal coliform, 200 colonies per 100 ml monthly average and 1,000 colonies per 100 ml daily maximum. The pH is limited to the range of 6.0 to 9.0. NPDES permit limits were not exceeded in the third quarter of 1991 at this outfall.



NPDES MONITORING LOCATIONS

FIGURE 3-5

SCALE 0 500 1000 FT
0 152.4 304.8 M

REPORT NO.: DOE/OR/21548-257	EXHIBIT NO.: A/CP/276/1291	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 12/91

TABLE 3-5 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006

Outfall NP-0001 NPDES data for Q3 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Jul. 2	1,660,920	538	0.5	32.4	6.85	ND	133	0.291	198

Outfall NP-0002 NPDES data for Q3 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Jul. 2	809,280	283	0.2	19.3	6.84	ND	31.8	0.059	49.0
Aug.	No Discharge								
Sep. 4	101,888	ND	<0.1	ND	6.87	ND	40.1	0.142	96.3

Outfall NP-003 NPDES data for Q3 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Jul. 2	422,352	38	<0.1	0.01	6.73	ND	13.3	0.02	14.0
Aug.	No discharge								
Sep. 4	140,843	ND	<0.1	0.410	6.75	ND	94.80	0.374	253.6

* Indicates value which exceeded effluent limitation
** Indicates flow rate at time of sample collection

TABLE 3-5 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006 (Continued)

Outfall NP-0004 NPDES data for Q3 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Aug. 27	ND	15	---	1.81	6.92	ND	43.2	0.0067	4.5

Outfall NP-0005 NPDES data for Q3 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Jul. 2	108,288	212	0.7	33.9	6.64	ND	48.7	0.071	48.0
Aug.	No discharge								
Sep. 1	1,440	ND	<0.1	5.07	6.45	ND	134	0.417	282.7

* Indicates value which exceeded effluent limitation

Outfall NP-0006 NPDES data for Q3 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	BOD	FECAL COLIFORMS	pH
UNITS	GPD**	mg/l	mg/l	No./100 ml	pH units
Jul. 17	1,890	6.0	<3.0	<1	6.4
Aug. 8	2,115	10.0	<6.0	<1	6.5
Sep. 11	2,178	1.0	<3.0	<1	6.2

** Indicates flow rate at time of sample collection

A characterization sample was collected from Outfall NP-0006 on August 27. The sample was analyzed for the following parameters and the results are shown in parentheses: lithium (ND), nitrate (15.7 mg/l), uranium-natural (ND), TSS (7.0 mg/l), gross alpha (ND).

4 AIR MONITORING

4.1 Radon Gas

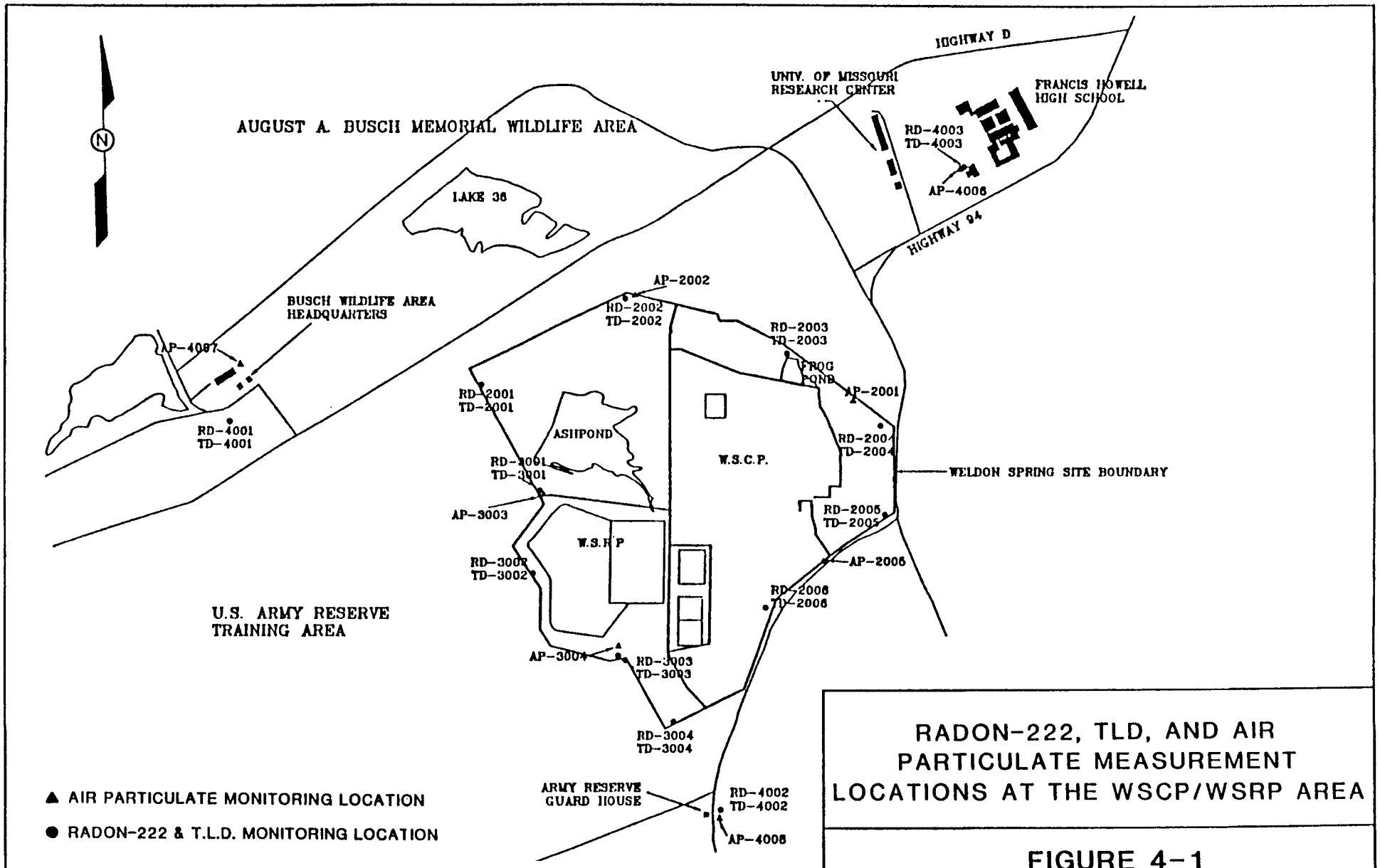
The radon gas monitoring program utilizes a pair of radon detectors at each of 22 permanent locations; each detector is exchanged quarterly. These detectors are deployed at six locations at the Weldon Spring Chemical Plant, six locations at the Weldon Spring Quarry, four locations at the Weldon Spring raffinate pits, and six off-site locations. Radon monitoring locations are shown in Figures 4-1, 4-2, and 4-3. On-site detectors are distributed around the perimeter fences to ensure adequate detection of radon dispersing from the properties under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005, and RD-4006 were used to monitor background levels near the site.

Table 4-1 summarizes the third quarter 1991 radon concentrations detected at all site perimeter and off-site monitoring locations. Also contained in Table 4-1 is a comparison of the measured concentration with the Federally permitted radon concentration (for unrestricted areas) of 3 pCi/l (110 Bq/m^3) above background as authorized by U.S. Department of Energy (DOE) Order 5400.5.

An average ambient background concentration was determined by calculating the arithmetic average for the four background locations. This data yielded an average ambient background radon concentration of 0.6 pCi/l for the third quarter of 1991. This concentration was then subtracted from the concentration for each monitoring station, and compared to the DOE guideline of 3 pCi/l above background.

Radon concentrations at the site and quarry perimeters and at off-site locations for the third quarter of 1991 were within the typical range expected during periods of below normal precipitation as was the condition for this period. The quarterly radon concentrations (background included) ranged from 0.5 pCi/l at RD-4001 to 2.0 pCi/l at monitoring location RD-1001 and RD-1002.

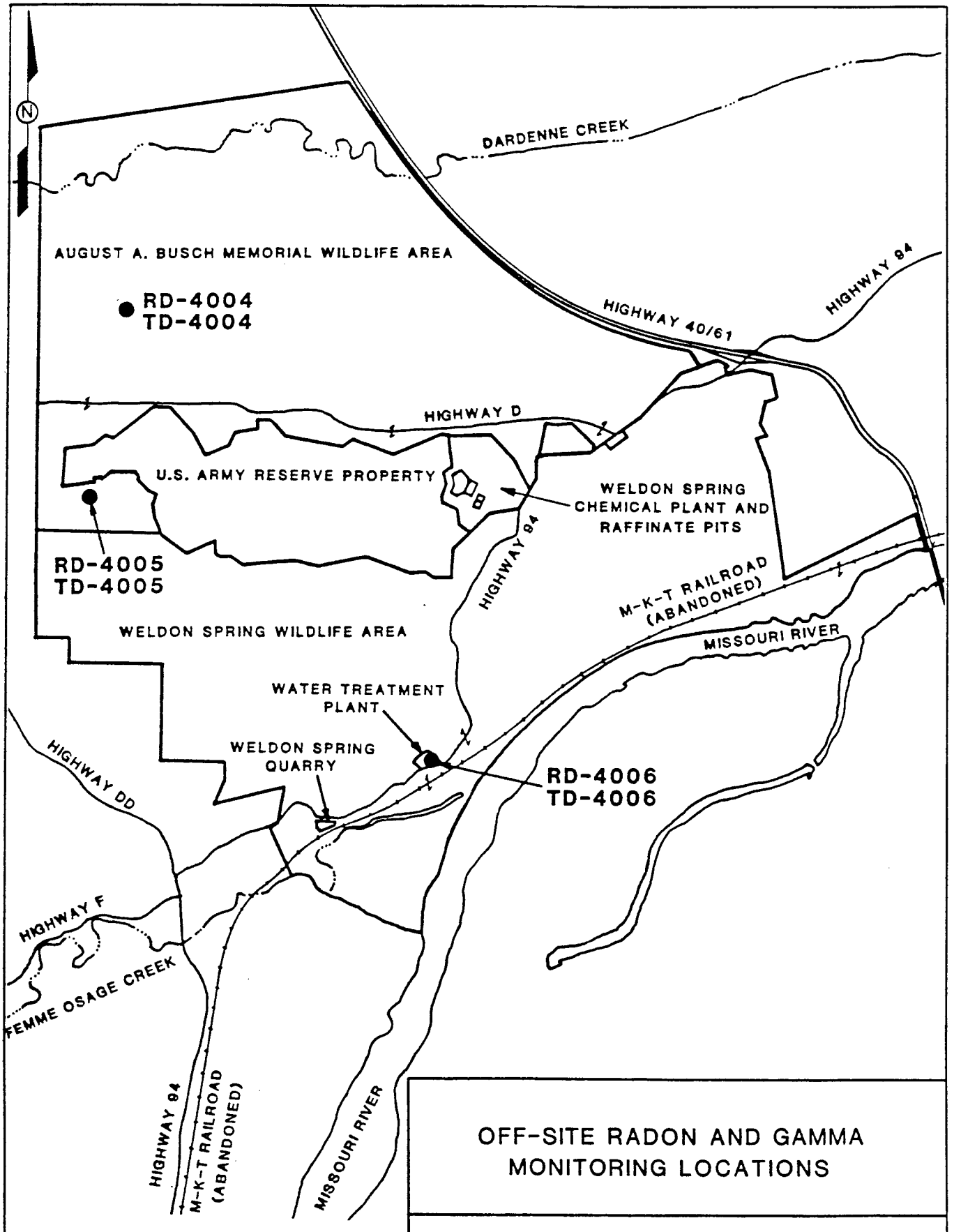
Radon concentrations found in the quarry are higher than concentrations measured at other locations because the radium concentrations in quarry wastes are typically much higher than other areas, and because the quarry is a large depression with side walls ranging from 3 m to 15 m (10 ft to 50 ft) high. In conjunction with stable meteorological conditions,



RADON-222, TLD, AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 4-1

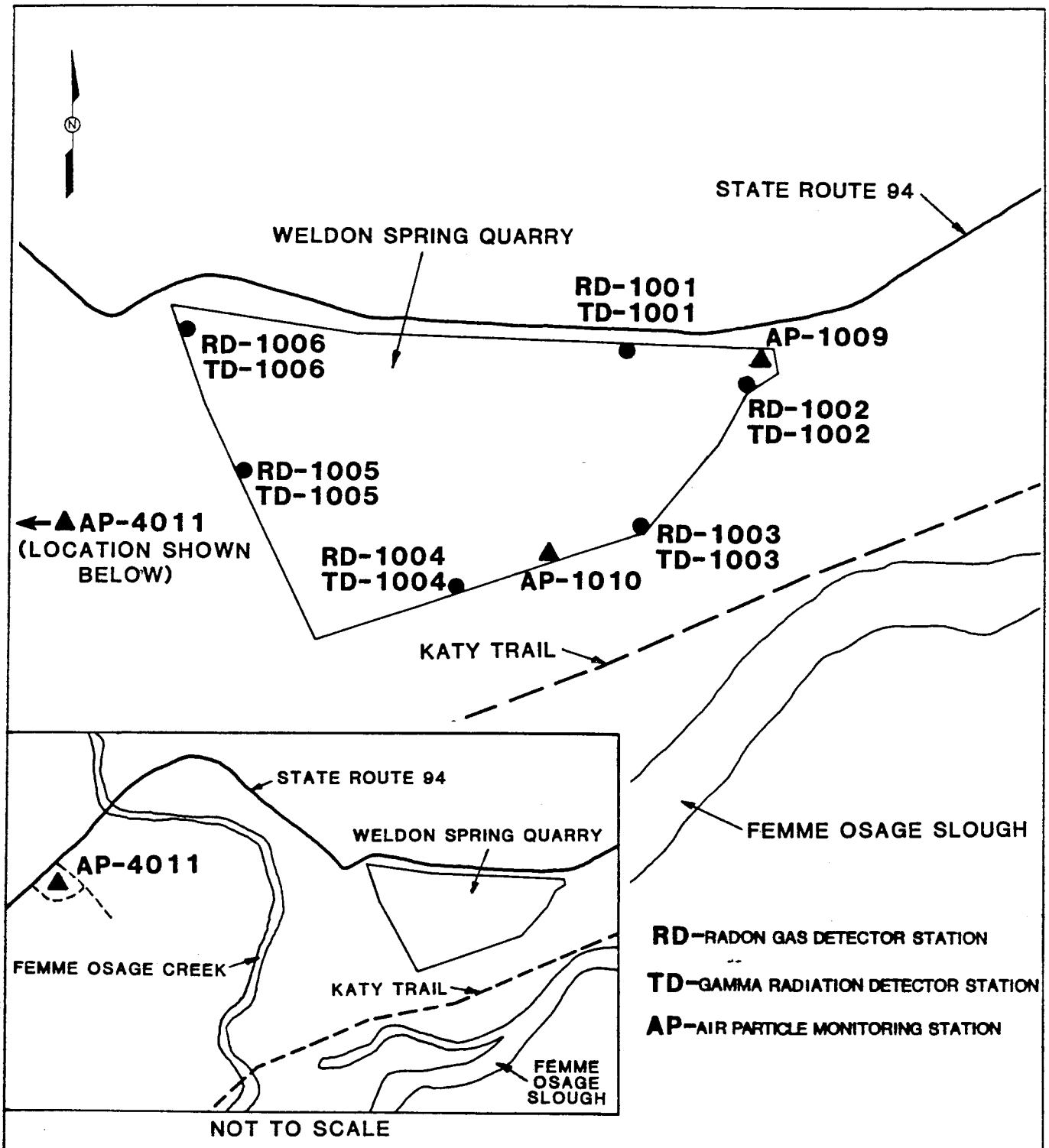
REPORT NO: DOE/OR/21548-257		EXHIBIT NO.:	A/VP/195/1291
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE:	12/91



OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

FIGURE 4-2

REPORT NO.:	DOE/OR/21548-257	EXHIBIT NO.:	A/VP/196/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91



RADON-222, THERMO LUMINESCENT DOSIMETER (TLD) AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 4-3

REPORT NO. DOE/OR/21548-257	EXHIBIT NO. A/QY/123/1291	
ORIGINATOR CSJ	DRAWN BY GLN	DATE 12/91

TABLE 4-1 1991 Track Etch Radon Results[a]

LOCATION ID	3RD QUARTER pCi/l	PERCENT OF GUIDANCE [b]
WSQ		
RD-1001	1.9	43
RD-1002	2.0	47
RD-1003	0.8	7
RD-1004	0.9	10
RD-1005	0.8	7
RD-1006	0.7	3
WSCP		
RD-2001	0.5	0
RD-2002	0.7	3
RD-2003	0.5	0
RD-2004	0.4	0
RD-2005	0.5	0
RD-2006	0.7	3
WSRP		
RD-3001	0.8	7
RD-3002	0.8	7
RD-3003	0.5	0
RD-3004	0.5	0
OFF-SITE		
RD-4001*	0.5	0
RD-4002	0.6	0
RD-4003	0.6	0
RD-4004*	0.6	0
RD-4005*	0.6	0
RD-4006*	0.7	3

(a) Results include natural background.
(b) Percent of guideline calculated by taking the quarterly average minus the average of the background stations divided by the DOE concentration guideline for RN-222 which is 3 pCi/l (100 Bq/m^3)(Annual average above background) for uncontrolled areas.
* Denotes Background Station

this configuration tends to trap emanating radon within the quarry and raise the concentrations along the quarry perimeter.

4.2 Gamma Radiation Exposure

To monitor exposure from gamma radiation, spherical environmental thermoluminescent dosimeters (TLDs) were deployed at 22 locations. The gamma monitoring station locations are the same as the ambient radon monitoring locations (see Section 4.1).

Table 4-2 summarizes the first, second, and third quarter results of total gamma radiation monitoring at the 16 Weldon Spring site (WSS) perimeter monitoring stations, the Francis Howell High School, the Weldon Spring Army Reserve Training Area, and at the four background monitoring stations.

The annual average background gamma exposures measured with TLDs in 1989 and 1990 were 68 mR/year and 62 mR/year, respectively. The gamma exposures measured with TLDs in the first, second, and third quarter of 1991 were consistent with 1989 and 1990 data. This was expected because no significant changes in the configuration or location of the wastes have occurred.

4.3 Radioactive Air Particulates

Eleven low volume air particulate samplers monitor the Weldon Spring site continuously. Five of these (AP-2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the Weldon Spring Chemical Plant (WSCP) perimeter and two are located around the quarry perimeter as shown in Figure 4-3. Three monitoring stations (AP-4006, AP-4008, and AP-4011) are located off site at sensitive receptor locations; including Francis Howell High School, the Army Reserve property, and near a residential site west of the quarry. The monitoring station at the August A. Busch Wildlife Area (AP-4007) is used to monitor background levels in the vicinity of the WSCP. The off-site monitoring stations are also shown in Figure 4-2.

TABLE 4-2 1991 Environmental TLD Results[a]

LOCATION ID	1ST QUARTER mrem	2ND QUARTER mrem	3RD QUARTER mrem
WSQ			
TD-1001	24	17	21
TD-1002	20	15	17
TD-1003	20	20	19
TD-1004	19	17	18
TD-1005	20	17	18
TD-1006	19	18	17
WSCP			
TD-2001	18	16	15
TD-2002	17	16	17
TD-2003	18	17	16
TD-2004	19	17	17
TD-2005	18	14	15
TD-2006	17	15	16
WSRP			
TD-3001	22	14	15
TD-3002	17	13	13
TD-3003	19	17	16
TD-3004	16	14	16
OFF-SITE			
TD-4001*	18	16	---
TD-4002	16	13	14
TD-4003	16	12	12
TD-4004*	19	--	16
TD-4005*	16	13	12
TD-4006*	17	15	17

(a) Results include natural background.
\- Denotes loss of TLD.
* Denotes background station.

The sampling station near the August A. Busch Wildlife Area (ABWA) headquarters is used as a background air monitoring station. This station is approximately 0.8 km (0.5 mile) from the WSCP perimeter in a northwestern direction. The terrain between the WSCP and this sampling station is hilly and forested, providing a significant physical barrier to airborne particulates originating from the WSCP/Weldon Spring raffinate pits (WSRP).

Table 4-3 summarizes the quarterly average concentrations and the standard deviations for the 11 air monitoring locations. The quarterly average concentration for each monitoring location was calculated by averaging either the weekly air particulate analysis results or the counting instrument's lower limit of detection (LLD), whichever was greater. The "<" sign in Table 4-3 appears when the actual average is less than the calculated average due to the use of LLD values in the calculation. The standard deviation for each of the monitoring locations was calculated using only results that were above the LLD. Due to maintenance, all monitors were not operating the entire 13 weeks as indicated in Table 4-3. However, the sensitive receptor monitoring stations (AP-4006, AP-4008, and AP-4011) were in operation the majority of the time and these stations are also equipped with high volume air monitoring. The high volume air monitors are part of the WSS radionuclide National Emissions Standards for Hazardous Air Pollutants (NESHAPs) requirements and were in operation the third quarter. The high volume monitoring results will be presented in the *Annual Site Environmental Report.*

The third quarter net alpha concentrations ranged from $<1.20 \times 10^{-15}$ µCi/ml to $<1.60 \times 10^{-15}$ µCi/ml with 1.22×10^{-15} µCi/ml detected at the background station.

4.4 Asbestos

No environmental asbestos monitoring was performed in the third quarter of 1991.

TABLE 4-3 Radiological Air Particulate Third Quarter 1991

MONITOR IDENTIFICATION NUMBER	QUARTERLY AVG. CONCENTRATION (1E-15 μCi/ml)	STANDARD DEVIATION	NUMBER OF WEEKS COLLECTED	NUMBER OF VALUES ABOVE LLD
AP-2001	<1.54E-15	7.36E-16	13	12
AP-2002	1.49E-15	5.53E-16	11	11
AP-3003	<1.22E-15	5.92E-16	11	8
AP-3004	<1.20E-15	2.61E-16	9	7
AP-2005	<1.51E-15	3.86E-16	10	8
AP-4006	<1.38E-15	3.62E-16	13	11
AP-4007*	1.22E-15	2.94E-16	13	12
AP-4008	1.60E-15	6.95E-16	12	12
AP-1009	<1.58E-15	5.35E-16	9	7
AP1010	<1.40E-15	4.62E-16	9	9
AP-4011	<1.57E-15	6.81E-16	12	10

* Indicates background monitor station.
To convert μCi/ml to Bq/M^3, multiply by 3.7E10.
NA Not available

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March 9, 1992

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CHEMICAL PLANT SITE REMEDIAL INVESTIGATION/FEASIBILITY STUDY DATA VALIDATION REPORT, FEBRUARY 1992

Enclosed is a copy of the Chemical Plant Site Remedial Investigation/Feasibility Study Data Validation Report. This report culminates approximately two years of intense activity by DOE to assess the validity and useability of the data in the Weldon Spring Site Remedial Action Project (WSSRAP) Remedial Investigation database.

The work associated with this effort began in December 1989 and required laboratory documentation to verify the database for transcription errors and to validate the database for useability.

The appendices associated with this document are not included due to their volume (2,296 pages). A copy of the document, including appendices, will be available in the WSSRAP public reading room.

Sincerely,

Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

cc w/o enclosure:
Jim Powers, PMC

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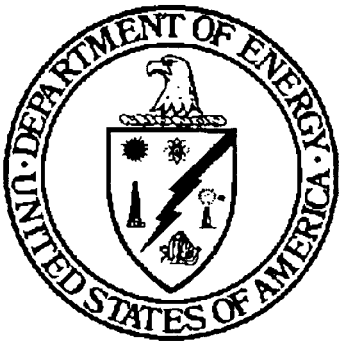
CHEMICAL PLANT SITE REMEDIAL INVESTIGATION/FEASIBILITY STUDY DATA VALIDATION REPORT

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

FEBRUARY 1992 **REV. 0**



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Weldon Spring Site Remedial Action Project

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Weldon Spring Site Remedial Action Project

Chemical Plant Site
Remedial Investigation/Feasibility Study
Data Validation Report

Revision 0

February 1992

Prepared by

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and
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for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

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1 INTRODUCTION

1.1 Purpose

The purpose of this report is to define the quality of the data which were used as the basis of the remedial investigation, risk assessment and feasibility study for the site operable unit at the Weldon Spring Site Remedial Action Project (WSSRAP).

1.2 Scope

This report addresses the results of the data validation program established to validate the characterization and environmental monitoring data and supporting check sample data collected by the Project Management Contractor (PMC) and analyzed by the PMC's primary subcontract laboratories, metaTRACE, Inc., and IT Analytical Services (ITAS); and the secondary subcontract laboratories, JTC Environmental Consultants, Inc. (JTC) and Accu-Labs Research, Inc. (Accu-Labs).

This report addresses the data used as the basis for the site remedial investigation and feasibility study from samples that were collected and analyzed prior to March 31, 1990, and from supporting check samples collected between July 1990 and September 1990.

1.3 Background

1.3.1 Data Quality Requirements

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires that remedial action decisions be based on data of known quality so that decision makers can make informed decisions and so additional data needs can be identified.

Procedures for validating data vary considerably nationwide. At WSSRAP, the process of evaluating data quality involves establishing data quality requirements (DQRs) and verifying and validating the analytical results received from subcontract laboratories.

DQRs are quantitative statements of accuracy and precision that specify the quality of the data needed to support specified data uses. The WSSRAP DQRs used in the CERCLA decision making process and for routine environmental monitoring are shown in Attachment A.

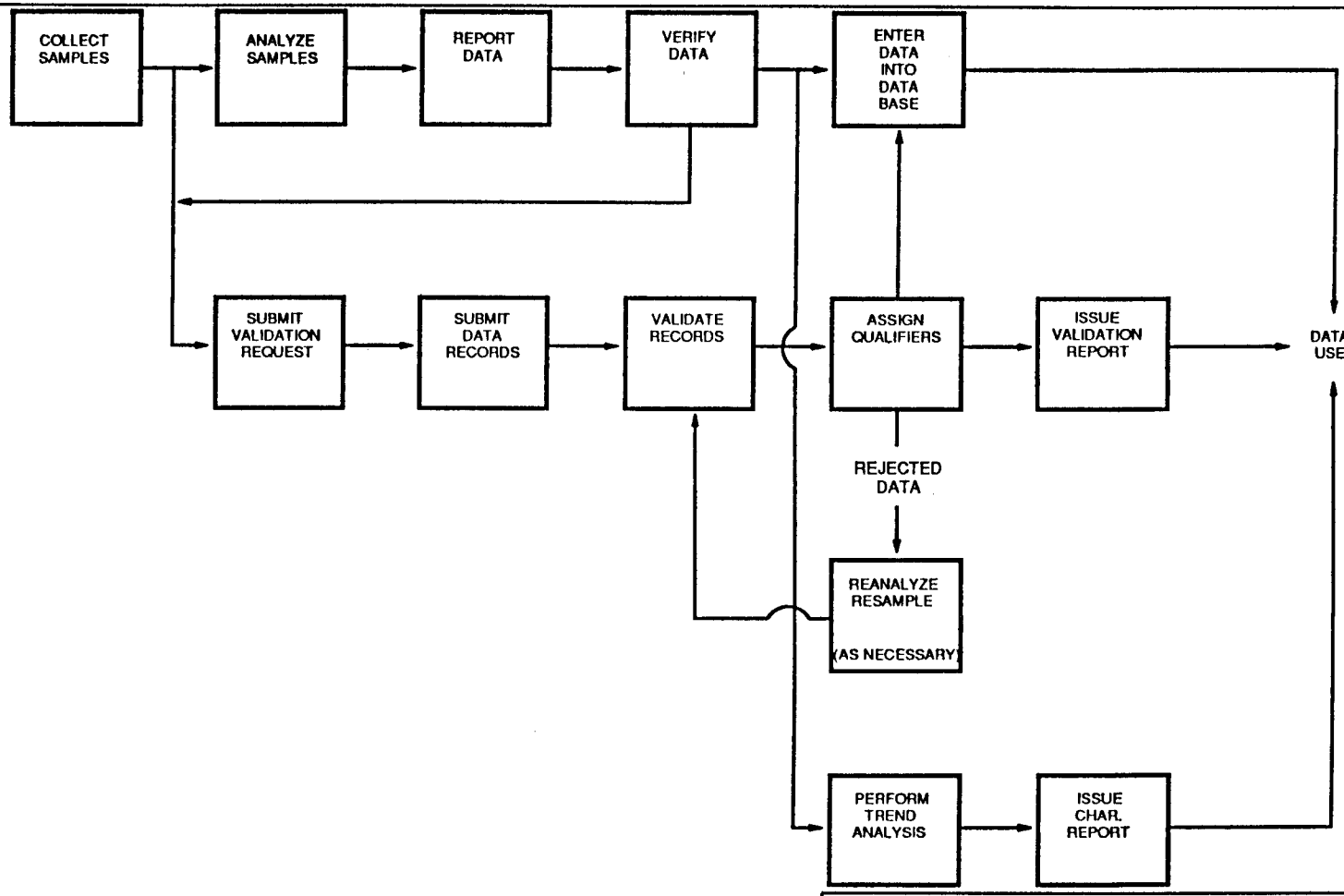
Data verification is a nonanalytical preliminary review of laboratory data and associated documentation to ensure that the samples were collected, preserved, shipped, maintained, analyzed, and reported in accordance with specified procedures. The WSSRAP data verification procedure is included in Attachment B.

Data validation involves a thorough analytical review of the data using laboratory records to assess laboratory performance relative to quality control criteria, DQRs, and other procedural and contractual requirements. Laboratories are also audited while they are analyzing the WSSRAP samples. If data quality problems or questions arise during the validation process, the PMC may require reanalysis of certain samples or may collect check samples to further define data quality. The WSSRAP procedure for the analytical review of laboratory data is shown in Attachment C.

The data verification and validation program is shown in Figure 1-1. These procedures are in-place and are routinely performed for newly acquired data, but a comprehensive and routine validation program was not performed on the data obtained prior to March 31, 1990. This report presents the results of the validation program for this previously collected data.

1.3.2 Validation Activities

In March 1989, the PMC began a formal data validation program by issuing a data validation work plan that described how the WSSRAP data would be validated. A key component of that work plan was the analytical review of approximately 4000 data points. This review included a review of the custody transfer records, a review of the laboratory's transcription of records that were merged into the WSSRAP electronic database, and of the laboratory and field quality control data. In February 1990, the final report addressing this review was submitted. The report indicated that a substantial number of data entry errors had occurred during the transcription of the data from the laboratory records into the electronic database by the subcontract laboratory. The report also indicated that a more thorough assessment of the database was necessary.



DATA VERIFICATION AND VALIDATION PROGRAM

FIGURE 1-1

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ORIGINATOR:	JJC	DRAWN BY:	GLN	DATE:	1/92

In response to this report the PMC implemented an expanded data validation program for the data collected prior to March 31, 1990. This program included:

- Establishing procedures for the verification and validation of WSSRAP data.
- Obtaining all available laboratory analytical records.
- Correcting the transcription of the data from the laboratory records into the electronic database.
- Performing a thorough analytical review of approximately 5,500 key data points from metaTRACE, JTC, and Accu-Labs.
- Performing a thorough analytical review of an additional 2,500 data points from metaTRACE to provide a more even distribution of sample matrix types included in the data population.
- Comparing the results of duplicate and split samples.
- Collecting check samples to resolve data quality questions.
- Performing a thorough analytical review of the approximate 4,000 check sample data points.
- Preparing an Environmental Data Administration Plan (EDAP).

The key data points were selected by technical specialists who prepared the site characterization reports. The initial 5,500 points are those values that were key data to the interpretation of the extent and distribution of the contaminants found at the site and were selected for all environmental media, all parameters analyzed, and the full range of contamination. Therefore the 5,500 points represent the data that are key data to preparation of the site remedial investigation and feasibility study. The initial 5,500 key data points, along with the additional 2,500 metaTRACE datapoints to even out the matrix distribution and the 4,000 check sample data points make up the 12,000 (or 12K) data points referenced in this report.

Other data validation efforts included performing trend analysis for the data from the routine water monitoring program, and validating data points specifically identified by data users. Table 1-1 shows the approximate number of data points that have been validated. As shown, WSSRAP did not validate 100% of the data points but rather validated a significant percentage of the data. This was then used to define the quality of the entire data base. This process is consistent with U.S. Environmental Protection Agency (EPA) CERCLA guidance on data validation procedures. WSSRAP had previously proposed to validate an additional 7000 data points, but based on the review of the results of the validation work on the 12K points and the recommendation of the EPA, the validation of the 7000 points was determined to be unnecessary. The results of the program are described in the following sections of this report. This data validation program was reviewed and approved in an August 16, 1990, memorandum from EPA, Region VII.

Table 1–1 Data Validation Data Point Summary

VALIDATION ACTIVITY	TYPE OF VALIDATION	APPROXIMATE NO. OF DATA POINTS	STATUS
Duplicate Samples	Sample Duplication	20,000	Complete
Initial Validation (March 1990)	Analytical Review	4,000	Complete
Key Data Points[1]	Analytical Review	5,500	Complete
Add'l metaTRACE Data Points	Analytical Review	2,500	Complete
Check Sample Data Points[2] (direct)	Analytical Review	4,000	Complete
Check Sample Data Points (reference)	Reference	4,000	Complete
Routine Water Monitoring Trend Analyses	Reference/Trend Analysis	45,000	Complete
Special Validation Requests	Analytical Review	1,000	Complete

[1] Consists of data generated from metaTRACE, JTC, and Accu–Labs.

[2] Consists of data generated from ITAS.

2 DATA VERIFICATION REVIEW

2.1 Introduction

In 1987, the effort to computerize analytical data from characterization and routine monitoring activities was initiated. Analytical data were received from metaTRACE, Inc. in hard copy and in electronic copy format. As sampling activities continued and analytical results were received, a computerized database was developed from the electronic records received from metaTRACE. The data were separated into files by sample matrix and programmatic scope such as groundwater and Phase 2 soils. The computerized Weldon Spring Site Remedial Action Project (WSSRAP) database was developed to provide an organized, retrievable format with which project personnel could utilize data for various reports and documents.

As a result of the initial inquiry into the validity of data analyzed by metaTRACE, it was determined that the electronic data records contained errors. The electronic records created by metaTRACE were not adequately verified or reviewed prior to shipment to WSSRAP and a lack of consistency in the reporting methods was noted. As a result, the review of the database records by the PMC was determined to be a requirement in the validation of data for use at WSSRAP.

2.2 Verification Procedures

The verification of records in the WSSRAP databases had two aspects. The verification review included a standardization of all data in the database sampled prior to March 31, 1990, and secondly, a transcription review of all metaTRACE data with detectable concentrations was performed. All data received for samples collected after March 31, 1990, were standardized and verified, as described in Section 2.2.1.

2.2.1 Data Standardization

The standardization of the databases included review of chemical categories, chemical parameters, units of measure, sample identification assignment, laboratory identification assignment, and format of non-detect values. Each data record was reviewed to determine if it met the standardization requirements.

These standardization requirements include a list of chemical categories, parameters and units of measure, matrix types, analytical methods and a format for the concentration value and was applied to all data (Attachment D). Unique listings of the sample identification numbers were created from the database records and reviewed by two WSSRAP personnel for accuracy according to ES&H 4.1.1, *Environmental Numbering System Procedure*. Corrections made to sample identification numbers were then checked by comparing the sample ID to the sample chain-of-custody (COC) form.

Unique laboratory identification numbers are assigned to the sample by the subcontractor laboratory when it arrives at the laboratory. This unique laboratory ID number was used throughout the course of sample analysis to identify and report sample results. A review of the accuracy of the laboratory identification number was also conducted. A unique listing of the sample identification number and laboratory identification number was produced and reviewed by two WSSRAP personnel. Corrections made to the database records based on the laboratory identification review were made by comparing database records to the laboratory's sample COC form.

The values held in the concentration field for each record were also reviewed for variation of non-detect codes. The databases contained such characters as "ND", "NA", "BQL", "----"," < DL" and blank fields to represent non-detectable concentrations. The standard "ND" code was used to replace other codes.

2.2.2 Transcription Review

The transcription review was directed at verifying all detect values reported by metaTRACE and comparing the values to the records held in the database files. Copies of the original data summary sheets or raw bench sheets were recovered from metaTRACE laboratories. The sheets were reviewed for positive or detect results of the analytical test. All detectable data results were then entered into two separate databases termed DATA1 and DATA2, thus providing double-key entry of data.

After all data were entered, the two "rekeyed" databases were compared to determine the accuracy of the double-key entry effort. A compiled dBASEIII+ software program called M-COMP was used to test the exactness of the two databases. Individual records from each database were written to secondary database files based upon the results of the test. Errors in

the double-key entry databases were manually reviewed and compared to the original data summary sheets. Corrections were made to the appropriate records in the associated data file and the M_COMP program was rerun. The comparison program and data review was repeated until all records matched and a single rekeyed database was created.

The double-key entry rekeyed database was used to verify the values held in the WSSRAP database files. As each record was compared, a change indicator was used to flag the differences between data records. The records held in the WSSRAP data files were modified (if needed) to reflect the rekeyed values found in the double-key entry database. Change indicators were copied into the COMMENTS field of each modified database record to document the modification. A listing of the change indicators and their interpretation is contained in Attachment E.

The WSSRAP database was also reviewed for duplications of records as a result of data records reported by metaTRACE. A compiled dBASEIII+ program called TRUDUPS was used to identify and segregate exact duplicates from the databases. In addition, a second program (DUPS) was used to identify duplicate records based on sample ID and parameter. The DUPS program created a new file that contained any duplicated records. These records were manually reviewed and compared to the hard copy records. The records that were determined to be correct were maintained in the database files, while duplicate incorrect records were deleted. The DUPS program was rerun until all duplicate records were eliminated or corrected.

2.3 Verification Results

Prior to first quarter 1991, the WSSRAP data bases contained approximately 140,000 data records of which approximately 136,000, or 97%, are data sampled prior to March 31, 1990. Of those records, approximately 131,000, or 96%, are data analyzed by metaTRACE during the 1987 to 1989 sampling years. The majority of the records (55%) are soil samples collected during the site characterization effort in 1988. The groundwater and sludge database comprise 31% of the data; the remaining records are held in various smaller databases and include spring, lake sediment, National Pollutant Discharge Elimination System (NPDES), industrial hygiene, radiation protection and air particulate data. Table 2-1 shows the distribution of data records in the various WSSRAP databases.

Table 2–1 Distribution of Data by Verification Review Status

(prior to first quarter 1991)

DATABASE	TOTAL RECORDS[1]	% OF ALL RECORDS	RECORDS IN REVIEW[2]	% RECORDS REVIEWED	RECORDS ANALYZED BY METATRACE	% OF TOTAL RECORDS	% OF REVIEWED RECORDS
Groundwater	20,356	14.5%	18,551	91%	14,854	73%	80%
Groundwater QA	3,432	2.4%	3,028	88%	2,282	66%	75%
Surface Water	3,608	2.6%	3,493	97%	3,368	93%	96%
Surface Water QA	444	0.3%	409	92%	359	81%	88%
Springs	3,644	2.6%	3,482	96%	3,368	92%	97%
Springs QA	270	0.2%	257	95%	195	72%	76%
Sludge	15,790	11.3%	14,785	94%	14,785	94%	100%
Sludge QA	3,919	2.8%	3,919	100%	3,919	100%	100%
Lakes and Steams	4,694	3.3%	4,694	100%	4,694	100%	100%
Lakes and Steams QA	612	0.4%	612	100%	612	100%	100%
NPDES	2,453	1.8%	2,310	94%	2,238	91%	97%
NPDES QA	48	0.0%	36	75%	36	75%	100%
Phase 1 Soils	5,214	3.7%	5,214	100%	5,214	100%	100%
IRA Soils	10,812	7.7%	10,812	100%	10,812	100%	100%
Phase 2 Soils	49,653	35.4%	49,653	100%	49,653	100%	100%
Phase 2 Soils QA	11,899	8.5%	11,899	100%	11,899	100%	100%
Radiological	499	0.4%	469	94%	339	68%	72%
Radiological QA	120	0.1%	120	100%	0[3]	0%	0%
Industrial Hygiene	2,035	1.5%	1,967	97%	1,824	90%	93%
Air Particulate	664	0.5%	664	100%	594	89%	89%
Total:	**140,166**		**136,374**		**131,045**		
% of All Data:			**97%**		**93%**		
% of Reviewed Data:					**96%**		

[1] as of 12/12/90

[2] all records sampled prior to 03/31/90

[3] all radiological QA samples were analyzed by another lab besides metaTRACE. Therefore, there were no radiological QA data obtained from metatTRACE for verification review.

Concentration values were used to classify data into detectable and non-detect populations. Sixty-nine percent of the pre-March 31, 1990, records (or reviewed records) were found to be non-detect concentrations and 31% were detectable values. The majority of detects reported were metals and anions while nitroaromatics, semi-volatiles, volatiles and pesticides/PCBs contained the majority of the non-detect values. The distribution of detects and non-detect populations compared to chemical categories is shown in Table 2-2.

Change indicators, as discussed in Section 2.2, were assigned to modified data records to document the type of modifications made. The indicators were tallied by database, concentration type and chemical category to determine trends found in the verification review process. Table 2-3 summarizes the modifications made based on detect and non-detect populations.

Overall, the results of the verification review indicate that modifications to the database were due primarily to standardization of field information. Information gathered during the review process also showed that specific types of typographical errors were made in the data entry process by metaTRACE. Other modifications were attributed to the U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) requirements for adjusting the concentration values of soil data for percent moisture. Percent moisture adjustments were not consistently calculated on the metaTRACE laboratory bench sheets. Percent moisture adjustments typically increased concentration values by 10% to 15% for soils.

2.3.1 Standardization of Data

The verification review showed that many modifications were attributed to the standardization test conducted. Use of computerized data requires the standardization of field information in order to consistently retrieve and present data for use at the WSSRAP. Of the total number of modifications made, the category and parameter checks resulted in a large percentage (23%) of modifications overall and they occurred in each of the databases. Differences in the use of units of measure also were noted (3%).

The use of the category "Metals" versus "EP Tox Metals" attributed to the many of the category modifications. Data records were erroneously classified into the EP Tox Metals category. Data analyzed under routine EPA CLP methods should be classified to the METALS

Table 2–2 Distribution of Data by Chemical Category[1]

DETECT Population

DATABASE	TOTAL RECORDS	# OF DETECTS	%	ANIONS	%	NITROS	%	METALS	%	RAD	%	PEST/ PCBs	%	SEMI-VOA	%	VOA	%	MISC	%
Air Particulate	664	165	25%	0	0%	0	0%	18	11%	147	89%	0	0%	0	0%	0	0%	0	0%
Groundwater	18,551	5339	29%	1,967	37%	688	13%	1,124	21%	678	13%	9	0%	25	0%	32	1%	816	15%
Groundwater QA	3,028	1063	35%	365	34%	234	22%	197	19%	116	11%	2	0%	66	6%	11	1%	72	7%
Industrial Hygiene	1,799	345	19%	5	1%	0	0%	87	25%	50	14%	120	35%	0	0%	8	2%	75	22%
IRA Soils	10,812	3649	34%	532	15%	4	0%	2,625	72%	0	0%	7	0%	71	2%	5	0%	405	11%
Lakes & Steams	4,694	929	20%	0	0%	1	0%	630	68%	178	19%	2	0%	0	0%	0	0%	118	13%
Lakes & Steams QA	610	169	28%	0	0%	12	7%	101	60%	5	3%	0	0%	43	25%	0	0%	8	5%
NPDES	2,310	1345	58%	191	14%	51	4%	169	13%	377	28%	0	0%	438	33%	0	0%	119	9%
NPDES QA	36	17	47%	2	12%	1	6%	6	35%	6	35%	0	0%	0	0%	0	0%	2	12%
Phase 1 Soils	5,214	3299	63%	509	15%	52	2%	2,589	78%	0	0%	0	0%	0	0%	0	0%	149	5%
Phase 2 Soils	49,653	14083	28%	2,287	16%	19	0%	9,818	70%	0	0%	25	0%	112	1%	304	2%	1,518	11%
Phase 2 Soils QA	11,899	4105	34%	552	13%	314	8%	2,226	54%	0	0%	69	2%	385	9%	213	5%	346	8%
Radiological	469	323	69%	0	0%	0	0%	0	0%	322	100%	0	0%	0	0%	0	0%	1	0%
Radiological QA	120	81	68%	0	0%	0	0%	0	0%	81	100%	0	0%	0	0%	0	0%	0	0%
Sludge	14,785	2847	19%	453	16%	0	0%	2,204	77%	8	0%	26	1%	12	0%	110	4%	34	1%
Sludge QA	3,919	962	25%	104	11%	42	4%	501	52%	74	8%	39	4%	84	9%	113	12%	5	1%
Springs	3,482	1011	29%	293	29%	78	8%	315	31%	136	13%	0	0%	0	0%	3	0%	186	18%
Springs QA	257	67	26%	16	24%	13	19%	21	31%	6	9%	0	0%	0	0%	3	4%	8	12%
Surface Water	3,493	1702	49%	573	34%	48	3%	311	18%	718	42%	0	0%	0	0%	0	0%	52	3%
Surface Water QA	409	194	47%	64	33%	17	9%	35	18%	71	37%	0	0%	0	0%	0	0%	7	4%
Totals:	136,204	41,695	31%	7,913	19%	1,574	4%	22,977	55%	2,973	7%	299	1%	1,236	3%	802	2%	3,921	9%

NON–DETECT Population

DATABASE	TOTAL RECORDS	# OF NON-DETECTS	%	ANIONS	%	NITROS	%	METALS	%	RAD	%	PEST/ PCBs	%	SEMI-VOA	%	VOA	%	MISC	%
Air Particulate	664	499	75%	0	0%	0	0%	0	0%	499	100%	0	0%	0	0%	0	0%	0	0%
Groundwater	18,551	13212	71%	581	4%	3,657	28%	2,115	16%	1,889	14%	1,581	12%	1,685	13%	1,082	8%	622	5%
Groundwater QA	3,028	1965	65%	137	7%	521	27%	245	12%	228	12%	293	15%	293	15%	187	10%	61	3%
Industrial Hygiene	1,799	1454	81%	0	0%	0	0%	41	3%	36	2%	1,364	94%	0	0%	4	0%	9	1%
IRA Soils	10,812	7163	66%	56	1%	878	12%	1,047	15%	0	0%	1,424	20%	3,634	51%	123	2%	1	0%
Lakes & Steams	4,694	3765	80%	0	0%	395	10%	313	8%	121	3%	264	7%	2,665	71%	0	0%	7	0%
Lakes & Steams QA	610	441	72%	0	0%	12	3%	37	8%	3	1%	42	10%	347	79%	0	0%	0	0%
NPDES	2,310	965	42%	37	4%	482	50%	183	19%	49	5%	0	0%	74	8%	0	0%	140	15%
NPDES QA	36	19	53%	0	0%	11	58%	8	42%	0	0%	0	0%	0	0%	0	0%	0	0%
Phase 1 Soils	5,214	1915	37%	87	5%	842	44%	986	51%	0	0%	0	0%	0	0%	0	0%	0	0%
Phase 2 Soils	49,653	35570	72%	1,068	3%	3,021	8%	3,112	9%	0	0%	3,026	9%	17,460	49%	7,649	22%	234	1%
Phase 2 Soils QA	11,899	7794	66%	190	2%	316	4%	618	8%	0	0%	627	8%	3,757	48%	2,239	29%	47	1%
Radiological	469	146	31%	0	0%	0	0%	0	0%	132	90%	14	10%	0	0%	0	0%	0	0%
Radiological QA	120	39	33%	0	0%	0	0%	0	0%	39	100%	0	0%	0	0%	0	0%	0	0%
Sludge	14,785	11938	81%	57	0%	423	4%	472	4%	494	4%	1,675	14%	6,483	54%	2,312	19%	22	0%
Sludge QA	3,919	2957	75%	18	1%	63	2%	147	5%	41	1%	393	13%	1,278	43%	1,015	34%	2	0%
Springs	3,482	2471	71%	39	2%	412	17%	886	36%	239	10%	702	28%	0	0%	187	8%	6	0%
Springs QA	257	190	74%	4	2%	41	22%	79	42%	10	5%	27	14%	0	0%	29	15%	0	0%
Surface Water	3,493	1791	51%	171	10%	320	18%	646	36%	627	35%	0	0%	0	0%	0	0%	27	2%
Surface Water QA	409	215	53%	20	9%	67	31%	61	28%	67	31%	0	0%	0	0%	0	0%	0	0%
Totals:	136,204	94,509	69%	2,465	3%	11,461	12%	10,996	12%	4,474	5%	11,432	12%	37,676	40%	14,827	16%	1,178	1%
Grand Totals:		136,204	100%	10,378	8%	13,035	10%	33,973	25%	7,447	5%	11,731	9%	38,912	29%	15,629	11%	5,099	4%

[1] as of 12/12/90

Table 2–3 Distribution of Database Modifications

DETECT Population							TYPE OF MODIFICATION													
DATABASE	TOTAL RECORDS	# OF DETECTS	%	# NOT CHANGED	%	# OF MODS	CATE-GORY	%	PARA-METER	%	CONC. VALUE	%	UNITS	%	RAD ERR. VALUE	%	DETECT. LIMIT	%	NO REVIEW	%	NEW ADD'N	%
Air Particulate	664	165	25%	18	11%	326	18	6%	113	35%	15	5%	15	5%	105	32%	0	0%	42	13%	18	6%
Groundwater	18,551	5,339	29%	2,077	39%	4,155	552	13%	747	18%	636	15%	58	1%	714	17%	15	0%	814	20%	619	15%
Groundwater QA	3,028	1,063	35%	233	22%	985	91	9%	216	22%	128	13%	2	0%	107	11%	6	1%	186	19%	249	25%
Industrial Hygiene	1,799	345	19%	21	6%	418	143	34%	58	14%	1	0%	38	9%	8	2%	0	0%	156	37%	14	3%
IRA Soils	10,812	3,649	34%	2,166	59%	1,542	293	19%	24	2%	702	46%	21	1%	7	0%	1	0%	212	14%	282	18%
Lakes & Steams	4,694	929	20%	9	1%	1,275	120	9%	168	13%	149	12%	630	49%	180	14%	17	1%	0	0%	11	1%
Lakes & Steams QA	610	169	28%	1	1%	222	8	4%	15	7%	23	10%	103	46%	41	18%	0	0%	32	14%	0	0%
NPDES	2,310	1,345	58%	197	15%	1,628	121	7%	419	26%	193	12%	29	2%	275	17%	0	0%	457	28%	134	8%
NPDES QA	36	17	47%	2	12%	20	0	0%	6	30%	2	10%	0	0%	6	30%	0	0%	0	0%	6	30%
Phase 1 Soils	5,214	3,299	63%	991	30%	2,356	159	7%	47	2%	1,719	73%	6	0%	0	0%	0	0%	425	18%	0	0%
Phase 2 Soils	49,653	14,083	28%	6,565	47%	7,999	2,681	34%	603	8%	1,711	21%	13	0%	158	2%	0	0%	590	7%	2,243	28%
Phase 2 Soils QA	11,899	4,105	34%	1,689	41%	2,521	616	24%	117	5%	578	23%	25	1%	49	2%	18	1%	644	26%	474	19%
Radiological	469	323	69%	0	0%	547	0	0%	219	40%	20	4%	0	0%	199	36%	0	0%	78	14%	31	6%
Radiological QA	120	81	68%	0	0%	81	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	81	100%	0	0%
Sludge	14,785	2,847	19%	1,255	44%	3,249	290	9%	640	20%	1,449	45%	31	1%	511	16%	176	5%	86	3%	66	2%
Sludge QA	3,919	962	25%	187	19%	1,004	86	9%	111	11%	261	26%	59	6%	122	12%	60	6%	302	30%	3	0%
Springs	3,482	1,011	29%	472	47%	672	225	33%	148	22%	68	10%	23	3%	84	13%	4	1%	62	9%	58	9%
Springs QA	257	67	26%	23	34%	51	13	25%	23	45%	9	18%	0	0%	4	8%	0	0%	1	2%	1	2%
Surface Water	3,493	1,702	49%	334	20%	2,120	204	10%	882	42%	326	15%	10	0%	479	23%	16	1%	125	6%	78	4%
Surface Water QA	409	194	47%	51	26%	224	21	9%	79	35%	39	17%	1	0%	51	23%	1	0%	21	9%	11	5%
Totals:	136,204	41,695	31%	16,291	39%	31,395	5,641	18%	4,635	15%	8,029	26%	1,064	3%	3,100	10%	314	1%	4,314	14%	4,298	14%

NON–DETECT Population							TYPE OF MODIFICATION													
DATABASE	TOTAL RECORDS	# OF NON-DETECTS	%	# NOT CHANGED	%	# OF MODS	CATE-GORY	%	PARA-METER	%	CONC. VALUE	%	UNITS	%	RAD ERR. VALUE	%	DETECT. LIMIT	%	NO REVIEW	%	NEW ADD'N	%
Air Particulate	664	499	75%	0	0%	538	0	0%	463	86%	9	2%	13	2%	17	3%	0	0%	36	7%	0	0%
Groundwater	18,551	13,212	71%	627	5%	13,154	916	7%	4,018	31%	273	2%	259	2%	287	2%	7	0%	5,138	39%	2,256	17%
Groundwater QA	3,028	1,965	65%	64	3%	1,979	90	5%	671	34%	33	2%	5	0%	76	4%	0	0%	622	31%	482	24%
Industrial Hygiene	1,799	1,454	81%	61	4%	2,187	1,342	61%	82	4%	0	0%	386	18%	32	1%	266	12%	69	3%	10	0%
IRA Soils	10,812	7,163	66%	452	6%	7,018	175	2%	653	9%	193	3%	184	3%	68	1%	3	0%	5,741	82%	1	0%
Lakes & Steams	4,694	3,765	80%	28	1%	4,890	283	6%	512	10%	25	1%	357	7%	3,188	65%	161	3%	343	7%	21	0%
Lakes & Steams QA	610	441	72%	4	1%	561	44	8%	45	8%	4	1%	41	7%	415	74%	0	0%	12	2%	0	0%
NPDES	2,310	965	42%	47	5%	1,004	37	4%	115	11%	196	20%	25	2%	18	2%	0	0%	527	52%	86	9%
NPDES QA	36	19	53%	0	0%	19	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	13	68%	6	32%
Phase 1 Soils	5,214	1,915	37%	369	19%	1,555	5	0%	149	10%	477	31%	1	0%	0	0%	0	0%	923	59%	0	0%
Phase 2 Soils	49,653	35,570	72%	697	2%	35,865	1,011	3%	3,595	10%	875	2%	399	1%	223	1%	0	0%	29,413	82%	349	1%
Phase 2 Soils QA	11,899	7,794	66%	50	1%	7,924	176	2%	815	10%	214	3%	95	1%	73	1%	71	1%	6,470	82%	10	0%
Radiological	469	146	31%	0	0%	212	14	7%	102	48%	12	6%	2	1%	32	15%	0	0%	30	14%	20	9%
Radiological QA	120	39	33%	0	0%	39	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	39	100%	0	0%
Sludge	14,785	11,938	81%	68	1%	11,898	325	3%	1,292	11%	151	1%	495	4%	139	1%	258	2%	9,185	77%	53	0%
Sludge QA	3,919	2,957	75%	10	0%	3,174	56	2%	311	10%	26	1%	477	15%	9	0%	177	6%	2,111	67%	7	0%
Springs	3,482	2,471	71%	384	16%	2,148	82	4%	418	19%	151	7%	9	0%	1	0%	21	1%	1,460	68%	6	0%
Springs QA	257	190	74%	21	11%	184	18	10%	49	27%	12	7%	0	0%	6	3%	4	2%	95	52%	0	0%
Surface Water	3,493	1,791	51%	17	1%	2,024	430	21%	931	46%	65	3%	29	1%	25	1%	12	1%	522	26%	10	0%
Surface Water QA	409	215	53%	13	6%	234	30	13%	94	40%	4	2%	1	0%	8	3%	0	0%	82	35%	15	6%
Totals:	136,204	94,509	69%	2,912	3%	96,607	5,034	5%	14,315	15%	2,720	3%	2,778	3%	4,617	5%	980	1%	62,831	65%	3,332	3%
Grand Totals:		136,204	100%	19,203	14%	128,002	10,675	8%	18,950	15%	10,749	8%	3,842	3%	7,717	6%	1,294	1%	67,145	52%	7,630	6%

category. EP Toxicity is an extraction procedure and is documented in the database in the Method field as 3010/6010 and is given the category assignment of "EP Tox Metals. Records with the EP Toxicity designation were reviewed with chain-of-custody records to confirm extraction methods requested. As a result of the review, only the industrial hygiene database contains samples extracted by the EP Tox method.

The category "Miscellaneous" is used for classification of analytical measurements such as total organic carbon, flashpoint and percent moisture. Prior to this review, each of these miscellaneous parameters carried its own category name. The grouping of these parameters into the miscellaneous category assists users in accessing data.

Modifications were also made to records for parameter or analyze misspellings. Radiological data were classified in various manners. For example, total uranium was shown as "Total Uranium," "Natural Uranium" and other variations. Again, the computerized data resulted in some difficulty in the use of data based upon misspellings and classification errors. All records were modified to the parameter standards as listed in Attachment D.

The addition of other subcontract laboratories in October of 1989 also contributed to standardization errors. Units of measure were reported differently between laboratories and accounted for 3% of the changes. MetaTRACE reported Fluoride as mg/l while other laboratories reported fluoride in μg/l. Radiological data were reported as pCi/l and mg/l. Units were standardized according to data quality requirements (DQRs) during the verification review.

2.3.2 Transcription Review

The second review of database records assessed the types of transcriptional errors made by metaTRACE during the data entry process. This review effort was directed at determining the accuracy of transcribing data results of detectable concentrations. Values for concentration, detection limits, units and radiological errors were reviewed under the transcription process.

A change indicator of "V" was used to mark database records based on changes in concentration values. Eight percent of the total modifications made (or 8% of the records held in all databases) were modified for concentration values. While the modification of concentration field was noted during the review process, the degree of change of the concentration values was not. A separate analysis was done to determine the magnitude of the

differences between values previously held in the database and those held after transcription review. The detection limit and radiological error fields were also analyzed for percent change under the screening levels. The general finding was that relatively few values were statistically significant in concentration between the re-keyed data and records held in the database.

Most of the changes made to the concentration field were attributed to extraneous characters, such as quotes, CLP qualifiers, etc. However, most numerical changes made to the concentration values were attributed to rounding and significant figures. EPA CLP protocol indicates that three significant figures should be used in reporting concentrations. MetaTRACE did not consistently report to three significant figures and/or did not round to the closest integer. Most of these changes resulted in concentration value differences of $<0.5\%$.

Data quality requirements set for the WSSRAP designate specific reporting requirements for units of measure for each analyte. In the review of reporting units held in the databases, it was found that errors in unit conversion and appropriate sample matrix units were made. During the re-key effort, the review of laboratory bench sheets showed analytical results reported in various units for certain analytes. This was particularly true for metals analysis where data were analyzed in mg/l but reported in μg/l. For approximately 1% of all data records, the conversions of concentrations for units were either not made or were calculated erroneously by metaTRACE during the data entry process. More typical was the misuse of the proper units in the reporting of data. Most of the records with incorrect units were the site-designated quality control samples. The field and equipment water blanks were shipped to metaTRACE with soil samples for analysis. The bench sheets reflected the proper units of measure for each matrix but during the reporting phase, errors were made in reporting water blanks in weight-to-weight measurements (i.e., μg/g) instead of weight-to-volume measurements (i.e., mg/l).

Other types of transcription errors noted were caused by inappropriate data entry procedures used by metaTRACE. MetaTRACE consistently reported radiological error values as a value of 10% of the concentration instead of the calculated radiological error. During the re-key process, the calculated error values reported on the laboratory bench sheet were used to update the WSSRAP database records. Some other analytical categories show a high percentage of modifications in the error field. These changes are due to metaTRACE entering CLP qualifier values in the error field where no value was needed or expected. CLP qualifiers are

not held in the WSSRAP database and only radiological error values are held in the error field. All non-radiological records were standardized to blanks in the error field.

Detection limits were reported by metaTRACE using the standard EPA CLP CRDL values in some cases, and not provided at all in others. According to CLP protocol, detection limits should be corrected to account for dilutions and percent moisture adjustment made during the analytical testing. During manual review of the data records, some concentration values required correction to reflect dilutions and percent moisture adjustments. Adjustments to detection limits for percent moisture and dilution were only made when the WSSRAP data validation group requested changes be made based on their technical reviews.

All of the corrections described on the preceding pages were made to the database prior to use as the basis for the chemical plant remedial investigation, risk assessment, and feasibility study.

3 DATA VALIDATION

The major objectives of the data validation program are:

- To assess laboratory performance and data to quality control criteria, data quality objectives, and procedural requirements.
- To assess analytical data and qualify data for useability.
- To report data validation findings to the data users.

In support of the Weldon Spring Site Remedial Action Project (WSSRAP) remedial investigation, approximately 12,000 data points (12K data) were selected for a detailed data validation review. The samples and analyses associated with this validation effort are listed in Attachment F. Seven thousand two hundred ninety-nine data points (or 61.6%) were from analyses performed by metaTRACE, Inc.; 570 data points (4.8%) were from JTC; 101 data points (0.9%) were from Accu-Labs; and 3,878 data points (32.7%) were from ITAS. Table 3-1 provides a data point distribution of the 12K data by sample matrix and by laboratory.

3.1 Validation Procedures

The data validation process involved retracing the laboratory analyses from beginning to end and comparing the results of that validation "retracing" with those that were reported by the laboratories. In addition, sample custody transfer records and analytical holding times were reviewed to assess sample integrity. Any deviations from protocol, quality control deficiencies, compromises to sample integrity, or mathematical/transcription errors were noted and used to qualify or reject the data.

In order to accomplish the validation "retrace", the analytical documentation that pertained to the analysis (such as instrument printouts, standard preparation logs, sample preparation logs, sample data summary/calculation sheets, quality control (QC) control charts, chain-of-custody records) were reviewed for the samples of interest, instrument calibrations and tunes, and for the associated quality control samples and standards.

Table 3–1 Data Point Distribution for 12K Data

DISTRIBUTION BY SAMPLE MATRIX

MATRIX	ANIONS	METALS	MISC	NITROS	PEST/ PCBs	RAD	SEMI– VOA	VOA	TOTALS	%
Air [1]	0	0	0	0	0	18	0	0	18	0.2%
Groundwater	100	358	14	162	0	114	1,430	884	3,062	25.8%
NPDES	3	0	5	0	0	8	0	0	16	0.1%
Oil	0	0	0	0	112	0	0	0	112	0.9%
Sludge	115	649	13	144	612	100	2,470	1,530	5,633	47.5%
Soil	16	190	9	264	195	0	1,105	510	2,289	19.3%
Spring Water	0	25	0	48	0	8	0	0	81	0.7%
Surface Water	20	250	0	36	0	36	260	0	602	5.1%
Waste	0	0	1	0	0	33	0	0	34	0.3%
Total	254	1,472	42	654	919	317	5,265	2,924	11,847	100.0%

DISTRIBUTION BY LABORATORY

LAB [2]	ANIONS	METALS	MISC	NITROS	PEST/ PCBs	RAD	SEMI– VOA	VOA	TOTALS	%
metaTRACE	201	1,331	25	294	528	174	3,250	1,496	7,299	61.6%
JTC	53	113	17	114	139	0	65	68	569	4.8%
Accu–Lab [3]	0	0	0	0	0	101	0	0	101	0.9%
ITAS	0	28	0	246	252	42	1,950	1,360	3,878	32.7%
Totals	254	1,472	42	654	919	317	5,265	2,924	11,847	100.0%

[1] With the exception of a few samples analyzed for lead, all air particulate analyses were limited to radiochemical parameters.

[2] metaTRACE = metaTRACE, Inc. JTC = JTC Environmental Consultants, Inc. Accu–Lab = Accu–Labs Research, Inc. ITAS = IT Analytical Services, Inc.

[3] Accu–Labs provided only radiochemical services to WSSRAP.

Calculations were repeated; accuracy and precision were measured; and the analytical process (preparatory and instrumental) was reviewed.

The analytical documentation was grouped and cataloged into data sets synonymous to the laboratory analytical lot and assigned a unique data set number. Within each data set, all analyses or injections were further cataloged chronologically and assigned a sequence number. Using this approach, each analysis or injection could be referenced by the combined data set and sequence numbers. No two analyses or injections would have the same combined numbers. An analysis-specific worksheet was maintained with each data set and was used for maintaining validation notes and comments, and as a checklist to ensure critical items for each analysis were reviewed. Calculation checks for each data set were performed and documented by computerized spreadsheet and were maintained with each data set.

The results from each validation review were compared with those that have been reported by the laboratories and/or were maintained in the WSSRAP database. This comparison included not only the reported parameter concentration values, but also the reported error values (for radiochemical analyses only), the units, and the detection limits. Discrepancies associated with these comparisons were noted.

The analyses were evaluated for useability based on the requirements established for the analytical protocol or method (i.e., U.S. Environmental Protection Agency (EPA), Contract Laboratory Program (CLP), U.S. Army Toxic and Hazardous Materials Agency (USATHAMA)) used to obtain the resulting data. However, there are numerous accepted protocols available for a given parameter, and a simple deviation from the intended protocol would not necessarily lessen the degree of confidence to a level where the data would not be usable. As such, if a sufficient amount of quality control and analytical checks were performed during an analysis (which is standard analytical practice), then the accuracy and precision for the analysis could be measured, the degree of confidence assessed, and an informed decision about the analysis and its data could be made. Such data would not be automatically rejected as unusable, but would be flagged as data from an analysis not following the intended protocol.

The results from the data validation review were summarized in the form of validation qualifiers. The use of qualifiers is similar to the technique used by the EPA with its CLP program, and provide a means for incorporating validation results into the WSSRAP database. The list of qualifiers adopted for WSSRAP and their meaning is provided in Table 3-2.

For each parameter in a given data set, the analytical accuracy and precision was calculated. In general, accuracy was calculated from the recovery of the parameter of interest in the laboratory control spike sample (or blank spike) or from the matrix spike sample. In cases were several control samples were available per data set, the recoveries were averaged. For volatiles, semi-volatiles, and pesticide/PCBs, accuracy was measured from the recovery of the analytical surrogate compounds included in each sample for analysis. Precision was measured as the relative percent difference between duplicate analyses of the same sample for the same parameters. Such precision measurements were made from laboratory duplicates, field duplicates, or matrix spike duplicates. In cases where duplicates or control samples were not available, no accuracy and/or precision determinations could be made and the resulting data were qualified accordingly. In as much as duplicate data are often matrix specific and such precision measurements are not used as a rejection criteria in the EPA CLP program, poor or missing precision measurements were not automatically taken as cause for rejection of the WSSRAP data.

3.2 Validation Criteria

Listed below are the evaluation criteria that were used during data validation. Several evaluation criteria were general and were applied to all analyses. These general criteria were:

- Reject data if the analyte of interest was present in the associated analytical blank at a level that was within 10 times the level of that analyte present in the sample (per CLP).

- Accept but flag data if the analyte of interest was present in the associated analytical blank and the level in the sample of interest exceeded the level present in the blank by a factor of ten or more (per CLP).

- Accept data if the analyte of interest was present in the associated blank but was not detected in the sample of interest.

Table 3–2 WSSRAP Data Validation Qualifier List

QUALIFIER

4 (or A+)	Data meeting all QA/QC requirements.
3	Good quantitative data not meeting all objective QA/QC requirements, but are generally valid.
2	Data that are adequate for semi–quantitative comparisons (i.e. the order of magnitude of the reported value is credible, but the exactness of the value is questionable).
1	Data that are adequate for a qualitative assessment (ie. the target analyte is a real artifact, not contamination), but have no quantitative validity.
A	Acceptable, but has restrictions (has attached flags).
V	Data that appear to be valid based on good comparison to data from identical sampling locations or to data from historical records.
R	Data that are not valid.
N	Data not petitioned for validation; or validation documentation not yet received from the laboratory.
O	Validation Technical Review ON–HOLD.
P	Validation Technical Review IN–PROGRESS or PENDING.
X	Data Not Validatable.

FLAGS[1]

>	High Bias (i.e. accuracy > DQR limit)
<	Low Bias (i.e. accuracy < DQR limit)
C	Calibration/Quantitation Deficiencies
Q	Quality Control Deficiencies
I	Qualitative Deficiencies or Instrument Interferences Present
B	Contamination or High Background Present
H(#/#)	Holding Time(s) Exceeded (# days exceeded for prep/analysis)
F	Matrix–Related Interferences Present
J	Estimated Value (may be linked with other flags)
Y	Custody Deficiencies
T	Typographical or Mathematical Error Present
M	Poor Matrix Spike Recoveries (matrix accuracy)
D	Poor Duplicate RPD (precision)
?	Other (see applicable validation report)

[1] To be used in conjunction with any of the above qualifiers, except for qualifier 4 or A+, which by definition shall stand alone.

- Reject data if any analytical condition or circumstance suggested low analytical confidence (i.e. spectral interferences, poor spectral match, faulty calibrations etc.).

- Accept but flag data if any associated precision measurement exceeded the CLP 20% criteria (no flag is necessary where the analyte concentration is less than or equal to five times the applicable detection limit).

- Accept but flag any data associated with a matrix spike or matrix spike duplicate where the CLP criteria were not met ($\pm$25% recovery was used for non-CLP parameters).

- Accept but flag data if expected quality control samples (which are protocol requirements) were missing from the analytical run; reject data if the missing quality control requirements could be interpreted as standard analytical practice (i.e. control spikes, analytical blanks).

- Place on-hold any data value mismatches or omissions in the WSSRAP database that were due to transcription errors[1]. The on-hold status would be changed when the transcription error was corrected.

- Declare any data non-validatable if documentation critical to supporting the data and the analysis (i.e. instrument print-outs) were not available.

The additional analysis-specific evaluation criteria are as described in the following sections.

Anions

There were 74 samples or 254 data points involved in this validation effort for anions. These data were grouped into 66 data sets for validation purposes.

[1] If another situation existed that would reject the data or make the data non-validatable even after the transcription error or omission was corrected, the data would be rejected or declared non-validatable.

The analytical method employed by metaTRACE, Inc. was EPA 300.0, Ion Chromatography. The analytical methods employed by JTC were the EPA 300 series wet chemistry methods for the individual anions.

An analytical value for anions was accepted or rejected by data validation based on the following criteria:

- Reject data if the associated initial calibration curve was non-linear (as determined by a correlation coefficient of < 0.995).

- Reject data if the percent recovery of the daily calibration verification checks that bracket the sample of interest were $<85\%$ and the sample was non-detect (or within 10 X DL), otherwise flag. Flag if the calibration check exceeds 115%.

- Reject data if the associated analytical accuracy exceeded the WSSRAP data quality requirement (DQR) limits.

- Accept but flag data if the accuracy exceeded the laboratory control limits, as determined by QC control charts provided. If control charts are not available, use control limits of $\pm 20\%$.

- Accept but flag data if the holding time was exceeded and the sample was positive for the analyte of interest.

- Reject data if the holding time was exceeded by seven days and the sample was negative.

Metals

There were 85 samples or 1472 data points involved in this validation effort for metals. These data were grouped into 148 data sets for validation purposes.

The analytical methods employed by the laboratories were the EPA CLP inductively coupled plasma (ICAP), graphite furnace (GFAA), and cold vapor (CV) methods. Sample

preparation was in accordance with the applicable EPA CLP procedure for each particular sample matrix type.

An analytical value for metals was accepted or rejected by data validation based on the following criteria:

- Reject data if the associated initial calibration curve was non-linear (as determined by a correlation coefficient of < 0.995).

- Reject data if the daily calibration verification checks that bracket the sample of interest exceeded recovery limits of 85% to 115%; accept but flag if the checks exceeded the CLP limits of 90% to 110%.

- Reject data if the analytical accuracy exceeded the WSSRAP DQR limits or the laboratory control limits (whichever are greater).

- Accept but flag data if the accuracy exceeded the WSSRAP DQR limits or the laboratory warning limits (whichever are greater).

- Accept but flag data if the precision exceeded the DQR (and CLP) limits of 20% (or 35% for non-aqueous samples).

- Accept but flag data if the holding time was exceeded.

Miscellaneous

There were 33 samples or 42 data points in this validation effort for the miscellaneous parameters (cyanide, total organic carbon, total organic halides, grease & oil). These data were grouped into 27 data sets for validation purposes.

EPA approved methods were employed by the laboratories for these analyses. An analytical value for the miscellaneous parameters was accepted or rejected by data validation based on the following criteria:

- Reject data if the associated initial calibration curve (if applicable) was non-linear (as determined by a correlation coefficient of < 0.995).

- Reject data if the daily calibration verification checks (if applicable) that bracket the sample of interest exceeded recovery limits of 85% to 115%.

- Reject data if the associated analytical accuracy exceeded the WSSRAP DQR limits.

- Accept but flag data if the holding time was exceeded and the sample was positive for the analyte of interest.

- Reject data if the holding time was exceeded by seven days and the sample is negative.

Nitroaromatics

There were 108 samples or 654 data points involved in this validation effort for nitroaromatics. These data were grouped into 47 data sets for validation purposes.

The analytical methods employed by the laboratory were based on procedures certified by the USATHAMA, which involved sample preparation[2] and analysis by high performance liquid chromatography (HPLC).

An analytical value for nitroaromatics was accepted or rejected by data validation based on the following criteria:

- Reject data if the associated initial calibration curve is non-linear (as determined by a correlation coefficient of <0.995).

- Reject data if the daily calibration verification checks associated with the sample of interest exceeded recovery limits of 80% to 120%; accept but flag if the checks exceeded recovery limits of 85% to 115%.

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2 A solid phase extraction sample preparation method was used by metaTRACE, Inc.; JTC used a "dilute and shoot" method, while ITAS used a solvent "shake-out."

- Reject data if the associated analytical accuracy exceeded the laboratory control limits, as determined by QC control charts provided. If control charts are not available, use control limits of ±50%.

- Accept but flag data if the accuracy exceeded the laboratory warning limits, as determined by QC control charts provided. If control charts are not available, use warning limits of ±25%.

- Accept but flag data if the holding time was exceeded by 30 days or less[3].

- Reject data if the holding time is exceeded by more than 30 days.

Pesticides/PCBs

There were 77 samples or 919 data points involved in this validation effort for pesticides/PCBs. These data were grouped into 24 data sets for validation purposes.

The analytical methods employed by the laboratory were the EPA CLP procedures for sample preparation and analysis by gas chromatography (GC). Several PCB-only samples were analyzed in accordance with EPA Method 608 or SW846 Method 8080.

An analytical value for pesticides/PCBs was accepted or rejected by data validation based on the following criteria:

- Accept but flag data if the relative standard deviation of the calibration factors in the three evaluation standard mixes exceeded the CLP 10% criteria.

- Accept but flag data if the percent breakdown for endrin or DDT exceeded the CLP 20% criteria.

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[3] The 30 day holding time cut-off is based on a USATHAMA/EPA holding time study performed by Martin-Marietta which demonstrated parameter stability for up to 30 days if the samples are maintained at a temperature of 4° C.

- Accept but flag data if the percent difference of the calibration factors for each standard in the individual mixes A and B exceeded the CLP 15% criteria during the analytical run.

- Accept but flag data if the dibutylchlorendate (DBC) surrogate recoveries (accuracy) exceeded the CLP advisory limits.

- Reject data if a reported positive compound did not confirm during the conformational analysis.

- Reject data if the holding times were exceeded by more than 15 days; flag otherwise.

- Reject data if a reported positive multi-peak compound did not match the peak pattern from the compound's associated standard in the analytical run.

Radiochemical

There were 122 samples or 317 data points involved in this validation effort for radiochemical parameters. These data were grouped into 103 data sets for validation purposes.

The analytical method employed by the laboratories were from the EPA 900 series methods utilizing alpha, beta, or gamma spectrometry, as appropriate. Fluorometry (EPA 908.1) was employed by Accu-Labs for natural uranium.

An analytical value for radiochemical parameters was accepted or rejected by data validation based on the following criteria:

- Reject data if the associated analytical accuracy exceeded the WSSRAP DQR limits or laboratory control limits (whichever are greater). If control limits are not available use $\pm 25\%$.

- Accept but flag data if the accuracy exceeded the WSSRAP DQR limits or laboratory warning limits (whichever are greater). If limits are not available, use $\pm 20\%$.

Semi-Volatile Organics

There were 81 samples or 5,265 data points involved in this validation effort for semi-volatile organics. These data were grouped into 39 data sets for validation purposes.

The analytical methods employed by the laboratories were the EPA CLP procedures for sample preparation and analysis by gas chromatography/mass spectrometry (GC/MS).

An analytical value for semi-volatile organics was accepted or rejected by data validation based on the following criteria:

- Initial and continuing (or daily) calibrations were evaluated and qualified as described in Appendix G.
- Reject all acid compounds if the acid surrogate recoveries did not meet the CLP criteria.
- Reject all base/neutral compounds if the base/neutral surrogate recoveries did not meet the CLP criteria.
- Reject all compounds associated with an internal standard if the CLP criteria for that internal standard were not met.
- Accept but flag all associated compounds if the surrogate compounds in the associated blank were low and did not meet the CLP criteria.
- Accept but flag all associated compounds if the internal standard area counts in the associated blank exceeded the CLP upper limits.
- Reject all data if the CLP instrument tuning criteria were not met.
- Reject all data if the holding times were exceeded by more than 15 days; flag otherwise.

Volatile Organics

There were 81 samples or 2,924 data points involved in this validation effort for volatile organics. These data were grouped into 27 data sets for validation purposes.

The analytical methods employed by the laboratories were the EPA CLP procedures for sample preparation and analysis by gas chromatography/mass spectrometry (GC/MS).

An analytical value for volatile organics was accepted or rejected by data validation based on the following criteria:

- Initial and continuing (or daily) calibrations were evaluated and qualified as described in Appendix G.
- Reject all compounds if the surrogate recoveries did not meet the CLP criteria.
- Reject all compounds associated with an internal standard if the CLP criteria for that internal standard were not met.
- Accept but flag all compounds if the surrogate compounds in the associated blank were low and did not meet the CLP criteria.
- Accept but flag all associated compounds if the internal standard area counts in the associated blank exceeded the CLP upper limits.
- Reject all data if the CLP instrument tuning criteria were not met.
- Reject all data if the holding times were exceeded by more than 15 days; flag otherwise.

3.3 Validation Results

Table 3-3 summarizes the validation qualifiers that were assigned to the data points associated with the 12K data point validation project. These qualifiers are presented for all laboratories associated with these data, and independently for metaTRACE, Inc., JTC/Accu-labs, and ITAS.

Of the 11,847 total data points referenced in Table 3-3, 80.5% are accepted, 10.4% rejected, 5.9% validated by reference, and 3.2% are not validatable. The data points that were "validated by reference" consist of 486 pesticide/PCB and 217 nitroaromatic data points that were judged for useability by comparison to similar samples collected in the check sample program (discussed in Section 4 of this report). The non-validatable percentage represents analyses where essential laboratory documentation (i.e., instrument printouts associated with the analyses) could not be located. These analyses were not rejected (unless other circumstances associated with the analysis were present that would have rejected the analysis even if the missing documentation was present), but were not accepted since the supporting documentation was missing.

Table 3-4 summarizes the accuracy and precision for each parameter in the 12K data points. The accuracy and precision values are the average from all data sets for each parameter, where n is equal to each data population size. The accuracy values for aqueous, non-aqueous, and total samples are listed as a $\pm$ percentage from 100% (where 100% or $\pm$0% represents the best accuracy). The precision values for aqueous, non-aqueous, and total samples are listed as a percentage from 0% (where 0% represents the best precision). In cases where a sample of a particular matrix was not included with the 12K data points, a "None" is listed. In cases where precision or accuracy measurements are not available (i.e. due to missing analytical QC) a "****" is listed.

In general, the accuracy and precision values listed in Table 3-4 were within the DQR limits and within the range expected for the types of analyses and matrices involved. However, a number of values are worth discussion:

1. The 51% precision for nitrate in non-aqueous samples (with a data population of 17) was influenced by the 121.5% precision for five samples in dataset 41 and the 141.7%

Table 3–3 Data Validation Qualifier Summary

All Labs

# of datapoints	Anions	Metals	Misc.	Nitros	Pest/ PCB	Radio– chem.	Semi– VOA	VOA	Total
Accepted (A)	208	1073	33	240	369	235	4649	2724	**9531**
Valid by Ref. (V)	0	0	0	215	486	0	0	0	**701**
On–Hold (O)	0	0	0	0	0	0	0	0	**0**
Non–Validatable (X)	5	159	3	60	22	63	32	34	**378**
Rejected (R)	41	240	6	139	42	19	584	166	**1237**
Total	**254**	**1472**	**42**	**654**	**919**	**317**	**5265**	**2924**	**11847**

Percentages	Anions	Metals	Misc.	Nitros	Pest/ PCB	Radio– chem.	Semi– VOA	VOA	Total
Accepted (A)	81.9%	72.9%	78.6%	36.7%	40.2%	74.1%	88.3%	93.2%	**80.5%**
Valid by Ref. (V)	0.0%	0.0%	0.0%	32.9%	52.9%	0.0%	0.0%	0.0%	**5.9%**
On–Hold (O)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Non–Validatable (X)	2.0%	10.8%	7.1%	9.2%	2.4%	19.9%	0.6%	1.2%	**3.2%**
Rejected (R)	16.1%	16.3%	14.3%	21.3%	4.6%	6.0%	11.1%	5.7%	**10.4%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

% Completeness	83.5%	81.7%	84.6%	76.6%	95.3%	92.5%	88.8%	94.3%	89.2%

Table 3–3 Data Validation Qualifier Summary (cont'd)

metaTRACE, Inc.

# of datapoints	Anions	Metals	Misc.	Nitros	Pest/ PCB	Radio– chem.	Semi– VOA	VOA	Total
Accepted (A)	172	941	22	0	0	105	2639	1380	**5259**
Valid by Ref. (V)	0	0	0	215	486	0	0	0	**701**
On–Hold (O)	0	0	0	0	0	0	0	0	**0**
Non–Validatable (X)	4	157	2	12	0	60	32	0	**267**
Rejected (R)	25	233	1	67	42	9	579	116	**1072**
Total	**201**	**1331**	**25**	**294**	**528**	**174**	**3250**	**1496**	**7299**

Percentages	Anions	Metals	Misc.	Nitros	Pest/ PCB	Radio– chem.	Semi– VOA	VOA	Total
Accepted (A)	85.6%	70.7%	88.0%	0.0%	0.0%	60.3%	81.2%	92.2%	**72.1%**
Valid by Ref. (V)	0.0%	0.0%	0.0%	73.1%	92.0%	0.0%	0.0%	0.0%	**9.6%**
On–Hold (O)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Non–Validatable (X)	2.0%	11.8%	8.0%	4.1%	0.0%	34.5%	1.0%	0.0%	**3.7%**
Rejected (R)	12.4%	17.5%	4.0%	22.8%	8.0%	5.2%	17.8%	7.8%	**14.7%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

% Completeness	87.3%	80.2%	95.7%	76.2%	92.0%	92.1%	82.0%	92.2%	84.8%

Table 3–3 Data Validation Qualifier Summary (cont'd)

JTC / Accu–Labs

# of datapoints	Anions	Metals	Misc.	Nitros	Pest/ PCB	Radio– chem.	Semi– VOA	VOA	Total
Accepted (A)	36	104	11	6	124	88	64	33	**466**
Valid by Ref. (V)	0	0	0	0	0	0	0	0	**0**
On–Hold (O)	0	0	0	0	0	0	0	0	**0**
Non–Validatable (X)	1	2	1	48	15	3	0	34	**104**
Rejected (R)	16	7	5	60	0	10	1	1	**100**
Total	**53**	**113**	**17**	**114**	**139**	**101**	**65**	**68**	**670**

Percentages	Anions	Metals	Misc.	Nitros	Pest/ PCB	Radio– chem.	Semi– VOA	VOA	Total
Accepted (A)	67.9%	92.0%	64.7%	5.3%	89.2%	87.1%	98.5%	48.5%	**69.6%**
Valid by Ref. (V)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
On–Hold (O)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Non–Validatable (X)	1.9%	1.8%	5.9%	42.1%	10.8%	3.0%	0.0%	50.0%	**15.5%**
Rejected (R)	30.2%	6.2%	29.4%	52.6%	0.0%	9.9%	1.5%	1.5%	**14.9%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

% Completeness	69.2%	93.7%	68.8%	9.1%	100.0%	89.8%	98.5%	97.1%	82.3%

Table 3–3 Data Validation Qualifier Summary (cont'd)

IT Analytical Services

# of datapoints	Anions	Metals	Misc.	Nitros	Pest/ PCB	Radio– chem.	Semi– VOA	VOA	Total
Accepted (A)	0	28	0	234	245	42	1946	1311	**3806**
Valid by Ref. (V)	0	0	0	0	0	0	0	0	**0**
On–Hold (O)	0	0	0	0	0	0	0	0	**0**
Non–Validatable (X)	0	0	0	0	7	0	0	0	**7**
Rejected (R)	0	0	0	12	0	0	4	49	**65**
Total	**0**	**28**	**0**	**246**	**252**	**42**	**1950**	**1360**	**3878**

Percentages	Anions	Metals	Misc.	Nitros	Pest/ PCB	Radio– chem.	Semi– VOA	VOA	Total
Accepted (A)	0.0%	100.0%	0.0%	95.1%	97.2%	100.0%	99.8%	96.4%	**98.1%**
Valid by Ref. (V)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
On–Hold (O)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Non–Validatable (X)	0.0%	0.0%	0.0%	0.0%	2.8%	0.0%	0.0%	0.0%	**0.2%**
Rejected (R)	0.0%	0.0%	0.0%	4.9%	0.0%	0.0%	0.2%	3.6%	**1.7%**
Total	**0.0%**	**100.0%**	**0.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

% Completeness		100.0%		95.1%	100.0%	100.0%	99.8%	96.4%	98.3%

Table 3–4 Accuracy & Precision Summary from Validation of the 12K Data Points[1] (cont'd)

	Aqueous				Non–Aqueous				Total			
NITROAROMATICS	**% Acc.**	**n**	**% Prec.**	**n**	**% Acc.**	**n**	**% Prec.**	**n**	**% Acc.**	**n**	**% Prec.**	**n**
1,3,5–TRINITROBENZENE	± 22.8	33	0.8	13	± 8.3	61	6.5	17	± 13.4	94	4.0	30
1,3–DINITROBENZENE	± 22.3	35	0.9	15	± 1.7	61	10.2	17	± 9.2	96	5.8	32
2,4,6–TNT	± 19.2	36	0.9	16	± 1.2	61	15.4	17	± 7.9	97	8.4	33
2,4–DNT	± 15.6	36	2.9	16	± 1.6	61	4.2	17	± 4.8	97	3.5	33
2,6–DNT	± 19.5	36	2.7	16	± 11.6	61	5.7	17	± 0.1	97	4.2	33
NITROBENZENE	± 19.5	36	1.9	16	± 2.1	55	1.8	11	± 6.5	91	1.8	27
RADIOCHEMICAL												
GROSS ALPHA	± 14.5	7	34.9	4	None	0	None	0	± 14.5	7	34.9	4
GROSS BETA	± 7.3	1	28.9	1	None	0	None	0	± 7.3	1	28.9	1
LEAD–210	± 58.9	4	9.2	4	± 4.0	2	8.0	2	± 40.6	6	8.8	6
RADIUM–226	± 6.3	22	3.9	14	± 32.7	12	38.1	11	± 7.5	34	18.9	25
RADIUM–228	± 27.5	5	28.9	5	± 24.9	2	21.0	2	± 26.8	7	26.6	7
THORIUM–228	± 15.6	5	****	5	± 0.9	8	88.3	6	± 6.6	13	88.3	6
THORIUM–230	± 4.9	24	28.8	19	± 40.8	9	17.5	24	± 14.7	33	22.5	43
THORIUM–232	± 11.3	22	55.3	16	± 15.2	13	36.6	11	± 1.5	35	47.7	27
URANIUM, TOTAL	± 11.8	69	12.1	54	± 9.7	11	8.9	7	± 11.5	80	11.7	61
URANIUM–234	None	0	None	0	± 18.9	27	33.2	13	± 18.9	27	33.2	13
URANIUM–235	None	0	None	0	± 9.2	18	34.5	11	± 9.2	18	34.5	11
URANIUM–238	None	0	None	0	± 19.8	27	39.7	13	± 19.8	27	39.7	13
PESTICIDES/PCBs												
4,4'–DDD	± 104.0	1	****	1	± 31.4	13	0.5	8	± 36.6	14	0.5	8
4,4'–DDE	± 104.0	1	****	1	± 31.4	13	0.0	15	± 36.6	14	0.0	15
4,4'–DDT	± 104.0	1	****	1	± 31.4	13	11.8	14	± 36.6	14	11.8	14
ALDRIN	± 104.0	1	****	1	± 31.4	13	37.9	15	± 36.6	14	37.9	15
ALPHA–BHC	± 104.0	1	****	1	± 31.4	13	0.0	14	± 36.6	14	0.0	14
ALPHA–CHLORDANE	± 104.0	1	****	1	± 31.4	13	0.0	14	± 36.6	14	0.0	14
AROCLOR–1016	± 104.0	1	****	1	± 8.1	67	8.1	58	± 9.5	68	8.1	58
AROCLOR–1221	± 104.0	1	****	1	± 8.1	67	8.1	58	± 9.5	68	8.1	58
AROCLOR–1232	± 104.0	1	****	1	± 8.1	67	8.1	58	± 9.5	68	8.1	58
AROCLOR–1242	± 104.0	1	****	1	± 8.1	67	8.1	58	± 9.5	68	8.1	58
AROCLOR–1248	± 104.0	1	****	1	± 8.1	67	8.1	58	± 9.5	68	8.1	58
AROCLOR–1254	± 104.0	1	****	1	± 8.1	67	8.1	58	± 9.5	68	8.1	58
AROCLOR–1260	± 104.0	1	****	1	± 8.1	67	8.1	58	± 9.5	68	8.1	58
BETA–BHC	± 104.0	1	****	1	± 31.4	13	2.4	12	± 36.6	14	2.4	12
DELTA–BHC	± 104.0	1	****	1	± 31.4	13	0.0	15	± 36.6	14	0.0	15
DIELDRIN	± 104.0	1	****	1	± 31.4	13	13.1	14	± 36.6	14	13.1	14
ENDOSULFAN I	± 104.0	1	****	1	± 31.4	13	0.0	9	± 36.6	14	0.0	9
ENDOSULFAN II	± 104.0	1	****	1	± 31.4	13	0.0	14	± 36.6	14	0.0	14
ENDOSULFAN SULFATE	± 104.0	1	****	1	± 31.4	13	10.4	15	± 36.6	14	10.4	15
ENDRIN	± 104.0	1	****	1	± 31.4	13	10.3	14	± 36.6	14	10.3	14
ENDRIN KETONE	± 104.0	1	****	1	± 31.4	13	0.0	12	± 36.6	14	0.0	12
GAMMA–BHC (LINDANE)	± 104.0	1	****	1	± 31.4	13	39.8	15	± 36.6	14	39.8	15
GAMMA–CHLORDANE	± 104.0	1	****	1	± 31.4	13	1.3	10	± 36.6	14	1.3	10
HEPTACHLOR	± 104.0	1	****	1	± 31.4	13	38.3	15	± 36.6	14	38.3	15
HEPTACHLOR EPOXIDE	± 104.0	1	****	1	± 31.4	13	0.0	15	± 36.6	14	0.0	15
METHOXYCHLOR	± 104.0	1	****	1	± 31.4	13	0.0	15	± 36.6	14	0.0	15
TOXAPHENE	± 104.0	1	****	1	± 31.4	13	0.0	15	± 36.6	14	0.0	15

Table 3–4 Accuracy & Precision Summary from Validation of the 12K Data Points[1] (cont'd)

	Aqueous				Non–Aqueous				Total			
SEMI–VOLATILES	% Acc.	n	% Prec.	n	% Acc.	n	% Prec.	n	% Acc.	n	% Prec.	n
1,2,4–TRICHLOROBENZENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
1,2–DICHLOROBENZENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
1,3–DICHLOROBENZENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
1,4–DICHLOROBENZENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
2,4,5–TRICHLOROPHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
2,4,6–TRICHLOROPHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
2,4–DICHLOROPHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
2,4–DIMETHYLPHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
2,4–DINITROPHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
2,4–DINITROTOLUENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
2,6–DINITROTOLUENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
2–CHLORONAPHTHALENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
2–CHLOROPHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
2–METHYLNAPHTHALENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
2–METHYLPHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
2–NITROANILINE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
2–NITROPHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
3,3'–DICHLOROBENZIDINE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
3–NITROANILINE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
4,6–DINITRO–2–METHYLPHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
4–BROMOPHENYL PHENYL ETHER	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
4–CHLORO–3–METHYL PHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
4–CHLOROANILINE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
4–CHLOROPHENYL PHENYL ETHER	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
4–METHYLPHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
4–NITROANILINE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
4–NITROPHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
ACENAPHTHENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
ACENAPHTHYLENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
ANTHRACENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
BENZO(A)ANTHRACENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
BENZO(A)PYRENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
BENZO(B)FLUORANTHENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
BENZO(G,H,I)PERYLENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
BENZO(K)FLUORANTHENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
BENZOIC ACID	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
BENZYL ALCOHOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
BIS(2–CHLOROETHOXY)METHANE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
BIS(2–CHLOROETHYL)ETHER	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
BIS(2–CHLOROISOPROPYL)ETHER	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
BIS(2–ETHYLHEXYL)PHTHALATE	± 9.9	27	17.1	7	± 33.8	54	5.9	16	± 25.8	81	9.3	23
BUTYLBENZYLPHTHALATE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
CHRYSENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
DI–N–BUTYLPHTHALATE	± 9.9	27	17.1	7	± 33.8	54	4.1	16	± 25.8	81	8.1	23
DI–N–OCTYLPHTHALATE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
DIBENZO(A,H)ANTHRACENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
DIBENZOFURAN	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
DIETHYLPHTHALATE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
DIMETHYLPHTHALATE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
FLUORANTHENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25

Table 3–4 Accuracy & Precision Summary from Validation of the 12K Data Points[1]

	Aqueous				Non–Aqueous				Total			
ANIONS	% Acc.	n	% Prec.	n	% Acc.	n	% Prec.	n	% Acc.	n	% Prec.	n
CHLORIDE	± 0.4	33	1.3	17	± 7.4	21	20.7	11	± 2.6	54	8.9	28
FLUORIDE	± 3.4	28	2.7	17	± 0.5	24	6.3	15	± 2.1	52	4.4	32
NITRATE	± 5.5	31	6.4	18	± 2.0	22	51.0	17	± 2.4	53	28.0	35
NITRITE	± 11.1	2	****	2	± 11.1	24	8.6	14	± 11.1	26	8.6	14
SULFATE	± 1.4	33	8.7	17	± 3.6	25	15.6	16	± 2.4	58	12.0	33
METALS												
ALUMINUM	± 0.7	26	1.9	9	± 4.2	20	14.0	17	± 1.4	46	9.8	26
ANTIMONY	± 3.6	26	0.0	9	± 10.2	20	0.6	17	± 6.5	46	0.4	26
ARSENIC	± 2.2	29	0.0	11	± 0.6	23	20.2	19	± 1.0	52	12.8	30
BARIUM	± 3.1	26	0.5	10	± 3.1	11	14.8	11	± 3.1	37	8.0	21
BERYLLIUM	± 1.7	27	0.0	10	± 2.0	18	8.0	15	± 1.8	45	4.8	25
CADMIUM	± 1.1	26	0.0	9	± 2.2	18	6.5	10	± 1.5	44	3.4	19
CALCIUM	± 1.9	26	5.0	9	± 4.9	18	10.1	14	± 0.9	44	8.1	23
CHROMIUM	± 2.2	33	8.3	16	± 0.5	19	54.8	15	± 1.2	52	30.8	31
COBALT	± 2.6	26	0.0	9	± 1.9	18	0.0	10	± 0.8	44	0.0	19
COPPER	± 0.6	26	0.0	9	± 5.0	18	16.6	15	± 1.7	44	10.3	24
IRON	± 0.6	26	4.1	6	± 4.7	20	39.3	17	± 1.7	46	30.1	23
LEAD	± 4.9	25	4.0	8	± 3.9	29	29.6	20	± 0.2	54	22.3	28
LITHIUM	± 10.3	26	0.0	10	± 35.3	12	0.0	19	± 18.2	38	0.0	29
MAGNESIUM	± 0.2	26	5.4	9	± 2.8	20	9.6	16	± 1.3	46	8.1	25
MANGANESE	± 0.8	26	1.3	9	± 1.6	20	33.7	17	± 0.2	46	22.5	26
MERCURY	± 2.3	8	7.0	21	± 4.0	26	2.1	15	± 2.5	34	5.0	36
MOLYBDENUM	± 2.1	26	0.0	9	± 0.9	15	22.4	12	± 1.7	41	12.8	21
NICKEL	± 1.1	33	0.0	16	± 5.3	19	15.4	14	± 2.7	52	7.2	30
POTASSIUM	± 6.5	26	0.8	9	± 6.9	9	0.0	10	± 3.1	35	0.4	19
SELENIUM	± 3.8	23	4.6	7	± 7.8	30	9.0	28	± 6.1	53	8.1	35
SILVER	± 52.6	25	0.0	9	± 12.6	31	0.0	15	± 30.4	56	0.0	24
SODIUM	± 1.0	26	5.4	9	± 2.1	9	5.8	15	± 0.2	35	5.6	24
THALLIUM	± 6.5	25	0.0	9	± 0.4	24	6.4	20	± 3.5	49	4.4	29
VANADIUM	± 4.9	26	0.0	9	± 6.2	18	17.5	14	± 5.4	44	10.6	23
ZINC	± 4.1	26	0.6	8	± 1.3	18	12.7	15	± 1.9	44	8.5	23
ZIRCONIUM	± 16.3	1	****	1	± 18.4	24	12.4	16	± 18.3	25	12.4	16
MISCELLANEOUS												
BIOCHEMICAL OXYGEN DEMAND	None	0	None	0	None	0	None	0	None	0	None	0
CYANIDE	None	0	None	0	± 1.5	3	0.0	2	± 1.5	3	0.0	2
OIL & GREASE	None	0	None	0	± 3.3	4	****	4	± 3.3	4	****	4
PERCENT SOLID	NA	0	NA	0	****	4	1.6	4	****	4	1.6	4
PH	None	0	None	0	± 1.8	2	0.8	2	± 1.8	2	0.8	2
TOTAL DISSOLVED SOLIDS	None	0	None	0	± 2.0	1	1.2	1	± 2.0	1	1.2	1
TOTAL ORGANIC CARBON	± 1.6	14	9.1	9	± 4.7	3	0.0	2	± 2.2	17	7.4	11
TOTAL SUSPENDED SOLIDS	± 7.4	5	0.0	5	NA	0	NA	0	± 7.4	5	0.0	5
TOX	None	0	None	0	± 5.3	5	0.0	4	± 5.3	5	0.0	4

Table 3–4 Accuracy & Precision Summary from Validation of the 12K Data Points[1] (cont'd)

	Aqueous				Non–Aqueous				Total			
SEMI–VOLATILES (cont'd)	% Acc.	n	% Prec.	n	% Acc.	n	% Prec.	n	% Acc.	n	% Prec.	n
FLUORENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
HEXACHLOROBENZENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
HEXACHLOROBUTADIENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
HEXACHLOROCYCLOPENTADIENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
HEXACHLOROETHANE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
INDENO(1,2,3–CD)PYRENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
ISOPHORONE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
N–NITROSO–DI–N–PROPYLAMINE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
N–NITROSODIPHENYLAMINE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
NAPHTHALENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
NITROBENZENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
PENTACHLOROPHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
PHENANTHRENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25
PHENOL	± 53.2	27	17.1	7	± 33.3	54	3.4	18	± 39.9	81	7.3	25
PYRENE	± 9.9	27	17.1	7	± 33.8	54	3.7	18	± 25.8	81	7.4	25

Table 3–4 Accuracy & Precision Summary from Validation of the 12K Data Points[1] (cont'd)

VOLATILES	Aqueous				Non–Aqueous				Total			
	% Acc.	n	% Prec.	n	% Acc.	n	% Prec.	n	% Acc.	n	% Prec.	n
1,1,1–TRICHLOROETHANE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
1,1,2,2–TETRACHLOROETHANE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
1,1,2–TRICHLOROETHANE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
1,1–DICHLOROETHANE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
1,1–DICHLOROETHENE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
1,2–DICHLOROETHANE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
1,2–DICHLOROETHENE (TOTAL)	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
1,2–DICHLOROPROPANE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
2–BUTANONE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
2–HEXANONE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
4–METHYL–2–PENTANONE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
ACETONE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
BENZENE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
BROMODICHLOROMETHANE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
BROMOFORM	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
BROMOMETHANE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
CARBON DISULFIDE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
CARBON TETRACHLORIDE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
CHLOROBENZENE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
CHLOROETHANE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
CHLOROFORM	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
CHLOROMETHANE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
CIS–1,3–DICHLOROPROPENE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
DIBROMOCHLOROMETHANE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
ETHYL BENZENE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
METHYLENE CHLORIDE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
STYRENE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
TETRACHLOROETHENE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
TOLUENE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
TRANS–1,3–DICHLOROPROPENE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
TRICHLOROETHENE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
VINYL ACETATE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
VINYL CHLORIDE	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44
XYLENES, TOTAL	± 0.2	27	2.5	17	± 1.8	59	4.0	27	± 1.3	86	3.4	44

**** – Value not available due to missing analytical QC (ie. analytical duplicates, control sample)

None – No samples of this matrix in the data group.

NA – Analysis not applicable to this matrix.

n – Data Population.

% Acc. – Based on percent recovery (subtracted from 100%) of the target compound or surrogate compounds in the control sample, matrix spike or target sample (surrogates).

% Prec. – Based on % difference of the target compound concentration or surrogate recoveries from analytical duplicates or MS/MSD pair.

[1] All accuracy and precision values relating to CLP parameters are within the acceptance range as defined by EPA CLP protocols, except for those discussed in Section 3 of this report. Attachment A contains the WSSRAP Data Quality Requirments (DQRs) for comparison to the accuracy and precision values in this table.

precision for one sample in dataset 42. These two occurrences (datasets) may reflect sample non-homogeneity that is typically seen in non-aqueous samples.

2. The 54.8% precision for chromium in non-aqueous samples (with a data population of 15) was influenced by the 124% precision for three samples and a matrix spike/matrix spike duplicate (MS/MSD) pair in dataset 277 and the 71.4% precision for one sample in dataset 273. The 39.3% precision for iron in non-aqueous samples (with a data population of 17) was influenced by the 72.7% precision for four samples and one field duplicate in dataset 278 and the 114.6% precision for one sample in dataset 1,016. In each of these cases, sample non-homogeneity is suspected.

3. The ±35.3% accuracy for lithium in non-aqueous samples (with a data population of 12) was influenced by the 23.8% recovery of the control sample for five samples in dataset 269. This probably reflects poor sample preparation and the lithium datapoints for those five samples in the dataset have been rejected by data validation.

4. The ±52.6% accuracy for silver in aqueous samples (with a data population of 25) was influenced by the 52% control sample recovery for three samples in dataset 259, by the 6.0% control sample recovery for one sample in dataset 307, and by the 4.0% control sample recovery for 10 samples in dataset 297. The poor recoveries of these control samples probably reflect poor sample preparation (i.e., loss of silver as AgCl during digestion) or reflects inductively coupled plasma (ICP) spectral interferences. All 14 data points have been rejected by data validation.

5. The ±58.9% accuracy for Lead-210 in aqueous samples (with a data population of four) was influenced by the 158.9% control spike recovery for four samples in dataset 119. Control charts were not available for this analysis and the quality of the resulting recovery is uncertain. Due to this uncertainty and the fact that the 158.9% recovery may reflect poor sample preparation, the four datapoints have been rejected by data validation.

6. The ±32.7% accuracy for Radium-226 in non-aqueous samples (with a data population of 12) was influenced by the 57% control sample recovery for two samples in dataset 91; by the 48.2% control sample recovery for two samples in dataset 87; by the 56.4% control sample recovery for one sample in dataset 89; by the 59.3% control sample

recovery for one sample in dataset 90; and by the 77.9% control sample recovery for one sample in dataset 86. All five sets of analyses were done by radon-emanation, which according to the control charts provided by the laboratory, has lower recoveries compared to gas proportional counting. All associated datapoints have been properly flagged by data validation.

7. The ±27.5% accuracy for Radium-228 in aqueous samples (with a data population of five) was influenced by the 125.6% control sample recovery for one sample in dataset 914 and the 128% control sample recovery for four samples in dataset 99. All associated datapoints have been properly flagged by data validation.

8. The 28.9% precision for Radium-228 in aqueous samples (with a data population of five) was influenced by the 144.5% precision for one sample in dataset 914. This datapoint has been properly flagged by data validation.

9. The 88.3% precision for Thorium-228 in non-aqueous samples (with a data population of six) was influenced by the 88.3% precision for two samples in dataset 919. This may reflect sample non-homogeneity; both datapoints have been properly flagged.

10. The 28.8% precision for Thorium-230 in aqueous samples (with a data population of 19) was influenced by the 285% precision for one sample in dataset 941 and by the 52.4% precision for five samples in dataset 928. Sample preparation is suspect; all six datapoints have been properly flagged by data validation.

11. The ±40.8% accuracy for Thorium-230 in non-aqueous samples (with a data population of nine) was influenced by the 179.6% control sample recovery for one sample in dataset 100, and by the 78.1% control sample recovery for two samples in dataset 919. These recoveries probably reflect the efficiency of the sample preparation for the analysis. Due to the large deviation in recovery of the control sample in dataset 100, the target Thorium-230 datapoint in that dataset had been rejected by data validation. All three associated datapoints in the discussion have been properly flagged by data validation.

12. The 55.3% precision for Thorium-232 in aqueous samples (with a data population of 16) was influenced by the 177.0% precision for five samples in dataset 928. Sample preparation is suspect; all five datapoints have been properly flagged.

13. The ±104% accuracy for pesticides and polychlorinated biphenyls (PCBs) in aqueous samples is influenced by the 204% DBC surrogate recovery in the single target sample in the aqueous population. Due to the lack of available aqueous pesticide and PCB samples, or to the lack of available complete laboratory documentation, a larger data population was not possible. For the single sample in question (from dataset 196), the DBC surrogate recovery exceeds the CLP advisory upper limit of 175%; the data for this sample have been properly flagged by data validation.

For the volatile and semi-volatile parameters, the accuracy and precision values are within the ranges typically seen for the type of analysis. For example, the accuracies listed for the acid parameters (±53.2% for aqueous and ±33.3% for non-aqueous) and for the base/neutral parameters (±9.9% for aqueous and ±33.8% for non-aqueous) are within the acceptance ranges established from CLP (which averages ±86% for acid compounds and ±63% for base neutral compounds).

During the validation of the 12K data points, numerous problems surfaced; however, most of these problems were resolved. The most widespread problem related to missing laboratory documentation. A major effort was undertaken by the PMC to gather all WSSRAP documentation from the contract laboratories, and most of this documentation was collected. However, several pieces were not located, which has resulted in some of the data points (3.2%) being declared non-validatable (X). Listed below are several other problems that were analysis-specific:

1. Numerous manual integrations were observed with the volatile and semi-volatile data. Manual integrations occurred when the instrument operator over-rode the instrument's software integration technique which could have allowed calibration bias to enter into the analysis. However, "pictures" of these manual integrations were obtained from the laboratory, which allowed the validation team to determine which integrations were acceptable and which were not. Corrections to the data were made for the improper integrations and evaluations of the data were based on the corrected analyses.

2. Only one nitroaromatic initial calibration curve was used for compound quantitation by metaTRACE for a period of at least 13 months. This single calibration curve was applied to all but two of the metaTRACE nitroaromatic data sets. Instrument stability over that span of time is extremely unusual. According to USATHAMA protocol, a new

initial calibration is required at instrument start-up, after any instrument or column maintenance, or when the daily calibration check fails to meet the laboratory established limits. For several of the affected data sets, the daily calibration checks did not meet the acceptance criteria, and instrument maintenance by a service representative was noted during that 13 month period. Since a new calibration curve was not established, the sensitivity or ability of the instrument to detect nitroaromatic compounds at the reported detection limits was uncertain to the validation team. As such, the reliability of the nitroaromatic data (and particularly the "non-detects") in 31 of 33 metaTRACE data sets were in question.

To resolve this uncertainty, additional nitroaromatic samples were collected in a check sample program that is discussed further in Section 4 of this report, and the resulting data were validated and compared to the metaTRACE data. Except for two data points, there was complete agreement among the data. The non-detects reported by metaTRACE remained as non-detects from the check sample program, thus adding confidence and support to the viability and sensitivity of the single metaTRACE initial calibration curve used over the 13 month period. The nitroaromatic data in the affected metaTRACE data sets have been validated by reference (V) to the check sample data. The qualifier summary on Table 3-3 reflects these reference approvals.

Of the two conflicting data points, both were associated with sample S2-051280, 100890-2.0,4.0. MetaTRACE reported 1.21 μg/g for 1,3,5-TNT while the check sample was a non-detect. Since the 1.21 μg/g value is on the low end of the calibration curve, this value has been determined to be too unreliable and has been rejected by the validation team. For 2,4,6-TNT, metaTRACE reported 647 μg/g while the check sample yielded a non-detect. The metaTRACE instrument chromatogram was reviewed again by the validation team, and again confirmed the presence of 2,4,6-TNT. This discrepancy may suggest sample non-homogeneity. However, due to the poor comparison to the check sample data and the qualitative uncertainty of the chromatographic peak being 2,4,6-TNT, the metaTRACE data point has been rejected by the validation team.

3. Instrument calibration and sensitivity for the metaTRACE pesticide/PCB analyses were uncertain. To resolve this uncertainty, additional samples for PCB analysis were collected in the check sample program and the resulting data validated and compared with the metaTRACE PCB data. For all sample matrices except soils, the comparisons

matched. As such, the data from the associated metaTRACE data sets have been validated by reference to the check sample data. Table 3-3 reflects these reference approvals. However for soils, the data comparisons were poor in approximately 50% of the soil samples analyzed for PCBs in the check sample program. Significant quantities (ranging from 50 μg/kg to 38,000 μg/kg) of Aroclors 1260 and/or 1254 were observed in the check samples where non-detects were reported by metaTRACE in corresponding samples. The significant quantities of PCBs and the 50% poor match does not lend support to the uncertainty associated with the metaTRACE calibrations. The poor comparison could possibly reflect sample non-homogeneity, but this fact is uncertain. As such, the metaTRACE pesticide/PCB data associated with the soils in the 12K data points have been rejected by the validation team.

4. A large percentage of the laboratory documentation needed for validating the isotopic thorium analyses by metaTRACE was not located during the documentation search performed by both metaTRACE and the PMC. In particular, most of the Thorium-229 tracer counts were missing, which directly impacts validating the efficiency of the isotopic thorium analyses. Though these data points are not validatable, their rejection is not certain since the percent acceptance of the validatable data population for isotopic thorium is high (82%).

5. For many of the metals analyses, some of the CLP required QC samples (i.e. serial dilutions, end-of-run interference check samples, post-digestion spikes) were not included in the analytical runs. Though important, their absence has not hindered evaluation of the data. These data were evaluated, but flagged as not following CLP protocol.

6. For anions, all metaTRACE analyses were done by ion chromatography which requires an unpreserved sample. The holding time for nitrate on an unpreserved sample is 48 hours (as opposed to 28 days for a preserved sample). For this reason, the holding time was generally exceeded for all nitrate analyses. In addition, the routine end-of-run calibration verification check was not always included. Those data have been flagged accordingly.

Detailed print-outs of the 12K data point validation findings are available in appendixes A through D under separate cover. These findings have been arranged by WSSRAP ID and by analytical category. For each data point, the following information has been provided.

a. WSSRAP sample ID.
b. Sample percent solids (if applicable).
c. Validation dataset number and sequence number.
d. Laboratory code and analysis request number (if available).
e. Laboratory sample ID number.
f. Parameter.
g. Analytical category.
h. Analytical concentration ($\pm$Rad. error) in WSSRAP GURU database.
i. Analytical concentration ($\pm$Rad. error) from validation review.
j. Analytical detection limit in WSSRAP GURU database.
k. Analytical detection limit from validation review.
l. Validation qualifier and flags.
m. Validation comments (if any).
n. Analytical accuracy and precision.

4 CHECK SAMPLING PROGRAM DESCRIPTION

This section contains a discussion of the results of quality assurance (QA) samples collected and analyzed by secondary laboratories as well as the rationale, procedures, and results of the check sampling program.

4.1 Quality Assurance Sample Results

Quality assurance (QA) samples were collected throughout all site characterization and routine environmental monitoring activities at the Weldon Spring Site Remedial Action Project (WSSRAP). Two types of QA samples were used to support data validation activities; duplicate samples, which were analyzed by the same laboratory as the original sample, and replicate samples which were analyzed by a different laboratory.

Duplicate and replicate samples were collected at the same time and in the same manner as regular samples. Generally, both duplicate and replicate samples were collected at the frequency of one sample per 20 regular samples. Replicate samples were not collected for raffinate sludges due to constraints on the analysis of radioactive materials. The results of QA samples were generally presented in the data reports. Numerous reports generically summarize the QA sample results by stating the general agreement between QA samples and regular samples and present the QA sample results in an appendix or table. The number of samples collected and analyzed to evaluate interlaboratory variability is summarized in Table 4-1. QA sample results were statistically evaluated in the Phase II Chemical Soil Investigation. The results are discussed in detail in the following paragraphs.

Duplicate and replicate samples were collected during the Phase II Chemical Soil Investigation. A detailed analysis was performed for those compounds with sufficient detected concentrations. Duplicate samples from this investigation yielded an average relative percent difference of 23.6% for metals analyses and 21.1% for inorganic anions. This general agreement indicates that the primary laboratory performed analyses in a consistent manner. The average relative percent difference for replicate samples was 25%. This general agreement between laboratories indicates that the analyses were performed consistent with the required analytical methods. Also, a combined total of 65 volatile organic, semi-volatile organic and pesticide and polychlorinated biphenyl (PCB) analyses performed by the secondary laboratory

Table 4-1 Summary of Samples Collected to Assess Interlaboratory Variability

WATER SAMPLES

Analytical Category	Number of Samples
Volatile Organics	0
Semivolatile Organics	0
Pest/PCBs	0
Metals	1
Nitroaromatics	24
Anions	24
Radiological	38
Misc.	4

SOIL SAMPLES

Analytical Category	Number of Samples
Volatile Organics	22
Semivolatile Organics	32
Pest/PCBs	11
Metals	68
Nitroaromatics	31
Anions	70
Radiological	12
Misc.	74

agreed completely (except for laboratory contaminants) with the results from the primary laboratory.

4.2 Check Sample Procedures

The purpose of the check sampling program was to collect and analyze samples from media and locations for which the existing data were not of documentable quality to support the Remedial Investigation/Feasibility Study (RI/FS) process (see Section 3.3). This effort focused on documenting the absence of specific contaminants as well as confirming the presence and concentrations of contaminants previously detected. A sampling plan was prepared and submitted to the U.S. Environmental Protection Agency (EPA). Samples were collected from the raffinate pit sludges, on-site soils, groundwater, and surface water. The analytical parameters included volatile organic compounds, semivolatile organic compounds, PCBs, nitroaromatic compounds and radiological species.

Check samples were collected according to site-specific procedures. Samples were preserved as appropriate prior to shipment to the analytical laboratory. Chain of custody was maintained for all samples according to the site-specific chain of custody procedure. The rational for sampling locations and analytical parameters is discussed by media in the respective sections.

Samples collected under this check sampling program were analyzed according to standard EPA Contract Laboratory Program (CLP) methods for volatile organic, semivolatile organic, and PCB compounds. Samples requiring nitroaromatic compound analyses were analyzed using EPA SW846 Method 8330. Radiological analyses were performed using methods consistent with the EPA 900 series procedures.

4.3 Check Sample Results

Results from the check sampling program are discussed by medium in the following sections. The data from this program have been used to validate previous analytical results and to confirm the absence of groups of compounds. The data collected as a result of this program have been entered into the WSSRAP database.

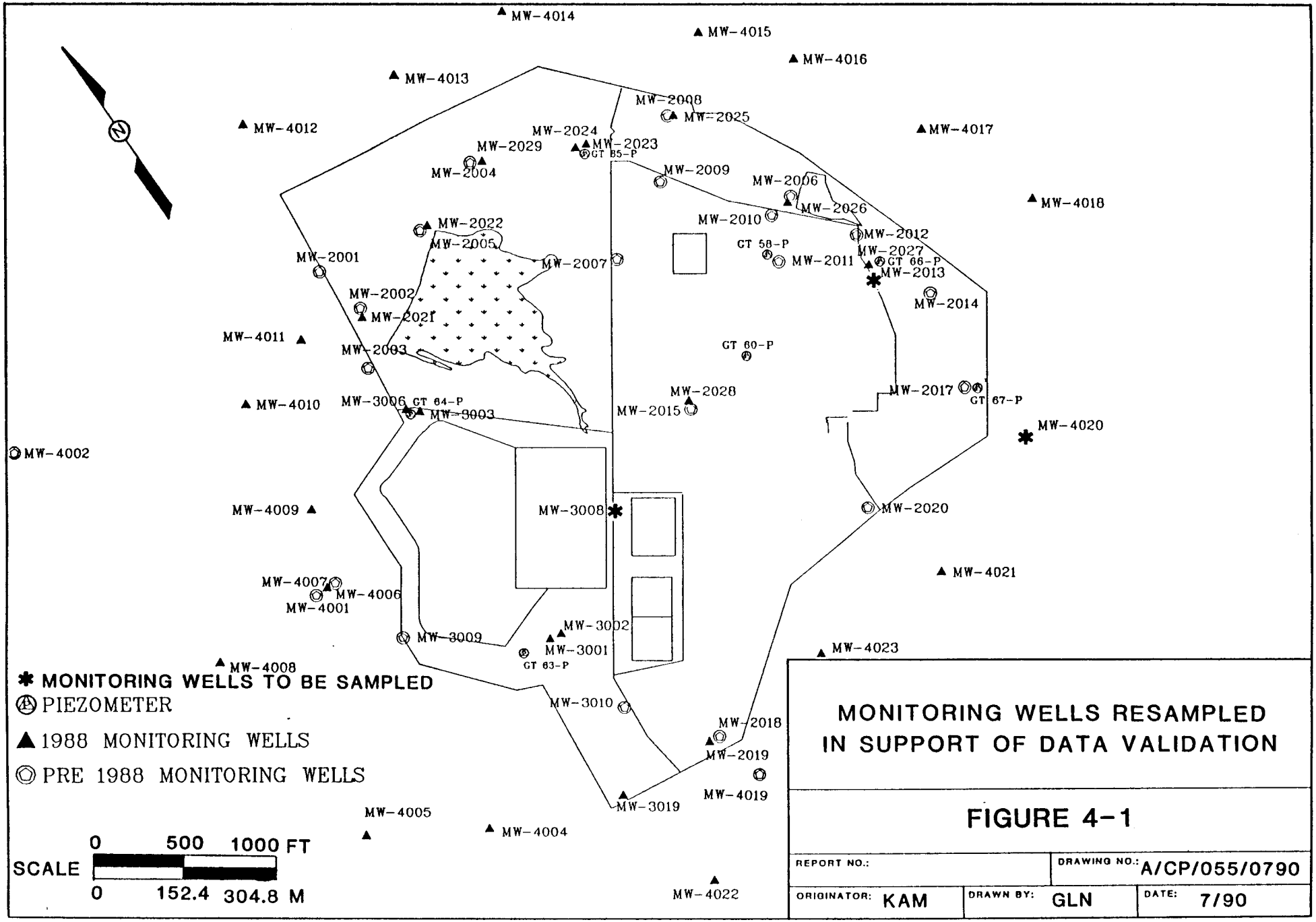
4.3.1 Groundwater

Data quality problems with the groundwater portion of the database included the inability to completely validate volatile and semivolatile organic compound results and the infrequent calibration of laboratory instruments used to perform nitroaromatic analyses. The check sampling program for groundwater consisted of resampling to provide data confirming the previous volatile and semivolatile organic results and comparing historical nitroaromatic results (performed by metaTRACE) with current environmental monitoring data performed by the U.S. Army Environmental Hygiene Agency (AEHA).

Three groundwater monitoring wells were sampled to confirm the absence of volatile and semivolatile organic compounds. These wells, MW-2013, MW-3008 and MW-4020, are located in the nitroaromatic and raffinate pit plumes and in an area not impacted by either area of contaminated groundwater. The location of these wells is shown in Figure 4-1.

Samples were collected using dedicated bladder pumps from three monitoring wells on site and analyzed for volatile and semivolatile organic compounds. The results of the check samples from these wells confirm that the groundwater is not contaminated with these compounds.

In addition to the check sampling program, nitroaromatic compound results from routine environmental monitoring performed in 1990 were compared to the historical metaTRACE results. This comparison indicates that the historical nitroaromatic concentrations observed in groundwater are consistent with the concentrations observed during recent environmental monitoring. A direct, statistical comparison is not practical due to the dynamic nature of the groundwater system. However, in 1989, 44 of 89 wells contained detectable concentrations of nitroaromatic compounds with seven wells exhibiting nitroaromatic concentrations above 10 μg/l. During the first half of 1990, 31 of 89 wells contained detectable concentrations of nitroaromatic compounds with 12 wells exhibiting concentrations above 10 μg/l. These minor differences between 1989 and 1990 are due to the fact that the 1990 numbers are based on a single sampling event, while the 1989 numbers are based on at least two sampling events. Wells with low concentrations of nitroaromatic compounds have historically varied between detecting and not detecting concentrations near the detection limit. The increase in the number of wells with



MONITORING WELLS RESAMPLED IN SUPPORT OF DATA VALIDATION

FIGURE 4-1

REPORT NO.:		DRAWING NO.: A/CP/055/0790
ORIGINATOR: KAM	DRAWN BY: GLN	DATE: 7/90

higher concentration is consistent with recent trend analyses and may be partially attributed to slight concentration fluctuations. This is supported by variation in nitroaromatic concentrations between 1987 and 1989. Overall, 1990 AEHA nitroaromatic results are consistent with 1987, 1988, and 1989 metaTRACE results.

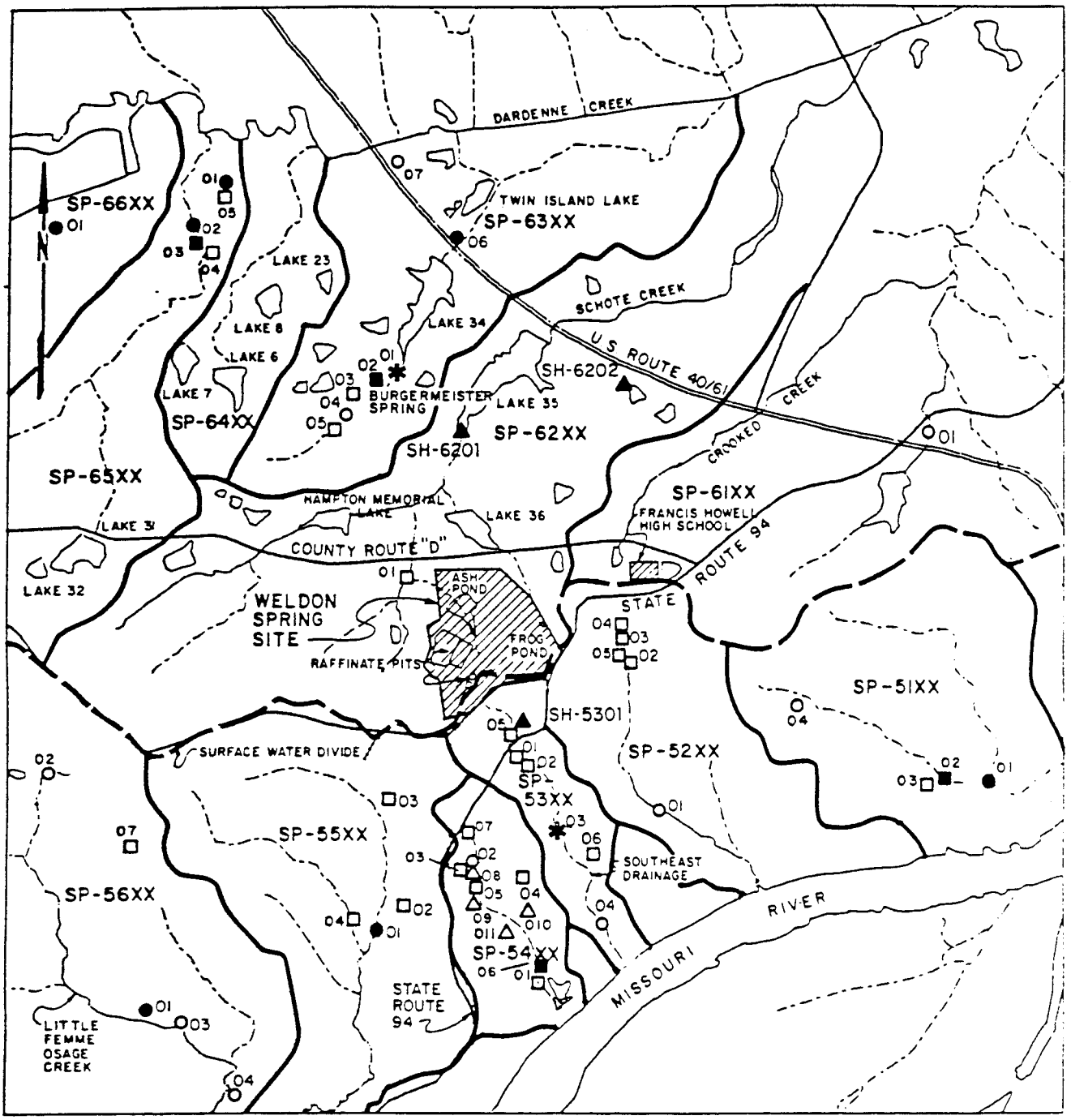
4.3.2 Surface Water

The rational for the surface water check sampling program was similar to the groundwater check sample program. Routine monitoring confirmed the levels of contaminants present. The check sampling program was designed to confirm previous characterization efforts which documented the absence of contamination. The check sampling program consisted of sampling a spring north and a spring south of the site for both volatile and semivolatile organic compounds. The springs sampled are shown in Figure 4-2. These springs were selected because they are impacted by the WSSRAP and would indicate whether a significant problem existed. No volatile or semivolatile organic compounds were detected, confirming previous characterization data.

4.3.3 Sludge

The sludge check sampling program consisted of collecting a total of 17 samples from the four raffinate pits. The locations of these samples are presented in Figure 4-3. Analytical parameters for raffinate sludge included volatile and semivolatile organic compounds, PCBs, and nitroaromatic compounds. These analytical parameters were selected because the initial characterization indicated that these compounds were not present in the raffinate sludge. Sludge samples were also analyzed for silver and zirconium to provide data to compare with the initial results.

Sludge samples were collected using a ponar dredge from all four raffinate pits. The check samples collected confirmed the previous data which indicated that the raffinate sludges do not contain nitroaromatic, volatile organic, semivolatile organic, or PCB compounds. The check samples did detect small amounts of acetone and methylene chloride. These compounds are common laboratory solvents and their detection indicates laboratory contamination and does not represent actual values.



SOURCE: MDNR, 1989

LEGEND :

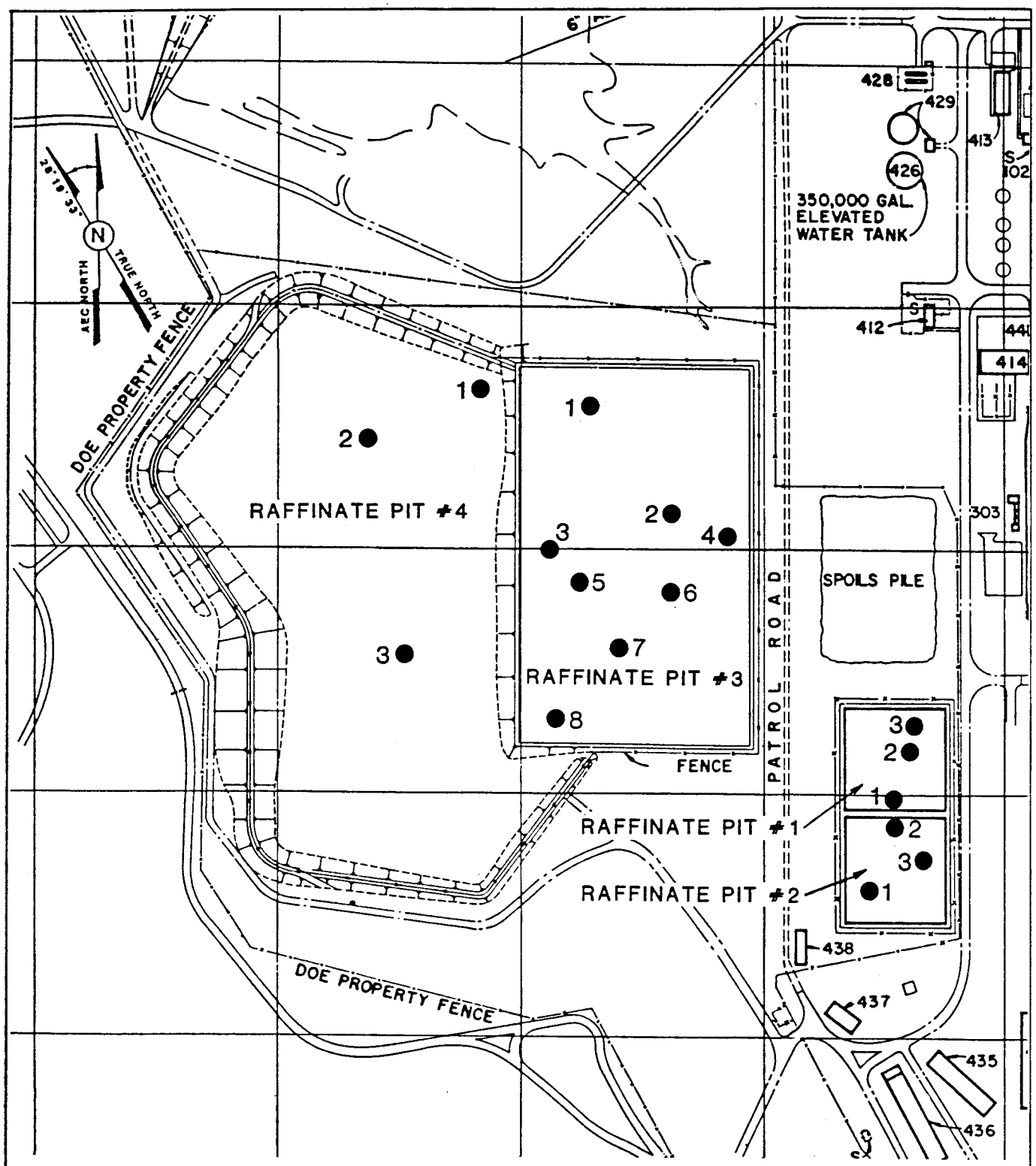
- SURFACE WATER DIVIDE BETWEEN MISSISSIPPI RIVER AND MISSOURI RIVER
- DRAINAGE BOUNDARY
- CREEK OR SURFACE DRAINAGE
- POND OR LAKE
- ● PERENNIAL SPRING WITH LARGE MAXIMUM FLOW
- ○ PERENNIAL SPRING WITH SMALL MAXIMUM FLOW
- ■ WET WEATHER SPRING WITH LARGE MAXIMUM FLOW
- □ WET WEATHER SPRING WITH SMALL MAXIMUM FLOW
- ▲ SHALLOW HOLE (SH)
- △ SEEP
- SP-63XX SPRING OR SEEP IN DESIGNATED DRAINAGE AREA NUMBER 63. XX REPRESENTS THE DESIGNATED SPRING NUMBER IN DRAINAGE 63.
- ✱ SPRINGS TO BE SAMPLED

SCALE 0 3200 6400 FT
0 975.4 1950.7 M

SPRINGS SAMPLED IN SUPPORT OF DATA VALIDATION

FIGURE 4-2

REPORT NO.:		DRAWING NO.: A/VP/036/0790
ORIGINATOR: KAM	DRAWN BY: GLN	DATE: 7/90



●-SAMPLE LOCATION

0 300 600 FT

0 91.4 182.4 M

SCALE

SLUDGE SAMPLING LOCATIONS FOR DATA VALIDATION

FIGURE 4-3

REPORT NO.: NA		DRAWING NO.: A/RP/001/0790	
ORIGINATOR: KAM	DRAWN BY: GLN	DATE: 7/90	

Check sample results from Raffinate Pit 3 indicate that silver results in the original data set may be biased low since all check sample results for silver were above the maximum observed concentration. Zirconium results were within the expected range.

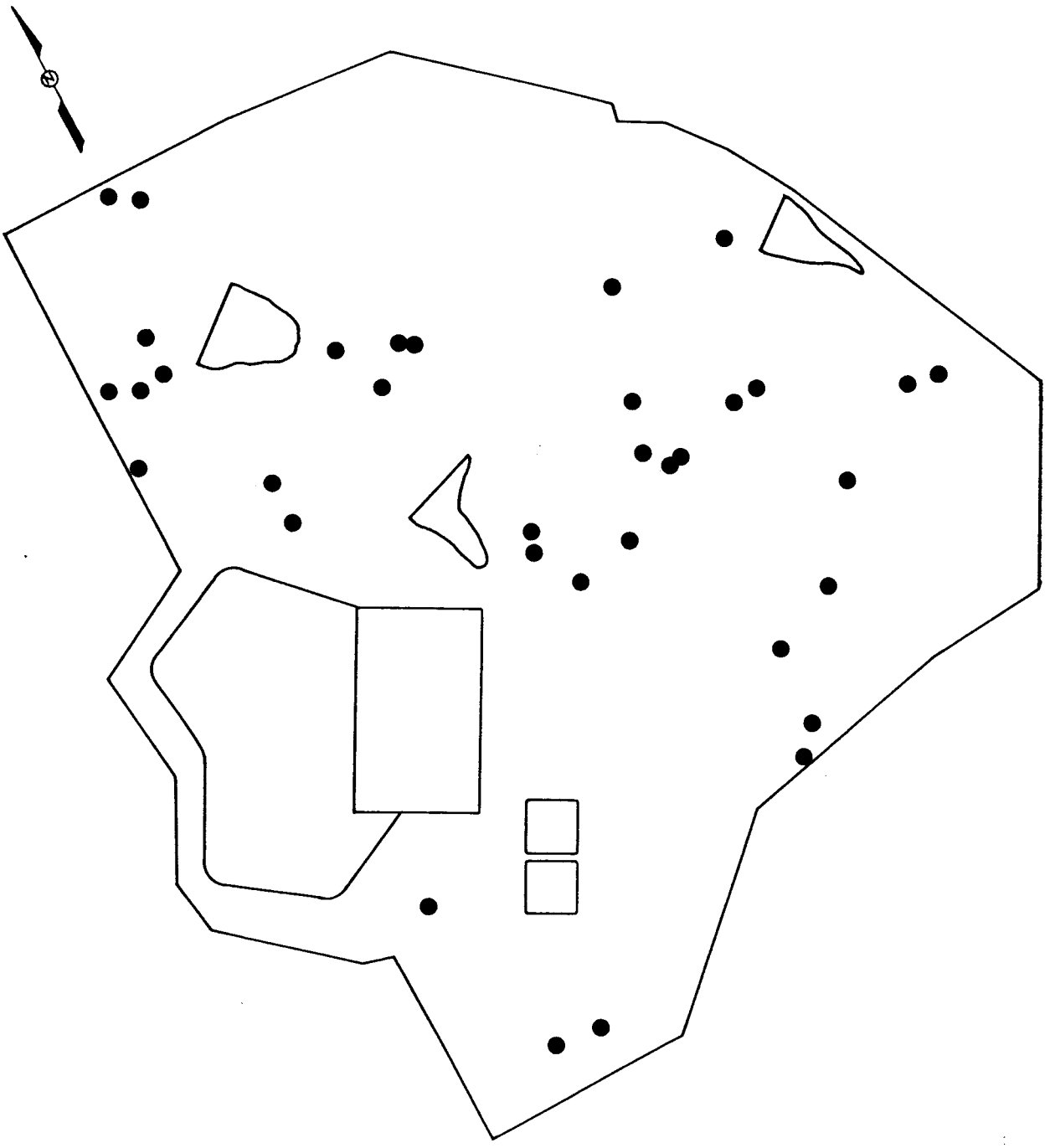
4.3.4 Soil

The check sampling program for soils focused on confirming the absence of significant volatile organic, semivolatile organic, and PCB compound contamination. Samples were also collected and analyzed for nitroaromatic compounds to confirm the presence of contamination, and to confirm that the concentrations observed accurately reflect site conditions. Samples were collected from the locations shown on Figure 4-4. The coordinates, depths, and analytical parameters are presented in Table 4-2.

All soil sampling locations were surveyed prior to sample collection. Soil samples were collected using a bucket auger. Soil from the desired location and interval was placed in a clean stainless steel pan and homogenized (except for sample aliquot used for volatiles) prior to filling the samples containers. Sampling equipment was decontaminated between samples.

Thirteen soil samples from 10 locations were collected and analyzed for volatile organic compounds. The locations sampled during this effort were selected because past known practices indicated the highest probability of volatiles contamination. No detected concentrations of volatile organic compounds were detected during the resampling effort, confirming the absence of these compounds. No tentatively identified compounds other than those related to the analysis (Aldol condensation products) or those present in laboratory blanks were detected.

Thirteen soil samples were collected from 10 locations and analyzed for semivolatile organic compounds. The only compounds detected during the check sample program were common phthalate esters and low concentrations of polyaromatic hydrocarbons (PAH). Phthalates were detected during previous investigations and generally reflect laboratory contamination. The PAHs were detected in the fire training pit as originally observed during the Phase II Chemical Soil Investigation. PAHs were also observed at concentrations below the contract required quantitation limits (CRQL) at site coordinates 50040 East and 100700 North in the 2 ft to 2.5 ft depth interval. No tentatively identified compounds other than those related to the analysis (Aldol condensation products) or those present in laboratory blanks were detected.



● – SOIL SAMPLE LOCATION

0 500 1000 FT
0 152.4 304.8 M
SCALE

SAMPLING LOCATIONS FOR SOIL RESAMPLING

FIGURE 4-4

REPORT NO.:	DOE/OR/21548-256	EXHIBIT NO.:	A/CP/004/0192		
ORIGINATOR:	JJC	DRAWN BY:	GLN	DATE:	1/92

TABLE 4-2 Soil Sampling Location Coordinants, Depths and Analytical Parameters

EAST	NORTH	DEPTH	PARAMETERS
52400	100700	0 - 1	NITROAROMATICS
52300	100700	0 - 1	"
51300	100850	0 - 1	"
51320	100850	0 - 1	"
51225	98825	0 - 2, 2 - 4	"
51760	100243	0 - 2, 2 - 4	"
52220	100750	0 - 2, 2 - 4	"
50850	100100	0 - 2, 2 - 4	"
49468	100712	0 - 2, 2 - 4	"
52400	101400	0 - 2, 2 - 4	"
50100	100650	0 - 6", 2 - 2.5	VOA,SV,PCB
50040	100700	0 - 6", 2 - 2.5	VOA,SV,PCB
50440	100450	0 - 6"	VOA,SV,PCB
50340	100420	0 - 6", 2 - 2.5	VOA,SV,PCB
50610	98370	0 - 6"	VOA,PCB
49370	100740	0 - 2, 2 - 4	NITROAROMATICS
52280	100890	0 - 2, 2 - 4	NITROAROMATICS
51815	100360	0 - 2, 2 - 4	NITROAROMATICS
50850	100185	0 - 2, 2 - 4	NITROAROMATICS
51565	100850	0 - 2, 2 - 4	NITROAROMATICS
51225	98825	0 - 2, 2 - 4	NITROAROMATICS
50140	101225	0 - 2, 2 - 4	NITROAROMATICS
52300	101400	0 - 2, 2 - 4	NITROAROMATICS
52900	100400	0 - 2, 2 - 4	NITROAROMATICS
51400	100700	0 - 2, 2 - 4	NITROAROMATICS
49860	99340	0 - 6"	VOA,SV
50550	101070	0 - 6"	SV
50500	100140	0 - 6", 2 - 2.5	VOA,SV,PCB*
49775	99975	0 - 6", 2 - 2.5	VOA,SV,PCB*
49830	99470	0 - 6"	VOA,SV
50480	100640	0 - 6", 2 - 2.5	PCB
FIRE TRAINING PIT			VOA,SV,PCB
50790	98300	0 - 6", 2 - 2.5	PCB
49950	99740	0 - 6", 2 - 2.5	PCB
50680	99990	0 - 6", 2 - 2.5	PCB
49700	100360	0 - 6", 2 - 2.5	PCB
50310	100450	0 - 6"	PCB

* - ONLY PCB/PESTICIDE ANALYSES TO BE PERFORMED ON DEEPER SAMPLE

Twenty-three soil samples were collected from 14 locations and analyzed for PCBs. The results from these samples indicate that low concentrations of Aroclor-1254 and Aroclor-1260 are present near transformer pads. Check samples also confirmed that PCBs are not widely distributed in site soils. The check sample results detected higher concentrations of PCBs than the original samples. These variances were noted at site coordinants 49700 East and 100360 North. Check samples detected a total of 74 μg/g of Aroclors while the original sample did not detect PCBs. This heterogeneity may be attributed to the nature of the source. PCB contamination adjacent to transformer pads likely originated as small spills during routine transformer servicing.

Thirty-two soil samples were collected from 18 locations and analyzed for nitroaromatics. The results generally agree with historical data which determined that nitroaromatic compounds are present only in low concentration in isolated areas. The check sampling program only yielded two locations with detected concentrations of nitroaromatic compounds. A sample collected from 0 ft to 2 ft at site coordinates 51565 east and 100850 north contained 0.049 μg/g of nitrotoluene. A sample from this location originally detected 1.73 μg/g of 2,6-DNT in the 4 ft to 6 ft depth interval. The original investigations did not include analysis for nitrotoluene. A check sample collected from the 2 ft to 4 ft depth interval at site coordinants 50850 East and 100850 North detected 0.14 μg/g of trinitrotoluene (TNT). Original samples from this location did not detect contamination.

All other check samples did not detect nitroaromatic compounds, including those collected from site coordinants 51280 east and 100890 north. Samples from this location originally detected 647 μg/g of TNT and 1.21 μg/g of 1,3,5-Trinitrobenzene. The absence of contamination in the check samples indicates that the contamination is very isolated and not uniformly distributed over a large area.

4.3.5 Summary

Analytical results confirmed the absence of significant volatile organic, semivolatile organic and PCB compound contamination in raffinate sludges and soils. Minor PCB soil contamination was confirmed near transformer pads. Isolated areas of low concentrations of nitroaromatic compounds were detected in soils at former ordnance production areas. Silver results for raffinate sludges may have been biased low in the original analyses. The absence of volatile organic or semivolatile organic compounds in both groundwater and surface water was

confirmed. These results are summarized in Table 4-3. The historical concentrations and distributions of nitroaromatic compounds in groundwater were also confirmed.

In summary, the check sampling program satisfied the objectives of the sampling plan. The data collected during this program has been validated and supports the validation of the historical data.

TABLE 4-3 Summary of Check Sample Results versus Original Sample Results

Analytical Category		Percentage Identical
PCBs	- Soil	76%
	- Sludge	82%
Volatile Organics Compounds	- Soil	92%
	- Sludge	91%
	- Water	100%
Semivolatile Organic Compounds	- Soil	97%
	- Sludge	99%
	- Water	100%
Nitroaromatic Compounds	- Soil	97%
	- Sludge	100%

Percentage identical is based on number of exactly identical results (on a parameter to parameter check) in both the check sample and the original sample. Samples with detected concentrations of laboratory contaminants, with estimated concentrations, or with concentrations below the contract required detection limits (CRDL) were used in calculating these percentages.

5 CONCLUSION AND RECOMMENDATIONS

Based on the review of the comparability of the duplicate samples, the validation of the 12K data points, and the check sample program the Project Management Contractor (PMC) has concluded that the database is adequate for use as the basis for the *Chemical Plant and Raffinate Pit Remedial Investigation and Feasibility Study* (RI/FS). The database provides an accurate basis for determining which contaminants are present at Weldon Spring Site Remedial Action Project (WSSRAP) and which are not present, and also provides an accurate basis for defining the range and distribution of the contamination. The data are adequate to determine remedial action costs to a +50% and -30% accuracy as required for an RI/FS.

However, the quality of the data must be continually reassessed as the project progresses through the RI/FS phase and on to design, where a more detailed definition of the range and distribution of the contaminants is necessary. Specifically, the following tasks are recommended.

1. Additional soil samples should be collected and analyzed for pesticides and polychlorinated biphenyls (PCBs). As discussed in Section 4.0 the check sample program did not always show good agreement between the samples analyzed by metaTRACE and the samples collected for the check sample program. The lack of agreement is probably due to the fact that the exact location of the previous samples could not be duplicated (the previous sample locations were disturbed) by the check sample program. Since the PCB spills were small confined spills, any variation in the location of the samples would result in somewhat differing measured concentrations. The check sample program did confirm that PCBs are only present in low concentrations in very localized areas near former transformer locations and additional sampling will assist in more accurately defining the extent of the contamination.

2. A limited number of additional water samples should be collected and analyzed for isotopic thorium. Although there is no reason to indicate that the previous samples were improperly analyzed, a large percentage of the laboratory records could not be found and it is considered prudent to further confirm the previous analyses.

3. The accuracy and precision of the data has been evaluated against the action levels developed through the FS process. As shown in Table 3-4 the accuracy and/or precision

of certain contaminants does not meet WSSRAP data quality requirements (DQRs). These contaminants are primarily soil and sludge samples which are very difficult to analyze and improving the accuracy and/or precision may not be possible. Generally, these chemicals are not important to the site because they occur in very low concentrations. However, following the development of action levels, the PMC will evaluate whether the accuracy and precision of chemicals with concentrations near the action levels are adequate.

4. While the database is sound and has an overall estimated percent completeness of 89.2% (refer to Table 3-3), users of the data must be aware that if they choose to use a single data point or a small group of data points for a key calculation, that data point or group of points should be validated. This is necessary because WSSRAP has validated a significant percentage of the database and applied the results of this validation to define the quality of the entire database as recommended by the U.S. Environmental Protection Agency (EPA) RI/FS guidance documents. Other than this, there should be no further restrictions placed on the use of the data.

ATTACHMENT A
DATA QUALITY REQUIREMENTS

DATA QUALITY REQUIREMENTS FOR THE WSSRAP

PRECISON AND ACCURACY GUIDELINES FOR ROUTINE MONITORING AND CHARACTERIZATION

CATEGORY	ANALYTICAL PARAMETER	ANALYTICAL LEVEL	ANALYTICAL METHOD	MDL a (ug/g)	SOIL PRECISION	SOIL ACCURACY	MDL a (ug/l)	WATER PRECISION	WATER ACCURACY	COMMENTS
Radiation Screening	Gross Alpha	I	2.6.4 *	NA	NA	NA	NA	NA	NA	ES&H SOP
	Gross Beta/Gamma	I	2.6.3 *	NA	NA	NA	NA	NA	NA	ES&H SOP
Field Measurements	pH	I	4.5.1 *	NA	NA	NA	NA	20	NA	ES&H SOP
	Temperature	I	4.5.1 *	NA	NA	NA	NA	20	NA	ES&H SOP
	Conductivity	I	4.5.2 *	NA	NA	NA	NA	20	NA	ES&H SOP
	Specific Ions	I	4.5.5 *	NA	NA	NA	NA	20	NA	ES&H SOP
	Organic Vapors	I	3.1.1 *	NA	NA	NA	NA	20	NA	ES&H SOP
	Settleable Solids	I	4.5.7 *	NA	NA	NA	0.1	NA	NA	ES&H SOP
	Th-230, Th-232	II	UNC	2 pCi/g	50	50	NA	NA	NA	
Onsite Radiological Measurements	U-238, U-235	III	901.1	1 pCi/g	50	30	NA	NA	NA	
	Ra-226, Ra-228	III	901.1	1 pCi/g	50	20	NA	NA	NA	
	Th-230, Th-232	II	UNC	2 pCi/g	50	20	NA	NA	NA	
	Gross Alpha	III	2.4.3 *	NA	NA	NA	NA	NA	NA	ES&H SOP
Offsite Radiological Measurements	Nat. Uranium	III	EPA 908.0	1 pCi/g	50	30	1 pCi/l	20	20	
	Ra-226, Ra-228	III	EPA 903.1	1 pCi/g	50	30	1 pCi/l	20	20	
	Th-230, Th-232	III	EERF 00/07	1 pCi/g	50	30	1 pCi/l	20	20	
	Gross Alpha	III	EPA 900.0	3 pCi/g	50	30	3 pCi/l	40	40	
	Gross Beta	III	EPA 900.0	3 pCi/g	50	30	8 pCi/l	40	40	
Nitroaromatic Compounds	2,4,6-TNT	III	Chromatographic	1.2	d	d	0.03 c	e	e	
	2,4-DNT	III	Chromatographic	0.75	d	d	0.03 c	e	e	
	2,6-DNT	III	Chromatographic	1.41	d	d	0.01 c	e	e	
	1,3,5-TNB	III	Chromatographic	0.57	d	d	0.03 c	e	e	
	1,3-DNB	III	Chromatographic	0.9	d	d	0.09 c	e	e	
	Nitrobenzene	III	Chromatographic	1.44	d	d	0.03 c	e	e	
Organics	Volatiles (CLP)	IV	CLP	CRQL	as required by CLP		CRQL	as required by CLP		
	Semi-Volatiles (CLP)	IV	CLP	CRQL	as required by CLP		CRQL	as required by CLP		
	Pesticides/PCBs (CLP)	IV	CLP	CRQL	as required by CLP		CRQL	as required by CLP		

DATA QUALITY REQUIREMENTS FOR THE WSSRAP

PRECISON AND ACCURACY GUIDELINES FOR ROUTINE MONITORING AND CHARACTERIZATION (cont'd)

CATEGORY	ANALYTICAL PARAMETER	ANALYTICAL LEVEL	ANALYTICAL METHOD	MDL a (ug/g)	SOIL PRECISION	SOIL ACCURACY	MDL a (ug/l)	WATER PRECISION	WATER ACCURACY	COMMENTS
Misc.	TSS	III	EPA 160.2	NA	NA	NA	2	20	20	
	TDS	III	EPA 160.2	NA	NA	NA		20	20	
	TOC	III	EPA 415.1				0.1	20	20	
	Lithium	III	EPA 200.7	5	50	50	50	20	20	
	Molybdenum	III	EPA 200.7	4	50	50	4	20	20	
	Zirconium	III	EPA 200.7	20	50	50	20	20	20	
	Trivalent Chromium	III	EPA 200.7		50	50	10	20	20	
	Hexavalent Chromium	III	Colorimetric		50	50	5	20	20	
	TOX	III	EPA 450.0	5	50	50		20	20	
	Nitrate	III	300.0/353.2 b	0.5	50	50	0.25/0.1 b*	20	20	mg/l
	Sulfate	III	300.0/375.4 b	5	50	50	1.0/1.0 b*	20	20	mg/l
	Chloride	III	300.0/325.1 b	1.5	50	50	0.25/0.2 b*	20	20	mg/l
	Fluoride	III	300.0/340.2 b	1.25	50	50	0.25/0.6 b*	20	20	mg/l
	Nitrite	III	300.0	0.5	50	50		20	20	mg/l
	% Moisture	II	ASTM	NA	50	NA	NA	NA	NA	
	pH (soil)	III	EPA 160.2	NA	50	NA	NA	NA	NA	
	Asbestos–PCM/TEM	III	3.1.4 *	NA	NA	NA	NA	NA	NA	ES&H SOP
Metals	Aluminum	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Antimony	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Arsenic	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Barium	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Beryllium	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Cadmium	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Calcium	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Chromium	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Cobalt	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Copper	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Iron	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Lead	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Magnesium	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Manganese	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Mercury	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Nickel	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		

DATA QUALITY REQUIREMENTS FOR THE WSSRAP

PRECISON AND ACCURACY GUIDELINES FOR ROUTINE MONITORING AND CHARACTERIZATION (cont'd)

CATEGORY	ANALYTICAL PARAMETER	ANALYTICAL LEVEL	ANALYTICAL METHOD	MDL a (ug/g)	SOIL PRECISION	SOIL ACCURACY	MDL a (ug/l)	WATER PRECISION	WATER ACCURACY	COMMENTS
Metals (cont'd)	Potassium	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Selenium	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Silver	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Sodium	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Thallium	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Vanadium	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
	Zinc	IV	CLP	CRDL	as required by CLP		CRDL	as required by CLP		
Other Parameters not listed		II,III,IV	TBD	TBD	50	50	TBD	20	20	See Note

* – See Comment Section.

TBD – To Be Determined.

NA – Not Applicable.

Accuracy = Percent Bias = Percent Recovery – 100

a – Detection limits and methods from contract with metaTRACE, inc. – new limits and/or methods to be established with new laboratories.

b – JTC methods and detection limits.

c – Army Environmetal Hygiene Agency (AEHA) detection limits

d – To be negotiated with the laboratory.

e – To be provided by AEHA.

NOTE: Generic DQRs apply to media and/or analytical methods not listed in this table. Specific DQRs may be developed as a part of future sampling and analysis plans.

ATTACHMENT B
DATA VERIFICATION PROCEDURE

ES&H 4.9.1a ENVIRONMENTAL MONITORING DATA VERIFICATION

SET I.D. #028

1.0 PURPOSE

The purpose of this procedure is to establish the system for data verification and provide the objective evidence necessary for timely review and verification of laboratory analytical results for the Weldon Spring Site Remedial Action Project (WSSRAP).

2.0 SCOPE

This procedure applies to all environmental, waste management, health physics, and geotechnical samples collected at the WSS, and data from chemical, radiological, and physical analyses performed by off-site subcontractor laboratories. Verification includes review of hard copy, electronic data, and other documentation. This procedure excludes data collected from field measurements.

3.0 REFERENCES

3.1 EPA, SW-846, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods.*

3.2 EPA, *A Compendium of Superfund Field Operations Methods*, Volume 2, Section 16.

3.3 *Environmental Data Administration Plan*, May 1990, DOE/OR/21548-119.

4.0 DEFINITIONS

4.1 Verification: A non-analytical preliminary review of analytical laboratory data and associated documentation performed to ensure that the samples are preserved, shipped, maintained, and analyzed in accordance with established data quality objectives and standard operating procedures.

4.2 Holding time: The period of time from sample collection to the time the sample is extracted and analyzed.

4.3 Validation: A thorough review of the analytical data utilizing laboratory analytical records to assess laboratory performance to quality control criteria, data quality objectives and procedural requirements.

ACRONYMS

DQO Data Quality Objectives
QC Quality Control
EDAP Environmental Data Administration Plan

5.0 RESPONSIBILITIES

The Environmental Protection Manager shall be responsible for implementing this procedure.

6.0 PROCEDURE

6.1 All laboratory data are to be received by the Procurement Department and delivered to the Verification Group.

6.2 All documentation collected as a result of data verification activities shall be retained in verification packages. The verification packages shall be filed by shipment or laboratory request number.

6.3 The Verification Group will receive hard copies and electronic copies of the analytical data. The original hard copies shall be sent to the Quality Assurance Department and copies shall be maintained in the ES&H filing system. The electronic copies shall be maintained in the ES&H filing system.

6.4 Hard copy data results shall be distributed to the designated data reviewers for review. This review process shall be documented on Form 4.9.1.1, Data Verification Data Review Sheet.

6.5 Completed Data Verification Data Review Sheets shall be returned to the Verification Department within two working days of the date distributed.

6.6 After the hard copy data has been reviewed for consistency with validated historical data, they shall be evaluated using Form 4.9.1.2, the Data Verification Checklist. The data shall be reviewed for timeliness of the report, chain-of-custody compliance, accurate sample identifications, completeness and correctness of the data report, and compliance to extraction and analytical holding time.

6.7 Electronic data records shall be compared to the verified hard copy data reports prior to incorporation into the WSSRAP computerized database system. All electronic records shall be standardized to appropriate categories, parameters, and units of measure (see Exhibit 5). Electronic records shall be compared manually on a record-by-record basis with the hard copy reports. Corrections shall be made as required and final verified printouts of the electronic data shall be attached to the Verification Checklist. The verified electronic data shall then be merged into the WSSRAP databases.

6.8 Electronic data requiring unit conversions shall be calculated using equations listed in Exhibit 6. Results of all conversions shall be shown on the hard copy report which shall be retained as part of the verification checklist package. All calculations shall be double checked by a second reviewer.

6.9 Deficiencies and/or discrepancies noted during the verification process shall be documented on Form 4.9.1.4, Verification Discrepancy Documentation Form. Corrective actions shall be made according to Standard Operating Procedures ES&H 4.1.1a, 4.1.2s, 4.4.1s, the Environmental Monitoring Plan, and data quality objectives defined in the EDAP. Corrective actions shall be reviewed by two persons and documented on form 4.9.1.4 (Exhibit 3).

6.10 Data validation shall be conducted according to SOP ENG-9a. Data reviewed during the verification process can be petitioned for validation review. Requests for data validation shall be completed by the ES&H Department or other WSSRAP participants using the Data Validation Request Form 4.9.1.5 (Exhibit 4). All validation requests shall be submitted to the validation group for processing.

7.0 RECORDS

Verification packages, including data verification data review sheets and discrepancy documentation, shall be transmitted to the Quality Assurance Department for retention as QA records in accordance with QAPP-9 for the duration of the project or as directed by DOE. Copies of data reports shall be maintained in the ES&H Department files. Data in electronic format shall be maintained in database files with access protection methods. Periodic backups of electronic data shall be made and stored in fireproof areas.

8.0 EXHIBITS

Exhibit 1 - Data Verification Data Review Sheet, Form 4.9.1.1
Exhibit 2 - Data Verification Checklist, Form 4.9.1.2
Exhibit 3 - Verification Discrepancy Documentation, Form 4.9.1.4
Exhibit 4 - Data Validation Request Form 4.9.1.5
Exhibit 5 - Reporting Standards for Parameters and Units
Exhibit 6 - Unit Conversion Methods

EXHIBIT 1
DATA VERIFICATION DATA REVIEW SHEET

WELDON SPRING REMEDIAL ACTION PROJECT (WSSRAP)
DATA VERIFICATION DATA REVIEW SHEET
FORM 4.9.1.1

Laboratory: _____

Request Number(s): _____

Date Received: _____

Reviewer(s): _____

Review Date: _____

Data is: Acceptable:__ Unacceptable:__

Comments: _____

_____

_____

_____

_____

_____

Signature: _____

Date Returned: _____

REVIEWER: THIS SHEET SHOULD BE RETURNED TO THE VERIFICATION DEPARTMENT WITHIN TWO WORKING DAYS OF DATE RECEIVED.

EXHIBIT 2

DATA VERIFICATION CHECKLIST

WELDON SPRING SITE REMEDIAL ACTION PROJECT (WSSRAP)

VERIFICATION CHECKLIST

FORM 4.9.1.2

Request Number: _____

Date Sampled: _____

Date Shipped: _____

Date laboratory received samples: _____

Date WSSRAP received analytical results: _____

Turnaround time requested:__S(28 days) __P(14 days) __U(5 days) __E(48 hrs.)

Were turnaround times met?__yes __no If not, specify/explain: _____

_____

Laboratory name: _____

Sample ID numbers: _____

Parameters requested: _____

Samples preserved and labelled at WSSRAP according to applicable procedure:

☐yes ☐no

Chain of custody completed according to established procedure: ☐yes ☐no

Extraction holding times met? ☐yes ☐no

Comments: _____

_____

Analytical holding times met? ☐yes ☐no

Comments: _____

_____

Data reviewed by: _____

Verification Checklist completed by:

Signature: _____ Date: _____

EXHIBIT 3

VERIFICATION DISCREPANCY DOCUMENTATION

FORM 4.9.1.4

Date:_____

WSSRAP Sample ID:_____

Laboratory Performing Analysis:_____

Laboratory ID:_____

Describe Discrepancy:_____

_____

_____

_____

_____

_____

_____

Corrective Action Taken:_____

_____

_____

_____

_____

_____

Reviewed By:_____

Signature:_____ Date:_____

EXHIBIT 4
DATA VALIDATION REQUEST FORM

FORM 4.9.1.5

Requestor:_____
WBS Code:_____
Department:_____
Date:_____

USE ONE FORM PER LABORATORY
Lab Name:_____
Request No:_____

SAMPLES RECOMMENDED FOR VALIDATION:

WSSRAP IDENTIFICATION	LAB I.D.	SAMPLE DATE	PARAMETER	FOR REVIEW USE

FOR REVIEW USE:

DATE REC'D:_____
SUBMITTED TO VALIDATION:_____
DATE OF REQUEST TO LAB:_____
DATE COMPLETED:_____

EXHIBIT 5
REPORTING STANDARDS FOR PARAMETERS AND UNITS

--,--.

WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
** CATEGORY IONS		
BROMIDE	MG/L	UG/G
CHLORIDE	MG/L	UG/G
FLUORIDE	MG/L	UG/G
NITRATE	MG/L	UG/G
NITRITE	MG/L	UG/G
SULFATE	MG/L	UG/G
SULFIDE	MG/L	UG/G
** CATEGORY METALS		
ALUMINUM	UG/L	UG/G
ANTIMONY	UG/L	UG/G
ARSENIC	UG/L	UG/G
BARIUM	UG/L	UG/G
BERYLLIUM	UG/L	UG/G
CADMIUM	UG/L	UG/G
CALCIUM	UG/L	UG/G
CHROMIUM	UG/L	UG/G
COBALT	UG/L	UG/G
COPPER	UG/L	UG/G
IRON	UG/L	UG/G
LEAD	UG/L	UG/G
LITHIUM	UG/L	UG/G
MAGNESIUM	UG/L	UG/G
MANGANESE	UG/L	UG/G
MERCURY	UG/L	UG/G
MOLYBDENUM	UG/L	UG/G
NICKEL	UG/L	UG/G
POTASSIUM	UG/L	UG/G
SELENIUM	UG/L	UG/G
SILVER	UG/L	UG/G
SODIUM	UG/L	UG/G
THALLIUM	UG/L	UG/G
TITANIUM	UG/L	UG/G
VANADIUM	UG/L	UG/G
ZINC	UG/L	UG/G
ZIRCONIUM	UG/L	UG/G
** CATEGORY MISC.		
2,4,5-TP (SILVEX)	UG/L	UG/G
2,4-D	UG/L	UG/G
ASBESTOS		F/MM2
ASH		PRCNT
BIOCHEMICAL OXYGEN DEMAND	MG/L	UG/G
BTU	CALORIES	
CONDUCTIVITY	MMHOS/C	
CYANIDE	UG/L	UG/G

EXHIBIT 5 (Continued)

WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
ETHYLENE GLYCOL	UG/L	UG/G
FECAL COLIFORM	MG/L	UG/G
FLASHPOINT	DEG C	
FLOW RATE	GPM	
HARDNESS	MG/L	UG/G
HEPTACHLORODIBENZO-P-DIOXIN	NG/L	NG/G
HEPTACHLORODIBENZOFURAN	NG/L	NG/G
HEXACHLORODIBENZO-P-DIOXIN	NG/L	NG/G
HEXACHLORODIBENZOFURAN	NG/L	NG/G
HEXANE	MG/L	UG/KG
NUISANCE DUST		MG
OCTACHLORODIBENZO-P-DIOXIN	NG/L	NG/G
OCTACHLORODIBENZOFURAN	NG/L	NG/G
OIL & GREASE	MG/L	UG/G
PENTACHLORODIBENZO-P-DIOXIN	NG/L	NG/G
PENTACHLORODIBENZOFURAN	NG/L	NG/G
PERCENT MOISTURE		PRCNT
PERCENT SOLID		PRCNT
PH	UNITS	UNITS
PHOSPHOROUS	MG/L	UG/G
REACTIVITY	MG/L	UG/G
SPECIFIC GRAVITY	N/A	N/A
TEMPERATURE (IN-SITU)	DEG C	
TETRACHLORODIBENZO-P-DIOXIN	NG/L	NG/G
TETRACHLORODIBENZOFURAN	NG/L	NG/G
TOLUENE	UG/L	UG/KG
TOTAL DISSOLVED SOLIDS	MG/L	UG/G
TOTAL ORGANIC CARBON	MG/L	UG/G
TOTAL RECOVERABLE HYDROCARBONS	MG/L	UG/G
TOTAL SOLIDS	MG/L	UG/G
TOX	MG/L	UG/G
TOXAPHENE	UG/L	UG/KG
TRICHLOROEHTYLENE	UG/L	UG/KG
TOTAL SUSPENDED SOLIDS	MG/L	UG/G
TURBIDITY	MG/L	UG/G
WATER LEVEL IN WELL (TOC)	FEET	
** CATEGORY NITROAROMATICS		
1,3,5-TRINITROBENZENE	UG/L	UG/KG
1,3-DINITROBENZENE	UG/L	UG/KG
2,4,6-TNT	UG/L	UG/KG
2,4,6-TRINITROBENZENE	UG/L	UG/KG
2,4-DNT	UG/L	UG/KG
2,6-DNT	UG/L	UG/KG
NITROBENZENE	UG/L	UG/KG
NITROTOLUENE	UG/L	UG/KG

WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
** CATEGORY PESTICIDE /PCB'S		
4,4'-DDD	UG/L	UG/KG
4,4'-DDE	UG/L	UG/KG
4,4'-DDT	UG/L	UG/KG
ALDRIN	UG/L	UG/KG
ALPHA-BHC	UG/L	UG/KG
ALPHA-CHLORDANE	UG/L	UG/KG
AROCLOR-1016	UG/L	UG/KG
AROCLOR-1221	UG/L	UG/KG
AROCLOR-1232	UG/L	UG/KG
AROCLOR-1242	UG/L	UG/KG
AROCLOR-1248	UG/L	UG/KG
AROCLOR-1254	UG/L	UG/KG
AROCLOR-1260	UG/L	UG/KG
BETA-BHC	UG/L	UG/KG
DELTA-BHC	UG/L	UG/KG
DIELDRIN	UG/L	UG/KG
ENDOSULFAN I	UG/L	UG/KG
ENDOSULFAN II	UG/L	UG/KG
ENDOSULFAN SULFATE	UG/L	UG/KG
ENDRIN	UG/L	UG/KG
ENDRIN KETONE	UG/L	UG/KG
GAMMA-BHC (LINDANE)	UG/L	UG/KG
GAMMA-CHLORDANE	UG/L	UG/KG
HEPTACHLOR	UG/L	UG/KG
HEPTACHLOR EPOXIDE	UG/L	UG/KG
METHXYCHLOR	UG/L	UG/KG
TOXAPHENE	UG/L	UG/KG
CHLORDANE	UG/L	UG/KG
TOTAL PCB'S	UG/L	UG/KG
** CATEGORY RADIOCHEMICAL		
GROSS ALPHA	PCI/L	PCI/G
GROSS BETA	PCI/L	PCI/G
LEAD 210	PCI/L	PCI/G
POLONIUM-210	PCI/L	PCI/G
RADIUM	PCI/L	PCI/G
RADIUM-226	PCI/L	PCI/G
RADIUM-228	PCI/L	PCI/G
RADON-222	PCI/L	PCI/G
THORIUM-228	PCI/L	PCI/G
THORIUM-230	PCI/L	PCI/G
THORIUM-232	PCI/L	PCI/G
URANIUM, TOTAL	PCI/L	PCI/G
URANIUM-234	PCI/L	PCI/G
URANIUM-235	PCI/L	PCI/G
URANIUM-238	PCI/L	PCI/G

EXHIBIT 5 (Continued)

WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
** CATEGORY SEMI-VOLATILES		
1,2,4-TRICHLOROBENZENE	UG/L	UG/KG
1,2-DICHLOROBENZENE	UG/L	UG/KG
1,3-DICHLOROBENZENE	UG/L	UG/KG
1,4-DICHLOROBENZENE	UG/L	UG/KG
2,4,5-TRICHLOROPHENOL	UG/L	UG/KG
2,4,6-TRICHLOROPHENOL	UG/L	UG/KG
2,4-DICHLOROPHENOL	UG/L	UG/KG
2,4-DIMETHYLPHENOL	UG/L	UG/KG
2,4-DINITROPHENOL	UG/L	UG/KG
2,4-DINITROTOLUENE	UG/L	UG/KG
2,6-DINITROTOLUENE	UG/L	UG/KG
2-CHLORONAPHTHALENE	UG/L	UG/KG
2-CHLOROPHENOL	UG/L	UG/KG
2-METHYLNAPHTHALENE	UG/L	UG/KG
2-METHYLPHENOL	UG/L	UG/KG
2-NITROANILINE	UG/L	UG/KG
2-NITROPHENOL	UG/L	UG/KG
3,3'-DICHLOROBENZIDINE	UG/L	UG/KG
3-METHYLPHENOL	UG/L	UG/KG
3-NITROANILINE	UG/L	UG/KG
4,6-DINITRO-2-METHYLPHENOL	UG/L	UG/KG
4-BROMOPHENYL PHENYL ETHER	UG/L	UG/KG
4-CHLORO-3-METHYL PHENOL	UG/L	UG/KG
4-CHLOROANILINE	UG/L	UG/KG
4-CHLOROPHENYL PHENYL ETHER	UG/L	UG/KG
4-METHYLPHENOL	UG/L	UG/KG
4-NITROANILINE	UG/L	UG/KG
4-NITROPHENOL	UG/L	UG/KG
ACENAPHTHENE	UG/L	UG/KG
ACENAPHTHYLENE	UG/L	UG/KG
ANILINE	UG/L	UG/KG
ANTHRACENE	UG/L	UG/KG
BENZIDINE	UG/L	UG/KG
BENZO(A)ANTHRACENE	UG/L	UG/KG
BENZO(A)PYRENE	UG/L	UG/KG
BENZO(B)FLUORANTHENE	UG/L	UG/KG
BENZO(G,H,I)PERYLENE	UG/L	UG/KG
BENZO(K)FLUORANTHENE	UG/L	UG/KG
BENZOIC ACID	UG/L	UG/KG
BENZYL ALCOHOL	UG/L	UG/KG
BIS(2-CHLORIOSIPROPYL)ETHER	UG/L	UG/KG
BIS(2-CHLOROETHOXY)METHANE	UG/L	UG/KG
BIS(2-CHLOROETHYL)ETHER	UG/L	UG/KG
BIS(2-CHLOROISOPROPYL)ETHER	UG/L	UG/KG
BIS(2-ETHYLHEXYL)PHTHALATE	UG/L	UG/KG

EXHIBIT 5 (Continued)

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WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
BUTYLBENZYLPHTHALATE	UG/L	UG/KG
CHRYSENE	UG/L	UG/KG
DI-N-BUTYL PHTHALATE	UG/L	UG/KG
DI-N-OCTYL PHTHALATE	UG/L	UG/KG
DIBENZO(A,H)ANTHRACENE	UG/L	UG/KG
DIBENZOFURAN	UG/L	UG/KG
DIETHYLPHTHALATE	UG/L	UG/KG
DIMETHYLPHTHALATE	UG/L	UG/KG
FLUORANTHENE	UG/L	UG/KG
FLUORENE	UG/L	UG/KG
HEXACHLOROBENZENE	UG/L	UG/KG
HEXACHLOROBUTADIENE	UG/L	UG/KG
HEXACHLOROCYCLOPENTADIENE	UG/L	UG/KG
HEXACHLOROETHANE	UG/L	UG/KG
INDENO(1,2,3-CD)PYRENE	UG/L	UG/KG
ISOPHORONE	UG/L	UG/KG
METHOXYCHLOR	UG/L	UG/KG
N-NITROSO-DI-N-DIPROPYLAMINE	UG/L	UG/KG
N-NITROSODIMETHYLAMINE	UG/L	UG/KG
N-NITROSODIPHENYLAMINE	UG/L	UG/KG
NAPHTHALENE	UG/L	UG/KG
NITROBENZENE	UG/L	UG/KG
PENTACHLOROPHENOL	UG/L	UG/KG
PERCENT MOISTURE	UG/L	UG/KG
PHENANTHRENE	UG/L	UG/KG
PHENOL	UG/L	UG/KG
PYRENE	UG/L	UG/KG
PYRIDINE	UG/L	UG/KG
** CATEGORY VOLATILES		
1,1,1-TRICHLOROETHANE	UG/L	UG/KG
1,1,2,2-TETRACHLOROETHANE	UG/L	UG/KG
1,1,2-TRICHLOROETHANE	UG/L	UG/KG
1,1-DICHLOROETHANE	UG/L	UG/KG
1,1-DICHLOROETHENE	UG/L	UG/KG
1,2-DICHLOROETHANE	UG/L	UG/KG
1,2-DICHLOROETHENE (TOTAL)	UG/L	UG/KG
1,2-DICHLOROETHYLENE	UG/L	UG/KG
1,2-DICHLOROPROPANE	UG/L	UG/KG
2-BUTANONE	UG/L	UG/KG
2-HEXANONE	UG/L	UG/KG
4-METHYL-2-PENTANONE	UG/L	UG/KG
ACETONE	UG/L	UG/KG
ACROLEIN	UG/L	UG/KG
ACRYLONTRILE	UG/L	UG/KG
BENZENE	UG/L	UG/KG
BROMODICHLOROMETHANE	UG/L	UG/KG

EXHIBIT 5 (Continued)

WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
BROMOFORM	UG/L	UG/KG
BROMOMETHANE	UG/L	UG/KG
CARBON DISULFIDE	UG/L	UG/KG
CARBON TETRACHLORIDE	UG/L	UG/KG
CHLOROBENZENE	UG/L	UG/KG
CHLOROETHANE	UG/L	UG/KG
CHLOROFORM	UG/L	UG/KG
CHLOROMETHANE	UG/L	UG/KG
CIS-1,3-DICHLOROPROPENE	UG/L	UG/KG
DIBROMOCHLOROMETHANE	UG/L	UG/KG
ETHYL BENZENE	UG/L	UG/KG
METHYLENE CHLORIDE	UG/L	UG/KG
PERCENT MOISTURE	UG/L	UG/KG
STYRENE	UG/L	UG/KG
TETRACHLOROETHENE	UG/L	UG/KG
TOLUENE	UG/L	UG/KG
TRANS-1,3-DICHLOROPROPENE	UG/L	UG/KG
TRICHLOROETHENE	UG/L	UG/KG
VINYL ACETATE	UG/L	UG/KG
VINYL CHLORIDE	UG/L	UG/KG
XYLENES, TOTAL	UG/L	UG/KG

EXHIBIT 6
UNIT CONVERSION METHODS

UNIT CONVERSION

SUMMARY OF UNITS

Parts per million (ppm)	Parts per billion (ppb)
ug/g	ug/kg
mg/l	ug/l
ug/ml	
mg/kg	

$$ppm * 1000 = ppb$$

$$\frac{ppb}{1000} = ppm$$

RADIOCHEMICAL DATA
UG/L * 0.68 = PCI/L
MG/L * 680 = PCI/L
UG/ML * 680 = PCI/L
$UCI/ML * 10^9 = PCI/L$
UG/G * 0.68 = PCI/G
$UCI/G * 10^8 = PCI/G$
NG/1000 = UG/G

ATTACHMENT C
DATA VALIDATION PROCEDURE

S.T.I.D. # 048

RC-31a ENVIRONMENTAL MONITORING DATA VALIDATION

1.0 PURPOSE

The purpose of this procedure is to specify the practices and processes relating to the technical review and validation of the laboratory analytical data for the Weldon Spring Site Remedial Action Project (WSSRAP).

2.0 SCOPE

This procedure applies to all environmental and radiological analytical measurements, excluding field measurements, performed by subcontract laboratories for WSSRAP.

3.0 REFERENCES

3.1 U.S. Department of Energy, Order 5400.1.
3.2 *USEPA Organic, Inorganic, and Dioxin CLP Scopes of Work.*
3.3 *WSSRAP Environmental Data Administration Plan.*
3.4 Procedure ES&H 4.9.1a, *Environmental Monitoring Data Verification.*
3.5 QAPP-9, *Quality Assurance Records.*

Environmental Compliance Procedures:
3.6 RC-34s, *Data Validation - Inorganic Parameters* (in preparation)
3.7 RC-35s, *Data Validation - Organic Parameters* (in preparation)
3.8 RC-36s, *Data Validation - Radiochemical Parameters* (in preparation)

4.0 DEFINITIONS

4.1 Preliminary Review - a cursory screening of the data deliverables packages to identify and correct any obvious deficiencies and to setup the validation datasets in preparation for the technical review.

4.2 Technical Review - A thorough evaluation of the analytical data utilizing the data deliverables to qualify the data quality and useability based on sample integrity, laboratory performance, procedural quality control (QC) criteria, and data quality objectives (DQOs); and to measure the accuracy, precision, and completeness of the reported analytical data.

4.3 Validation - The preliminary review and technical review of the target samples and target analyses.

4.4 Target Sample - A WSSRAP sample that has been selected for data validation.

4.5 Target Analysis - The analysis associated with a target sample that is requested for data validation.

4.6 Accuracy - A statistical measurement, expressed as a percentage, which represents how close the analytical data are to the "true" value. This measurement is based on the percent recoveries associated with the laboratory analytical control spikes (blank spikes), surrogate spikes, or matrix spikes. 100% accuracy is the best accuracy.

4.7 Precision - A statistical measurement, expressed as a percentage, which represents the repeatability of the analytical system. This measurement is based on the percent differences between laboratory duplicates. 0% precision is the best precision.

4.8 Completeness - The percentage of acceptable datapoints associated with a group of data, such as those in a validation request or those addressed in a quarterly or summary validation report. Acceptable datapoints are all datapoints that have been qualified with an A, A+, 1, 2, 3, 4, or V qualifier.

4.9 Qualifiers - A set of codes and flags which abbreviate the results and findings of the data validation technical review (See Exhibit 1).

4.10 Dataset - the minimum analytical sequence consisting of the target samples and associated QC measurements as required by the analytical protocol that can be evaluated independently; is often synonymous with the laboratory analytical lot.

4.11 Data Deliverables - laboratory analytical records including, but not limited to:

- CLP Deliverables Package (as defined in the most recent USEPA CLP Scope of Work)
- Sample custody transfer records (WSSRAP and laboratory records)
- Sample preparation/extraction/digestion logs
- Sample and QC data summary sheets/benchsheets/log-book entries
- Instrument printouts/chromatograms/spectra
- Analytical run-sequence logs
- Instrument tuning and calibration printouts and data
- Control charts
- Corrective action/exception reports
- Standards preparation logs
- Percent moisture determinations

5.0 RESPONSIBILITIES

5.1 The Environmental Compliance Manager shall be responsible for ensuring implementation of this procedure.

5.2 The Data Validation Manager shall be responsible for implementing this procedure.

6.0 PROCEDURE

6.1 Requests for Data Validation

6.1.1 Requests for data validation shall fall into one of the following three categories:

- Random requests, which are selected for validation prior to shipment of samples to the laboratory for analysis. The laboratory is not to know these data are to be validated until after the analysis is complete. These requests shall be initiated by the Data Verification Manager.

- Biased requests, which are selected for validation after the data have been reported by the laboratory. These requests shall be initiated by any user of WSSRAP data.

- Special requests, which are selected for validation based on the use of the data. These requests shall be initiated by any user of WSSRAP data.

6.1.2 All requests for validation shall be made in writing from the requestor and directed to the Data Verification Group. The Verification Group shall be responsible for requesting the validation documentation from the laboratory through the Procurement Department and shall be responsible for notifying the Validation Group of the pending request.

6.1.3 Requests for validation shall be maintained by the Data Validation Group as random, biased, or special requests. When the validation data deliverables package is received, the data package shall be logged into a Validation Tracking Record (Exhibit 2) which shall be used to track the status of the validation activity.

6.2 Datasets

6.2.1 The data from the target samples and analyses shall be grouped into datasets for the purpose of validation review and record keeping. A unique, sequential dataset number (i.e. 00001) shall be assigned to each dataset. A rubber stamp shall be utilized to maintain the next dataset number in sequence. This number shall be placed on the cover pages of all validation data documentation and validation review checklists and spreadsheets.

6.2.2 All samples (including QC samples) within each dataset shall be arranged chronologically. The date/time "stamp" from the analytical instrumentation may be used for this purpose. In cases where an instrumental date/time "stamp" is not available or in cases where samples from an analytical lot have not been provided by the laboratory (i.e. non-WSSRAP samples), the data reviewer shall use a "best guess" estimate to reconstruct the analytical order. A sequence number shall be assigned to each sample in the dataset to represent this order of analysis. The sequence number shall be identified on the raw data in such a fashion that it is clear which data are associated with which sequence number. No two analytical injections, aspirations, or measurements shall have the same combination of dataset number and sequence number.

6.2.3 A computerized database file shall be used to cross reference each target sample and target analysis with its assigned dataset number and sequence number. This database will be maintained by the data validation group.

6.3 Validation Reviews

6.3.1 The data validation technical review process for each dataset shall be directed by analysis-specific checklists and shall utilize computerized spreadsheets to confirm and document analytical calculations. The checklists and spreadsheets shall become part of the validation dataset documentation package.

Each technical review shall address as a minimum:

- Sample Integrity
- Calibration and Quantitation
- Qualitative Identification
- Background and Contamination
- Accuracy and Precision

The details associated with the technical review and the use of the corresponding checklists are described in separate SOPs for inorganics, organics, and radiochemical analyses.

6.3.2 The validation technical review requires evaluating the data and the analysis for compliance with established performance criteria (i.e. USEPA CLP). During the review of a particular dataset, it shall be appropriate for the reviewer to use the validation checklist only as a guide. Circumstances may arise that are not specifically handled by the checklist. Consequently, some degree of professional judgement will be required during the review. Since many published analytical procedures define data evaluation criteria, the mathematics involved, and the irregularities that may be intrinsic to certain types of samples, it is important that the data reviewer read and understand the analytical procedures being assessed.

6.3.3 Any changes made to any validation documentation shall be made by drawing a single line through the old entry, adding the new entry (if any), and initialing/dating the changes. Major changes (i.e. large portions of a page) may be made by drawing a single "X" through the page block, initialing, dating, and providing a brief note explaining the change.

6.3.4 All validation checklists shall be signed and dated by the reviewer, and reviewed, countersigned and dated by the Data Validation Manager.

6.3.5 An example of a validation checklist is included in this procedure (see Exhibit 5).

6.4 Reports

6.4.1 Data Validation Summary Reports shall be prepared to report the results of the validation review. Each summary report shall address the target samples and

analyses associated with an individual validation request.

6.4.2 All summary reports shall be addressed to the Data Verification Manager and shall include a copy to the Environmental Compliance Manager and to the Quality Assurance Department.

6.4.3 For Biased and Special validation requests, copies of the summary reports shall also be forwarded to the individual data requester. For Random validation requests, copies shall be forwarded to the ES&H Environmental Protection Manager.

6.4.4 Each summary report shall address at a minimum:
- WSSRAP Sample ID
- Analysis
- Lab Number
- Dataset Number
- Validation Qualifiers
- Accuracy and Precision
- Completeness for the Summary Report
- Analytical Deficiencies (if any)

6.4.5 Quarterly validation status reports shall be prepared and submitted to the Deputy Project Manager, Environmental Compliance Manager, ES&H Environmental Protection Manager, and the Quality Assurance Manager.

6.4.6 The quarterly status reports shall identify the quarterly completeness by laboratory, and shall identify the samples and analyses for which:
- validation documentation had been received during the quarter
- the validation review had been completed during the quarter
- the validation review is in progress
- the validation review is ON-HOLD, the reasons and the remedies

6.4.7 The quarterly status reports shall also calculate and report the percentages of validation requests made during the quarter for the bias and random requests. The percentage calculation shall be based on the total number of samples collected during the quarter versus the number of those samples for which validation requests have been made. If the requested percentage for a quarter falls below 5%, the Validation Manager shall notify the Verification Manager in writing in an effort to initiate additional requests to raise the percentage to at least 5%.

6.5 Qualifiers

6.5.1 Data validation qualifiers and flags shall be used to report the results of the data validation review in the WSSRAP database files (GURU). A qualifier shall be assigned to each and every parameter associated with an analysis. The qualifiers designate the validation status; the flags serve an informational purpose.

6.5.2 The validation qualifiers shall be assigned by the data reviewer and approved by the Data Validation Manager. Access rights to append, edit, or delete qualifiers in the qualifier field of the database files shall be limited to the Data Validation Group and the database administrators.

6.5.3 A list of Data Validation Qualifiers and Flags is provided as Exhibit 1. Additional qualifiers and flags may be implemented for use by the Data Validation Manager. Amendments to the qualifier list shall be issued to the data users when additions or changes are made.

6.5.4 The "N" qualifier (meaning not selected for data validation) shall be automatically assigned to the qualifier field of each new data record as it is received by the Data Verification Group from the laboratory.

6.5.5 When samples are selected for validation and their associated data deliverables are received, the "P" qualifier (meaning data validation is in progress) shall replace the "N" qualifier.

6.5.6 Upon completion of the validation review, the "P" qualifier shall be replaced with the qualifiers assigned to the data point based on the data quality determined during the review.

6.5.7 When information critical to the validation of the data is missing from the data deliverables package, or when data in the WSSRAP database files are incorrect, the data shall be placed on-hold using the "O" qualifier. Reasons for the on-hold status, actions taken to remedy the situation, and follow-up actions shall be documented Data Validation ON-HOLD Form (Exhibit 3) and maintained with the dataset.

6.5.8 In the cases where critical information needed for validation is missing and is unlikely to be retrieved from the laboratory, the affected data are to be determined non-validatable and labeled with an "X" qualifier. The non-validatable status shall be documented on the Data validation NON-VALIDATABLE form (Exhibit 4) and maintained with the dataset.

NOTE: When data are non-validatable, the data users are encouraged to take alternate means to substitute those data points with other data points (i.e., use other samples or resample and reanalyze.

6.6 Software Controls

Computerized software needed for data validation is commercially available (i.e., Quattro Pro, Lotus 1-2-3, dBase III, and dBase IV) and requires adherence to manufacturer controls only.

7.0 RECORDS

7.1 Data validation records, including checklists, spreadsheet printouts, logs, notes, and laboratory analytical records, shall be maintained on file with the data validation group

while they are active and validation reviews are in progress. Information pertaining to a specific dataset shall be filed numerically by dataset number.

Information pertaining to a specific dataset are to be filed numerically by laboratory and dataset number. Information that relates to numerous datasets (i.e. initial calibrations, instrument tunes, extraction/digestion records, custody transfer records) shall be maintained in master files and shall be filed by laboratory and type and in chronological order.

7.2 The data validation filing cabinets shall be kept locked and custody maintained by the Data Validation Manager.

7.3 Originals of the data validation records shall be transmitted to the Quality Assurance Department for retention as QA records in accordance with QAPP-9 as soon as practical upon completion of the validation review process and after the records are no longer active or in use.

8.0 EXHIBITS

Exhibit 1 - WSSRAP Data Validation Qualifier List
Exhibit 2 - Data Validation Tracking Record
Exhibit 3 - Data Validation ON-HOLD Listing Form
Exhibit 4 - Data Validation NON-VALIDATABLE Listing Form
Exhibit 5 - Example Validation Checklist

EXHIBIT 1
WSSRAP DATA VALIDATION QUALIFIER LIST

WSSRAP DATA VALIDATION QUALIFIER LIST

QUALIFIER

4 (or A+)	-	Data meeting all QA/QC requirements.
3	-	Good quantitative data not meeting all objective QA/QC requirements, but are generally valid.
2	-	Data that are adequate for semi-quantitative comparisons (i.e., the order of magnitude of the reported value is credible, but the exactness of the value is questionable).
1	-	Data that are adequate for a qualitative assessment (i.e., the target analyte is a real artifact, not contamination), but have no quantitative validity.
A	-	Acceptable, but has restrictions.
V	-	Data that appear to be valid based on data from identical sampling locations or by comparison to historical records.
R	-	Data that are not valid.
N	-	Data not petitioned for validation; or validation documentation not yet received from the laboratory.
O	-	Validation Technical Review ON-HOLD.
P	-	Validation Technical Review IN-PROGRESS or PENDING.
X	-	Data not validatable.

FLAGS[1]

>	-	High Bias (i.e., accuracy > DQO limit)
<	-	Low Bias (i.e., accuracy < DQO limit)
C	-	Calibration/Quantitation Deficiencies
Q	-	Quality Control Deficiencies
I	-	Qualitative Deficiencies or Instrument Interferences Present
B	-	Contamination or High Background Present
H(##)	-	Holding Times Exceeded (#days exceeded for prep/analysis)
F	-	Matrix-Related Interferences Present
J	-	Estimated Value (may be linked with other flags)
Y	-	Custody Deficiencies
T	-	Typographical/Mathematical Error
M	-	Poor Matrix Spike Recoveries (matrix accuracy)
D	-	Poor Duplicate RPD (precision)
?	-	Other (see applicable validation report)

NOTE: Other flags may be added as needed.

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1 To be used in conjunction with any of the above qualifiers, except for qualifier 4 or A+, which by definition shall stand alone.

EXHIBIT 2
DATA VALIDATION TRACKING RECORD

DATA VALIDATION REQUEST & TRACKING LOG

PAGE____OF_____
YEAR_____QUARTER_____

LAB:_____
REQ.#:_____ 5% RANDOM_____ 5% BIASED_____

	WSSRAP ID	ANALYSIS	P	VALD RECPT DATE	DATA REC'D COMPL(CHK)	DS #	LAB #	COMPL. DATE	QUALS. (see sum sht)	REPORT DATE
1.										
2.										
3.										
4.										
5.										
6.										
7.										
8.										
9.										
10.										
11.										
12.										
13.										
14.										
15.										
16.										
17.										
18.										
19.										
20.										
21.										
22.										
23.										
24.										
25.										

EXHIBIT 3
DATA VALIDATION ON-HOLD LISTING FORM

DATA VALIDATION FORM GEN 5
ON-HOLD LISTING

DATASET:_____
LAB:_____
REQ. #:_____
DATE:_____
SIGNATURE:_____

VALIDATION ON-HOLD

ANALYSIS:	
SAMPLES (list)	
1.	11.
2.	12.
3.	13.
4.	14.
5.	15.
6.	16.
7.	17.
8.	18.
9.	19.
10.	20.
REASON (describe)	
CORRECTIVE ACTION	
Date:	
RESOLVED	
Date:	

EXHIBIT 4
DATA VALIDATION NON-VALIDATABLE LISTING FORM

DATA VALIDATION FORM GEN 6
ON-HOLD LISTING

DATASET:_____
LAB:_____
REQ. #:_____
DATE:_____
SIGNATURE:_____

NON-VALIDATABLE

SAMPLE	PARAMETER

Add additional pages, if needed.

EXHIBIT 5
EXAMPLE VALIDATION CHECKLIST

Dataset#:_____

WSSRAP DATA VALIDATION REVIEW CHECKLIST
MERCURY BY COLD VAPOR ATOMIC ABSORPTION (CVAA)

The criteria in this review are based on the USEPA "FUNCTIONAL GUIDELINES FOR EVALUATING INORGANIC ANALYSES", July 1, 1988.	Laboratory & Req.#

I. The following WSSRAP samples are included in this dataset:

	WSSRAP Sample ID	Lab ID	Sample Date	Analysis Date
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				

Analytical Protocol (check one):

- ☐ CLP
- ☐ SW846
- ☐ EPA 200 Series
- ☐ Other (list)

Date Reviewer Date	Review Approved for Release by Date

Dataset#_____

WSSRAP DATA VALIDATION REVIEW CHECKLIST
MERCURY BY COLD VAPOR ATOMIC ABSORPTION (CVAA)

II. PRELIMINARY REVIEW

Check Action

	A. Assign Analytical Sequence Numbers to the instrument printout.
	B. Prepare Analytical Sequence Run Log if not provided by the laboratory.
	C. Prepare a Sample Qualifier Summary for each sample.

III. DOCUMENT SUBMITTAL

A. CLP Data Forms

Check the list of documents below that have been received for validation. If "Not Applicable" check "NA". If the document item is required and has not been received, place the sample ON-HOLD and request the documents from the laboratory.

Y	N		
		1. Organic Cover Page	
		2. Sample Data Sheets(FORM I)	
		3. Calibrations (FORM IIA)	
		4. Blanks (FORM III)	
		5. Matrix Spike (FORM V)	
		6. Duplicate (FORM VI)	
		7. LCS (FORM VII)	
		8. Holding Times (FORM X)	
		9. IDLs (FORM XIII)	REQUIRED
		10. Prep Log (FORM XIII)	
		11. Analysis Log (FORM XIV)	

B. Raw Data

Check the list of documentation below that have been received for validation. If "Not Applicable" check "NA". If the document item is applicable and required and has not been received, place the sample ON-HOLD and request the documents from the laboratory. If item has not been performed by lab, check "X".

Y	NA	X		
			1. Target Samples	REQUIRED
			2. Calibration Standards	REQUIRED
			3. Blanks	REQUIRED
			4. Matrix Spike	REQUIRED
			5. Duplicates	REQUIRED
			6. LCS	REQUIRED

EXHIBIT 5
EXAMPLE VALIDATION CHECKLIST

Dataset#:_____

WSSRAP DATA VALIDATION REVIEW CHECKLIST —
MERCURY BY COLD VAPOR ATOMIC ABSORPTION (CVAA)

C. True Values

Check the list of true values below that been received for validation. If "Not Applicable", check "NA". If the information is required and has not been received, place the sample ON-HOLD and request the information from the laboratory. If the item has not been performed by lab, check "X".

Y	NA	3X		
			1. Initial Calibration Verification	REQUIRED
			2. Continuing Calibration Verification	REQUIRED
			3. Laboratory Control Sample	REQUIRED

D. Other

Check the list of documentation below that have been received for validation. If "Not Applicable", check "NA". If the document is required and has not been received, place the sample ON-HOLD and request the document from the laboratory.
NOTE: The WSSRAP Custody Sheet may be retrieved from Data Verification.

Y	NA		
		1. Sample Digestion Log	REQUIRED
		2. % Solids Data	
		3. WSSRAP Custody Sheet	
		4. Laboratory Custody Sheet	
		5. Case Narrative	

COMMENTS:

Datase#:_____

WSSRAP DATA VALIDATION REVIEW CHECKLIST
MERCURY BY COLD VAPOR ATOMIC ABSORPTION (CVAA)

IV. TECHNICAL REVIEW

A. Calculation Confirmation

When checking or confirming any calculation, place a check mark next to the data item on the form or spreadsheet to show the item has been checked. The recommended spreadsheet to confirm calculations for the related items is listed below in parentheses for each item.

Check Action

- [ ] 1. Holding Time Calculations (DV Form HG 1)
- [ ] 2. WSSRAP Sample Data Calculations (DV Form HG 2)
- [ ] 3. Calibration Verifications Calculations (DV Form HG 3)
- [ ] 4. Preparation Blank Calculations (DV Form HG 5)
- [ ] 5. Calibration Blank Calculations (DV Form HG 5)
- [ ] 6. Matrix Spike Calculations (DV Form HG 6)
- [ ] 7. Sample Duplicate Calculations (DV Form HG 7)
- [ ] 8. Laboratory Control Sample Calculations (DV Form HG 8)

For the following sections, a set of criteria are listed. If a given criterion is not met, a recommended Data Validation action is listed. These actions are only recommendations and may be changed or omitted (with comment) by the data reviewer. If an item is not applicable, enter "NA".

[ ] B. Sample Integrity

Criteria	If Criteria not met....
Sample Custody: o Documented with signatures by WSSRAP samplers and lab custodian.	o -"Y" flag the affected sample data.
Sample Preservation o Documented on custody sheet Nitric acid to pH < 2 for aqueous samples; 4°C±2°C for non-aqueous samples	o -Handled on a case-by-case basis.
Holding Times o analysis completed with 26 days or less from sample date for aqueous and non-aqueous samples.	o -"H" flag all affected data. o -If negative and exceeded by > 10 days, REJECT all affected data. o -If positive and exceeded by > 10 days, "J" flag all affected data.
Data Consistency o No improper manipulations, font changes, time gaps, auto-zeroing, etc. are present with data.	o -Handled on a case-by-case basis.

Dataset#:_____

WSSRAP DATA VALIDATION REVIEW CHECKLIST
MERCURY BY COLD VAPOR ATOMIC ABSORPTION (CVAA)

[ ] C. Wavelengths

Mercury measurements are typically made at 253.7 nm. Note if the wavelength used is other than 253.7 nm.

[ ] D. Instrument Calibration

Criteria	If Criteria not met....
Initial Calibration: o performed with each analytical run o consists of 4 stds and 1 blk o correlation coefficient ≥0.995	o -REJECT ALL ASSOCIATED DATA & "C" FLAG. o -if consists of 3 stds and blk, "Q" flag all associated data o -if 2 stds or less, REJECT ALL ASSOCIATED DATA & "C" FLAG. o -"C"flag all associated data.

Correlation Coefficient:	Y Intercept:	Slope:

Verification Checks: o performed 1 per 10 samples or per 2 hours o % recovery between 80-120%	o -"Q" flag all samples not within 6 samples of a CCV. o -if within 65-79%, "C" flag associated data. o -if within 121-135%, "C" flag positive data. o -if < 65%, REJECT DATA & "C" flag. o -If > 135%, REJECT POSITIVE DATA & "C" flag.
Calibration Blanks: o performed 1 per 10 samples or per 2 hours o absolute value ≤ CRDL	o -"Q" flag all samples not within 6 samples of a CCB. o -Evaluate closely; reject & "B" flag if necessary

[ ] E. Preparation Blank

Criteria	If Criteria not met...
o performed at least 1 prep blank per matrix o performed 1 prep blk/20 samples or batch o sample once. < 10X prep blank conc.	o -If sample data > IDL, REJECT & "B" FLAG. o -"Q" flag all positive data. o -REJECT AFFECTED DATA & "B" FLAG.

If more than 1 prep blank, use the blank with highest concentrations.

Dataset#_____

WSSRAP DATA VALIDATION REVIEW CHECKLIST
MERCURY BY COLD VAPOR ATOMIC ABSORPTION (CVAA)

[ ] F. Laboratory Control Sample

Criteria	If Criteria not met....
o performed at least 1 LCS per matrix NOTE: An aqueous LCS is not required for Mercury, per CLP. o performed 1 LCS per 20 samples or batch	o -REJECT ASSOCIATED SAMPLE DATA & "Q" FLAG. o "Q" flag all associated data.
Aqueous LCS: o % recovery between 80-120%.	o -If > 120% & sample data negative, no action o -If > 120% & sample data positive, ">" flag. o -If between 50-79%, "<" flag associated data. o -If < 50%, REJECT ASSOCIATED DATA & "<" FLAG.
Non-Aqueous LCS o % recovery within established control limits	o -If > upper limit & sample data negative, no action. o -If > upper limit & sample data positive, ">" flag. o -If < lower limit, "<" flag all associated data.

[ ] G. Sample Duplicates

Criteria	If Criteria not met....
o performed 1 dup pair/20 samples or batch (excluding field blanks)	o -"Q" flag associated data. Note that precision measurements are not available.
Aqueous Samples IF both Sample conc. ≥5X CRDL o RPD ≤ 20% ELSE either Sample conc. <5X CRDL o Diff < CRDL	 o -"D" flag associated data. o -"D" flag associated data.
Non-Aqueous Samples If both Sample conc. ≥ 5X CRDL o RPD ≤ 35% ELSE either Sample conc. < 5X CRDL o Diff < 2X CRDL	 o -"D" flag associated data. o -"D" flag associated data.

NOTE: If the sample duplicate data are rejected based on the criteria listed above AND these duplicates are the only source of precision for the analytical lot, the precision value from these duplicates are not useable and the target sample data should be "D" flagged and noted that PRECISION DATA ARE NOT AVAILABLE.

 Dataset#_____

WSSRAP DATA VALIDATION REVIEW CHECKLIST
MERCURY BY COLD VAPOR ATOMIC ABSORPTION (CVAA)

☐ H. Matrix Spike

Criteria	If Criteria not met....
o performed 1 MS per 20 samples or batch	o -"Q" flag associated data
o % recovery between 75-125% AND sample conc. < 4X spike level	o -if > 125% and sample data negative, no action. o -if > 125% and sample data positive, "M" flag associated data. o -If < 30% and negative, REJECT ASSOCIATED DATA AND "M" FLAG. o -If < 30% and positive, "M" flag associated data.

☐ I. WSSRAP Field Samples

Criteria	If Criteria not met....
o no observed transcription, mathematic, or other errors observed o all readings within the HG curve linear range o all IDLs ≤ CRDL	o -If necessary, place data ON-HOLD UNTIL ERROR IS CORRECTED o -"C" flag all data over range. o -REJECT AND "C" FLAG ALL DATA < applicable IDL.

J. Supplemental Validation Checklists/Forms

☐ 1. DV HG 1 - Holding Time Assessment
☐ 2. DV HG 2 - Sample Data Summary
☐ 3. DV HG 3 - Calibration Verifications
☐ 4. DV HG 5 - Prep and Cal Blanks
☐ 5. DV HG 6 - Matrix Spike
☐ 6. DV HG 7 - Sample Duplicates
☐ 7. DV HG 8 - Lab Control Sample (LCS)
☐ 8. DV GEN 1 - Analytical Sequence
☐ 9. DV GEN 2 - Metals Qualifiers Summary (1 per sample)
☐ 10. DV Review Checklist for EP Tox/TCLP Method of Standard Addition
☐ 11. Other (list)

Notes: (attached additional pages if necessary)

It is appropriate for the data reviewer to make professional judgements and express concerns and comments on the validity of the overall data in this dataset. This is particularly appropriate when there are several QC criteria out of specification. The additive nature of QC factors out of specification is difficult to assess in an objective manner, but the reviewer has a responsibility to inform the data users concerning data quality and data limitations in order to assist those users from inappropriate use of the data, while not precluding any consideration of the data at all. As a consequence, it may often be necessary for the data reviewer to use subjective means when assigning the final qualifiers (A, 1,2,3,4,R,V) to the data in this dataset.

ATTACHMENT D
STANDARD DATA PRESENTATION FORMAT

WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
** CATEGORY IONS		
BROMIDE	mg/l	µg/g
CHLORIDE	mg/l	µg/g
FLUORIDE	mg/l	µg/g
NITRATE	mg/l	µg/g
NITRITE	mg/l	µg/g
SULFATE	mg/l	µg/g
SULFIDE	mg/l	µg/g
** CATEGORY METALS		
ALUMINUM	µg/l	µg/g
ANTIMONY	µg/l	µg/g
ARSENIC	µg/l	µg/g
BARIUM	µg/l	µg/g
BERYLLIUM	µg/l	µg/g
CADMIUM	µg/l	µg/g
CALCIUM	µg/l	µg/g
CHROMIUM	µg/l	µg/g
COBALT	µg/l	µg/g
COPPER	µg/l	µg/g
IRON	µg/l	µg/g
LEAD	µg/l	µg/g
LITHIUM	µg/l	µg/g
MAGNESIUM	µg/l	µg/g
MANGANESE	µg/l	µg/g
MERCURY	µg/l	µg/g
MOLYBDENUM	µg/l	µg/g
NICKEL	µg/l	µg/g
POTASSIUM	µg/l	µg/g
SELENIUM	µg/l	µg/g
SILVER	µg/l	µg/g
SODIUM	µg/l	µg/g

WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
THALLIUM	µg/l	µg/g
TITANIUM	µg/l	µg/g
VANADIUM	µg/l	µg/g
ZINC	µg/l	µg/g
ZIRCONIUM	µg/l	µg/g
** CATEGORY MISC.		
2,4,5-TP (SILVEX)	µg/l	µg/g
2,4-D	µg/l	µg/g
ASBESTOS		f/mm^2
ASH		PRCNT
BIOCHEMICAL OXYGEN DEMAND	mg/l	µg/g
BTU	CALORIES	
CONDUCTIVITY	MMHOS/C	
CYANIDE	µg/l	µg/g
ETHYLENE GLYCOL	µg/l	µg/g
FECAL COLIFORM	mg/l	µg/g
FLASHPOINT	DEG C	
FLOW RATE	GPM	
HARDNESS	mg/l	µg/g
HEPTACHLORODIBENZO-P-DIOXIN	ng/l	ng/g
HEPTACHLORODIBENZOFURAN	ng/l	ng/g
HEXACHLORODIBENZO-P-DIOXIN	ng/l	ng/g
HEXACHLORODIBENZOFURAN	ng/l	ng/g
HEXANE	mg/l	µg/kg
NUISANCE DUST		mg
OCTACHLORODIBENZO-P-DIOXIN	ng/l	ng/g
OCTACHLORODIBENZOFURAN	ng/l	ng/g
OIL & GREASE	mg/l	µg/g
PENTACHLORODIBENZO-P-DIOXIN	ng/l	ng/g
PENTACHLORODIBENZOFURAN	ng/l	ng/g
PERCENT MOISTURE		PRCNT
PERCENT SOLID		PRCNT
PH	UNITS	UNITS
PHOSPHORUS	mg/l	µg/g

WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
REACTIVITY	mg/l	µg/g
SPECIFIC GRAVITY	N/A	N/A
TEMPERATURE (IN-SITU)	DEG C	
TETRACHLORODIBENZO-P-DIOXIN	ng/l	ng/g
TETRACHLORODIBENZOFURAN	ng/l	ng/g
TOLUENE	µg/l	µg/kg
TOTAL DISSOLVED SOLIDS	mg/l	µg/g
TOTAL ORGANIC CARBON	mg/l	µg/g
TOTAL RECOVERABLE HYDROCARBONS	mg/l	µg/g
TOTAL SOLIDS	mg/l	µg/g
TOX	mg/l	µg/g
TOXAPHENE	µg/l	µg/kg
TRICHLOROETHYLENE	µg/l	µg/kg
TOTAL SUSPENDED SOLIDS	mg/l	µg/g
TURBIDITY	mg/l	µg/g
WATER LEVEL IN WELL (TOC)	FEET	
** CATEGORY NITROAROMATICS		
1,3,5-TRINITROBENZENE	µg/l	µg/kg
1,3-DINITROBENZENE	µg/l	µg/kg
2,4,6-TNT	µg/l	µg/kg
2,4,6-TRINITROBENZENE	µg/l	µg/kg
2,4-DNT	µg/l	µg/kg
2,6-DNT	µg/l	µg/kg
NITROBENZENE	µg/l	µg/kg
NITROTOLUENE	µg/l	µg/kg
** CATEGORY PESTICIDE/PCB'S		
4,4'-DDD	µg/l	µg/kg
4,4'-DDE	µg/l	µg/kg
4,4'-DDT	µg/l	µg/kg
ALDRIN	µg/l	µg/kg
ALPHA-BHC	µg/l	µg/kg
ALPHA-CHLORDANE	µg/l	µg/kg

WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
AROCLOR-1016	µg/l	µg/kg
AROCLOR-1221	µg/l	µg/kg
AROCLOR-1232	µg/l	µg/kg
AROCLOR-1242	µg/l	µg/kg
AROCLOR-1248	µg/l	µg/kg
AROCLOR-1254	µg/l	µg/kg
AROCLOR-1260	µg/l	µg/kg
BETA-BHC	µg/l	µg/kg
DELTA-BHC	µg/l	µg/kg
DIELCRIN	µg/l	µg/kg
ENDOSULFAN I	µg/l	µg/kg
ENDOSULFAN II	µg/l	µg/kg
ENDOSULFAN SULFATE	µg/l	µg/kg
ENDRIN	µg/l	µg/kg
ENDRIN KETONE	µg/l	µg/kg
GAMMA-BHC (LINDANE)	µg/l	µg/kg
GAMMA-CHLORDANE	µg/l	µg/kg
HEPTACHLOR	µg/l	µg/kg
HEPTACHLOR EPOXIDE	µg/l	µg/kg
METHOXYCHLOR	µg/l	µg/kg
TOXAPHENE	µg/l	µg/kg
CHLORDANE	µg/l	µg/kg
TOTAL PCB'S	µg/l	µg/kg
** CATEGORY RADIOCHEMICAL		
GROSS ALPHA	Pci/l	Pci/g
GROSS BETA	Pci/l	Pci/g
LEAD 210	Pci/l	Pci/g
POLONIUM-210	Pci/l	Pci/g
RADIUM	Pci/l	Pci/g
RADIUM-226	Pci/l	Pci/g
RADIUM-228	Pci/l	Pci/g
RADON-222	Pci/l	Pci/g
THORIUM-228	Pci/l	Pci/g
THORIUM-230	Pci/l	Pci/g

WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
THORIUM 232	Pci/l	Pci/g
URANIUM, TOTAL	Pci/l	Pci/g
URANIUM-234	Pci/l	Pci/g
URANIUM-235	Pci/l	Pci/g
URANIUM-238	Pci/l	Pci/g
** CATEGORY SEMI-VOLATILES		
1,2,4-TRICHLOROBENZENE	µg/l	µg/kg
1,2-DICHLOROBENZENE	µg/l	µg/kg
1,3-DICHLOROBENZENE	µg/l	µg/kg
1,4-DICHLOROBENZENE	µg/l	µg/kg
2,4,5-TRICHLOROPHENOL	µg/l	µg/kg
2,4,6-TRICHLOROPHENOL	µg/l	µg/kg
2,4-DICHLOROPHENOL	µg/l	µg/kg
2,4-DIMETHYLPHENOL	µg/l	µg/kg
2,4-DINITROPHENOL	µg/l	µg/kg
2,4-DINITROTOLUENE	µg/l	µg/kg
2,6-DINITROTOLUENE	µg/l	µg/kg
2-CHLORONAPHTHALENE	µg/l	µg/kg
2-CHLOROPHENOL	µg/l	µg/kg
2-METHYLNAPHTHALENE	µg/l	µg/kg
2-METHYLPHENOL	µg/l	µg/kg
2-NITROANILINE	µg/l	µg/kg
2-NITROPHENOL	µg/l	µg/kg
3,3'-DICHLOROBENZIDINE	µg/l	µg/kg
3-METHYLPHENVOL	µg/l	µg/kg
3-NITROANILINE	µg/l	µg/kg
4,6-DINITRO-2-METHYLPHENOL	µg/l	µg/kg
4-BROMOPHENYL PHENYL ETHER	µg/l	µg/kg
4-CHLORO-3-METHYL PHENOL	µg/l	µg/kg
4-CHLOROANILINE	µg/l	µg/kg
4-CHLOROPHENYL PHENYL ETHER	µg/l	µg/kg
4- METHYLPHENOL	µg/l	µg/kg
4-NITROANILINE	µg/l	µg/kg
4-NITROPHENOL	µg/l	µg/kg

WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
ACENAPHTHENE	µg/l	µg/kg
ACENAPHTHYLENE	µg/l	µg/kg
ANILINE	µg/l	µg/kg
ANTHRACENE	µg/l	µg/kg
BENZIDINE	µg/l	µg/kg
BENZO(A)ANTHRACENE	µg/l	µg/kg
BENZO(A)PYRENE	µg/l	µg/kg
BENZO(B)FLUORANTHENE	µg/l	µg/kg
BENZO(G,H,I)PERYLENE	µg/l	µg/kg
BENZO(K)FLUORANTHENE	µg/l	µg/kg
BENZOIC ACID	µg/l	µg/kg
BENZYL ALCOHOL	µg/l	µg/kg
BIS(2-CHLORIOSIPROPYL)ETHER	µg/l	µg/kg
BIS(2-CHLOROETHOXY)METHANE	µg/l	µg/kg
BIS(2-CHLOROETHYL)ETHER	µg/l	µg/kg
BIS(2-CHLOROISOPROPYL)ETHER	µg/l	µg/kg
BIS(2-ETHYLHEXYL)PHYTHALATE	µg/l	µg/kg
BUTYLBENZYLPHTHALATE	µg/l	µg/kg
CHRYSENE	µg/l	µg/kg
DI-N-BUTYL PHTHALATE	µg/l	µg/kg
DI-N-OCTYL PHTHALATE	µg/l	µg/kg
DIBENZO(A,H)ANTHRACENE	µg/l	µg/kg
DIBENZOFURAN	µg/l	µg/kg
DIETHYLPHTHALATE	µg/l	µg/kg
DIMETHYLPHTHALATE	µg/l	µg/kg
FLUORANTHENE	µg/l	µg/kg
FLUORENE	µg/l	µg/kg
HEXACHLOROBENZENE	µg/l	µg/kg
HEXACHLOROBUTADIENE	µg/l	µg/kg
HEXACHLOROCYCLOPENTADIENE	µg/l	µg/kg
HEXACHLOROETHANE	µg/l	µg/kg
INDENO(1,2,3-CD)PYRENE	µg/l	µg/kg
ISOPHORONE	µg/l	µg/kg
METHOXYCHLOR	µg/l	µg/kg
N-NITROSO-DI-N-DIPROPYLAMINE	µg/l	µg/kg
N-NITROSODIMETHYLAMINE	µg/l	µg/kg

WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
N-NITROSODIPHENYLAMINE	µg/l	µg/kg
NAPHTHALENE	µg/l	µg/kg
NITROBENZENE	µg/l	µg/kg
PENTACHLOROPHENOL	µg/l	µg/kg
PERCENT MOISTURE	µg/l	µg/kg
PHENANTHRENE	µg/l	µg/kg
PHENOL	µg/l	µg/kg
PYRENE	µg/l	µg/kg
PYRIDINE	µg/l	µg/kg
** CATEGORY VOLATILES		
1,1,1-TRICHLOROETHANE	µg/l	µg/kg
1,1,2,2-TETRACHLOROETHANE	µg/l	µg/kg
1,1,2-TRICHLOROETHANE	µg/l	µg/kg
1,1-DICHLOROETHANE	µg/l	µg/kg
1,1-DICHLOROETHENE	µg/l	µg/kg
1,2-DICHLOROETHANE	µg/l	µg/kg
1,2-DICHLOROETHENE (TOTAL)	µg/l	µg/kg
1M2-DICHLOROETHYLENE	µg/l	µg/kg
1,2-DICHLOROPROPANE	µg/l	µg/kg
2-BUTANONE	µg/l	µg/kg
2-HEXANONE	µg/l	µg/kg
4-METHYL-2-PENTANONE	µg/l	µg/kg
ACETONE	µg/l	µg/kg
CROLEIN	µg/l	µg/kg
ACRYLONTRILE	µg/l	µg/kg
BENZENE	µg/l	µg/kg
BROMODICHLOROMETHANE	µg/l	µg/kg
BROMOFORM	µg/l	µg/kg
BROMOMETHANE	µg/l	µg/kg
CARBON DISULFIE	µg/l	µg/kg
CARBON TETRACHLORIDE	µg/l	µg/kg
CHLOROBENZENE	µg/l	µg/kg
CHLOROETHANE	µg/l	µg/kg
CHLOROFORM	µg/l	µg/kg

WSSRAP Environmental Database
Standards for Reporting
Category, Parameter, Units

Parameter	Units of Measure (Water)	Units of Measure (Soils)
CHLOROMETHANE	µg/l	µg/kg
CIS-1,3-DICHLOROPROPENE	µg/l	µg/kg
DIBROMOCHLOROMETHANE	µg/l	µg/kg
ETHYL BENZENE	µg/l	µg/kg
METHYLENE CHLORIDE	µg/l	µg/kg
PERCENT MOISTURE	µg/l	µg/kg
STYRENE	µg/l	µg/kg
TETRACHLOROETHANE	µg/l	µg/kg
TOLUENE	µg/l	µg/kg
TRANS-1,3-DICHLOROPROPENE	µg/l	µg/kg
TRICHLOROETHENE	µg/l	µg/kg
VINYL ACETATE	µg/l	µg/kg
VINYL CHLORIDE	µg/l	µg/kg
XYLENES, TOTAL	µg/l	µg/kg

ATTACHMENT E
LISTING OF CHANGE INDICATORS

Database Change Indicators

Indicator	Modification
OK	No modification - accurate as originally reported
V	Value in Concentration Field
P	Parameter spelling
C	Category spelling/assignment
E	Value in Radiological Field
U	Units of measure assignment
M	Missing or new add record
ND3	Values below CRDL to "ND" value
T	Change in record due to 12K data points validation results

ATTACHMENT F
LISTING OF 12000 DATA POINTS VALIDATED

ATTACHMENT G
CALIBRATION CRITERIA

ATTACHMENT G

Calibration Criteria for Volatiles & Semi-Volatiles by GCMS
(based on UPEPA CLP requirements)

I. Calibrations for the Control Compounds

A. Control compound present in sample

1. % RSD criteria not met in initial[1]

a. initial RRF20 closer to 1 than mean RRF

1) daily RRF closer to 1 than mean RRF
-if conc. < 20 ppb[2]; reject & flag (C)
-if conc. ≥ 20 ppb; accept & flag (CJ)

2) daily RRF farther from 1 than mean RRF; reject & flag (C)

b. initial RRF20 farther from 1 than mean RRF

1) daily RRF closer to 1 than mean RRF
-if conc. < 50 ppb[3]; reject & flag (C)
-if conc. ≥ 50 ppb; accept & flag (CJ)

2) daily RRF farther from 1 than mean RRF; reject & flag (C)

2. % RSD criteria met in the initial

a. % Diff criteria not met in daily

1) daily RRF closer to 1 than mean RRF
-if conc. < 50 ppb; reject & flag (C)
-if conc. ≥ 50 ppb; accept & flag (CJ)

---

1 Curve not linear

2 Level of the lowest initial calibration standard (use 660 ug/kg for soils)

3 Level of the daily calibration standard (use 1600 ug/kg for soils).

2) daily RRF farther from 1 than mean RRF; reject & flag (C)

b. % Diff criteria met in daily; accept

B. Control compound <u>not</u> present in sample

1. % RSD criteria not met in initial[4]

a. initial RRF20 closer to 1 than mean RRF

1) daily RRF closer to 1 than mean RRF; accept & flag (C)
2) daily RRF farther from 1 than mean RRF; reject & flag (C)

b. initial RRF20 farther from 1 than mean RRF

1) daily RRF closer to 1 than mean RRF; accept & flag (CJ)
2) daily RRF farther from 1 than mean RRF; reject & flag (C)

2. % RSD criteria met in the initial

a. % Diff criteria not met in daily

1) daily RRF closer to 1 than mean RRF; accept & flag (C)
2) daily RRF farther from 1 than mean RRF; reject & flag (C)

b. % Diff criteria met in daily; accept

[4] The non-linearity of the initial curve may not effect the ND result for the compound(s).

II. Calibrations for the NON-Control Compounds

A. Compound present in sample

1. % RSD from initial > 30%; accept & flag (CJ)
2. % RSD from initial ≤ 30%

a. % Diff from daily > 25%; accept & flag (CJ)
b. % Diff from daily ≤ 25%; accept

B. Compound <u>not</u> present in sample

1. % RSD from initial > 30%; accept & flag (C)
2. % RSD from initial ≤ 30%

a. % Diff from daily > 25%; accept & flag (C)
b. % Diff from daily ≤ 25%; accept

ATTACHMENT F
LISTING OF 12000 DATA POINTS VALIDATED

VALIDATION SAMPLE LISTING – 12K DATA POINTS

WSSRAP SAMPLE ID	LAB	ANIONS	METALS	MISC	NITROS	PEST/PCB	RADIOCHEM	SEMIVOA	VOA
AIR SAMPLES									
AP-1009-Q389	ACCU						*		
AP-1010-Q389	ACCU						*		
AP-4011-Q389	ACCU						*		
GROUNDWATER SAMPLES									
GW-1002-Q187	META								*
GW-1005-Q187	META								*
GW-1005-Q188-DU	ACCU						*		
GW-1006-Q289-DU	JTC	*			*				
GW-1006-Q289-DU	ACCU						*		
GW-1007-Q289	ACCU						*		
GW-1010-Q187	META							*	*
GW-1011-Q187	META							*	*
GW-1012-Q188-DU	ACCU						*		
GW-1015-Q289-DU	JTC	*			*				
GW-1017-Q188-DU	ACCU						*		
GW-1018-0787	META							*	
GW-1018-Q188-DU	ACCU						*		
GW-1021-Q388	META				*		*		
GW-1024-Q388	META	*		*	*		*		
GW-1024-Q488	META				*		*		
GW-1026-Q289	META				*		*		
GW-1027-Q289	META	*					*		
GW-1028-031290	JTC	*							
GW-106D-030790	ACCU						*		
GW-106S-030790-DU	ACCU						*		
GW-2001-Q187	META							*	*
GW-2001-Q187-MS	META							*	*
GW-2001-Q187-MSD	META							*	*
GW-2001-Q388	META	*	*	*	*		*		
GW-2003-Q488-DU	JTC	*		*	*				
GW-2004-Q187	META							*	*
GW-2004-Q388	META		*						
GW-2005-Q187	META							*	
GW-2006-Q488-DU	JTC	*		*	*				
GW-2008-Q388	META	*	*	*	*		*		
GW-2009-Q187	META							*	*
GW-2010-Q187	META							*	*
GW-2011-Q187	META							*	*
GW-2012-Q187	META							*	*
GW-2013-Q187	META								*
GW-2014-Q187	META								*

WSSRAP SAMPLE ID	LAB	ANIONS	METALS	MISC	NITROS	PEST/PCB	RADIOCHEM	SEMIVOA	VOA
GROUNDWATER SAMPLES (cont'd)									
GW-2017-Q187	META								*
GW-2017-Q388	META						*		
GW-2019-Q187	META							*	
GW-2020-Q187	META							*	*
GW-2020-Q388	META		*						
GW-2021-Q289	ACCU						*		
GW-2023-Q388	META	*							
GW-2024-Q388	META	*							
GW-2028-Q388	META	*							
GW-2101-Q187	META							*	
GW-2101-Q388	META	*		*	*		*		
GW-2108-Q388	META	*	*	*	*		*		
GW-3001-Q187	META							*	
GW-3001-Q289-DU	ACCU						*		
GW-3002-Q187	META							*	*
GW-3002-Q388	META	*	*	*	*		*		
GW-3003-Q187	META							*	*
GW-3003-Q388	META	*					*		
GW-3006-Q388	META	*					*		
GW-3006-Q489-DU	ACCU						*		
GW-3008-Q187	META							*	*
GW-3008-Q187-FB	META							*	*
GW-3101-Q187	META							*	
GW-3102-Q388	META	*	*	*	*		*		
GW-3106-Q489-DU	ACCU						*		
GW-4003-Q389-DU	JTC	*							
GW-4003-Q489	ACCU						*		
GW-4008-Q289-DU	ACCU						*		
GW-4012-Q388	META	*	*	*	*		*	*	*
GW-4012-Q489	ACCU						*		
GW-4013-Q388	META	*	*	*	*		*		
GW-4013-Q389-DU	JTC				*				
GW-4013-Q489-PB	ACCU						*		
GW-4014-Q388	META		*						
GW-4015-Q289-DU	JTC				*				
GW-4015-Q388	META				*				
GW-4016-Q189-DU	JTC	*							
GW-4018-Q489	ACCU						*		
GW-4018-Q489 MD	ACCU						*		
GW-4018-Q489 MS	ACCU						*		
GW-4019-032790	JTC	*							

VALIDATION SAMPLE LISTING – 12K DATA POINTS (CONT'D)

WSSRAP SAMPLE ID	LAB	ANIONS	METALS	MISC	NITROS	PEST/PCB	RADIOCHEM	SEMIVOA	VOA
GROUNDWATER SAMPLES (cont'd)									
GW-4019-Q388	META		*						
GW-4020-Q388	META	*	*				*		
GW-4021-Q388	META	*	*	*	*		*		
GW-4022-032790	JTC	*							
GW-4022-Q388	META	*	*	*	*		*		
GW-4022-Q489	ACCU						*		
GW-4023-Q489	ACCU						*		
GW-4109-Q489	JTC	*							
GW-4113-Q388	META	*	*	*	*		*		
GW-FIELD BLANK-030287	META								
GW-FIELD BLANK-030687	META								
GW-FIELD BLANK-031087	META								
GW-FIELD BLANK-031187	META								
GW-FIELD BLANK-031287	META								
GW-PW02-041189	META				*		*		
GW-PW02-Q190	JTC		*						
GW-PW03-Q489	ACCU						*		
GW-PW04-Q190	ACCU						*		
GW-PW07-Q489	ACCU						*		
GW-RMW1-Q189-DU	ACCU						*		
GW-RMW1-Q489	JTC	*	*		*				
GW-RMW2-041189	META		*		*		*		
GW-RMW4-Q489	JTC	*	*						
GW-RMWX-Q489	JTC	*	*		*				
GW-RMWX-Q489	ACCU						*		
NPDES SAMPLES									
NP-0001-020290	JTC	*		*					
NP-0001-020290	ACCU						*		
NP-0002-030890	JTC	*		*					
NP-0002-030890	ACCU						*		
NP-0003-030190	ACCU						*		
NP-0003-041090	ACCU						*		
NP-0003-111589	JTC			*					
NP-0005-041090	JTC			*					
NP-0005-041090	ACCU						*		
NP-000X-041090	JTC	*		*					
NP-000X-041090	ACCU						*		
WIPES/OIL SAMPLES									
OT-2000-051189	JTC					*			
OT-2001-030190	JTC					*			

WSSRAP SAMPLE ID	LAB	ANIONS	METALS	MISC	NITROS	PEST/PCB	RADIOCHEM	SEMIVOA	VOA
WIPES/OIL SAMPLES (cont'd)									
OT-2009-021589	JTC					*			
OT-2011-031389	JTC					*			
OT-2012-021589	JTC					*			
OT-2012-031389	JTC					*			
OT-2019-022789	JTC					*			
OT-2020-022789	JTC					*			
OT-2020-051689	JTC					*			
OT-2021-022789	JTC					*			
OT-2021-051789 MS	JTC					*			
OT-2021-051789 MSD	JTC					*			
OT-2022-052489	JTC					*			
OT-2023-052489	JTC					*			
OT-2029-022889	JTC					*			
OT-2031-022889	JTC					*			
WASTE SAMPLES									
RS-BA41-072689-B	ACCU						*		
RS-BA43-072689-B	ACCU						*		
RS-BA44-072689-B	ACCU						*		
RS-BA46-072689-B	ACCU						*		
RS-BA49-072689-B	ACCU						*		
RS-WSC610-022790	ACCU						*		
RS-WSC611-022790	ACCU						*		
RS-WSCHEM54-032990	JTC			*					
RS-WSQ-4(12"-18")	META						*		
WSQ-28(6"-12"0)(SS-4)	META						*		
WSQ-70(O"-6")(TS-8)	META						*		
WSQ-75(0"-6")(ORS-3)	META						*		
WSQ-84(O"-6")(ORS-4)	META						*		
WSQ-89(36-48)-1	META						*		
SLUDGE SAMPLES									
SD-3101-071790	ITAS							*	*
SD-3101-0990	ITAS								*
SD-3102-0406-I	META	*	*						
SD-3102-0406-O	META				*	*		*	
SD-3102-071790	ITAS							*	*
SD-3102-0990	ITAS								*
SD-3103-0204-I	META	*	*						
SD-3103-0204-O	META					*		*	
SD-3103-0204-V	META								*
SD-3103-0406-RC	META						*		

VALIDATION SAMPLE LISTING – 12K DATA POINTS (CONT'D)

WSSRAP SAMPLE ID	LAB	ANIONS	METALS	MISC	NITROS	PEST/PCB	RADIOCHEM	SEMIVOA	VOA
SLUDGE SAMPLES (cont'd)									
SD-3103-0608-I	META	*	*						
SD-3103-0608-O	META				*			*	
SD-3103-0608-V	META								*
SD-3103-071790	ITAS							*	*
SD-3103-0990	ITAS								*
SD-3103-0990 DU	ITAS								*
SD-3104-0406-I	META	*	*						
SD-3104-0406-I-FD	META	*	*						
SD-3104-0406-O	META							*	
SD-3104-0406-O-FD	META							*	
SD-3104-0406-V	META								*
SD-3104-0406-V-FD	META								*
SD-3201-0002-I	META	*	*						
SD-3201-0002-O	META				*			*	
SD-3201-0002-V	META								*
SD-3201-0204-I.C	META						*		
SD-3201-071890	ITAS		*		*	*	*		*
SD-3201-0990	ITAS								*
SD-3202-071890	ITAS		*		*	*	*	*	*
SD-3202-0810-I	META	*	*						
SD-3202-0810-I-MD	META	*	*						
SD-3202-0810-I-MS	META	*	*						
SD-3202-0810-O	META				*	*		*	
SD-3202-0810-O-MD	META				*	*		*	
SD-3202-0810-O-MS	META				*	*		*	
SD-3202-0810-V	META								*
SD-3202-0810-V-MD	META								*
SD-3202-0810-V-MS	META								*
SD-3202-0990	ITAS								*
SD-3203-071890	ITAS		*		*	*	*	*	*
SD-3203-0810-I	META	*	*						
SD-3203-0810-I-FC	META	*	*						
SD-3203-0810-I-O-FC	META				*				
SD-3203-0810-I.C.	META						*		
SD-3203-0810-O	META				*				
SD-3203-0810-V	META								*
SD-3203-0810-V-FC	META								*
SD-3203-0990	ITAS								*
SD-3205-0002-I	META	*	*						
SD-3205-0002-O	META			*					
SD-3205-0002-O.C.	META			*					
SD-3210-071890	ITAS							*	

WSSRAP SAMPLE ID	LAB	ANIONS	METALS	MISC	NITROS	PEST/PCB	RADIOCHEM	SEMIVOA	VOA
SLUDGE SAMPLES (cont'd)									
SD-3301-0004-I	META	*	*				*		
SD-3301-0408-O	META					*			
SD-3301-071990	ITAS		*			*	*	*	*
SD-3301-0812-I	META	*	*						
SD-3301-0812-I-FD	META	*	*						
SD-3301-0812-O	META			*		*		*	
SD-3301-0812-O-FD	META			*		*		*	
SD-3301-0812-V	META								*
SD-3301-0812-V-FD	META								*
SD-3301-1216-I	META	*	*				*		
SD-3302-0408-O	META			*		*		*	
SD-3302-0408-V	META								*
SD-3302-071990	ITAS		*			*	*	*	*
SD-3303-071990	ITAS		*			*	*	*	*
SD-3304-0608	META						*		
SD-3304-071990	ITAS		*			*	*	*	*
SD-3305-071990	ITAS		*			*	*	*	*
SD-3306-0002-I.C.	META						*		
SD-3306-071990	ITAS		*			*	*	*	*
SD-3307-0204-O	META			*					
SD-3307-0204-O-FD	META			*					
SD-3307-0204-V	META								*
SD-3307-0204-V-FD	META								*
SD-3307-071990	ITAS		*			*	*	*	*
SD-3308-0608-O	META				*	*			
SD-3308-0608-O-AB	META							*	
SD-3308-0608-O-FC	META							*	
SD-3308-0608-O.C. FC	META				*	*			
SD-3308-071990	ITAS		*			*	*	*	*
SD-3312-0406-I	META	*	*						
SD-3312-0406-O	META				*	*		*	
SD-3401-071890	ITAS		*		*	*	*	*	*
SD-3401-0990	ITAS								*
SD-3402-071890	ITAS		*		*	*	*	*	*
SD-3402-0990	ITAS								*
SD-3403-0002-I	META	*	*						
SD-3403-0002-O	META				*	*		*	
SD-3403-071890	ITAS		*		*	*	*	*	*
SD-3403-0990	ITAS								*
SD-3404-0002-I	META	*	*						
SD-3404-0002-O	META				*	*		*	
SD-3404-0002-V	META								*

VALIDATION SAMPLE LISTING – 12K DATA POINTS (CONT'D)

WSSRAP SAMPLE ID	LAB	ANIONS	METALS	MISC	NITROS	PEST/PCB	RADIOCHEM	SEMIVOA	VOA
SLUDGE SAMPLES (cont'd)									
SD-3406-0204-I	META	*	*						
SD-3406-0204-I.C.FC	META	*	*						
SD-3406-0204-O	META				*	*			
SD-3406-0204-O.C.FC	META				*	*			
SD-3406-0204-V	META								*
SD-3408-0002-I	META	*	*						
SD-3408-0002-I.C	META						*		
SD-3408-0002-O	META				*	*			
SD-3417-0002-I	META	*	*						
SD-3417-0002-O	META				*	*		*	
SD-3417-0002-V	META								*
SD-3419-0002-I.C. BU	META						*		
SD-4002:0-6	META							*	
SD-4004:0-6	META						*		
SD-4006:0-6	META						*		
SD-4007:0-6	META						*		
SD-4008:0-6	META		*		*	*	*	*	
SD-4012:0-6	META						*		
SD-4036:0-6	META						*		
SD-4047:0-6	META						*		
SD-4049:0-6	META						*		
SD-4049:6-12	META						*		
SD-4063:0-6	META					*			
SD-4065:0-6	META					*			
SD-4066:0-6	META					*	*	*	
SD-4068:0-6	META						*		
SD-4076:0-6	META						*		
SOIL SAMPLES									
S2-044143,106675-0.0,7.0 RE	JTC	*		*					
S2-044321,106293-8.0,15.0 RE	JTC	*	*						
S2-049270,100420-0.0,7.0 RE	JTC				*				
S2-049370,100740-6.0,8.0	META				*				
S2-049410,100758-12.0,14.0 RE	JTC		*						
S2-049700,100360-0.0,0.5	META					*			
S2-049750,099900-8.0,15.0 RE	JTC			*					
S2-049800,100620-0.0,0.5	META							*	
S2-049830,099470-0.0,1.0	META		*						
S2-049910,099830-3.0,5.0 RE	JTC	*		*		*		*	*
S2-050000,100020-8.0,15.0 RE	JTC	*	*	*	*				
S2-050340,100420-4.5,5.0	META		*						
S2-050350,100480-0.0,1.0	META					*			
S2-050360,100660-0.0,0.5	META		*						

WSSRAP SAMPLE ID	LAB	ANIONS	METALS	MISC	NITROS	PEST/PCB	RADIOCHEM	SEMIVOA	VOA
SOIL SAMPLES (cont'd)									
S2-050360,100660-2.0,3.5 RE	JTC								*
S2-050500,098350-0.0,7.0 RE	JTC				*				
S2-050550,0987790-8.0,15.0	META	*							
S2-050550,101210-0.0,1.0	META		*					*	
S2-050600,100950-8.0,10.0 RE	JTC	*	*		*				
S2-050750,100770-0.0,2.0 RE	JTC		*	*					
S2-050760,100150-0.0,2.0	META		*						
S2-050850,100185-4.0,6.0 RE	JTC	*		*					
S2-050910,100860-GRAB	META		*					*	
S2-051000,099430-0.0,7.0	META	*							
S2-051280,100890-2.0,4.0	META				*				
S2-051300,100850-0.0,1.0	META	*							
S2-051320,100878-0.0,2.0	META	*							
S2-051400,100450-4.0,6.0	META				*				
S2-051450,098850-8.0-15.0	META		*						
S2-051565,100850-0.0,2.0	META		*						
S2-051770,100430-8.0,15.0	META		*						
S2-051970,100520-0.0,1.5 RE	JTC				*				
S2-052000,100900-8.0,14.0 RE	JTC				*				
S2-052116,100760-0.0,2.0	META		*						
SO-049370,100740-0,2-0990	ITAS				*				
SO-049370,100740-2,4-0990	ITAS				*				
SO-049468,100712-0,2-0990	ITAS				*				
SO-049468,100712-2,4-0990	ITAS				*				
SO-049700,100360-0,0.5-0790	ITAS					*			
SO-049700,100360-2,2.5-0790	ITAS					*			
SO-049775,099975-0,0.5-0790	ITAS							*	*
SO-049830,099470-0,0.5-0790	ITAS							*	*
SO-049830,099470-2,2.5-0790	ITAS					*			
SO-049860,099340-0,0.5-0790	ITAS							*	*
SO-049950,099740-0,0.5-0790	ITAS					*			
SO-049950,099740-2,2.5-0790	ITAS					*			
SO-050040,100700-0,0.5-0790	ITAS					*		*	*
SO-050040,100700-2,2.5-0790	ITAS					*		*	*
SO-050100,100650-0,0.5-0790	ITAS					*		*	*
SO-050100,100650-2,2.5-0790	ITAS					*		*	*
SO-050140,101225-0,2-0990	ITAS				*				
SO-050140,101225-2,4-0990	ITAS				*				
SO-050310,100450-0,0.5-0790	ITAS					*			
SO-050340,100420-0,0.5-0790	ITAS					*		*	*
SO-050340,100420-2,2.5-0790	ITAS					*		*	*
SO-050430,100640-0,0.5-0790	ITAS					*			

VALIDATION SAMPLE LISTING – 12K DATA POINTS (CONT'D)

WSSRAP SAMPLE ID	LAB	ANIONS	METALS	MISC	NITROS	PEST/PCB	RADIOCHEM	SEMIVOA	VOA
SOIL SAMPLES (cont'd)									
SO-050430,100640-2,2.5-0790	ITAS					*			
SO-050440,100450-0.0.5-0790	ITAS					*		*	*
SO-050500,100140-0,0.5-0790	ITAS							*	*
SO-050500,100140-2,2.5-0790	ITAS					*			
SO-050550,101070-0,0.5-0790	ITAS							*	
SO-050610,098370-0,0.5-0790	ITAS					*			*
SO-050680,099990-0,0.5-0790	ITAS					*			
SO-050680,099990-2,2.5-0790	ITAS					*			
SO-050790,093300-0,0.5-0790	ITAS					*			
SO-050790,093300-2,2.5-0790	ITAS					*			
SO-050850,100100-0,2-0990	ITAS				*				
SO-050850,100185-0,2-0990	ITAS				*				
SO-050850,100185-2,4-0990	ITAS				*				
SO-050850-100100-0,2-0990	ITAS				*				
SO-051225,098825-0,2-0790	ITAS				*				
SO-051225,098825-2,4-0790	ITAS				*				
SO-051280,100890-0,2-0990	ITAS				*				
SO-051280,100890-2,4-0990	ITAS				*				
SO-051300,100850-0,1-0990	ITAS				*				
SO-051300,100850-0,1-0990DU	ITAS				*				
SO-051320,100850-0,1-0990	ITAS				*				
SO-051400,100400-0,2-0790	ITAS				*				
SO-051400,100400-2,4-0790	ITAS				*				
SO-051400,100700-0,2-0990	ITAS				*				
SO-051400,100700-2,4-0990	ITAS				*				
SO-051400,100800-2,4-0687	META		*						
SO-051565,100850-0,2-0990	ITAS				*				
SO-051565,100850-0,2-0990DU	ITAS				*				
SO-051565,100850-2,4-0990	ITAS				*				
SO-051760,100243-0,2-0790	ITAS				*				
SO-051815,100360-0,2-0790	ITAS				*				
SO-051815,100360-2,4-0790	ITAS				*				
SO-052220,100750-0,2-0790	ITAS				*				
SO-052220,100750-2,4-0790	ITAS				*				
SO-052300,101400-0,2-0790	ITAS				*				
SO-052300,101400-2,4-0790	ITAS				*				
SO-052350,100700-0,1-0790	ITAS				*				
SO-052400,100400-0,2-0790	ITAS				*				
SO-052400,100700-0,1-0790	ITAS				*				
SO-052400,101400-2,4-0790	ITAS				*				
SO-FRTP-0790	ITAS					*		*	*

WSSRAP SAMPLE ID	LAB	ANIONS	METALS	MISC	NITROS	PEST/PCB	RADIOCHEM	SEMIVOA	VOA
SPRING WATER SAMPLES									
SP-5203-022588	META				*		*		
SP-5301-Q489	JTC				*				
SP-5302-Q489	JTC				*				
SP-5303-022988	META				*		*		
SP-5503-120887	META				*		*		
SP-6301-121087-D2	ACCU						*		
SP-6301-Q189-B	META				*		*		
SP-6301-Q190	JTC		*						
SP-6306-022988	META				*		*		
SP-6306-Q489	JTC				*				
SURFACE WATER SAMPLES									
SW-0000-Q489	JTC	*							
SW-1002-031689	META				*				
SW-1002-Q189	META						*		
SW-1005-Q289	META	*			*		*		
SW-1006-0389	META				*		*		
SW-1008-Q489 MS	JTC				*				
SW-1008-Q489 MSD	JTC				*				
SW-1009-031689	META				*				
SW-1009-Q189	META						*		
SW-2002-Q188	META	*					*		
SW-2006-Q488	META	*					*		
SW-3001-031789	META		*				*		
SW-3001-031789-DISS	META		*						
SW-3001-Q187	META							*	
SW-3002-031789	META		*				*		
SW-3002-031789-DISS	META		*						
SW-3002-Q187	META							*	
SW-3003-031789	META		*				*		
SW-3003-031789-DISS	META		*						
SW-3003-Q187	META							*	
SW-3003-Q489	JTC	*							
SW-3004-031789	META		*				*		
SW-3004-031789-B	META		*				*		
SW-3004-031789-B-DISS	META		*						
SW-3004-Q187	META							*	
SW-3004-Q489	JTC	*							
SW-3004-031789-DISS	META		*						

ACCU = Accu-Labs
META = metaTRACE, Inc.
JTC = JTC Analytical
ITAS = IT Analytical Services (check samples)

ATTACHMENT G
CALIBRATION CRITERIA

ATTACHMENT G

Calibration Criteria for Volatiles & Semi-Volatiles by GCMS
(based on UPEPA CLP requirements)

I. Calibrations for the Control Compounds

A. Control compound present in sample

1. % RSD criteria not met in initial[1]

a. initial RRF20 closer to 1 than mean RRF

1) daily RRF closer to 1 than mean RRF
-if conc. < 20 ppb[2]; reject & flag (C)
-if conc. ≥ 20 ppb; accept & flag (CJ)

2) daily RRF farther from 1 than mean RRF; reject & flag (C)

b. initial RRF20 farther from 1 than mean RRF

1) daily RRF closer to 1 than mean RRF
-if conc. < 50 ppb[3]; reject & flag (C)
-if conc. ≥ 50 ppb; accept & flag (CJ)

2) daily RRF farther from 1 than mean RRF; reject & flag (C)

2. % RSD criteria met in the initial

a. % Diff criteria not met in daily

1) daily RRF closer to 1 than mean RRF
-if conc. < 50 ppb; reject & flag (C)
-if conc. ≥ 50 ppb; accept & flag (CJ)

---

1 Curve not linear

2 Level of the lowest initial calibration standard (use 660 ug/kg for soils)

3 Level of the daily calibration standard (use 1600 ug/kg for soils).

2) daily RRF farther from 1 than mean RRF; reject & flag (C)

b. % Diff criteria met in daily; accept

B. Control compound not present in sample

1. % RSD criteria not met in initial[4]

a. initial RRF20 closer to 1 than mean RRF

1) daily RRF closer to 1 than mean RRF; accept & flag (C)
2) daily RRF farther from 1 than mean RRF; reject & flag (C)

b. initial RRF20 farther from 1 than mean RRF

1) daily RRF closer to 1 than mean RRF; accept & flag (CJ)
2) daily RRF farther from 1 than mean RRF; reject & flag (C)

2. % RSD criteria met in the initial

a. % Diff criteria not met in daily

1) daily RRF closer to 1 than mean RRF; accept & flag (C)
2) daily RRF farther from 1 than mean RRF; reject & flag (C)

b. % Diff criteria met in daily; accept

[4] The non-linearity of the initial curve may not effect the ND result for the compound(s).

II. Calibrations for the NON-Control Compounds

A. Compound present in sample

1. % RSD from initial > 30%; accept & flag (CJ)
2. % RSD from initial ≤ 30%

a. % Diff from daily > 25%; accept & flag (CJ)
b. % Diff from daily ≤ 25%; accept

B. Compound <u>not</u> present in sample

1. % RSD from initial > 30%; accept & flag (C)
2. % RSD from initial ≤ 30%

a. % Diff from daily > 25%; accept & flag (C)
b. % Diff from daily ≤ 25%; accept

CHEMICAL PLANT
202-1.12

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
7295 Highway 94 South
St. Charles, Missouri 63304

March 10, 1992

Distribution

QUARTERLY ENVIRONMENTAL DATA SUMMARY, FOURTH QUARTER 1991

Enclosed for your information and use is a copy of the Quarterly Environmental Data Summary. This document summarizes the environmental monitoring data for the Fourth Quarter 1991, highlights any potentially significant findings, and offers preliminary interpretations. Final interpretations will appear in the 1991 Annual Site Environmental Report.

The report concludes that no significant differences or changes have occurred at the Weldon Spring Site Remedial Action Project (WSSRAP) during the reporting period.

If you have any questions, please call Alan Gibson.

Sincerely,

Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

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QUARTERLY ENVIRONMENTAL DATA SUMMARY—FOURTH QUARTER 1991

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

MARCH 1992 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

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APPROVALS

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Weldon Spring Site Remedial Action Project

Quarterly Environmental Data Summary Fourth Quarter 1991

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ABSTRACT AND WELDON SPRING SITE QUARTERLY SELF ASSESSMENT FOURTH QUARTER 1991

The purpose of this Quarterly Environmental Data Summary is to provide to the public preliminary data acquired as part of the Weldon Spring Site Remedial Action Project (WSSRAP) environmental monitoring program. The document summarizes the preliminary environmental data, highlights any potentially significant findings, and offers tentative intepretations. Validated data and final interpretations will appear in the 1991 Annual Site Environmental Report.

This report includes preliminary data from environmental monitoring activities at the Weldon Spring site (WSS) during the fourth quarter of 1991. Groundwater, surface water, and air were sampled in order to monitor potential exposure pathways. Analytical parameters included radionuclides, nitroaromatic compounds, inorganic anions, and direct gamma exposure. The results are used to calculate exposure doses (where applicable) and assess the impact of the contaminants at the site on potentially exposed populations.

In summary, no significant differences were observed in off-site exposures during the fourth quarter of 1991 relative to exposures calculated in previous quarters. Contaminated groundwater did not affect the St. Charles County well field. Surface water containing elevated uranium activity continued to impact the Femme Osage Slough. Off-site gamma results are not available at this time; however, off-site radon, and air particulate exposures remained indistinguishable from background. Off-site monitoring demonstrated that exposure levels at the Francis Howell High School, the Busch Wildlife Area Headquarters, and the Weldon Spring Training Area remain indistinguishable from background levels.

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1 INTRODUCTION

This document is the seventh in a series of documents designed to provide a summary of the findings from the routine environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). These documents supplement the *Annual Site Environmental Report* (ASER) by providing interested outside agencies and organizations with more frequent access to WSSRAP data. They provide data resulting from routine environmental sampling as described in the *WSSRAP Environmental Monitoring Plan* (EMP) (MKF and JEG 1991) and a brief interpretation of that data.

It is the goal of this document to summarize and briefly discuss the data, highlighting data that differ significantly from observations made in previous reports. The full interpretation of these data (as well as data in other quarterly summaries) will be undertaken in the 1991 ASER. It is recommended that interested readers refer to previous EMPs, ASERs, and project documents for more information on existing site conditions, site history, transport mechanisms, and quantified contaminant levels. The monitoring scheme for every calendar year is established prior to that year in the annual EMP. Each sampling location to be monitored during the upcoming year is identified in the EMP and the schedule of analytical parameters is tabulated for easy reference. These reports may be obtained by visiting the WSSRAP reading room or contacting the WSSRAP Community Relations Manager at 314-441-8086.

These quarterly reports are intended to include data from all quarterly environmental monitoring programs conducted at the WSSRAP including groundwater, surface water, National Pollutant Discharge Elimination System (NPDES), radon gas, gamma radiation, and air particulates (including asbestos and radioactive particulates). However, because of delays in data delivery from the analytical laboratories, some of the data that was expected to be included in this report are not yet available for reporting. The unavailability of data is due to a nationwide shortage in analytical services. These data will be reported in the 1991 ASER. Sludges, soils, and biological specimens are not sampled on a routine basis; therefore, analytical results for these parameters are not included in this report. Trend analyses are being prepared from historical data for surface water, groundwater and air pathways. These analyses will be presented in the 1991 ASER. Quality control (QC) data for the fourth quarter and all other quarters will be presented in the 1991 ASER.

2 GROUNDWATER MONITORING

The groundwater is sampled regularly at both the Weldon Spring Chemical Plant/raffinate pits/vicinity properties (WSCP/RP/VP) and the Weldon Spring Quarry (WSQ). Due to differences in the environmental settings and sources of contaminants, separate monitoring schedules are followed. Therefore, results of groundwater monitoring at the WSCP/RP/VP and WSQ will be discussed separately.

2.1 Chemical Plant/Raffinate Pits/Vicinity Properties

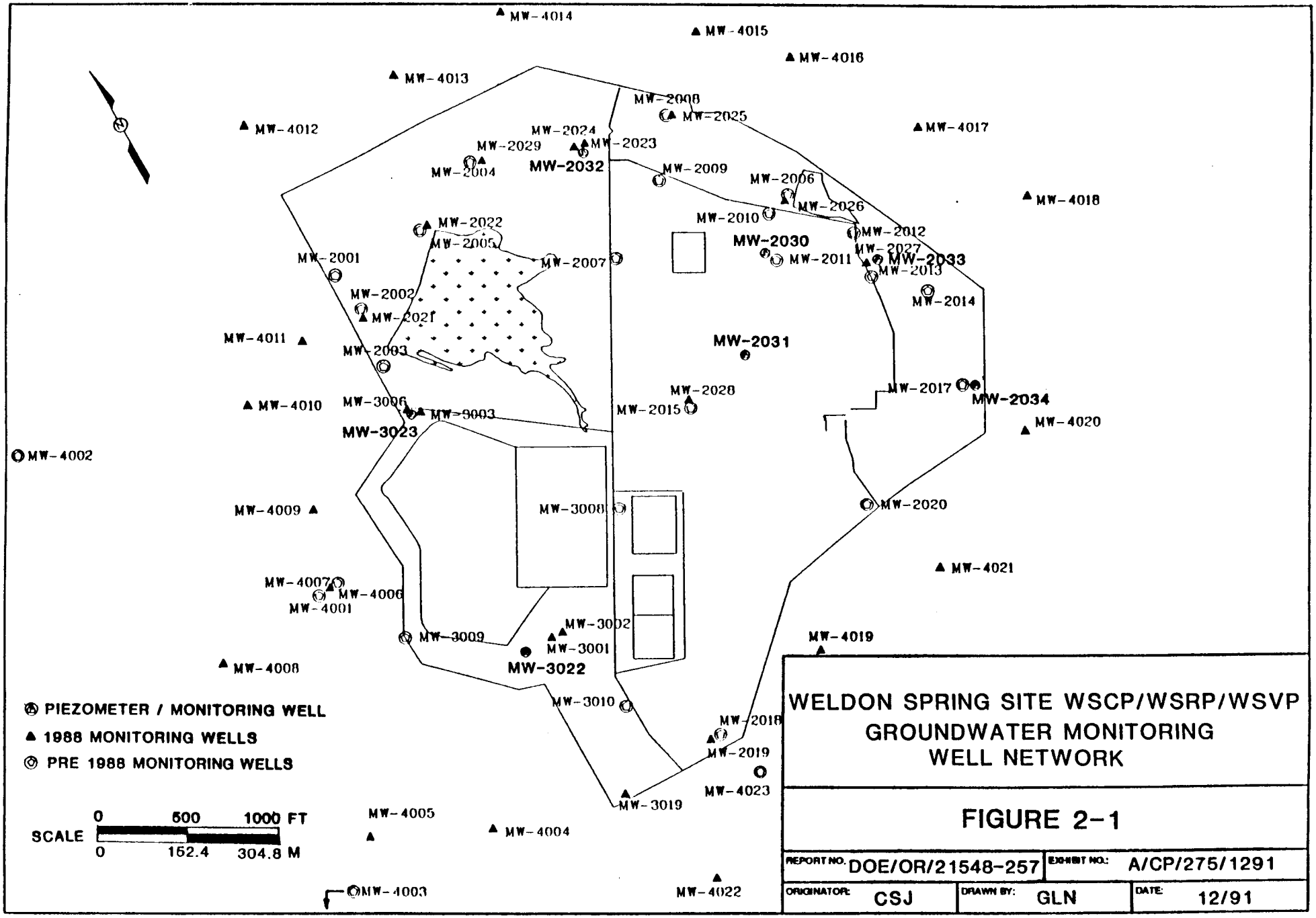
The groundwater at the chemical plant/raffinate pits/vicinity properties area is monitored on a semi-annual basis with the exception of MW-2001, MW-2002, MW-2003, MW-3003, MW-3006, MW-3008, MW-3009, MW-3023, MW-4012, and MW-4013 which are monitored quarterly for uranium, nitrate, sulfate, and metals. Monitoring well locations are shown in Figure 2-1.

2.1.1 Nitroaromatic Results

Table 2-1 contains nitroaromatic data from samples collected from the semiannually monitored groundwater wells at the WSCP/RP/VP area. Nitroaromatic compounds were detected in seven samples for which data are currently available. Concentration levels for these compounds are within their historical range.

2.1.2 Radiological Results

The radiological results for samples from quarterly monitored wells at the WSCP/RP/VP are presented in Table 2-2. The upper bound for natural uranium background concentration in groundwater at the WSCP/RP/VP has been determined to be 3.4 pCi/l (MKF and JEG 1989). The U.S. Environmental Protection Agency (EPA) has not yet established a drinking water standard for uranium; however, the proposed maximum contaminant level (MCL) currently set at 20 μg/l which is equal to 12 pCi/l using site specific conversion factors. The U.S. Department of Energy (DOE) has a health-based, derived concentration guideline (DCG) of 600 pCi/l in surface water effluent.



WELDON SPRING SITE WSCP/WSRP/WSVP GROUNDWATER MONITORING WELL NETWORK

FIGURE 2-1

REPORT NO.	DOE/OR/21548-257	EXHIBIT NO.	A/CP/275/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91

TABLE 2-1 Semi-Annual Nitroaromatic Data for Groundwater at the WSCP/RP/VP

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-2001-111491	NR	NR	NR	NR	NR	NR
GW-2002-111491	NR	NR	NR	NR	NR	NR
GW-2003-Q491	NR	NR	NR	NR	NR	NR
GW-2004-111891	ND	ND	ND	ND	ND	ND
GW-2006-110591	ND	ND	0.13	2.40	ND	12.0
GW-2013-110591	ND	0.13	0.31	19.0	0.88	6.20
GW-2015-111291	ND	ND	ND	ND	ND	ND
GW-2018-111291	ND	ND	ND	ND	ND	ND
GW-2020-103191	ND	ND	ND	ND	ND	ND
GW-2023-110691	ND	ND	ND	ND	ND	ND
GW-2028-102991	ND	ND	ND	ND	ND	ND
GW-2029-102491	ND	ND	ND	ND	ND	ND
GW-2030-111891	ND	ND	0.20	30.0	8.00	3.10
GW-2031 Abandoned in 1991						
GW-2032-111891	ND	ND	0.094	3.50	5.60	3.10
GW-2033-111891	ND	ND	0.23	2.80	0.80	2.60
GW-2034-111891	ND	ND	ND	ND	ND	ND
GW-3001-102491	NA	NA	NA	NA	NA	NA
GW-3003-Q491	NR	NR	NR	NR	NR	NR
GW-3006-110691	ND	ND	ND	ND	ND	ND
GW-3008-Q491	NR	NR	NR	NR	NR	NR
GW-3009-Q491	NR	NR	NR	NR	NR	NR
GW-3010 Abandoned in 1991						
GW-3022 Abandoned in 1991						
GW-3023-Q491	NR	NR	NR	NR	NR	NR
GW-4012-Q491	NR	NR	NR	NR	NR	NR
GW-4013-Q491	NR	NR	NR	NR	NR	NR
GW-4015-120291	ND	ND	0.070	1.00	ND	0.56
GW-4016-120391	ND	ND	ND	ND	ND	ND

TABLE 2-1 Semi-Annual Nitroaromatic Data for Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-4017-120491	ND	ND	ND	ND	ND	ND
GW-4020-120391	ND	ND	ND	ND	ND	ND
GW-4022-102391	NA	NA	NA	NA	NA	NA
GW-4023-102191	ND	ND	0.059	0.045	ND	0.13

NA - Not Available
ND - Not Detected
NR - Not Required 4th quarter

TABLE 2-2 Fourth Quarter and Semiannual Uranium and Inorganic Anion Data in Groundwater at the WSCP/RP/VP

SAMPLE ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)
GW-2001-111491	22.5	7.70	NA
GW-2002-111491	501	105	NA
GW-2003-Q491	380	135	NA
GW-2004-111891	0.89	2.00	0.750
GW-2006-110591	6.50	33.8	ND
GW-2013-110591	0.57	17.7	ND
GW-2015-111291	ND	93.9	0.810
GW-2018-111291	0.22	9.60	1.15
GW-2020-103191	0.38	142	4.93
GW-2023-110691	ND	17.7	2.74
GW-2028-102991	ND	126	2.34
GW-2029-102491	ND	19.4	1.99
GW-2030-111891	1.40	43.6	0.894
GW-2031	Abandoned in 1991		
GW-2032-111891	76.7	49.2	0.577
GW-2033-111891	0.93	21.6	1.18
GW-2034-111891	0.64	674	14.7
GW-3001-102491	874	20.5	1.90
GW-3003-Q491	354	164	NA
GW-3006-110691	ND	21.9	1.41
GW-3008-Q491	760	74.2	NA
GW-3009-Q491	98.7	72.7	NA
GW-3010	Abandoned in 1991		
GW-3022	Abandoned in 1991		
GW-3023-Q491	347	370	NA
GW-4012-Q491	0.32	48.1	NA
GW-4013-Q491	182	47.0	NA
GW-4015-120291	1.80	14.5	2.88
GW-4016-120391	ND	14.6	3.29

TABLE 2-2 Fourth Quarter and Semiannual Uranium and Inorganic Anion Data in Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)
GW-4017-120491	0.49	6.70	ND
GW-4020-120391	ND	125	15.3
GW-4022-102391	0.25	49.9	2.71
GW-4023-102191	4.90	75.5	1.18

ND - Not Detected
NA - Not Available

The highest uranium level detected from the available data was 15.3 pCi/l from a sample obtained from monitoring well MW-4020. The concentrations reported in Table 2-2 continue to indicate levels below the proposed drinking water standard for uranium.

2.1.3 Sulfate and Nitrate Results

Sulfate and nitrate concentrations are given in Table 2-2. The fourth quarter results are similar to historical ranges for these parameters.

2.1.4 Geochemical Results: Metals and Inorganic Anions

Geochemical parameters were added to the *Environmental Monitoring Plan* for the 1991 monitoring year. Results of analyses for samples from quarterly monitored wells at the WSCP/RP/VP are presented in Table 2-3. Concentrations from most geochemical constituents are similar to their previously measured levels; however, nickel and bromide concentrations display a notable drop to NDs from previously measurable levels. These changes in nickel and bromide are thought to reflect an analytical discrepancy and are currently being investigated.

2.2 Weldon Spring Quarry

Chemical and radiological wastes at the quarry are of particular concern because of their proximity to the St. Charles County well field. The well field is located approximately 0.8 km (0.5 mi) to the south of the Weldon Spring Quarry. Monitoring of contaminants in groundwater and the protection of the well field is a top priority at the Weldon Spring Site Remedial Action Project (WSSRAP).

Groundwater is currently being monitored in 48 wells in and around the quarry. Thirty-six monitoring wells installed by the DOE currently exist in or near the quarry. Four monitoring wells were installed by St. Charles County in 1986 and are currently included in the DOEs monitoring program. Eight St. Charles County municipal wells are also included in the DOEs monitoring program. All monitoring well locations are shown in Figures 2-2 and 2-3. These wells draw water from both bedrock and alluvial aquifers.

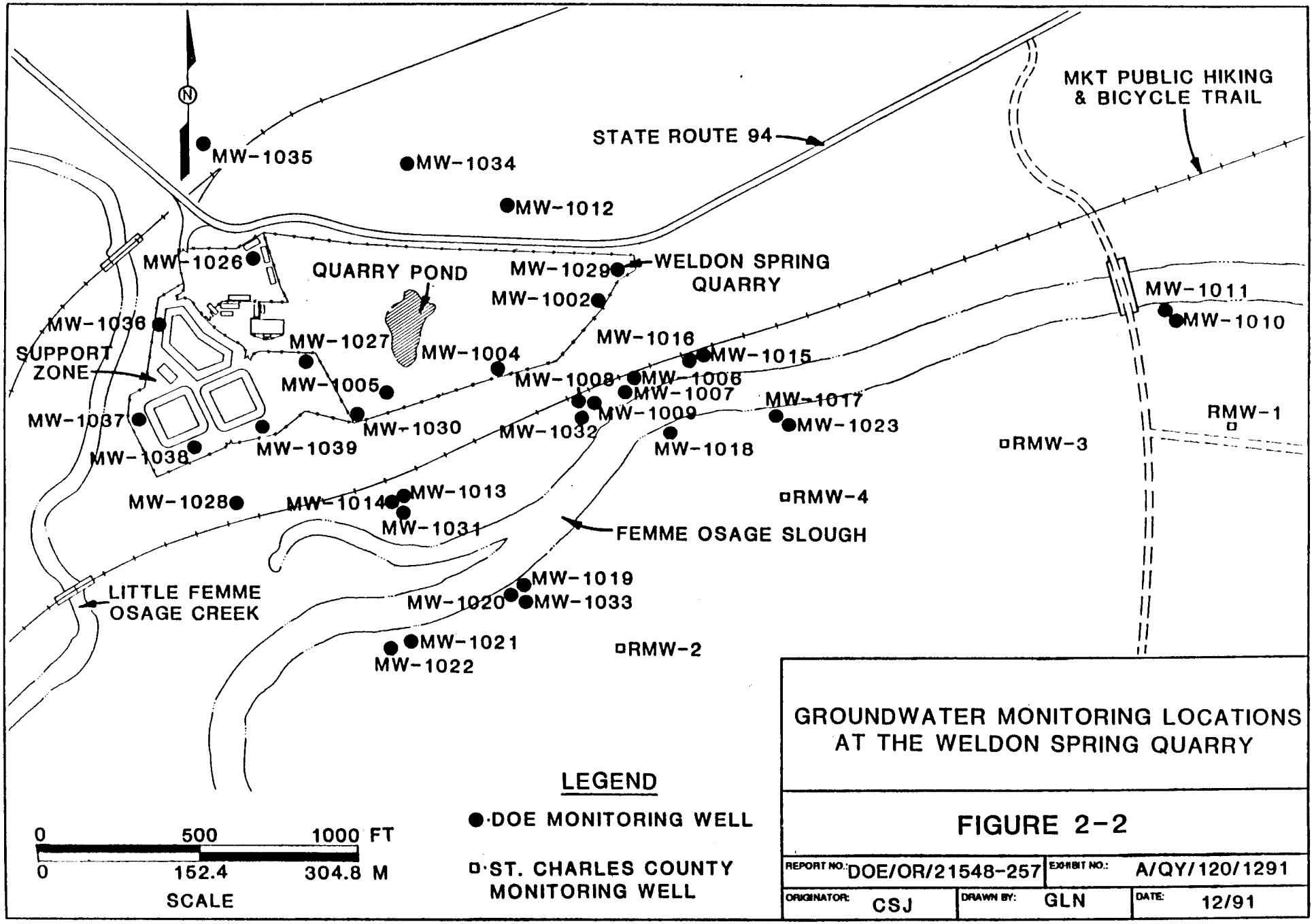
TABLE 2-3 Fourth Quarter Geochemical Results for Groundwater at the WSCP/RP/VP

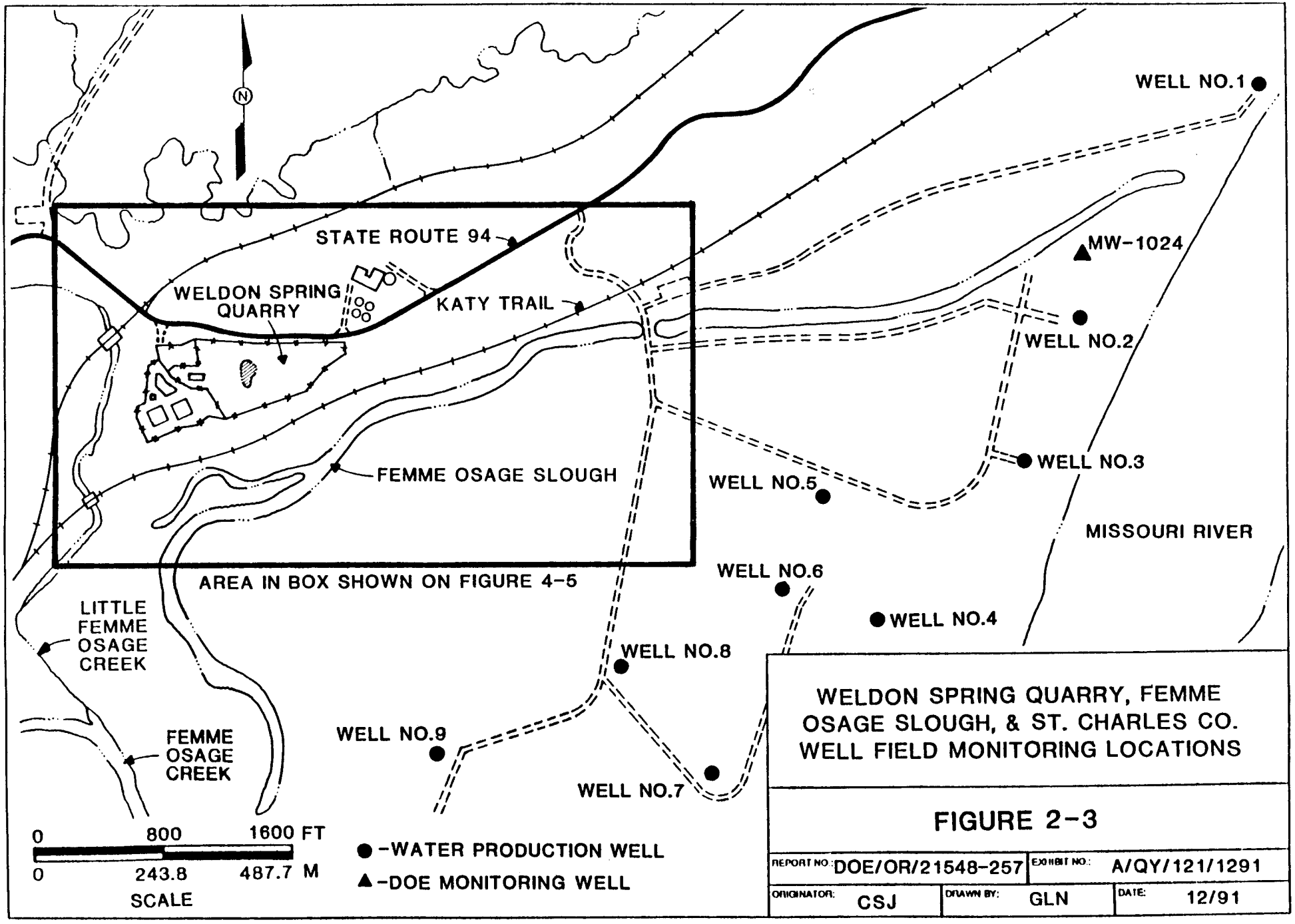
SAMPLE ID	ARSENIC (µg/l)	BARIUM (µg/l)	CALCIUM (µg/l)	CHROMIUM (µg/l)	IRON (µg/l)	LITHIUM (µg/l)	MAGNESIUM (µg/l)	MANGANESE (µg/l)	NICKEL (µg/l)
GW-2001-111491	ND	ND	87100	ND	72.3	ND	40600	ND	ND
GW-2002-111491	ND	24.7	290000	ND	ND	453	96300	ND	ND
GW-2003-Q491	ND	153	263000	ND	85.5	503	92300	3.29	ND
GW-3003-Q491	ND	150	253000	ND	ND	501	143000	17.9	ND
GW-3006-110691	ND	152	62400	ND	169	ND	50100	158	ND
GW-3008-Q491	ND	292	662000	ND	ND	255	175000	ND	ND
GW-3009-Q491	ND	1090	112000	ND	59.8	ND	62000	7.00	20.1
GW-3023-Q491	8.30	90.3	385000	32.4	8860	851	87400	176	ND
GW-4012-Q491	ND	30.0	17900	99.0	55.6	ND	31600	ND	ND
GW-4013-Q491	ND	147	146000	ND	ND	ND	52900	ND	ND

TABLE 2-3 Fourth Quarter Geochemical Results for Groundwater at the WSCP/RP/VP (Continued)

SAMPLE ID	POTASSIUM (µg/l)	SODIUM (µg/l)	STRONTIUM (µg/l)	NITRITE (µg/l)	BROMIDE (µg/l)	CHLORIDE (µg/l)	PHOSPHORUS TOTAL (µg/l)	SILICA, DISSOLVED (µg/l)	ALKALINITY (mg/l)
GW-2001-111491	1500	8080	87.7	ND	ND	5900	60	8590	320
GW-2002-111491	9670	113000	360	ND	ND	10200	80	11600	270
GW-2003-Q491	6870	117000	490	ND	ND	9690	60	11000	262
GW-3003-Q491	9520	162000	597	160	ND	13000	90	9090	280
GW-3006-110691	1260	17600	207	ND	ND	2100	600	10500	360
GW-3008-Q491	2000	244000	1750	ND	ND	24400	50	11500	230
GW-3009-Q491	869	25900	225	ND	ND	5000	ND	8200	170
GW-3023-Q491	5260	228000	664	1390	ND	16500	50	10600	270
GW-4012-Q491	71600	45500	63.0	ND	ND	3100	50	14300	300
GW-4013-Q491	7000	35100	154	ND	930	8190	110	11800	300

NA - Not Available
ND - Not Detected


N
MW-1035
MW-1034
STATE ROUTE 94
MKT PUBLIC HIKING & BICYCLE TRAIL
MW-1012
MW-1026
QUARRY POND
MW-1029
WELDON SPRING QUARRY
MW-1002
MW-1011
MW-1010
MW-1036
SUPPORT ZONE
MW-1027
MW-1004
MW-1016
MW-1015
MW-1005
MW-1008
MW-1006
MW-1007
MW-1017
MW-1009
RMW-1
MW-1037
MW-1030
MW-1032
MW-1023
MW-1039
MW-1018
RMW-3
MW-1038
MW-1028
MW-1014
MW-1013
RMW-4
MW-1031
FEMME OSAGE SLOUGH
MW-1019
LITTLE FEMME OSAGE CREEK
MW-1020
MW-1033
MW-1021
RMW-2
MW-1022
0 500 1000 FT
0 152.4 304.8 M
SCALE
LEGEND
DOE MONITORING WELL
ST. CHARLES COUNTY MONITORING WELL
GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING QUARRY
FIGURE 2-2
REPORT NO.: DOE/OR/21548-257
EXHIBIT NO.: A/QY/120/1291
ORIGINATOR: CSJ
DRAWN BY: GLN
DATE: 12/91



WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, & ST. CHARLES CO. WELL FIELD MONITORING LOCATIONS

FIGURE 2-3

REPORT NO:	DOE/OR/21548-257	EXHIBIT NO.:	A/QY/121/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91

Two separate groundwater monitoring programs have been developed for the quarry. The first program is a bimonthly sampling of all wells north of the Femme Osage Slough and MW-1010 and MW-1011. Also note that MW-1035, MW-1036, MW-1037, MW-1038, and MW-1039 will be sampled monthly until operation of the Weldon Spring Quarry water treatment plant is initiated. The second program is the quarterly sampling of all wells south of the Femme Osage Slough, excluding MW-1010 and MW-1011 but including the St. Charles County well field. Both the raw and treated waters from the St. Charles County water treatment plant are also sampled.

2.2.1 Radiological Results

Radiological data are presented in Tables 2-4, 2-5, and 2-6 for samples collected on a bimonthly and quarterly basis. The results show typical fluctuations near the average levels in the WSQ area with the exception of MW-1006. Uranium concentrations in this well were higher than recent values but did not exceed recent results for MW-1004 which appears to be hydrologically related.

2.2.2 Nitroaromatic Compounds Results

Analytical results for nitroaromatic compounds are presented in Tables 2-7, 2-8, and 2-9. No monitoring wells south of the Femme Osage Slough showed detectable concentrations of nitroaromatic compounds during the fourth quarter of 1991. The distribution and magnitude of nitroaromatic contamination near the quarry remains unchanged.

2.2.3 Inorganic Anions Results

Two inorganic anions--nitrate and sulfate--were measured in quarry wells. The analytical results for fifth and sixth bimonthly periods and the fourth quarter are presented in Tables 2-4, 2-5, and 2-6, respectively. These results are consistent with data reported in the previous environmental monitoring reports. The WSQ groundwater samples continue to indicate no significant nitrate contamination of the groundwater. The high nitrate value of 3020 mg/l in RMW3-Q491 is attributed to a sampling error. This sample appears to have been inadvertently preserved with nitric acid.

TABLE 2-4 Fifth Bimonthly (Sept/Oct) Inorganic Anions and Radiological Results in Groundwater at the Weldon Spring Quarry

SAMPLE ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)
GW-1002-091291	0.79	49.5	4.61
GW-1004-091291	ND	230	2770
GW-1005-102291	ND	214	2260
GW-1006-101591	0.62	417	4730
GW-1007-101591	0.12	2.80	44
GW-1008-101591	Well Dry		
GW-1009-101591	0.10	349	ND
GW-1010-101691	0.13	ND	ND
GW-1011-101691	Well Dry		
GW-1012-110491*	0.40	63.5	3.37
GW-1013-101691	0.14	114	926
GW-1014-101691	ND	108	623
GW-1015-101691	2.30	387	1510
GW-1016-101691	1.70	343	609
GW-1026-090591	ND	ND	ND
GW-1027-090591	0.21	118	1085
GW-1028-110491*	ND	77.6	ND
GW-1029-102291	0.11	77.4	2.85
GW-1030-102291	ND	105	8.45
GW-1031-091191	ND	45.0	21.6
GW-1032-102191	ND	253	952
GW-1034-	Not accessible due to construction		
GW-1035-	Not accessible due to construction		
GW-1036-091091	0.26	58.8	2.88
GW-1036-102191	ND	57.4	3.95
GW-1037-091791	ND	20.3	1.15
GW-1037-100791	0.89	19.3	1.20
GW-1038-091791	ND	48.1	2.02

TABLE 2-4 Fifth Bimonthly (Sept/Oct) Inorganic Anions and Radiological Results in Groundwater at the Weldon Spring Quarry (Continued)

SAMPLE ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)
GW-1038-100791	ND	44.5	3.17
GW-1039-091791	0.45	60.8	3.17
GW-1039-100791	ND	73.1	1.44

ND - Not Detected
NA - Not Detected
NS - Not Sampled
* - Sampled after the fifth bimonthly period.

TABLE 2-5 Sixth Bimonthly (Nov/Dec) Inorganic Anions and Radiological Results in Groundwater at the Weldon Spring Quarry

SAMPLE ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)
GW-1002-112591	1.30	569	3.14
GW-1004-112591	0.25	254	5040
GW-1005-112591	ND	207	2350
GW-1006-121691	1.89	399	4540
GW-1007-121691	0.16	209	155
GW-1008-121191	0.52	273	5330
GW-1009-121191	0.69	281	ND
GW-1010-121791	NR	NR	ND
GW-1011-121791	Well Dry		
GW-1012-121191	1.70	62.5	3.63
GW-1013-121191	0.37	115	923
GW-1014-121191	0.55	114	511
GW-1015-121691	3.79	294	1300
GW-1016-121791	1.89	242	602
GW-1026-111191	ND	0.64	ND
GW-1027-111191	0.11	83.0	1060
GW-1028-120491	0.14	87.5	1.38
GW-1029-112591	ND	731	2.65
GW-1030-112591	ND	1000	11.21
GW-1031-102191*	ND	30.5	30.0
GW-1032-120491	ND	266	931
GW-1032-121191	0.54	255	949
GW-1034-110491	0.22	86.7	2.68
GW-1035-120591	0.19	41.9	1.01
GW-1036-111191	ND	54.1	4.38
GW-1036-120591	0.21	66.6	3.81
GW-1037-111191	ND	16.0	1.61
GW-1037-120591	ND	17.0	1.10

TABLE 2-5 Sixth Bimonthly (Nov/Dec) Inorganic Anions and Radiological Results in Groundwater at the Weldon Spring Quarry (Continued)

SAMPLE ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)
GW-1038-111191	ND	44.3	3.37
GW-1038-120591	ND	51.3	5.13
GW-1039-111191	ND	60.0	2.45
GW-1039-120591	ND	73.1	1.82

ND - Not Detected
NA - Not Detected
NS - Not Sampled
NR - Not Required fourth quarter
* - Sampled before the sixth bimonthly period.

TABLE 2-6 Fourth Quarter Inorganic Anions and Radiological Results for the Weldon Spring Quarry

SAMPLE ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)	GROSS ALPHA (pCi/l)
GW-1017-100991	ND	0.99	ND	NR
GW-1018-101791	ND	25.8	ND	NR
GW-1019-100791	ND	3.50	ND	NR
GW-1020-100791	ND	16.7	ND	NR
GW-1021-100891	ND	ND	0.577	NR
GW-1022-100891	ND	ND	0.577	NR
GW-1023-100991	ND	5.70	1.15	NR
GW-1024-101091	ND	ND	2.59	NS
GW-1033-101791	ND	19.2	1.64	NR
GW-RMW1-Q491	ND	279	1.44	NA
GW-RMW2-Q491	5.80	249	4.398	NA
GW-RMW3-Q491	3020+	34.2	ND	NA
GW-RMW4-Q491	4.20	340	NA	NA
GW-RAWW-Q491	NR	NR	ND	NA
GW-FINW-Q491	NR	NR	ND	NA
GW-PW02-Q491	NR	NR	ND	NA
GW-PW03-Q491	NR	NR	ND	NA
GW-PW04-Q491	NR	NR	ND	NA
GW-PW05-Q491	NR	NR	ND	NA
GW-PW06	Not on line			
GW-PW07-Q491	NR	NR	ND	NA
GW-PW08-Q491	NR	NR	ND	NA
GW-PW09-Q491	NR	NR	ND	NA

ND - Not Detected
NA - Not Available
NR - Not Required fourth quarter
+ - Data questionable, appears to be sampling error.

TABLE 2-7 Fifth Bimonthly (Sept/Oct) Nitroaromatic Data for Groundwater at the Weldon Spring Quarry

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1002-091291	ND	0.13	0.042	7.00	19.0	140
GW-1004-091291	ND	ND	2.60	4.60	8.00	3.00
GW-1005-102291	ND	ND	0.14	0.050	ND	ND
GW-1006-101591	ND	ND	0.40	7.20	24.0	160
GW-1007-101591	ND	ND	ND	ND	ND	ND
GW-1008-101591	Well Dry					
GW-1009-101591	ND	ND	ND	ND	ND	ND
GW-1010-101691	ND	ND	ND	ND	ND	ND
GW-1011-101691	Well Dry					
GW-1012-110491*	ND	ND	ND	ND	ND	ND
GW-1013-101691	ND	ND	0.11	0.035	ND	ND
GW-1014-101691	ND	ND	0.060	0.016	ND	ND
GW-1015-101691	ND	0.33	0.053	0.85	19.0	110
GW-1016-101691	ND	ND	ND	0.13	2.10	14.0
GW-1026-090591	ND	ND	ND	ND	ND	ND
GW-1027-090591	ND	ND	3.00	4.40	32.0	0.12
GW-1028-110491*	ND	ND	ND	ND	ND	ND
GW-1029-102291	ND	ND	ND	ND	ND	ND
GW-1030-102291	ND	ND	0.054	ND	ND	ND
GW-1031-091191	ND	ND	ND	ND	ND	ND
GW-1032-102191	ND	ND	0.091	1.10	1.00	ND
GW-1034	Not accessible due to construction					
GW-1035	Not accessible due to construction					
GW-1036-102191	ND	ND	ND	ND	ND	ND
GW-1036-091091	ND	ND	ND	ND	ND	ND
GW-1037-091791	ND	ND	ND	ND	ND	ND
GW-1037-100791	ND	ND	ND	ND	ND	ND
GW-1038-091791	ND	ND	ND	ND	ND	ND

TABLE 2-7 Fifth Bimonthly (Sept/Oct) Nitroaromatic Data for Groundwater at the Weldon Spring Quarry (Continued)

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1038-100791	ND	ND	ND	ND	ND	ND
GW-1039-091791	ND	ND	ND	ND	ND	ND
GW-1039-100791	ND	ND	ND	ND	ND	ND

ND - Not Detected
NA - Not Available
* - Sampled after the fifth bimonthy period.

TABLE 2-8 Sixth Bimonthly (Nov/Dec) Nitroaromatic Data for Groundwater at the Weldon Spring Quarry

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1002-112591	ND	0.19	0.093	28.0	60.0	250
GW-1004-112591	ND	ND	2.60	4.20	7.00	2.80
GW-1005-112591	ND	ND	0.11	0.046	ND	ND
GW-1006-121691	ND	ND	0.28	4.20	10.0	55.0
GW-1007-121691	ND	ND	ND	ND	ND	ND
GW-1008-121191	ND	ND	0.030	0.60	1.90	0.25
GW-1009-121191	ND	ND	ND	ND	ND	ND
GW-1010-121791	NR	NR	NR	NR	NR	NR
GW-1011-121791	NR	NR	NR	NR	NR	NR
GW-1012-121191	ND	ND	ND	ND	ND	ND
GW-1013-121191	ND	ND	0.12	0.042	ND	ND
GW-1014-121191	ND	ND	0.068	0.017	ND	ND
GW-1015-121691	ND	0.25	0.055	0.93	20.0	120
GW-1016-121791	ND	ND	ND	0.20	3.20	17.0
GW-1026-111191	ND	ND	ND	ND	ND	ND
GW-1027-111191	ND	ND	3.00	2.80	17.0	0.12
GW-1028-120491	ND	ND	ND	ND	ND	ND
GW-1029-112591	ND	ND	ND	ND	ND	ND
GW-1030-112591	ND	ND	0.047	ND	ND	ND
GW-1031-102191*	ND	ND	ND	ND	ND	ND
GW-1032-120491	ND	ND	0.13	0.48	0.15	ND
GW-1032-121191	ND	ND	0.48	0.67	2.10	0.080
GW-1034-110491	ND	ND	ND	ND	ND	ND
GW-1035-120591	ND	ND	ND	ND	ND	ND
GW-1036-111191	ND	ND	ND	ND	ND	ND
GW-1036-120591	ND	ND	ND	ND	ND	ND
GW-1037-111191	ND	ND	ND	ND	ND	ND
GW-1037-120591	ND	ND	ND	ND	ND	ND

TABLE 2-8 Sixth Bimonthly (Nov/Dec) Nitroaromatic Data for Groundwater at the Weldon Spring Quarry (Continued)

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1038-111191	ND	ND	ND	ND	ND	ND
GW-1038-120591	ND	ND	ND	ND	ND	ND
GW-1039-111191	ND	ND	ND	ND	ND	ND
GW-1039-120591	ND	ND	ND	ND	ND	ND

ND - Not Dectected
NS - Not Sampled
NA - Not Available
NR - Not Required fourth quarter
* - Sampled before the sixth bimonthly period.

TABLE 2-9 Fourth Quarter Nitroaromatic Data for Groundwater at the Weldon Spring Quarry

SAMPLE ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1017-100991	ND	ND	ND	ND	ND	ND
GW-1018-101791	ND	ND	ND	ND	ND	ND
GW-1019-100791	ND	ND	ND	ND	ND	ND
GW-1020-100791	ND	ND	ND	ND	ND	ND
GW-1021-100891	ND	ND	ND	ND	ND	ND
GW-1022-100891	ND	ND	ND	ND	ND	ND
GW-1023-100991	ND	ND	ND	ND	ND	ND
GW-1024-101091	ND	ND	ND	ND	ND	ND
GW-1033-101791	ND	ND	ND	ND	ND	ND
GW-RMW1-Q491	ND	ND	ND	ND	ND	ND
GW-RMW2-Q491	ND	ND	ND	ND	ND	ND
GW-RMW3-Q491	ND	ND	ND	ND	ND	ND
GW-RMW4-Q491	ND	ND	ND	ND	ND	ND
GW-RAWW-Q491	ND	ND	ND	ND	ND	ND
GW-FINW-Q491	ND	ND	ND	ND	ND	ND
GW-PW02-Q491	ND	ND	ND	ND	ND	ND
GW-PW03-Q491	ND	ND	ND	ND	ND	ND
GW-PW04-Q491	ND	ND	ND	ND	ND	ND
GW-PW05-Q491	ND	ND	ND	ND	ND	ND
GW-PW06	Not on line					
GW-PW07-Q491	ND	ND	ND	ND	ND	ND
GW-PW08-Q491	ND	ND	ND	ND	ND	ND
GW-PW09-Q491	ND	ND	ND	ND	ND	ND

ND - Not Detected
NA - Not Available
NS - Not Sampled

2.2.4 Metals Results

A selected group of quarry wells located south of the Femme Osage Slough are sampled for arsenic and barium. Analytical results of these metals are given in Tables 2-10, 2-11 and 2-12. Results from the fifth and sixth bimonthly and fourth quarter analyses of arsenic and barium continue to indicate elevated concentrations in a few wells. The highest levels reported are 169 μ/l for arsenic and 1050 μ/l for barium, both from MW-1017. The high Ba value (5380 μg/l) reported for GW-RMW3-Q391 in the third quarter Quarterly Environmental Data Summary (QEDS) was a typographical error and should be changed in 538 μg/l.

TABLE 2-10 Fifth Bimonthly (Sept/Oct) Results for Metals in Groundwater at the Weldon Spring Quarry

SAMPLE ID	ARSENIC (µg/l)	BARIUM (µg/l)
GW-1002-091291	ND	104
GW-1004-091291	ND	22.6
GW-1005-102291	ND	67.7
GW-1006-101591	ND	71.9
GW-1007-101591	26.3	566
GW-1008-101591	Well Dry	
GW-1009-101591	5.90	357
GW-1010-101691	107	367
GW-1011-101691	Well Dry	
GW-1012-110491*	ND	126
GW-1013-101691	2.90	144
GW-1014-101691	ND	192
GW-1015-101691	ND	113
GW-1016-101691	ND	141
GW-1026-090591	19.6	386
GW-1027-090591	ND	110
GW-1028-110491*	3.00	311
GW-1029-102291	ND	111
GW-1030-102291	5.10	370
GW-1031-091191	ND	76.6
GW-1032-102191	ND	122
GW-1034	Not accessible due to construction	
GW-1035	Not accessible due to construction	
GW-1036-091091	ND	263
GW-1036-102191	ND	303
GW-1037-091791	ND	495
GW-1037-100791	ND	556
GW-1038-091791	ND	234

TABLE 2-10 Fifth Bimonthly (Sept/Oct) Results for Metals in Groundwater at the Weldon Spring Quarry (Continued)

SAMPLE ID	ARSENIC (µg/l)	BARIUM (µg/l)
GW-1038-100791	ND	264
GW-3039-091791	ND	416
GW-1039-100791	ND	526

ND - Not Detected
NA - Not Available
* - Sampled after the fifth bimonthly period.

TABLE 2-11 Sixth Bimonthly (Nov/Dec) Results for Metals in Groundwater at the Weldon Spring Quarry

SAMPLE ID	ARSENIC (µg/l)	BARIUM (µg/l)
GW-1002-112591	ND	122
GW-1004-112591	ND	37.2
GW-1005-112591	ND	61.7
GW-1006-121691	ND	51.0
GW-1007-121691	26.8	381
GW-1008-121191	ND	47.7
GW-1009-121191	8.80	390
GW-1010-121791	NR	NR
GW-1011-121791	NR	NR
GW-1012-121191	ND	130
GW-1013-121191	3.10	161
GW-1014-121191	ND	234
GW-1015-121691	ND	110
GW-1016-121791	ND	123
GW-1026-111191	22.4	420
GW-1027-111191	ND	104
GW-1028-120491	ND	334
GW-1029-112591	ND	109
GW-1030-112591	7.10	383
GW-1031-102191*	ND	106
GW-1032-120491	ND	112
GW-1032-121191	ND	120
GW-1034-110491	ND	166
GW-1035-120591	ND	258
GW-1036-111191	ND	282
GW-1036-120591	ND	263
GW-1037-111191	ND	512
GW-1037-120591	ND	495

TABLE 2-11 Sixth Bimonthly (Nov/Dec) Results for Metals in Groundwater at the Weldon Spring Quarry (Continued)

SAMPLE ID	ARSENIC (µg/l)	BARIUM (µg/l)
GW-1038-111191	ND	247
GW-1038-120591	ND	281
GW-1039-111191	ND	533
GW-1039-120591	ND	499

ND - Not Detected
NA - Not Available
NR - Not Required
* - Sampled before the sixth bimonthly period.

TABLE 2-12 Fourth Quarter Results for Metals in Groundwater at the Weldon Spring Quarry

SAMPLE ID	ARSENIC (µg/l)	BARIUM (µg/l)
GW-1017-100991	169	1050
GW-1018-101791	113	601
GW-1019-100791	70.8	688
GW-1020-100791	21.4	391
GW-1021-100891	79.6	863
GW-1022-100891	138	545
GW-1023-100991	75.6	381
GW-1024-101091	6.60	462
GW-1033-101791	ND	307
GW-RMW1-Q491	6.10	492
GW-RMW2-Q491	12.9	207
GW-RMW3-Q491	36.5	596
GW-RMW4-Q491	8.0	198
GW-RAWW-Q491	ND	389
GW-FINW-Q491	ND	98.30
GW-PW02-Q491	ND	351
GW-PW03-Q491	ND	286
GW-PW04-Q491	ND	295
GW-PW05-Q491	ND	368
GW-PW06	Not on line	
GW-PW07-Q491	ND	456
GW-PW08-Q491	ND	501
GW-PW09-Q491	3.00	514

ND - Not Detected
NA - Not Available

3 SURFACE WATER MONITORING

Routine samples were collected during the fourth quarter of 1991 from both on-site and off-site surface water and spring locations. All surface water samples were analyzed without filtering, unless a specific comparison of dissolved versus total contaminant concentrations was desired. Some analytical results are not available at this time; however, they will be presented in the 1991 Annual Site Environmental Report (ASER).

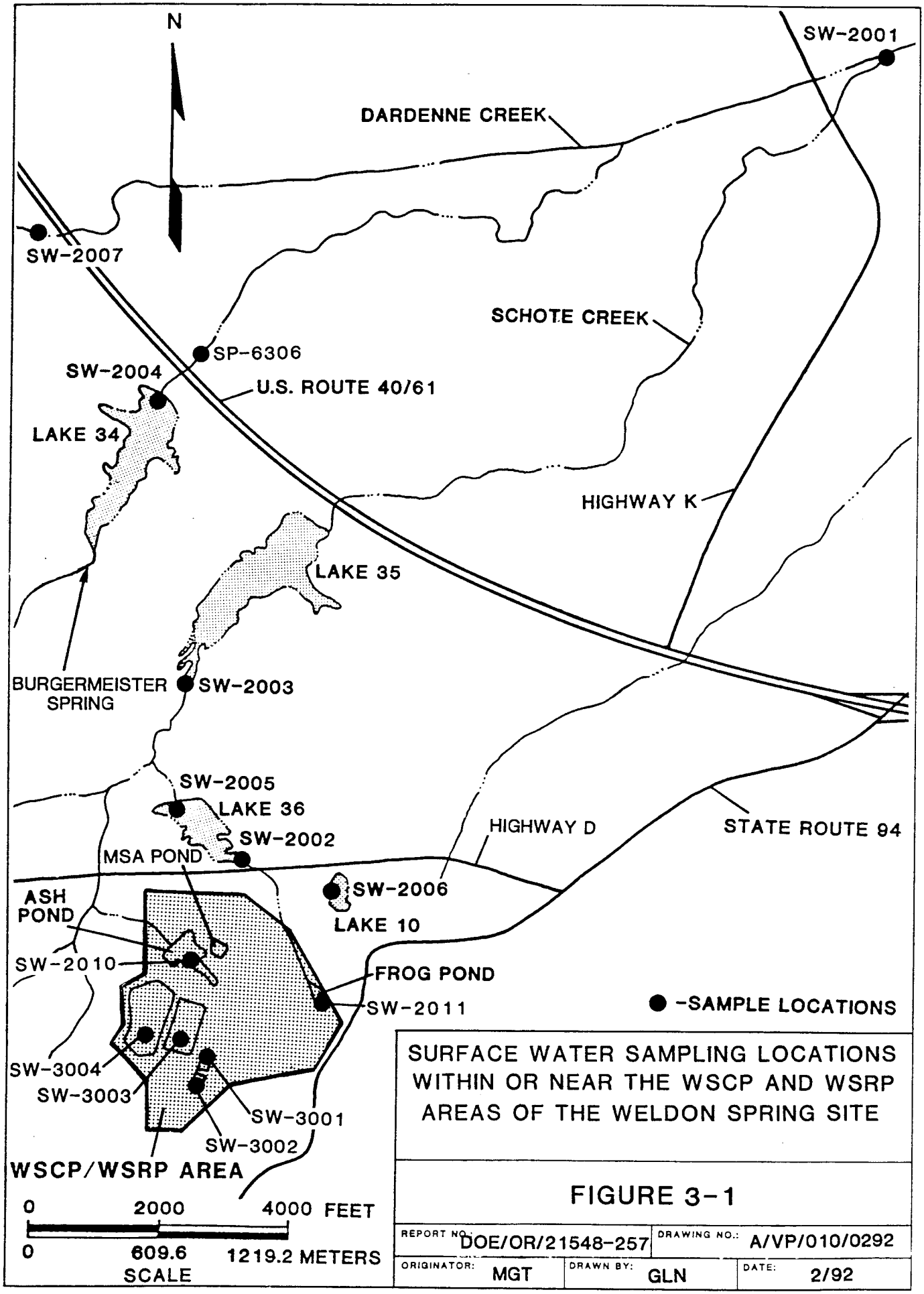
3.1 Chemical Plant/Raffinate Pits/Vicinity Properties

During the fourth quarter, surface water samples were collected from the 13 surface water sampling locations shown in Figure 3-1 and analyzed for uranium. The results, presented in Table 3-1, indicate that conditions remain similar to historical values.

3.2 Weldon Spring Quarry

Surface water samples were collected for uranium analyses from the 10 locations shown in Figure 3-2 and three locations in Figure 3-3. The results are presented in Table 3-2. Samples were collected from sampling locations SW-1003, SW-1004, SW-1005, SW-1007, SW-1009, and SW-1010 on a monthly basis to monitor slightly elevated uranium concentrations noted in the Quarterly Environmental Data Summary (QEDS) for the first and second quarters of 1991. Fourth quarter uranium concentrations for these locations are similar to lower pre-1991 values. The highest measured uranium concentration (1,950 pCi/l) was detected at the quarry pond (sampling location SW-1008) and is within the historical range for this site. Nitroaromatics, radionuclides, nitrate, and sulfate were measured for SW-1008 and are presented in Table 3-3. Concentrations of these constituents are similar to previously measured levels.

The fourth quarter uranium values measured for the Missouri River (SW-1011, SW-1012, and SW-1013) are similar to the third quarter values. In addition to the quarterly Missouri River samples, filtered and unfiltered samples (indicated by FI and NF in Table 3-2) were analyzed to evaluate the source of historical fluctuations in uranium concentrations at these locations as described in the Third Quarter QEDS. The fourth quarter data display little variation, either among the filtered and unfiltered samples from a single locale, or among samples from the three locales.



SURFACE WATER SAMPLING LOCATIONS WITHIN OR NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

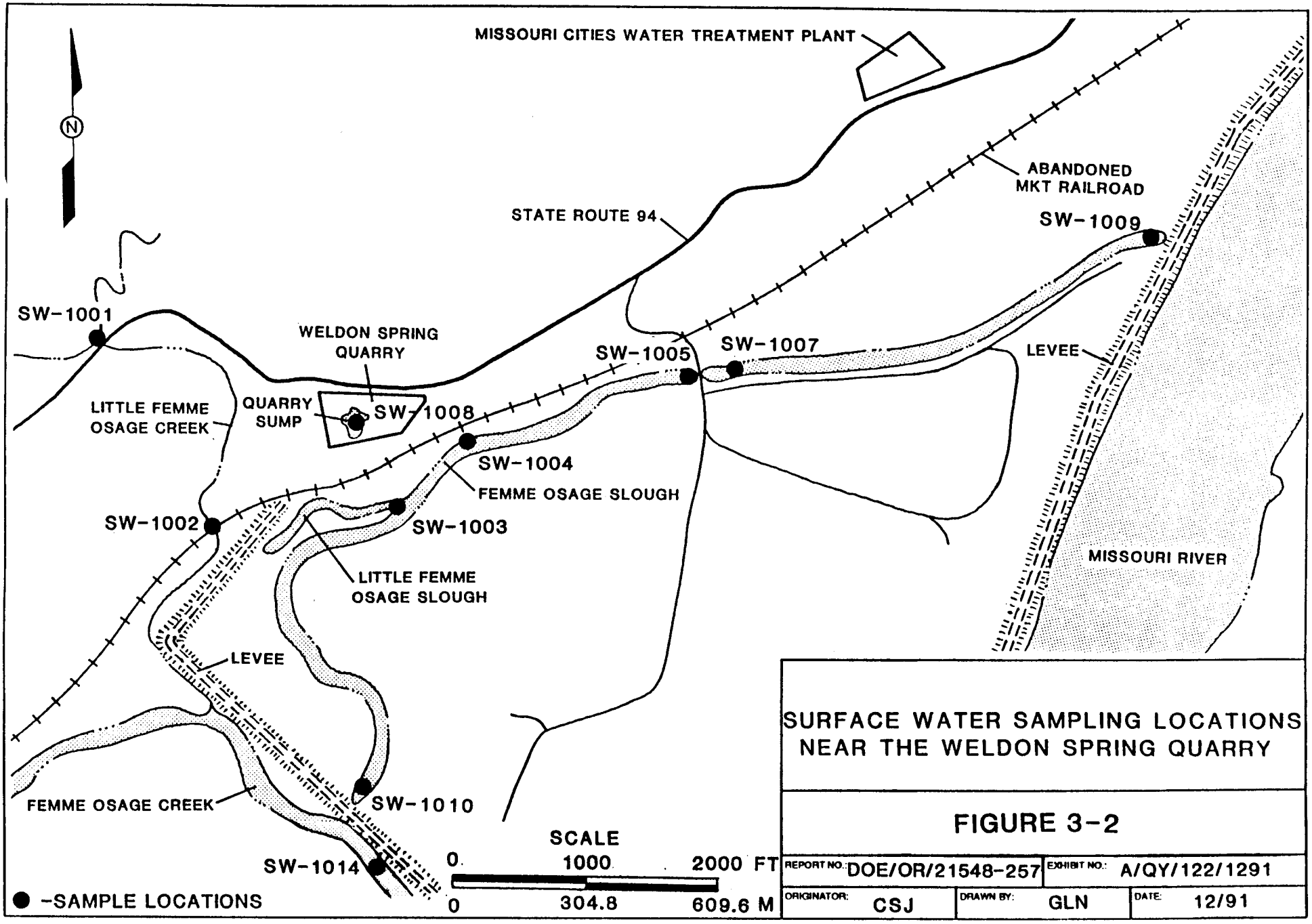
FIGURE 3-1

REPORT NO.	DOE/OR/21548-257	DRAWING NO.:	A/VP/010/0292
ORIGINATOR:	MGT	DRAWN BY:	GLN	DATE:	2/92

Table 3-1 Fourth Quarter Uranium Results in Surface Water at the WSCP/RP/VP

Sample ID	Uranium Total (pCi/l)
SW-2001-Q491	NA
SW-2002-Q491	NA
SW-2003-Q491	12.2
SW-2004-Q491	17.6
SW-2005-Q491	27.1
SW-2007-Q491	NA
SW-2010-Q491	NA
SW-2011-Q491	NA
SW-3001-Q491	72.1
SW-3002-Q491	1370
SW-3003-Q491	95.9
SW-3004-Q491	1750

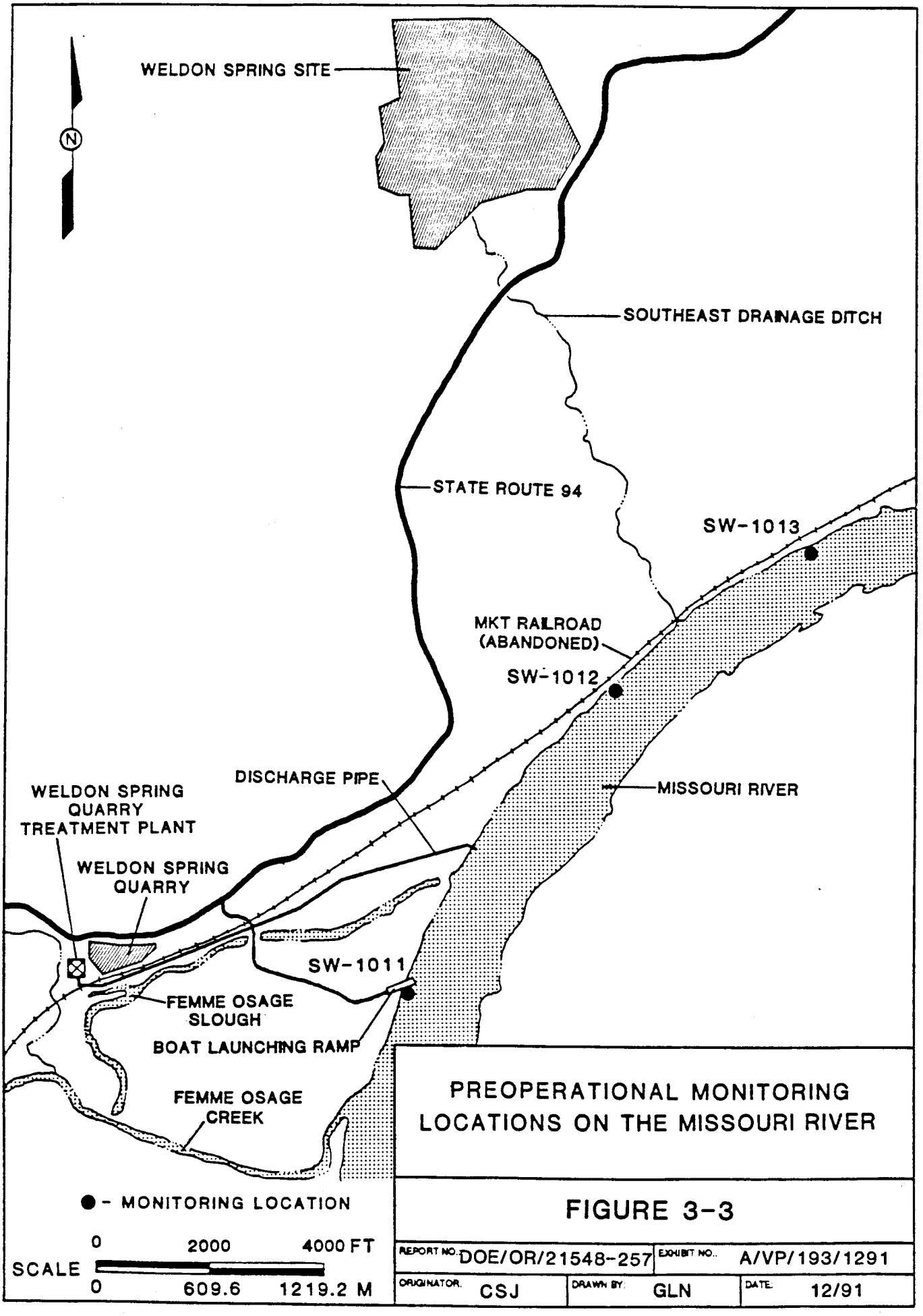
ND Not Detected
NA Not Available



SURFACE WATER SAMPLING LOCATIONS
NEAR THE WELDON SPRING QUARRY

FIGURE 3-2

REPORT NO.	DOE/OR/21548-257	EXHIBIT NO.	A/QY/122/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91



PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

FIGURE 3-3

REPORT NO.	DOE/OR/21548-257	EXHIBIT NO.	A/VP/193/1291		
ORIGINATOR	CSJ	DRAWN BY	GLN	DATE	12/91

Table 3-2 Fourth Quarter Uranium Results in Surface Water at the Weldon Spring Quarry

Sample ID	Uranium, Total (pCi/l)
SW-1001-Q491	NA
SW-1002-Q491	2.05
SW-1003-Q491	34.0
SW-1003-101191	66.0
SW-1003-120291	65.1
SW-1004-Q491	40.1
SW-1004-101191	56.4
SW-1004-120291	66.9
SW-1005-Q491	8.65
SW-1005-101191	5.77
SW-1005-120291	8.02
SW-1007-0491	13.1
SW-1007-101191	20.4
SW-1008-Q491	1950
SW-1009-Q491	13.0
SW-1009-101191	16.0
SW-1009-120291	10.2
SW-1010-Q491	33.4
SW-1010-101191	52.4
SW-1010-120291	22.2
SW-1011-121091	3.92
SW-1011-121391-FI	2.85
SW-1011-121391-NF	2.85
SW-1012-Q491	2.02
SW-1012-121391-F1	2.60
SW-1013-0491	2.28
SW-1013-121391-F1	3.00
SW-1013-121391-NF	2.74

Table 3-2 Fourth Quarter Uranium Results in Surface Water at the Weldon Spring Quarry (Continued)

Sample ID	Uranium, Total (pCi/l)
SW-1014-0491	3.00
SW-1015-121391-F1	3.00
SW-1015-121391-NF	3.37

NA Not Available
FI Sample filtered
NF Sample not filtered

Table 3-3 Fourth Quarter Results for SW-1008

Parameter	Concentration	Units
1,3,5-TNB	0.32	µg/l
1,3-DNB	ND	µg/l
2,4,6-TNT	60.0	µg/l
2,4-DNT	11.0	µg/l
2,6-DNT	2.10	µg/l
Nitrobenzene	ND	µg/l
Nitrate	0.19	mg/l
Sulfate	79.9	mg/l
Radium-226	0.687	pCi/l
Thorium-230	3.82	pCi/l
Thorium-232	ND	pCi/l

ND Not detected

3.3 Springs

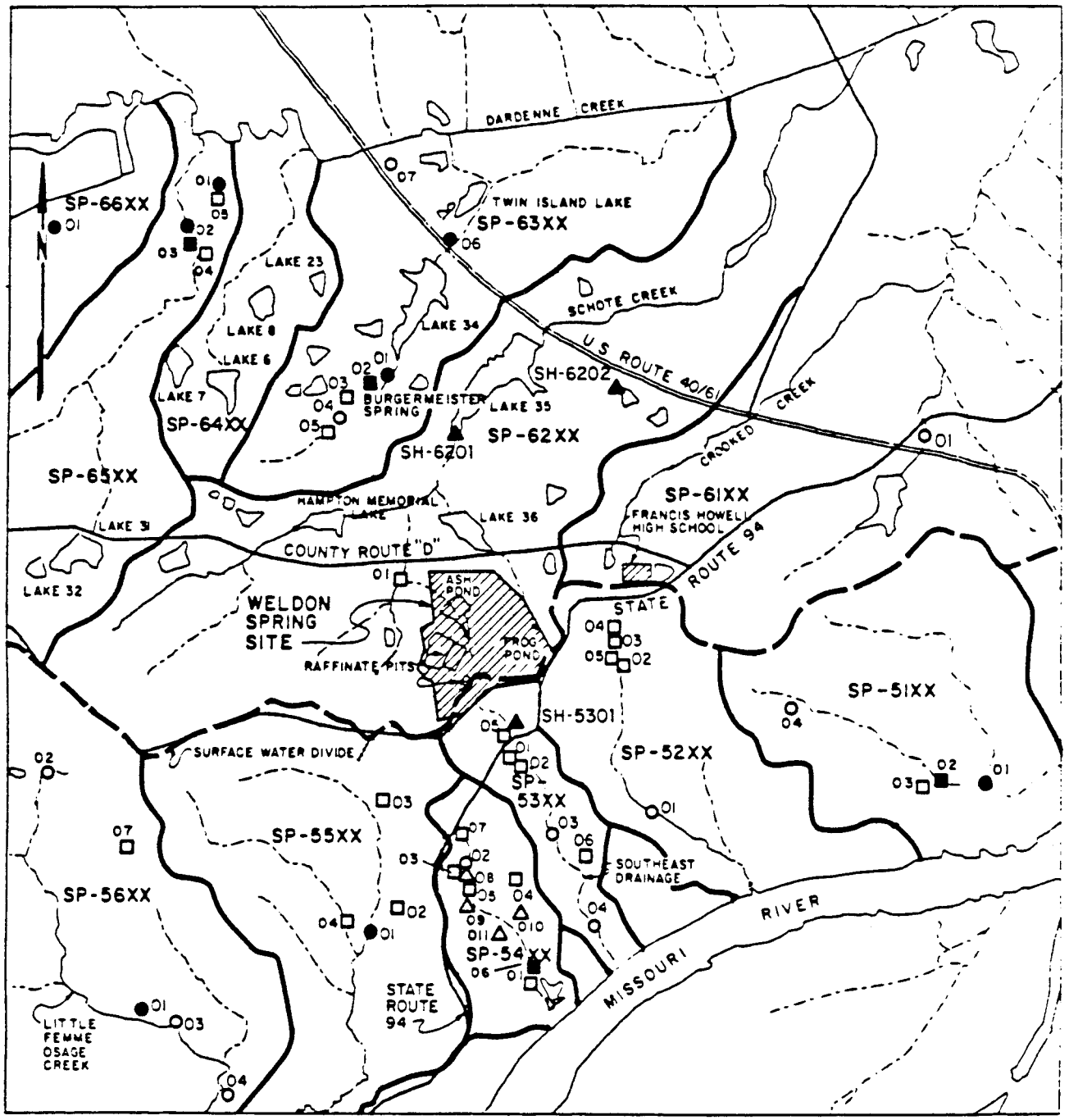
Nine springs around the Weldon Spring site (WSS) are sampled during fourth quarter (see Figure 3-4 for spring locations). Previous spring monitoring indicated that waters from six perennial springs and one wet-weather spring are measurably influenced by site-related contaminants. These springs include SP-5301 through SP-5304, SP-6301, SP-6302, and SP-6306. All spring samples are analyzed for uranium with a select few also analyzed for nitroaromatics, inorganics and metals. Available analytical results for these parameters are listed in Tables 3-4, 3-5, and 3-6. Values for these parameters remain consistent with historical values.

3.4 National Pollutant Discharge Elimination System Data Review

Surface water and effluent samples were collected and analyzed in compliance with the Weldon Spring site NPDES permits. Permit No. MO-0107701 was issued on October 1, 1990, and currently addresses the five storm water and two wastewater discharges shown in Figure 3-5. Outfalls NP-0001 through NP-0005 represent storm water discharges; Outfall NP-0006 represents the treated effluent discharge associated with the administration building sanitary wastewater treatment plant; and Outfall NP-0007 represents the site contaminated water treatment plant, which is under construction, but not yet completed. There was no discharge from NP-0007. Outfalls NP-0006 and NP-0007 have effluent limitations. The five storm water outfalls have monitoring requirements only. Fourth quarter 1991 analytical data for each outfall is presented in Table 3-6. Permit No. MO-0108987 was issued on May 5, 1989, for Outfall NP-1001 of the Weldon Spring Quarry contaminated water treatment plant. The plant construction is not completed, and no discharge took place during the fourth quarter of 1991.

3.4.1 Radiological Analysis

Gross alpha and total uranium analyses corresponded reasonably well with past data. The highest uranium levels were present in surface flow from Outfalls NP-0001, NP-0002, NP-0003, and NP-0005. The peaks for these points were 220 pCi/l, 332 pCi/l, 313pCi/l, and 614 pCi/l, respectively. Outfall NP-0004 had a uranium concentration of 9.98 pCi/l from a single sample analysis. Although not required by the NPDES permit, the outfall from the administration building sanitary wastewater treatment plant (Outfall NP-0006) was also monitored for total uranium. No uranium was detected at this outfall.



SOURCE: MDNR, 1989

LEGEND :

- SURFACE WATER DIVIDE BETWEEN MISSISSIPPI RIVER AND MISSOURI RIVER
- DRAINAGE BOUNDARY
- CREEK OR SURFACE DRAINAGE
- POND OR LAKE
- ● PERENNIAL SPRING WITH LARGE MAXIMUM FLOW
- ○ PERENNIAL SPRING WITH SMALL MAXIMUM FLOW
- ■ WET WEATHER SPRING WITH LARGE MAXIMUM FLOW
- □ WET WEATHER SPRING WITH SMALL MAXIMUM FLOW
- ▲ SHALLOW HOLE (SH)
- △ SEEP
- SP-63XX SPRING OR SEEP IN DESIGNATED DRAINAGE AREA NUMBER 63. XX REPRESENTS THE DESIGNATED SPRING NUMBER IN DRAINAGE 63.

SCALE 0 3200 6400 FT
0 975.4 1950.7 M

SPRINGS AND SEEPS IN THE VICINITY OF THE WSS

FIGURE 3-4

REPORT NO: DOE/OR/21548-257		EXHIBIT NO.:	A/VP/194/1291
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE:	12/91

Table 3-4 Fourth Quarter Uranium Results in Springs Near the Weldon Spring Site

Sample ID	Total Uranium (pCi/l)
SP-5203-Q491	NA
SP-5301-Q491	231
SP-5302-Q491	264
SP-5303-Q491	NA
SP-5304-Q491	NA
SP-6301-Q491	70.0
SP-6302-Q491	NA
SP-6303-Q491	2.51
SP-6306-Q491	NA

NA Not Available
ND Not Detected

Table 3-5 Fourth Quarter Nitroaromatic Results in Spring Near the Weldon Spring Site

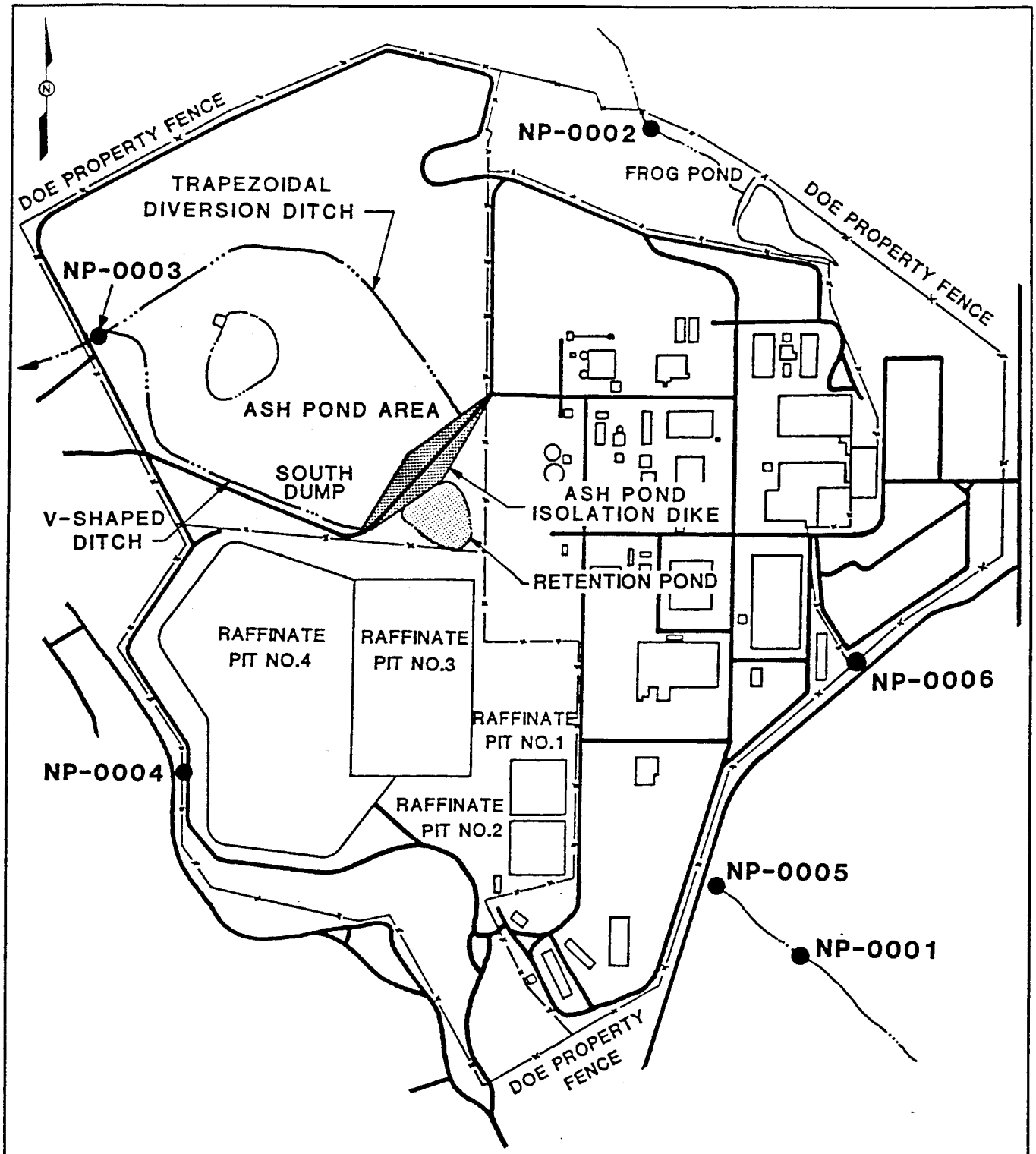
Sample ID	1,3,5-TNB (µg/l)	1,3-DNB (µg/l)	2,4,6-TNT (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	NB (µg/l)
SP-6302	NA	NA	NA	NA	NA	NA
SP-6306-Q491	ND	ND	ND	ND	1.05	ND

ND Not Detected
NA Not Available

Table 3-6 Fourth Quarter Metal Results for SP-6306

Parameters	Concentration (µg/l)
Aluminum	ND
Antimony	ND
Arsenic	4.90
Barium	324
Beryllium	ND
Cadmium	ND
Calcium	34400
Chromium	ND
Cobalt	ND
Copper	16.5
Iron	4470
Lead	2.00
Lithium	ND
Magnesium	8190
Manganese	7380
Mercury	ND
Molybdenum	ND
Nickel	11.1
Potassium	2970
Selenium	ND
Silver	ND
Sodium	9870
Thallium	ND
Vanadium	ND
Zinc	10.0

ND Not Detected



SCALE 0 500 1000 FT
0 152.4 304.8 M

NPDES MONITORING LOCATIONS

FIGURE 3-5

REPORT NO.:	DOE/OR/21548-257	EXHIBIT NO.:	A/CP/276/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91

TABLE 3-7 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006

Outfall NP-0001 NPDES data for Q4 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Oct. 24	5000	554	<0.1	0.64	8.0	ND	150	0.324	220

Outfall NP-0002 NPDES data for Q4 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Oct. 24	57,888	4	<0.1	ND	8.1	ND	49	.091	62
Nov. 14	2,448	6	<0.1	.25	6.4	ND	164	.362	246
Dec. 6	9,800	33	<0.1	1.2	6.0	ND	237	.488	332

Outfall NP-0003 NPDES data for Q4 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Oct. 2	163,152	5	<0.1	ND	6.4	ND	101	.025	17.2
Oct. 24	22,464	213	<0.1	ND	7.9	ND	92	.147	100
Nov. 14	10,656	11	<0.1	1.2	6.7	ND	193	.391	265
Nov. 27	21,600	--	<0.1	--	6.3	--	46	.079	54
Dec. 6	25,400	18	<0.1	17.5	6.1	ND	232	.460	313

TABLE 3-7 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006 (Continued)

Outfall NP-0004 NPDES data for Q4 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Nov. 7	1440	451	--	1.7	7.1	ND	9.1	.015	9.98
Dec. 26	1440	--	<0.1	--	7.3	--	--	--	--

Outfall NP-0005 NPDES data for Q4 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Oct. 24	16,992	ND	0.3	1.27	8.0	ND	150	.236	160
Nov. 14	4,464	23	<0.1	3.2	7.0	ND	500	.903	614
Dec. 6	2,900	16	<0.1	21.2	6.1	ND	314	.498	339

Outfall NP-0006 NPDES data for Q4 1991

DATE SAMPLED	FLOW	SUSP. SOLIDS	BOD	FECAL COLIFORMS	pH
UNITS	GPD**	mg/l	mg/l	Colonies/100 ml	pH units
Oct. 4	1,440	13	--	--	5.8*
Oct. 7	2,340	11	<6.0	1	6.5
Nov. 13	2,700	11	13.9*	2,100*	6.7
Dec. 4	1,458	24*	<6.0	1	7.0
Dec. 18	--	10	--	--	6.6

* Indicates value which exceeded effluent limitation
** Indicates flow rate at time of sample collection

3.4.2 Other Analysis

Other analyses for NP-0001 through NP-0005 included physical analyses (settleable solids and total suspended solids) and chemical analyses (nitrate, pH, and lithium). Fourth quarter 1991 values generally correspond to past values for the majority of parameters. Four exceptions were high total suspended solids (TSS) values for Outfalls NP-0001, NP-0003, and NP-0004 and high settlable solids (SS) for Outfall NP-0005. The elevated values of TSS for outfalls NP-0001 and SS for NP-0005 were caused by surface water runoff from off-site water line construction activity and by excavation for the site water treatment plant. The elevated TSS at Outfall NP-0003 may have been due to the collection of floating debris; no other unusual circumstances were noted. The elevated value of TSS at NP-0004 may have been caused by stream bed disturbance during sample collection since very low flow in the shallow stream channel makes it difficult to collect a sample without stirring up small amounts of sediment.

The discharge from the administration building treatment plant, Outfall NP-0006, has effluent limitations and a requirement to monitor once per quarter. Flow must be measured once a month. The Subcontractor monitors the effluent once a month to assess plant performance, thus generating two additional sample analyses a quarter. The NPDES permit specifies effluent limitations for biochemical oxygen demand (BOD), total suspended solids (TSS), pH, and fecal coliform at this outfall. The limits for BOD are 10 mg/l monthly average and 15 mg/l weekly average; for TSS, 15 mg/l monthly average and 20 mg/l weekly average; for fecal coliform, 400 colonies per 100 ml monthly average and 1,000 colonies per 100 ml daily maximum. During the quarter, the effluent exceeded permitted limits four times; once for each of the four parameters. On November 13, 1991, BOD was 13.9 mg/l, which exceeded the monthly average limit of 10 mg/l; fecal coliform was 2,100 colonies/100 ml; which exceeded the daily maximum of 1,000 and the monthly average limit of 400 colonies/100 ml. On December 4, 1991, TSS was 24, which exceeded the weekly average limitation of 20 mg/l. An additional sample was collected on December 18, 1991, for TSS with a resultant value of 10 mg/l. The two samples average out to 17 mg/l, which is over the monthly average limit of 15. On October 4, 1991, pH was measured at 5.8 which is outside the permitted range of 6.0 to 9.0 (standard units). The Subcontractor added lime to the aeration compartment to increase the pH to above 6.0.

The Subcontractor will test the total residual chlorine of the effluent and inspect the chlorinator three times a week to ensure that the chlorine tablet supply is adequate. This should allow fecal coliform limits to be met. Sewage is delivered to the treatment plant by a lift station

causing an uneven flow which could cause high BOD, TSS, and fecal coliform levels. To foster a more consistent and effective treatment of the administration building wastewater, a flow equalization tank will be installed between the lift station and the sewage treatment plant. A request for specifications and an engineering proposal have been sent to an off-site A/E firm with oversight by our Engineering Department. The revised specifications for wastewater treatment facility services are under final review. The specifications will require the Subcontractor to sample the effluent during the first seven days of the calendar month and telephone or fax the results to the Project Management Contractor (PMC) as soon as they are available. The PMC will ensure that these requirements are met. This will allow time for additional sampling by the Subcontractor or the PMC if it is required.

A characterization sample was collected from Outfall NP-0006 on December 6, 1991. The sample was analyzed for the following parameters and the results are shown in parentheses: uranium-natural (ND), gross alpha (ND) and pH (5.3).

4 AIR MONITORING

4.1 Radon Gas

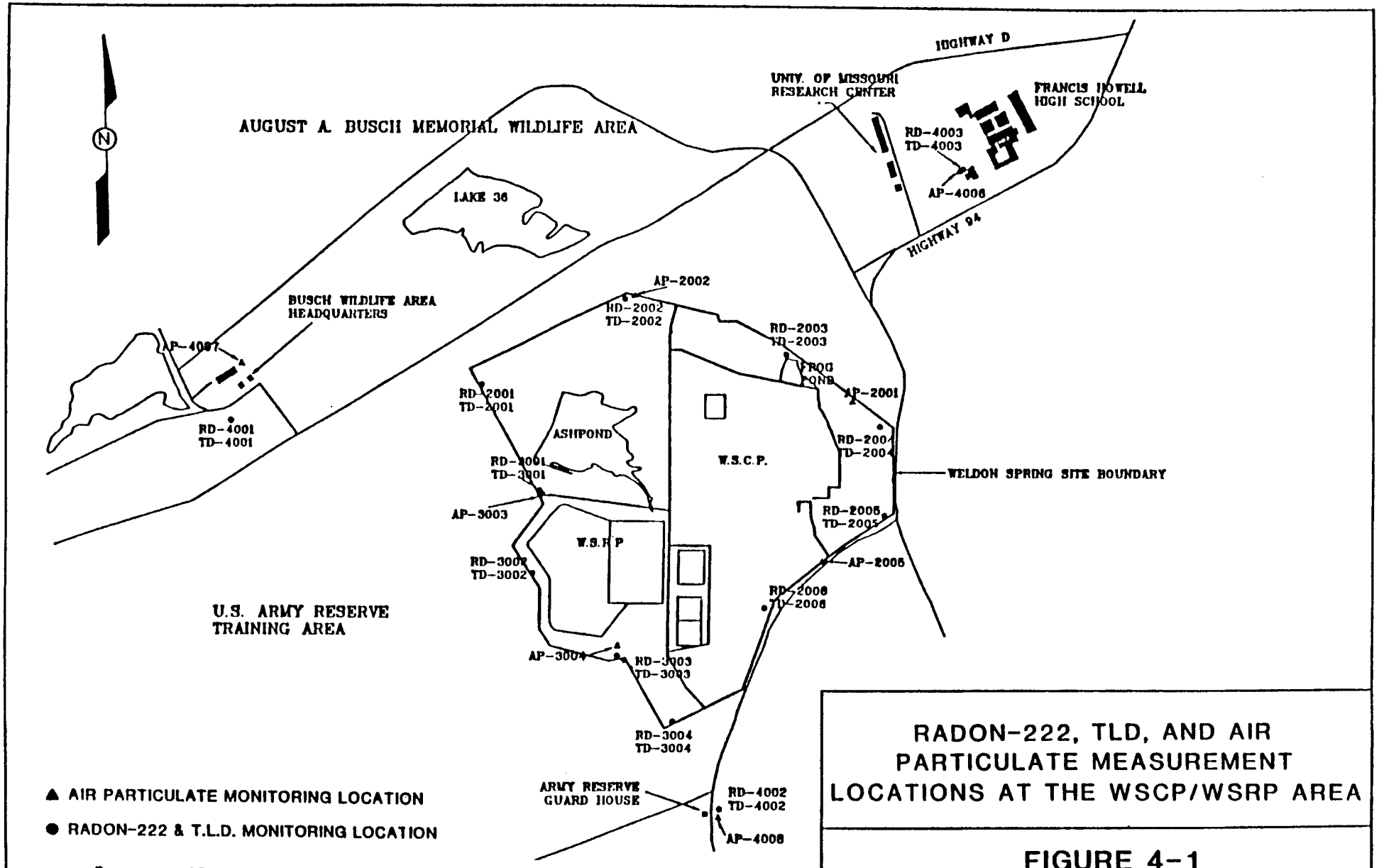
The radon gas monitoring program utilizes a pair of radon detectors at each of 22 permanent locations; each detector is exchanged quarterly. These detectors are deployed at six locations at the Weldon Spring Chemical Plant, six locations at the Weldon Spring Quarry, four locations at the Weldon Spring raffinate pits, and six off-site locations. Radon monitoring locations are shown in Figures 4-1, 4-2, and 4-3. On-site detectors are distributed around the perimeter fences to ensure adequate detection of radon dispersing from the properties under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005, and RD-4006 were used to monitor background levels near the site.

Table 4-1 summarizes the fourth quarter 1991 radon concentrations detected at all site perimeter and off-site monitoring locations. Also contained in Table 4-1 is a comparison of the measured concentration with the Federally permitted radon concentration (for unrestricted areas) of 3 pCi/l (110 Bq/m^3) above background as authorized by U.S. Department of Energy (DOE) Order 5400.5.

An average ambient background concentration was determined by calculating the arithmetic average for the four background locations. This data yielded an average ambient background radon concentration of 0.2 pCi/l for the fourth quarter of 1991. This concentration was then subtracted from the concentration for each monitoring station, and compared to the DOE guideline of 3 pCi/l above background.

Radon concentrations at the site and quarry perimeters and at off-site locations for the fourth quarter of 1991 were within the typical range expected during periods of normal precipitation as was the condition for this period. The quarterly radon concentrations (background included) ranged from 0.1 pCi/l at four monitoring locations to 1.8 pCi/l at monitoring location RD-1002.

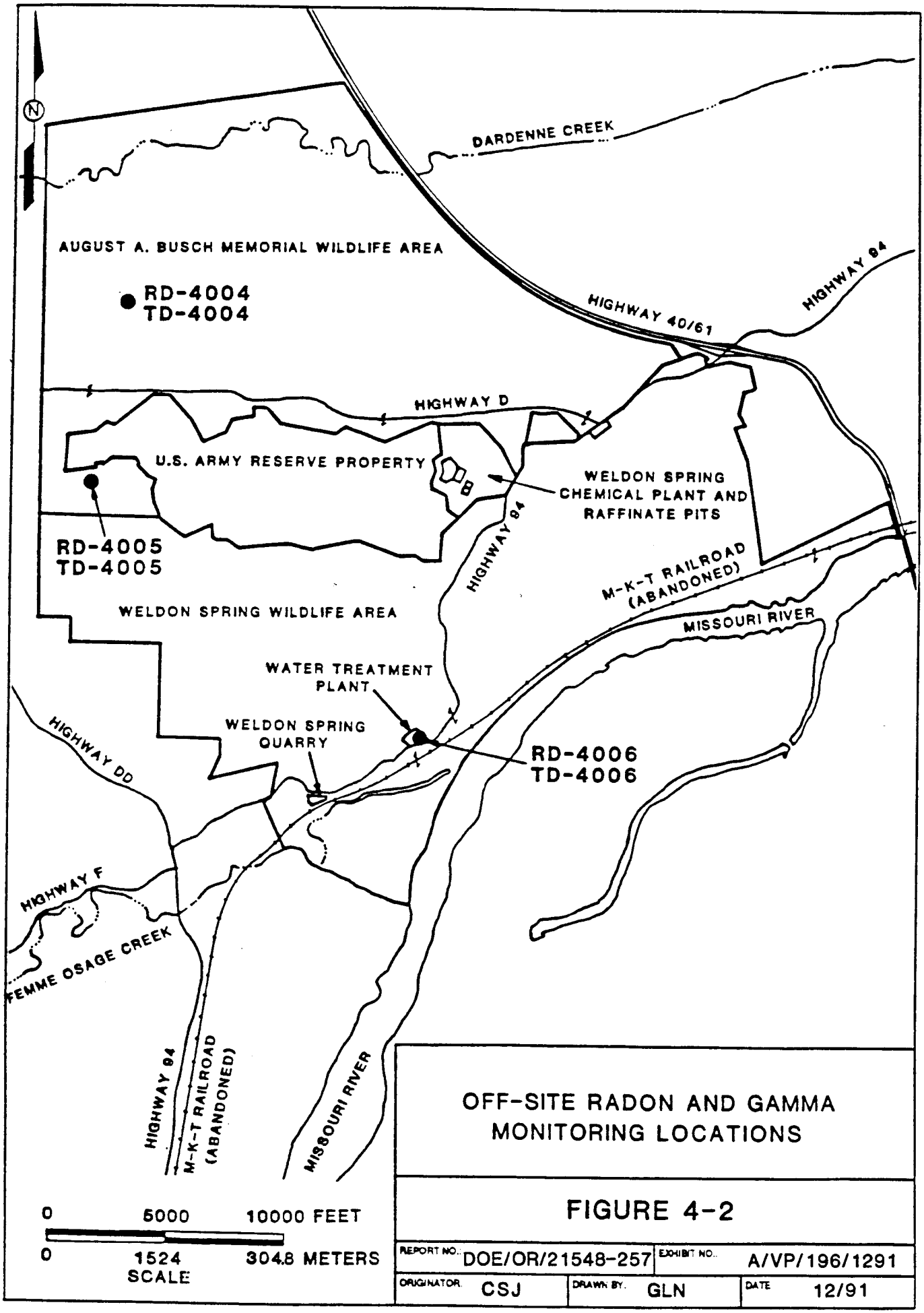
Radon concentrations found in the quarry are higher than concentrations measured at other locations because the radium concentrations in quarry wastes are typically much higher than other areas, and because the quarry is a large depression with side walls ranging from 3 m to 15 m (10 ft to 50 ft) high. In conjunction with stable meteorological conditions,



RADON-222, TLD, AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 4-1

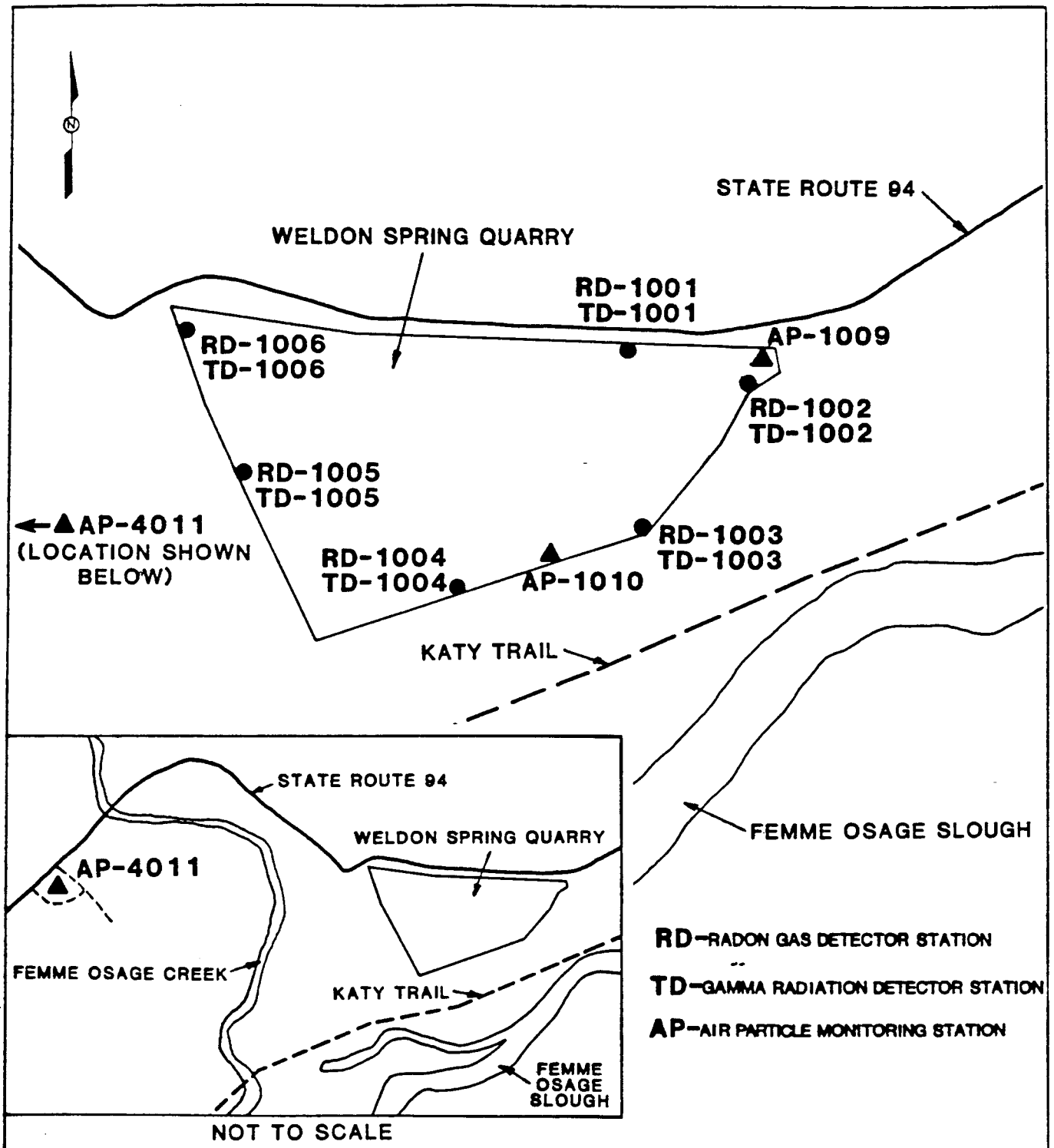
REPORT NO: DOE/OR/21548-257		EXHIBIT NO:	A/VP/195/1291
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE:	12/91



OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

FIGURE 4-2

REPORT NO.	DOE/OR/21548-257	EXHIBIT NO.	A/VP/196/1291		
ORIGINATOR	CSJ	DRAWN BY	GLN	DATE	12/91



RADON-222, THERMO LUMINESCENT DOSIMETER (TLD) AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 4-3

REPORT NO. DOE/OR/21548-257	EXHIBIT NO A/QY/123/1291	
ORIGINATOR CSJ	DRAWN BY GLN	DATE 12/91

TABLE 4-1 1991 Track Etch Radon Results[a]

LOCATION ID	4TH QUARTER pCi/l	PERCENT OF GUIDANCE [b]
WSQ		
RD-1001	1.1	30
RD-1002	1.8	53
RD-1003	0.8	20
RD-1004	0.4	7
RD-1005	0.6	13
RD-1006	0.2	0
WSCP		
RD-2001	0.3	3
RD-2002	0.2	0
RD-2003	0.1	0
RD-2004	0.2	0
RD-2005	0.1	0
RD-2006	0.3	0
WSRP		
RD-3001	0.3	3
RD-3002	0.2	0
RD-3003	0.2	0
RD-3004	0.1	0
OFF-SITE		
RD-4001*	0.2	0
RD-4002	0.2	0
RD-4003	0.2	0
RD-4004*	0.2	0
RD-4005*	0.1	0
RD-4006*	0.2	0

(a) Results include natural background.

(b) Percent of guideline calculated by taking the quarterly average minus the average of the background stations divided by the DOE concentration guideline for RN-222 which is 3 pCi/l (110 Bq/m^3)(Annual average above background) for uncontrolled areas.

* Denotes Background Station

this configuration tends to trap emanating radon within the quarry and raise the concentrations along the quarry perimeter.

4.2 Gamma Radiation Exposure

To monitor exposure from gamma radiation, spherical environmental thermoluminescent dosimeters (TLDs) were deployed at 22 locations. The gamma monitoring station locations are the same as the ambient radon monitoring locations (see Section 4.1).

Table 4-2 summarizes the first, second, and third quarter results of total gamma radiation monitoring at the 16 Weldon Spring site (WSS) perimeter monitoring stations, the Francis Howell High School, the Weldon Spring Army Reserve Training Area, and at the four background monitoring stations.

The annual average background gamma exposures measured with TLDs in 1989 and 1990 were 68 mR/year and 62 mR/year, respectively. The gamma exposures measured with TLDs in the first, second, and third quarter of 1991 were consistent with 1989 and 1990 data. This was expected because no significant changes in the configuration or location of the wastes have occurred.

The fourth quarter data was not available when this document was drafted. The data will be available upon request and will be included in the 1991 *Annual Site Environmental Report*.

4.3 Radioactive Air Particulates

Eleven low volume air particulate samplers monitor the Weldon Spring site continuously. Five of these (AP-2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the Weldon Spring Chemical Plant (WSCP) perimeter and two are located around the quarry perimeter as shown in Figure 4-3. Three monitoring stations (AP-4006, AP-4008, and AP-4011) are located off site at sensitive receptor locations; including Francis Howell High School; the Army Reserve property; and near a residential site west of the quarry. The monitoring station at the August A. Busch Wildlife Area (AP-4007) is used to monitor background levels in the vicinity of the WSCP. The off-site monitoring stations are also shown in Figure 4-2.

TABLE 4-2 1991 Environmental TLD Results[a]

Location ID	1st Quarter mrem	2nd Quarter mrem	3rd Quarter mrem	4th Quarter mrem
WSQ				
TD-1001	24	17	21	NA
TD-1002	20	15	17	NA
TD-1003	20	20	19	NA
TD-1004	19	17	18	NA
TD-1005	20	17	18	NA
TD-1006	19	18	17	NA
WSCP				
TD-2001	18	16	15	NA
TD-2002	17	16	17	NA
TD-2003	18	17	16	NA
TD-2004	19	17	17	NA
TD-2005	18	14	15	NA
TD-2006	17	15	16	NA
WSRP				
TD-3001	22	14	15	NA
TD-3002	17	13	13	NA
TD-3003	19	17	16	NA
TD-3004	16	14	16	NA
OFF-SITE				
TD-4001*	18	16	---	NA
TD-4002	16	13	14	NA
TD-4003	16	12	12	NA
TD-4004*	19	--	16	NA
TD-4005*	16	13	12	NA
TD-4006*	17	15	17	NA

(a) Results include natural background.
- Denotes loss of TLD.
* Denotes background station.
NA Not Available

TABLE 4-3 Radiological Air Particulate Fourth Quarter 1991

MONITOR IDENTIFICATION NUMBER	QUARTERLY AVG. CONCENTRATION (μCi/ml)	STANDARD DEVIATION (μCi/ml)	NUMBER OF WEEKS COLLECTED	NUMBER OF VALUES ABOVE LLD
AP-2001	<1.47E-15	5.38E-16	13	11
AP-2002	<1.78E-15	6.69E-16	13	12
AP-3003	<1.64E-15	7.18E-16	13	11
AP-3004	<1.57E-15	7.05E-16	12	11
AP-2005	1.57E-15	6.75E-16	13	13
AP-4006	<1.74E-15	6.82E-16	13	11
AP-4007*	1.64E-15	5.91E-16	12	12
AP-4008	1.77E-15	7.40E-16	13	13
AP-1009	1.81E-15	7.95E-16	12	12
AP1010	<1.77E-15	7.23E-16	13	12
AP-4011	1.75E-15	8.16E-16	13	13

* Indicates background monitor station.
To convert μCi/ml to Bq/M^3, multiply by 3.7E10.
NA Not available

The sampling station near the August A. Busch Wildlife Area (ABWA) headquarters is used as a background air monitoring station. This station is approximately 0.8 km (0.5 mile) from the WSCP perimeter in a northwestern direction. The terrain between the WSCP and this sampling station is hilly and forested, providing a significant physical barrier to airborne particulates originating from the WSCP/Weldon Spring raffinate pits (WSRP).

Table 4-3 summarizes the quarterly average concentrations and the standard deviations for the 11 air monitoring locations. The quarterly average concentration for each monitoring location was calculated by averaging either the weekly air particulate analysis results or the counting instrument's lower limit of detection (LLD), whichever was greater. The "<" sign in Table 4-3 appears when the actual average is less than the calculated average due to the use of LLD values in the calculation. The standard deviation for each of the monitoring locations was calculated using only results that were above the LLD. Due to maintenance, all monitors were not operating the entire 13 weeks as indicated in Table 4-3. However, the sensitive receptor monitoring stations (AP-4006, AP-4008, and AP-4011) were in operation the entire quarter and these stations are also equipped with high volume air monitoring. The high volume air monitors are part of the WSS radionuclide National Emissions Standards for Hazardous Air Pollutants (NESHAPs) requirements and were in operation the fourth quarter. The high volume monitoring results will be presented in the *Annual Site Environmental Report*.

The fourth quarter net alpha concentrations ranged from $< 1.47 \times 10^{-15}$ μCi/ml to $< 1.81 \times 10^{-15}$ μCi/ml with 1.64×10^{-15} μCi/ml detected at the background station.

4.4 Asbestos

No environmental asbestos monitoring was performed in the fourth quarter of 1991.

5 REFERENCES

MK-Ferguson Company and Jacobs Engineering Group, 1989. *Phase II Groundwater Quality Assessment for the Weldon Spring Site, Chemical Plant, Raffinate Pits and Surrounding Vicinity Properties*, Rev. 0. DOE/OR/21548-078. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. September.

MK-Ferguson Company and Jacobs Engineering Group, 1991. *Environmental Monitoring Plan.* Rev. 0. DOE/OR/21548-237. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. November.

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CHEMICAL PLANT
202-1.13

Department c
Oak Ridge Op
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June 12, 1992

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QUARTERLY ENVIRONMENTAL DATA SUMMARY, FIRST QUARTER 1992

Enclosed for your information and use is a copy of the Quarterly Environmental Data Summary. This document summarized the environmental monitoring data for the first Quarter 1992, highlights any potentially significant findings, and offers preliminary interpretations. Final interpretations will appear in the 1992 Annual Site Environmental Report.

Two items were highlighted in the document. First, toluene was detected in nine samples. Toluene is not a contaminant at the WSSRAP. After data validation rejected the nine suspect data points and negative results were obtained on resampling, further investigation revealed that the tape used to secure labels to the sample vials was a likely source for the sample contamination. Second, methylene chloride was detected in one sample. Methylene Chloride, used to clean laboratory glassware, is one of the most common laboratory contaminants. Data validation rejected this suspect data point.

In summary, no significant differences were observed in off-site exposures during the first quarter of 1992 relative to previous quarters.

If you have any questions, please call Alan Gibson.

Sincerely,

Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
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QUARTERLY ENVIRONMENTAL DATA SUMMARY - FIRST QUARTER 1992

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

JUNE 1992 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

MK-FERGUSON A MORRISON KNUDSEN COMPANY	
Weldon Spring Site Remedial Action Project Contract No. DE-AC05-86OR21548	Rev. No. 0
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Weldon Spring Site Remedial Action Project

Quarterly Environmental Data Summary - First Quarter 1992

Revision 0

June 1992

Prepared by

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and
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for the

U.S. DEPARTMENT OF ENERGY
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ABSTRACT AND WELDON SPRING SITE QUARTERLY SELF ASSESSMENT FIRST QUARTER 1992

The purpose of this *Quarterly Environmental Data Summary* is to provide to the public preliminary data acquired as part of the Weldon Spring Site Remedial Action Project (WSSRAP) environmental monitoring program. The document summarizes the preliminary environmental data, highlights any potentially significant findings, and offers tentative interpretations. Validated data and final interpretations will appear in the 1992 Annual Site Environmental Report.

This report includes preliminary data from environmental monitoring activities at the Weldon Spring site (WSS) during the first quarter of 1992. Groundwater, surface water, and air samples were collected in order to monitor potential exposure pathways. Analytical parameters included radionuclides, nitroaromatic compounds, inorganic anions, and direct gamma exposure. The results are used to evaluate possible exposure scenarios and assess the impact of the contaminants at the site on potentially exposed populations.

In summary, no significant differences were observed in off-site exposures during the first quarter of 1992 relative to exposures calculated in previous quarters. Contaminated groundwater did not affect the St. Charles County well field.

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1 INTRODUCTION

This document is the eighth in a series of quarterly reports which summarize the findings from the routine environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). These documents supplement the Annual Site Environmental Report (ASER) by providing interested outside agencies and organizations with more frequent access to WSSRAP data. They provide data resulting from routine environmental sampling as described in the WSSRAP *Environmental Monitoring Plan* (EMP) (MKF and JEG 1992) and a brief interpretation of that data.

It is the goal of this document to summarize and briefly discuss the data, highlighting data that differ significantly from historical observations. The full interpretation of these data (as well as data in other quarterly summaries) will be undertaken in the 1992 ASER. It is recommended that interested readers refer to previous EMPs, ASERs, and project documents for more information on existing site conditions, site history, transport mechanisms, and quantified contaminant levels. The monitoring scheme for every calendar year is established prior to that year in the annual EMP. Each sampling location to be monitored during the upcoming year is identified in the EMP and the schedule of analytical parameters is tabulated for easy reference. These reports may be obtained by visiting the WSSRAP reading room or contacting the WSSRAP Community Relations Manager at (314) 441-8086.

These quarterly reports are intended to include data from all quarterly environmental monitoring programs conducted at the WSSRAP including groundwater, surface water, National Pollutant Discharge Elimination System (NPDES), radon gas, gamma radiation, and air particulates (including asbestos and radioactive particulates). However, because of delays in data delivery from the analytical laboratories, some of the data that were expected to be included in this report are not yet available for reporting. The unavailability of data is due to a nationwide shortage in analytical services. These data will be reported in the 1992 ASER. Sludges and soils are not sampled on a routine basis; therefore, analytical results for these parameters are not included in this report. Trend analyses are being prepared from historical data for surface water, groundwater and air pathways. These analyses will be presented in the 1992 ASER. Quality control (QC) data for the first quarter and all other quarters will be presented in the 1992 ASER.

2 GROUNDWATER MONITORING

The groundwater is sampled regularly at both the Weldon Spring Chemical Plant/raffinate pits/vicinity properties (WSCP/RP/VP) and the Weldon Spring Quarry (WSQ). Due to differences in the environmental settings and sources of contaminants, separate monitoring schedules are followed. Therefore, results of groundwater monitoring at the WSCP/RP/VP and WSQ will be discussed separately.

2.1 Chemical Plant/Raffinate Pits/Vicinity Properties

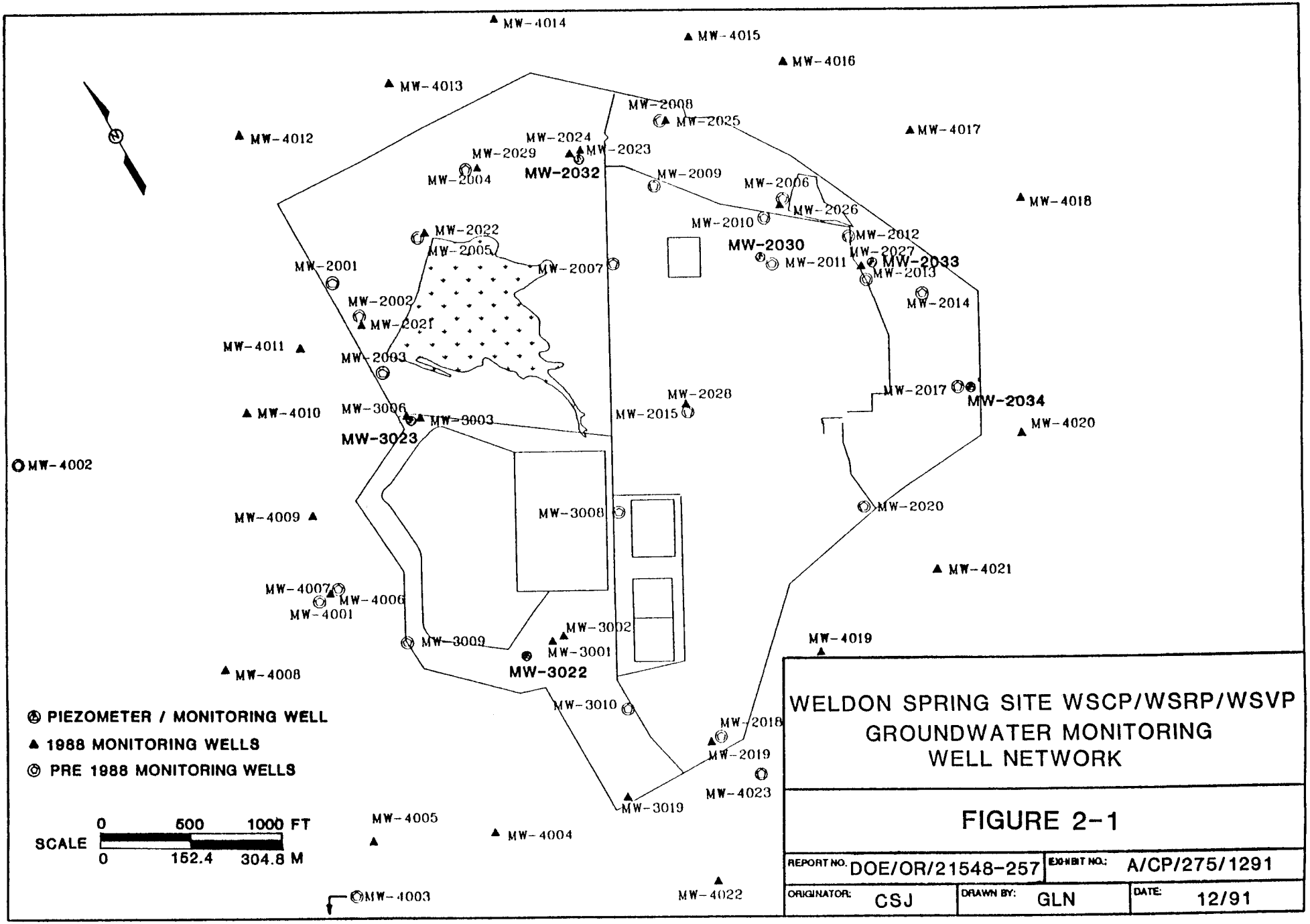
Groundwater at the chemical plant/raffinate pits/vicinity properties area is monitored on a quarterly or semi-annual basis (locations are given in Figure 2-1). The number of quarterly sampled wells has increased substantially; a complete list of wells scheduled for quarterly and semiannual sampling is given in the 1992 *Environmental Monitoring Plan* (EMP) (MKF and JEG 1992). Total uranium, inorganic anions, and nitroaromatic compounds are measured during each monitoring period for both quarterly and semiannual wells. Other radiological parameters are measured annually during the first period for all wells. Geochemical parameters (metals and inorganic anions) are measured each period for the quarterly wells only.

2.1.1 Nitroaromatic Results

Table 2-1 contains nitroaromatic data from samples collected from the quarterly monitored groundwater wells. Nitroaromatic compounds were detected in 14 of the 31 locations for which data are currently available. Concentration levels for these compounds are within their historical range. Some nitroaromatic compounds detected in monitoring wells GW-2030, GW-2032, and GW-2033 were the lowest recorded values to date.

2.1.2 Radiological Results

Total uranium results for samples from the quarterly monitored wells at the WSCP/RP/VP are presented in Table 2-2. The upper bound for natural uranium background concentration in groundwater at the WSCP/RP/VP has been determined to be 3.4 pCi/l (MKF and JEG 1989). The U.S. Environmental Protection Agency (EPA) has not yet established a drinking water standard for uranium; however, the proposed maximum contaminant



WELDON SPRING SITE WSCP/WSRP/WSVP GROUNDWATER MONITORING WELL NETWORK

FIGURE 2-1

REPORT NO.	DOE/OR/21548-257	EXHIBIT NO.:	A/CP/275/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91

TABLE 2-1 First Quarter Nitroaromatic Data for Groundwater at the WSCP/RP/VP

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-2001-Q192	ND	ND	0.083	0.074	ND	0.031
GW-2002-012892	ND	ND	0.071	0.38	ND	ND
GW-2003-Q192	ND	ND	0.17	0.68	ND	ND
GW-2030-Q192	ND	ND	0.19	4.60	3.60	0.32
GW-2031	ABANDONED					
GW-2032-Q192	ND	ND	0.15	3.70	0.90	0.092
GW-2033-Q192	ND	ND	0.18	15.0	0.082	0.036
GW-3003-Q192	NA	NA	NA	NA	NA	NA
GW-3006-Q192	ND	ND	ND	ND	ND	ND
GW-3008-Q192	ND	ND	0.15	0.44	ND	ND
GW-3009-Q192	ND	ND	0.18	0.093	ND	0.17
GW-3023-Q192	NA	NA	NA	NA	NA	NA
GW-4001-010992	ND	0.22	6.00	3.50	1.30	46.0
GW-4002-Q192	ND	ND	ND	ND	ND	ND
GW-4003-Q192	ND	ND	ND	ND	ND	ND
GW-4004-Q192	ND	ND	ND	ND	ND	ND
GW-4005-Q192	ND	ND	ND	ND	ND	ND
GW-4006-Q192	ND	ND	0.16	3.60	ND	16.0
GW-4007-Q192	ND	ND	ND	ND	ND	ND
GW-4008-Q192	ND	ND	ND	ND	ND	ND
GW-4009-Q192	ND	ND	ND	ND	ND	ND
GW-4010-Q192	ND	ND	ND	ND	ND	ND
GW-4011-Q192	ND	ND	ND	ND	ND	ND
GW-4012-Q192	ND	ND	ND	ND	ND	ND
GW-4013-Q192	ND	ND	0.079	1.30	0.057	48.0
GW-4014-Q192	ND	ND	ND	0.082	0.037	0.44
GW-4015-Q192	ND	ND	0.14	1.30	ND	0.70
GW-4016-Q192	ND	ND	ND	ND	ND	ND
GW-4017-Q192	ND	ND	ND	ND	ND	ND

TABLE 2-1 First Quarter Nitroaromatic Data for Groundwater at the WSCP/RP/VP (Continued)

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-4018-Q192	ND	ND	ND	ND	ND	ND
GW-4019-Q192	NA	NA	NA	NA	NA	NA
GW-4020-Q192	ND	ND	ND	ND	ND	ND
GW-4021-Q192	ND	ND	ND	ND	ND	ND
GW-4022-Q192	ND	ND	ND	ND	ND	ND
GW-4023-Q192	ND	ND	0.10	0.062	ND	0.21

NA - Not Available
ND - Not Detected

TABLE 2-2 First Quarter Uranium and Inorganic Anion Data in Groundwater at the WSCP/RP/VP

Sample ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)
GW-2001-Q192	26.2	8.50	ND
GW-2002-012892	312	132	1.18
GW-2003-Q192	339	134	1.58
GW-2030-Q192	1.50	43.7	13.5
GW-2031	ABANDONED		
GW-2032-Q192	119	56.2	10.1
GW-2033-Q192	0.790	23.6	4.28
GW-3003-Q192	312	128	15.0
GW-3006-Q192	ND	23.8	ND
GW-3008-Q192	844	77.4	7.96
GW-3009-Q192	109	82.1	NA
GW-3023-Q192	308	353	10.3
GW-4001-010992	32.5	63.9	3.84
GW-4002-Q192	0.940	14.1	ND
GW-4003-Q192	0.760	33.5	ND
GW-4004-Q192	0.800	26.5	NA
GW-4005-Q192	2.00	25.3	NA
GW-4006-Q192	5.20	29.9	ND
GW-4007-Q192	0.190	14.5	3.33
GW-4008-Q192	ND	14.9	1.97
GW-4009-Q192	0.630	18.3	3.13
GW-4010-Q192	0.220	25.2	3.67
GW-4011-Q192	30.6	58.8	4.62
GW-4012-Q192	0.17	55.5	NA
GW-4013-Q192	5.20	43.5	3.60
GW-4014-Q192	5.20	27.8	4.28
GW-4015-Q192	0.20	13.3	NA
GW-4016-Q192	316	14.8	NA
GW-4017-Q192	NA	NA	NA

TABLE 2-2 First Quarter, Uranium and Inorganic Anion Data in Groundwater at the WSCP/RP/VP (Continued)

Sample ID	NITRATE (mg/l)	SULFATE (mg/l)	URANIUM (pCi/l)
GW-4018-Q192	6.29	8.00	NA
GW-4019-Q192	0.230	11.6	2.11
GW-4020-Q192	0.11	133	NA
GW-4021-Q192	ND	274	6.94
GW-4022-Q192	NA	NA	NA
GW-4023-Q192	1.89	76.2	4.62

ND - Not Detected
NA - Not Available

level (MCL) is 20 μg/l, which converts to 13.6 pCi/l (0.50 Bq/l) using a new site-specific conversion factor of 0.68 pCi/μg (assuming isotopic equilibrum). The increase to 13.6 pCi/l (0.50 Bq/l) from the previously reported value of 12 pCi/l (0.44 Bq/l) reflects improved quantification of the average U-234/U-238 activity ratios for uranium present at the Weldon Spring Site Remedial Action Project (WSSRAP). The U.S. Department of Energy (DOE) has a health-based, derived concentration guideline (DCG) of 600 pCi/l (22.2 Bq/l) in surface water effluent.

Uranium concentrations remained within historical ranges at most locations for which data are presently available. Higher than previously detected values have been recorded for GW-2030, GW-2032, GW-2033, GW-3023, GW-4013, and GW-4014. All of these higher values are only slightly elevated above previously high levels. At present, insufficient data are available to determine whether these values are part of an upward trend or are merely extremes within the normal range of variation for these wells.

Additional radiological parameters are measured for groundwater at all WSCP/RP/VP wells during the first monitoring period of each year. The results of these analyses are given in Table 2-3. Historically, concentration levels for these parameters have been below the detection limits. In general, the increase in detectable values for 1992 predominantly reflects improved analytical sensitivity rather than high concentration levels for these parameters. Exceptions are Th-230 and both radium isotopes. The elevated Th-230 values are thought to be an artifact of analytical interferences. The source of the slightly higher radium concentrations is unclear and is currently under investigation. All locations having apparently elevated Th-230, Ra-226, or Ra-228 values have been scheduled for resampling during the third quarter to confirm these results.

2.1.3 Sulfate and Nitrate Results

Sulfate and nitrate concentrations are measured during each monitoring period. Results of these analyses are given in Table 2-2. First quarter results are within historical ranges at all locations with the exception of nitrate in GW-4016. Because historical nitrate levels for this well have been below the detection limit, the first quarter measurement of 316 mg/l is being investigated. Laboratory validation has been requested for this sample.

TABLE 2-3 First Quarter Radiological Results for Groundwater at the WSCP/RP/VP

Sample ID	Th-228 (µg/l)	Th-230 (µg/l)	Th-232 (µg/l)	Ra-226 (µg/l)	Ra-228 (µg/l)	Po-210 (µg/l)	Pb-210 (µg/l)	Ac-227 (µg/l)
GW-2001-Q192	ND	1.74	ND	ND	ND	ND	ND	ND
GW-2002-012892	ND	1.43	ND	ND	ND	ND	ND	ND
GW-2003-Q192	ND	2.22	ND	ND	ND	ND	ND	ND
GW-2030-Q192	ND	ND	ND	1.00	1.10	NS	NS	NS
GW-2031	ABANDONED							
GW-2032-Q192	0.700	0.900	0.200	1.10	1.80	NS	NS	NS
GW-2033-Q192	ND	0.300	ND	1.20	ND	NS	NS	NS
GW-3003-Q192	ND	ND	ND	ND	ND	NS	NS	NS
GW-3006-Q192	ND	1.18	ND	ND	ND	ND	ND	ND
GW-3008-Q192	ND	ND	ND	0.700	2.00	NS	NS	NS
GW-3009-Q192	NA	NA	NA	NA	NA	NA	NA	NA
GW-3023-Q192	ND	ND	ND	0.300	ND	NS	NS	NS
GW-4001-010992	ND	2.61	ND	ND	ND	ND	ND	ND
GW-4002-Q192	ND	2.30	ND	0.287	ND	ND	ND	ND
GW-4003-Q192	ND	0.25	ND	ND	ND	NS	NS	NS
GW-4004-Q192	ND	ND	ND	ND	5.00	NS	NS	NS
GW-4005-Q192	ND	ND	ND	ND	5.00	NS	NS	NS
GW-4006-Q192	ND	6.63	ND	ND	ND	ND	ND	ND
GW-4007-Q192	ND	0.500	ND	3.40	ND	NS	NS	NS
GW-4008-Q192	ND	ND	0.50	ND	ND	NS	NS	NS
GW-4009-Q192	ND	ND	ND	ND	ND	NS	NS	NS
GW-4010-Q192	ND	ND	ND	ND	ND	NS	NS	NS
GW-4011-Q192	ND	ND	ND	ND	ND	NS	NS	NS
GW-4012-Q192	NA	NA	NA	NA	NA	NA	NA	NA
GW-4013-Q192	ND	ND	ND	0.400	1.10	NS	NS	NS
GW-4014-Q192	ND	ND	ND	ND	ND	NS	NS	NS
GW-4015-Q192	NA	NA	NA	NA	NA	NA	NA	NA
GW-4016-Q192	NA	NA	NA	NA	NA	NA	NA	NA
GW-4017-Q192	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 2-3 First Quarter Radiological Results for Groundwater at the WSCP/RP/VP (Continued)

Sample ID	Th-228 (µg/l)	Th-230 (µg/l)	Th-232 (µg/l)	Ra-226 (µg/l)	Ra-228 (µg/l)	Po-210 (µg/l)	Pb-210 (µg/l)	Ac-227 (µg/l)
GW-4018-Q192	NA	NA	NA	NA	NA	NA	NA	NA
GW-4019-Q192	ND	0.200	ND	ND	ND	NS	NS	NS
GW-4020-Q192	NA	NA	NA	NA	NA	NA	NA	NA
GW-4021-Q192	ND	ND	ND	ND	1.60	NS	NS	NS
GW-4022-Q192	NA	NA	NA	NA	NA	NA	NA	NA
GW-4023-Q192	ND	ND	ND	0.600	ND	NS	NS	NS

ND - Not Detected
NA - Not Available
NS - Not Sampled

2.1.4 Geochemical Results: Metals and Inorganic Anions

Table 2-4 contains the first quarter geochemical data (metals and inorganic anions) for quarterly monitored wells at the WSCP/RP/VP area. In 1992, the WSSRAP increased both the number of wells and the frequency of sampling for geochemical parameters. Many of these wells (especially in the GW-40XX and GW-203X series) had been sampled only two or three times prior to 1992, with the most recent sampling event occurring in 1988 or 1989. Thus comparisons with past concentration levels are inconclusive. For the majority of the wells, concentrations for the first quarter of 1992 are consistent with previously measured values; however, notable exceptions were observed for the GW-203X wells, which contained high levels of aluminum, iron, manganese, and moderately elevated lead. The source of these elevations is unclear and is currently being investigated. Improved analytical sensitivity has resulted in an increase in the number of wells showing detectable concentrations for Ar, Ba, Ni, Cr and K and does not reflect higher concentration levels for these parameters.

2.2 Weldon Spring Quarry

Groundwater at the WSQ has become radiologically and chemically contaminated as a result of contact with or migration from wastes present in the WSQ. Monitoring of the groundwater at and near the WSQ is of particular concern because of the proximity of the St. Charles County well field. The well field is located approximately 0.8 km (0.5 mi) to the south of the WSQ. Monitoring of contaminants in groundwater and the protection of the well field is a top priority at the WSSRAP.

Groundwater is currently being monitored at 48 wells located in and around the quarry area. Thirty-six monitoring wells installed by the DOE are currently utilized in or near the quarry. Four monitoring wells were installed by St. Charles County in 1986 and are currently included in the DOE's monitoring program. Eight St. Charles County municipal wells, and the treated and untreated water from the St. Charles County water treatment plant are also monitored for the presence of these contaminants. All monitoring well locations are shown in Figures 2-2 and 2-3. These wells monitor groundwater in both the bedrock and alluvial aquifers associated with the WSQ.

Two separate groundwater monitoring programs have been developed for the WSQ area. The first program is a bimonthly sampling of all wells north of the Femme Osage Slough and

TABLE 2-4 First Quarter Geochemical Results for Groundwater at the WSCP/RP/VP

Sample ID	Arsenic (µg/l)	Barium (µg/l)	Calcium (µg/l)	Chromium (µg/l)	Iron (µg/l)	Lithium (µg/l)	Magnesium (µg/l)	Manganese (µg/l)	Nickel (µg/l)	Lead (µg/l)	Silver (µg/l)
GW-2001-Q192	ND	227	93200	ND	ND	ND	43500	ND	ND	NS	NS
GW-2002-012892	ND	213	315000	ND	ND	521	103000	ND	ND	NS	NS
GW-2003-Q192	ND	136	256000	ND	ND	455	87400	ND	ND	NS	NS
GW-2030-Q192	ND	255	153000	ND	4780	ND	24000	163	18.0	26.3	ND
GW-2031	ABANDONED										
GW-2032-Q192	2.89	660	242000	21.7	23300	ND	69000	1060	41.5	33.7	ND
GW-2033-Q192	3.39	176	252000	ND	4780	ND	20000	255	12.2	37.6	ND
GW-3003-Q192	ND	168	230000	ND	ND	511	138000	8.90	ND	2.70	ND
GW-3006-Q192	ND	145	63500	ND	138	ND	51800	72.3	ND	ND	ND
GW-3008-Q192	ND	248	549000	ND	456	277	153000	72.4	ND	4.59	ND
GW-3009-Q192	ND	979	12400	ND	ND	ND	64300	7.59	46.1	ND	ND
GW-3023-Q192	NS	NS	366000	ND	1730	905	84800	90.8	ND	18.6	ND
GW-4001-010992	ND	101	88400	ND	ND	ND	33600	ND	ND	NS	NS
GW-4002-Q192	ND	115	44500	ND	ND	ND	32000	3.00	ND	ND	ND
GW-4003-Q192	ND	224	60500	ND	ND	ND	37500	ND	ND	NS	NS
GW-4004-Q192	ND	55.2	31600	ND	ND	ND	28900	ND	ND	7.00	ND
GW-4005-Q192	ND	82.0	45700	ND	ND	ND	27600	2.00	ND	21.39	ND
GW-4006-Q192	ND	170	51600	ND	ND	ND	22500	ND	ND	NS	NS
GW-4007-Q192	ND	75.9	29400	ND	120	ND	21100	47.4	ND	22.0	ND

TABLE 2-4 First Quarter Geochemical Results for Groundwater at the WSCP/RP/VP (Continued)

Sample ID	Arsenic (µg/l)	Barium (µg/l)	Calcium (µg/l)	Chromium (µg/l)	Iron (µg/l)	Lithium (µg/l)	Magnesium (µg/l)	Manganese (µg/l)	Nickel (µg/l)	Lead (µg/l)	Silver (µg/l)
GW-4008-Q192	ND	108	38700	ND	ND	ND	33000	34.7	ND	ND	ND
GW-4009-Q192	4.20	26.2	14000	8.40	ND	ND	8070	ND	ND	ND	ND
GW-4010-Q192	ND	69.4	55400	ND	ND	ND	39800	ND	ND	ND	ND
GW-4011-Q192	ND	109	59100	ND	ND	ND	40000	ND	ND	ND	ND
GW-4012-Q192	ND	40.2	25400	59.0	ND	ND	34600	ND	ND	2.39	ND
GW-4013-Q192	ND	147	143000	ND	ND	ND	52000	ND	ND	ND	ND
GW-4014-Q192	ND	117	65200	ND	74.4	ND	44000	45.9	ND	2.00	ND
GW-4015-Q192	ND	190	55100	ND	ND	ND	28100	ND	ND	4.00	ND
GW-4016-Q192	ND	240	42000	ND	ND	ND	28200	54.8	ND	3.29	ND
GW-4017-Q192	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GW-4018-Q192	ND	206	96600	ND	ND	ND	53800	ND	ND	2.70	ND
GW-4019-Q192	ND	187	38400	ND	ND	ND	45700	ND	ND	13.7	ND
GW-4020-Q192	ND	92.8	93700	26.6	ND	ND	62200	136	12.3	2.39	ND
GW-4021-Q192	ND	37.5	118000	ND	ND	ND	117000	47.8	ND	4.50	ND
GW-4022-Q192	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GW-4023-Q192	ND	91.3	96600	ND	ND	ND	39700	ND	ND	9.09	ND

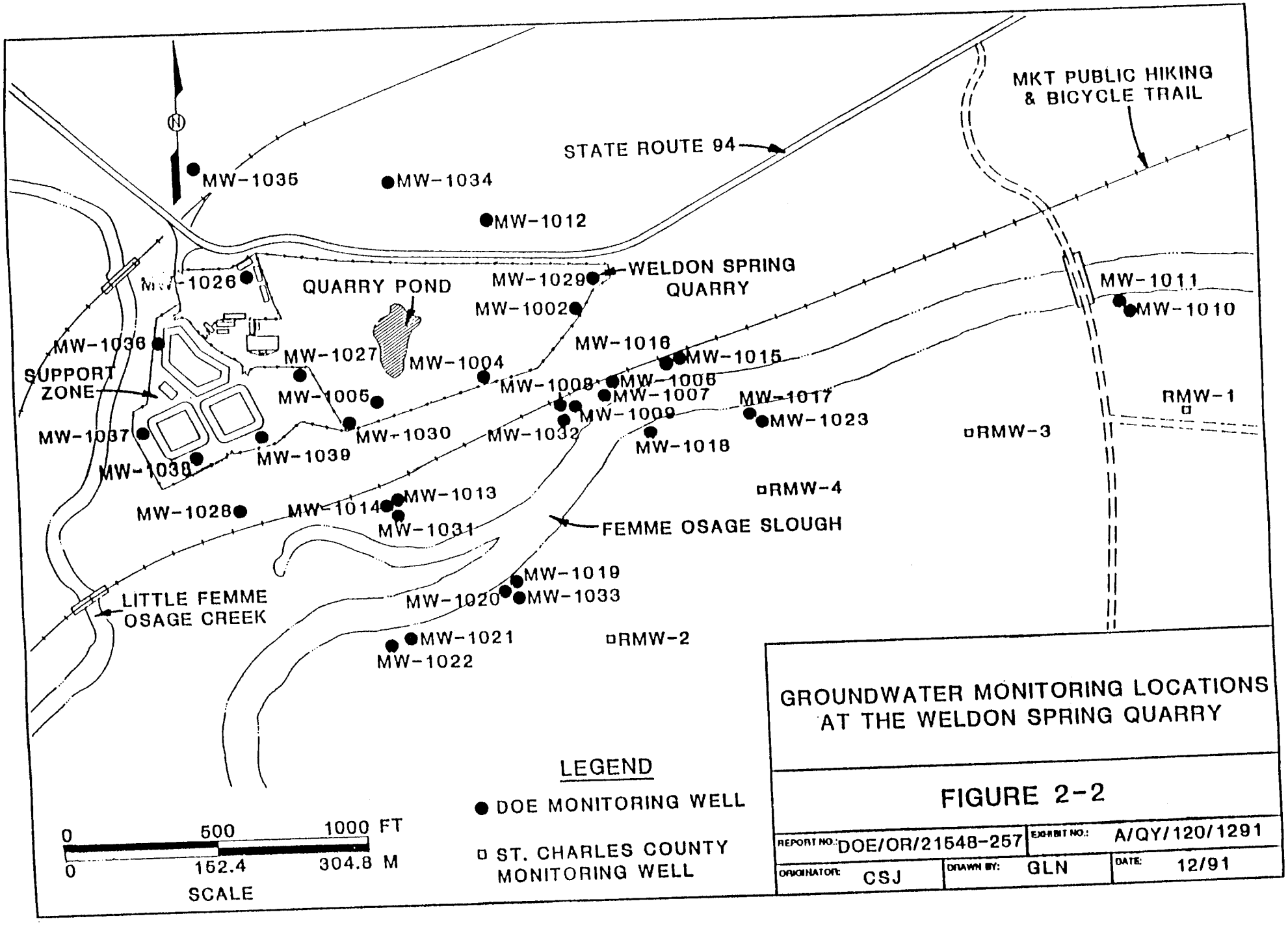
TABLE 2-4 First Quarter Geochemical Results for Groundwater at the WSCP/RP/VP (Continued)

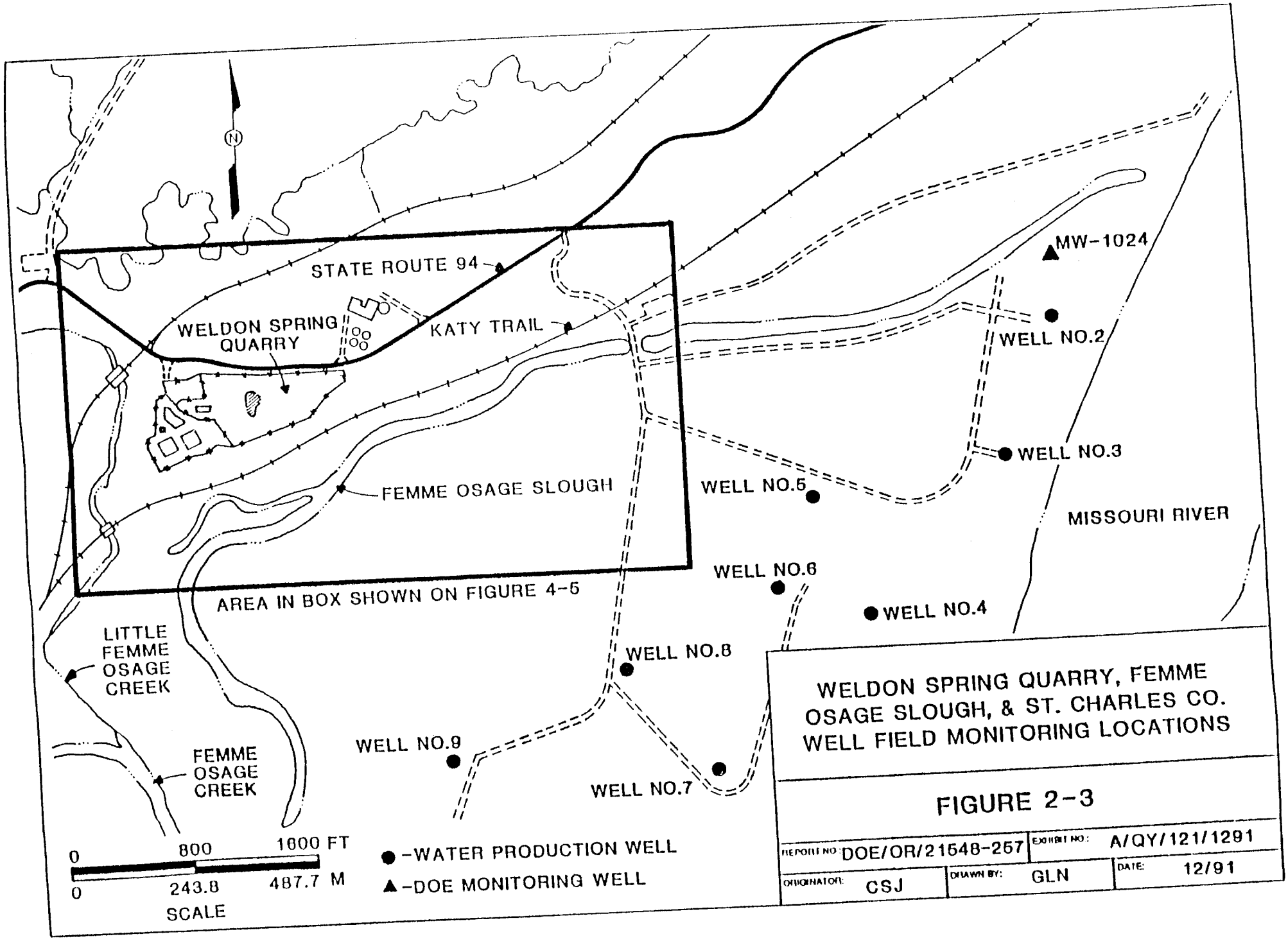
Sample ID	Potassium (µg/l)	Sodium (µg/l)	Strontium (µg/l)	Nitrite (mg/l)	Bromide (mg/l)	Chloride (mg/l)	Phosphorus Total (mg/l)	Silica, Dissolved (mg/l)	Alkalinity (mg/l)	Aluminum (µg/l)
GW-2001-Q192	1800	9140	103	ND	1.30	7.00	0.34	7.79	330	NS
GW-2002-012892	10200	127000	408	ND	ND	13.1	0.020	14.3	265	NS
GW-2003-Q192	6900	114000	460	ND	ND	8.90	0.050	11.8	270	NS
GW-2030-Q192	4770	54600	183	0.010	ND	39.5	0.130	8.40	470	2270
GW-2031	ABANDONED									
GW-2032-Q192	4130	67800	362	0.010	ND	21.4	0.84	7.00	400	13000
GW-2033-Q192	4400	87600	174	0.010	ND	10.7	0.370	9.30	550	1550
GW-3003-Q192	9920	160000	580	ND	ND	12.3	0.040	4.79	290	ND
GW-3006-Q192	925	18600	233	ND	ND	1.80	0.020	8.40	370	ND
GW-3008-Q192	2420	218000	1540	ND	ND	21.5	0.14	13.1	186	127
GW-3009-Q192	1150	26200	234	NS	ND	5.59	ND	12.3	168	ND
GW-3023-Q192	3310	229000	NS	1.30	ND	17.2	0.130	14.1	NS	579
GW-4001-010992	1530	20600	77.3	ND	ND	3.89	0.050	14.9	204	NS
GW-4002-Q192	867	4900	92.4	ND	ND	1.80	0.050	7.58	254	ND
GW-4003-Q192	1520	8880	118	0.110	0.440	8.09	ND	3.79	264	NS
GW-4004-Q192	964	10100	112	0.050	2.20	9.19	0.170	8.68	186	ND
GW-4005-Q192	2200	6770	156	ND	0.42	8.19	0.08	10.8	209	ND
GW-4006-Q192	ND	7440	59.0	ND	ND	2.39	0.020	12.2	162	NS
GW-4007-Q192	2940	28600	89.5	ND	ND	1.20	0.170	4.40	200	258

TABLE 2-4 First Quarter Geochemical Results for Groundwater at the WSCP/RP/VP (Continued)

Sample ID	Potassium (µg/l)	Sodium (µg/l)	Strontium (µg/l)	Nitrite (mg/l)	Bromide (mg/l)	Chloride (mg/l)	Phosphorus Total (mg/l)	Silica, Dissolved (mg/l)	Alkalinity (mg/l)	Aluminum (µg/l)
GW-4008-Q192	ND	3510	112	ND	0.590	3.29	0.080	10.0	220	ND
GW-4009-Q192	53400	37100	102	ND	ND	1.30	0.480	5.70	188	ND
GW-4010-Q192	1530	12400	174	ND	ND	1.89	0.080	6.79	190	ND
GW-4011-Q192	7620	69900	283	ND	0.440	6.40	0.650	14.8	280	ND
GW-4012-Q192	57800	50200	86.8	ND	ND	2.79	0.05	10.8	315	ND
GW-4013-Q192	6610	35700	153	0.010	ND	6.20	0.030	5.29	310	ND
GW-4014-Q192	ND	6460	162	ND	ND	4.09	ND	4.29	290	ND
GW-4015-Q192	1660	7470	63.4	ND	0.46	5.29	0.12	13.8	240	ND
GW-4016-Q192	920	7870	89.7	ND	ND	2.50	0.07	10.4	240	ND
GW-4017-Q192	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GW-4018-Q192	2440	8670	113	ND	ND	16.8	0.03	12.8	440	ND
GW-4019-Q192	ND	9880	173	ND	ND	1.60	0.030	2.89	290	ND
GW-4020-Q192	8540	24500	227	ND	ND	14.8	0.04	9.40	380	ND
GW-4021-Q192	ND	15000	223	ND	ND	1.80	0.05	10.3	510	ND
GW-4022-Q192	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GW-4023-Q192	ND	60300	176	ND	ND	14.9	0.02	14.7	470	ND

NA - Not Available
ND - Not Detected
NS - Not Sampled


MKT PUBLIC HIKING & BICYCLE TRAIL
STATE ROUTE 94
MW-1035
MW-1034
MW-1012
MW-1026
QUARRY POND
MW-1029
WELDON SPRING QUARRY
MW-1002
MW-1011
MW-1010
MW-1036
MW-1027
MW-1004
MW-1016
MW-1015
SUPPORT ZONE
MW-1005
MW-1008
MW-1006
MW-1007
MW-1017
RMW-1
MW-1009
MW-1023
MW-1037
MW-1030
MW-1032
RMW-3
MW-1039
MW-1018
MW-1038
RMW-4
MW-1028
MW-1014
MW-1013
MW-1031
FEMME OSAGE SLOUGH
MW-1019
LITTLE FEMME OSAGE CREEK
MW-1020
MW-1033
MW-1021
RMW-2
MW-1022
LEGEND
DOE MONITORING WELL
ST. CHARLES COUNTY MONITORING WELL
0 500 1000 FT
0 152.4 304.8 M
SCALE
GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING QUARRY
FIGURE 2-2
REPORT NO: DOE/OR/21548-257
EXHIBIT NO.: A/QY/120/1291
ORIGINATOR: CSJ
DRAWN BY: GLN
DATE: 12/91


N
STATE ROUTE 94
WELDON SPRING QUARRY
KATY TRAIL
MW-1024
WELL NO.2
WELL NO.3
FEMME OSAGE SLOUGH
WELL NO.5
MISSOURI RIVER
AREA IN BOX SHOWN ON FIGURE 4-5
WELL NO.6
WELL NO.4
LITTLE FEMME OSAGE CREEK
WELL NO.8
WELL NO.9
FEMME OSAGE CREEK
WELL NO.7
0 800 1600 FT
0 243.8 487.7 M
SCALE
● -WATER PRODUCTION WELL
▲ -DOE MONITORING WELL
WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, & ST. CHARLES CO. WELL FIELD MONITORING LOCATIONS
FIGURE 2-3
REPORT NO: DOE/OR/21548-257
EXHIBIT NO: A/QY/121/1291
ORIGINATOR: CSJ
DRAWN BY: GLN
DATE: 12/91

MW-1010 and MW-1011 located south of the slough. In addition, wells MW-1035, MW-1036, MW-1037, MW-1038, and MW-1039 will be sampled bimonthly until operation of the Weldon Spring Quarry water treatment plant is initiated. The second program is the quarterly sampling of all wells south of the Femme Osage Slough, excluding MW-1010 and MW-1011, but including the St. Charles County well field. Both the raw and treated waters from the St. Charles County water treatment plant are sampled.

2.2.1 Radiological Results

Radiological data are presented in Tables 2-5 and 2-6 for samples collected on the first bimonthly period and first quarter. The results show typical fluctuations near the average levels in the WSQ area with the exception of MW-1008 and MW-1032. Uranium concentrations in these wells exceeded the 1991 annual averages but do not exceed the 1991 results for MW-1004, which appear to be hydrologically related.

The monitoring wells south of the Femme Osage Slough, the St. Charles County monitoring wells, and the St. Charles County production wells are sampled annually for the radiological species of radium, thorium, gross alpha, and gross beta. The results of these samples analyses are presented in Table 2-7. The concentrations in these wells are consistent with historical values of waters in or near the WSQ.

2.2.2 Nitroaromatic Compounds Results

Analytical results for the first bimonthly period and first quarter for nitroaromatic compounds are presented in Tables 2-8 and 2-9, respectively. No monitoring wells south of the Femme Osage Slough showed detectable concentrations of nitroaromatic compounds during the first quarter of 1992. The distribution and magnitude of nitroaromatic contamination in wells near the quarry remain consistent with historical levels.

2.2.3 Inorganic Anions Results

Two inorganic anions, nitrate and sulfate, were sampled in all the wells monitored at the WSQ. The analytical results for the first bimonthly period and the first quarter are presented in Tables 2-5 and 2-6, respectively. These results are consistent with data reported in the

TABLE 2-5 First Bimonthly (Jan/Feb) Inorganic Anions and Uranium Results for Groundwater at the Weldon Spring Quarry

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-1002-022592	0.870	57.6	2.92
GW-1004-021092	0.420	249	4400
GW-1005-021092	0.120	145	1700
GW-1006-012092	0.65	448	3160
GW-1007-012092	0.26	294	125
GW-1008-012092	0.41	296	5940
GW-1009-012092	0.23	294	2.14
GW-1010-021092	0.120	0.410	ND
GW-1011	Well Dry		
GW-1012-012792	1.20	72.3	2.65
GW-1013-012092	0.47	111	1050
GW-1014-012092	0.38	111	802
GW-1015-012092	5.59	307	1560
GW-1016-012092	2.20	270	734
GW-1026-011392	ND	88.3	ND
GW-1027-011392	0.26	102	1030
GW-1028-031292*	0.230	72.7	3.47
GW-1029-022592	0.560	74.4	2.72
GW-1030-021092	ND	98.4	ND
GW-1031-012192	0.34	28.8	20.2
GW-1032-012192	0.28	238	1560
GW-1034-022792	0.19	169	2.92
GW-1035-022792	ND	66.6	0.408
GW-1036-012792	ND	61.3	3.95
GW-1037-012792	ND	13.1	0.925
GW-1038-012792	ND	50.9	1.76
GW-1039-012292	ND	64.7	ND

ND - Not Detected

* - Sampled after the First Bimonthly Period

TABLE 2-6 First Quarter Inorganic Anions and Uranium Results for Groundwater at the Weldon Spring Quarry

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-1017-Q192	0.28	2.10	ND
GW-1018-Q192	ND	35.0	ND
GW-1019-Q192	ND	3.70	ND
GW-1020-Q192	ND	18.9	ND
GW-1021-013092	ND	ND	ND
GW-1022-013092	ND	ND	ND
GW-1023-Q192	0.28	8.00	ND
GW-1024-Q192	ND	1.39	ND
GW-1033-Q192	0.14	12.5	NA
GW-RMW1-Q192	ND	41.6	ND
GW-RMW2-Q192	ND	21.7	5.50
GW-RMW3-Q192	ND	2.70	ND
GW-RMW4-Q192	ND	30.4	1.95
GW-PW02-Q192	ND	114	ND
GW-PW03-Q192	ND	104	ND
GW-PW04-Q192	ND	107	ND
GW-PW05-Q192	ND	77.3	ND
GW-PW06-Q192	ND	97.9	ND
GW-PW07-Q192	ND	66.8	ND
GW-PW08-Q192	ND	53.1	ND
GW-PW09-Q192	ND	40.0	ND
GW-RAWW-Q192	ND	91.7	ND
GW-FINW-Q192	0.77	92.4	ND

ND - Not Detected
NA - Not Available

TABLE 2-7 First Quarter Radiological Results for Groundwater at the WSQ

Sample ID	Th-228 (pCi/l)	Th-230 (pCi/l)	Th-232 (pCi/l)	Ra-226 (pCi/l)	Ra-228 (pCi/l)	Gross Alpha (pCi/l)	Gross Beta (pCi/l)
GW-1017-Q192	ND	3.55	ND	1.21	ND	ND	ND
GW-1018-Q192	ND	ND	ND	ND	3.00	ND	ND
GW-1019-Q192	0.232	ND	0.198	ND	3.00	ND	ND
GW-1020-Q192	ND	ND	ND	ND	ND	ND	ND
GW-1021-013092	ND	2.43	ND	1.65	ND	ND	ND
GW-1022-013092	ND	2.70	ND	0.431	ND	ND	ND
GW-1023-Q192	ND	3.40	ND	0.983	ND	ND	ND
GW-1024-Q192	0.15	0.22	ND	ND	ND	ND	ND
GW-1033-Q192	NA	NA	NA	NA	NA	NA	NA
GW-RMW1-Q192	ND	ND	ND	ND	5.36	ND	ND
GW-RMW2-Q192	ND	ND	ND	ND	ND	ND	ND
GW-RMW3-Q192	ND	ND	ND	ND	5.16	ND	ND
GW-RMW4-Q192	ND	ND	ND	ND	4.80	ND	ND
GW-PW02-Q192	ND	0.12	ND	ND	ND	ND	ND
GW-PW03-Q192	ND	ND	ND	ND	ND	ND	ND
GW-PW04-Q192	ND	ND	ND	ND	ND	ND	ND
GW-PW05-Q192	ND	ND	ND	ND	ND	ND	ND
GW-PW06-Q192	ND	ND	ND	ND	ND	ND	ND
GW-PW07-Q192	ND	ND	ND	ND	ND	ND	ND
GW-PW08-Q192	ND	ND	ND	ND	ND	ND	ND
GW-PW09-Q192	ND	ND	ND	ND	ND	ND	ND
GW-RAWW-Q192	ND	ND	ND	ND	6.59	ND	ND
GW-FINW-Q192	ND	ND	ND	ND	5.95	ND	ND

ND - Not Detected
NA - Not Available

TABLE 2-8 First Bimonthly (Jan/Feb) Nitroaromatic Data Results for Groundwater at the Weldon Spring Quarry

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1002-022592	ND	ND	ND	ND	ND	207
GW-1004-021092	ND	ND	2.80	4.60	14.0	4.50
GW-1005-021092	ND	ND	0.14	0.040	ND	ND
GW-1006-012092	ND	ND	0.19	2.20	5.80	26.0
GW-1007-012092	ND	ND	ND	ND	ND	ND
GW-1008-012092	ND	ND	ND	0.096	0.22	0.047
GW-1009-012092	ND	ND	ND	ND	ND	ND
GW-1010-021092	ND	ND	ND	ND	ND	ND
GW-1011	Well Dry					
GW-1012-012792	ND	ND	ND	ND	ND	ND
GW-1013-012092	ND	ND	0.097	0.030	ND	ND
GW-1014-012092	ND	ND	0.042	0.014	ND	ND
GW-1015-012092	ND	0.12	0.060	1.00	30.0	220
GW-1016-012092	ND	ND	ND	0.23	5.80	38.0
GW-1026-011392	ND	ND	ND	ND	ND	ND
GW-1027-011392	ND	ND	9.00	3.10	3.80	0.033
GW-1028-031292*	NA	NA	NA	NA	NA	NA
GW-1029-022592	ND	ND	ND	ND	ND	ND
GW-1030-021092	ND	ND	0.040	ND	ND	ND
GW-1031-012192	ND	ND	ND	ND	ND	ND
GW-1032-012192	ND	ND	0.067	1.10	3.00	0.043
GW-1034-022792	ND	ND	ND	ND	ND	ND
GW-1035-022792	ND	ND	ND	ND	ND	ND
GW-1036-012792	ND	ND	ND	ND	ND	ND
GW-1037-012792	ND	ND	ND	ND	ND	ND
GW-1038-012792	ND	ND	ND	ND	ND	ND
GW-1039-012292	ND	ND	ND	ND	ND	ND

ND - Not Detected
NA - Not Available
* - Sampled after the First Bimonthly Period

TABLE 2-9 First Quarter Nitroaromatic Data for Groundwater at the Weldon Spring Quarry

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1017-Q192	ND	ND	ND	ND	ND	ND
GW-1018-Q192	ND	ND	ND	ND	ND	ND
GW-1019-Q192	ND	ND	ND	ND	ND	ND
GW-1020-Q192	ND	ND	ND	ND	ND	ND
GW-1021-013092	ND	ND	ND	ND	ND	ND
GW-1022-013092	ND	ND	ND	ND	ND	ND
GW-1023-Q192	ND	ND	ND	ND	ND	ND
GW-1024-Q192	ND	ND	ND	ND	ND	ND
GW-1033-Q192	ND	ND	ND	ND	ND	ND
GW-RMW1-Q192	ND	ND	ND	ND	ND	ND
GW-RMW2-Q192	ND	ND	ND	ND	ND	ND
GW-RMW3-Q192	ND	ND	ND	ND	ND	ND
GW-RMW4-Q192	ND	ND	ND	ND	ND	ND
GW-PW02-Q192	ND	ND	ND	ND	ND	ND
GW-PW03-Q192	ND	ND	ND	ND	ND	ND
GW-PW04-Q192	ND	ND	ND	ND	ND	ND
GW-PW05-Q192	ND	ND	ND	ND	ND	ND
GW-PW06-Q192	ND	ND	ND	ND	ND	ND
GW-PW07-Q192	ND	ND	ND	ND	ND	ND
GW-PW08-Q192	ND	ND	ND	ND	ND	ND
GW-PW09-Q192	ND	ND	ND	ND	ND	ND
GW-RAWW-Q192	ND	ND	ND	ND	ND	ND
GW-FINW-Q192	ND	ND	ND	ND	ND	ND

ND - Not Detected
NA - Not Available

previous environmental monitoring reports. The WSQ groundwater samples continue to indicate no significant nitrate contamination of the groundwater. The results indicate that elevated sulfate levels are present in groundwater within the WSQ and north of the Femme Osage Slough.

2.2.4 Metals Results

All the wells in the WSQ monitoring program are sampled for arsenic and barium. The St. Charles county production wells are also analyzed for lead, cadmium, and mercury. The results for the first bimonthly period and first quarter are presented in Tables 2-10 and 2-11, respectively. Arsenic levels were consistent with historical values for groundwater in the vicinity of the WSQ. Elevated barium levels have remained in the wells in the vicinity of the Femme Osage Slough.

2.2.5 Organics Results

The St. Charles County RMW series monitoring wells, the St. Charles County production wells, untreated and treated water from the St. Charles County water treatment plant, and monitoring well MW-1024 were sampled in the first quarter for organics; volatile and semi-volatile, pesticides, and polychlorinated biphenyls (PCBs). A listing of the parameters analyzed is in Appendix A. The results of the analyses indicated slight concentrations of toluene at nine of the 14 sampling locations. The concentration of toluene appears to be attributed to the sealing of the sample vials and labels with clear adhesive tape. Resampling of several of the wells which previously indicated toluene concentrations reported non-detects of toluene. A concentration of methylene chloride (9 μg/l) was indicated in RMW-2. This slight concentration was attributed to typical laboratory contamination as a result of container cleaning practices. No detectable concentrations of pesticides or PCBs were indicated at any of the sampling locations.

2.3 Springs

Five springs around the Weldon Spring site (WSS) were sampled during the first quarter (see Figure 2-4). Previous spring monitoring indicated that waters from six perennial springs and one wet-weather spring are measurably influenced by site-related contaminants. These springs include SP-5301 through SP-5304, SP-6301, SP-6302, and SP-6306. All spring samples were analyzed for uranium. Analytical results for these are not available at this time.

TABLE 2-10 First Bimonthly (Jan/Feb) Metal Results in Groundwater at the Weldon Spring Quarry

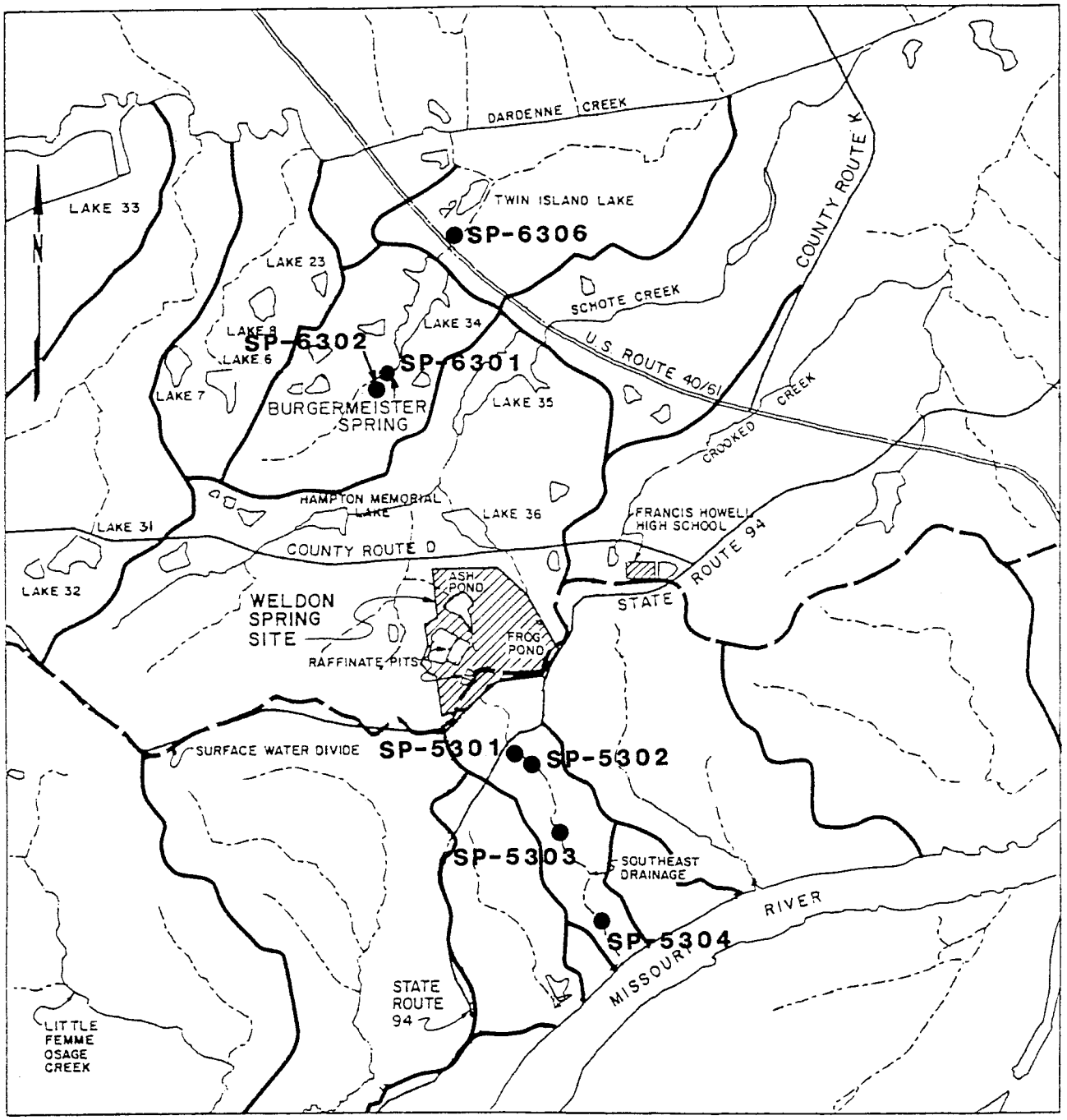
Sample ID	Arsenic (µg/l)	Barium (µg/l)
GW-1002-022592	ND	120
GW-1004-021092	ND	38.5
GW-1005-021092	ND	57.3
GW-1006-012092	ND	47.9
GW-1007-012092	20.3	349
GW-1008-012092	ND	47.3
GW-1009-012092	8.80	486
GW-1010-021092	102	356
GW-1011	Well Dry	
GW-1012-012792	ND	131
GW-1013-012092	2.89	156
GW-1014-012092	ND	219
GW-1015-012092	ND	126
GW-1016-012092	ND	140
GW-1026-011392	21.6	389
GW-1027-011392	ND	148
GW-1028-031292*	ND	293
GW-1029-022592	ND	38.8
GW-1030-021092	7.40	404
GW-1031-012192	ND	96.9
GW-1032-012192	ND	95.4
GW-1034-022792	ND	155
GW-1035-022792	ND	256
GW-1036-012792	ND	308
GW-1037-012792	ND	549
GW-1038-012792	ND	248
GW-1039-012292	ND	509

ND - Not Detected
NA - Not Available
* - Sampled after the first bimonthly period

TABLE 2-11 First Quarter Results for Metals in Groundwater at the Weldon Spring Quarry

Sample ID	Arsenic (µg/l)	Barium (µg/l)	Lead (µg/l)	Cadmium (µg/l)	Mercury (µg/l)
GW-1017-Q192	146	985	NR	NR	NR
GW-1018-Q192	123	581	NR	NR	NR
GW-1019-Q192	69.8	838	NR	NR	NR
GW-1020-Q192	27.4	413	NR	NR	NR
GW-1021-013092	76.0	899	NR	NR	NR
GW-1022-013092	147	584	NR	NR	NR
GW-1023-Q192	72.0	316	NR	NR	NR
GW-1024-Q192	10.6	550	NR	NR	NR
GW-1033-Q192	ND	241	NR	NR	NR
GW-RMW1-Q192	7.70	423	NR	NR	NR
GW-RMW2-Q192	14.1	265	NR	NR	NR
GW-RMW3-Q192	39.3	629	NR	NR	NR
GW-RMW4-Q192	26.5	225	NR	NR	NR
GW-PW02-Q192	ND	347	4.90	ND	ND
GW-PW03-Q192	ND	278	2.70	ND	ND
GW-PW04-Q192	ND	281	ND	ND	ND
GW-PW05-Q192	ND	332	ND	ND	ND
GW-PW06-Q192	ND	284	ND	ND	ND
GW-PW07-Q192	ND	468	ND	ND	ND
GW-PW08-Q192	2.39	426	ND	ND	ND
GW-PW09-Q192	2.79	496	ND	ND	ND
GW-RAWW-Q192	ND	363	NS	NS	NS
GW-FINW-Q192	ND	89.0	NS	NS	NS

ND - Not Detected
NA - Not Available
NR - Not Required
NS - Not Sampled



● SPRING

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SCALE

SPRINGS IN THE VICINITY OF THE WSS

FIGURE 2-4

REPORT NO.:		EXHIBIT NO.:	A/VP/040/0592
ORIGINATOR: MGT	DRAWN BY: GLN	DATE: 5/92	

3 SURFACE WATER MONITORING

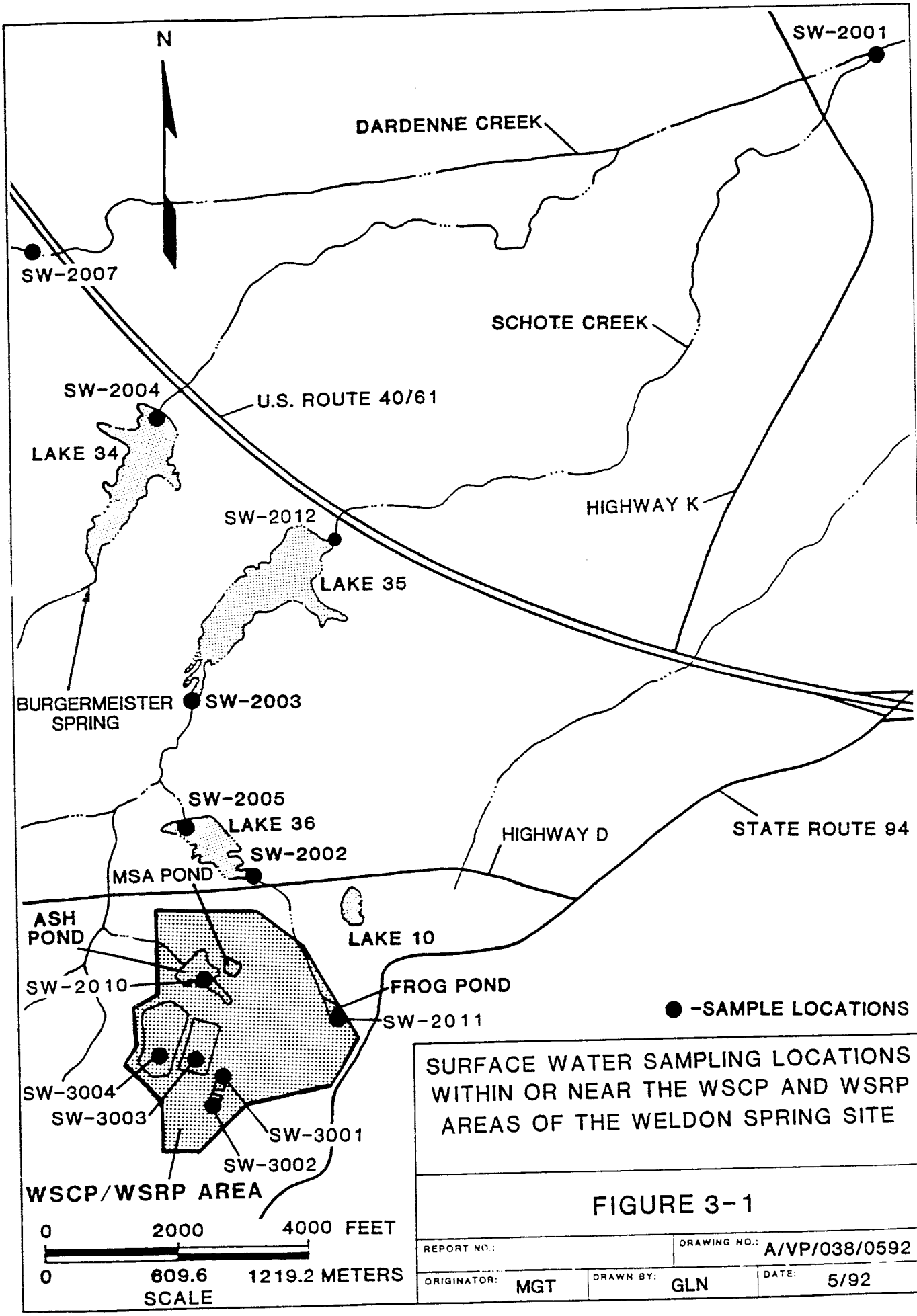
Routine samples were collected during the first quarter of 1992 from both on-site and off-site surface water locations. All surface water samples were analyzed without filtering, unless a specific comparison of dissolved versus total contaminant concentrations was desired. Some analytical results are not available at this time; however, they will be presented in the 1992 Annual Site Environmental Report (ASER).

3.1 Chemical Plant/Raffinate Pits/Vicinity Properties

During the first quarter, surface water samples were collected from the 10 of 15 surface water sampling locations shown in Figure 3-1 and analyzed for uranium. Monitoring location SW-2016 was added to the surface water monitoring plan due to an elevated uranium concentration reported by the U.S. Geological Survey (USGS) at that location. Monitoring point SW-2016 is located at the intersection of Dardenne Creek and County Highway N and is now the furthest location downstream at which to measure contaminant levels in Dardenne Creek after receiving the Schote Creek contribution. Results from SW-2002 indicated an elevated uranium concentration of 171 pCi/l (6.3 Bq/l). Although this value is greater than the 1991 annual average it does not exceed the historical high of 240 pCi/l (8.9 Bq/l) for this location. The results, presented in Table 3-1, indicated that conditions at the other sampling locations remain consistent with historical values.

3.2 Weldon Spring Quarry

Surface water samples were collected for uranium and metals (arsenic and barium) analyses from the 13 locations shown in Figures 3-2 and 3-3. The results are presented in Table 3-2. First quarter uranium and metals concentrations for the sampling locations in the Femme Osage Slough and Little Femme Osage Creek remain within historical ranges. The highest measured uranium concentration of 2060 pCi/l (76.2 Bq/l) was detected at the quarry pond (SW-1008) and is within the historical range. In addition, nitroaromatics, radionuclides, nitrate, and sulfate were measured for SW-1008. The results for the radiological parameters were not available for incorporation into this data summary. Table 3-3 presents the results of the nitroaromatic analyses which are within historical ranges. Uranium and barium values for all three Missouri River samples (SW-1011, SW-1012, and SW-1013) are higher than previously



SURFACE WATER SAMPLING LOCATIONS WITHIN OR NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

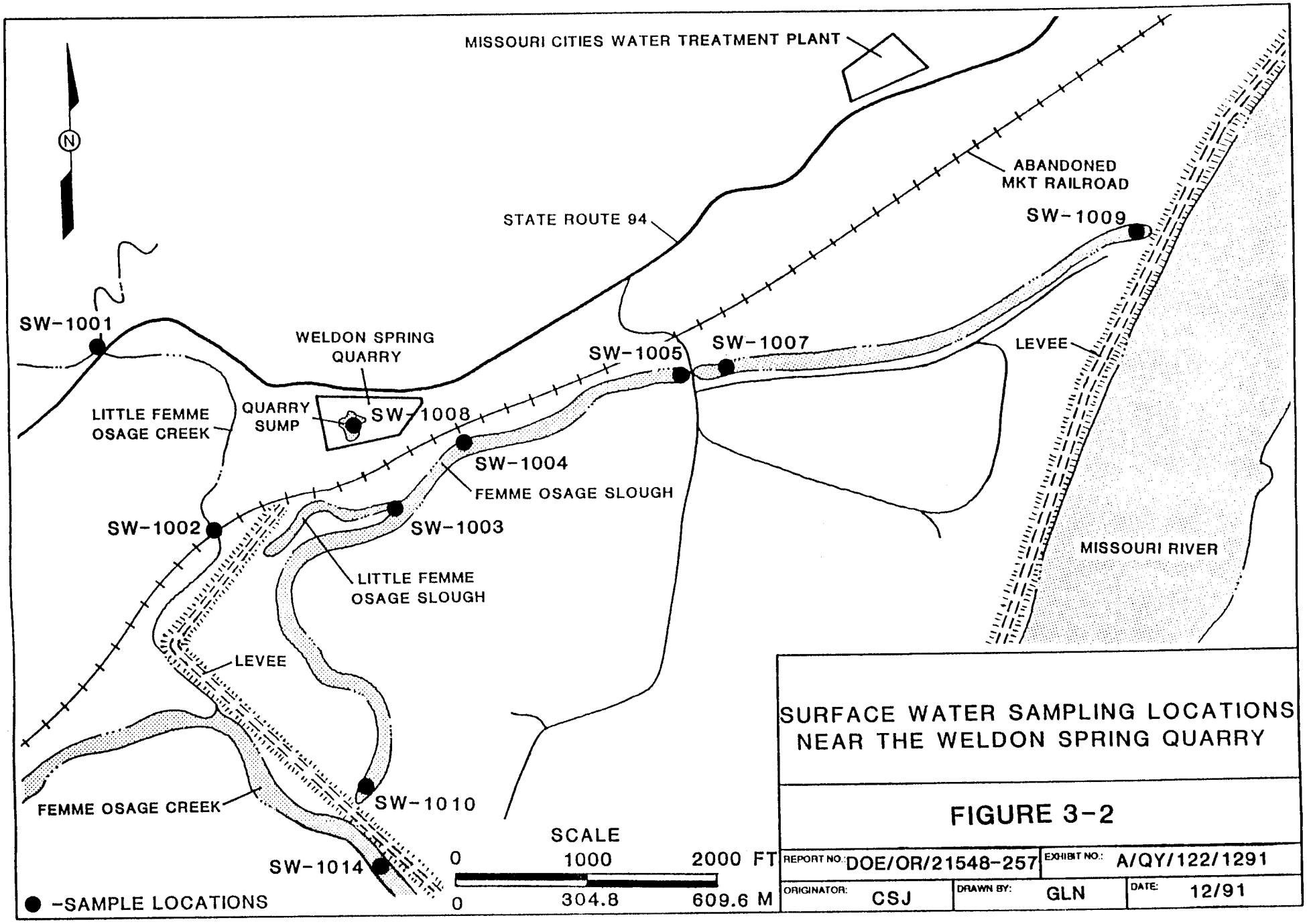
FIGURE 3-1

REPORT NO.:		DRAWING NO.: A/VP/038/0592	
ORIGINATOR: MGT	DRAWN BY: GLN	DATE: 5/92	

TABLE 3-1 First Quarter Results for Uranium in Surface Water at the WSCP/WSRP/WSVP

Sample ID	Uranium (pCi/l)
SW-2001-Q192	NA
SW-2002-Q192	171
SW-2003-Q192	13.7
SW-2004-Q192	17.8
SW-2005-Q192	35.6
SW-2007-Q192	NA
SW-2010-Q192*	NA
SW-2011-Q192*	NA
SW-2012**	No Flow
SW-2016-Q192	NA
SW-3001	NR
SW-3002	NR
SW-3003	NR
SW-3004	NR
SW-5311	NS

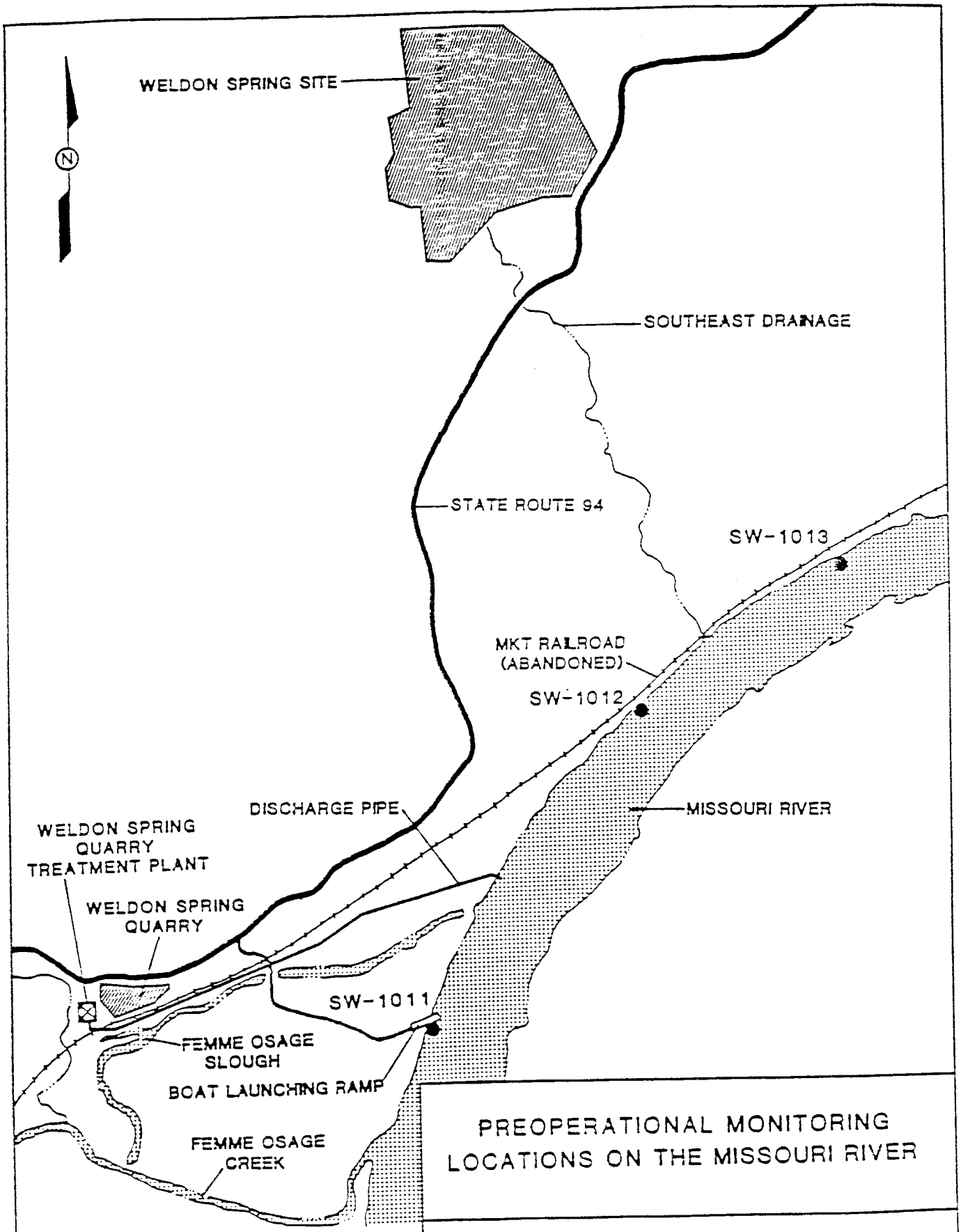
ND - Not Detected
NA - Not Available
NR - Not Required
NS - Not Sampled
* - Samples after the first quarter
** - To be sampled when flow is available



SURFACE WATER SAMPLING LOCATIONS
NEAR THE WELDON SPRING QUARRY

FIGURE 3-2

REPORT NO:	DOE/OR/21548-257	EXHIBIT NO.:	A/QY/122/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91



PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

FIGURE 3-3

REPORT NO.	DOE/OR/21548-257	EXHIBIT NO.	A/VP/193/1291		
ORIGINATOR	CSJ	DRAWN BY	GLN	DATE	12/91

TABLE 3-2 First Bimonthly (Jan/Feb) Results for Uranium and Metals in Surface Water at the Weldon Spring Quarry

Sample ID	Uranium (pCi/l)	Arsenic (µg/l)	Barium (µg/l)
SW-1001-022192	0.748	NA	NA
SW-1002-022192	1.36	NA	NA
SW-1003-013192	47.0	2.29	89.4
SW-1004-013192	53.0	ND	65.7
SW-1005-013192	10.0	3.79	120
SW-1007-013192	13.0	2.20	125
SW-1008-021992	NA	NA	NA
SW-1009-013192	14.0	ND	123
SW-1010-013192	39.0	ND	60.7
SW-1011-022192	9.79	NA	NA
SW-1012-022192	9.11	NA	NA
SW-1013-022192	10.0	NA	NA
SW-1014-013192	ND	ND	77.8

ND - Not Detected
NA - Not Available

TABLE 3-3 First Bimonthly (Jan/Feb) Radiological Results for SW-1008

Parameter	Concentration	Units
Nitrobenzene	ND	µg/l
1,3-DNB	ND	µg/l
2,4-DNT	4.94	µg/l
2,6-DNT	ND	µg/l
2,4,6-TNT	ND	µg/l
1,3,5-TNB	ND	µg/l
Nitrate	NA	mg/l
Sulfate	NA	mg/l

ND - Not Detected
NA - Not Available

measured values for these locations. These elevations are not related to conditions at the Weldon Spring site and likely reflect spring run-off from up-river crystalline rock terrain.

4 EFFLUENT MONITORING

The National Pollutant Discharge Elimination System (NPDES) permit process is authorized by Section 402(a)(1) of the Clean Water Act of 1977. The authority to issue permits is delegated to the State of Missouri by the U.S. Environmental Protection Agency (EPA). The State of Missouri has issued four NPDES permits to the U.S. Department of Energy (DOE) allowing the discharge of stormwater and treated wastewater to waters of the state. The permits require that samples of the wastewater be collected periodically and the results reported to the Missouri Department of Natural Resources. The following sections contain the analytical results for samples collected during January, February, and March of 1992.

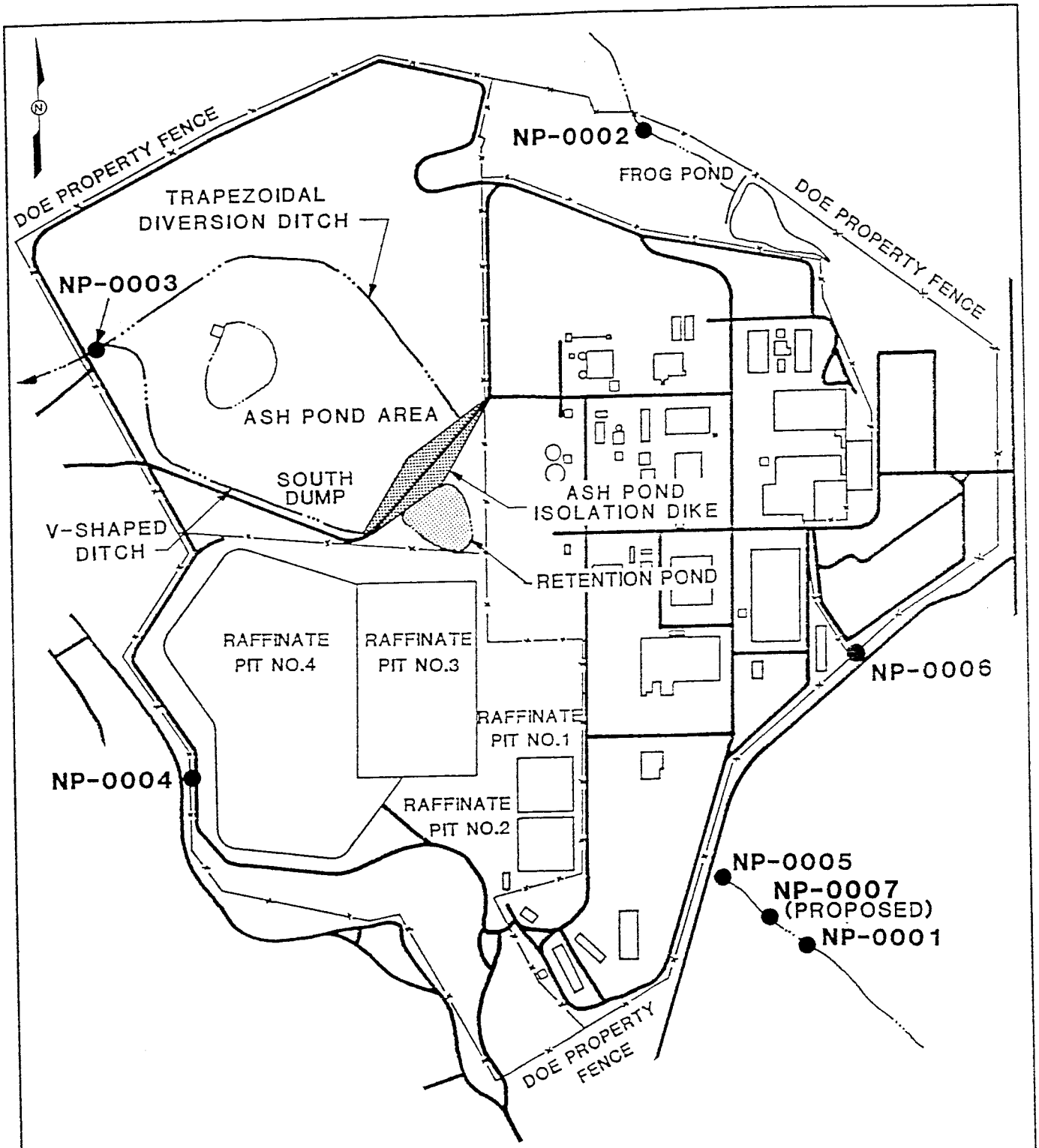
4.1 National Pollutant Discharge Elimination System Data Review

Effluent samples were collected and analyzed in compliance with the Weldon Spring site NPDES permits. Permit No. MO-0107701 was issued on October 1, 1990, and currently addresses the five storm water and two wastewater discharges shown in Figure 4-1. Outfalls NP-0001 through NP-0005 represent storm water discharges; Outfall NP-0006 represents the treated wastewater discharge associated with the administration building sanitary wastewater treatment plant; and Outfall NP-0007 represents the site water treatment plant, which is under construction, but not yet completed. There was no discharge from NP-0007. Outfalls NP-0006 and NP-0007 have effluent limitations. The five storm water outfalls have monitoring requirements only. First quarter 1992 analytical data for each outfall are presented in Table 4-1.

Permit No. MO-0108987 was issued on May 5, 1989, for Outfall NP-1001 of the Weldon Spring Quarry water treatment plant. The plant construction is not complete, and no discharge took place during the first quarter of 1992.

NPDES permit No. MO-G340001 was issued on December 19, 1991. This permit is for discharge of uncontaminated water used for new tank and basin testing at the quarry water treatment plant. First quarter 1992 analytical data is presented in Table 4-2. This permit number has been changed to MO-G680001.

NPDES permit No. MO-G340002 was issued on February 7, 1992. This permit is for discharge of uncontaminated water used for new tank and basin testing at the site water treatment



NPDES SURFACE WATER SAMPLING LOCATIONS AT THE WSCP/RP

FIGURE 4-1

SCALE 0 500 1000 FT
0 152.4 304.8 M

REPORT NO.: DOE/OR/21548-257	EXHIBIT NO.: A/CP/050/0592	
ORIGINATOR: TW	DRAWN BY: GLN	DATE: 5/92

TABLE 4-1 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006

Outfall NP-0001 NPDES data for Q1 1992

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Jan. 8	4320	13.0	ND (0.1)	0.48	7.1	ND (0.1)	732	1.6	1090
Feb. 12	5970	11.0	ND (0.1)	0.45	6.3	ND (0.1)	150	0.271	184

Outfall NP-0002 NPDES data for Q1 1992

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Jan. 8	43800	6.0	ND (0.1)	0.58	6.6	ND (0.1)	310	0.643	437
Feb. 24	14400	ND (5.0)	ND (0.1)	0.89	5.7	ND (0.1)	270	0.420	286
Mar. 4	900	8.0	ND (0.1)	0.97	6.3	ND (0.1)	260	0.422	287

Outfall NP-0003 NPDES data for Q1 1992

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Jan. 8	43000	63.0	ND (0.1)	8.3	7.0	ND (0.1)	163	.349	237
Feb. 12	5100	10.0	ND (0.1)	1.8	6.4	ND (0.1)	820	1.7	1156
Feb. 24	45600	10.0	ND (0.1)	4.09	6.0	ND (0.1)	1590	2.47	1680
Feb. 26	72000	14.0	ND (0.1)	--	--	--	--	--	--
Mar. 4	25000	ND (5)	ND (0.1)	3.39	6.6	ND (0.1)	1500	1.59	1081
Mar. 25	29000	3460	ND (0.1)	0.62	6.17	ND (0.1)	120	.0472	32

TABLE 4-1 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006 (Continued)

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Mar. 31	72000	--	ND (0.1)	--	6.87	--	--	--	--

Outfall NP-0004 NPDES data for Q1 1992

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Mar. 2	720	97	ND (0.1)	0.57	7.1	ND (0.1)	10	.009	6.12

Outfall NP-0005 NPDES data for Q1 1992

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
Jan. 8	25800	6.0	ND (0.1)	129	6.6	ND (0.1)	338	.691	470
Feb. 6	720	9890	60	0.62	--	0.142	92	.0799	54
Feb. 24	2900	9.0	ND (0.1)	76.2	5.9	ND (0.1)	450	.556	378
Mar. 18	144000	270	ND (0.1)	4.26	5.5	.0044	220	.279	190

TABLE 4-1 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006 (Continued)

Outfall NP-0006 NPDES data for Q1 1992

DATE SAMPLED	FLOW	SUSP. SOLIDS	BOD	FECAL COLIFORMS	pH
UNITS	GPD**	mg/l	mg/l	Colonies/100 ml	pH units
Jan. 15	3555	6.0	ND (6.0)	ND (1.0)	7.4
Feb. 12	4200	23.0*	ND (3.0)	ND (10.0)	7.0
Mar. 4	3420	9.0	11.6*	ND (1.0)	6.4
Mar. 27	--	3.0	13.0*	0	7.0

* Indicates value/values which exceeded effluent limitation.
** Indicates flow rate at time of sample collection.
ND Not detected, detection limit is in parentheses.
-- Indicates analysis not done on this parameter.

plant. There was no discharge under this permit for the first quarter of 1992. This permit number has been changed to MO-G680002.

4.1.1 Radiological Analysis

Gross alpha and uranium analyses corresponded reasonably well with past data. There were higher than average uranium levels reported in samples collected from outfalls NP-0001 and NP-0003, but the levels were lower than recorded historical highs. The peak for NP-0001 was 1,090 pCi/l (1.6 mg/l) and for NP-0003, 1,680 pCi/l (2.47 mg/l). Uranium levels were similarly higher at outfalls NP-0001 and NP-0003 during the first quarter of 1991.

The stormwater outfalls had the following ranges of uranium concentrations. The process sewer outfall NP-0001 had only two sample values of 184 pCi/l (0.271 mg/l) and 1,090 pCi/l (1.6 mg/l). The Frog Pond outfall NP-0002 had values of 286 pCi/l (0.420 mg/l) to 437 pCi/l (0.643 mg/l). The Ash Pond outfall NP-0003, had values of 32 pCi/l (0.0472 mg/l) to 1,680 pCi/l (2.47 mg/l). A single sample was analyzed for outfall NP-0004 behind Raffinate Pit 4 with a value of 6.12 pCi/l (0.009 mg/l) and the southeast drainage outfall NP-0005 had values from 54 pCi/l (0.0799 mg/l) to 470 pCi/l (0.691 mg/l).

In addition to the required radiological monitoring, gross beta was quantified at 110 pCi/l (4.07 Bq/l) at outfall NP-0002 for the March 4, 1992, sample; at 630 (23.3 Bq/l) and 180 pCi/l (6.66 Bq/l) at outfall NP-0003 for the March 4 and March 25, 1992, samples; and at 11 pCi/l (0.41 Bq/l) at outfall NP-0004 for the March 2, 1992, sample.

Hydrostatic test water pumped from the quarry water treatment plant basins was analyzed for uranium in addition to the required permit parameters. The analyses showed that uranium was not present at detectable levels; see Table 4-2.

4.1.2 Other Analysis

Other analyses for NP-0001 through NP-0005 include physical analyses (settleable solids and total suspended solids) and chemical analyses (nitrate, pH, and lithium). First quarter 1992 values generally correspond to past values for the majority of parameters. Exceptions were high total suspended solids (TSS) values at NP-0003 on March 25, 1992, and at NP-0005 on February 6 and March 18, 1992; a high settleable solids (SS) level at NP-0005 on

Table 4-2 Results of NPDES Monitoring for Permit MO-G340001

Date Sampled	Flow*	Oil and Grease	Susp. Solids	Total Uranium		pH
Units	Gallons	mg/l	mg/l	mg/l	pCi/l	
Feb. 4		ND (5.0)	ND (5.0)	- -	ND (.68)	7.6, 7.7
Feb. 5		ND (5.0)	5.0	- -	ND (.68)	7.4
Feb. 6		ND (5.0)	7.0	- -	ND (.68)	7.9
TOTAL	1,000,000	- -	- -	- -	- -	- -

ND Not detected, detection limit is in parentheses.
- - Not applicable.
* Total flow was determined by calculating the volume pumped from the basin.

February 6, 1992; and high nitrate values at NP-0005 on January 8, 1992, and February 24, 1992.

The elevated TSS value at NP-0003 may have been caused by runoff from the construction of the material storage area (MSA) Phase II and III; no other causes could be determined. The high total suspended solids (TSS) value at outfall NP-0005 on February 6, 1992, was the result of an off-site water line break. There was no other flow at the time and the discharge was very short term. The high TSS value at NP-0005 on March 18, 1992 can be attributed to the ongoing construction at the site water treatment plant and off site water line construction by Missouri Cities Water Company. The high settleable solids level at NP-0005 on February 6, 1992, was also caused by the water line break. The high nitrate levels at NP-0005 may also have been caused by ongoing construction at the site water treatment plant area.

The permit for the discharge from the administration building treatment plant at outfall NP-0006 has effluent limitations and a requirement to monitor once per quarter. Flow must be measured once a month. The Subcontractor monitors the effluent once a month to assess plant performance, thus generating two additional sample analyses a quarter. The NPDES permit specifies effluent limitations for biochemical oxygen demand (BOD), TSS, pH, and fecal coliform at this outfall. The limits for BOD are 10 mg/l monthly average and 15 mg/l weekly average; for TSS, 15 mg/l monthly average and 20 mg/l weekly average; for fecal coliform, 400 colonies per 100 ml monthly average and 1,000 colonies per 100 ml daily maximum. The effluent exceeded permit limits twice during the quarter. On February 12, 1992, the total suspended solids were 23 mg/l, exceeding the monthly average limit of 15 mg/l. During March BOD results were 11.6 mg/l and 13 mg/l. These results were in compliance with the weekly limit of 15 mg/l, but the monthly average of 12.3 mg/l was out of compliance with the monthly average limit of 10 mg/l. The Subcontractor is continuing to make operational changes to improve plant performance. In addition, the plans to add a flow equalization system are at the 60% design review phase. The equalization of flow will greatly improve the operation of the plant. An application for a construction permit will be submitted to the Missouri Department of Natural Resources when plans and specifications are complete. Until the flow equalization is added, the treatment plant will be monitored more frequently than would normally be required.

Hydrostatic test water pumped from the quarry water treatment plant basins was in compliance with permitted units (Table 4-2).

5 AIR MONITORING

5.1 Radon Gas

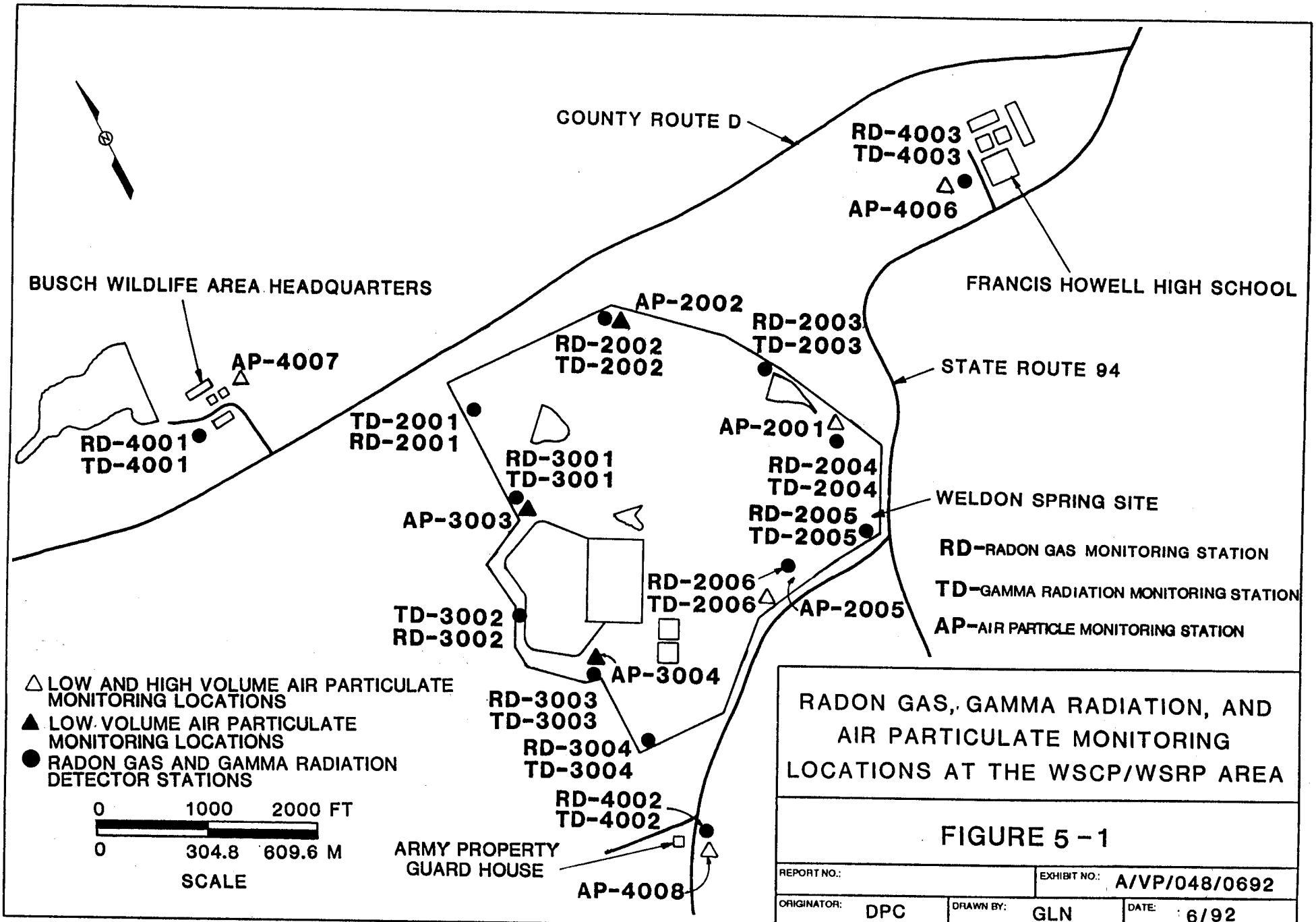
The radon gas monitoring program utilizes a pair of radon detectors at each of 25 permanent locations; each detector is exchanged quarterly. These detectors are deployed at six locations at the Weldon Spring Chemical Plant, eight locations at the Weldon Spring Quarry, four locations at the Weldon Spring raffinate pits, and seven off-site locations. Radon monitoring locations are shown in Figures 5-1, 5-2, and 5-3. On-site detectors are distributed around the perimeter fences to ensure adequate detection of radon dispersing from the properties under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005, RD-4006 and RD-4007 were used to monitor background levels near the site.

Two new monitoring stations (RD/TD-1007 and RD/TD-1008) were added to the western and northern quarry water treatment plant perimeters in addition to the relocation of monitoring station (RD/TD-1005) from the western quarry inner fence perimeter to the southern quarry water treatment plant perimeter. Another background monitoring station (RD/TD-4007) was added and is located west of Femme Osage Creek (Figure 5-3).

Table 5-1 summarizes the first quarter 1992 radon concentrations detected at all site perimeter and off-site monitoring locations. Also contained in Table 5-1 is a comparison of the measured concentration with the Federally permitted radon concentration (for unrestricted areas) of 3 pCi/l (111 Bq/m^3) above background as authorized by U.S. Department of Energy (DOE) Order 5400.5.

An average ambient background concentration was determined by calculating the arithmetic average for the five background locations. This data yielded an average ambient background radon concentration of 0.3 pCi/l (11.1 Bq/m^3) for the first quarter of 1992. This concentration was then subtracted from the concentration for each monitoring station, and compared to the DOE guideline of 3 pCi/l (111 Bq/m^3) above background.

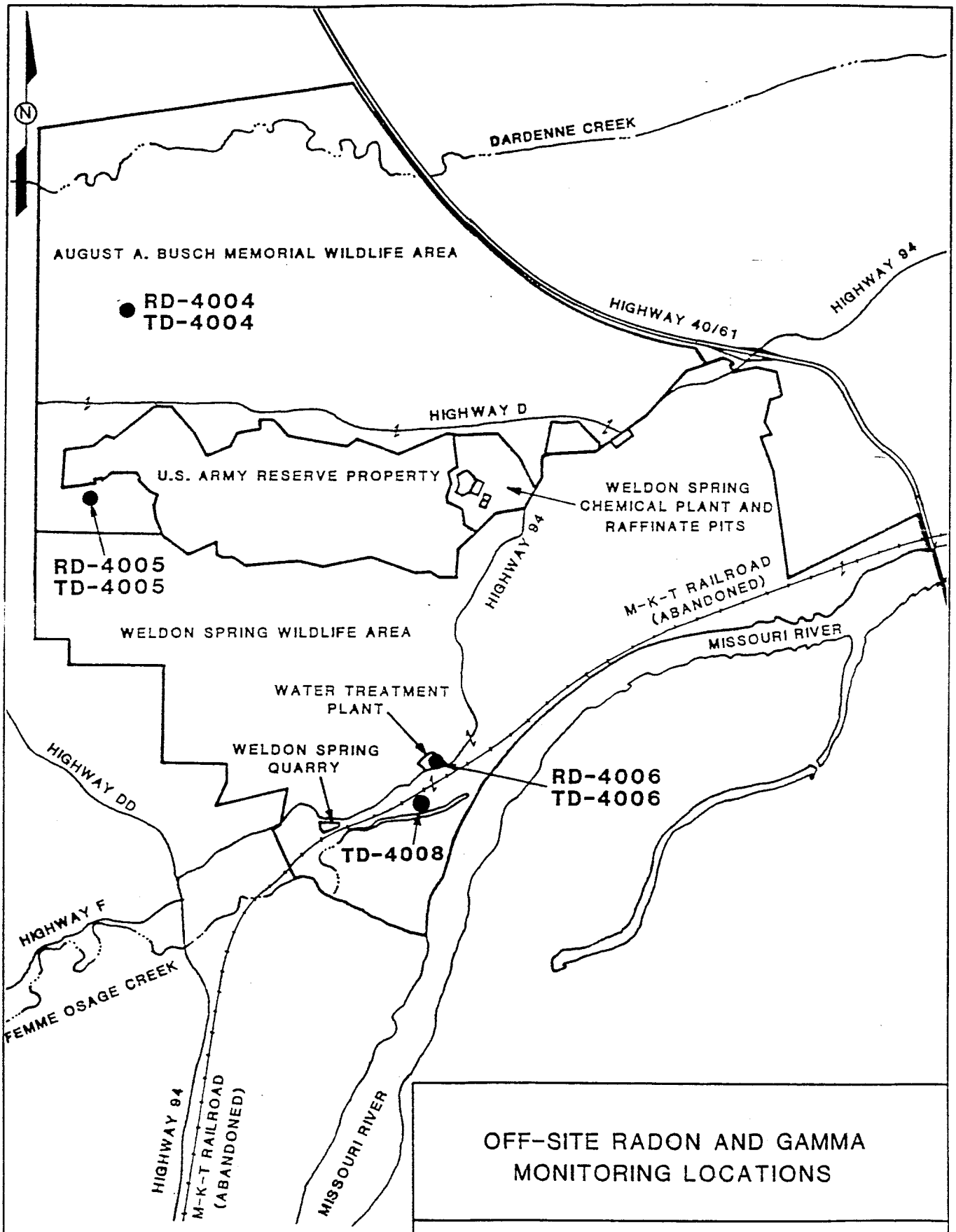
Radon concentrations at the site and quarry perimeters and at off-site locations for the first quarter of 1992 were within the typical range expected during periods of normal precipitation as was the condition for this period. The quarterly radon concentrations at the



RADON GAS, GAMMA RADIATION, AND AIR PARTICULATE MONITORING LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 5-1

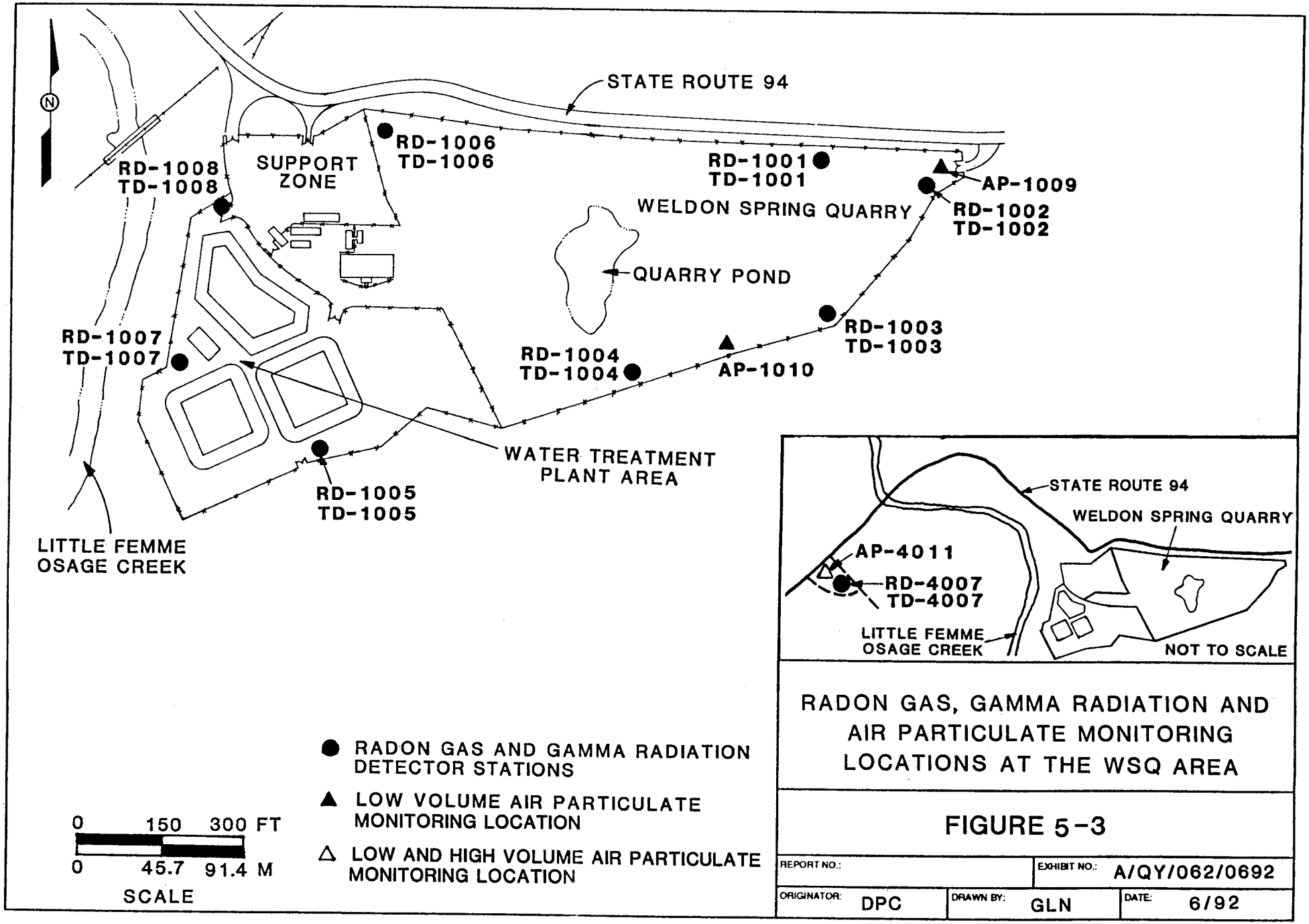
REPORT NO.:		EXHIBIT NO.: A/VP/048/0692
ORIGINATOR: DPC	DRAWN BY: GLN	DATE: 6/92



OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

FIGURE 5-2

REPORT NO.:		EXHIBIT NO.:	A/VP/042/0592
ORIGINATOR: DPC	DRAWN BY: GLN	DATE:	5/92



RADON GAS, GAMMA RADIATION AND AIR PARTICULATE MONITORING LOCATIONS AT THE WSQ AREA

FIGURE 5-3

REPORT NO.:		EXHIBIT NO.:	A/QY/062/0692
ORIGINATOR:	DPC	DRAWN BY: GLN	DATE: 6/92

TABLE 5-1 First Quarter 1992 Track Etch Radon Monitoring Results[a]

Location ID	1st Quarter pCi/l	Percent of Guideline [b]
WSQ		
RD-1001	1.1	27
RD-1002	1.9	53
RD-1003	0.7	13
RD-1004	0.4	3
RD-1005	0.4	3
RD-1006	0.4	3
RD-1007	0.5	7
RD-1008	0.4	3
WSCP		
RD-2001	0.3	0
RD-2002	0.2	0
RD-2003	0.3	0
RD-2004	0.3	0
RD-2005	0.3	0
RD-2006	0.3	0
WSRP		
RD-3001	0.3	0
RD-3002	0.4	0
RD-3003	0.3	0
RD-3004	0.2	0
OFF-SITE		
RD-4001*	0.2	0
RD-4002	0.4	3
RD-4003	0.4	3
RD-4004*	0.3	0
RD-4005*	0.4	3

TABLE 5-1 First Quarter 1992 Track Etch Radon Monitoring Results[a] (Continued)

Location ID	1st Quarter pCi/l	Percent of Guideline [b]
RD-4006*	0.4	3
RD-4007*	0.4	3

(a) Results include natural background.

(b) Percent of guideline calculated by taking the quarterly average minus the average of the background stations divided by the DOE concentration guideline for Rn-222 which is 3 pCi/l (111 Bq/m^3)(Annual average above background) for uncontrolled areas.

* Denotes Background Station.

Weldon Spring Chemical Plant/Raffinate Pit (WSCP/RP) area averaged 0.3 pCi/l (11.1 Bq/m^3) while the quarterly radon concentrations at the Weldon Spring quarry (WSQ) averaged 0.7 pCi/l (26.8 Bq/m^3). The quarterly radon concentrations (background included) ranged from 0.2 pCi/l (7.4 Bq/m^3) at three monitoring locations to 1.9 pCi/l (70.3 Bq/m^3) at monitoring location RD-1002.

Radon concentrations found at the quarry are higher than concentrations measured at other locations because the radium concentrations in quarry wastes are typically much higher than in other areas. Also, the quarry is a large depression with side walls ranging from 3 m to 15 m (10 ft to 50 ft) high which tends to trap emanating radon within the quarry and raise the concentrations along the quarry perimeter.

5.2 Gamma Radiation Exposure

To monitor exposure from gamma radiation, spherical environmental thermoluminescent dosimeters (TLDs) were deployed at 26 locations. The gamma monitoring station locations are identified in Figures 5-1, 5-2, and 5-3 with a prefix TD-.

Table 5-2 summarizes the first quarter results of total gamma radiation monitoring at the 18 Weldon Spring site (WSS) perimeter monitoring stations, Francis Howell High School, the Weldon Spring Army Reserve Training Area, and at the six background monitoring stations.

The annual average background gamma exposure rates measured with TLDs in 1989, 1990, and 1991 were 68 mR/year, 62 mR/year, and 69 mR/year, respectively. The gamma exposure rates measured with TLDs in the first quarter of 1992 were consistent with 1989 through 1991 data. In fact, the first quarter TLD data were consistently lower than data from first quarter 1991 at all locations. This result was unexpected as the off-site laboratory increased the gamma response function by 15% prior to reporting the fourth quarter 1991 results. This increase was observed in the fourth quarter 1991 results and was expected to be reflected in the results for the first quarter 1992. However, the first quarter 1992 results at all locations were lower than those reported in the first quarter of 1991 and much lower than the results reported for the fourth quarter 1991. There were no problems identified through on-site investigations as to what caused the elevated TLD readings for the last quarter of 1991. Thus, different types of TLDs have been placed at a few locations on site for the second quarter and will be handled separately.

TABLE 5-2 First Quarter 1992 Environmental TLD Monitoring Results[a]

Location ID	1st Quarter mrem
WSQ	
TD-1001	22
TD-1002	18
TD-1003	21
TD-1004	17
TD-1005	18
TD-1006	17
TD-1007	19
TD-1008	16
WSCP	
TD-2001	17
TD-2002	15
TD-2003	18
TD-2004	18
TD-2005	15
TD-2006	16
WSRP	
TD-3001	17
TD-3002	13
TD-3003	17
TD-3004	14
OFF-SITE	
TD-4001*	19
TD-4002	17
TD-4003	--
TD-4004*	15

TABLE 5-2 First Quarter 1992 Environmental TLD Monitoring Results[a] (Continued)

Location ID	1st Quarter mrem
TD-4005*	17
TD-4006*	17
TD-4007*	17
TD-4008*	18

(a) Results include natural background.
- Denotes loss of TLD.
* Denotes background station.

These experimental TLDs will likely provide insight as to whether or not laboratory handling and processing were responsible for the unusual fourth quarter results.

5.3 Radioactive Air Particulates

Eleven low volume air particulate samplers monitor the Weldon Spring site continuously. Five of these (AP–2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the Weldon Spring Chemical Plant (WSCP) perimeter and two are located around the quarry perimeter as shown in Figure 5-3. Three monitoring stations (AP-4006, AP-4008, and AP-4011) are located off site at sensitive receptor locations including Francis Howell High School, the Army Reserve property, and near a residential site west of the quarry. The monitoring station at the August A. Busch Wildlife Area (ABWA) (AP-4007) is used to monitor background levels in the vicinity of the WSCP. The off-site monitoring stations are also shown in Figure 5-2.

The sampling station near the ABWA headquarters is used as a background air monitoring station. This station is approximately 0.8 km (0.5 mile) from the WSCP perimeter in a northwestern direction. The terrain between the WSCP and this sampling station is hilly and forested, providing a significant physical barrier to airborne particulates originating from the WSCP/RP area.

Table 5-3 summarizes the quarterly average concentrations and the standard deviations for the 11 air monitoring locations. The quarterly average concentration for each monitoring location was calculated by averaging all weekly air particulate analysis results including results lower than the instruments lower limit of detection (LLD). The corresponding standard deviation for each monitoring location was also calculated using all weekly air particulate analysis results. Due to maintenance, all monitors were not operating the entire 13 weeks as indicated in Table 5-3. However, the sensitive receptor monitoring stations (AP-4006, AP-4008, and AP-4011) were in operation the entire quarter. These stations are also equipped with high volume air samplers which are the focus of the WSS National Emissions Standards for Hazardous Air Pollutants (NESHAPs) plan. The high volume monitoring results will be presented in the 1992 calendar year Annual Site Environmental Report.

The first quarter long-lived gross alpha concentrations ranged from 7.5×10^{-16} μCi/ml to 1.06×10^{-15} μCi/ml an average background concentration of with 1.05×10^{-15} μCi/ml detected at the background station.

TABLE 5-3 First Quarter 1992 Radiological Air Particulate Monitoring Results

Monitor Identification Number	Quarterly AVG. CONCENTRATION (μCi/ml)	STANDARD DEVIATION (μCi/ml)	NUMBER OF WEEKS COLLECTED	NUMBER OF VALUES ABOVE LLD
AP-2001	8.40E-16	2.42E-16	13	13
AP-2002	9.15E-16	5.62E-16	13	10
AP-3003	8.09E-16	5.34E-16	11	9
AP-3004	9.04E-16	3.59E-16	13	10
AP-2005	8.38E-16	3.72E-16	13	10
AP-4006	7.63E-16	4.16E-16	13	9
AP-4007*	1.05E-15	3.99E-16	13	13
AP-4008	1.06E-15	3.61E-16	12	12
AP-1009	9.87E-16	3.25E-16	12	12
AP1010	7.48E-16	7.35E-16	13	8
AP-4011	8.53E-16	3.53E-16	13	12

* Indicates background monitor station.
To convert μCi/ml to Bq/m^3, multiply by 3.7E10.

5.4 Asbestos

No environmental asbestos monitoring was performed in the first quarter of 1992.

6 REFERENCES

MK-Ferguson Company and Jacobs Engineering Group, 1989. *Phase II Groundwater Quality Assessment for the Weldon Spring Site, Chemical Plant, Raffinate Pits and Surrounding Vicinity Properties*, Rev. 0. DOE/OR/21548-078. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. September.

MK-Ferguson Company and Jacobs Engineering Group, 1992. *Environmental Monitoring Plan*, Rev. 1. DOE/OR/21548-237. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. January.

DOE Orders

5400.5 *Radiation Protection of the Public and the Environment*

APPENDIX A

LISTING OF VOLATILES, SEMI-VOLATILES AND PESTICIDE/PCB'S

VOLATILES

1,1,1-TRICHLOROETHANE
1,1,2,2-TETRACHLOROETHANE
1,1,2-TRICHLOROETHANE
1,1-DICHLOROETHANE
1,1-DICHLOROETHENE
1,2-DICHLOROETHANE
1,2-DICHLOROETHENE (TOTAL)
1,2-DICHLOROPROPANE
2-BUTANONE
2-HEXANONE
4-METHYL-2-PENTANONE
ACETONE
BENZENE
BROMODICHLOROMETHANE
BROMOFORM
BROMOMETHANE
CARBON DISULFIDE
CARBON TETRACHLORIDE
CHLOROBENZENE
CHLOROETHANE
CHLOROFORM
CHLOROMETHANE
CIS-1,3-DICHLOROPROPENE
DIBROMOCHLOROMETHANE
ETHYL BENZENE
METHYLENE CHLORIDE
STYRENE
TETRACHLOROETHENE
TOLUENE
TRANS-1,3-DICHLOROPROPENE
TRICHLOROETHENE
VINYL ACETATE
VINYL CHLORIDE
XYLENES, TOTAL

SEMI-VOLATILES

1,2,4-TRICHLOROBENZENE
1,2-DICHLOROBENZENE
1,3-DICHLOROBENZENE
1,4-DICHLOROBENZENE
2,4,5-TRICHLOROPHENOL
2,4,6-TRICHLOROPHENOL
2,4-DICHLOROPHENOL
2,4-DIMETHYLPHENOL
2,4-DINITROPHENOL
2,4-DINITROTOLUENE
2,6-DINITROTOLUENE
2-CHLORONAPHTHALENE
2-CHLOROPHENOL
2-METHYLNAPHTHALENE
2-METHYLPHENOL
2-NITROANILINE
2-NITROPHENOL
3,3'-DICHLOROBENZIDINE
3-NITROANILINE
4,6-DINITRO-2-METHYLPHENOL
4-BROMOPHENYL PHENYL ETHER
4-CHLORO-3-METHYL PHENOL
4-CHLOROANILINE
4-CHLOROPHENYL PHENYL ETHER
4-METHYLPHENOL
4-NITROANILINE
4-NITROPHENOL
ACENAPHTHENE
ACENAPHTHYLENE
ANTHRACENE
BENZO(A)ANTHRACENE
BENZO(A)PYRENE
BENZO(B)FLUORANTHENE
BENZO(G,H,I)PERYLENE
BENZO(K)FLUORANTHENE
BENZOIC ACID
BENZYL ALCOHOL
BIS(2-CHLOROETHOXY)METHANE
BIS(2-CHLOROETHYL)ETHER
BIS(2-CHLOROISOPROPYL)ETHER
BIS(2-ETHYLHEXYL)PHTHALATE
BUTYLBENZYLPHTHALATE
CHRYSENE
DI-N-BUTYL PHTHALATE
DI-N-OCTYL PHTHALATE
DIBENZO(A,H)ANTHRACENE
DIBENZOFURAN
DIETHYLPHTHALATE
DIMETHYLPHTHALATE
FLUORANTHENE
FLUORENE
HEXACHLOROBENZENE
HEXACHLOROBUTADIENE
HEXACHLOROCYCLOPENTADIENE
HEXACHLOROETHANE
INDENO(1,2,3-CD)PYRENE
ISOPHORONE
N-NITROSO-DI-N-PROPYLAMINE
N-NITROSODIPHENYLAMINE
NAPHTHALENE
NITROBENZENE
PENTACHLOROPHENOL
PHENANTHRENE
PHENOL
PYRENE

PESTICIDE/PCB'S

4,4'-DDD
4,4'-DDE
4,4'-DDT
ALDRIN
ALPHA-BHC
ALPHA-CHLORDANE
HEPTACHLOR EPOXIDE
AROCLOR - 1016
AROCLOR - 1221
AROCLOR - 1232
AROCLOR - 1242
AROCLOR - 1248
AROCLOR - 1254
METHOXYCHLOR
AROCLOR-1260
BETA-BHC
DELTA-BHC
DIELDRIN
ENDOSULFAN I
ENDOSULFAN II
TOXAPHENE
ENDOSULFAN SULFATE
ENDRIN
ENDRIN KETONE
GAMMA-BHC (LINDANE)
GAMMA-CHLORDANE
HEPTACHLOR

CHEMICAL PLANT ADMINISTRATIVE RECORD FILE

ARFS FILE # C-202-4

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	C-200-202-1.16	SUMMARIES OF ANALYTICAL DATA ON 60 PRIVATE DRINKING WATER WELLS IN THE VICINITY OF THE WELDON SPRING SITE
	C-200-202-1.17	QUARTERLY ENVIRONMENTAL DATA SUMMARY 3RD QUARTER 1992
	C-200-202-1.18	QUARTERLY ENVIRONMENTAL DATA SUMMARY 4TH QUARTER 1992

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

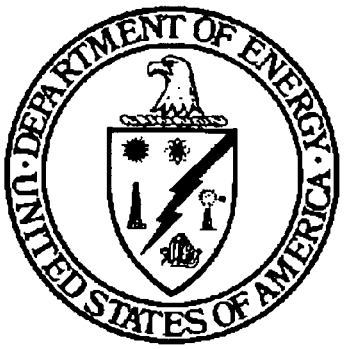
CHEMICAL PLANT
202-1.14

DOE/OR/21548-337
CONTRACT NO. DE-AC05-86OR21548

QUARTERLY ENVIRONMENTAL DATA SUMMARY - 2ND QUARTER 1992

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

SEPTEMBER 1992 **REV. 0**



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APPROVALS

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DOE/OR/21548-337

Weldon Spring Site Remedial Action Project

Quarterly Environmental Data Summary - Second Quarter 1992

Revision 0

September 1992

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U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

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ABSTRACT

The purpose of this *Quarterly Environmental Data Summary* is to provide to the public preliminary data acquired as part of the Weldon Spring Site Remedial Action Project (WSSRAP) environmental monitoring program. The document summarizes the preliminary environmental data, highlights any potentially significant findings, and offers tentative interpretations. Validated data and final interpretations will appear in the 1992 annual site environmental report.

This report includes preliminary data from environmental monitoring activities at the Weldon Spring site (WSS) during the second quarter of 1992. Groundwater, surface water, and air samples were collected in order to monitor potential exposure pathways. Analytical parameters included radionuclides, nitroaromatic compounds, inorganic anions, and direct gamma exposure. The results are used to evaluate possible exposure scenarios and assess the impact of the contaminants at the site on potentially exposed populations.

In summary, off-site exposures during the second quarter of 1992 did not differ significantly from exposures calculated in previous quarters. Contaminated groundwater did not affect the St. Charles County well field.

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1 INTRODUCTION

This quarterly report summarizes the findings from the routine environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). These reports supplement the annual site environmental report (ASER) by providing interested outside agencies and organizations with more frequent access to WSSRAP data. They provide data resulting from routine environmental sampling as described in the WSSRAP *Environmental Monitoring Plan* (EMP) (MKF and JEG 1992a) and a brief interpretation of that data.

It is the goal of this document to summarize and briefly discuss the data, highlighting data that differ significantly from historical observations. The full interpretation of these data (as well as data in other quarterly summaries) will be undertaken in the 1992 ASER. It is recommended that interested readers refer to previous EMPs, ASERs, and project documents for more information on existing site conditions, site history, transport mechanisms, and quantified contaminant levels. The monitoring scheme for every calendar year is established prior to that year in the annual EMP. Each sampling location to be monitored during the upcoming year is identified in the EMP and the schedule of analytical parameters is tabulated for easy reference. These reports may be obtained by visiting the WSSRAP reading room or contacting the WSSRAP Community Relations Manager at (314) 441-8086.

These quarterly reports are intended to include data from all quarterly environmental monitoring programs conducted at the WSSRAP including groundwater, surface water, National Pollutant Discharge Elimination System (NPDES), radon gas, gamma radiation, and air particulates (including asbestos and radioactive particulates). This document summarizes the preliminary environmental data, highlights any potentially significant findings, and offers tentative interpretations. Validated data and final interpretations will appear in the 1992 annual site environmental report. Because standard turnaround time to receive data from the laboratories is 45 days, not all second quarter data are available for reporting. These data will be reported in the 1992 ASER. Sludges and soils are not sampled on a routine basis; therefore, analytical results for these parameters are not included in this report. Trend analyses are being prepared from historical data for surface water, groundwater, and air pathways. These analyses will be presented in the 1992 ASER. Quality control (QC) data for the second quarter, and all other quarters, will also be presented in the 1992 ASER.

2 GROUNDWATER MONITORING

The groundwater is sampled regularly at both the Weldon Spring Chemical Plant/raffinate pits/vicinity properties (WSCP/RP/VP) and the Weldon Spring Quarry (WSQ). Due to differences in the environmental settings and sources of contaminants, separate monitoring schedules are followed. Therefore, results of groundwater monitoring at the WSCP/RP/VP and WSQ will be discussed separately.

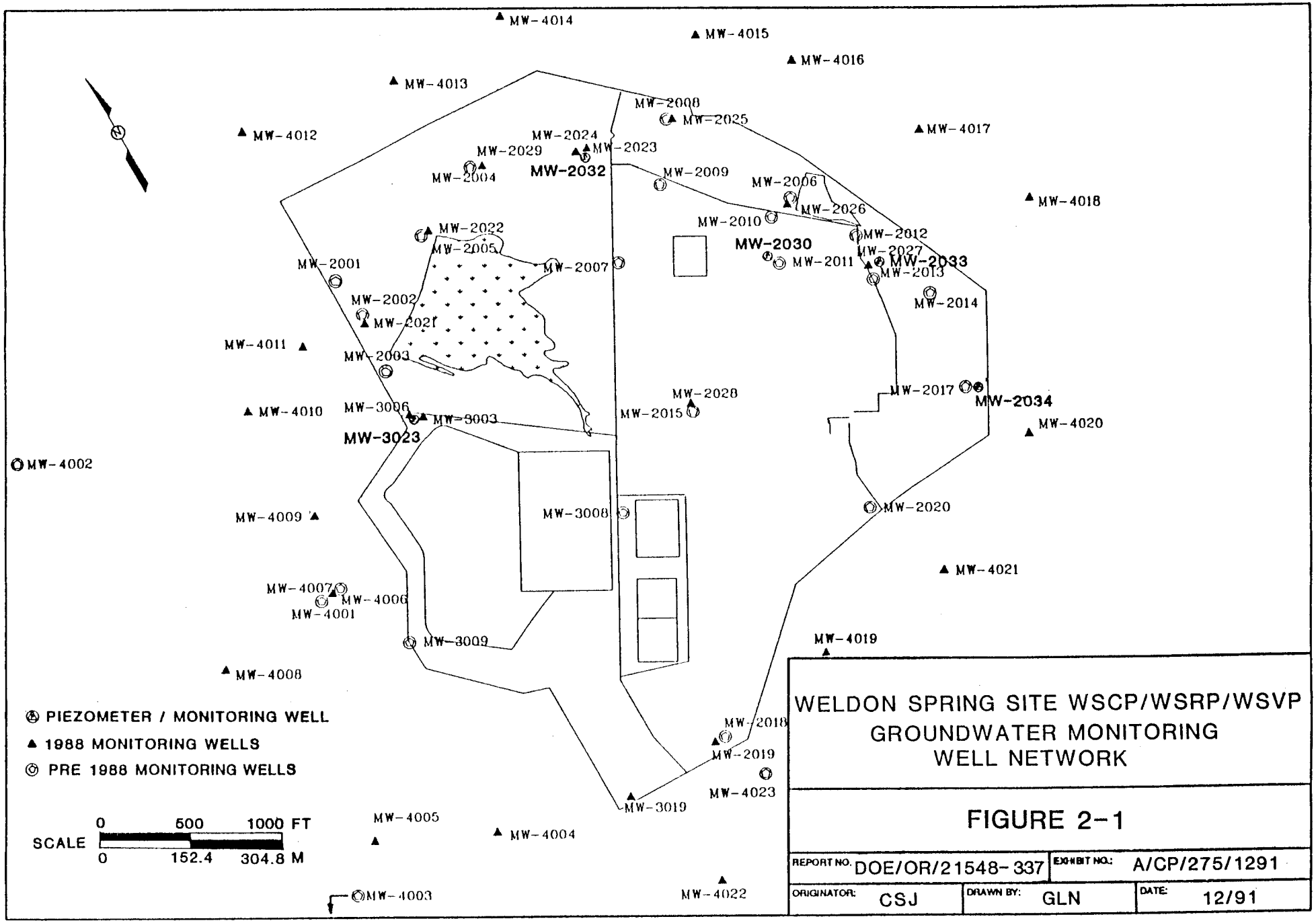
2.1 Chemical Plant/Raffinate Pits/Vicinity Properties

Groundwater at the chemical plant/raffinate pits/vicinity properties area is monitored on a quarterly or semiannual basis (specific to each well as prescribed in the 1992 EMP). Locations are given in Figure 2-1. The number of quarterly sampled wells has increased substantially; a complete list of wells scheduled for quarterly and semiannual sampling is given in the 1992 *Environmental Monitoring Plan* (EMP) (MKF and JEG 1992a). Total uranium, inorganic anions, and nitroaromatic compounds are measured during each monitoring period for both quarterly and semiannual wells. Other radiological parameters are measured annually during the first period for all wells. Geochemical parameters (metals and inorganic anions) are measured each period for the quarterly wells only.

2.1.1 Nitroaromatic Results

Table 2-1 contains nitroaromatic data from samples collected from the quarterly monitored groundwater wells. Nitroaromatic compounds were detected in 16 of the 32 locations for which data are currently available. Concentration levels for these compounds are within their historical range.

Table 2-2 contains nitroaromatic data from samples collected from the semiannually monitored groundwater wells. Nitroaromatic compounds were detected in 10 of the 19 wells for which data are available. Concentrations for these compounds are within their historical range.



WELDON SPRING SITE WSCP/WSRP/WSVP GROUNDWATER MONITORING WELL NETWORK

FIGURE 2-1

REPORT NO.	DOE/OR/21548-337	EXHIBIT NO.	A/CP/275/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91

TABLE 2-1 Second Quarter Nitroaromatic Results for Groundwater at the WSCP/RP/VP

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-2001-Q292	ND	ND	0.080	0.044	ND	0.040
GW-2002-Q292	ND	ND	0.052	0.30	ND	ND
GW-2003-Q292	ND	ND	0.18	0.66	ND	ND
GW-2030-Q292	ND	ND	0.13	5.5	8.1	4.2
GW-2032-Q292	ND	ND	0.12	4.0	2.2	0.30
GW-2033-Q292	ND	ND	0.16	10	1.1	2.8
GW-3003-Q292	ND	ND	0.031	0.079	ND	ND
GW-3006-Q292	ND	ND	ND	ND	ND	ND
GW-3008-Q292	ND	ND	0.097	0.24	ND	ND
GW-3009-Q292	ND	ND	0.19	0.091	ND	0.17
GW-3023-Q292	ND	ND	8.0	7.5	0.033	ND
GW-4001-Q292	ND	0.098	3.0	5.0	1.6	65
GW-4002-Q292	ND	ND	ND	0.034	0.044	ND
GW-4003-Q292	ND	ND	ND	ND	ND	ND
GW-4004-Q292	ND	ND	ND	ND	ND	ND
GW-4005-Q292	ND	ND	ND	ND	ND	ND
GW-4006-Q292	ND	ND	0.10	3.60	ND	17
GW-4007-Q292	NA	NA	NA	NA	NA	NA
GW-4008-Q292	ND	ND	ND	ND	ND	ND
GW-4009-Q292	ND	ND	ND	ND	ND	ND
GW-4010-Q292	ND	ND	ND	ND	ND	ND
GW-4011-Q292	ND	ND	ND	ND	ND	ND
GW-4012-Q292	ND	ND	ND	ND	ND	ND
GW-4013-Q292	ND	ND	0.065	0.90	0.048	46
GW-4014-Q292	ND	ND	ND	0.031	ND	0.23
GW-4015-Q292	NA	NA	NA	NA	NA	NA
GW-4016-Q292	ND	ND	ND	ND	ND	ND
GW-4017-Q292	ND	ND	ND	ND	ND	ND
GW-4018-Q292	ND	ND	ND	ND	ND	ND

TABLE 2-1 Second Quarter Nitroaromatic Results for Groundwater at the WSCP/RP/VP (Continued)

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-4019-Q292	ND	ND	ND	ND	ND	ND
GW-4020-Q292	ND	ND	ND	ND	ND	ND
GW-4021-Q292	ND	ND	ND	ND	ND	ND
GW-4022-Q292	ND	ND	ND	ND	ND	ND
GW-4023-Q292	ND	ND	0.067	0.052	ND	0.17

NA - Not Available
ND - Not Detected

TABLE 2-2 Semiannual Nitroaromatic Results for Groundwater at the WSCP/RP/VP

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-2004-042392	ND	ND	ND	ND	ND	ND
GW-2005-012392	ND	ND	0.076	0.12	ND	ND
GW-2006-011692	ND	ND	0.14	1.20	ND	10.0
GW-2007-011392	ND	ND	ND	ND	ND	ND
GW-2008-S192	ND	ND	0.071	0.86	ND	0.41
GW-2009-S192	ND	ND	0.070	0.270	ND	ND
GW-2010-011692	ND	ND	0.080	0.47	0.28	0.14
GW-2011-042292	0.040	ND	0.092	2.3	ND	0.76
GW-2012-042292	ND	ND	0.081	1.1	0.64	2.0
GW-2013-012392	ND	ND	0.26	5.80	0.58	3.80
GW-2014-S192	ND	ND	0.13	0.98	ND	3.6
GW-2015-011392	ND	ND	ND	ND	ND	ND
GW-2017-S192	ND	ND	ND	ND	ND	ND
GW-2018-S192	ND	ND	ND	ND	ND	ND
GW-2019-S192	ND	ND	ND	ND	ND	ND
GW-2020-S192	ND	ND	0.038	ND	ND	ND
GW-2021-062392	NA	NA	NA	NA	NA	NA
GW-2022-062392	NA	NA	NA	NA	NA	NA
GW-2023-062392	NA	NA	NA	NA	NA	NA
GW-2024-062392	NA	NA	NA	NA	NA	NA
GW-2025-062992	NA	NA	NA	NA	NA	NA
GW-2026-062292	NA	NA	NA	NA	NA	NA
GW-2027-062292	NA	NA	NA	NA	NA	NA
GW-2028-062292	NA	NA	NA	NA	NA	NA
GW-2029-S192	ND	ND	ND	ND	ND	ND
GW-2034-S192	ND	ND	ND	ND	ND	ND
GW-3019-012392	ND	ND	ND	ND	ND	ND

NA - Not Available
ND - Not Detected

2.1.2 Radiological Results

Total uranium results for samples from the quarterly monitored wells at the WSCP/RP/VP are presented in Table 2-3. The upper bound for natural uranium background concentration in groundwater at the WSCP/RP/VP has been determined to be 3.4 pCi/l (0.13 Bq/l) (MKF and JEG 1989). The U.S. Environmental Protection Agency (EPA) has not yet established a drinking water standard for uranium; however, the proposed maximum contaminant level (MCL) is 20 μg/l, which converts to 13.6 pCi/l (0.50 Bq/l) using a new site-specific conversion factor of 0.68 pCi/μg (assuming isotopic equilibrum). The increase to 13.6 pCi/l (0.50 Bq/l) from the previously reported value of 12 pCi/l (0.44 Bq/l) reflects improved quantification of the average U-234/U-238 activity ratios for uranium present at the Weldon Spring Site Remedial Action Project (WSSRAP). The U.S. Department of Energy (DOE) has a health-based, derived concentration guideline (DCG) of 600 pCi/l (22.2 Bq/l) in surface water effluent.

Uranium concentrations remained within historical ranges at most locations for which data are presently available. A higher than previously detected value was recorded for MW-2030. This higher value was only slightly elevated above previously high levels, and may be related to higher values for certain metals (see discussion in Section 2.1.4). At present, insufficient data are available to determine whether this value is part of an upward trend or merely an extreme within the normal range of variation for this well.

Table 2-4 contains uranium data from samples collected from the semiannually monitored groundwater wells. Uranium concentrations in these wells are within their historical range.

Additional radiological parameters are measured for groundwater at all WSCP/RP/VP wells during the second quarter. The results of these analyses are given in Table 2-5. Historically, concentration levels for these parameters have been below the detection limits. In general, the increase in detectable values for 1992 predominantly reflects improved analytical sensitivity rather than high concentration levels for these parameters; exceptions are Th-230 and both radium isotopes. The elevated Th-230 values are thought to be an artifact of analytical interferences. The source of the slightly higher radium concentrations is unclear and is currently under investigation. All locations having apparently elevated Th-230, Ra-226, or Ra-228 values have been scheduled for resampling during the third quarter to confirm these results.

TABLE 2-3 Second Quarter Uranium and Inorganic Anion Results for Groundwater at the WSCP/RP/VP

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-2001-Q292	22.0	8.09	0.82
GW-2002-Q292	181	89.8	ND
GW-2003-Q292	266	106	1.2
GW-2030-Q292	1.20	41.6	16
GW-2032-Q292	86.0	53.2	9.9
GW-2033-Q292	0.96	24.2	1.0
GW-3003-Q292	252	181	2.3
GW-3006-Q292	0.44	22.0	1.4
GW-3008-Q292	644	77.2	3.40
GW-3009-Q292	3250	85.3	59.0
GW-3023-Q292	316	343	NA
GW-4001-Q292	ND	67.3	1.4
GW-4002-Q292	0.98	15.4	1.4
GW-4003-Q292	0.60	33.6	NA
GW-4004-Q292	1.00	19.7	NA
GW-4005-Q292	2.00	24.7	NA
GW-4006-Q292	4.20	28.0	ND
GW-4007-Q292	0.98	12.9	1.5
GW-4008-Q292	0.17	14.0	1.10
GW-4009-Q292	0.19	13.9	3.30
GW-4010-Q292	0.13	22.0	3.40
GW-4011-Q292	37.1	53.8	4.50
GW-4012-Q292	1180	47.9	2.90
GW-4013-Q292	85.6	45.1	1.10
GW-4014-Q292	1.10	25.5	ND
GW-4015-Q292	2.90	16.9	NA
GW-4016-Q292	ND	14.9	NA
GW-4017-Q292	0.45	6.20	NA

TABLE 2-3 Second Quarter Uranium and Inorganic Anion Results for Groundwater at the WSCP/RP/VP (Continued)

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-4018-Q292	2.00	6.70	ND
GW-4019-Q292	0.40	6.40	NA
GW-4020-Q292	0.34	134	14.0
GW-4021-Q292	ND	255	4.10
GW-4022-Q292	0.41	29.0	NA
GW-4023-Q292	3.60	68.5	1.10

ND - Not Detected
NA - Not Available

TABLE 2-4 Semiannual Uranium and Inorganic Anion Results for Groundwater at the WSCP/RP/VP

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-2004-042392	0.78	1.80	0.3
GW-2005-012392	69.8	26.4	ND
GW-2006-011692	6.20	34.8	ND
GW-2007-011392	0.20	15.3	0.605
GW-2008-S192	3.29	40.0	ND
GW-2009-S192	1.60	105	2.10
GW-2010-011692	1.30	32.5	ND
GW-2011-042292	5.50	12.8	0.4
GW-2012-042292	0.71	78.1	0.3
GW-2013-012392	1.10	15.3	ND
GW-2014-S192	1.00	33.6	0.2
GW-2015-011392	0.52	96.2	1.30
GW-2017-S192	0.11	754	5.3
GW-2018-S192	0.24	9.19	NA
GW-2019-S192	ND	42.4	NA
GW-2020-S192	0.52	130	NA
GW-2021-S192	0.20	13.0	ND
GW-2022-S192	0.25	14.2	ND
GW-2023-S192	0.46	15.5	ND
GW-2024-S192	0.22	30.0	ND
GW-2025-062992	NA	NA	NA
GW-2026-S192	ND	14.4	ND
GW-2027-S192	ND	7.40	2.5
GW-2028-S192	ND	121	ND
GW-2029-S192	0.12	23.4	2.2
GW-2034-S192	0.18	623	9.6
GW-3019-012392	ND	7.00	ND

ND - Not Detected
NA - Not Available

TABLE 2-5 Semiannual Radiological Results for Groundwater at the WSCP/RP/VP

Sample ID	Th-228 (pCi/l)	Th-230 (pCi/l)	Th-232 (pCi/l)	Ra-226 (pCi/l)	Ra-228 (pCi/l)	Po-210 (pCi/l)	Pb-210 (pCi/l)	Ac-227 (pCi/l)
GW-2004-042392	ND	0.6	ND	0.2	ND	NS	NS	NS
GW-2005-012392	NA	NA	NA	NA	NA	NA	NA	NA
GW-2006-011692	ND	3.07	ND	ND	17.1	ND	ND	ND
GW-2007-011392	ND	4.87	ND	ND	ND	ND	ND	ND
GW-2008-S192	ND	ND	ND	ND	ND	NS	NS	NS
GW-2009-S192	ND	ND	ND	ND	ND	NS	NS	NS
GW-2010-011692	ND	4.90	ND	ND	ND	5.17	ND	ND
GW-2011-042292	ND	ND	ND	ND	ND	NS	NS	NS
GW-2012-042292	ND	0.2	ND	ND	ND	NS	NS	NS
GW-2013-012392	ND	2.89	ND	ND	ND	ND	ND	ND
GW-2014-S192	ND	ND	ND	ND	ND	NS	NS	NS
GW-2015-011392	ND	1.75	ND	ND	ND	ND	ND	ND
GW-2017-S192	ND	ND	ND	0.2	ND	NS	NS	NS
GW-2018-S192	NA	NA	NA	NA	NA	NA	NA	NA
GW-2019-S192	NA	NA	NA	NA	NA	NA	NA	NA
GW-2020-S192	NA	NA	NA	NA	NA	NA	NA	NA
GW-2021-S192	ND	1.15	ND	ND	ND	NS	NS	NS
GW-2022-S192	ND	ND	ND	ND	ND	NS	NS	NS
GW-2023-S192	ND	1.99	0.302	ND	ND	NS	NS	NS
GW-2024-S192	ND	ND	0.666	ND	ND	NS	NS	NS
GW-2025-062992	NA	NA	NA	NA	NA	NA	NA	NA
GW-2026-S192	0.819	2.18	1.23	ND	ND	NS	NS	NS
GW-2027-S192	0.297	0.779	0.223	ND	ND	NS	NS	NS
GW-2028-S192	ND	ND	ND	ND	ND	NS	NS	NS
GW-2029-S192	ND	ND	ND	ND	ND	NS	NS	NS
GW-2034-051192	ND	ND	ND	ND	ND	NS	NS	NS
GW-3019-012392	ND	3.50	ND	ND	ND	ND	ND	ND

ND - Not Detected
NA - Not Available
NS - Not Sampled

2.1.3 Sulfate and Nitrate Results

Sulfate and nitrate concentrations are measured during each monitoring period. Results from the quarterly monitored wells are shown in Table 2-3. Second quarter results are within historical ranges with the exception of the nitrate value for MW-4012. The source of this elevation is being investigated. Sulfate and nitrate results from semiannually monitored wells are shown in Table 2-4. These concentrations are within their historical range.

2.1.4 Geochemical Results: Metals and Inorganic Anions

Table 2-6 contains the second quarter geochemical data (metals and inorganic anions) for quarterly monitored wells at the WSCP/RP/VP area. In 1992, the WSSRAP increased both the number of wells and the frequency of sampling for geochemical parameters. For the majority of the wells, concentrations for the second quarter of 1992 are consistent with previously measured values. However, notable exceptions were observed for the MW-203X wells, MW-3023, MW-4017, and MW-4022; which contained high levels of aluminum, iron, manganese, and moderately elevated lead. These wells were filtered before preservation and analysis. The failure to filter these samples resulted in metals being leached from the suspended solid material upon preservation. This leaching may also be responsible for the high uranium observed in MW-2030. Future samples from these wells will be filtered prior to preservation.

2.2 Weldon Spring Quarry

Groundwater at the WSQ has become radiologically and chemically contaminated as a result of contact with, or migration from, wastes present in the WSQ. Monitoring of the groundwater at, and near, the WSQ is of particular concern because of the proximity of the St. Charles County well field. The well field is located approximately 0.8 km (0.5 mi) to the south of the WSQ. Monitoring of contaminants in groundwater and the protection of the well field is a top priority at the WSSRAP.

Groundwater is currently being monitored at 48 wells located in and around the quarry area. Thirty-six monitoring wells installed by the DOE are currently utilized in or near the quarry. Four monitoring wells were installed by St. Charles County in 1986 and are currently included in the DOE's monitoring program. Eight St. Charles County municipal wells, and the treated and untreated water from the St. Charles County water treatment plant, are also

TABLE 2-6 Quarterly Geochemical Results for Groundwater at the WSCP/RP/VP

Sample ID	Arsenic (µg/l)	Barium (µg/l)	Calcium (µg/l)	Chromium (µg/l)	Iron (µg/l)	Lithium (µg/l)	Magnesium (µg/l)	Manganese (µg/l)	Nickel (µg/l)	Lead (µg/l)	Silver (µg/l)
GW-2001-Q292	ND	233	93800	ND	ND	ND	45400	ND	ND	ND	ND
GW-2002-Q292	ND	148	218000	ND	ND	303	63100	ND	ND	ND	ND
GW-2003-Q292	ND	175	279000	ND	ND	480	107000	ND	ND	ND	ND
GW-2030-Q292	ND	187	123000	ND	1420	ND	20100	47.4	ND	8.59	ND
GW-2032-Q292	ND	440	188000	11.1	13500	35.4	54200	814	27.6	18.8	ND
GW-2033-Q292	ND	172	238000	ND	3830	ND	18900	304	ND	26.0	ND
GW-3003-Q292	ND	140	221000	ND	ND	465	130000	3.29	ND	ND	ND
GW-3006-Q292	2.60	134	61100	ND	123	ND	49400	34.4	ND	ND	ND
GW-3008-Q292	ND	214	503000	ND	ND	246	145000	ND	ND	3.20	ND
GW-3009-Q292	ND	856	104000	ND	19.4	ND	62500	8.90	44.8	ND	ND
GW-3023-Q292	ND	86.5	329000	ND	1530	794	75100	32.0	ND	12.0	ND
GW-4001-Q292	ND	90.4	90600	ND	ND	ND	33700	2.29	ND	ND	ND
GW-4002-Q292	ND	118	45600	ND	42.5	ND	31800	3.39	ND	ND	ND
GW-4003-Q292	ND	163	50700	ND	ND	ND	30700	2.00	ND	2.50	ND
GW-4004-Q292	ND	83.3	30200	ND	ND	ND	28000	ND	ND	ND	ND
GW-4005-Q292	ND	130	64600	ND	ND	30.5	40200	ND	ND	ND	ND
GW-4006-Q292	ND	161	46300	ND	ND	ND	20600	ND	ND	ND	ND
GW-4007-Q292	ND	91.0	32000	ND	ND	ND	22200	52.3	ND	3.70	ND
GW-4008-Q292	ND	105	37800	ND	ND	ND	31800	16.9	ND	ND	ND

TABLE 2-6 Quarterly Geochemical Results for Groundwater at the WSCP/RP/VP (Continued)

Sample ID	Arsenic (µg/l)	Barium (µg/l)	Calcium (µg/l)	Chromium (µg/l)	Iron (µg/l)	Lithium (µg/l)	Magnesium (µg/l)	Manganese (µg/l)	Nickel (µg/l)	Lead (µg/l)	Silver (µg/l)
GW-4009-Q292	ND	53.5	32400	ND	ND	38.2	21100	ND	ND	ND	ND
GW-4010-Q292	ND	74.1	50900	ND	40.5	ND	37000	ND	ND	12.8	ND
GW-4011-Q292	2.00	88.5	46600	ND	ND	ND	27100	2.00	ND	ND	ND
GW-4012-Q292	ND	53.9	32100	54.4	22.2	42.4	33800	ND	ND	ND	ND
GW-4013-Q292	ND	136	134000	ND	ND	51.4	48600	ND	ND	ND	ND
GW-4014-Q292	ND	102	57700	ND	66.3	ND	40900	39.8	ND	ND	ND
GW-4015-Q292	ND	221	55900	ND	ND	35.4	28500	ND	ND	ND	ND
GW-4016-Q292	ND	269	46000	ND	ND	ND	31100	75.8	ND	ND	ND
GW-4017-Q292	ND	179	58800	13.2	1200	ND	38100	93.6	ND	18.3	ND
GW-4018-Q292	ND	225	106000	ND	ND	ND	58800	ND	ND	6.79	ND
GW-4019-Q292	ND	206	36800	ND	ND	ND	42600	ND	ND	ND	ND
GW-4020-Q292	ND	89.1	94000	15.8	ND	ND	58400	110	ND	2.50	ND
GW-4021-Q292	ND	38.3	121000	ND	21.7	ND	117000	10.6	ND	ND	ND
GW-4022-Q292	4.00	344	96400	87.8	42400	32.9	46400	1540	151	40.0	9.10
GW-4023-Q292	ND	82.4	86500	ND	ND	ND	35800	ND	ND	ND	ND

TABLE 2-6 Quarterly Geochemical Results for Groundwater at the WSCP/RP/VP (Continued)

Sample ID	Potassium (µg/l)	Sodium (µg/l)	Strontium (µg/l)	Nitrite (mg/l)	Bromide (mg/l)	Chloride (mg/l)	Phosphorus Total (mg/l)	Silica, Dissolved (mg/l)	Alkalinity (mg/l)	Aluminum (µg/l)
GW-2001-Q292	1080	9370	1080	ND	ND	5.50	0.07	7.70	280	ND
GW-2002-Q292	6000	81800	287	ND	ND	7.90	0.05	16.0	310	ND
GW-2003-Q292	6710	121000	533	ND	ND	9.19	0.03	11.0	265	ND
GW-2030-Q292	4040	46000	172	ND	ND	30.7	0.10	10.7	470	650
GW-2032-Q292	3640	62700	352	0.12	ND	16.2	0.46	11.1	410	6050
GW-2033-Q292	2510	83300	178	ND	0.42	5.40	0.36	14.0	540	1130
GW-3003-Q292	9060	145000	575	ND	ND	10.1	0.10	10.3	334	ND
GW-3006-Q292	ND	17500	219	ND	ND	1.30	0.14	11.9	392	ND
GW-3008-Q292	2680	210000	1400	ND	ND	17.6	ND	10.1	200	ND
GW-3009-Q292	1870	24800	214	0.34	ND	4.50	0.04	10.0	190	ND
GW-3023-Q292	3510	214000	615	0.89	ND	17.7	0.13	11.8	260	674
GW-4001-Q292	ND	23300	90.1	ND	2.50	7.09	0.08	11.6	220	ND
GW-4002-Q292	ND	4890	82.9	ND	ND	1.30	0.17	9.00	226	ND
GW-4003-Q292	941	7950	94.2	ND	ND	6.09	0.10	10.1	270	ND
GW-4004-Q292	ND	6670	79.0	ND	ND	3.39	0.11	4.40	180	ND
GW-4005-Q292	6430	62200	308	ND	1.60	7.70	0.08	7.30	210	ND
GW-4006-Q292	ND	6990	60.9	ND	0.57	2.00	0.23	9.50	170	ND
GW-4007-Q292	1500	15200	91.5	0.01	ND	0.88	0.11	9.80	200	ND
GW-4008-Q292	ND	3330	104	ND	ND	0.98	0.05	8.30	225	ND

TABLE 2-6 Quarterly Geochemical Results for Groundwater at the WSCP/RP/VP (Continued)

Sample ID	Potassium (µg/l)	Sodium (µg/l)	Strontium (µg/l)	Nitrite (mg/l)	Bromide (mg/l)	Chloride (mg/l)	Phosphorus Total (mg/l)	Silica, Dissolved (mg/l)	Alkalinity (mg/l)	Aluminum (µg/l)
GW-4009-Q292	27300	18400	146	ND	ND	0.84	0.16	9.50	230	ND
GW-4010-Q292	1510	11400	137	ND	0.98	2.40	0.07	10.6	295	ND
GW-4011-Q292	1290	7490	139	ND	ND	5.90	0.30	12.8	270	ND
GW-4012-Q292	41300	44600	107	ND	ND	10.0	0.08	10.7	300	ND
GW-4013-Q292	6630	33000	145	ND	ND	6.50	0.06	10.8	300	ND
GW-4014-Q292	1620	6050	150	ND	ND	2.60	ND	10.0	285	ND
GW-4015-Q292	1470	7680	64.6	ND	ND	ND	0.06	10.0	250	ND
GW-4016-Q292	1500	8680	96.5	ND	ND	1.10	0.05	10.4	230	ND
GW-4017-Q292	3210	10300	119	ND	ND	1.60	0.14	10.9	340	235
GW-4018-Q292	3280	8870	119	ND	ND	16.7	0.03	9.50	430	ND
GW-4019-Q292	947	8770	180	ND	1.39	2.50	ND	9.09	280	ND
GW-4020-Q292	5780	23600	217	ND	1.39	15.9	0.07	10.3	390	ND
GW-4021-Q292	1130	15300	219	ND	ND	1.20	0.04	9.00	510	ND
GW-4022-Q292	3120	11800	284	ND	ND	5.29	0.89	13.3	380	26000
GW-4023-Q292	ND	55300	153	ND	0.64	12.4	0.02	15.7	400	ND

ND - Not Detected

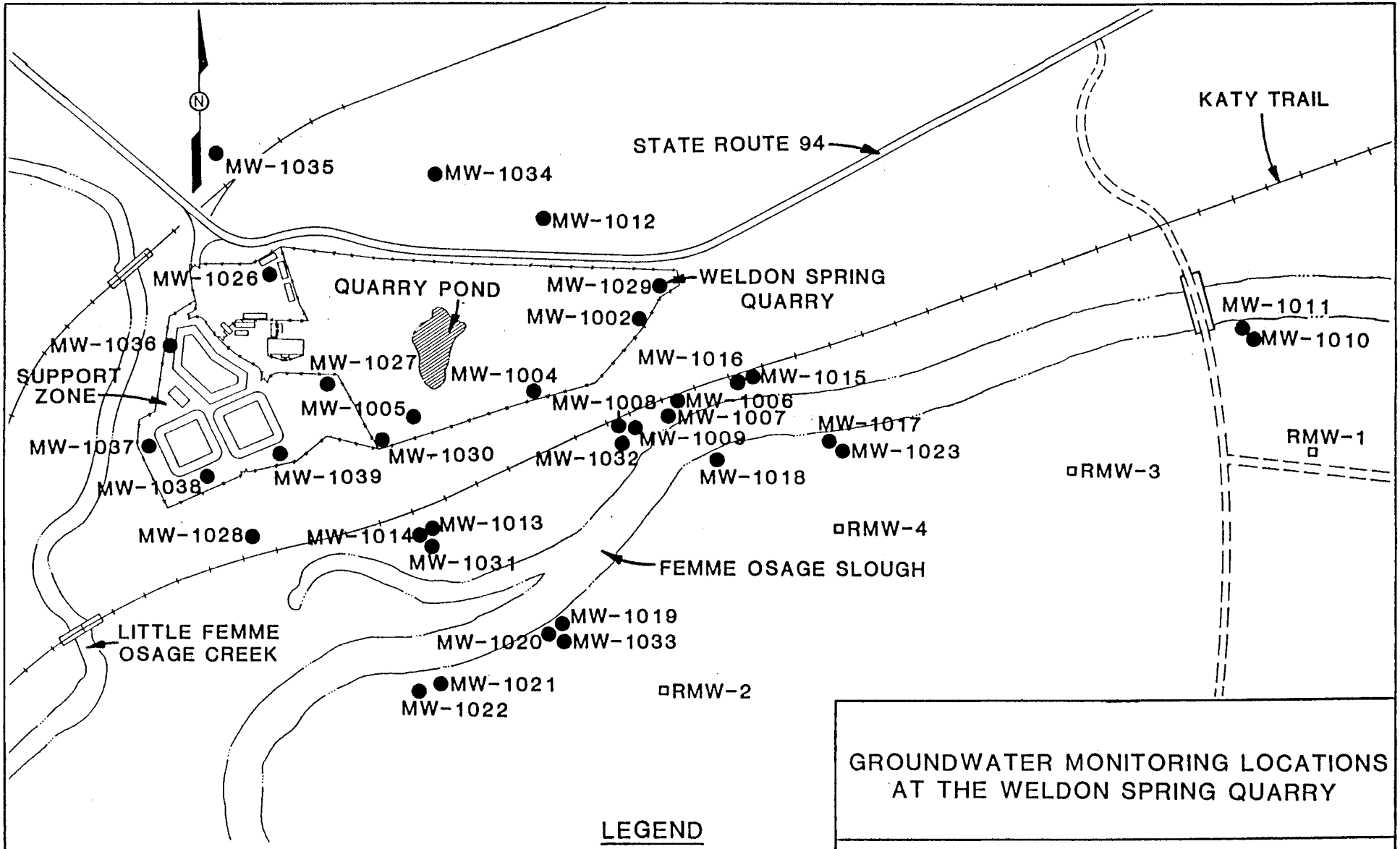
monitored for the presence of these contaminants. All monitoring well locations are shown in Figures 2-2 and 2-3. These wells monitor groundwater in both the bedrock and alluvial aquifers associated with the WSQ.

Two separate groundwater monitoring programs have been developed for the WSQ area. The first program is a bimonthly sampling of all wells north of the Femme Osage Slough and MW-1010 and MW-1011 located south of the slough. In addition, wells MW-1035, MW-1036, MW-1037, MW-1038, and MW-1039 will be sampled bimonthly until operation of the Weldon Spring Quarry water treatment plant is initiated. The second program is the quarterly sampling of all wells south of the Femme Osage Slough, excluding MW-1010 and MW-1011, but including the St. Charles County well field. Both the raw and treated waters from the St. Charles County water treatment plant are sampled quarterly.

2.2.1 Radiological Results

Radiological data are presented in Tables 2-7 through 2-9 for samples collected for the second and third bimonthly periods and second quarter. The results show typical fluctuations near the average levels in the WSQ area with the exception of MW-1007 and MW-1032. The uranium concentrations in MW-1007 exceeded the historic average and validation has been requested to determine whether this is a real value for uranium at this location. Results for the third bimonthly period returned to within historic ranges for this sampling location. The uranium concentration in MW-1032 exceeded the historic average and continued monitoring will be performed to determine whether this is a trend. Detectable concentrations of uranium were indicated from RMW-series wells and the St. Charles County production wells. These levels are within historic averages and representative of background levels.

The monitoring wells north of the Femme Osage Slough are sampled annually for the radiological species of radium, thorium, gross alpha, and gross beta. The results of these samples analyses are presented in Table 2-10. Calendar year 1992 is the first routine sampling of these wells for radiological species other than urnaium since 1989. Wells within the WSQ boundary show elevated levels of both gross alpha and gross beta, and are consistent with the quarry pond (SW-1008) concentrations which are the source of impact. Monitoring wells MW-1013 through MW-1016, located south of the quarry, also show elevated levels. The concentrations in the remainder of the wells are consistent with background values of waters in or near the WSQ.



GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 2-2

REPORT NO.:	DOE/OR/21548-337	EXHIBIT NO.:	A/QY/120/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91

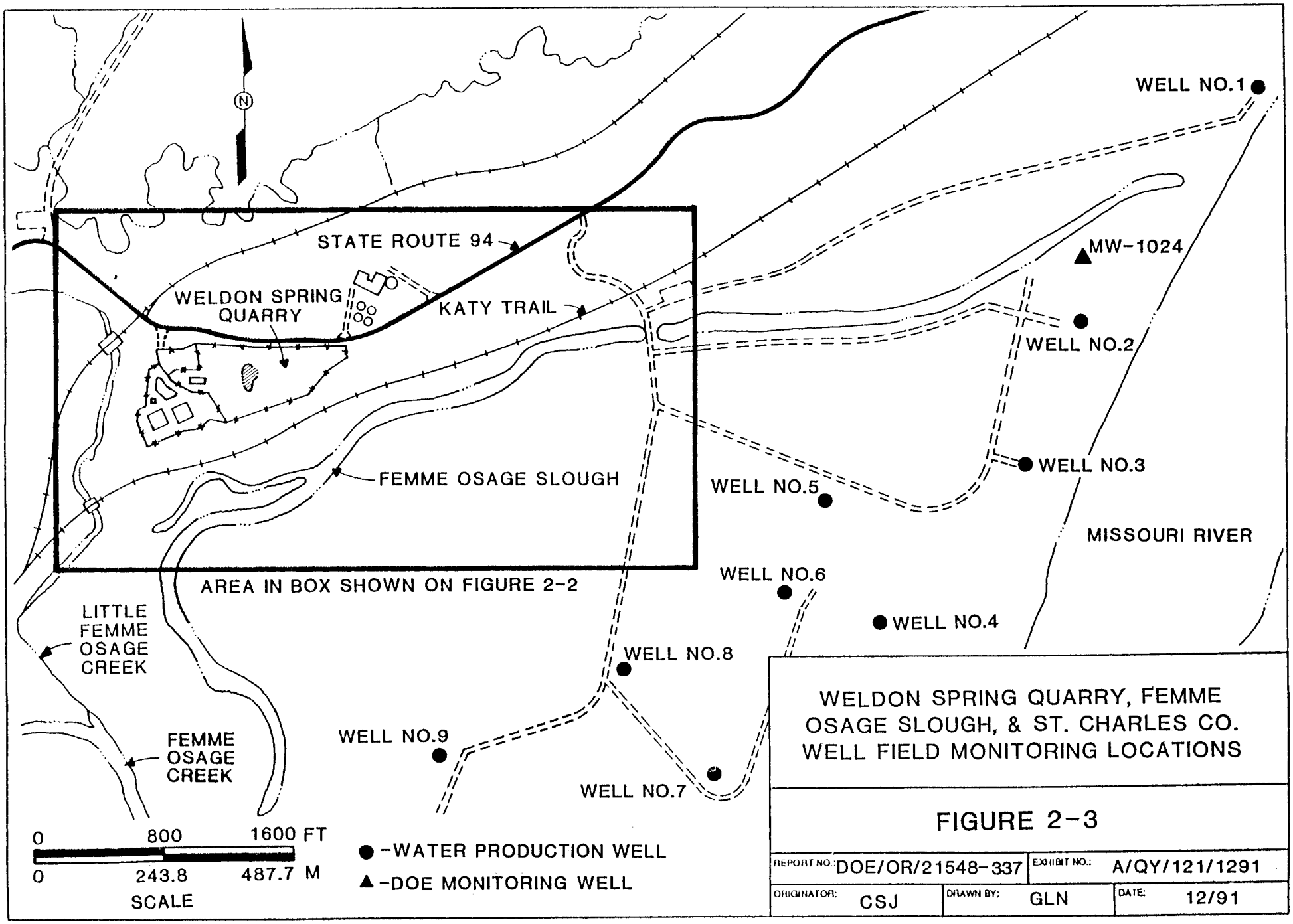

N
WELL NO.1
STATE ROUTE 94
MW-1024
WELDON SPRING QUARRY
KATY TRAIL
WELL NO.2
WELL NO.3
FEMME OSAGE SLOUGH
WELL NO.5
MISSOURI RIVER
AREA IN BOX SHOWN ON FIGURE 2-2
WELL NO.6
WELL NO.4
LITTLE FEMME OSAGE CREEK
WELL NO.8
WELL NO.9
FEMME OSAGE CREEK
WELL NO.7
0 800 1600 FT
0 243.8 487.7 M
SCALE
●-WATER PRODUCTION WELL
▲-DOE MONITORING WELL
WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, & ST. CHARLES CO. WELL FIELD MONITORING LOCATIONS
FIGURE 2-3
REPORT NO.: DOE/OR/21548-337
EXHIBIT NO.: A/QY/121/1291
ORIGINATOR: CSJ
DRAWN BY: GLN
DATE: 12/91

TABLE 2-7 Second Bimonthly (March/April) Uranium and Inorganic Anion Results for Groundwater at the WSQ

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-1002-B292	1.60	67.4	1.2
GW-1004-B292	0.11	296	5300
GW-1005-B292	ND	140	1900
GW-1006-B292	0.28	146	3200
GW-1007-B292	ND	307	1700
GW-1008-B292	0.310	216	5600
GW-1009-B292	ND	288	4.4
GW-1010-B292	0.010	ND	3.54
GW-1011-B292	ND	30.6	11
GW-1012-B292	0.68	179	2.7
GW-1013-B292	0.14	103	800
GW-1014-B292	ND	114	920
GW-1015-B292	1.50	313	1400
GW-1016-B292	0.93	266	640
GW-1026-B292	0.140	0.670	0.68
GW-1027-B292	0.280	89.3	619
GW-1028-B292	ND	70.4	0.3
GW-1029-B292	ND	77.4	2.2
GW-1030-B292	ND	96.9	11
GW-1031-B292	ND	41.5	17
GW-1032-B292	ND	258	1300
GW-1034-B292	ND	86.9	1.6
GW-1035-B292	0.27	38.8	2.4
GW-1036-B292	0.10	58.6	8.5
GW-1037-B292	0.14	10.5	2.8
GW-1038-B292	ND	47.1	2.8
GW-1039-B292	ND	61.5	4.3

ND - Not Detected
NA - Not Available

TABLE 2-8 Third Bimonthly (May/June) Uranium and Inorganic Anion Results for Groundwater at the WSQ

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-1002-B392	2.10	77.2	2.0
GW-1004-B392	0.38	430	5900
GW-1005-B392	ND	143	1600
GW-1006-B392	NA	NA	3500
GW-1007-B392	NA	NA	400
GW-1008-B392	ND	252	4100
GW-1009-B392	ND	289	4.7
GW-1010-B392	ND	ND	ND
GW-1011-B392	ND	39	17.0
GW-1012-B392	0.84	58.4	3.1
GW-1013-B392	NA	NA	880
GW-1014-B392	NA	NA	1100
GW-1015-B392	1.00	346	1500
GW-1016-B392	0.57	246	670
GW-1026-B392	ND	1.00	0.5
GW-1027-B392	0.31	99.4	640
GW-1028-B392	NA	NA	ND
GW-1029-B392	0.42	75.7	2.1
GW-1030-B392	8.19	98.7	6.0
GW-1031-B392	NA	NA	28
GW-1032-B392	ND	272	1700
GW-1034-B392	1.10	79.1	1.6
GW-1035-B392	0.10	39.1	0.3
GW-1036-B392	0.17	52.6	5.1
GW-1037-B392	0.10	9.80	0.68
GW-1038-B392	ND	45.6	2.7
GW-1039-B392	0.13	49.0	0.68

ND - Not Detected
NA - Not Available

TABLE 2-9 Second Quarter Uranium, Gross Alpha and Inorganic Anion Results for Groundwater at the WSQ

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)	Gross Alpha (pCi/l)
GW-1017-Q292	ND	0.60	ND	NR
GW-1018-Q292	ND	50.7	0.2	NR
GW-1019-Q292	ND	1.10	ND	NR
GW-1020-Q292	ND	43.9	0.2	NR
GW-1021-Q292	ND	ND	1.4	NR
GW-1022-Q292	ND	ND	1.2	NR
GW-1023-Q292	ND	9.30	0.3	NR
GW-1024-Q292	ND	ND	ND	18
GW-1033-Q292	ND	10.0	2.1	NR
GW-RMW1-Q292	ND	23.0	0.68	3.3
GW-RMW2-Q292	ND	58.4	5.6	4.9
GW-RMW3-Q292	ND	7.29	0.4	2.3
GW-RMW4-Q292	0.79	34.8	2.4	ND
GW-PW02-Q292	NA	NA	0.95	ND
GW-PW03-Q292	NA	NA	0.68	ND
GW-PW04-Q292	NA	NA	0.2	ND
GW-PW05-Q292	NA	NA	0.4	ND
GW-PW06-Q292	NA	NA	ND	ND
GW-PW07-Q292	NA	NA	ND	3.7
GW-PW08-Q292	NA	NA	0.5	ND
GW-PW09-Q292	NA	NA	1.2	4.8
GW-RAWW-Q292	NA	NA	0.4	ND
GW-FINW-Q292	NA	NA	0.4	1.1

ND - Not Detected
NA - Not Available
NR - Not Required

TABLE 2-10 Second Bimonthly (March/April) Radiological Results for Groundwater at the WSQ

Sample ID	Th-228 (pCi/l)	Th-230 (pCi/l)	Th-232 (pCi/l)	Ra-226 (pCi/l)	Ra-228 (pCi/l)	Gross Alpha (pCi/l)	Gross Beta (pCi/l)
GW-1002-B292	ND	0.2	ND	ND	ND	7	12
GW-1004-B292	ND	ND	ND	0.3	ND	3700	2840
GW-1005-B292	ND	1.0	ND	ND	ND	1480	1070
GW-1006-B292	ND	ND	ND	0.4	ND	4300	2230
GW-1007-B292	ND	0.3	ND	0.6	ND	2300	1320
GW-1008-B292	ND	ND	ND	ND	ND	6000	3400
GW-1009-B292	ND	ND	ND	0.2	ND	15	11
GW-1010-B292	ND	ND	ND	0.4	2.1	ND	6.4
GW-1011-B292	ND	ND	ND	0.2	ND	22	22
GW-1012-B292	ND	0.3	ND	0.3	ND	23	13
GW-1013-B292	ND	ND	ND	0.7	ND	1100	610
GW-1014-B292	ND	ND	ND	ND	ND	600	510
GW-1015-B292	ND	1.5	ND	0.3	ND	1400	810
GW-1016-B292	ND	ND	ND	ND	ND	480	300
GW-1026-B292	ND	ND	ND	0.20	ND	25	18
GW-1027-B292	ND	ND	ND	ND	1.10	680	280
GW-1028-B292	ND	ND	ND	0.3	ND	6.8	13
GW-1029-B292	ND	ND	ND	ND	ND	13	12
GW-1030-B292	1.2	2.2	0.8	4.8	2.7	98	190
GW-1031-B292	ND	ND	ND	0.2	ND	22	13
GW-1032-B292	ND	ND	ND	0.5	1.1	860	780
GW-1034-B292	ND	1.6	ND	0.2	ND	3.1	5.8
GW-1035-B292	ND	ND	ND	0.4	ND	ND	5.9
GW-1036-B292	ND	ND	ND	0.2	ND	8.5	9.6
GW-1037-B292	ND	0.2	ND	0.3	ND	3.9	5.9
GW-1038-B292	ND	ND	ND	0.2	ND	ND	8.1
GW-1039-B292	ND	ND	ND	ND	0.9	5.0	8.7

ND - Not Detected
NA - Not Available

2.2.2 Nitroaromatic Compounds Results

Analytical results for the second and third bimonthly period, and the second quarter for nitroaromatic compounds, are presented in Tables 2-11 through 2-13. No monitoring wells south of the Femme Osage Slough showed detectable concentrations of nitroaromatic compounds during the second quarter of 1992. Elevated levels of nitroaromatic compounds were detected in rim wells MW-1002 and MW-1004 and alluvial monitoring well MW-1007. The distribution and magnitude of nitroaromatic contamination in the remainder of the wells near the quarry remain consistent with historical levels.

2.2.3 Inorganic Anions Results

Two inorganic anions, nitrate and sulfate, are sampled in all of the wells monitored at the WSQ. The analytical results for the second and third bimonthly period, and for the first quarter, are presented in Tables 2-7 through 2-9. An elevated level of sulfate was detected in alluvial monitoring well MW-1007 and an elevated level of nitrate was detected in rim well MW-1030. The results for the remainder of the monitoring wells are consistent with data reported in the previous environmental monitoring reports. The WSQ groundwater samples continue to indicate no significant nitrate contamination of the groundwater. The results indicate that elevated sulfate levels are present in groundwater within the WSQ and north of the Femme Osage Slough.

2.2.4 Metals Results

All wells in the WSQ monitoring program are sampled for arsenic and barium. The results for the second and third bimonthly periods, and the second quarter, are presented in Tables 2-14 through 2-16. Arsenic levels were consistent with historical values for groundwater in the vicinity of the WSQ. Elevated arsenic levels were reported for bedrock monitoring well MW-1028. Barium levels have remained elevated in the wells in the vicinity of the Femme Osage Slough. Elevated barium levels were indicated for rim monitoring wells MW-1002 and MW-1004.

TABLE 2-11 Second Bimonthly (March/April) Nitroaromatic Results for Groundwater at the WSQ

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1002-B292	ND	0.36	0.13	27.0	85.0	480
GW-1004-B292	ND	ND	3.20	6.60	22.0	6.00
GW-1005-B292	ND	ND	0.10	0.040	ND	ND
GW-1006-B292	ND	ND	0.30	3.20	10.0	62.0
GW-1007-B292	ND	ND	ND	0.21	0.56	0.18
GW-1008-B292	ND	ND	ND	0.24	0.80	0.15
GW-1009-B292	ND	ND	ND	ND	ND	ND
GW-1010-B292	ND	ND	ND	ND	ND	ND
GW-1011-B292	ND	ND	ND	ND	ND	ND
GW-1012-B292	ND	ND	ND	ND	ND	ND
GW-1013-B292	ND	ND	0.063	0.024	ND	ND
GW-1014-B292	ND	ND	ND	ND	ND	ND
GW-1015-B292	ND	ND	0.054	0.75	27.0	240
GW-1016-B292	ND	ND	ND	0.22	5.40	32.0
GW-1026-B292	ND	ND	ND	ND	ND	ND
GW-1027-B292	ND	ND	0.42	3.10	9.00	0.066
GW-1028-B292	ND	ND	ND	ND	ND	ND
GW-1029-B292	ND	ND	ND	ND	ND	ND
GW-1030-B292	ND	ND	0.044	ND	ND	ND
GW-1031-B292	ND	ND	ND	ND	ND	ND
GW-1032-B292	ND	ND	0.088	0.088	ND	ND
GW-1034-B292	ND	ND	ND	ND	ND	ND
GW-1035-B292	ND	ND	ND	ND	ND	ND
GW-1036-B292	ND	ND	ND	ND	ND	ND
GW-1037-B292	ND	ND	ND	ND	ND	ND
GW-1038-B292	ND	ND	ND	ND	ND	ND
GW-1039-B292	ND	ND	ND	ND	ND	ND

NA - Not Available
ND - Not Detected

TABLE 2-12 Third Bimonthly (May/June) Nitroaromatic Results for Groundwater at the WSQ

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1002-B392	ND	0.35	0.12	23	90	600
GW-1004-B392	ND	ND	3.8	7.4	25	8.5
GW-1005-B392	ND	ND	0.086	0.031	ND	ND
GW-1006-B392	ND	ND	0.17	3.6	12	70
GW-1007-B392	ND	ND	ND	ND	ND	ND
GW-1008-B392	ND	ND	ND	0.078	ND	ND
GW-1009-B392	ND	ND	ND	ND	ND	ND
GW-1010-B392	ND	ND	ND	ND	ND	ND
GW-1011-B392	ND	ND	ND	ND	ND	ND
GW-1012-B392	ND	ND	ND	ND	ND	ND
GW-1013-B392	ND	ND	0.053	0.016	ND	ND
GW-1014-B392	ND	ND	ND	ND	ND	ND
GW-1015-B392	ND	ND	0.055	0.80	24	190
GW-1016-B392	ND	ND	ND	0.21	4.5	24
GW-1026-B392	ND	ND	ND	ND	ND	ND
GW-1027-B392	ND	ND	0.62	2.4	17	0.065
GW-1028-B392	ND	ND	ND	ND	ND	ND
GW-1029-B392	ND	ND	ND	ND	ND	ND
GW-1030-B392	ND	ND	0.049	ND	ND	ND
GW-1031-B392	ND	ND	ND	ND	ND	ND
GW-1032-B392	ND	ND	0.20	0.12	ND	ND
GW-1034-B392	ND	ND	ND	ND	ND	ND
GW-1035-B392	ND	ND	ND	ND	ND	ND
GW-1036-B392	ND	ND	ND	ND	ND	ND
GW-1037-B392	ND	ND	ND	ND	ND	ND
GW-1038-B392	ND	ND	ND	ND	ND	ND
GW-1039-B392	ND	ND	ND	ND	ND	ND

NA - Not Available
ND - Not Detected

TABLE 2-13 Second Quarter Nitroaromatic Results for Groundwater at the WSQ

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1017-Q292	ND	ND	ND	ND	ND	ND
GW-1018-Q292	ND	ND	ND	ND	ND	ND
GW-1019-Q292	ND	ND	ND	ND	ND	ND
GW-1020-Q292	ND	ND	ND	ND	ND	ND
GW-1021-Q292	ND	ND	ND	ND	ND	ND
GW-1022-Q292	ND	ND	ND	ND	ND	ND
GW-1023-Q292	ND	ND	ND	ND	ND	ND
GW-1024-Q292	ND	ND	ND	ND	ND	ND
GW-1033-Q292	ND	ND	ND	ND	ND	ND
GW-RMW1-Q292	ND	ND	ND	ND	ND	ND
GW-RMW2-Q292	ND	ND	ND	ND	ND	ND
GW-RMW3-Q292	ND	ND	ND	ND	ND	ND
GW-RMW4-Q292	ND	ND	ND	ND	ND	ND
GW-PW02-Q292	ND	ND	ND	ND	ND	ND
GW-PW03-Q292	ND	ND	ND	ND	ND	ND
GW-PW04-Q292	ND	ND	ND	ND	ND	ND
GW-PW05-Q292	ND	ND	ND	ND	ND	ND
GW-PW06-Q292	ND	ND	ND	ND	ND	ND
GW-PW07-Q292	ND	ND	ND	ND	ND	ND
GW-PW08-Q292	ND	ND	ND	ND	ND	ND
GW-PW09-Q292	ND	ND	ND	ND	ND	ND
GW-RAWW-Q292	ND	ND	ND	ND	ND	ND
GW-FINW-Q292	ND	ND	ND	ND	ND	ND

NA - Not Available
ND - Not Detected

TABLE 2-14 Second Bimonthly (March/April) Metal Results for Groundwater at the WSQ

Sample ID	Arsenic (µg/l)	Barium (µg/l)
GW-1002-B292	ND	37.8
GW-1004-B292	ND	140
GW-1005-B292	ND	56.7
GW-1006-B292	ND	42.5
GW-1007-B292	10.6	249
GW-1008-B292	ND	48.8
GW-1009-B292	3.89	364
GW-1010-B292	88.0	110
GW-1011-B292	ND	288
GW-1012-B292	ND	122
GW-1013-B292	3.39	140
GW-1014-B292	ND	194
GW-1015-B292	ND	105
GW-1016-B292	ND	127
GW-1026-B292	22.3	409
GW-1027-B292	ND	107
GW-1028-B292	6.29	300
GW-1029-B292	ND	109
GW-1030-B292	4.40	340
GW-1031-B292	ND	95.5
GW-1032-B292	ND	96.8
GW-1034-B292	ND	167
GW-1035-B292	ND	225
GW-1036-B292	ND	300
GW-1037-B292	ND	626
GW-1038-B292	ND	242
GW-1039-B292	ND	479

ND - Not Detected
NA - Not Available

TABLE 2-15 Third Bimonthly (May/June) Metal Results for Groundwater at the WSQ

Sample ID	Arsenic (µg/l)	Barium (µg/l)
GW-1002-B392	ND	142
GW-1004-B392	ND	44.8
GW-1005-B392	ND	51.8
GW-1006-B392	NA	NA
GW-1007-B392	NA	NA
GW-1008-B392	ND	49.1
GW-1009-B392	ND	344
GW-1010-B392	88.5	362
GW-1011-B392	ND	188
GW-1012-B392	ND	123
GW-1013-B392	NA	NA
GW-1014-B392	NA	NA
GW-1015-B392	ND	117
GW-1016-B392	ND	139
GW-1026-B392	22.1	381
GW-1027-B392	ND	98.1
GW-1028-B392	NA	NA
GW-1029-B392	ND	119
GW-1030-B392	5.20	353
GW-1031-B392	NA	NA
GW-1032-B392	ND	89.9
GW-1034-B392	ND	169
GW-1035-B392	ND	223
GW-1036-B392	ND	281
GW-1037-B392	ND	615
GW-1038-B392	2.39	222
GW-1039-B392	ND	461

ND - Not Detected
NA - Not Available

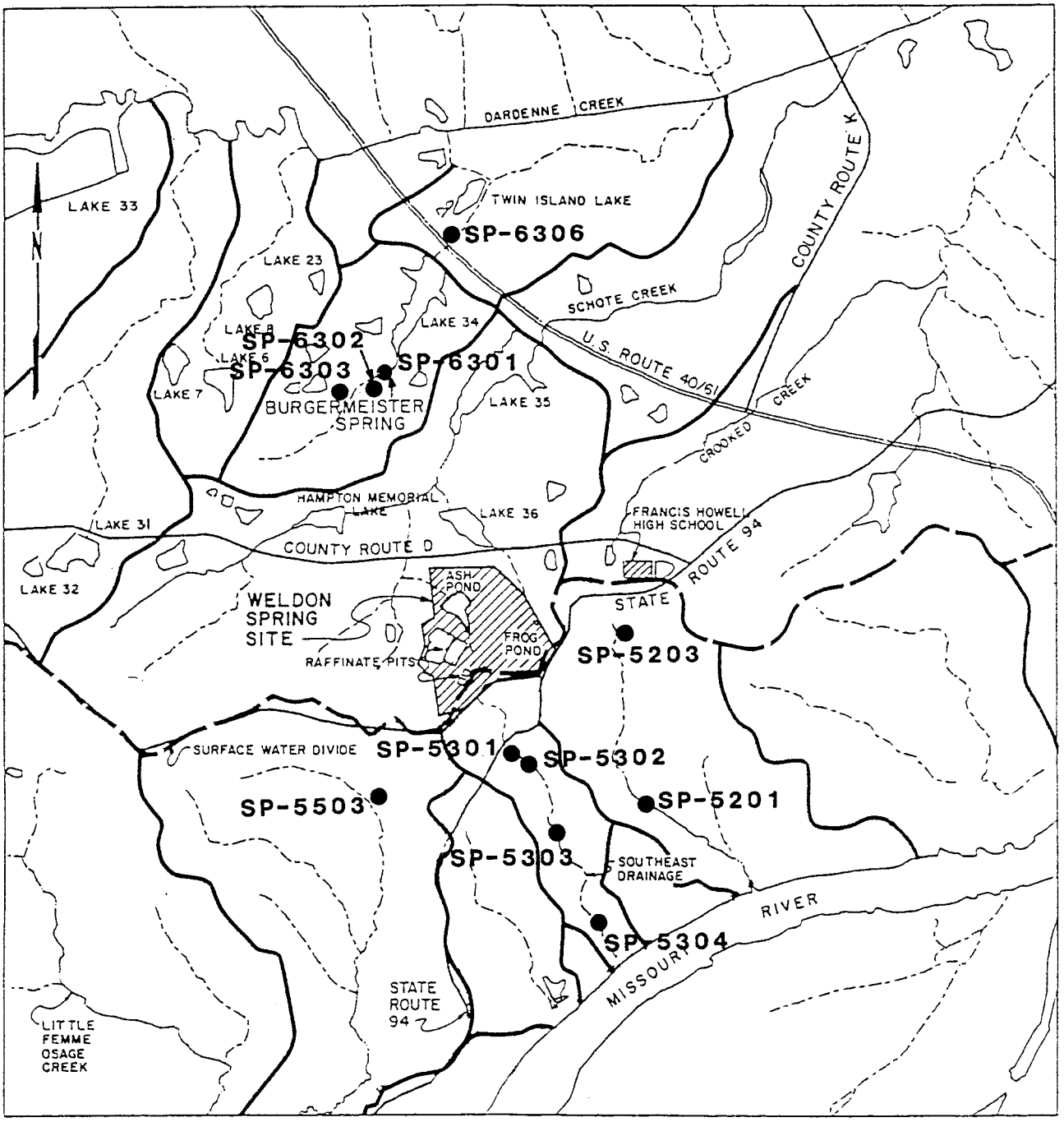
TABLE 2-16 Second Quarter Metal Results for Groundwater at the WSQ

Sample ID	Arsenic (µg/l)	Barium (µg/l)
GW-1017-Q292	128	996
GW-1018-Q292	102	633
GW-1019-Q292	71.5	818
GW-1020-Q292	32.5	412
GW-1021-Q292	71.2	849
GW-1022-Q292	146	531
GW-1023-Q292	55.3	293
GW-1024-Q292	10.5	134
GW-1033-Q292	ND	320
GW-RMW1-Q292	7.00	481
GW-RMW2-Q292	13.0	237
GW-RMW3-Q292	34.3	646
GW-RMW4-Q292	6.79	165
GW-PW02-Q292	ND	335
GW-PW03-Q292	ND	313
GW-PW04-Q292	ND	287
GW-PW05-Q292	ND	355
GW-PW06-Q292	ND	334
GW-PW07-Q292	2.29	476
GW-PW08-Q292	3.39	446
GW-PW09-Q292	3.50	485
GW-RAWW-Q292	ND	369
GW-FINW-Q292	ND	103

ND - Not Detected
NA - Not Available

2.3 Springs

Five springs around the Weldon Spring site (WSS) were sampled during the first quarter (see Figure 2-4). Previous spring monitoring indicated that waters from six perennial springs and one wet-weather spring are measurably influenced by site-related contaminants. These springs include SP-5301 through SP-5304, SP-6301, SP-6302, and SP-6306. SP-6301 and SP-6306 were to be sampled during high and low flow periods. High flow samples were not attained during second quarter, but will be collected during 3rd quarter. Unavailable analytical results will be reported in the 1992 annual site environmental report (ASER). During second quarter, spring samples were analyzed for radiological, inorganic anions, and nitroaromatics (see Table 2-17).



● SPRING

0 3200 6400 FT

0 975.4 1950.7 M

SCALE

SPRINGS IN THE VICINITY OF THE WSS

FIGURE 2-4

REPORT NO.: DOE/OR/21548-337			EXHIBIT NO.: A/VP/040/0592		
ORIGINATOR: MGT		DRAWN BY: GLN		DATE: 5/92	

TABLE 2-17 Second Quarter Results in Springs Near the Weldon Spring Site

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
SP-6301-Q292-H	NS	NS	NS	NS	NS	NS
SP-6301-Q292-L	ND	ND	0.042	0.61	0.27	0.045
8SP-6306-Q292-H	NS	NS	NS	NS	NS	NS
SP-6306-Q292-L	ND	ND	ND	ND	ND	ND
SP-5303-Q292	NA	NA	NA	NA	NA	NA
SP-5304-Q292	DRY					
SP-5201-Q292	NA	NA	NA	NA	NA	NA

Sample ID	Th-228 (pCi/l)	Th-230 (pCi/l)	Th-232 (pCi/l)	Ra-226 (pCi/l)	Ra-228 (pCi/l)	Uranium (pCi/l)
SP-6301-Q292-H	NS	NS	NS	NS	NS	NS
SP-6301-Q292-L	ND	ND	ND	ND	ND	90
SP-6306-Q292-H	NS	NS	NS	NS	NS	NS
SP-6306-Q292-L	NA	NA	NA	NA	NA	NA
SP-5303-Q292	NA	NA	NA	NA	NA	NA
SP-5304-Q292	DRY					
SP-5201-Q292	NA	NA	NA	NA	NA	NA

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)
SP-6301-Q292	NS	NS
SP-6301-Q292-L	47.6	51.3
SP-6306-Q292	NS	NS
SP-6306-Q292-L	0.18	8.90
SP-5303-Q292	NA	NA
SP-5304-Q292	DRY	
SP-5201-Q292	NA	NA

ND - Not Detected
NA - Not Available
NS - Not Sampled

3 SURFACE WATER MONITORING

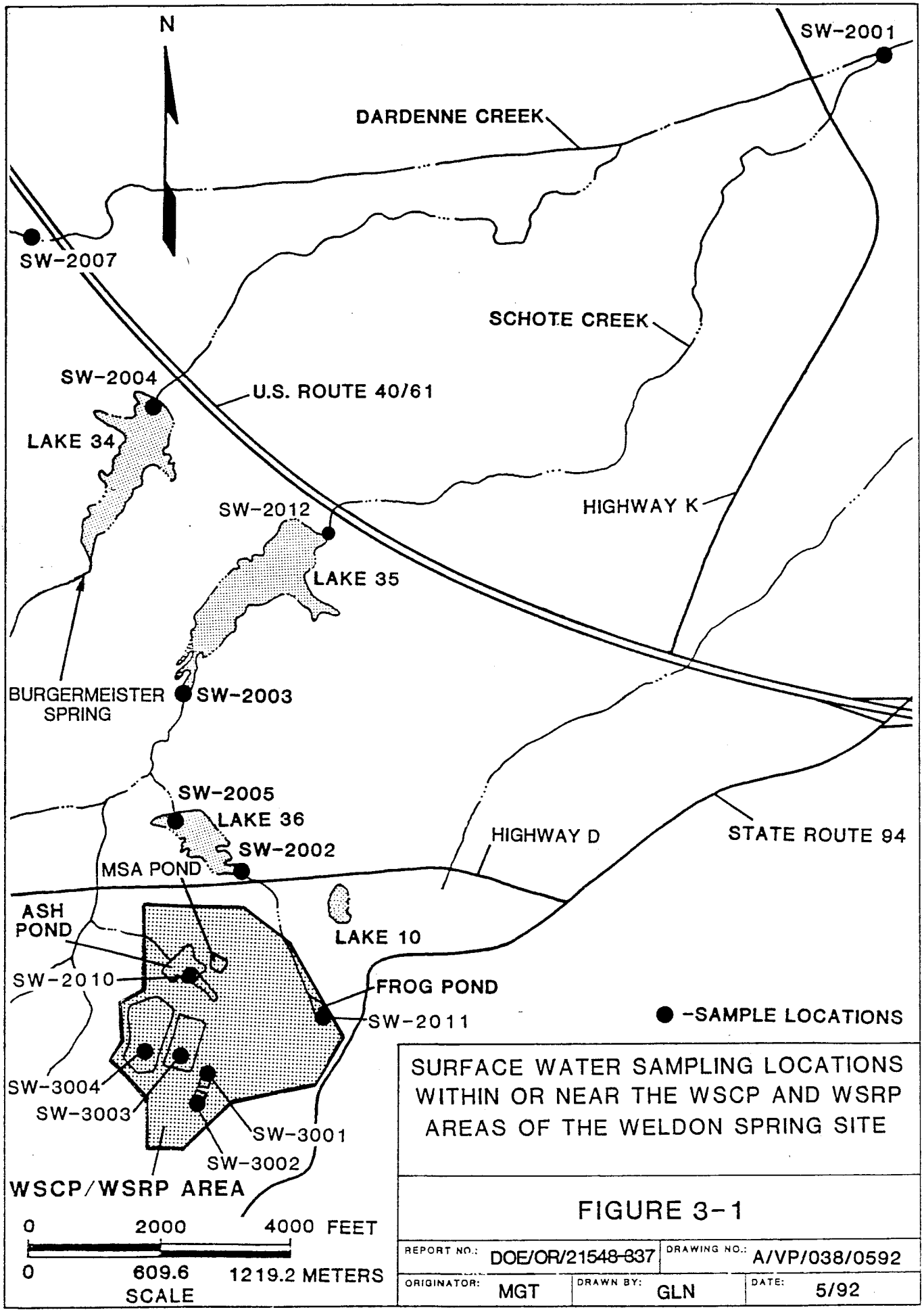
Routine samples were collected during the second quarter of 1992 from both on-site and off-site surface water locations. All surface water samples were analyzed without filtering, unless a specific comparison of dissolved versus total contaminant concentrations was desired. Some analytical results are not available at this time; however, they will be presented in the 1992 annual site environmental report (ASER).

3.1 Chemical Plant/Raffinate Pits/Vicinity Properties

During the first quarter, surface water samples were collected from 14 of the 15 surface water sampling locations shown in Figure 3-1 and analyzed for uranium and metals. Monitoring point SW-2016, not shown in Figure 3-1, is located at the intersection of Dardenne Creek and County Highway N. This is now the furthest location downstream at which to measure contaminant levels in Dardenne Creek after it has received the Schote Creek contribution. The results, presented in Tables 3-1 and 3-2, indicated that conditions at sampling locations remain consistent with historical values. The nitrate value for SW-2005 is considered suspect and full validation has been requested.

3.2 Weldon Spring Quarry

Monitoring locations SW-1001, SW-1002, and SW-1014 (Figure 3-2) monitor the Little Femme Osage Creek at points upstream and downstream of the Weldon Spring quarry (WSQ). Six sampling locations, SW-1003 through SW-1005, SW1007, SW-1009, and SW-1010, are distributed along the Femme Osage Slough in the vicinity of the WSQ. These locations within the slough were chosen to provide the most representative data of potentially impacted areas from the quarry contamination. Location SW-1008 monitors the ponded water within the WSQ and provides a rough deterination of the concentrations of the various contaminants in the WSQ pond, which may migrate to groundwater. Locations SW-1011 through SW-1013 (Figure 3-3) and SW-1015 (Howard Bend) were added to the monitoring program to provide baseline water quality data for the Missouri River at points both upstream and downstream from the WSQ and the Southeast Drainage (5300) easement.



SURFACE WATER SAMPLING LOCATIONS WITHIN OR NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

FIGURE 3-1

REPORT NO.: DOE/OR/21548-837	DRAWING NO.: A/VP/038/0592	
ORIGINATOR: MGT	DRAWN BY: GLN	DATE: 5/92

TABLE 3-1 Second Quarter Uranium and Inorganic Anion Results for Surface Water at the WSCP/RP/VP

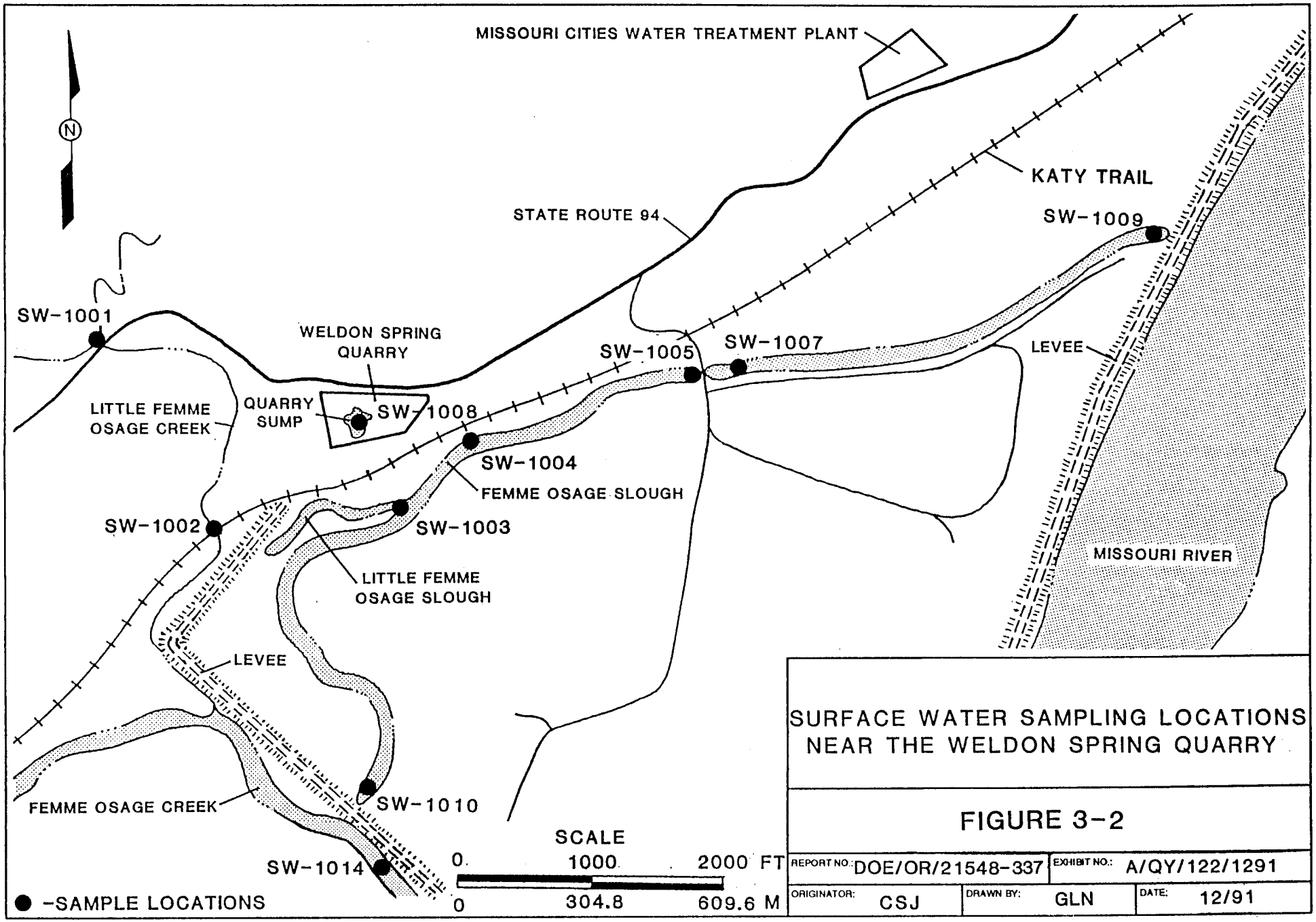
Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
SW-2001-Q292	0.76	40.6	1.70
SW-2002-Q292	0.17	34.4	56.0
SW-2003-Q292	0.50	17.4	13.0
SW-2004-Q292	1.20	22.4	11.0
SW-2005-Q292	1300	28.9	35
SW-2007-Q292	NA	NA	2.0
SW-2010-Q292	NA	NA	NA
SW-2011-Q292	0.38	57.1	280
SW-2012-Q292	Dry		
SW-2016-Q292	1.00	48.6	1.80
SW-3001-Q292	NA	NA	NA
SW-3002-Q292	NA	NA	NA
SW-3003-Q292	NA	NA	NA
SW-3004-Q292	NA	NA	NA
SW-5311-Q292	NA	NA	NA

ND - Not Detected
NA - Not Available

TABLE 3-2 Second Quarter Results for Metals in Surface Water at the WSCP/RP/VP

Sample ID	Arsenic (µg/l)	Barium (mg/l)	Beryllium (µg/l)	Cadmium (µg/l)	Chromium (µg/l)	Lead (µg/l)	Mercury (µg/l)	Antimony (µg/l)	Selenium (µg/l)	Silver (µg/l)	Thallium (µg/l)
SW-2001-Q292	ND	110	ND	ND	ND	ND	ND	ND	ND	ND	ND
SW-2002-Q292	ND	76.4	1.39	ND	ND	ND	ND	ND	ND	ND	ND
SW-2003-Q292	ND	60.7	1.39	ND	ND	ND	ND	ND	ND	ND	ND
SW-2004-Q292	ND	78.0	1.39	ND	ND	ND	ND	ND	ND	ND	ND
SW-2005-Q292	ND	72.4	2.39	ND	ND	ND	ND	ND	ND	ND	ND
SW-2007-Q292	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SW-2010-Q292	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SW-2011-Q292	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SW-2012-Q292	Dry										
SW-2016-Q292	ND	134	ND	ND	ND	ND	ND	ND	ND	ND	ND
SW-3001-Q292	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SW-3002-Q292	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SW-3003-Q292	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SW-3004-Q292	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SW-5311-Q292	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

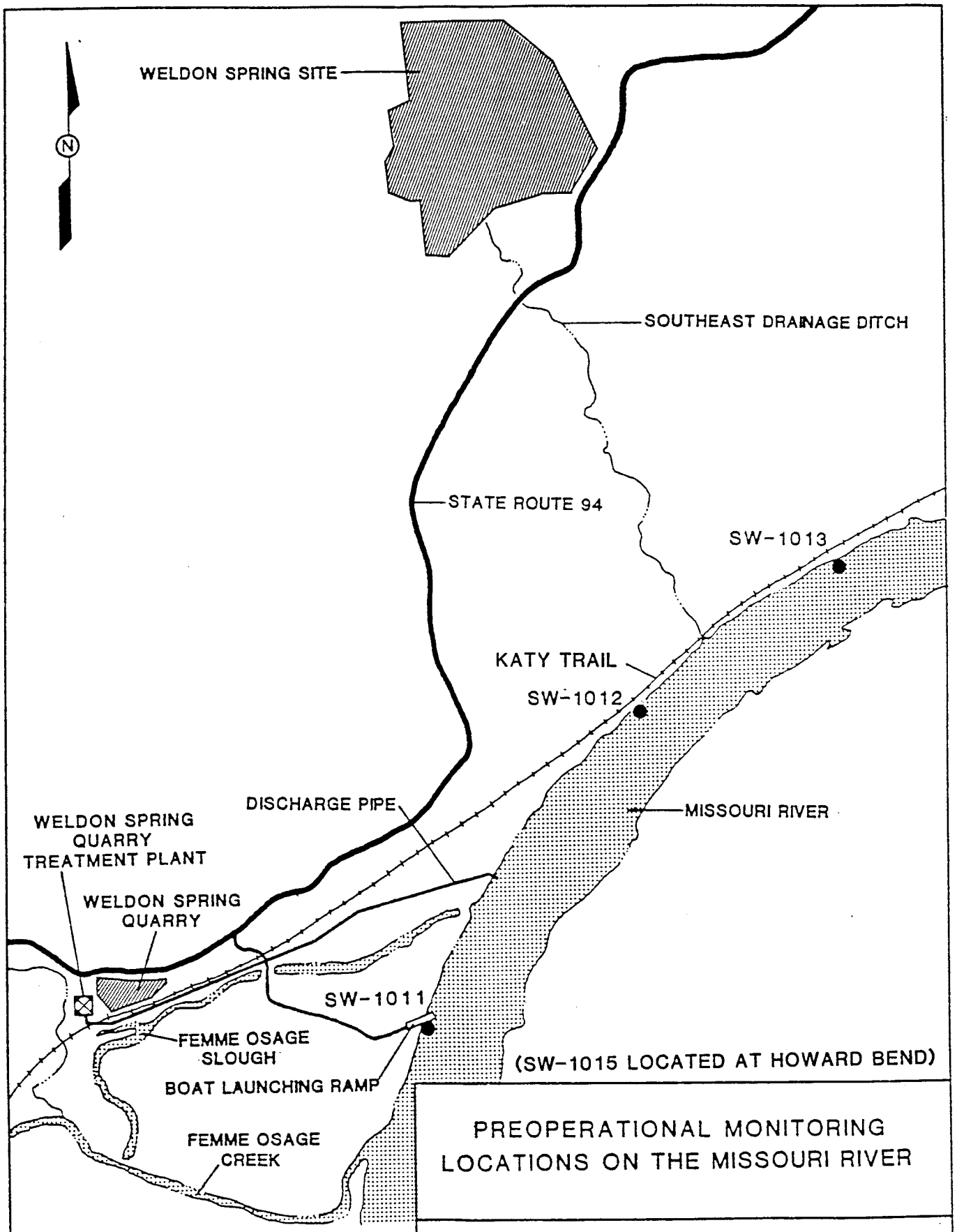
ND - Not Detected
NA - Not Available



SURFACE WATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 3-2

REPORT NO.: DOE/OR/21548-337	EXHIBIT NO.: A/QY/122/1291	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 12/91



PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

FIGURE 3-3

REPORT NO.	DOE/OR/21548-337	EXHIBIT NO.:	A/VP/193/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91

3.2.1 Radiological Results

Surface water samples were collected for radiological analyses from the 13 locations shown in Figures 3-2 and 3-3. The uranium results for the second and third bimonthly periods are presented in Tables 3-4 and 3-5. Second and third bimonthly uranium concentrations for the sampling locations in the Femme Osage Slough and Little Femme Osage Creek remain within historical ranges. The highest measured uranium concentration of 1200 pCi/l (44.4 Bq/l) was detected at the quarry pond (SW-1008) and is within the historical range. In addition, the surface water locations were sampled for the radiological species of radium and thorium, gross alpha, and gross beta during the second bimonthly period. The results are presented in Table 3-3.

3.2.2 Nitroaromatic Compounds Results

Analytical results for nitroaromatic compounds during the second bimonthly period, are presented in Table 3-6. No nitroaromatic analyses have been performed at these sampling locations since 1989. Elevated levels of 2,4-dinitrotoluene (DNT), 2,6-DNT, and 2,4,6-trinitrotoluene (TNT) have been detected at the SW-1001 location. This location has been established as background for the WSQ. Additional sampling will be performed to determine the presence of a trend and the possible upstream source of impact.

3.2.3 Inorganic Anion Results

Surface water samples were collected from the sampling locations in the second bimonthly period for nitrate and sulfate analysis. Inorganic anions have not been analyzed at these locations since 1988 except for SW-1008 and SW-1011 through SW-1013. The results for this bimonthly period are within or below historic levels and background for nitrate and sulfate.

3.2.4 Weldon Spring Quarry Pond Results

A summary of the analytical results for the third bimonthly sampling period is presented in Table 3-7. This sampling location is summarized separately to characterize the surface waters in the WSQ which may migrate and effect groundwater. The results for this bimonthly period are within historic ranges for all parameters analyzed.

TABLE 3-3 Second Bimonthly (March/April) Radiological Results in Surface Water at the WSQ

Sample ID	Th-228 (pCi/l)	Th-230 (pCi/l)	Th-232 (pCi/l)	Ra-226 (pCi/l)	Ra-228 (pCi/l)	Gross Alpha (pCi/l)	Gross Beta (pCi/l)
SW-1001-B292	ND	4.8	ND	0.2	ND	ND	8.9
SW-1002-B292	ND	ND	ND	ND	ND	ND	ND
SW-1003-B292	ND	2.2	ND	ND	ND	77	72
SW-1004-B292	ND	2.1	ND	0.4	1.4	180	140
SW-1005-B292	ND	1.5	ND	0.2	ND	30	28
SW-1007-B292	ND	0.3	ND	ND	1.3	17	14
SW-1008-B292	NA	NA	NA	NA	NA	NA	NA
SW-1009-B292	ND	ND	ND	0.6	ND	12	19
SW-1010-B292	ND	ND	ND	ND	ND	ND	ND
SW-1011-B292	0.6	1.6	0.6	1.1	2.6	10	14
SW-1012-B292	ND	ND	ND	ND	ND	ND	ND
SW-1013-B292	ND	ND	ND	ND	ND	ND	ND
SW-1014-B292	ND	ND	ND	ND	ND	ND	ND

ND - Not Detected
NA - Not Available

TABLE 3-4 Second Bimonthly (March/April) Uranium and Inorganic Anion Results in Surface Water at the WSQ

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
SW-1001-B292	0.590	27.0	0.82
SW-1002-B292	0.170	50.1	5.03
SW-1003-B292	ND	86.2	110
SW-1004-B292	ND	70.7	300
SW-1005-B292	ND	63.1	42
SW-1007-B292	ND	44.5	16
SW-1008-050192	ND	76.9	NA
SW-1009-B292	ND	47.0	18
SW-1010-B292	0.140	39.3	54.5
SW-1011-B292	1.39	80.1	8.5
SW-1012-B292	2.00	85.9	5.85
SW-1013-B292	1.70	87.5	5.51
SW-1014-B292	0.800	30.6	4.08

ND - Not Detected
NA - Not Available

TABLE 3-5 Third Bimonthly (May/June) Uranium Results in Surface Water at the WSQ

Sample ID	Uranium (pCi/l)
SW-1001-B392	ND
SW-1002-B392	ND
SW-1003-B392	46.0
SW-1004-B392	73.0
SW-1005-B392	26
SW-1007-B392	7.6
SW-1008-B392	1200
SW-1009-B392	6.1
SW-1010-B392	43
SW-1011-B392	3.30
SW-1012-B392	1.8
SW-1013-B392	5.0
SW-1014-B392	3.8

ND - Not Detected

TABLE 3-6 Second Bimonthly (March/April) Nitroaromatic Results in Surface Water at the WSQ

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
SW-1001-B292	ND	ND	0.37	0.014	0.067	ND
SW-1002-B292	ND	ND	ND	ND	ND	ND
SW-1003-B292	ND	ND	ND	ND	ND	ND
SW-1004-B292	ND	ND	ND	ND	ND	ND
SW-1005-B292	ND	ND	ND	ND	ND	ND
SW-1007-B292	ND	ND	ND	ND	ND	ND
SW-1008-B292	NA	NA	NA	NA	NA	NA
SW-1009-B292	ND	ND	ND	ND	ND	ND
SW-1010-B292	ND	ND	ND	ND	ND	ND
SW-1011-B292	ND	ND	ND	ND	ND	ND
SW-1012-B292	ND	ND	ND	ND	ND	ND
SW-1013-B292	ND	ND	ND	ND	ND	ND
SW-1014-B292	ND	ND	ND	ND	ND	ND

NA - Not Available
ND - Not Detected

TABLE 3-7 Third Bimonthly (May/June) Results for SW-1008

Parameter	Concentration	Units
Ra-226	0.8	pCi/l
Ra-228	ND	pCi/l
Th-230	0.2	pCi/l
Th-232	ND	pCi/l
Gross Alpha	1650	pCi/l
Gross Beta	690	pCi/l
Uranium	1200	pCi/l
Nitrate	ND	mg/l
Sulfate	71.5	mg/l
Nitrobenzene	ND	µg/l
1,3-DNB	ND	µg/l
2,4-DNT	0.30	µg/l
2,6-DNT	0.016	µg/l
2,4,6-TNT	ND	µg/l
1,3,5-TNB	ND	µg/l

4 EFFLUENT MONITORING

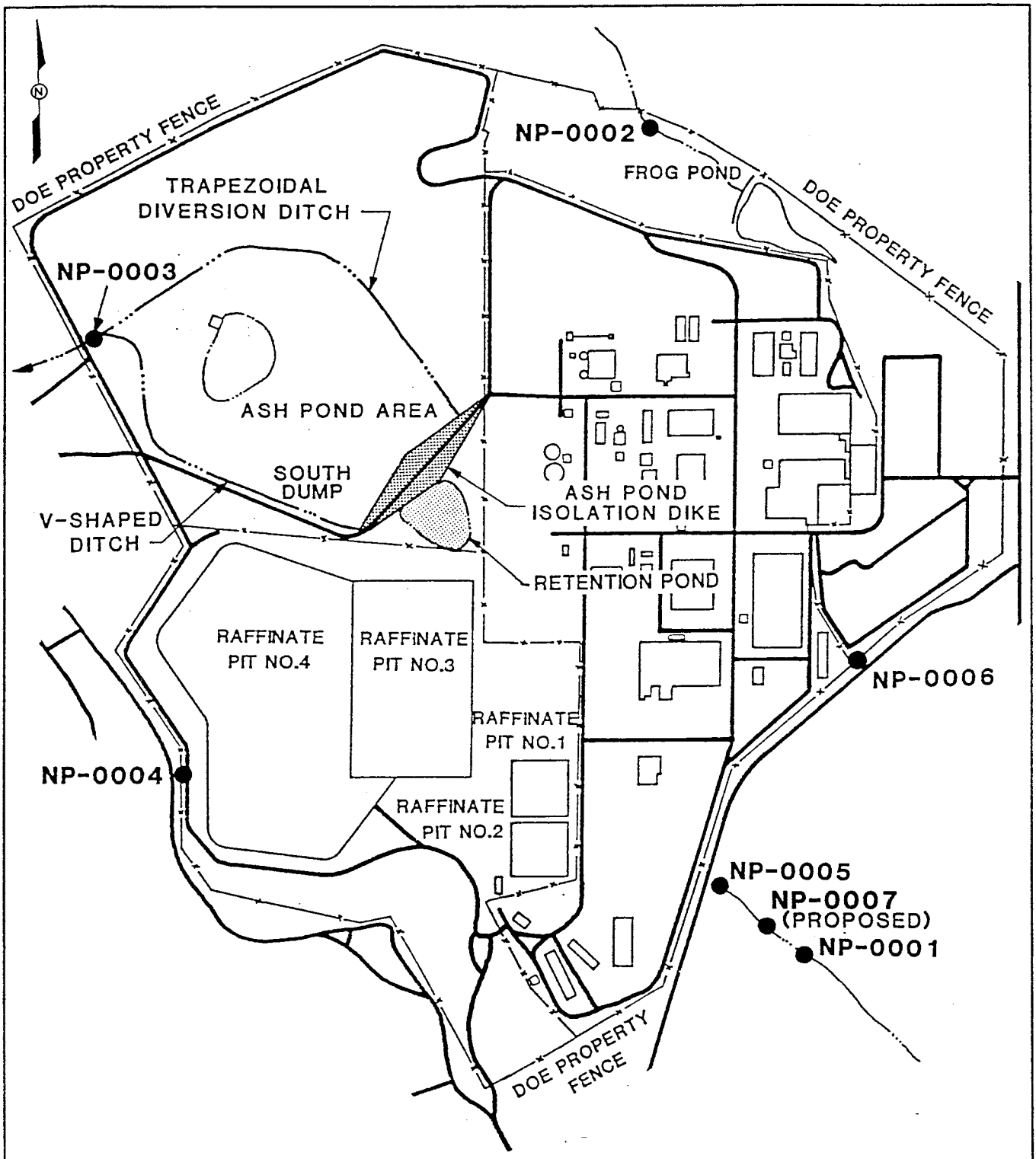
The National Pollutant Discharge Elimination System (NPDES) permit process is authorized by Section 402(a)(1) of the *Clean Water Act of 1977*. The authority to issue permits is delegated to the State of Missouri by the U.S. Environmental Protection Agency (EPA). The State of Missouri has issued four NPDES permits to the U.S. Department of Energy (DOE) allowing the discharge of stormwater hydrostatic test water, and treated wastewater to waters of the state. The permits require that samples of the wastewater be collected periodically and the results reported to the Missouri Department of Natural Resources. The following sections contain the analytical results for samples collected during April, May, and June of 1992.

4.1 National Pollutant Discharge Elimination System Data Review

Effluent samples were collected and analyzed in compliance with the Weldon Spring site NPDES permits. Permit No. MO-0107701 was issued on October 1, 1990, and currently addresses the five storm water and two wastewater discharges shown in Figure 4-1. Outfalls NP-0001 through NP-0005 represent storm water discharges; Outfall NP–0006 represents the treated wastewater discharge associated with the administration building sanitary wastewater treatment plant; and Outfall NP-0007 represents the site water treatment plant, which is under construction, but not yet completed. There was no discharge from Outfall NP-0007. Outfalls NP-0006 and NP-0007 have effluent limitations. The five storm water outfalls have "monitoring only" requirements. A lack of flow due to inadequate precipitation prevented the collection of samples from outfalls NP-0003 and NP-0005 during the month of June. NP-0004 also had no discharge during the second quarter, and therefore was not sampled. Second quarter 1992 analytical data for each outfall are presented in Table 4-1.

A lack of flow due to inadequate precipitation prevented the collection of samples from outfalls NP-0003 and NP-0005 during the month of June. NP-0004 also had no discharge during the second quarter, and therfore was not sampled.

Permit No. MO-0108987 was issued on May 5, 1989, for Outfall NP-1001 of the Weldon Spring Quarry water treatment plant. The plant construction is not complete and no discharge took place during the second quarter of 1992.



NPDES SURFACE WATER SAMPLING LOCATIONS AT THE WSCP/RP

FIGURE 4-1

SCALE 0 500 1000 FT
0 152.4 304.8 M

REPORT NO.:	DOE/OR/21548-337	EXHIBIT NO.:	A/CP/050/0592		
ORIGINATOR:	TW	DRAWN BY:	GLN	DATE:	5/92

TABLE 4-1 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006

Outfall NP-0001 NPDES data for Q2 1992

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
April 20	99,500	15.0	ND (0.1)	0.50	6.01	ND (0.1)	410	0.663	450

Outfall NP-0002 NPDES data for Q2 1992

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
April 20	787,000	38.0	ND (0.1)	1.10	6.0	ND (0.1)	140	0.151	103
May 13	73,200	48.0	ND (0.1)	0.41	7.28	ND (0.1)	220	0.222	151
June 4	25,400	16.0	ND (0.1)	0.47	7.54	ND (0.023)	190	0.255	173

Outfall NP-0003 NPDES data for Q2 1992

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
April 20	740,600*	40.0	ND (0.1)	3.39	6.04	ND (0.1)	540	0.799	543
May 13	17,568*	10.0	ND (0.1)	0.21	7.61	ND (0.1)	280	0.392	267

TABLE 4-1 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006 (Continued)

Outfall NP-0004 NPDES data for Q2 1992

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
No Discharge	--	--	--	--	--	--	--	--	--

Outfall NP-0005 NPDES data for Q2 1992

DATE SAMPLED	FLOW	SUSP. SOLIDS	SET. SOLIDS	NITRATE	pH	LITHIUM	GROSS ALPHA	TOTAL URANIUM	
UNITS	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
April 20	174,500*	129	ND (0.1)	18.6	6.08	ND (0.1)	350	0.526	358
May 13	3,312*	35	ND (0.1)	0.31	8.01	ND (0.1)	460	0.749	509

Outfall NP-0006 NPDES data for Q2 1992

DATE SAMPLED	FLOW	SUSP. SOLIDS	BOD	FECAL COLIFORMS	pH
UNITS	GPD**	mg/l	mg/l	Colonies/100 ml	pH units
April 3	5400	8.0	1.0	ND (1.0)	6.5
May 7	3,000	7.0	1.0	ND (1.0)	7.0
June 5	5,000	7.0	1.0	ND (1.0)	7.0

* Indicates an updated flow value which differs from that found in the second quarter 1992 Discharge Monitoring Report.
** Indicates flow rate at time of sample collection.
ND Not detected, detection limit is in parentheses.
-- Indicates analysis not done on this parameter.

Table 4-2 Results of NPDES Monitoring for Permit MO-G680001

Date Sampled	Flow*	Oil and Grease	Susp. Solids	pH
Units	Gallons	mg/l	mg/l	
April 24	66,500	ND (5.0)	ND (5.0)	6.74
April 28	178,500	ND (5.0)	28.0	6.14
April 29	178,500	ND (5.0)	16.0	6.82
April 30	178,500	ND (5.0)	5.0	6.97
June 17	*	ND (5.0)	8.0	6.71
June 19	*	ND (5.0)	10.0	8.67
June 22	500,000	ND (5.0)	9.0	6.99
June 26	750,000	6.29	5.0	8.84
June 29	4,000	ND (5.0)	ND (5.0)	7.92

* The June 22 flow value represents the total amount of water discharged from June 17 through June 22, 1992.

NPDES permit No. MO-G680001 was issued on December 19, 1991. This permit is for discharge of uncontaminated water used for new tank and hydrostatic basin testing at the quarry water treatment plant. Second quarter 1992 analytical data are presented in Table 4-2.

NPDES permit No. MO-G680002 was issued on February 7, 1992. This permit is for discharge of uncontaminated water used for new tank and hydrostatic basin testing at the site water treatment plant. There was no discharge under this permit for the second quarter of 1992.

4.1.1 Radiological Analysis

Gross alpha and uranium analyses corresponded well with past data. The storm water outfalls had the following ranges of uranium concentrations. The process sewer outfall NP-0001, had only one sample value of 450 pCi/l (0.663 mg/l). Frog Pond outfall, NP-0002, had values from 103 pCi/l (0.151 mg/l) to 173 pCi/l (0.255 mg/l). The Ash Pond outfall, NP-0003, had values of 543 pCi/l (0.799 mg/l) and 267 pCi/l (0.392 mg/l). There was no discharge from NP-0004 during the second quarter. The Southeast Drainage outfall, NP-0005, had values of 358 pCi/l (0.526 mg/l) and 509 pCi/l (0.749 mg/l).

In addition to the required radiological monitoring, gross beta was quantified for most samples. The one sample collected from NP-0001 had a gross beta count of 150 pCi/l (5.55 Bq/l). Two samples from NP-0002 were analyzed for gross beta. The sample collected on April 20 had a gross beta count of 29 pCi/l (1.07 Bq/l), and the sample collected on May 13 had a gross beta count of 61 pCi/l (2.26 Bq/l). The gross beta concentrations for NP-0003 were 190 pCi/l (7.03 Bq/l) for the April 20 sample, and 49 pCi/l (1.81 Bq/l) for the May 13 sample. The gross beta concentrations for NP-0005 were 160 pCi/l (5.92 Bq/l) for the April 20 sample, and 55 pCi/l (2.04 Bq/l) for the May 13 sample.

4.1.2 Other Analysis

Other analyses for NP-0001 through NP-0005 include physical analyses (settleable solids and total suspended solids) and chemical analyses (nitrate, pH, and lithium). Second quarter 1992 values correspond well with past values for all parameters.

The permit for the discharge from the administration building treatment plant at outfall NP-0006 has effluent limitations and a requirement to monitor once per quarter. Flow must be

measured once a month. The Subcontractor monitors the effluent once a month to assess plant performance, thus generating two additional sample analyses a quarter. The NPDES permit specifies effluent limitations for biochemical oxygen demand (BOD), total suspended solids (TSS), pH, and fecal coliform at this outfall. The limits for BOD are 10 mg/l monthly average and 15 mg/l weekly average; for TSS, 15 mg/l monthly average and 20 mg/l weekly average; for fecal coliform, 400 colonies per 100 ml monthly average and 1,000 colonies per 100 ml daily maximum. The Subcontractor is continuing to make operational changes to improve plant performance. In addition, the plans to add a flow equalization system are complete. The equalization of flow should greatly improve the operation of the plant. An application for a construction permit, as well as the plans and specifications, were submitted to the Missouri Department of Natural Resources. When the construction permit is issued, construction will begin. Until the flow equalization is added, the treatment plant will be monitored more frequently than would normally be required.

Hydrostatic test water pumped from the quarry water treatment plant basins was in compliance with permitted limits (Table 4-2). Analytical data are shown in Table 4-2.

5 AIR MONITORING

5.1 Radon Gas

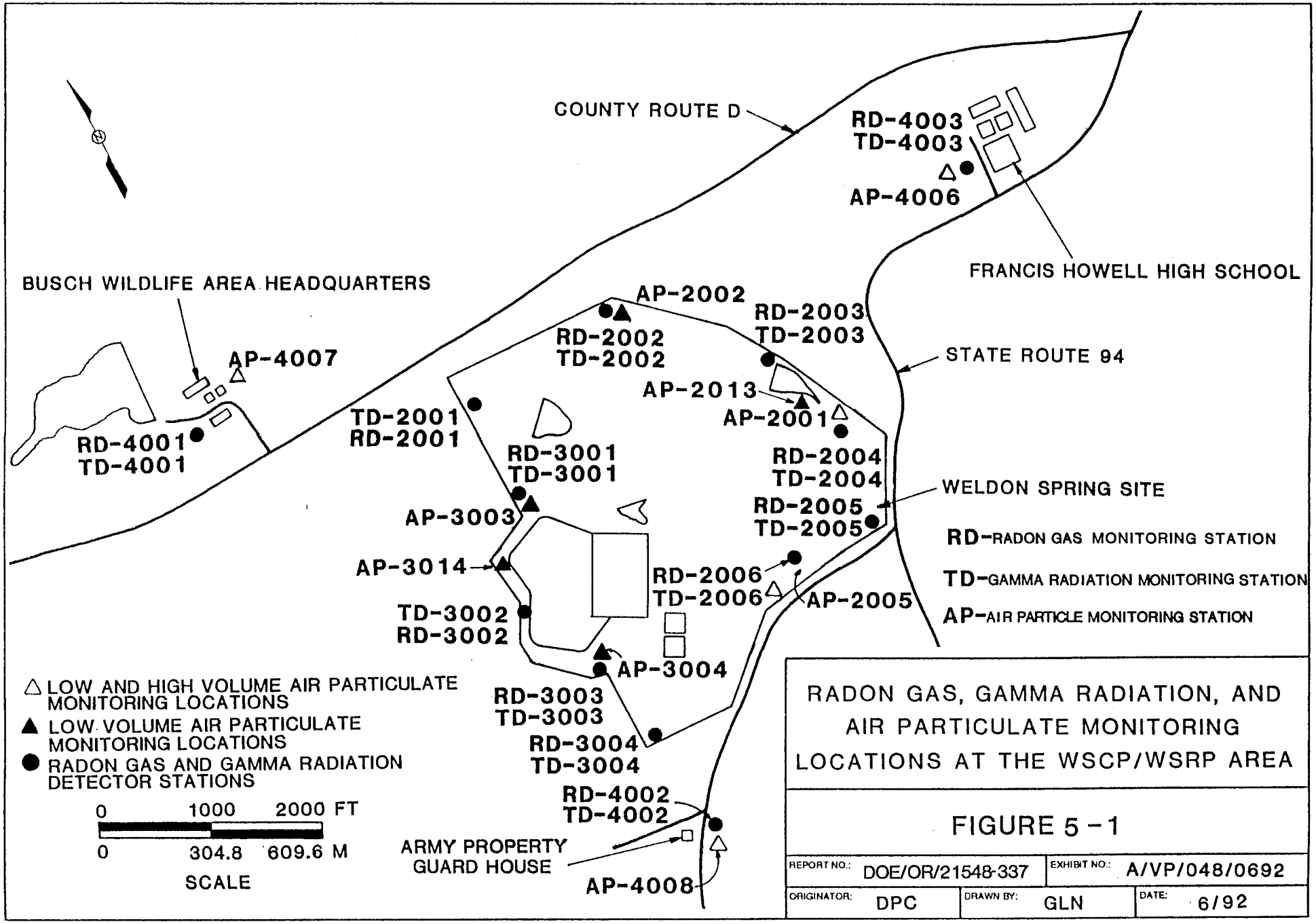
The radon gas monitoring program utilizes a pair of alpha track radon detectors at each of the 25 permanent locations; each detector is exchanged quarterly. These detectors are deployed at six locations at the Weldon Spring Chemical Plant, eight locations at the Weldon Spring Quarry, four locations at the Weldon Spring raffinate pits, and at seven off-site locations. Radon monitoring locations are shown in Figures 5-1, 5-2, and 5-3. On-site detectors are distributed around the perimeter fences to ensure adequate detection of radon dispersing from the properties under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005, RD-4006, and RD-4007 monitor background levels near the site.

Beginning this quarter, a new type of alpha track monitor was used for radon monitoring. The new detector is the new Type F track etch detector. This replaces the Radtrack monitor used for radon monitoring during the first quarter of 1992. The change was made because the Radtrack monitor is designed for indoor monitoring, while the Type F is better suited for outdoor monitoring. The detection mechanism in both these monitors is identical, consisting of a track etch detector.

Table 5-1 summarizes the second quarter 1992 radon concentrations detected at all site perimeter and off-site monitoring locations. Also contained in the third column of Table 5-1 is a comparison of the measured concentration with the Federally permitted radon concentration (for unrestricted areas) of 3 pCi/l (111 Bq/m^3) above background as authorized by U.S. Department of Energy (DOE) Order 5400.5.

An average ambient background concentration was determined by calculating the arithmetic average for the five background locations. This data yielded an average ambient background radon concentration of 0.25 pCi/l (9.25 Bq/m^3) for the first quarter of 1992. This concentration was then subtracted from the concentration for each monitoring station, and compared to the DOE guideline of 3 pCi/l (111 Bq/m^3) above background.

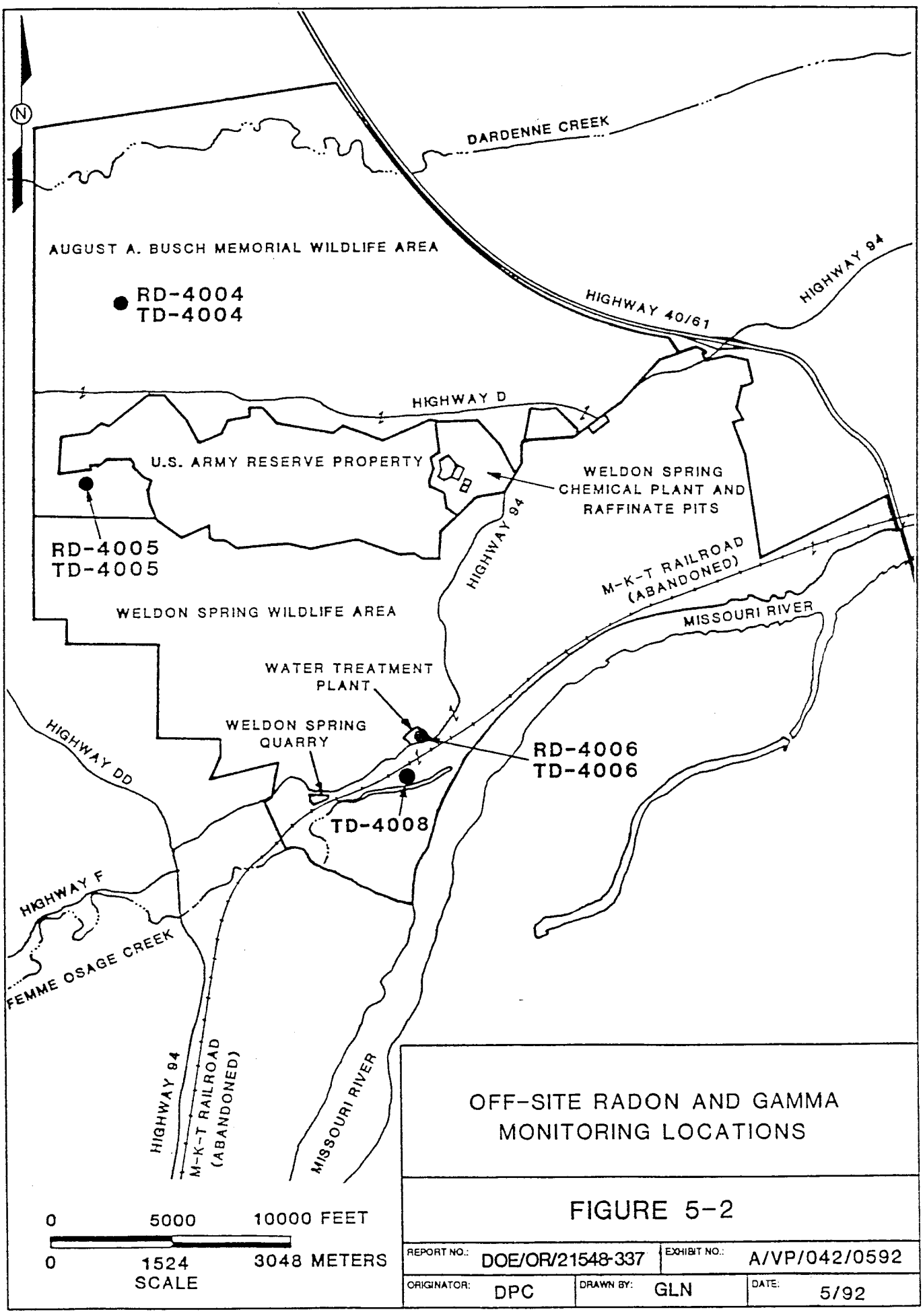
Radon concentrations at the site and quarry perimeters and at off-site locations for the first quarter of 1992 were within the typical range expected during periods of normal precipitation. During the second quarter, the radon concentrations measured with the new type



RADON GAS, GAMMA RADIATION, AND AIR PARTICULATE MONITORING LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 5-1

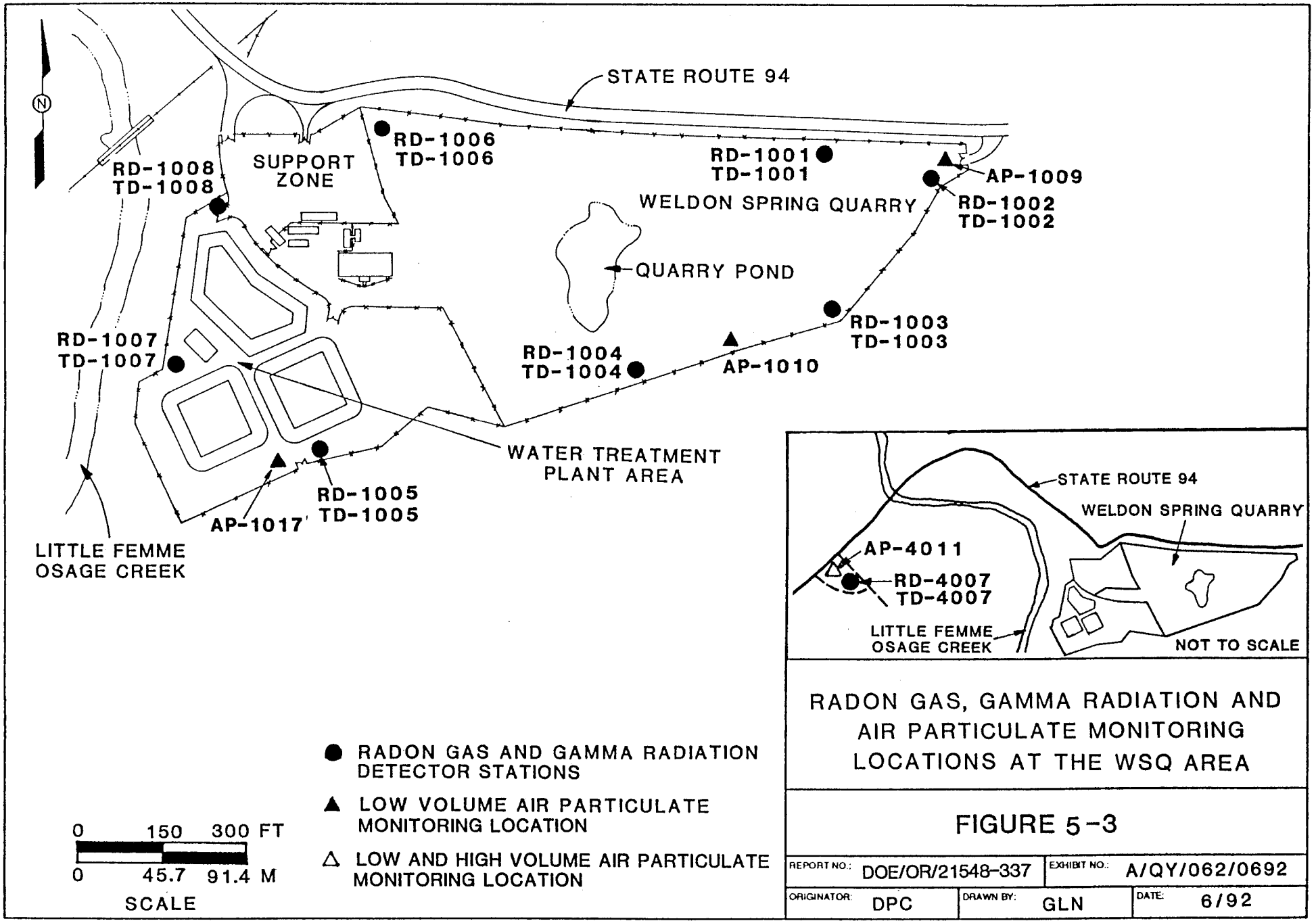
REPORT NO.:	DOE/OR/21548-337	EXHIBIT NO.:	A/VP/048/0692		
ORIGINATOR:	DPC	DRAWN BY:	GLN	DATE:	6/92



OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

FIGURE 5-2

REPORT NO.:	DOE/OR/21548-337	EXHIBIT NO.:	A/VP/042/0592
ORIGINATOR:	DPC	DRAWN BY:	GLN
DATE:	5/92		



RADON GAS, GAMMA RADIATION AND AIR PARTICULATE MONITORING LOCATIONS AT THE WSQ AREA

FIGURE 5-3

REPORT NO.:	DOE/OR/21548-337	EXHIBIT NO.:	A/QY/062/0692		
ORIGINATOR:	DPC	DRAWN BY:	GLN	DATE:	6/92

TABLE 5-1 Second Quarter 1992 Track Etch Radon Monitoring Results[a]

Location ID	2nd Quarter pCi/l	Percent of Guideline [b]
WSQ		
RD-1001	1.31	33
RD-1002	1.4	38
RD-1003	0.5	7
RD-1004	0.3	2
RD-1005	0.4	3
RD-1006	0.3	2
RD-1007	0.3	0
RD-1008	0.3	0
WSCP		
RD-2001	0.4	3
RD-2002	0.2	0
RD-2003	0.3	2
RD-2004	0.3	2
RD-2005	0.2	0
RD-2006	0.2	0
WSRP		
RD-3001	0.3	1
RD-3002	0.4	5
RD-3003	0.5	7
RD-3004	0.4	3

TABLE 5-1 Second Quarter 1992 Track Etch Radon Monitoring Results[a] (Continued)

Location ID	2nd Quarter pCi/l	Percent of Guideline [b]
OFF-SITE		
RD-4001*	0.2	
RD-4002	0.2	0
RD-4003	0.2	0
RD-4004*	0.3	
RD-4005*	0.3	
RD-4006*	0.3	
RD-4007*	0.2	

(a) Results include natural background.

(b) Percent of guideline calculated by taking the quarterly average minus the average of the background stations divided by the DOE concentration guideline for Rn-222 which is 3 pCi/l (111 Bq/m^3)(Annual average above background) for uncontrolled areas.

* Denotes Background Station.

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of detectors were also within the typical range expected during periods of normal precipitation. The quarterly radon concentrations at the Weldon Spring Chemical Plant/raffinate pit (WSCP/RP) area averaged 0.3 pCi/l (11.8 Bq/m^3), while the quarterly radon concentrations at the Weldon Spring Quarry (WSQ) averaged 0.6 pCi/l (22.2 Bq/m^3). The quarterly radon concentrations (background included) ranged from 0.03 pCi/l (1.11 Bq/m^3) to 1.2 pCi/l (44.4 Bq/m^3).

Radon concentrations found at the quarry are higher than concentrations measured at other locations, because the radium concentrations in quarry wastes are typically much higher than in other areas. Also, the quarry is a large depression with side walls ranging from 3 m to 15 m (10 ft to 50 ft) high, which tends to trap emanating radon within the quarry and raise the concentrations along the quarry perimeter.

5.2 Gamma Radiation Exposure

To monitor exposure from gamma radiation, environmental thermoluminescent dosimeters (TLDs) were deployed at 26 locations. The gamma monitoring station locations are identified in Figures 5-1, 5-2, and 5-3 with a prefix TD-.

Table 5-2 summarizes the second quarter results of total gamma radiation monitoring at the 18 Weldon Spring site (WSS) perimeter monitoring stations, Francis Howell High School, the Weldon Spring Army Reserve Training Area, and at the six background monitoring stations.

The Weldon Spring Site Remedial Action Project (WSSRAP) is in the process of changing TLD vendors. To facilitate this change, duplicate TLDs, one from the existing vendor and one from the new vendor, were deployed at four monitoring locations during this quarter. This changeover will be effective starting with the third quarter 1992.

The average gamma radiation measured at the 26 locations during the second quarter of 1992 (30.2 mrem) was about twice that measured in the second quarter of 1991 (15.5 mrem). Based upon the readings of the control TLD (which read 14.8 mrem for the second quarter 1991, and 37 mrem for the second quarter 1992), we believe that the elevated TLD results were due either to irradiation of dosimeters after shipment to the vendor or to vendor processing problems. Also, the results of the new dosimeters that were deployed as duplicates at four locations were comparable with historical data. This further supports the contention that the elevated readings were not attributable to actual increases in environmental gamma radiation levels in the second quarter 1992. The arithmetic average of the dose measured at the five background locations is 31 mrem. This dose is not significantly different than what was seen at other locations monitored. Thus it may be concluded that the elevated readings measured at the site and quarry were not the result of work activities performed at the site. The cause of the elevated results is still under investigation. The final results will be reported in the 1992 ASER.

5.3 Radioactive Air Particulates

Fourteen low volume air particulate samplers monitor the Weldon Spring site continuously. Five of these (AP-2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the Weldon Spring Chemical Plant (WSCP) perimeter and two are located around the quarry perimeter. There are three sensitive monitoring stations, AP-4006, AP-4008, and

TABLE 5-2 Second Quarter 1992 Environmental TLD Monitoring Results[a]

Location ID	2nd Quarter mrem
WSQ	
TD-1001	34
TD-1002	29
TD-1003	35
TD-1004	29
TD-1005	28
TD-1006	30
TD-1007	30
TD-1008	33
WSCP	
TD-2001	30
TD-2002	30
TD-2003	30
TD-2004	32
TD-2005	29
TD-2006	30
WSRP	
TD-3001	37
TD-3002	25
TD-3003	31
TD-3004	29
OFF-SITE	
TD-4001*	32
TD-4002	23
TD-4003	25
TD-4004*	32

TABLE 5-2 Second Quarter 1992 Environmental TLD Monitoring Results[a] (Continued)

Location ID	2nd Quarter mrem
TD-4005*	30
TD-4006*	29
TD-4007*	32
TD-4008*	32

(a) Results include natural background.
- Denotes loss of TLD.
* Denotes background station.

AP-4011, located off-site at the Francis Howell high School, the Army Reserve property, and near a residential site west of the quarry, respectively. Three new monitoring stations were added during the second quarter. Two monitoring stations, AP-2013 and AP-3014, were installed at the WSCP perimeter. The other new station, AP-1017, was installed at the WSQ perimeter. The monitoring station at the August A. Busch Wildlife Area (ABWA) (AP-4007) is used to monitor background levels in the vicinity of the WSCP. The air particulate monitoring stations are shown in Figure 5-1 and 5-3.

The background sampling station AP-4007, is approximately 0.8 km (0.5 mile) from the WSCP perimeter in a northwestern direction. The terrain between the WSCP and this sampling station is hilly and forested, providing a significant physical barrier to airborne particulates originating from the WSCP/RP area.

Table 5-3 summarizes the quarterly average concentrations and the standard deviations for the 11 air monitoring locations. The quarterly average concentration for each monitoring location was calculated by averaging all weekly air particulate analysis results including results lower than the instruments lower limit of detection (LLD). The corresponding standard deviation for each monitoring location was also calculated using all weekly air particulate analysis results. Due to maintenance and installation of new samplers, all samplers were not operating the entire 13 weeks, as indicated in the fourth column of Table 5-3. The WSSRAP has deployed high volume air samplers at critical receptor locations. The critical receptor locations include the Francis Howell High School, the Missouri Department of the Army

TABLE 5-3 Second Quarter 1992 Radiological Air Particulate Monitoring Results

Monitor Identification Number	Quarterly AVG. CONCENTRATION (μCi/ml)	STANDARD DEVIATION (μCi/ml)	NUMBER OF WEEKS COLLECTED	NUMBER OF VALUES ABOVE LLD
AP-2001	1.31E-15	2.57E-16	13	9
AP-2002	1.50E-15	6.47E-16	13	12
AP-3003	1.09E-15	4.54E-16	12	10
AP-3004	1.29E-15	7.75E-16	13	10
AP-2005	1.34E-15	5.39E-16	13	11
AP-4006	1.16E-15	4.08E-16	13	13
AP-4007	1.33E-15	4.87E-16	13	13
AP-4008	1.04E-15	4.25E-16	12	11
AP-1009	1.48E-15	6.57E-16	13	12
AP-1010	1.28E-15	7.66E-16	12	9
AP-4011	1.23E-15	3.75E-16	13	12
AP-2013	1.03E-15	4.45E-16	13	12
AP-3014	1.99E-15	4.86E-16	3	3
AP-1017	1.05E-15	1.35E-16	2	2

* Indicates background monitor station.
To convert μCi/ml to Bq/m^3, multiply by 3.7E10.

Reserve property, the WSSRAP administration building, and the residential area west of the quarry. These high volume samplers are used in accordance with the *Plan for Monitoring Radionuclide Emissions Other Than Radon at the Weldon Spring Site Critical Receptors* (MKF and JEG 1992b). The high volume monitoring results will be presented in the 1992 annual site environmental report.

The second quarter average long-lived gross alpha concentrations ranged from 1.03×10^{-15} μCi/ml to 1.99×10^{-15} μCi/ml for perimeter and off site locations. The average background concentration measured at AP-4007 was 1.33×10^{-15} μCi/ml.

5.4 Asbestos

No environmental asbestos monitoring was conducted during the second quarter of 1992. As outlined in the *Environmental Monitoring Plan* (MKF and JEG 1992a), environmental asbestos monitoring is required to be performed only during asbestos removal activities. Since there were no asbestos removal operations during the second quarter of 1992, there was no need to perform environmental asbestos monitoring.

6 REFERENCES

MK-Ferguson Company and Jacobs Engineering Group, 1989. *Phase II Groundwater Quality Assessment for the Weldon Spring Site, Chemical Plant, Raffinate Pits and Surrounding Vicinity Properties*, Rev. 0. DOE/OR/21548-078. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. September.

MK-Ferguson Company and Jacobs Engineering Group, 1992a. *Environmental Monitoring Plan*, Rev. 1. DOE/OR/21548-237. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. January.

MK-Ferguson Company and Jacobs Engineering Group, 1992b. *Plan for Monitoring Radionuclide Emissions Other Than Radon at the Weldon Spring Site Critical Receptors*, Rev. 1. DOE/OR/21548-127. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO.

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5400.5 *Radiation Protection of the Public and the Environment*

Procedures

ES&H Procedure 4.4.1s *Groundwater Sampling*

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SUBJECT Transmittal of Site Soil Permeability Data

AUTHOR VanFossen, J.S. TO Beckan, D.E. DATE 12/2/92

SUBJECT CODE/WORK PACKAGE NUMBER 1 03010

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Dr. David E. Bedan
Division of Environmental Quality
Missouri Department of Natural Resources
Post Office Box 176
Jefferson City, Missouri 65102

Dear Dr. Bedan:

TRANSMITTAL OF SITE SOIL PERMEABILITY DATA

A technical memorandum from the Project Management Contractor (PMC) staff is enclosed for your information and review. This document outlines the results of recent data gathering activities relating to leachate permeability of site soils at the Weldon Spring Site. Specific data collected includes:

- Laboratory permeability testing of undisturbed soils with both water and synthesized leachate as a permeant, performed to assess the effects of leachate on permeability.
- Field permeability testing of insitu site soils using a two-state borehole (TSB) procedure.

General conclusions from this effort include:

- Results of TSB testing indicate that in situ hydraulic conductivity is not affected by macropore features such as cracks or fractures.
- Logarithimic mean field permeability values (TSB results) range from 1.28 E^{-08} to 3.34 E^{-09} (cm/s).
- Hydraulic conductivity values obtained under recent efforts are consistent with prior data, and support the suitability of the proposed area for a disposal site.
- Synthesized leachate has no detectable effect on permeability. Logarithmic mean hydraulic conductivity values range from 1.26 E^{-09} cm/s (leachate) to 1.66 E^{-09} cm/s (water).
- These values indicate that a 20 ft layer of site clay soils will retard the migration of hazardous constituents contained in the waste to at least the same degree that 30 ft of material having a coefficient of permeability of 1.0 E^{-07} cm/s would retard the migration of water.

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This information was collected at the request of the MDNR technical staff. A technical memorandum is enclosed that includes data interpretation, data tables, technical references, example calculations, and graphical presentations of the data. A formal report will be forthcoming.

If you have any questions please contact Ken Lawver of my staff at (314)441-8978.

Sincerely,

for

Jerry S. Van Fossen
Deputy Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

w/enclosure:
Dan Wall, EPA
Mimi Garstang, MDNR-DGLS

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◆ SUBJECT Transmittal of Site Soil Permeability Data To the Missouri Dept of Natural Resources

◆ FROM J R Powers ◆ TO S H McCracken ◆ DATE

◆ SUBJECT CODE/WORK PACKAGE NUMBER 7-6020

REFERENCED DOCUMENT(S)

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November 24, 1992

U. S. Department of Energy
Weldon Spring Site Remedial Action Project
ATTN: Mr. Stephen H. McCracken
Project Manager
7295 Highway 94 South
St. Charles, MO 63304

SUBJECT: Contract No. DE-AC05-86OR21548
TRANSMITTAL OF SITE SOIL PERMEABILITY DATA TO THE MISSOURI DEPARTMENT OF NATURAL RESOURCES.

Dear Mr. McCracken:

Information from recent data gathering activities relating to permeability of undisturbed site soils is attached. This data was collected at the recommendation of the MDNR/DGLS technical staff, and relates to the technical requirements for hazardous waste landfill siting standards as presented in 10 CSR 25-7. Although this regulation is not considered applicable, we have agreed to utilize these requirements to develop design criteria, including the use of engineered fill to meet these standards. Specific data collected include:

- Laboratory permeability testing of undisturbed soils with both water and synthesized leachate as a permeant, performed to assess the effects of leachate on permeability.

- Field permeability testing of insitu site soils using a two-stage borehole (TSB) procedure.

General conclusions from these data are as follows:

- Results of TSB testing indicate that *in situ* hydraulic conductivity is not affected by macropore features such as cracks or fractures.

- Logarithmic mean field permeability values (TSB results) range from 1.28 E^{-08} to 3.34 E^{-09} (cm/s).

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 TRANSMITTAL OF SITE SOIL PERMEABILITY DATA TO THE MO. DEPT. OF NATURAL RESOURCES.

- Hydraulic conductivity values obtained under recent efforts are consistent with prior data, and support the suitability of the proposed area for a disposal site.

- Synthesized leachate has no detectable effect on permeability. Logarithmic mean hydraulic conductivity values range from 1.26 E^{-09} cm/s (leachate) to 1.66 E^{-09} cm/s (water).

- These values indicate that a 20 ft layer of site clay soils will retard the migration of hazardous constituents contained in the waste to at least the same degree that 30 ft of material having a coefficient of permeability of 1.0 E^{-07} cm/s would retard the migration of water.

A technical memorandum is attached that includes data interpretation, data tables, technical references, example calculations, and graphical presentations of the data. A formal report will be forthcoming.

Please transmit this information to the MDNR and the EPA. A draft letter of transmittal is included for your use. A copy of this letter with attachments will be placed into the administrative record. Please contact Rick Ferguson or Ken Warbritton of my staff should you have any questions.

Sincerely,

James R. Powers

James R. Powers
Project Director

JRP/krw/kem

Attachment

cc: Walker K. Love

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
7295 Highway 94 South
St. Charles, Missouri 63304

December 2, 1992

Dr. David E. Bedan
Division of Environmental Quality
Missouri Department of Natural Resources
Post Office Box 176
Jefferson City, Missouri 65102

Dear Dr. Bedan:

TRANSMITTAL OF SITE SOIL PERMEABILITY DATA

A technical memorandum from the Project Management Contractor (PMC) staff is enclosed for your information and review. This document outlines the results of recent data gathering activities relating to leachate permeability of site soils at the Weldon Spring Site. Specific data collected includes:

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- Hydraulic conductivity values obtained under recent efforts are consistent with prior data, and support the suitability of the proposed area for a disposal site.

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- These values indicate that a 20 ft layer of site clay soils will retard the migration of hazardous constituents contained in the waste to at least the same degree that 30 ft of material having a coefficient of permeability of 1.0 E^{-07} cm/s would retard the migration of water.

This information was collected at the request of the MDNR technical staff. A technical memorandum is enclosed that includes data interpretation, data tables, technical references, example calculations, and graphical presentations of the data. A formal report will be forthcoming.

If you have any questions please contact Ken Lawver of my staff at (314)441-8978.

Sincerely,

Jerry S. Van Fossen
Deputy Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

cc w/enclosure:
Dan Wall, EPA
Mimi Garstang, MDNR-DGLS

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A DIVISION OF
MORRISON KNUDSEN CORPORATION

INTER-OFFICE CORRESPONDENCE

DATE: November 23, 1992

TO: R. Ferguson

FROM: Kenyon Warbritton/Jeff Carman

SUBJECT: **TECHNICAL MEMORANDUM PRESENTING RESULTS OF RECENT LABORATORY AND FIELD PERMEABILITY TESTS.**

The PMC has recently completed Two-Stage Borehole (TSB) field permeability testing performed at the request of MDNR/DGLS personnel. These tests were performed on the Ferrelview Formation and clay till unit at locations within the Disposal Facility Study Area.

An additional testing program, triaxial permeability testing of small undisturbed samples, is nearly complete. These tests were performed using both water and a synthesized leachate as a permeant. This program is not yet finalized, however key findings are available at this time for review by interested parties.

Samples of these test programs were obtained in accordance with "Sampling Plan for Determination of Hydraulic Properties of Undisturbed Soils in the Weldon Spring Disposal Facility Study Area", Rev. 1, MK-JEG, Oct. 92. Data and conclusions from these two test programs, in addition to prior WSSRAP testing, were utilized to calculate travel times for water through a 20 ft. layer of site soil. These travel time values were compared to travel time values calculated for a 30 ft. layer of material with a hydraulic conductivity of 1.0 E^{-07} cm/s (as described in 10 CSR 25-7).

TWO-STAGE BOREHOLE FIELD PERMEABILITY TESTS

I. Please find the following attachments relating to the TSB test effort.

Attachment 1 - Figure indicating the locations of TSB tests.

Attachments 2A and 2B - Spreadsheet calculation summaries which yield initial temperature corrected hydraulic conductivity values for stage 1 (K1CT) and stage 2 (K2CT).

Attachments 3A and 3B - Plots of time versus hydraulic conductivity for stage 1 and stage 2.

Attachment 4A and 4B - Calculations of the final time-weighted average hydraulic conductivity (K1' and K2').

Attachment 5 - Spreadsheet calculation summary of the derived Kv and Kh values.

Attachment 6 - TSB Method Reference, "The STEI Two-Stage Borehole Field Permeability Test", Boutwell, March 1992.

II. Results of the TSB test program are summarized as follows:

- Table 1 provides a summary of TSB test results.

b:\mdnr.1

- Table 2 provides a summary of basic statistics generated from the TSB results presented in Table 1.

- Results of TSB testing indicate that *in situ* hydraulic conductivity is not affected by macropore features such as cracks or fractures.

- TSB no. 9 exhibited the highest permeability and also exhibited some erratic behavior early in the testing program, leading PMC staff to question the integrity of this test boring. This data is presented and is utilized in the attached data summaries. PMC staff have recently added dye to the permeameter (TSB-9) to investigate potential leakage when abandoning this hole using controlled excavation.

WATER/LEACHATE PERMEABILITY TESTING

I. Please find the following attachments relating to water/leachate permeability testing:

Attachment 7 - Figure indicating locations for undisturbed site soil samples which were subjected to permeability testing (ASTM Method D-5084).

Attachment 8 - Summary of leachate synthesis methodology.

II. Results of the water/leachate permeability testing are summarized as follows:

- Table 3 summarizes the results to date of permeability tests run using water and leachate as a permeant.

- The effect of synthesized leachate on permeability values for these undisturbed soils was not detectable. Permeability values for two samples increased slightly, values for two samples decreased slightly, and values for two samples remained essentially the same when synthesized leachate was used as the permeant after tap water. These slight differences are within the range of accuracy obtained by test measurements.

CONCLUSIONS RESULTING FROM COMBINED DATA

I. Please find the following attachments relating to water/leachate permeability testing:

Attachment 9 - Presents calculations of travel time and permittivity which compare a 20 ft. thickness with hydraulic conductivity values from various WSSRAP sampling efforts (laboratory and field efforts) to a 30 ft. layer of soil with a hydraulic conductivity of 1.0 E^{-07} cm/s (per 10 CSR 25-7).

Attachment 10 - Presents a list of pertinent reference documents associated with the data and conclusions in this technical memorandum.

II. Conclusions resulting from review of combined data are summarized as follows:

Studies conducted to date have focuses on the hydrologic performance of site soils on a conservative basis. Geochemical performance studies focusing on leachate/mineral interaction are currently being negotiated with Pacific Northwest Laboratory (PNL). The hydrologic data presented herein are considered a "worst case" assessment of the material effects of leachate/mineral interaction.

- Field hydraulic conductivity testing by the Two-Stage Borehole method indicates that macropore features such as cracks and fractures do not result in larger hydraulic conductivity values than have previously been determined for the Ferrelview Formation and clay till soil units in the Disposal Facility Study Area.

- Laboratory triaxial permeability tests have shown synthesized leachate to have an undetectable effect on hydraulic conductivity of Ferrelview Formation and clay till soil unit samples.

- Travel time and permittivity calculations are used to demonstrate that the soil units comprising the foundation of the proposed disposal facility will provide a level of protection superior to the minimum criteria specified under 10 CSR 25-7.

- The data and calculations presented herein for the Ferrelview Formation and clay till soil units satisfy the criteria set forth under 10 CSR 25-7.264 (2)(N)1.A.(III) which addressed minimum soil performance requirements relative to the movement of hazardous constituents.

This information substantiates the suitability of the WSSRAP site for location of a disposal facility. A formal report regarding this data is forthcoming, pending completion of all associated testing. If you have any questions or comments, please contact K. Warbritton (ext. 3309) or J. Carman (ext. 3506).

cc (w/attach.):

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G. Nibler (MKE-BHO)
D. Daniel (UT)
D. Conover (MKE-BHO)
K. Lee (MKE-SFO)
J. Bognar
RC-22-26-3A

cc (w/o attach.):

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J. Williams
K. Greenwell
J. Meier
P. Cate

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TABLE 1

SUMMARY OF HYDRAULIC CONDUCTIVITY
VALUES FROM
TWO-STAGE BOREHOLE TESTING

TSB NO.	Formation	K1′	K2′	Kv	Kh
TSB-01	FF	$3.03\ E^{-09}$	$2.80\ E^{-09}$	$4.09\ E^{-09}$	$2.25\ E^{-09}$
TSB-02	CT	$3.04\ E^{-09}$	$2.58\ E^{-08}$	$9.11\ E^{-10}$	$1.01\ E^{-08}$
TSB-03	FF	$2.23\ E^{-09}$	$3.19\ E^{-09}$	$1.08\ E^{-09}$	$4.58\ E^{-09}$
TSB-04	CT	$3.05\ E^{-09}$	$5.56\ E^{-09}$	$9.14\ E^{-10}$	$1.02\ E^{-08}$
TSB-05	CT	$5.07\ E^{-09}$	$1.69\ E^{-09}$	$1.52\ E^{-09}$	$1.69\ E^{-08}$
TSB-06	CT	$4.12\ E^{-09}$	$1.21\ E^{-08}$	$1.24\ E^{-09}$	$1.37\ E^{-08}$
TSB-07	FF	$2.40\ E^{-09}$	$1.48\ E^{-09}$	$2.09\ E^{-09}$	$2.75\ E^{-09}$
TSB-08	CT	$4.00\ E^{-09}$	$4.33\ E^{-08}$	$1.20\ E^{-09}$	$1.33\ E^{-08}$
TSB-09	FF	$9.59\ E^{-09}$	$1.67\ E^{-07}$	$8.36\ E^{-09}$	$1.10\ E^{-08}$
TSB-10	FF	$6.06\ E^{-09}$	$5.01\ E^{-08}$	$8.18\ E^{-09}$	$4.49\ E^{-09}$
TSB-11	CT	$1.83\ E^{-09}$	$1.34\ E^{-08}$	$5.49\ E^{-10}$	$6.10\ E^{-09}$
TSB-12	FF	$1.85\ E^{-09}$	$2.42\ E^{-08}$	$2.50\ E^{-09}$	$1.37\ E^{-09}$
TSB-13	CT	$2.59\ E^{-09}$	$5.22\ E^{-08}$	$7.76\ E^{-10}$	$8.64\ E^{-09}$

All hydraulic conductivity values are presented in units of cm/s.

K1′ = Arithmetic time-weighted average stage 1 hydraulic conductivity.

K2′ = Arithmetic time-weighted average stage 2 hydraulic conductivity.

Kv = Final calculated vertical component of hydraulic conductivity.

Kh = Final calculated horizontal component of hydraulic conductivity.

FF = Ferrelview Formation

CT = Clay Till unit

TABLE 2

TWO STAGE BOREHOLE TESTING STATISTICS

	K1′	K2′	Kv	Kh
Maximum K Value (FF)	9.59 E^{-09}	1.67 E^{-09}	8.36 E^{-09}	1.10 E^{-08}
Minimum K Value (FF)	1.85 E^{-09}	1.48 E^{-09}	1.08 E^{-09}	1.37 E^{-09}
Logarithmic Mean (FF)	3.47 E^{-09}	1.18 E^{-08}	3.41 E^{-09}	3.52 E^{-09}
Maximum K Value (CT)	5.07 E^{-09}	5.22 E^{-08}	1.20 E^{-09}	1.69 E^{-08}
Minimum K Value (CT)	1.83 E^{-09}	1.69 E^{-09}	5.49 E^{-10}	6.10 E^{-09}
Logarithmic Mean (CT)	3.23 E^{-09}	1.37 E^{-08}	9.69 E^{-10}	1.08 E^{-08}
Maximum K (Both Units)	9.59 E^{-09}	1.67 E^{-07}	8.36 E^{-09}	1.69 E^{-08}
Minimum K (Both Units)	1.83 E^{-09}	1.48 E^{-09}	5.49 E^{-10}	1.37 E^{-09}
Logarithmic Mean (Both Units)	3.34 E^{-09}	1.28 E^{-03}	1.73 E^{-09}	6.43 E^{-09}

All hydraulic conductivity values are presented in units of cm/s.

K1′ = Arithmetic time-weighted average stage 1 hydraulic conductivity.

K2′ = Arithmetic time-weighted average stage 2 hydraulic conductivity.

Kv = Final calculated vertical component of hydraulic conductivity.

Kh = Final calculated horizontal component of hydraulic conductivity.

FF = Ferrelview Formation

CT = Clay Till unit

TABLE 3

SUMMARY
OF
WATER/LEACHATE HYDRAULIC CONDUCTIVITY DATA

	Formation	Plasticity Index	Water K	Leachate K
GT80-ST12	CT	33	1.74 E^{-09}	1.22 E^{-09}
GT83-ST06	FF	44	1.25 E^{-09}	1.2 E^{-09}
GT83-ST12	CT	35	1.0 E^{-09}	1.2 E^{-09}
GT82-ST05	FF	60	5.0 E^{-10}	6.5 E^{-10}
GT82-ST08	CT	38	1.5 E^{-08}	2.68 E^{-09}
GT84-ST07	FF	61	1.3 E^{-09}	1.3 E^{-09}

Overall natural log mean hydraulic conductivity value for water is 1.66 E^{-09} cm/s.
Overall natural log mean hydraulic conductivity value for leachate is 1.26 E^{-09} cm/s.

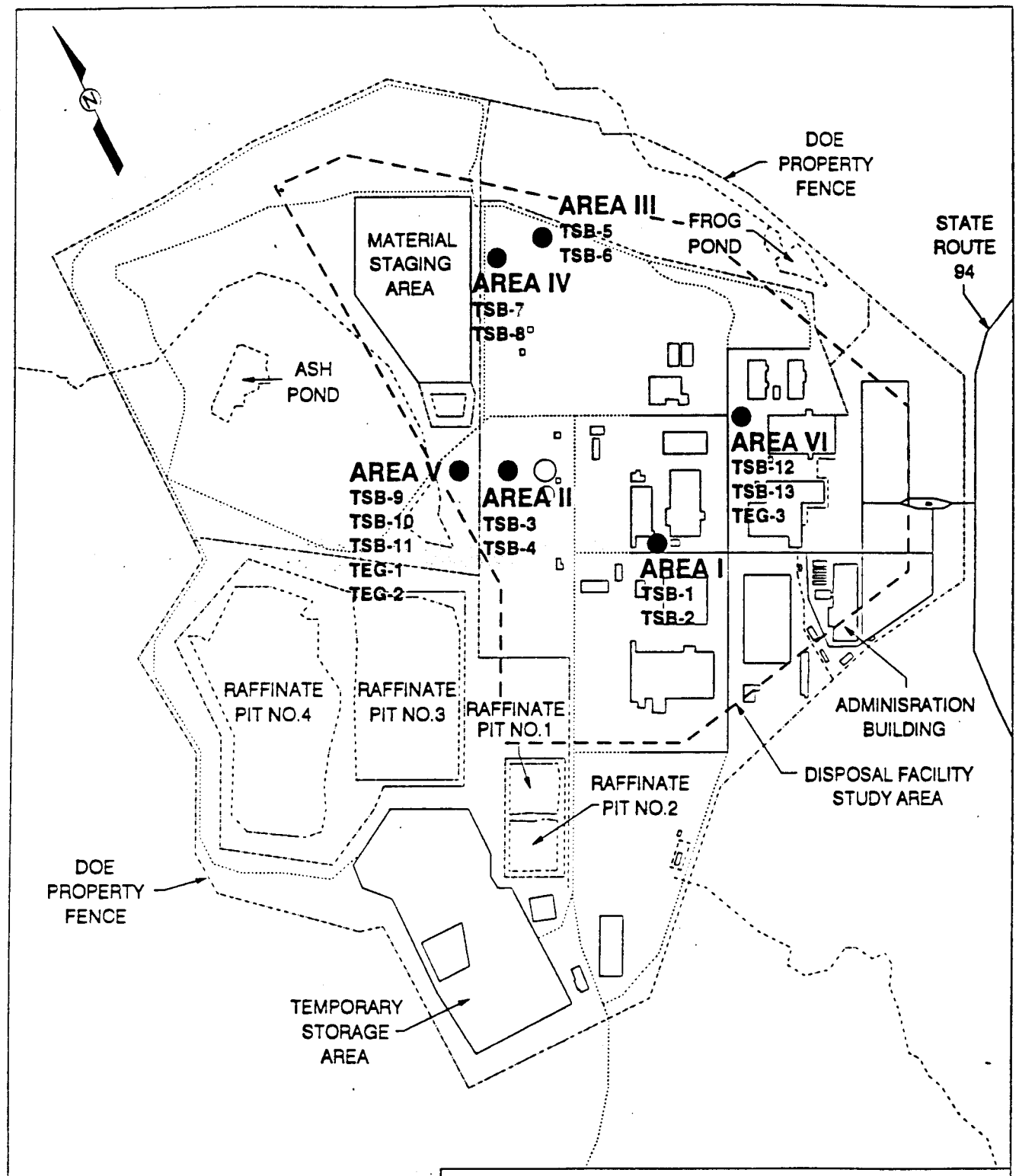
Sample ID	Formation	Days Water	Days Leachate	Water Pore Vol.	Leachate Pore Vol.	Total Pore Vol.
GT80-ST12	CT	5	38	0.18	0.70	0.88
GT83-ST06	FF	4	40	0.43	2.59	3.02
GT83-ST12	CT	7	23	0.53	1.79	2.32
GT82-ST05	FF	7	23	0.19	0.77	0.96
GT82-ST08	CT	8	16	3.53	3.91	7.44
GT84-ST07	FF	8	18	0.92	1.35	2.27

CT = Clay Till Soil Formation
FF = Ferrelview Clay Formation

Note: Values presented are current as of Nov. 16, 1992. Values for plasticity index are included for information. No correlations are proposed at this stage, relating PI to hydraulic conductivity. Hydraulic conductivity (K) values are shown in units of cm/s. Permeability testing with leachate will continue until all samples exceed 1.0 pore volume of leachate. Total pore volumes are estimated from calculations for total porosity for each sample.

ATTACHMENT 1

LOCATIONS OF TSB TESTS



TWO-STAGE BOREHOLE (TSB) PERMEABILITY TESTS LOCATION MAP

FIGURE 2-3

REPORT NO.:		EXHIBIT NO.: A/CP/089/0892	
ORIGINATOR: SDG	DRAWN BY: GLN	DATE: 8/92	

ATTACHMENT 2A

TSB
SPREADSHEET CALCULATION SUMMARY

STAGE 1 (K1')

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-1
Geometric factor-G=0.04030
Depth factor=239.12"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
										0	-	-	START
10/09	1019	-	0.00	33.25	-	-	-	-	-				
10/09	1215	6960	1.93	32.93	6.81E-09	-0.12	4.25E-09	1.1	4.68E-09	1.03	4.68E-09	-	
10/09	1359	6240	3.67	32.66	1.19E-09	0.00	1.19E-09	1.1	1.31E-09	1.19	3.06E-09	41%	
10/09	1624	8700	6.08	31.75	1.93E-08	0.00	1.93E-08	1.1	2.12E-08	4.82	1.03E-08	108%	
10/10	822	57480	22.05	14.00	4.75E-08	-0.12	4.72E-08	1.1	5.19E-08	61.84	4.04E-08	119%	
10/10	1600	13080	25.66	12.50	1.83E-08	-0.19	1.80E-08	1.1	1.76E-08	66.66	3.72E-08	8%	
10/10	1601	14460	29.70	12.13	4.10E-09	0.06	4.77E-09	1.1	5.24E-09	67.85	3.29E-08	12%	
10/10	1605	240	29.77	35.31	4.10E-09	0.00	4.77E-09	1.1	5.25E-09	67.85	3.28E-08	0%	Refill
10/11	809	57840	45.83	20.75	3.80E-08	-0.12	3.77E-08	1.1	4.14E-08	114.82	3.58E-08	9%	
10/11	1133	12240	49.23	19.13	2.06E-08	-0.19	1.82E-08	1.1	2.00E-08	119.83	3.47E-08	3%	
10/11	1555	15720	53.60	17.88	1.24E-08	0.06	1.30E-08	1.1	1.43E-08	123.84	3.31E-08	5%	
10/11	1558	180	53.65	33.75	1.24E-08	0.00	1.30E-08	1.1	1.43E-08	123.84	3.31E-08	0%	Refill
10/12	750	57120	69.52	25.25	2.23E-08	-0.06	2.22E-08	1.1	2.44E-08	151.15	3.11E-08	6%	
10/12	1153	14580	73.57	23.31	2.04E-08	-0.19	1.84E-08	1.1	2.02E-08	157.36	3.05E-08	2%	
10/12	1535	13320	77.27	22.50	9.35E-09	0.12	1.07E-08	1.1	1.18E-08	159.96	2.96E-08	3%	
10/13	743	58080	93.40	16.81	9.66E-09	-0.12	9.53E-09	1.1	1.05E-08	171.83	2.63E-08	12%	
10/13	1705	33720	102.77	17.38	6.64E-09	-0.31	5.20E-09	1.1	5.72E-09	176.43	2.44E-08	7%	
10/14	819	54840	118.00	14.63	7.92E-09	0.06	8.09E-09	1.1	8.90E-09	185.26	2.24E-08	9%	
10/14	1600	27660	125.68	14.25	2.16E-09	0.36	4.37E-09	1.1	4.81E-09	186.46	2.13E-08	5%	
10/15	855	60900	142.60	10.50	9.87E-09	-0.50	8.54E-09	1.1	9.40E-09	198.53	1.99E-08	7%	
10/15	1356	18060	147.62	10.12	3.40E-09	0.12	4.47E-09	1.1	4.92E-09	199.75	1.94E-08	3%	
10/16	806	65400	165.78	7.75	5.89E-09	-0.12	5.59E-09	1.1	6.15E-09	207.36	1.80E-08	8%	
10/16	1623	29820	174.07	6.88	4.77E-09	-0.07	4.39E-09	1.1	4.83E-09	210.16	1.73E-08	4%	
10/17	847	59040	190.47	5.50	3.84E-09	0.00	3.84E-09	1.1	4.22E-09	214.59	1.62E-08	7%	
10/18	928	88860	215.15	3.69	3.37E-09	-0.06	3.26E-09	1.1	3.58E-09	220.41	1.48E-08	9%	
10/18	929	60	215.17	33.00	3.37E-09	0.00	3.26E-09	1.1	3.59E-09	220.41	1.48E-08	0%	Refill
10/19	921	85980	239.05	23.25	1.71E-08	0.00	1.71E-08	1.1	1.88E-08	251.73	1.52E-08	3%	
10/19	1630	25740	246.20	21.63	9.70E-09	-0.06	9.34E-09	1.1	1.03E-08	256.94	1.50E-08	1%	
10/20	1635	86700	270.26	17.13	8.09E-09	-0.25	7.64E-09	1.1	8.40E-09	271.39	1.44E-08	4%	
10/21	1635	86400	294.26	14.88	4.11E-09	-0.06	4.00E-09	1.1	4.40E-09	278.82	1.36E-08	6%	
10/22	1700	87900	318.70	13.13	3.17E-09	0.00	3.17E-09	1.1	3.49E-09	284.24	1.28E-08	6%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-1
Geometric factor-G=0.04030
Depth factor=239.12"
TC values from TEC-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/23	1637	85020	342.32	11.50	3.07E-09	0.00	3.07E-09	1.1	3.38E-09	289.48	1.22E-08	5%	
10/24	1533	82560	365.25	9.94	3.05E-09	0.00	3.05E-09	1.1	3.35E-09	294.49	1.16E-08	5%	
10/25	1555	91320	390.62	8.69	2.22E-09	-0.31	1.87E-09	1.1	1.84E-09	298.50	1.10E-08	6%	+1 Hr Daylight
10/26	1310	76500	411.87	7.50	2.54E-09	-0.50	1.47E-09	1.1	1.62E-09	302.33	1.05E-08	5%	Savings Time

END OF TEST TSB-1

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-2
Geometric factor-G=0.04030
Depth factor=358.75"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (t,wa)	RPD (K1,wa)	Comments
10/09	1020	-	0.00	33.12	-	-	-	-	-	0.00	-	-	START
10/09	1216	6960	1.93	31.81	1.94E-08	-0.12	1.76E-08	1.1	1.94E-08	4.21	1.94E-08	-	
10/09	1400	6240	3.67	31.31	8.27E-09	0.00	8.27E-09	1.1	9.10E-09	5.81	1.45E-08	29%	
10/09	1624	8040	6.07	30.81	5.98E-09	0.00	5.98E-09	1.1	6.58E-09	7.42	1.14E-08	24%	
10/10	823	57540	22.05	28.06	4.96E-09	-0.12	4.74E-09	1.1	5.22E-09	16.25	6.91E-09	49%	
10/10	952	5340	23.53	27.89	7.22E-09	-0.19	3.51E-09	1.1	3.86E-09	17.44	6.72E-09	3%	
10/10	955	180	23.58	32.75	7.22E-09	0.00	3.51E-09	1.1	3.86E-09	17.44	6.71E-09	0%	
10/10	1201	7560	25.68	32.44	4.22E-09	-0.19	1.63E-09	1.1	1.80E-09	67.85	6.31E-09	6%	
10/10	1807	14760	29.78	32.00	3.07E-09	0.06	3.49E-09	1.1	3.84E-09	69.26	5.97E-09	6%	
10/11	810	57780	45.83	29.83	4.24E-09	-0.12	4.03E-09	1.1	4.43E-09	76.66	5.43E-09	9%	
10/11	1134	12240	49.23	29.06	4.84E-09	-0.19	3.22E-09	1.1	3.55E-09	78.71	5.30E-09	2%	
10/11	1559	15900	53.65	28.81	1.83E-09	0.06	2.03E-09	1.1	2.23E-09	123.84	5.05E-09	5%	
10/12	751	57120	69.52	28.68	3.52E-09	-0.06	3.41E-09	1.1	3.75E-09	130.04	4.75E-09	6%	
10/12	1153	14520	73.55	28.31	4.11E-09	-0.19	2.74E-09	1.1	3.01E-09	131.87	4.66E-09	2%	
10/12	1536	13380	77.27	28.30	7.82E-11	0.12	1.02E-09	1.1	1.12E-09	131.90	4.49E-09	4%	
10/13	744	58080	93.40	24.25	3.70E-09	-0.12	3.49E-09	1.1	3.84E-09	136.49	4.38E-09	3%	
10/13	1706	33720	102.77	23.82	1.97E-09	-0.31	9.99E-10	1.1	1.10E-09	140.51	4.08E-09	7%	
10/14	819	54780	117.98	21.75	3.61E-09	0.06	3.72E-09	1.1	4.09E-09	146.52	4.08E-09	0%	
10/14	1602	27780	125.70	22.00	9.53E-10	0.38	4.96E-10	1.1	5.45E-10	145.72	3.86E-09	5%	
10/15	654	60720	142.57	19.81	3.83E-09	-0.50	2.95E-09	1.1	3.25E-09	152.75	3.79E-09	2%	
10/15	1357	18180	147.62	19.69	7.03E-10	0.12	1.41E-09	1.1	1.55E-09	153.14	3.71E-09	2%	
10/16	807	65400	165.78	17.50	3.56E-09	-0.12	3.36E-09	1.1	3.72E-09	160.17	3.71E-09	0%	
10/16	1624	29820	174.07	16.50	3.60E-09	-0.07	3.34E-09	1.1	3.68E-09	163.39	3.71E-09	0%	
10/17	846	58920	190.43	14.75	3.20E-09	0.00	3.20E-09	1.1	3.52E-09	169.01	3.69E-09	0%	
10/18	930	89040	215.17	12.02	3.32E-09	-0.06	3.25E-09	1.1	3.57E-09	177.78	3.66E-09	0%	
10/19	920	85800	239.00	9.88	2.72E-09	0.00	2.72E-09	1.1	2.99E-09	184.65	3.61E-09	2%	
10/19	1630	25800	246.17	9.25	2.67E-09	-0.06	2.42E-09	1.1	2.66E-09	186.68	3.58E-09	1%	
10/20	1637	86820	270.28	7.00	2.85E-09	-0.25	2.53E-09	1.1	2.78E-09	193.90	3.51E-09	2%	
10/21	1635	86280	294.25	5.13	2.39E-09	-0.06	2.32E-09	1.1	2.55E-09	199.91	3.43E-09	2%	
10/21	1640	300	294.33	34.81	2.39E-09	0.00	2.32E-09	1.1	2.55E-09	199.91	3.43E-09	0%	Refill
10/22	1701	87660	318.68	32.31	2.93E-09	0.00	2.93E-09	1.1	3.22E-09	207.94	3.42E-09	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-2
Geometric factor-G=0.04030
Depth factor=358.75"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/23	1640	85140	342.33	29.86	2.95E-09	-	2.95E-09	1.1	3.25E-09	215.75	3.41E-09	0%	RTEG 3 Temp
10/24	1535	82500	365.25	27.38	3.15E-09	-	3.15E-09	1.1	3.47E-09	223.78	3.41E-09	0%	Stabilizing
10/25	1558	91380	390.63	25.13	2.58E-09	-0.37	2.15E-09	1.1	2.37E-09	231.01	3.34E-09	2%	+1 Hr Daylight
10/26	1308	76200	411.80	22.94	3.03E-09	0.12	3.19E-09	1.1	3.51E-09	238.04	3.35E-09	0%	Savings Time

END OF TEST TSB-2

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-3
Geometric factor-G=0.04030
Depth factor=162.25"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/09	1515	0	0.00	32.81	-	-	-	-	-	0.00	-	-	START
10/09	1620	3900	1.08	32.75	3.18E-09	0.00	3.18E-09	1.1	3.50E-09	0.19	3.50E-09	-	
10/10	825	57900	17.17	30.13	9.42E-09	-0.13	8.94E-09	1.1	9.84E-09	6.81	9.44E-09	92%	
10/10	1207	13320	20.87	29.38	1.16E-08	-0.16	8.98E-09	1.1	9.88E-09	11.02	9.52E-09	1%	
10/10	1610	14580	24.92	29.13	3.61E-09	0.12	5.34E-09	1.1	5.88E-09	11.82	8.92E-09	6%	
10/11	814	57840	40.98	27.00	7.80E-09	-0.25	6.88E-09	1.1	7.57E-09	18.66	8.39E-09	6%	
10/11	1137	12180	44.37	26.56	7.70E-09	-0.19	4.37E-09	1.1	4.81E-09	20.08	8.12E-09	3%	
10/11	1603	15960	48.80	26.50	6.03E-10	0.12	2.41E-09	1.1	2.65E-09	20.27	7.82E-09	6%	
10/12	753	57000	64.63	24.88	6.09E-09	0.00	6.09E-09	1.1	6.70E-09	26.47	7.40E-09	3%	
10/12	1200	14820	68.75	24.63	3.84E-09	-0.32	6.09E-09	1.1	6.70E-09	26.26	7.36E-09	1%	
10/12	1538	13080	72.38	24.75	3.84E-09	0.19	1.15E-09	1.1	1.27E-09	25.89	7.05E-09	4%	
10/13	747	58140	88.53	23.13	6.03E-09	-0.12	5.58E-09	1.1	6.14E-09	31.10	6.86E-09	2%	
10/13	1655	32880	97.87	23.13	6.03E-09	0.06	3.97E-10	1.1	4.36E-10	31.10	6.26E-09	9%	
10/14	826	55860	113.18	22.00	4.41E-09	-0.25	3.43E-09	1.1	3.76E-09	34.73	5.94E-09	5%	
10/14	1609	27780	120.90	22.63	4.41E-09	0.43	3.43E-09	1.1	3.77E-09	32.70	5.80E-09	2%	
10/15	826	59820	137.52	21.00	5.97E-09	-0.50	4.13E-09	1.1	4.54E-09	37.94	5.65E-09	3%	
10/15	1402	18960	142.78	21.06	5.94E-09	0.06	4.11E-09	1.1	4.52E-09	37.75	5.61E-09	1%	
10/16	811	65340	160.93	19.82	4.66E-09	-0.06	4.66E-09	1.1	5.13E-09	42.37	5.55E-09	1%	
10/16	1629	29880	169.23	19.06	4.16E-09	0.00	4.16E-09	1.1	4.58E-09	44.17	5.50E-09	1%	
10/17	842	58380	185.45	17.86	4.51E-09	0.06	4.74E-09	1.1	5.21E-09	47.96	5.46E-09	0%	
10/18	924	88920	210.15	16.13	4.42E-09	0.00	4.42E-09	1.1	4.87E-09	53.58	5.41E-09	1%	
10/19	1635	112260	241.33	14.31	3.66E-09	-0.13	3.42E-09	1.1	3.76E-09	59.43	5.19E-09	4%	
10/20	1640	86700	265.42	13.00	3.46E-09	-0.25	2.80E-09	1.1	3.08E-09	63.64	5.00E-09	4%	
10/21	1643	86580	289.47	12.25	2.00E-09	0.13	2.34E-09	1.1	2.58E-09	66.05	4.80E-09	4%	
10/22	1704	87660	313.82	11.50	1.98E-09	0.00	1.98E-09	1.1	2.18E-09	68.46	4.60E-09	4%	
10/23	1642	85080	337.45	10.69	2.21E-09	0.00	2.21E-09	1.1	2.43E-09	71.06	4.45E-09	3%	
10/24	1543	82860	360.47	9.50	3.36E-09	0.00	3.36E-09	1.1	3.69E-09	74.88	4.40E-09	1%	
10/25	1600	91020	385.75	8.88	1.60E-09	-0.31	8.00E-10	1.1	8.80E-10	76.87	4.17E-09	5%	+1 Hr Daylight
10/26	1510	83400	408.92	7.88	2.83E-09	-0.44	1.58E-09	1.1	1.74E-09	80.09	4.03E-09	3%	Savings Time

END OF TEST TSB-3

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-4
Geometric factor-G=0.04030
Depth factor=239.25"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	RL	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tws)	RPD (K1ws)	Comments
										0.00	-	-	START
10/09	1516	0	0.00	34.25	-	-	-	-	-	0.61	8.02E-09	-	
10/09	1620	3840	1.07	34.06	7.29E-09	0.00	7.29E-09	1.1	8.02E-09	6.81	5.26E-09	42%	
10/10	826	57960	17.17	32.13	4.93E-09	-0.12	4.82E-09	1.1	5.06E-09	7.84	4.81E-09	13%	
10/10	1208	13320	20.87	31.81	3.57E-09	-0.19	1.45E-09	1.1	1.59E-09	8.03	4.08E-09	12%	
10/10	1612	14640	24.93	31.75	6.09E-10	0.06	1.22E-09	1.1	1.34E-09	12.05	3.74E-09	9%	
10/11	815	57780	40.98	30.50	3.22E-09	-0.12	2.91E-09	1.1	3.21E-09	17.44	3.84E-09	3%	
10/11	1138	12180	44.37	30.13	4.54E-09	-0.19	2.21E-09	1.1	2.43E-09	67.85	3.43E-09	6%	
10/11	1604	15960	48.80	30.06	6.56E-10	0.06	1.22E-09	1.1	1.34E-09	70.84	3.21E-09	7%	
10/12	754	57000	64.63	29.13	2.45E-09	-0.06	2.29E-09	1.1	2.52E-09	71.87	3.10E-09	3%	
10/12	1200	14760	68.73	28.81	3.26E-09	-0.19	1.32E-09	1.1	1.46E-09	74.47	2.83E-09	9%	
10/13	748	71280	88.53	28.00	1.71E-09	0.00	1.71E-09	1.1	1.88E-09	78.48	2.62E-09	8%	
10/14	825	88620	113.15	26.75	2.13E-09	-0.25	1.70E-09	1.1	1.86E-09	119.02	6.47E-09	85%	
10/15	845	87600	137.48	14.13	2.24E-08	-0.12	2.21E-08	1.1	2.44E-08	119.83	6.36E-09	2%	
10/15	1401	18960	142.75	13.88	2.10E-09	0.12	3.11E-09	1.1	3.42E-09	119.83	6.36E-09	0%	Refill
10/15	1442	60	142.77	34.75	2.10E-09	0.00	3.11E-09	1.1	3.42E-09	131.07	6.62E-09	4%	
10/16	810	62880	160.23	31.25	8.24E-09	-0.12	7.96E-09	1.1	8.75E-09	134.70	6.56E-09	1%	
10/16	1627	29820	168.52	30.12	5.86E-09	-0.07	5.31E-09	1.1	5.84E-09	140.71	6.46E-09	2%	
10/17	841	58440	184.75	28.25	4.80E-09	0.00	4.80E-09	1.1	5.28E-09	146.93	6.25E-09	3%	
10/18	925	89040	209.48	25.89	4.35E-09	-0.06	4.25E-09	1.1	4.67E-09	156.58	6.08E-09	3%	
10/19	932	86820	233.60	23.31	4.19E-09	0.00	4.19E-09	1.1	4.61E-09	156.57	6.01E-09	1%	
10/19	1634	25320	240.63	22.69	3.76E-09	-0.06	3.40E-09	1.1	3.74E-09	165.00	5.76E-09	4%	
10/20	1642	86880	264.77	20.69	3.56E-09	-0.25	3.11E-09	1.1	3.42E-09	170.43	5.57E-09	4%	
10/21	1644	86520	288.80	19.00	3.04E-09	-0.06	2.93E-09	1.1	3.22E-09	175.85	5.39E-09	3%	
10/22	1705	87660	313.15	17.31	3.02E-09	0.00	3.02E-09	1.1	3.32E-09	181.25	5.25E-09	3%	
10/23	1645	85200	336.82	15.63	3.11E-09	0.00	3.11E-09	1.1	3.42E-09	186.68	5.14E-09	2%	
10/24	1545	82800	359.82	13.94	3.24E-09	0.00	3.24E-09	1.1	3.56E-09	191.89	4.96E-09	4%	+1 Hr Daylight
10/25	1602	91020	385.10	12.38	2.74E-09	-0.31	2.19E-09	1.1	2.41E-09	196.93	4.82E-09	3%	Savings Time
10/26	1504	82920	408.13	10.75	3.16E-09	-0.50	2.19E-09	1.1	2.41E-09				

END OF TEST TSB-4

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSD-5
Geometric factor-G=0.04534
Depth factor=153.5"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
										0.00	-	-	START
10/10	853	0	0.00	33.50	-	-	-	-	-	1.19	3.86E-09	-	
10/10	1232	13140	3.65	33.13	6.83E-09	-0.18	3.51E-09	1.1	3.86E-09	1.41	3.65E-09	5%	
10/10	1636	14640	7.72	33.06	1.16E-09	0.12	3.15E-09	1.1	3.47E-09	10.44	9.26E-09	87%	
10/11	833	57420	23.67	30.25	1.20E-08	-0.25	1.09E-08	1.1	1.20E-08	12.24	9.13E-09	2%	
10/11	1159	12360	27.10	29.69	1.12E-08	-0.19	7.39E-09	1.1	8.13E-09	12.66	8.53E-09	7%	
10/11	1606	14940	31.25	29.56	2.15E-09	0.12	4.14E-09	1.1	4.56E-09	21.07	9.90E-09	15%	
10/12	758	57000	47.08	26.94	1.15E-08	0.00	1.15E-08	1.1	1.26E-08	23.29	9.67E-09	2%	
10/12	1203	14700	51.17	26.25	1.16E-08	-0.32	8.33E-09	1.1	8.96E-09	23.66	9.46E-09	2%	
10/12	1541	13080	54.80	26.13	2.31E-09	0.19	5.98E-09	1.1	6.58E-09	31.93	9.99E-09	5%	
10/13	751	58200	70.97	23.56	1.12E-08	-0.12	1.07E-08	1.1	1.18E-08	34.34	9.88E-09	3%	
10/13	1641	31800	79.80	22.81	6.05E-09	0.06	6.54E-09	1.1	7.19E-09	40.54	9.43E-09	3%	
10/14	853	58320	96.00	20.88	8.56E-09	-0.25	7.44E-09	1.1	8.19E-09	39.35	8.77E-09	7%	
10/14	1638	27900	103.75	21.25	-3.4E-09	0.43	5.59E-10	1.1	6.15E-10	46.58	8.77E-09	0%	
10/15	830	57120	119.62	19.00	1.03E-08	-0.50	7.99E-09	1.1	8.79E-09	47.36	8.57E-09	2%	
10/15	1416	20760	125.38	18.75	3.17E-09	0.06	3.93E-09	1.1	4.32E-09	53.39	8.50E-09	1%	
10/16	827	65460	143.57	16.88	7.56E-09	-0.06	7.32E-09	1.1	8.05E-09	55.41	8.38E-09	1%	
10/16	1642	29700	151.82	16.25	5.86E-09	0.00	5.86E-09	1.1	6.22E-09	60.04	8.32E-09	1%	
10/17	825	56580	167.53	14.81	6.83E-09	0.06	7.11E-09	1.1	7.82E-09	66.24	8.09E-09	3%	
10/18	857	88320	192.07	12.88	5.92E-09	0.00	5.92E-09	1.1	6.51E-09	72.28	7.96E-09	2%	
10/19	952	89700	216.98	11.00	5.74E-09	0.19	6.33E-09	1.1	6.96E-09	73.69	7.83E-09	2%	
10/19	1650	25080	223.95	10.56	4.84E-09	-0.13	3.41E-09	1.1	3.75E-09	78.70	7.52E-09	4%	
10/20	1650	86400	247.95	9.00	5.01E-09	-0.25	4.21E-09	1.1	4.63E-09	82.11	7.23E-09	4%	
10/21	1648	86280	271.92	7.94	3.44E-09	0.13	3.86E-09	1.1	4.25E-09	85.74	6.97E-09	4%	
10/22	1709	87660	296.27	6.81	3.63E-09	0.00	3.63E-09	1.1	4.00E-09	89.76	6.79E-09	3%	
10/23	1647	85080	319.90	5.56	4.17E-09	0.00	4.17E-09	1.1	4.59E-09	89.76	6.79E-09	0%	Refill
10/23	1650	180	343.58	34.00	4.17E-09	0.00	4.17E-09	1.1	4.59E-09	97.79	6.44E-09	5%	
10/24	1548	82680	366.55	31.50	7.36E-09	0.00	7.36E-09	1.1	8.10E-09	103.00	6.27E-09	3%	+1 Hr Daylight
10/25	1605	91020	391.83	29.88	4.38E-09	-0.31	3.54E-09	1.1	3.89E-09	108.62	6.14E-09	2%	Savings Time
10/26	1625	87600	416.17	28.13	4.96E-09	-0.44	3.71E-09	1.1	4.08E-09	112.05	6.12E-09	0%	
10/27	805	56400	431.83	27.06	4.75E-09	0.06	5.02E-09	1.1	5.52E-09	113.05	6.10E-09	0%	END OF TEST TS
10/27	1110	11100	434.92	26.75	7.02E-09	-0.19	2.72E-09	1.1	2.99E-09				

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-6
Geometric factor-G=0.04534
Depth factor=231.5"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tws)	RPD (K1ws)	Comments
10/10	923	0	0.00	33.82	-	-	-	-	-	0.00	-	-	START
10/10	959	2160	0.60	33.00	4.91E-08	0.00	4.91E-08	1.1	5.41E-08	1.99	5.41E-08	-	
10/10	1234	9300	3.18	31.31	3.13E-08	-0.19	2.77E-08	1.1	3.05E-08	7.42	3.49E-08	43%	
10/10	1638	14640	7.25	29.88	1.69E-08	0.06	1.76E-08	1.1	1.94E-08	12.01	2.82E-08	29%	
10/11	832	57240	23.15	26.50	1.03E-08	-0.12	9.94E-09	1.1	1.09E-08	22.87	1.57E-08	50%	
10/11	1200	12480	26.62	26.06	6.20E-09	-0.19	3.52E-09	1.1	3.87E-09	24.29	1.42E-08	10%	
10/11	1609	14940	30.77	25.88	2.12E-09	0.06	2.83E-09	1.1	3.11E-09	24.86	1.27E-08	11%	
10/12	759	57000	46.60	23.25	8.17E-09	-0.06	7.96E-09	1.1	8.76E-09	33.31	1.14E-08	11%	
10/12	1204	14700	50.68	22.86	4.46E-09	-0.19	2.18E-09	1.1	2.40E-09	34.50	1.06E-08	7%	
10/12	1542	13080	54.32	22.81	9.54E-10	0.12	2.59E-09	1.1	2.85E-09	34.73	1.01E-08	5%	
10/13	752	58200	70.48	20.25	7.86E-09	-0.12	7.51E-09	1.1	8.26E-09	42.95	9.89E-09	4%	
10/13	1643	31860	79.33	19.75	2.83E-09	-0.31	1.07E-09	1.1	1.18E-09	44.56	8.74E-09	10%	
10/14	854	58260	95.52	17.82	6.83E-09	0.06	6.81E-09	1.1	7.49E-09	51.40	8.53E-09	2%	
10/14	1639	27900	103.27	17.94	6.83E-09	0.36	3.91E-10	1.1	4.31E-10	50.37	7.92E-09	7%	
10/15	831	57120	119.13	15.83	7.39E-09	-0.50	5.78E-09	1.1	6.36E-09	57.79	7.71E-09	3%	
10/15	1416	20700	124.88	15.38	2.22E-09	0.12	3.28E-09	1.1	3.61E-09	58.59	7.52E-09	2%	
10/16	826	65400	143.05	13.00	6.72E-09	-0.12	6.38E-09	1.1	7.01E-09	66.24	7.46E-09	1%	
10/16	1627	29820	151.33	12.13	5.42E-09	-0.07	4.98E-09	1.1	5.48E-09	69.04	7.35E-09	1%	
10/17	841	56580	167.05	10.25	6.21E-09	0.00	6.21E-09	1.1	6.83E-09	75.07	7.30E-09	1%	
10/18	858	86320	191.58	7.94	4.93E-09	-0.06	4.50E-09	1.1	5.26E-09	82.50	7.04E-09	4%	
10/19	953	89700	216.50	5.50	5.18E-09	0.00	5.18E-09	1.1	5.70E-09	90.33	6.89E-09	2%	
10/19	953	0	216.50	31.44	5.18E-09	0.00	5.18E-09	1.1	5.70E-09	90.33	6.89E-09	0%	Refill
10/19	1650	25020	223.45	30.63	5.59E-09	-0.06	5.18E-09	1.1	5.69E-09	92.93	6.85E-09	1%	
10/20	1650	86400	247.45	28.31	4.67E-09	-0.25	4.16E-09	1.1	4.58E-09	100.38	6.63E-09	3%	
10/21	1651	86460	271.47	26.38	3.91E-09	-0.06	3.79E-09	1.1	4.17E-09	106.58	6.41E-09	3%	
10/22	1711	86824	296.14	24.38	3.97E-09	0.00	3.97E-09	1.1	4.37E-09	113.01	6.24E-09	3%	
10/23	1648	85020	319.76	22.38	4.18E-09	0.00	4.18E-09	1.1	4.60E-09	119.43	6.12E-09	2%	
10/24	1549	82860	342.77	20.50	4.07E-09	0.00	4.07E-09	1.1	4.47E-09	125.47	6.01E-09	2%	
10/25	1607	91080	368.07	18.50	3.97E-09	-0.31	3.35E-09	1.1	3.68E-09	131.90	5.85E-09	3%	+1 Hr Daylight
10/26	1627	87600	392.41	16.31	4.55E-09	-0.50	3.51E-09	1.1	3.86E-09	138.93	5.73E-09	2%	Savings Time

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-6
Geometric factor-G=0.04534
Depth factor=231.5"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (t,wa)	RPD (K1,wa)	Comments
10/27	804	56220	408.02	14.88	4.67E-09	-0.25	3.85E-09	1.1	4.23E-09	143.53	5.87E-09	1%	
10/27	1125	12060	411.37	14.83	3.82E-09	-0.07	2.75E-09	1.1	3.02E-09	144.33	5.85E-09	0%	

END OF TEST TSB-6

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-7
Geometric factor-G=0.04534
Depth factor=161.25"
TC values from TEC-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/09	1112	0	0.00	33.50	-	-	-	-	-	0.00	-	-	START
10/09	1450	13080	3.63	33.31	3.38E-09	-0.08	1.96E-09	1.1	2.15E-09	0.81	2.16E-09	-	
10/10	836	63960	21.40	31.87	4.66E-09	-0.13	4.79E-09	1.1	5.27E-09	5.24	4.74E-09	75%	
10/10	1228	13929	25.27	31.63	3.58E-09	-0.18	1.01E-09	1.1	1.11E-09	6.01	4.16E-09	12%	
10/10	1632	14640	29.33	31.50	1.85E-09	0.12	4.02E-09	1.1	4.42E-09	6.42	4.22E-09	1%	
10/11	829	57420	45.28	30.25	4.54E-09	-0.25	4.11E-09	1.1	4.52E-09	10.44	4.32E-09	2%	
10/11	1141	11520	48.48	30.06	3.45E-09	-0.19	4.11E-09	1.1	4.52E-09	11.05	4.34E-09	0%	
10/11	1611	16200	52.98	29.94	1.55E-09	0.12	3.51E-09	1.1	3.86E-09	11.44	4.30E-09	1%	
10/12	800	56940	68.80	29.06	3.25E-09	0.00	3.67E-09	1.1	4.04E-09	14.26	4.24E-09	1%	
10/12	1205	14700	72.88	28.88	2.58E-09	-0.32	3.67E-09	1.1	4.04E-09	14.84	4.23E-09	0%	
10/12	1543	13080	76.52	28.66	2.58E-09	0.19	3.47E-09	1.1	3.81E-09	14.84	4.21E-09	0%	
10/13	754	58260	92.70	27.86	3.63E-09	-0.12	3.61E-09	1.1	3.97E-09	16.05	4.17E-09	1%	
10/13	1645	31860	101.55	27.75	6.65E-10	0.06	1.43E-09	1.1	1.57E-09	16.47	3.94E-09	6%	
10/14	850	57900	117.63	26.81	3.45E-09	-0.25	2.86E-09	1.1	3.15E-09	21.49	3.83E-09	3%	
10/14	1835	27900	125.38	27.19	3.45E-09	0.43	4.32E-10	1.1	4.75E-10	20.27	3.82E-09	6%	
10/15	834	57540	141.37	26.13	3.93E-09	-0.50	2.35E-09	1.1	2.58E-09	23.68	3.51E-09	3%	
10/15	1413	20340	147.02	26.06	7.36E-10	0.06	1.55E-09	1.1	1.70E-09	23.90	3.44E-09	2%	
10/16	823	65400	165.18	25.00	3.48E-09	-0.06	3.71E-09	1.1	4.08E-09	27.31	3.51E-09	2%	
10/16	1640	29820	173.47	24.82	2.75E-09	0.00	3.11E-09	1.1	3.42E-09	28.53	3.50E-09	0%	
10/17	831	57060	189.32	23.88	2.80E-09	0.06	3.43E-09	1.1	3.77E-09	30.90	3.53E-09	1%	
10/18	900	86140	213.80	22.75	2.78E-09	0.00	3.15E-09	1.1	3.46E-09	34.53	3.52E-09	0%	
10/19	950	89400	238.63	21.75	2.44E-09	0.19	3.29E-09	1.1	3.62E-09	37.75	3.53E-09	0%	
10/19	1645	24900	245.55	21.50	2.20E-09	-0.13	1.19E-09	1.1	1.31E-09	38.55	3.47E-09	2%	
10/20	1654	86940	269.70	20.56	2.36E-09	-0.25	1.97E-09	1.1	2.17E-09	41.57	3.35E-09	3%	
10/21	1654	86400	293.70	19.88	1.74E-09	0.13	2.34E-09	1.1	2.58E-09	43.75	3.29E-09	2%	
10/22	1713	87540	318.02	19.19	1.75E-09	0.00	1.98E-09	1.1	2.17E-09	45.97	3.20E-09	3%	
10/23	1655	85320	341.72	18.38	2.11E-09	-	2.39E-09	1.1	2.63E-09	48.57	3.16E-09	1%	
10/24	1552	82620	364.67	17.50	2.30E-09	0.19	3.26E-09	1.1	3.61E-09	51.40	3.19E-09	1%	
10/25	1608	90960	389.93	16.75	1.65E-09	-0.31	1.23E-09	1.1	1.35E-09	53.81	3.07E-09	4%	+1 Hr Daylight
10/26	1628	87600	414.27	15.75	2.58E-09	-0.44	1.63E-09	1.1	1.79E-09	57.02	3.00E-09	2%	Savings Time
10/27	807	56340	429.92	15.25	2.01E-09	0.06	2.55E-09	1.1	2.81E-09	58.63	2.99E-09	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-7
Geometric factor-G=0.04534
Depth factor=161.25"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/27	930	4980	431.30	15.25	0.00E+00	0.08	3.10E-09	1.1	3.41E-09	58.83	2.99E-09	0%	

END OF TEST TSB-7

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-8
Geometric factor-G=0.04534
Depth factor=237.0"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/09	1110	0	0.00	33.62	-	-	-	-	-	0.00	-	-	START
10/09	1458	13680	3.80	33.31	3.80E-09	0.00	3.80E-09	1.1	4.18E-09	1.00	4.18E-09	-	
10/10	837	63540	21.45	31.06	5.96E-09	0.00	5.96E-09	1.1	6.56E-09	8.22	6.14E-09	38%	
10/10	1229	13920	25.32	30.75	3.77E-09	-0.19	1.46E-09	1.1	1.60E-09	9.22	5.45E-09	12%	
10/10	1633	14640	29.38	29.83	1.30E-08	0.06	1.37E-08	1.1	1.50E-08	12.82	8.77E-09	22%	
10/11	830	57420	45.33	27.83	5.95E-09	-0.12	5.59E-09	1.1	6.15E-09	19.24	6.55E-09	3%	
10/11	1142	11520	48.53	27.31	4.76E-09	-0.19	1.93E-09	1.1	2.13E-09	20.27	6.26E-09	5%	
10/11	1612	16200	53.03	27.19	1.27E-09	0.06	1.91E-09	1.1	2.10E-09	20.86	5.91E-09	6%	
10/12	801	56940	68.85	25.86	3.96E-09	-0.06	3.78E-09	1.1	4.15E-09	24.86	5.51E-09	7%	
10/12	1208	14700	72.93	25.63	2.93E-09	-0.19	7.04E-10	1.1	7.74E-10	25.87	5.24E-09	5%	
10/12	1544	13080	76.57	25.39	-7.9E-10	0.12	7.92E-10	1.1	8.71E-10	26.47	5.03E-09	4%	
10/13	755	58260	92.75	24.38	3.89E-09	-0.12	3.53E-09	1.1	3.89E-09	29.88	4.83E-09	4%	
10/14	852	89820	117.70	23.06	2.56E-09	-0.25	2.07E-09	1.1	2.28E-09	33.92	4.29E-09	12%	
10/15	833	85260	141.38	22.06	2.05E-09	-0.12	1.80E-09	1.1	1.98E-09	37.14	3.90E-09	9%	
10/15	1414	20460	147.07	22.00	5.13E-10	0.12	1.54E-09	1.1	1.69E-09	37.33	3.82E-09	2%	
10/16	824	65400	165.23	20.31	4.54E-09	-0.12	4.22E-09	1.1	4.64E-09	42.76	3.91E-09	2%	
10/16	1640	29760	173.50	19.63	4.03E-09	-0.07	3.62E-09	1.1	3.98E-09	44.94	3.91E-09	0%	
10/17	830	57000	189.33	18.44	3.70E-09	0.00	3.70E-09	1.1	4.07E-09	48.76	3.93E-09	0%	
10/18	900	86200	213.83	16.88	3.15E-09	-0.06	3.03E-09	1.1	3.33E-09	53.78	3.86E-09	2%	
10/19	950	89400	238.67	15.38	3.01E-09	0.00	3.01E-09	1.1	3.31E-09	58.59	3.80E-09	1%	
10/19	1647	25020	245.62	15.00	2.73E-09	-0.06	2.30E-09	1.1	2.53E-09	59.82	3.76E-09	1%	
10/20	1655	86880	269.75	13.69	2.72E-09	-0.25	2.20E-09	1.1	2.42E-09	64.02	3.64E-09	3%	
10/21	1655	86400	293.75	11.19	5.26E-09	-0.06	5.13E-09	1.1	5.65E-09	72.06	3.81E-09	4%	
10/22	1715	87600	318.08	9.25	4.06E-09	0.00	4.06E-09	1.1	4.47E-09	78.29	3.86E-09	1%	
10/23	1657	85320	341.78	7.25	4.33E-09	-	4.33E-09	1.1	4.77E-09	84.71	3.92E-09	2%	
10/24	1548	82260	364.63	5.50	3.96E-09	-	3.96E-09	1.1	4.36E-09	90.33	3.95E-09	1%	
10/25	1610	91320	390.00	3.94	3.20E-09	-0.31	2.57E-09	1.1	2.82E-09	95.35	3.88E-09	2%	+1 Hr Daylight
10/26	1629	87540	414.32	2.00	4.19E-09	-0.50	3.10E-09	1.1	3.42E-09	101.58	3.85E-09	1%	Savings Time
10/26	1632	180	414.37	22.38	4.19E-09	0.00	3.10E-09	1.1	3.41E-09	101.58	3.85E-09	0%	Refill
10/27	806	56040	429.93	20.50	5.89E-09	-0.25	4.57E-09	1.1	5.03E-09	107.62	3.89E-09	1%	
10/27	930	5040	431.33	20.50	5.89E-09	-0.25	4.57E-09	1.1	5.03E-09	114.04	3.89E-09	0%	Repeat

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSD-9
Geometric factor-G=0.04030
Depth factor=160.0"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/07	836	0	0.00	35.25	-	-	-	-	-	0.00	-	-	START
10/07	1109	12780	3.55	35.30	-8.1E-10	-	-8.1E-10	1.1	-8.9E-10	-0.16	-8.86E-10	-	
10/07	1720	22260	9.73	35.20	9.27E-10	-	9.27E-10	1.1	1.02E-09	0.16	3.24E-10	-430%	
10/08	732	51120	23.93	33.75	5.86E-09	-	5.86E-09	1.1	6.47E-09	4.82	3.97E-09	170%	
10/08	1214	16920	28.63	33.19	6.89E-09	-	6.89E-09	1.1	7.58E-09	6.62	4.56E-09	14%	
10/08	1544	12600	32.13	32.81	6.30E-09	-0.05	5.47E-09	1.1	6.01E-09	7.84	4.72E-09	3%	
10/09	815	59460	48.65	30.94	6.61E-09	-0.38	5.26E-09	1.1	5.78E-09	13.85	5.08E-09	7%	
10/09	1005	6600	50.48	30.88	6.32E-09	-0.13	4.16E-09	1.1	4.57E-09	14.66	5.06E-09	0%	
10/09	1541	20160	56.08	30.25	4.51E-09	-0.06	3.87E-09	1.1	4.04E-09	16.06	4.96E-09	2%	
10/10	830	60540	72.90	28.12	7.49E-09	-0.13	7.03E-09	1.1	7.74E-09	22.90	5.80E-09	12%	
10/10	1220	13800	76.73	27.83	7.82E-09	-0.18	4.82E-09	1.1	5.30E-09	24.48	5.59E-09	0%	
10/10	1620	14400	80.73	27.38	3.73E-09	0.12	5.52E-09	1.1	6.08E-09	25.28	5.61E-09	0%	
10/11	824	57840	96.80	24.69	1.01E-08	-0.25	9.13E-09	1.1	1.00E-08	33.92	6.35E-09	12%	
10/11	1153	12540	100.28	24.25	7.87E-09	-0.19	4.35E-09	1.1	4.79E-09	35.34	6.29E-09	1%	
10/11	1823	16200	104.78	23.81	5.95E-09	0.12	7.57E-09	1.1	8.33E-09	36.75	6.38E-09	1%	
10/12	815	57120	120.85	21.50	8.92E-09	0.00	8.92E-09	1.1	9.82E-09	44.17	6.83E-09	7%	
10/12	1215	14400	124.85	21.00	7.72E-09	-0.32	2.78E-09	1.1	3.05E-09	45.78	6.71E-09	2%	
10/12	1553	13080	128.28	20.63	8.30E-09	0.19	9.55E-09	1.1	1.05E-08	46.97	6.82E-09	2%	
10/13	807	58440	144.52	18.19	9.36E-09	-0.12	8.91E-09	1.1	9.81E-09	54.80	7.15E-09	5%	
10/13	1702	32100	153.43	17.31	8.22E-09	0.06	6.64E-09	1.1	7.30E-09	57.83	7.16E-09	0%	
10/14	828	55560	168.87	15.06	9.26E-09	-0.25	8.23E-09	1.1	9.05E-09	64.86	7.33E-09	2%	
10/14	1612	27840	176.60	14.50	4.64E-09	0.43	8.21E-09	1.1	9.03E-09	66.66	7.41E-09	1%	
10/15	837	59100	193.02	11.88	1.03E-08	-0.49	8.37E-09	1.1	9.21E-09	75.07	7.56E-09	2%	
10/15	1409	19920	198.55	11.25	7.43E-09	0.06	8.14E-09	1.1	8.95E-09	77.10	7.60E-09	1%	
10/16	819	65400	216.72	8.63	9.50E-09	-0.06	9.26E-09	1.1	1.02E-08	85.52	7.82E-09	3%	
10/16	1636	29820	225.00	7.38	1.01E-08	0.00	1.01E-08	1.1	1.11E-08	89.53	7.94E-09	2%	
10/17	834	57480	240.97	5.12	9.53E-09	0.06	9.79E-09	1.1	1.08E-08	96.79	8.13E-09	2%	
10/18	905	88260	265.48	1.88	9.05E-09	0.00	9.05E-09	1.1	9.95E-09	107.20	8.30E-09	2%	
10/18	906	88320	290.02	33.81	9.05E-09	0.00	9.05E-09	1.1	9.05E-09	107.20	8.36E-09	1%	Refill
10/19	1642	113760	321.62	27.88	1.10E-08	-0.13	1.06E-08	1.1	1.16E-08	126.25	8.70E-09	4%	
10/20	1702	87600	345.95	23.94	9.75E-09	-0.25	9.13E-09	1.1	1.00E-08	138.91	8.79E-09	1%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-9
Geometric factor-G=0.04030
Depth factor=160.0"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tws)	RPD (K1ws)	Comments
10/21	1707	86700	370.03	20.44	8.93E-09	0.13	9.26E-09	1.1	1.02E-08	150.15	8.89E-09	1%	
10/22	1728	87660	394.38	17.06	8.59E-09	0.00	8.59E-09	1.1	9.56E-09	161.01	8.93E-09	0%	
10/23	1710	85320	418.08	13.81	8.75E-09	-	8.75E-09	1.1	9.63E-09	171.45	8.97E-09	0%	
10/24	1810	82800	441.08	10.83	8.99E-09	-	8.99E-09	1.1	9.89E-09	181.86	9.02E-09	1%	
10/25	1625	90900	466.33	7.38	8.53E-09	-0.31	7.71E-09	1.1	8.48E-09	192.10	8.99E-09	0%	+1 Hr Daylight
10/26	1620	86100	490.25	4.13	9.18E-09	-0.44	7.92E-09	1.1	8.72E-09	202.55	8.97E-09	0%	Savings Time
10/26	1623	180	490.30	27.75	9.18E-09	0.00	7.92E-09	1.1	8.72E-09	202.55	8.97E-09	0%	Refill
10/27	813	57000	506.13	24.88	1.09E-08	0.06	1.11E-08	1.1	1.22E-08	211.77	9.07E-09	1%	

END OF TEST TSB-9

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-10
Geometric factor-G=0.04534
Depth factor=185.25"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/08	749	0	0.00	35.06	-	-	-	-	-	0.00	-	-	START
10/08	1032	9780	2.72	34.31	1.58E-08	-	1.58E-08	1.1	1.74E-08	2.41	1.74E-08	-	
10/08	1215	6180	4.43	33.56	2.51E-08	-	2.51E-08	1.1	2.76E-08	4.82	2.13E-08	20%	
10/08	1544	12540	7.92	33.00	9.27E-09	-0.05	8.44E-09	1.1	9.28E-09	8.82	1.60E-08	28%	
10/09	816	59520	24.45	30.31	9.45E-09	-0.38	8.11E-09	1.1	8.92E-09	15.26	1.12E-08	35%	
10/09	1008	6600	26.28	30.00	9.89E-09	-0.13	8.74E-09	1.1	8.31E-09	16.25	1.09E-08	3%	
10/09	1542	20160	31.88	29.44	5.86E-09	-0.08	5.02E-09	1.1	5.52E-09	18.05	9.94E-09	9%	
10/10	831	60540	48.70	27.00	6.56E-09	-0.13	6.10E-09	1.1	6.91E-09	25.89	9.58E-09	4%	
10/10	1222	13860	52.55	26.63	5.71E-09	-0.18	2.93E-09	1.1	3.22E-09	27.08	9.12E-09	5%	
10/10	1622	14400	56.55	26.25	5.65E-09	0.12	7.44E-09	1.1	8.18E-09	28.30	9.05E-09	1%	
10/11	825	57780	72.60	23.75	9.33E-09	-0.25	8.39E-09	1.1	9.23E-09	36.33	9.09E-09	0%	
10/11	1154	12540	76.08	23.31	7.62E-09	-0.19	4.33E-09	1.1	4.76E-09	37.75	8.89E-09	2%	
10/11	1624	16200	80.58	23.06	3.36E-09	0.12	4.97E-09	1.1	5.47E-09	38.55	8.70E-09	2%	
10/12	816	57120	96.45	20.88	8.35E-09	0.00	8.35E-09	1.1	9.19E-09	45.55	8.76E-09	1%	
10/12	1216	14400	100.45	20.44	6.73E-09	-0.32	1.83E-09	1.1	2.02E-09	46.97	8.51E-09	3%	
10/12	1553	13020	104.07	20.38	1.02E-09	0.19	4.24E-09	1.1	4.66E-09	47.16	8.38E-09	2%	
10/13	807	58440	120.30	18.06	8.80E-09	-0.12	8.35E-09	1.1	9.18E-09	54.81	8.49E-09	1%	
10/13	1700	31980	129.18	17.75	2.16E-09	0.06	2.58E-09	1.1	2.84E-09	55.81	8.10E-09	5%	
10/14	832	55920	144.72	15.75	8.03E-09	-0.25	7.02E-09	1.1	7.72E-09	62.03	8.06E-09	1%	
10/14	1632	28800	152.72	16.00	-2.0E-09	0.43	1.41E-09	1.1	1.55E-09	61.23	7.72E-09	4%	
10/15	838	57960	168.82	13.56	9.54E-09	-0.49	7.62E-09	1.1	8.38E-09	69.07	7.78E-09	1%	
10/15	1408	19800	174.32	13.38	2.07E-09	0.06	2.77E-09	1.1	3.04E-09	69.65	7.63E-09	2%	
10/16	816	65400	192.48	11.19	7.69E-09	-0.06	7.47E-09	1.1	8.22E-09	76.68	7.69E-09	1%	
10/16	1636	29880	200.78	10.25	7.26E-09	0.00	7.26E-09	1.1	8.01E-09	79.70	7.70E-09	0%	
10/17	835	57540	216.77	8.44	7.33E-09	0.06	7.57E-09	1.1	8.33E-09	85.52	7.75E-09	1%	
10/18	910	88500	241.35	6.00	6.49E-09	0.00	6.49E-09	1.1	7.14E-09	93.35	7.66E-09	1%	
10/18	911	60	241.37	31.50	6.49E-09	0.00	6.49E-09	1.1	7.14E-09	93.35	7.66E-09	0%	Refill
10/19	940	88140	265.85	28.50	7.17E-09	0.19	7.63E-09	1.1	8.39E-09	102.99	7.75E-09	1%	
10/19	1642	25320	272.88	27.44	6.90E-09	-0.13	7.81E-09	1.1	8.59E-09	106.39	7.77E-09	0%	
10/20	1704	87720	297.25	24.81	6.43E-09	-0.25	5.62E-09	1.1	6.40E-09	114.84	7.66E-09	1%	
10/21	1708	86640	321.32	22.75	5.16E-09	0.13	5.48E-09	1.1	6.03E-09	121.46	7.54E-09	2%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-10
Geometric factor-G=0.04534
Depth factor=185.25"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (t,ws)	RPD (K1,ws)	Comments
10/22	1729	87660	345.67	20.89	5.15E-09	0.00	5.15E-09	1.1	5.66E-09	128.08	7.41E-09	2%	
10/23	1711	85320	369.37	18.44	5.84E-09	-	5.84E-09	1.1	6.42E-09	135.30	7.34E-09	1%	
10/24	1613	82920	392.40	16.25	5.91E-09	-	5.91E-09	1.1	6.50E-09	142.34	7.29E-09	1%	
10/25	1626	90780	417.62	14.00	5.81E-09	-0.31	4.83E-09	1.1	5.32E-09	149.57	7.17E-09	2%	+1 Hr Daylight
10/26	1620	86040	441.52	11.89	6.15E-09	-0.44	4.97E-09	1.1	5.47E-09	156.99	7.08E-09	1%	Savings Time
10/27	813	57180	457.40	10.06	6.59E-09	0.06	6.83E-09	1.1	7.52E-09	162.22	7.10E-09	0%	

END OF TEST TSB-10

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-11
Geometric factor-G=0.04030
Depth factor=234.75"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
										0.00	-	-	START
10/08	0	0	0.00	33.75	-	-	-	-	-	0.00	-	-	START
10/08	1216	16860	4.68	32.87	7.85E-09	0.00	7.85E-09	1.1	8.63E-09	2.83	8.63E-09	-	
10/08	1545	12540	8.17	32.56	3.72E-09	0.00	3.72E-09	1.1	4.10E-09	3.82	6.70E-09	25%	
10/09	816	59460	24.68	30.87	4.30E-09	-0.32	3.48E-09	1.1	3.83E-09	9.25	4.78E-09	33%	
10/09	1007	6660	26.53	30.68	4.33E-09	-0.12	1.59E-09	1.1	1.75E-09	9.66	4.57E-09	5%	
10/09	1542	20100	32.12	30.38	2.27E-09	0.00	2.27E-09	1.1	2.49E-09	10.83	4.21E-09	8%	
10/10	832	60600	48.95	28.94	3.62E-09	-0.12	3.32E-09	1.1	3.65E-09	15.45	4.02E-09	5%	
10/10	1225	13980	52.83	28.69	2.73E-09	-0.19	6.56E-10	1.1	7.22E-10	16.25	3.77E-09	6%	
10/10	1625	14400	56.83	28.50	2.02E-09	0.06	2.66E-09	1.1	2.92E-09	16.87	3.71E-09	2%	
10/11	826	57660	72.85	26.94	4.15E-09	-0.12	3.83E-09	1.1	4.22E-09	21.86	3.82E-09	3%	
10/11	1155	12540	76.33	26.69	3.07E-09	-0.19	7.37E-10	1.1	8.11E-10	22.66	3.69E-09	4%	
10/11	1626	16260	80.85	26.56	1.23E-09	0.06	1.80E-09	1.1	1.96E-09	23.10	3.59E-09	3%	
10/12	817	57060	96.70	25.38	3.20E-09	-0.06	3.03E-09	1.1	3.34E-09	26.89	3.55E-09	1%	
10/12	1216	14340	100.68	25.00	4.11E-09	-0.19	2.05E-09	1.1	2.26E-09	28.11	3.50E-09	1%	
10/12	1554	13080	104.32	25.00	0.00E+00	0.12	1.42E-09	1.1	1.57E-09	28.11	3.43E-09	2%	
10/13	808	58440	120.55	23.50	3.99E-09	-0.12	3.67E-09	1.1	4.04E-09	32.93	3.51E-09	2%	
10/14	833	57900	144.97	22.25	2.22E-09	-0.25	1.78E-09	1.1	1.96E-09	38.94	3.25E-09	8%	
10/14	1630	28620	152.92	22.56	-1.7E-09	0.38	3.84E-10	1.1	4.22E-10	35.95	3.10E-09	5%	
10/15	839	58140	169.07	21.00	4.22E-09	-0.50	2.86E-09	1.1	3.15E-09	40.98	3.11E-09	0%	
10/15	1408	19740	174.55	20.94	4.79E-10	0.12	1.44E-09	1.1	1.58E-09	41.15	3.06E-09	2%	
10/16	817	65340	192.70	19.50	3.48E-09	-0.12	3.19E-09	1.1	3.51E-09	45.76	3.10E-09	1%	
10/16	1635	29880	201.00	19.00	2.65E-09	-0.07	2.28E-09	1.1	2.51E-09	47.38	3.06E-09	1%	
10/17	835	57600	217.00	17.88	3.09E-09	0.00	3.09E-09	1.1	3.40E-09	50.98	3.10E-09	1%	
10/18	912	68620	241.82	16.38	2.71E-09	-0.06	2.60E-09	1.1	2.86E-09	55.80	3.08E-09	1%	
10/19	940	68080	266.08	14.88	2.74E-09	0.00	2.74E-09	1.1	3.02E-09	60.62	3.07E-09	0%	
10/19	1641	25260	273.10	14.50	2.43E-09	-0.06	2.05E-09	1.1	2.25E-09	61.84	3.05E-09	1%	
10/20	1706	87900	297.52	13.19	2.42E-09	-0.25	1.95E-09	1.1	2.15E-09	66.05	2.98E-09	2%	
10/21	1709	86580	321.57	12.25	1.77E-09	-0.06	1.65E-09	1.1	1.82E-09	69.07	2.89E-09	3%	
10/22	1730	87660	345.92	11.25	1.87E-09	0.00	1.87E-09	1.1	2.05E-09	72.28	2.83E-09	2%	
10/23	1715	85500	369.67	10.25	1.92E-09	-	1.92E-09	1.1	2.11E-09	75.49	2.79E-09	2%	
10/24	1615	82800	392.67	9.25	1.99E-09	-	1.99E-09	1.1	2.19E-09	78.70	2.75E-09	1%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-11
Geometric factor-G=0.04030
Depth factor=234.75"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/25	1630	90900	417.92	6.25	1.82E-09	-0.31	1.26E-09	1.1	1.38E-09	81.92	2.67E-09	3%	+1 Hr Daylight
10/26	1621	85860	441.77	7.00	2.42E-09	-0.50	1.45E-09	1.1	1.60E-09	85.93	2.81E-09	2%	Savings Time
10/27	813	57120	457.83	6.25	2.19E-09	-0.25	1.46E-09	1.1	1.61E-09	88.34	2.57E-09	1%	

END OF TEST TSB-11

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-12
Geometric factor-G=0.04534
Depth factor=266.0"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tws)	RPD (K1ws)	Comments
										0.00	-	-	START
10/08	1057	0	0.00	31.00	-	-	-	-	-	0.00	-	-	
10/08	1230	5580	1.55	28.38	7.20E-08	0.00	7.20E-08	1.1	7.92E-08	6.42	7.92E-08	-	
10/08	1716	17160	6.32	28.36	1.80E-10	0.00	1.80E-10	1.1	1.97E-10	6.46	1.96E-06	121%	
10/09	819	54180	21.37	27.38	2.79E-09	-0.32	1.86E-09	1.1	2.07E-09	11.63	7.24E-09	92%	
10/09	1212	13980	25.25	27.06	3.54E-09	-0.12	2.21E-09	1.1	2.43E-09	12.66	6.50E-09	11%	
10/09	1614	14520	29.28	27.06	3.54E-09	0.00	3.54E-09	1.1	3.89E-09	12.66	6.15E-09	6%	Repeated value
10/10	856	60120	45.96	26.12	2.42E-09	-0.12	2.11E-09	1.1	2.32E-09	15.66	4.76E-09	25%	
10/11	850	86040	69.86	24.94	2.13E-09	-0.25	1.68E-09	1.1	1.85E-09	19.47	3.76E-09	23%	
10/11	1130	9600	72.55	24.81	2.11E-09	-0.12	1.82E-10	1.1	1.79E-10	19.89	3.63E-09	4%	
10/12	745	72900	92.80	24.13	1.46E-09	0.00	1.46E-09	1.1	1.60E-09	22.07	3.19E-09	13%	
10/12	1149	14640	96.87	23.86	2.67E-09	-0.12	1.39E-09	1.1	1.53E-09	22.87	3.12E-09	2%	
10/13	740	71460	116.72	23.31	1.25E-09	-0.12	9.86E-10	1.1	1.08E-09	24.70	2.77E-09	12%	
10/14	906	91560	142.15	22.25	1.82E-09	-0.25	1.39E-09	1.1	1.53E-09	26.11	2.55E-09	8%	
10/15	816	83520	165.35	21.75	9.42E-10	-0.12	7.16E-10	1.1	7.88E-10	29.72	2.30E-09	10%	
10/16	856	88680	189.98	21.56	3.38E-10	0.00	3.38E-10	1.1	3.71E-10	30.33	2.05E-09	11%	
10/16	1652	28560	197.92	20.25	7.25E-09	-0.07	6.86E-09	1.1	7.55E-09	34.53	2.27E-09	10%	
10/17	812	55200	213.25	19.25	2.87E-09	0.00	2.87E-09	1.1	3.16E-09	37.75	2.34E-09	3%	
10/18	844	88320	237.78	17.94	2.36E-09	-0.06	2.25E-09	1.1	2.48E-09	41.95	2.35E-09	1%	
10/19	1008	91440	263.18	16.63	2.29E-09	0.00	2.29E-09	1.1	2.52E-09	46.16	2.37E-09	1%	
10/19	1657	24540	270.00	16.38	1.84E-09	-0.06	1.24E-09	1.1	1.37E-09	46.97	2.34E-09	1%	
10/20	1630	84780	293.55	15.31	2.03E-09	-0.25	1.56E-09	1.1	1.71E-09	50.40	2.29E-09	2%	
10/21	1625	86160	317.48	14.50	1.52E-09	-0.06	1.40E-09	1.1	1.55E-09	53.01	2.24E-09	2%	
10/22	1656	88200	341.98	13.69	1.49E-09	0.00	1.49E-09	1.1	1.64E-09	55.81	2.19E-09	2%	
10/23	1630	84840	365.55	12.83	2.03E-09	-	2.03E-09	1.1	2.23E-09	59.01	2.19E-09	0%	Replacement
10/24	1630	82800	388.55	11.50	2.23E-09	-	2.23E-09	1.1	2.45E-09	62.84	2.21E-09	1%	TEG Stabilizg
10/25	1551	91260	413.90	10.63	1.56E-09	-0.31	1.00E-09	1.1	1.10E-09	65.44	2.14E-09	3%	+1 Hr Daylight
10/26	824	59580	430.45	9.50	3.11E-09	-0.35	2.15E-09	1.1	2.36E-09	69.07	2.15E-09	0%	Savings Time

END OF TEST TSB-12

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-13
Geometric factor-G=0.04030
Depth factor=356.8"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/08	1018	0	0.00	34.12	-	-	-	-	-	0.00	-	-	START
10/08	1233	8100	2.25	32.89	1.82E-08	0.00	1.82E-08	1.1	2.01E-08	4.59	2.01E-08	-	
10/08	1717	17040	6.98	31.75	5.71E-09	0.00	5.71E-09	1.1	6.29E-09	7.81	1.07E-08	61%	
10/09	820	54180	22.03	29.13	5.03E-09	-0.32	4.42E-09	1.1	4.86E-09	16.03	6.72E-09	46%	
10/09	1213	13980	25.92	28.50	4.71E-09	-0.12	3.81E-09	1.1	4.19E-09	18.05	6.34E-09	6%	
10/09	1615	14520	29.95	28.19	2.23E-09	0.00	2.23E-09	1.1	2.46E-09	19.05	5.82E-09	9%	
10/10	857	60120	46.65	26.06	3.72E-09	-0.12	3.51E-09	1.1	3.86E-09	25.89	5.12E-09	13%	
10/10	1244	13620	50.43	25.56	3.87E-09	-0.19	2.40E-09	1.1	2.64E-09	27.50	4.93E-09	4%	
10/11	851	72420	70.55	22.94	3.83E-09	-0.06	3.74E-09	1.1	4.11E-09	35.92	4.70E-09	5%	
10/11	1130	9540	73.20	22.56	4.23E-09	-0.19	2.11E-09	1.1	2.33E-09	37.14	4.61E-09	2%	
10/11	1550	15600	77.53	22.25	2.11E-09	0.06	2.52E-09	1.1	2.77E-09	38.13	4.51E-09	2%	
10/12	746	57360	93.47	20.50	3.25E-09	-0.06	3.14E-09	1.1	3.45E-09	43.75	4.33E-09	4%	
10/12	1150	14640	97.53	19.94	4.09E-09	-0.19	2.70E-09	1.1	2.97E-09	45.55	4.27E-09	1%	
10/12	1534	13440	101.27	19.81	1.03E-09	0.12	1.99E-09	1.1	2.19E-09	45.97	4.19E-09	2%	
10/13	741	58020	117.38	18.06	3.24E-09	-0.12	3.01E-09	1.1	3.31E-09	51.59	4.07E-09	3%	
10/13	1631	31800	126.22	17.44	2.10E-09	-0.31	1.05E-09	1.1	1.15E-09	53.58	3.87E-09	5%	
10/14	907	59760	142.82	15.83	3.27E-09	0.06	3.38E-09	1.1	3.72E-09	59.40	3.85E-09	0%	
10/14	1552	24300	149.57	15.81	-8.0E-10	0.36	8.91E-10	1.1	9.80E-10	58.82	3.72E-09	3%	
10/15	819	59220	166.02	13.81	3.66E-09	-0.50	2.75E-09	1.1	3.02E-09	65.24	3.65E-09	2%	
10/15	1432	22380	172.23	13.50	1.51E-09	0.12	2.09E-09	1.1	2.30E-09	66.24	3.60E-09	1%	
10/16	857	66300	190.65	11.56	3.19E-09	-0.12	2.99E-09	1.1	3.29E-09	72.47	3.57E-09	1%	
10/16	1653	28560	198.58	10.88	2.61E-09	-0.07	2.34E-09	1.1	2.57E-09	74.66	3.53E-09	1%	
10/17	813	55200	213.92	9.38	2.98E-09	0.00	2.98E-09	1.1	3.28E-09	79.48	3.52E-09	1%	
10/18	845	66320	238.45	7.25	2.66E-09	-0.06	2.59E-09	1.1	2.85E-09	86.32	3.45E-09	2%	
10/19	1009	91440	263.85	5.06	2.66E-09	0.00	2.66E-09	1.1	2.93E-09	93.35	3.40E-09	1%	
10/19	1658	24540	270.67	4.56	2.27E-09	-0.06	2.00E-09	1.1	2.20E-09	94.96	3.37E-09	1%	
10/20	1630	84720	294.20	2.75	2.39E-09	-0.25	2.06E-09	1.1	2.26E-09	100.77	3.26E-09	3%	
10/20	1730	3600	295.20	35.19	2.39E-09	0.00	2.06E-09	1.1	2.27E-09	101.02	3.27E-09	0%	Refill
10/21	1630	82800	318.20	32.86	2.86E-09	-0.06	2.80E-09	1.1	3.08E-09	108.44	3.26E-09	0%	
10/22	1656	87960	342.63	30.81	2.44E-09	0.00	2.44E-09	1.1	2.68E-09	115.09	3.22E-09	1%	
10/23	1633	85020	366.25	28.69	2.60E-09	-	2.60E-09	1.1	2.86E-09	121.90	3.20E-09	1%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE DATA

TSB-13
Geometric factor-G=0.04030
Depth factor=356.8"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (t wa)	RPD (K1 wa)	Comments
10/24	1530	82620	389.20	26.83	2.61E-09	-	2.61E-09	1.1	2.87E-09	128.52	3.18E-09	1%	
10/25	1552	91320	414.57	24.83	2.31E-09	-0.37	1.86E-09	1.1	2.07E-09	134.94	3.11E-09	2%	+1 Hr Daylight
10/26	825	59580	431.12	23.00	2.90E-09	-0.89	1.87E-09	1.1	1.84E-09	140.18	3.06E-09	2%	Savings Time

END OF TEST TSB-13

ATTACHMENT 2B

TSB
SPREADSHEET CALCULATION SUMMARY

STAGE 2 (K2')

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-1 STAGE TWO
Geometric factor - G = 0.006576"
Depth factor = 239.12"
TC values from Replacement TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/26	1500	0	0.00	32.06	-	-	-	-	-	0	-	-	START
10/27	756	60960	16.93	22.63	9.70E-09	-0.25	9.44E-09	1.1	1.04E-08	30.34	1.04E-08	-	
10/27	1356	21600	22.93	21.25	4.09E-09	-0.13	3.70E-09	1.1	4.07E-09	34.78	8.73E-09	17%	
10/27	1616	9400	25.27	20.81	3.36E-09	0.13	4.36E-09	1.1	4.79E-09	36.20	8.37E-09	4%	
10/28	751	56100	40.85	17.31	4.04E-09	0.06	4.11E-09	1.1	4.52E-09	47.46	6.90E-09	19%	
10/28	1320	19740	46.33	16.13	3.90E-09	-0.03	3.80E-09	1.1	4.18E-09	51.26	6.56E-09	5%	
10/28	1712	13920	50.20	15.56	2.88E-09	-0.12	2.12E-09	1.1	2.33E-09	53.09	6.25E-09	5%	
10/29	743	52260	64.72	12.69	3.62E-09	-0.13	3.46E-09	1.1	3.80E-09	62.32	5.70E-09	9%	
10/29	1140	14220	68.67	11.94	3.50E-09	0.00	3.50E-09	1.1	3.85E-09	64.74	5.59E-09	2%	
10/29	1603	15780	73.05	11.25	2.91E-09	0.13	3.46E-09	1.1	3.81E-09	66.96	5.49E-09	2%	
10/29	1608	300	73.13	34.38	2.91E-09	0.00	3.46E-09	1.1	3.81E-09	66.96	5.49E-09	0%	Refill
10/30	812	57840	89.20	30.13	4.52E-09	0.00	4.52E-09	1.1	4.97E-09	80.83	5.39E-09	2%	
10/30	1200	13680	93.00	29.19	4.27E-09	-0.19	3.41E-09	1.1	3.75E-09	83.86	5.33E-09	1%	
10/30	1600	14400	97.00	28.38	3.51E-09	0.00	3.51E-09	1.1	3.86E-09	86.27	5.27E-09	1%	
10/31	731	55860	112.52	25.25	3.52E-09	-0.08	3.45E-09	1.1	3.80E-09	96.34	5.08E-09	4%	
10/31	1140	14940	116.67	24.38	3.69E-09	-0.13	3.13E-09	1.1	3.45E-09	99.14	5.01E-09	1%	
10/31	1513	12780	120.22	23.75	3.13E-09	0.00	3.13E-09	1.1	3.44E-09	101.16	4.96E-09	1%	
11/01	933	66000	138.55	21.56	2.12E-09	-0.19	1.93E-09	1.1	2.13E-09	108.21	4.58E-09	8%	
11/01	1511	20280	144.18	19.75	5.74E-09	0.07	5.96E-09	1.1	6.56E-09	114.03	4.86E-09	2%	
11/02	806	60900	161.10	17.38	2.52E-09	0.25	2.79E-09	1.1	3.07E-09	121.66	4.49E-09	4%	
11/02	1324	19080	166.40	16.38	3.42E-09	-0.07	3.18E-09	1.1	3.50E-09	124.88	4.46E-09	1%	
11/02	1538	8040	168.63	16.25	1.06E-09	0.13	2.12E-09	1.1	2.33E-09	125.30	4.43E-09	1%	
11/03	805	59220	185.08	13.56	2.99E-09	0.12	3.12E-09	1.1	3.43E-09	133.95	4.35E-09	2%	
11/03	1048	9780	187.80	13.00	3.79E-09	0.00	3.79E-09	1.1	4.17E-09	135.75	4.34E-09	0%	
11/03	1510	15720	192.17	12.56	1.86E-09	0.25	2.91E-09	1.1	3.20E-09	137.17	4.32E-09	1%	
11/04	812	61320	209.20	9.81	2.99E-09	0.00	2.99E-09	1.1	3.29E-09	146.02	4.23E-09	2%	
11/04	1609	28620	217.15	8.69	2.63E-09	0.07	2.80E-09	1.1	3.08E-09	149.62	4.19E-09	1%	
11/05	759	57000	232.98	6.25	2.90E-09	-0.06	2.83E-09	1.1	3.11E-09	157.47	4.12E-09	2%	
11/05	801	120	233.02	35.75	2.90E-09	0.00	2.83E-09	1.1	3.11E-09	157.47	4.12E-09	0%	Refill
11/05	1626	30300	241.43	33.63	4.27E-09	0.06	4.39E-09	1.1	4.83E-09	164.29	4.14E-09	1%	
11/06	805	56340	257.08	30.38	5.65E-09	0.06	5.92E-09	1.1	6.51E-09	174.75	4.13E-09	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-1 STAGE TWO
Geometric factor - G = 0.006576"
Depth factor = 239.12"
TC values from Replacement TEC-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
11/06	1646	31380	265.80	28.69	3.35E-09	-0.06	3.23E-09	1.1	3.55E-09	180.19	4.11E-09	0%	
11/07	912	59040	282.20	25.83	3.25E-09	-0.06	3.19E-09	1.1	3.51E-09	190.03	4.07E-09	1%	
11/07	1600	24480	289.00	24.31	3.41E-09	-0.07	3.23E-09	1.1	3.55E-09	194.28	4.06E-09	0%	
11/08	635	59700	305.58	21.56	2.94E-09	0.07	3.01E-09	1.1	3.31E-09	203.13	4.02E-09	1%	
11/08	1605	27000	313.08	20.00	3.71E-09	-0.57	2.35E-09	1.1	2.59E-09	208.15	3.99E-09	1%	
11/09	722	55020	328.37	17.75	2.65E-09	-0.07	2.58E-09	1.1	2.82E-09	215.39	3.93E-09	1%	
11/09	1625	32580	337.42	16.38	2.74E-09	-0.13	2.48E-09	1.1	2.73E-09	219.79	3.90E-09	1%	
11/10	730	54300	352.50	14.19	2.65E-09	0.00	2.65E-09	1.1	2.91E-09	226.84	3.86E-09	1%	
11/10	1624	32040	361.40	12.75	2.97E-09	-0.19	2.58E-09	1.1	2.84E-09	231.47	3.83E-09	1%	END TEST

END OF TEST TSB-1 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-2 STAGE TWO
Geometric factor - G = 0.006459"
Depth factor = 356.75"
TC values from Replacement TEG-3

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	comments
10/26	1430	0	0.00	33.13	-	-	-	1.1	-	0	-	-	START
10/27	759	62940	17.46	32.38	-	-	-	1.1	-	106.80	-	-	Dry refill
10/27	1359	21600	23.46	17.94	2.86E-08	-0.13	2.83E-08	1.1	3.11E-08	153.06	7.96E-09	200%	
10/27	1616	9220	25.77	13.56	2.33E-08	0.19	2.44E-08	1.1	2.68E-08	167.15	9.63E-09	19%	
10/27	1623	420	25.88	32.63	2.33E-08	0.00	2.44E-08	1.1	2.68E-08	167.15	9.70E-09	1%	Refill
10/28	750	55620	41.33	2.31	2.38E-08	-0.19	2.36E-08	1.1	2.60E-08	264.71	1.56E-08	46%	
10/28	752	120	41.37	31.06	2.38E-08	0.00	2.36E-08	1.1	2.60E-08	264.71	1.56E-08	0%	Refill
10/28	1321	19740	46.85	19.50	2.50E-08	-0.13	2.47E-08	1.1	2.72E-08	301.91	1.71E-08	8%	
10/28	1713	13920	50.72	12.63	2.16E-08	0.32	2.26E-08	1.1	2.49E-08	324.01	1.77E-08	3%	
10/29	630	55020	66.00	35.50	2.16E-08	0.00	2.16E-08	1.1	2.38E-08	364.65	1.91E-08	8%	Dry refill
10/29	1141	11460	69.18	28.00	2.75E-08	-0.06	2.73E-08	1.1	3.00E-08	386.78	1.96E-08	3%	
10/29	1603	15720	73.55	19.13	2.42E-08	0.12	2.45E-08	1.1	2.70E-08	417.32	2.01E-08	2%	
10/29	1605	120	73.58	35.38	2.42E-08	0.00	2.45E-08	1.1	2.70E-08	417.32	2.01E-08	0%	Refill
10/30	815	58200	89.75	4.75	2.28E-08	-0.06	2.28E-08	1.1	2.50E-08	515.86	2.10E-08	4%	
10/30	817	120	89.78	35.50	2.28E-08	0.00	2.28E-08	1.1	2.51E-08	515.86	2.10E-08	0%	Refill
10/30	1202	13500	93.53	27.13	2.61E-08	-0.13	2.57E-08	1.1	2.82E-08	542.81	2.13E-08	1%	
10/30	1600	14280	97.50	19.13	2.41E-08	-0.06	2.39E-08	1.1	2.63E-08	568.55	2.15E-08	1%	
10/30	1605	300	97.58	35.50	2.41E-08	0.00	2.39E-08	1.1	2.63E-08	568.55	2.15E-08	0%	Refill
10/31	731	55560	113.02	6.50	2.26E-08	-0.12	2.25E-08	1.1	2.47E-08	661.86	2.19E-08	2%	
10/31	734	180	113.07	35.38	2.26E-08	0.00	2.25E-08	1.1	2.48E-08	661.86	2.19E-08	0%	Refill
10/31	1148	15240	117.30	25.94	2.61E-08	0.00	2.61E-08	1.1	2.87E-08	692.23	2.22E-08	1%	
10/31	1514	12360	120.73	19.38	2.28E-08	0.00	2.28E-08	1.1	2.51E-08	713.34	2.22E-08	0%	
10/31	1518	240	120.80	35.00	2.28E-08	0.00	2.28E-08	1.1	2.51E-08	713.34	2.22E-08	0%	Refill
11/01	931	65580	139.02	1.75	2.21E-08	-0.19	2.19E-08	1.1	2.41E-08	820.33	2.25E-08	1%	
11/01	937	360	139.12	33.63	2.21E-08	-0.19	2.19E-08	1.1	2.41E-08	820.33	2.25E-08	0%	Refill
11/01	1510	19980	144.67	21.81	2.51E-08	0.00	2.51E-08	1.1	2.76E-08	858.36	2.27E-08	1%	
11/02	811	61260	161.88	34.88	2.51E-08	0.00	2.51E-08	1.1	2.76E-08	928.54	2.01E-08	12%	Dry refill
11/02	1325	18840	166.92	23.50	2.55E-08	-0.13	2.53E-08	1.1	2.78E-08	965.15	2.33E-08	15%	
11/02	1540	8100	169.17	19.31	2.23E-08	0.05	2.26E-08	1.1	2.49E-08	978.64	2.34E-08	0%	
11/02	1636	3360	170.10	17.50	2.34E-08	0.13	2.51E-08	1.1	2.76E-08	984.46	2.34E-08	0%	
11/02	1640	240	170.17	35.19	2.34E-08	0.00	2.51E-08	1.1	2.76E-08	984.46	2.34E-08	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-2 STAGE TWO
Geometric factor - G = 0.006459"
Depth factor = 358.75"
TC values from Replacement TEC-3

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tws)	RPD (K1ws)	comments
11/03	808	55560	185.60	5.88	2.28E-08	0.00	2.28E-08	1.1	2.51E-08	1078.77	2.35E-08	1%	
11/03	1049	9780	188.32	1.56	2.00E-08	0.00	2.00E-08	1.1	2.20E-08	1092.67	2.35E-08	0%	
11/03	1200	4260	189.50	35.50	2.00E-08	0.00	2.00E-08	1.1	2.20E-08	1097.89	1.90E-08	21%	Dry refill
11/03	1511	11460	192.68	26.50	2.56E-08	0.18	2.63E-08	1.1	2.89E-08	1120.21	2.36E-08	22%	
11/03	1601	3000	193.52	34.69	2.56E-08	0.00	2.63E-08	1.1	2.89E-08	1120.21	1.91E-08	21%	Refill
11/04	813	58320	209.72	4.06	2.28E-08	-0.12	2.27E-08	1.1	2.50E-08	1218.77	2.37E-08	22%	
11/04	815	120	209.75	33.88	2.28E-08	0.00	2.27E-08	1.1	2.50E-08	1218.77	2.37E-08	0%	Refill
11/04	1611	28560	217.68	17.50	2.45E-08	0.06	2.46E-08	1.1	2.70E-08	1271.47	2.36E-08	1%	
11/04	1614	180	217.73	35.75	2.45E-08	0.00	2.46E-08	1.1	2.71E-08	1271.47	2.36E-08	0%	Refill
11/05	804	57000	233.57	5.56	2.29E-08	0.00	2.29E-08	1.1	2.52E-08	1368.81	2.39E-08	0%	
11/05	806	120	233.60	35.56	2.29E-08	0.00	2.29E-08	1.1	2.52E-08	1368.81	2.39E-08	0%	Refill
11/05	1627	30060	241.95	18.81	2.37E-08	0.18	2.40E-08	1.1	2.63E-08	1422.50	2.40E-08	0%	
11/05	1629	120	241.98	35.38	2.37E-08	0.00	2.40E-08	1.1	2.64E-08	1422.50	2.40E-08	0%	Refill
11/06	806	56220	257.60	5.19	2.33E-08	-0.06	2.32E-08	1.1	2.55E-08	1519.64	2.41E-08	0%	
11/06	808	120	257.63	35.25	2.33E-08	0.00	2.32E-08	1.1	2.55E-08	1519.64	2.41E-08	0%	Refill
11/06	1649	31260	266.32	17.25	2.45E-08	0.16	2.46E-08	1.1	2.72E-08	1577.56	2.42E-08	0%	
11/06	1650	60	266.33	35.50	2.45E-08	0.00	2.46E-08	1.1	2.73E-08	1577.56	2.42E-08	0%	Refill
11/07	913	58980	282.72	3.56	2.35E-08	-0.06	2.35E-08	1.1	2.58E-08	1680.33	2.43E-08	0%	
11/07	915	120	282.75	35.25	2.35E-08	0.00	2.35E-08	1.1	2.59E-08	1680.33	2.43E-08	0%	Refill
11/07	1601	24360	289.52	20.94	2.49E-08	-0.06	2.48E-08	1.1	2.73E-08	1726.37	2.44E-08	0%	
11/07	1604	180	289.57	35.81	2.49E-08	0.00	2.48E-08	1.1	2.73E-08	1726.37	2.44E-08	0%	Refill
11/08	836	59520	306.10	4.75	2.26E-08	0.00	2.26E-08	1.1	2.49E-08	1826.31	2.44E-08	0%	
11/08	837	60	306.12	35.31	2.26E-08	0.00	2.26E-08	1.1	2.49E-08	1826.31	2.44E-08	0%	Refill
11/08	1607	27000	313.62	20.25	2.37E-08	-0.36	2.31E-08	1.1	2.54E-08	1874.77	2.44E-08	0%	
11/08	1608	60	313.63	35.81	2.37E-08	0.00	2.31E-08	1.1	2.54E-08	1874.77	2.44E-08	0%	Refill
11/09	723	54900	328.88	6.75	2.29E-08	0.44	2.32E-08	1.1	2.55E-08	1968.27	2.45E-08	0%	
11/09	724	60	328.90	34.81	2.29E-08	0.00	2.32E-08	1.1	2.55E-08	1968.27	2.45E-08	0%	Refill
11/09	1626	32520	337.93	16.38	2.42E-08	-0.12	2.40E-08	1.1	2.64E-08	2027.57	2.45E-08	0%	
11/09	1627	60	337.95	35.75	2.42E-08	0.00	2.40E-08	1.1	2.64E-08	2027.57	2.45E-08	0%	Refill
11/10	731	54240	353.02	6.25	2.35E-08	0.00	2.35E-08	1.1	2.59E-08	2122.49	2.46E-08	0%	
11/10	732	60	353.03	34.56	2.35E-08	0.00	2.35E-08	1.1	2.59E-08	2122.49	2.46E-08	0%	Refill
11/10	1620	31680	361.83	16.13	2.49E-08	-0.13	2.47E-08	1.1	2.71E-08	2181.79	2.46E-08	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-2 STAGE TWO
Geometric factor - G = 0.006459"
Depth factor = 358.75"
TC values from Replacement TEG-3

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	comments
11/10	1621	60	361.85	35.94	2.49E-08	0.00	2.47E-08	1.1	2.72E-08	2161.79	2.46E-08	0%	Refill
11/11	735	54480	376.98	5.81	2.39E-08	0.00	2.39E-08	1.1	2.63E-08	2278.74	2.47E-08	0%	
11/11	736	60	377.00	35.00	2.39E-08	0.00	2.39E-08	1.1	2.63E-08	2278.74	2.47E-08	0%	Refill
11/11	1344	22080	383.13	21.50	2.59E-08	0.08	2.50E-08	1.1	2.86E-08	2322.16	2.48E-08	0%	END TEST

END OF TEST TSB-2 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-3 STAGE TWO
Geometric factor - G = 0.006401"
Depth factor = 162.25"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	KI	TC	KIC	visc. factor	KICT	cumulative volume (cc)	K (tws)	RPD (KIws)	Comments
10/26	1500	0	0.00	33.63	-	-	-	-	-	0.00	-	-	START
10/27	800	61200	17.00	29.31	5.92E-09	0.06	6.01E-09	1.1	6.61E-09	13.90	6.61E-09	-	
10/27	1400	57900	33.08	26.89	9.10E-10	-0.31	4.55E-10	1.1	5.00E-10	15.89	3.84E-09	58%	
10/28	755	64500	51.00	26.06	3.50E-09	0.06	3.56E-09	1.2	4.29E-09	24.36	3.87E-09	6%	
10/28	1325	19800	56.50	25.50	2.45E-09	-0.06	2.18E-09	1.1	2.40E-09	26.16	3.73E-09	4%	
10/28	1730	14700	60.58	25.06	2.60E-09	0.25	4.07E-09	1.1	4.48E-09	27.57	3.78E-09	1%	
10/29	747	51420	74.87	23.19	3.17E-09	0.00	3.17E-09	1.1	3.49E-09	33.59	3.72E-09	1%	
10/29	1142	14100	78.78	22.83	3.49E-09	0.00	3.49E-09	1.1	3.84E-09	35.39	3.73E-09	0%	
10/29	1612	16200	83.28	22.13	2.72E-09	0.06	3.04E-09	1.1	3.35E-09	37.00	3.71E-09	1%	
10/30	821	56140	99.43	19.88	3.43E-09	0.00	3.43E-09	1.2	4.12E-09	44.24	3.77E-09	2%	
10/30	1209	13680	103.23	19.31	3.73E-09	-0.19	2.48E-09	1.2	2.98E-09	46.06	3.74E-09	1%	
10/30	1610	14460	107.25	18.88	2.67E-09	0.00	2.67E-09	1.1	2.93E-09	47.46	3.71E-09	1%	
10/31	739	55740	122.73	16.88	3.24E-09	0.00	3.24E-09	1.1	3.56E-09	53.89	3.70E-09	1%	
10/31	1151	15120	126.93	16.25	3.79E-09	-0.12	3.07E-09	1.1	3.37E-09	55.92	3.68E-09	0%	
10/31	1541	13800	130.77	15.81	2.91E-09	0.00	2.91E-09	1.1	3.20E-09	57.34	3.67E-09	0%	
11/01	940	64740	148.75	13.88	2.74E-09	-0.13	2.55E-09	1.1	2.81E-09	63.55	3.57E-09	3%	
11/01	1515	20100	154.33	13.44	2.02E-09	0.00	2.02E-09	1.1	2.23E-09	64.96	3.52E-09	1%	
11/02	816	61260	171.35	11.50	2.95E-09	0.32	3.44E-09	1.1	3.78E-09	71.21	3.54E-09	1%	
11/02	1328	18720	176.55	10.94	2.80E-09	-0.07	2.45E-09	1.2	2.94E-09	73.01	3.53E-09	1%	
11/02	1545	8220	178.83	10.75	2.17E-09	0.13	3.66E-09	1.2	4.39E-09	73.62	3.54E-09	0%	
11/03	810	59100	195.25	8.69	3.30E-09	0.12	3.49E-09	1.2	4.19E-09	80.25	3.59E-09	2%	
11/03	1053	9780	197.97	8.31	3.70E-09	0.00	3.70E-09	1.2	4.44E-09	81.47	3.60E-09	0%	
11/03	1520	16020	202.42	8.06	1.49E-09	0.32	3.40E-09	1.2	4.08E-09	82.27	3.61E-09	0%	
11/04	820	61200	219.42	5.94	3.33E-09	0.18	3.61E-09	1.2	4.33E-09	89.10	3.67E-09	2%	
11/04	822	120	219.45	35.38	3.33E-09	0.00	3.61E-09	1.2	4.33E-09	89.10	3.67E-09	0%	Refill
11/04	1617	28500	227.37	33.56	5.26E-09	0.07	5.46E-09	1.2	6.56E-09	94.96	3.77E-09	3%	
11/05	808	57060	243.22	30.69	4.21E-09	0.00	4.21E-09	1.2	5.05E-09	104.19	3.85E-09	2%	
11/05	1632	30240	251.62	29.38	3.66E-09	0.12	4.00E-09	1.2	4.80E-09	108.41	3.89E-09	1%	
11/06	812	56400	267.28	26.81	3.89E-09	0.06	3.98E-09	1.2	4.78E-09	116.67	3.94E-09	1%	
11/06	1654	31320	275.98	25.44	3.76E-09	-0.06	3.61E-09	1.2	4.33E-09	121.08	3.95E-09	0%	
11/07	859	57900	292.07	23.13	3.46E-09	0.13	3.67E-09	1.25	4.59E-09	128.52	3.99E-09	1%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-3 STAGE TWO
Geometric factor - G = 0.006401"
Depth factor = 162.25"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
11/07	1609	25800	299.23	22.13	3.41E-09	-0.25	2.55E-09	1.2	3.07E-09	131.73	3.96E-09	1%	
11/08	840	59460	315.75	19.88	3.36E-09	0.18	3.83E-09	1.25	4.53E-09	138.97	3.99E-09	1%	
11/08	1610	27000	323.25	18.75	3.75E-09	-0.81	1.06E-09	1.2	1.27E-09	142.81	3.93E-09	2%	
11/09	726	55080	338.55	16.94	2.97E-09	0.13	3.18E-09	1.2	3.82E-09	148.43	3.93E-09	0%	
11/09	1629	32460	347.57	15.88	2.97E-09	-0.19	2.44E-09	1.2	2.93E-09	151.84	3.90E-09	1%	
11/10	737	54480	362.70	14.13	2.95E-09	0.06	3.05E-09	1.2	3.66E-09	157.47	3.89E-09	0%	
11/10	1629	31920	371.57	13.13	2.90E-09	-0.31	2.00E-09	1.1	2.20E-09	160.89	3.85E-09	1%	
11/11	740	54660	386.75	11.50	2.78E-09	-0.06	2.67E-09	1.1	2.94E-09	165.94	3.81E-09	1%	
11/11	1400	22800	393.08	10.81	2.84E-09	-0.06	2.59E-09	1.1	2.85E-09	168.16	3.80E-09	0%	END TEST

END OF TEST TSB-3 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-4 STAGE TWO
Geometric factor - G = 0.006514"
Depth factor = 239.25"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (t,ws)	RPD (K1ws)	Comments
10/26	1549	0	0.00	31.06	-	-	-	-	-	0.00	-	-	START
10/27	802	58380	16.22	26.88	4.42E-09	-0.25	4.15E-09	1.1	4.57E-09	13.45	4.57E-09	-	
10/27	1402	21600	22.22	25.25	4.71E-09	-0.13	4.33E-09	1.1	4.76E-09	18.89	4.62E-09	1%	
10/28	755	64380	40.10	20.83	4.53E-09	0.06	4.59E-09	1.1	5.05E-09	33.56	4.81E-09	4%	
10/28	1325	19800	45.60	19.06	5.06E-09	-0.04	4.93E-09	1.1	5.43E-09	38.61	4.88E-09	2%	
10/28	1728	14580	49.65	18.19	3.83E-09	-0.12	3.30E-09	1.1	3.63E-09	41.41	4.78E-09	2%	
10/29	748	51600	63.98	14.56	4.55E-09	-0.13	4.39E-09	1.1	4.83E-09	53.09	4.79E-09	0%	
10/29	1143	14100	67.90	13.56	4.63E-09	0.00	4.63E-09	1.1	5.10E-09	56.31	4.81E-09	0%	
10/29	1613	16200	72.40	12.50	4.29E-09	0.13	4.82E-09	1.1	5.30E-09	59.72	4.84E-09	1%	
10/30	820	58020	88.52	8.69	4.35E-09	0.00	4.35E-09	1.1	4.78E-09	71.98	4.83E-09	0%	
10/30	1206	13560	92.26	7.75	4.63E-09	-0.19	3.70E-09	1.1	4.07E-09	75.00	4.80E-09	1%	
10/30	1208	120	92.32	32.63	4.63E-09	0.00	3.70E-09	1.1	4.07E-09	75.00	4.80E-09	0%	Refill
10/30	1808	14400	96.32	31.13	6.36E-09	0.00	6.36E-09	1.1	6.99E-09	79.83	4.89E-09	2%	
10/31	738	55800	111.82	26.25	5.40E-09	-0.06	5.33E-09	1.1	5.87E-09	95.53	5.03E-09	3%	
10/31	1151	15180	116.03	24.88	5.64E-09	-0.13	5.10E-09	1.1	5.61E-09	99.94	5.05E-09	0%	
10/31	1540	13740	119.85	23.75	5.16E-09	0.00	5.16E-09	1.1	5.68E-09	103.57	5.07E-09	0%	
11/01	942	64920	137.88	18.81	4.83E-09	-0.19	4.65E-09	1.1	5.11E-09	119.47	5.07E-09	0%	
11/01	1516	20040	143.45	17.44	4.39E-09	0.07	4.62E-09	1.1	5.08E-09	123.88	5.07E-09	0%	
11/02	814	81080	160.42	13.50	4.19E-09	0.25	4.46E-09	1.1	4.90E-09	136.55	5.05E-09	0%	
11/02	1326	18840	165.65	12.13	4.77E-09	-0.07	4.53E-09	1.1	4.98E-09	140.96	5.05E-09	0%	
11/02	1546	8280	167.95	11.75	3.02E-09	0.13	4.06E-09	1.1	4.46E-09	142.18	5.04E-09	0%	
11/03	811	59100	184.37	7.75	4.50E-09	0.12	4.63E-09	1.1	5.10E-09	155.05	5.05E-09	0%	
11/03	1052	9660	187.05	7.06	4.79E-09	0.00	4.79E-09	1.1	5.27E-09	157.27	5.05E-09	0%	
11/03	1522	16200	191.55	6.19	3.61E-09	0.25	4.65E-09	1.1	5.12E-09	160.07	5.05E-09	0%	
11/04	825	61380	208.60	2.25	4.36E-09	0.00	4.36E-09	1.1	4.80E-09	172.75	5.03E-09	0%	
11/04	828	180	208.65	35.75	4.36E-09	0.00	4.36E-09	1.1	4.80E-09	172.75	5.03E-09	0%	Refill
11/04	1618	28200	216.48	32.75	6.44E-09	0.07	6.59E-09	1.1	7.25E-09	182.40	5.11E-09	2%	
11/05	809	57060	232.33	27.63	5.51E-09	0.00	5.51E-09	1.1	6.06E-09	198.88	5.18E-09	1%	
11/05	1633	30240	240.73	25.13	5.15E-09	0.06	5.27E-09	1.1	5.80E-09	206.92	5.20E-09	0%	
11/06	813	56400	256.40	20.50	5.16E-09	0.06	5.25E-09	1.1	5.78E-09	221.82	5.23E-09	1%	
11/06	1655	31320	265.10	18.06	4.99E-09	-0.06	4.86E-09	1.1	5.35E-09	229.67	5.24E-09	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-4 STAGE TWO
Geometric factor - G = 0.006514"
Depth factor = 239.25"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
11/07	900	57900	281.16	13.75	4.83E-09	-0.06	4.76E-09	1.1	5.24E-09	243.54	5.24E-09	0%	
11/07	1610	25800	288.35	11.86	4.76E-09	-0.07	4.58E-09	1.1	5.04E-09	249.55	5.23E-09	0%	
11/08	841	59460	304.87	7.81	4.55E-09	0.07	4.63E-09	1.1	5.09E-09	262.85	5.23E-09	0%	
11/08	842	60	304.88	36.00	4.55E-09	0.00	4.63E-09	1.1	5.09E-09	262.85	5.23E-09	0%	Refill
11/08	1611	26940	312.37	32.86	7.00E-09	-0.57	5.72E-09	1.1	6.29E-09	272.89	5.25E-09	0%	
11/09	729	55080	327.67	27.75	5.72E-09	-0.07	5.64E-09	1.1	6.20E-09	289.20	5.30E-09	1%	
11/09	1630	32460	336.68	24.81	5.64E-09	-0.13	5.39E-09	1.1	5.93E-09	298.85	5.31E-09	0%	
11/10	736	54480	351.82	20.38	5.14E-09	0.00	5.14E-09	1.1	5.65E-09	312.91	5.33E-09	0%	
11/10	1630	31920	360.68	17.86	5.02E-09	-0.19	4.83E-09	1.1	5.10E-09	320.95	5.32E-09	0%	
11/11	741	54660	375.87	14.00	4.80E-09	0.00	4.80E-09	1.1	5.06E-09	333.44	5.31E-09	0%	
11/11	1401	22800	382.20	12.36	4.66E-09	0.00	4.66E-09	1.1	5.12E-09	338.65	5.31E-09	0%	END TEST

END OF TEST TSB-4 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-5 STAGE TWO
Geometric factor - G = 0.006576"
Depth factor = 153.5"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/27	1140	0	0.00	33.88	-	-	-	1.1	-	0.00	-	-	START
10/27	1452	9900	2.75	32.31	1.42E-08	-0.31	4.48E-09	1.1	4.93E-09	5.05	4.93E-09	-	
10/27	1607	6120	4.45	32.21	1.47E-09	0.13	1.33E-09	1.1	1.46E-09	5.37	3.61E-09	31%	
10/28	810	57780	20.50	31.25	1.50E-09	0.06	6.27E-10	1.2	7.52E-10	8.46	1.37E-09	90%	
10/28	1345	20100	26.08	31.06	6.55E-10	-0.06	2.30E-10	1.1	2.53E-10	9.07	1.13E-09	19%	
10/28	1748	14580	30.13	31.00	3.72E-10	0.25	7.56E-10	1.1	8.34E-10	9.27	1.09E-09	4%	
10/29	751	50580	44.18	29.88	2.01E-09	0.00	7.92E-10	1.1	8.71E-10	12.87	1.02E-09	7%	
10/29	1158	14820	48.30	29.56	1.97E-09	0.00	7.75E-10	1.1	8.52E-10	13.90	1.01E-09	1%	
10/29	1638	16800	52.97	29.25	1.89E-09	0.06	7.92E-10	1.1	8.71E-10	14.90	9.95E-10	1%	
10/30	845	58020	69.08	27.88	2.17E-09	0.00	8.53E-10	1.2	1.02E-09	19.31	1.00E-09	1%	
10/30	1227	13320	72.78	27.50	2.83E-09	-0.19	5.17E-10	1.2	6.21E-10	20.53	9.83E-10	2%	
10/30	1638	15060	76.97	27.25	1.53E-09	0.00	6.04E-10	1.1	6.64E-10	21.33	9.85E-10	2%	
10/31	807	55740	92.45	25.75	2.50E-09	0.00	9.83E-10	1.1	1.08E-09	26.16	9.85E-10	2%	
10/31	1210	14580	96.50	25.38	2.37E-09	-0.12	6.29E-10	1.1	6.92E-10	27.35	9.72E-10	1%	
10/31	1552	13320	100.20	25.13	1.75E-09	0.00	6.90E-10	1.1	7.60E-10	28.15	9.65E-10	1%	
11/01	1018	66360	118.63	23.58	2.22E-09	-0.13	8.02E-10	1.1	8.82E-10	33.21	9.52E-10	1%	
11/01	1540	19320	124.00	23.25	1.51E-09	0.00	5.96E-10	1.1	6.56E-10	34.20	9.39E-10	1%	
11/02	653	61980	141.22	21.58	2.59E-09	0.32	1.21E-09	1.1	1.33E-09	39.84	9.87E-10	5%	
11/02	1343	17400	146.05	21.06	2.75E-09	-0.07	9.29E-10	1.2	1.12E-09	41.25	9.91E-10	0%	
11/02	1610	8820	148.50	20.75	3.37E-09	0.13	1.88E-09	1.2	2.26E-09	42.25	1.01E-09	2%	
11/03	815	57900	164.58	18.88	3.11E-09	0.12	1.30E-09	1.2	1.57E-09	48.26	1.07E-09	5%	
11/03	1107	10320	167.45	18.58	3.01E-09	0.00	1.16E-09	1.2	1.42E-09	49.29	1.07E-09	1%	
11/03	1530	15780	171.83	18.25	1.91E-09	0.32	1.53E-09	1.2	1.83E-09	50.29	1.09E-09	2%	
11/04	832	61320	188.87	16.06	3.50E-09	0.18	1.49E-09	1.2	1.79E-09	57.34	1.15E-09	6%	
11/04	1638	29160	196.97	15.31	2.54E-09	0.07	1.09E-09	1.2	1.31E-09	59.75	1.16E-09	1%	
11/05	836	57780	213.02	13.63	2.89E-09	0.00	1.14E-09	1.2	1.37E-09	65.16	1.18E-09	1%	
11/05	1356	19200	218.35	13.00	3.29E-09	0.00	1.29E-09	1.2	1.55E-09	67.18	1.19E-09	1%	
11/05	1700	11040	221.42	12.75	2.27E-09	0.12	1.33E-09	1.2	1.59E-09	67.99	1.19E-09	0%	
11/06	829	55740	236.90	11.00	3.17E-09	0.06	1.29E-09	1.2	1.55E-09	73.62	1.21E-09	2%	
11/06	1715	31560	245.67	10.06	3.03E-09	0.00	1.19E-09	1.2	1.43E-09	76.64	1.22E-09	1%	
11/07	833	55080	260.97	8.50	2.91E-09	0.13	1.24E-09	1.25	1.55E-09	81.66	1.24E-09	2%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-5 STAGE TWO
Geometric factor - G = 0.006576"
Depth factor = 153.5"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	KI	TC	KIC	visc. factor	KICT	cumulative volume (cc)	K (twa)	RPD (KIwa)	Comments
11/07	1613	27600	266.83	7.69	3.03E-09	-0.25	8.25E-10	1.2	9.90E-10	84.27	1.23E-09	1%	
11/08	908	60900	285.55	5.88	3.10E-09	0.18	1.34E-09	1.25	1.68E-09	90.09	1.26E-09	2%	
11/08	909	60	285.57	35.50	3.10E-09	0.00	1.34E-09	1.25	1.68E-09	90.09	1.26E-09	0%	Refill
11/08	1615	25560	292.67	34.00	5.21E-09	-0.61	9.41E-10	1.2	1.13E-09	94.92	1.26E-09	0%	
11/09	753	56280	308.30	31.94	3.28E-09	0.13	1.37E-09	1.2	1.65E-09	101.54	1.26E-09	2%	
11/09	1634	31260	316.98	30.88	3.06E-09	-0.19	9.89E-10	1.2	1.19E-09	104.96	1.27E-09	0%	
11/10	740	54360	332.08	29.19	2.83E-09	0.06	1.15E-09	1.2	1.38E-09	110.39	1.28E-09	0%	
11/10	1632	31920	340.95	27.89	4.31E-09	-0.31	1.35E-09	1.2	1.62E-09	115.22	1.29E-09	1%	
11/11	805	55980	356.50	25.25	4.05E-09	-0.06	1.55E-09	1.2	1.86E-09	123.07	1.31E-09	2%	
11/11	1354	20940	362.32	23.75	6.72E-09	-0.06	2.54E-09	1.2	3.05E-09	127.90	1.34E-09	2%	END TEST

END OF TEST TSB-5 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-6 STAGE TWO
Geometric factor - G = 0.006190"
Depth factor=231.5"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/27	1210	0	0.00	32.83	-	-	-	1.1	-	0.00	-	-	START
10/27	1430	6400	2.33	29.25	2.41E-08	-0.13	2.32E-08	1.1	2.55E-08	10.86	2.55E-08	-	
10/27	1606	5760	3.93	27.75	1.57E-08	0.13	1.71E-08	1.1	1.88E-08	15.70	2.26E-08	11%	
10/28	809	57924	20.02	12.50	1.65E-08	0.06	1.65E-08	1.1	1.82E-08	64.77	1.91E-08	16%	
10/28	1346	20220	25.64	8.31	1.35E-08	-0.05	1.33E-08	1.1	1.46E-08	78.25	1.81E-08	5%	
10/28	1350	240	25.71	33.83	1.35E-08	0.00	1.33E-08	1.1	1.46E-08	78.25	1.81E-08	0%	Refill
10/28	1746	14160	29.64	29.75	1.64E-08	-0.12	1.59E-08	1.1	1.74E-08	90.73	1.80E-08	0%	
10/29	752	50760	43.74	17.38	1.50E-08	-0.13	1.49E-08	1.1	1.63E-08	130.54	1.75E-08	3%	
10/29	1200	14880	47.87	14.00	1.44E-08	0.00	1.44E-08	1.1	1.59E-08	141.41	1.73E-08	1%	
10/29	1640	15600	52.54	10.44	1.37E-08	0.13	1.42E-08	1.1	1.56E-08	152.87	1.72E-08	1%	
10/29	1642	120	52.57	34.25	1.37E-08	0.00	1.42E-08	1.1	1.56E-08	152.87	1.72E-08	0%	Refill
10/30	846	57840	68.84	20.00	1.50E-08	0.00	1.50E-08	1.1	1.65E-08	198.72	1.70E-08	1%	
10/30	1226	13200	72.31	17.25	1.31E-08	-0.19	1.22E-08	1.1	1.34E-08	207.57	1.68E-08	1%	
10/30	1639	15180	76.52	14.25	1.26E-08	0.00	1.26E-08	1.1	1.38E-08	217.22	1.67E-08	1%	
10/30	1644	300	76.61	34.63	1.26E-08	0.00	1.26E-08	1.1	1.39E-08	217.22	1.67E-08	0%	Refill
10/31	808	55440	92.01	21.50	1.43E-08	-0.06	1.43E-08	1.1	1.57E-08	259.47	1.65E-08	1%	
10/31	1211	14580	96.06	16.44	1.31E-08	-0.13	1.26E-08	1.1	1.38E-08	269.31	1.64E-08	1%	
10/31	1553	13320	99.76	15.75	1.26E-08	0.00	1.26E-08	1.1	1.41E-08	277.97	1.63E-08	1%	
10/31	1557	240	99.82	35.00	1.26E-08	0.00	1.26E-08	1.1	1.41E-08	277.97	1.63E-08	0%	Refill
11/01	1017	66000	118.16	20.31	1.35E-08	-0.19	1.33E-08	1.1	1.47E-08	325.24	1.60E-08	2%	
11/01	1541	19440	123.58	16.44	1.25E-08	0.07	1.26E-08	1.1	1.40E-08	337.69	1.60E-08	1%	
11/01	1545	240	216.50	34.56	1.25E-08	0.00	1.26E-08	1.1	1.41E-08	337.69	9.11E-09	55%	Refill
11/02	653	61680	233.63	21.81	1.25E-08	0.25	1.26E-08	1.1	1.40E-08	378.71	9.47E-09	4%	
11/02	1344	17460	238.48	18.63	1.14E-08	-0.07	1.11E-08	1.1	1.22E-08	388.95	9.53E-09	1%	
11/02	1612	8880	240.95	17.13	1.06E-08	0.13	1.16E-08	1.1	1.27E-08	393.77	9.56E-09	0%	
11/03	816	57840	257.02	7.13	1.12E-08	0.12	1.13E-08	1.1	1.24E-08	425.95	9.74E-09	2%	
11/03	1106	10200	259.85	5.44	1.10E-08	0.00	1.10E-08	1.1	1.21E-08	431.39	9.77E-09	0%	
11/03	1529	15780	264.23	3.13	9.76E-09	0.25	1.08E-08	1.1	1.19E-08	438.82	9.80E-09	0%	
11/03	1532	180	264.28	33.69	9.76E-09	0.00	1.08E-08	1.1	1.19E-08	438.82	9.80E-09	0%	Refill
11/04	833	61260	281.30	21.00	1.26E-08	0.00	1.26E-08	1.1	1.38E-08	479.65	1.00E-08	2%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-6 STAGE TWO
Geometric factor - G = 0.006190"
Depth factor=231.5"
TC values from TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
11/04	1639	29160	289.40	15.81	1.12E-08	0.07	1.14E-08	1.1	1.25E-08	496.35	1.01E-08	1%	
11/04	1642	180	289.45	34.25	1.12E-08	0.00	1.14E-08	1.1	1.25E-08	496.35	1.01E-08	0%	Refill
11/05	838	57360	305.38	22.94	1.19E-08	0.00	1.19E-08	1.1	1.31E-08	532.74	1.03E-08	2%	
11/05	1357	19140	310.70	19.50	1.12E-08	0.00	1.12E-08	1.1	1.23E-08	543.81	1.03E-08	0%	
11/05	1659	10920	313.73	17.63	1.08E-08	0.06	1.11E-08	1.1	1.22E-08	549.83	1.03E-08	0%	
11/06	830	55860	329.25	6.25	1.08E-08	0.06	1.09E-08	1.1	1.20E-08	580.01	1.04E-08	1%	
11/06	832	120	329.28	34.86	1.08E-08	0.00	1.09E-08	1.1	1.20E-08	580.01	1.04E-08	0%	Refill
11/06	1716	31440	338.02	26.25	1.26E-08	-0.06	1.25E-08	1.1	1.37E-08	601.34	1.05E-08	1%	
11/07	834	55080	353.32	16.19	1.13E-08	-0.06	1.12E-08	1.1	1.23E-08	633.71	1.06E-08	1%	
11/07	1614	27600	360.98	13.63	1.05E-08	-0.07	1.03E-08	1.1	1.14E-08	646.36	1.06E-08	0%	
11/08	911	61020	377.93	3.69	1.07E-08	0.07	1.07E-08	1.1	1.18E-08	660.37	1.06E-08	1%	
11/08	912	60	377.95	34.81	1.07E-08	0.00	1.07E-08	1.1	1.18E-08	660.37	1.06E-08	0%	Refill
11/08	1616	25440	385.02	29.63	1.21E-08	-0.57	1.08E-08	1.1	1.19E-08	697.04	1.07E-08	0%	
11/09	754	56280	400.65	19.13	1.15E-08	-0.07	1.14E-08	1.1	1.25E-08	730.82	1.07E-08	1%	
11/09	1635	31260	409.33	13.75	1.09E-08	-0.13	1.06E-08	1.1	1.17E-08	746.13	1.06E-08	0%	
11/09	1637	120	409.37	35.19	1.09E-08	0.00	1.06E-08	1.1	1.17E-08	746.13	1.06E-08	0%	Refill
11/10	741	54240	424.43	24.44	1.19E-08	0.00	1.19E-08	1.1	1.31E-08	782.72	1.06E-08	1%	
11/10	1633	31920	433.30	16.75	1.11E-08	-0.19	1.07E-08	1.1	1.18E-08	801.03	1.09E-08	0%	
11/11	803	55800	448.80	9.63	1.05E-08	0.00	1.05E-08	1.1	1.15E-08	830.37	1.09E-08	0%	
11/11	1355	21120	454.67	6.25	1.05E-08	0.00	1.05E-08	1.1	1.16E-08	841.25	1.09E-08	0%	END TEST

END OF TEST TSB-6 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-7 STAGE TWO
Geometric factor - G = 0.006634"
Depth factor = 161.25"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/27	1015	0	0.00	34.25	-	-	-	1.1	-	0.00	-	-	START
10/27	1421	14760	3.63	33.56	4.04E-09	-0.31	2.22E-09	1.1	2.44E-09	2.22	2.76E-09	-	
10/27	1605	6240	5.36	33.50	6.32E-10	0.13	2.83E-09	1.1	2.90E-09	2.41	2.80E-09	2%	
10/28	815	58200	21.53	32.81	1.03E-09	0.06	1.12E-09	1.2	1.34E-09	4.83	1.71E-09	49%	
10/28	1340	19500	26.95	32.56	1.11E-09	-0.06	8.46E-10	1.1	9.31E-10	5.44	1.55E-09	10%	
10/28	1751	57420	42.90	32.38	2.73E-10	0.25	6.52E-10	1.1	7.17E-10	6.02	1.24E-09	22%	
10/29	756	50700	56.96	31.75	1.06E-09	0.00	1.06E-09	1.1	1.19E-09	6.04	1.23E-09	1%	
10/29	1202	14760	61.06	31.63	7.10E-10	0.00	7.10E-10	1.1	7.81E-10	6.43	1.20E-09	2%	
10/29	1645	16980	65.80	31.44	9.78E-10	0.06	1.29E-09	1.1	1.42E-09	9.04	1.21E-09	1%	
10/30	849	57840	81.86	30.75	1.05E-09	0.00	1.05E-09	1.2	1.25E-09	11.26	1.22E-09	1%	
10/30	1230	13284	85.55	30.53	1.26E-09	-0.19	1.05E-09	1.2	1.26E-09	11.87	1.22E-09	0%	Repeated value
10/30	1632	14520	89.59	30.44	7.26E-10	0.00	7.26E-10	1.1	7.99E-10	12.26	1.20E-09	2%	
10/31	802	55800	105.09	29.75	1.09E-09	0.00	1.09E-09	1.1	1.20E-09	14.48	1.20E-09	0%	
10/31	1209	14820	109.20	29.50	1.49E-09	-0.12	7.74E-10	1.1	8.52E-10	15.28	1.19E-09	1%	
10/31	1545	12960	112.80	29.36	8.18E-10	0.00	8.18E-10	1.1	9.00E-10	15.87	1.18E-09	1%	
11/01	1009	66240	131.20	28.63	1.00E-09	-0.13	8.29E-10	1.1	9.12E-10	18.06	1.14E-09	3%	
11/01	1534	19500	136.62	28.44	8.65E-10	0.00	8.65E-10	1.1	9.52E-10	18.69	1.14E-09	1%	
11/02	850	52500	151.20	27.56	1.49E-09	0.32	2.04E-09	1.1	2.24E-09	21.53	1.24E-09	9%	
11/02	1341	17460	156.05	27.38	9.20E-10	-0.07	5.82E-10	1.2	6.75E-10	22.10	1.22E-09	1%	
11/02	1614	9180	158.60	27.25	1.27E-09	0.13	2.53E-09	1.2	3.04E-09	22.52	1.25E-09	2%	
11/03	818	57840	174.67	26.31	1.46E-09	0.12	1.64E-09	1.2	1.97E-09	25.55	1.32E-09	5%	
11/03	1105	10020	177.45	26.13	1.61E-09	0.00	1.61E-09	1.2	1.94E-09	26.13	1.33E-09	1%	
11/03	1525	15600	181.79	26.00	7.50E-10	0.32	2.60E-09	1.2	3.12E-09	26.55	1.37E-09	3%	
11/04	635	61800	198.95	24.94	1.55E-09	0.18	1.81E-09	1.2	2.17E-09	29.96	1.44E-09	5%	
11/04	1644	29340	207.10	24.50	1.36E-09	0.07	1.56E-09	1.2	1.89E-09	31.37	1.46E-09	1%	
11/05	841	57420	223.05	23.56	1.49E-09	0.00	1.49E-09	1.2	1.79E-09	34.40	1.48E-09	2%	
11/05	1354	18780	228.27	23.25	1.51E-09	0.00	1.51E-09	1.2	1.81E-09	35.39	1.49E-09	1%	
11/05	1655	10860	231.29	23.06	1.60E-09	0.12	2.61E-09	1.2	3.13E-09	36.00	1.51E-09	1%	
11/06	834	56340	246.94	22.19	1.42E-09	0.06	1.51E-09	1.2	1.82E-09	38.80	1.53E-09	1%	
11/06	1710	30960	255.54	21.63	1.66E-09	-0.06	1.49E-09	1.2	1.78E-09	40.61	1.54E-09	1%	
11/07	836	55560	270.97	20.69	1.56E-09	0.13	1.78E-09	1.25	2.22E-09	43.63	1.58E-09	3%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-7 STAGE TWO
Geometric factor - G = 0.006634"
Depth factor = 161.25"
TC values from TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (t,ws)	RPD (K1,ws)	Comments
11/07	1617	27660	278.85	20.25	1.48E-09	-0.25	6.37E-10	1.2	7.64E-10	45.05	1.56E-09	1%	
11/08	902	60300	295.40	19.19	1.84E-09	0.18	1.92E-09	1.25	2.39E-09	48.46	1.80E-09	3%	
11/08	1619	28220	302.89	18.75	1.57E-09	-0.81	1.32E-09	1.2	1.58E-09	49.87	1.80E-09	0%	
11/09	747	55680	316.15	17.94	1.36E-09	0.13	1.56E-09	1.2	1.90E-09	52.48	1.82E-09	1%	
11/09	1639	31920	327.02	17.50	1.30E-09	-0.19	7.37E-10	1.2	8.84E-10	53.89	1.80E-09	1%	
11/10	744	54300	342.10	16.89	1.41E-09	0.06	1.51E-09	1.2	1.82E-09	56.50	1.81E-09	1%	
11/10	1635	31860	350.95	16.13	1.67E-09	-0.31	7.44E-10	1.2	8.92E-10	58.30	1.59E-09	1%	
11/11	755	55200	366.29	15.44	1.19E-09	-0.06	1.09E-09	1.2	1.30E-09	60.52	1.58E-09	1%	
11/11	1357	21720	372.32	15.06	1.67E-09	-0.06	1.41E-09	1.2	1.69E-09	61.75	1.58E-09	0%	END TEST

END OF TEST TSB-7 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-6 STAGE TWO
Geometric factor - G = 0.008459"
Depth factor = 237.00"
TC values from Replacement TEC-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/27	1110	0	0.00	34.88	-	-	-	-	-	0	-	-	START
10/27	1422	11520	3.20	25.83	4.93E-06	-0.13	4.86E-06	1.1	5.34E-06	29.76	5.34E-06	-	
10/27	1606	6240	4.93	21.00	4.66E-06	0.13	4.81E-06	1.1	5.29E-06	44.66	5.33E-06	0%	
10/28	815	58140	21.08	30.89	4.66E-06	0.00	4.81E-06	1.1	5.29E-06	112.23	5.30E-06	0%	Dry Refill
10/28	1341	19560	26.52	16.81	3.81E-06	-0.03	3.80E-06	1.1	4.18E-06	150.45	5.07E-06	4%	
10/28	1750	14940	30.87	12.31	2.83E-06	-0.12	2.77E-06	1.1	3.05E-06	171.37	4.80E-06	6%	
10/28	1755	300	30.75	34.88	2.83E-06	0.00	2.77E-06	1.1	3.05E-06	171.37	4.79E-06	0%	Refill
10/29	755	50400	44.75	6.94	3.26E-06	-0.13	3.25E-06	1.1	3.57E-06	254.83	4.41E-06	8%	
10/29	800	300	44.83	35.69	3.26E-06	0.00	3.25E-06	1.1	3.58E-06	254.83	4.41E-06	0%	Refill
10/29	1203	14580	48.88	28.31	3.94E-06	0.00	3.94E-06	1.1	4.33E-06	285.01	4.40E-06	0%	
10/29	1646	16980	53.60	17.81	3.17E-06	0.13	3.22E-06	1.1	3.54E-06	312.36	4.33E-06	2%	
10/29	1648	120	53.63	35.31	3.17E-06	0.00	3.22E-06	1.1	3.54E-06	312.36	4.33E-06	0%	Refill
10/30	850	57720	69.67	9.75	2.80E-06	0.00	2.80E-06	1.1	3.08E-06	394.60	4.04E-06	7%	
10/30	852	120	69.70	31.19	2.80E-06	0.00	2.80E-06	1.1	3.08E-06	394.60	4.04E-06	0%	Refill
10/30	1229	13020	73.32	25.56	2.67E-06	-0.19	2.58E-06	1.1	2.84E-06	412.72	3.96E-06	1%	
10/30	1631	14520	77.35	17.88	3.35E-06	0.00	3.35E-06	1.1	3.69E-06	437.43	3.96E-06	0%	
10/30	1635	240	77.42	35.69	3.35E-06	0.00	3.35E-06	1.1	3.69E-06	437.43	3.96E-06	0%	Refill
10/31	801	55500	92.63	7.88	3.18E-06	-0.06	3.17E-06	1.1	3.49E-06	526.91	3.89E-06	2%	
10/31	806	300	92.92	35.86	3.18E-06	0.00	3.17E-06	1.1	3.49E-06	526.91	3.89E-06	0%	Refill
10/31	1208	14520	96.95	26.50	3.95E-06	-0.13	3.90E-06	1.1	4.29E-06	557.09	3.90E-06	0%	
10/31	1548	13080	100.58	19.86	3.19E-06	0.00	3.19E-06	1.1	3.51E-06	578.39	3.89E-06	0%	
10/31	1550	240	100.65	35.63	3.19E-06	0.00	3.19E-06	1.1	3.51E-06	578.39	3.89E-06	0%	Refill
11/01	1011	66060	119.00	5.06	2.95E-06	-0.19	2.93E-06	1.1	3.23E-06	676.75	3.79E-06	3%	
11/01	1013	120	119.03	35.75	2.95E-06	0.00	2.93E-06	1.1	3.22E-06	676.75	3.79E-06	0%	Refill
11/01	1533	19200	124.37	24.44	3.62E-06	0.07	3.64E-06	1.1	4.01E-06	713.14	3.80E-06	0%	
11/01	1537	240	124.43	35.00	3.62E-06	0.00	3.64E-06	1.1	4.00E-06	713.14	3.80E-06	0%	Refill
11/02	849	61920	141.63	4.25	3.18E-06	0.25	3.21E-06	1.1	3.53E-06	812.08	3.76E-06	1%	
11/02	851	120	141.67	33.13	3.18E-06	0.00	3.21E-06	1.1	3.53E-06	812.08	3.76E-06	0%	Refill
11/02	1342	17460	146.52	20.50	4.50E-06	-0.07	4.47E-06	1.1	4.92E-06	852.72	3.80E-06	1%	
11/02	1615	9180	149.07	15.50	3.50E-06	0.13	3.60E-06	1.1	3.96E-06	868.81	3.80E-06	0%	
11/02	1618	180	149.12	35.56	3.50E-06	0.00	3.60E-06	1.1	3.96E-06	868.81	3.80E-06	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-8 STAGE TWO
Geometric factor - G = 0.006459"
Depth factor = 237.00"
TC values from Replacement TEC-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	Ki	TC	KtC	visc. factor	KtCT	cumulative volume (cc)	K (twa)	RPD (Ktwa)	Comments
11/03	819	57660	165.13	4.13	3.49E-08	0.12	3.50E-08	1.1	3.85E-08	969.94	3.81E-08	0%	
11/03	820	60	165.15	35.25	3.49E-08	0.00	3.50E-08	1.1	3.85E-08	969.94	3.81E-08	0%	Refill
11/03	1105	9900	167.90	28.69	4.04E-08	0.00	4.04E-08	1.1	4.45E-08	991.05	3.82E-08	0%	
11/03	1526	15660	172.25	19.75	3.59E-08	0.25	3.69E-08	1.1	4.06E-08	1019.81	3.82E-08	0%	
11/03	1556	1800	172.75	18.50	4.45E-08	0.25	5.34E-08	1.1	5.87E-08	1023.83	3.83E-08	0%	
11/03	1557	60	172.77	36.00	4.45E-08	0.00	5.34E-08	1.1	5.87E-08	1023.83	3.83E-08	0%	Refill
11/04	836	59940	189.42	2.63	3.57E-08	0.00	3.57E-08	1.1	3.93E-08	1131.20	3.84E-08	0%	
11/04	840	240	189.48	35.88	3.57E-08	0.00	3.57E-08	1.1	3.93E-08	1131.20	3.84E-08	0%	Refill
11/04	1645	29100	197.57	17.00	4.04E-08	0.07	4.06E-08	1.1	4.46E-08	1191.95	3.86E-08	1%	
11/04	1646	60	197.58	35.75	4.04E-08	0.00	4.06E-08	1.1	4.47E-08	1191.95	3.86E-08	0%	Refill
11/05	840	57240	213.48	3.63	3.59E-08	0.00	3.59E-08	1.1	3.95E-08	1295.30	3.87E-08	0%	
11/05	842	120	213.52	35.50	3.59E-08	0.00	3.59E-08	1.1	3.95E-08	1295.30	3.87E-08	0%	Refill
11/05	1352	18600	218.68	22.81	4.21E-08	0.00	4.21E-08	1.1	4.63E-08	1338.13	3.89E-08	0%	
11/05	1656	11040	221.75	18.69	3.54E-08	0.06	3.56E-08	1.1	3.94E-08	1355.82	3.89E-08	0%	
11/05	1657	60	221.77	35.31	3.54E-08	0.00	3.56E-08	1.1	3.94E-08	1355.82	3.89E-08	0%	Refill
11/06	835	56280	237.40	5.00	3.44E-08	0.06	3.45E-08	1.1	3.79E-08	1453.35	3.86E-08	0%	
11/06	837	120	237.43	35.75	3.44E-08	0.00	3.45E-08	1.1	3.80E-08	1453.35	3.86E-08	0%	Refill
11/06	1712	30900	246.02	16.19	3.95E-08	0.00	3.95E-08	1.1	4.35E-08	1516.29	3.90E-08	0%	
11/06	1713	60	246.03	35.88	3.95E-08	0.00	3.95E-08	1.1	4.35E-08	1516.29	3.90E-08	0%	Refill
11/07	837	55440	261.43	4.19	3.65E-08	-0.06	3.65E-08	1.1	4.01E-08	1618.26	3.91E-08	0%	
11/07	838	60	261.45	35.75	3.65E-08	0.00	3.65E-08	1.1	4.02E-08	1618.26	3.91E-08	0%	Refill
11/07	1618	27600	269.12	18.31	3.93E-08	0.06	3.94E-08	1.1	4.34E-08	1674.37	3.92E-08	0%	
11/07	1620	120	269.15	36.00	3.93E-08	0.00	3.94E-08	1.1	4.33E-08	1674.37	3.92E-08	0%	Refill
11/08	903	60180	285.87	2.00	3.63E-08	0.07	3.63E-08	1.1	4.00E-08	1783.77	3.92E-08	0%	
11/08	904	60	285.88	34.38	3.63E-08	0.00	3.63E-08	1.1	3.99E-08	1783.77	3.92E-08	0%	Refill
11/08	1619	26100	293.13	14.88	4.69E-08	0.12	4.72E-08	1.1	5.19E-08	1846.51	3.95E-08	1%	
11/08	1620	60	293.15	35.88	4.69E-08	0.00	4.72E-08	1.1	5.19E-08	1846.51	3.95E-08	0%	Refill
11/09	749	55740	308.63	35.81	4.69E-08	0.00	4.72E-08	1.1	5.19E-08	1961.96	4.02E-08	2%	-.25" Refill
11/09	1640	31860	317.48	13.44	4.41E-08	-0.13	4.38E-08	1.1	4.82E-08	2033.94	4.04E-08	1%	
11/09	1641	60	317.50	35.38	4.41E-08	0.00	4.38E-08	1.1	4.82E-08	2033.94	4.04E-08	0%	Refill
11/10	745	54240	332.57	4.19	3.68E-08	0.00	3.68E-08	1.1	4.05E-08	2134.30	4.04E-08	0%	
11/10	746	60	332.58	35.88	3.68E-08	0.00	3.68E-08	1.1	4.05E-08	2134.30	4.04E-08	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-8 STAGE TWO
Geometric factor - G = 0.006459"
Depth factor = 237.00"
TC values from Replacement TEC-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
11/10	1636	31800	341.42	16.69	3.76E-08	-0.19	3.72E-08	1.1	4.10E-08	2196.05	4.04E-08	0%	
11/10	1637	60	341.43	35.81	3.76E-08	0.00	3.72E-08	1.1	4.09E-08	2196.05	4.04E-08	0%	Refill
11/11	756	55140	356.75	6.25	3.41E-08	0.00	3.41E-08	1.1	3.75E-08	2291.16	4.03E-08	0%	
11/11	757	60	356.77	34.94	3.41E-08	0.00	3.41E-08	1.1	3.75E-08	2291.16	4.03E-08	0%	Refill
11/11	1358	21660	362.76	22.50	3.55E-08	0.00	3.55E-08	1.1	3.90E-08	2331.19	4.03E-08	0%	END TEST

END OF TEST TSB-8 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-9 STAGE TWO
Geometric factor - G = 0.006699"
Depth factor = 160.00"
TC values from Replacement TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/27	945	0	0.00	31.25	-	-	-	1.1	-	0	-	-	START
10/27	950	300	0.08	22.55	2.64E-06	0.06	2.66E-06	1.1	2.93E-06	27.99	2.93E-06	200%	
10/27	1000	600	0.25	13.13	1.50E-06	0.06	1.51E-06	1.1	1.66E-06	58.32	2.06E-06	34%	
10/27	1010	600	0.42	6.75	1.50E-06	0.06	1.51E-06	1.1	1.66E-06	78.83	1.92E-06	8%	
10/27	1020	600	0.58	1.25	9.51E-07	0.06	9.62E-07	1.1	1.06E-06	96.53	1.67E-06	14%	
10/27	1021	60	0.60	1.00	4.40E-07	0.06	5.46E-07	1.1	6.00E-07	97.33	1.64E-06	2%	
10/27	1407	13560	4.37	35.25	4.40E-07	0.00	5.46E-07	1.1	6.01E-07	100.55	7.43E-07	75%	Dry refill
10/27	1443	2160	4.97	21.25	5.86E-07	-0.13	5.80E-07	1.1	6.39E-07	145.60	7.31E-07	2%	
10/27	1601	4680	6.27	34.75	5.86E-07	0.00	5.80E-07	1.1	6.38E-07	213.97	7.12E-07	3%	Dry refill
10/28	804	57780	22.32	32.25	5.86E-07	0.00	5.80E-07	1.2	6.96E-07	325.78	7.00E-07	2%	Dry refill
10/28	1125	12060	25.67	32.75	5.86E-07	0.00	5.80E-07	1.1	6.38E-07	429.55	6.92E-07	1%	Dry refill
10/28	1335	7800	27.83	33.50	5.86E-07	0.00	5.80E-07	1.1	6.38E-07	534.93	6.86E-07	1%	Dry refill
10/28	1745	15000	32.00	35.50	5.86E-07	0.00	5.80E-07	1.1	6.38E-07	642.72	6.81E-07	1%	Dry refill
10/29	815	52200	46.50	35.00	5.86E-07	0.00	5.80E-07	1.1	6.38E-07	756.94	6.86E-07	2%	Dry refill
10/29	1150	12900	50.08	34.19	5.86E-07	0.00	5.80E-07	1.1	6.38E-07	869.56	6.86E-07	0%	Dry refill
10/29	1620	16200	54.58	35.25	5.86E-07	0.00	5.80E-07	1.1	6.38E-07	979.57	6.83E-07	0%	Dry refill
10/30	832	58320	70.78	35.00	5.86E-07	0.00	5.80E-07	1.2	6.96E-07	1092.99	6.71E-07	1%	
10/30	1217	13500	58.33	9.89	1.75E-07	-0.19	1.74E-07	1.2	2.09E-07	1174.42	6.34E-07	5%	
10/30	1222	300	58.42	35.63	1.75E-07	0.00	1.74E-07	1.2	2.09E-07	1174.42	6.34E-07	0%	Refill
10/30	1616	14016	62.31	10.13	3.21E-08	0.00	3.20E-08	1.1	3.52E-08	1256.47	5.96E-07	6%	
10/31	747	55860	77.83	33.50	3.21E-08	0.00	3.20E-08	1.1	3.52E-08	1269.06	4.84E-07	21%	Dry refill
10/31	1157	15000	81.99	6.38	1.71E-07	-0.12	1.70E-07	1.1	1.86E-07	1376.32	4.69E-07	3%	
10/31	1204	420	82.11	34.88	1.71E-07	0.00	1.70E-07	1.1	1.87E-07	1376.32	4.69E-07	0%	Refill
10/31	1527	12180	85.49	11.56	1.78E-07	0.00	1.78E-07	1.1	1.96E-07	1451.35	4.56E-07	2%	
10/31	1528	60	85.51	35.00	1.78E-07	0.00	1.78E-07	1.1	1.96E-07	1451.35	4.56E-07	0%	Refill
11/01	958	66600	104.01	34.63	1.78E-07	0.00	1.78E-07	1.1	1.96E-07	1563.97	4.11E-07	11%	Dry refill
11/01	1530	19920	109.54	33.50	1.78E-07	0.00	4.97E-09	1.1	1.96E-07	1675.39	4.01E-07	3%	Dry refill
11/01	1602	1920	110.08	25.63	3.68E-07	0.00	3.68E-07	1.1	4.05E-07	1700.71	4.01E-07	0%	
11/02	834	59520	126.81	32.06	3.68E-07	0.00	3.68E-07	1.1	4.05E-07	1783.18	4.01E-07	0%	Dry refill
11/02	1350	18960	131.88	33.50	3.68E-07	0.00	3.68E-07	1.2	4.42E-07	1886.34	4.03E-07	0%	Dry refill
11/02	1400	600	132.04	32.19	1.93E-07	-0.05	1.85E-07	1.2	2.22E-07	1890.55	4.02E-07	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-9 STAGE TWO
Geometric factor - G = 0.006699"
Depth factor = 160.00"
TC values from Replacement TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	KI	TC	KIC	visc. factor	KICT	cumulative volume (cc)	K (t,ws)	RPD (KI,ws)	Comments
11/02	1410	600	132.04	30.63	2.31E-07	-0.03	2.27E-07	1.2	2.72E-07	1895.57	4.03E-07	0%	
11/02	1420	600	132.21	29.31	1.97E-07	-0.01	1.96E-07	1.2	2.35E-07	1899.82	4.02E-07	0%	
11/02	1430	600	132.38	27.94	2.08E-07	0.01	2.07E-07	1.2	2.49E-07	1904.23	4.02E-07	0%	
11/02	1440	600	132.54	26.63	1.98E-07	0.03	2.03E-07	1.2	2.44E-07	1908.44	4.02E-07	0%	
11/02	1450	600	132.71	25.25	2.10E-07	0.05	2.18E-07	1.2	2.62E-07	1912.88	4.02E-07	0%	
11/02	1500	600	132.88	22.89	3.95E-07	0.07	4.06E-07	1.2	4.87E-07	1921.12	4.02E-07	0%	
11/02	1516	1060	133.16	22.00	5.98E-08	0.09	6.74E-08	1.2	8.09E-08	1923.34	4.01E-07	0%	
11/02	1530	720	133.36	20.56	1.86E-07	0.11	2.02E-07	1.2	2.43E-07	1927.97	4.01E-07	0%	
11/02	1550	1200	133.71	17.94	2.07E-07	0.13	2.18E-07	1.2	2.61E-07	1936.40	4.01E-07	0%	
11/02	1600	600	133.88	17.13	1.29E-07	0.13	1.50E-07	1.2	1.80E-07	1939.01	4.00E-07	0%	
11/02	1602	120	133.91	35.75	1.29E-07	0.00	1.50E-07	1.2	1.80E-07	1939.01	4.00E-07	0%	Refill
11/03	836	59640	150.46	36.00	1.29E-07	0.00	1.50E-07	1.2	1.80E-07	2054.04	3.76E-07	6%	Dry refill
11/03	1057	8460	152.83	19.63	1.75E-07	0.00	1.75E-07	1.2	2.10E-07	2108.71	3.73E-07	1%	
11/03	1545	17280	157.83	35.50	1.75E-07	0.00	1.75E-07	1.2	2.10E-07	2169.87	3.68E-07	1%	Dry refill
11/04	854	61740	174.78	34.56	1.75E-07	0.00	1.75E-07	1.2	2.10E-07	2264.10	3.53E-07	4%	Dry refill
11/04	1226	12720	178.31	11.13	1.72E-07	-0.06	1.71E-07	1.2	2.05E-07	2359.49	3.50E-07	1%	
11/04	1230	240	178.38	35.88	1.72E-07	0.00	1.71E-07	1.2	2.05E-07	2359.49	3.50E-07	0%	Refill
11/04	1623	13980	182.26	10.56	1.66E-07	0.13	1.69E-07	1.2	2.03E-07	2440.96	3.47E-07	1%	
11/04	1625	120	182.29	35.83	1.66E-07	0.00	1.69E-07	1.2	2.03E-07	2440.96	3.47E-07	0%	Refill
11/05	822	57420	198.24	33.50	1.66E-07	0.00	1.69E-07	1.2	2.03E-07	2555.60	3.35E-07	3%	Dry refill
11/05	1345	19380	203.63	2.31	1.54E-07	0.00	1.54E-07	1.2	1.85E-07	2655.96	3.31E-07	1%	
11/05	1346	60	203.64	35.75	1.54E-07	0.00	1.54E-07	1.2	1.85E-07	2655.96	3.31E-07	0%	Refill
11/05	1640	10440	206.54	16.81	1.66E-07	0.12	1.67E-07	1.2	2.00E-07	2716.90	3.29E-07	1%	
11/05	1641	60	206.56	35.81	1.66E-07	0.00	1.67E-07	1.2	2.00E-07	2716.90	3.29E-07	0%	Refill
11/06	820	56340	222.21	34.75	1.66E-07	0.00	1.67E-07	1.2	2.00E-07	2832.12	3.20E-07	3%	Dry refill
11/06	1412	21120	228.08	0.81	1.54E-07	-0.06	1.54E-07	1.2	1.85E-07	2941.33	3.17E-07	1%	
11/06	1413	60	228.09	35.94	1.54E-07	0.00	1.54E-07	1.2	1.85E-07	2941.33	3.17E-07	0%	Refill
11/06	1700	10020	230.88	18.13	1.62E-07	0.00	1.62E-07	1.2	1.94E-07	2998.64	3.15E-07	0%	
11/06	1701	60	230.89	35.88	1.62E-07	0.00	1.62E-07	1.2	1.94E-07	2998.64	3.15E-07	0%	Refill
11/07	848	56820	246.68	35.75	1.62E-07	0.00	1.62E-07	1.25	2.03E-07	3114.09	3.08E-07	2%	Dry refill
11/07	1414	19560	252.11	4.81	1.50E-07	-0.38	1.48E-07	1.2	1.77E-07	3213.64	3.05E-07	1%	
11/07	1415	60	252.13	35.75	1.50E-07	0.00	1.48E-07	1.2	1.78E-07	3213.64	3.05E-07	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-9 STAGE TWO
Geometric factor - G = 0.006699"
Depth factor = 160.00"
TC values from Replacement TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	Kt	TC	KtC	visc. factor	KtCT	cumulative volume (cc)	K (twa)	RPD (Ktwa)	Comments
11/07	1632	6220	254.41	21.83	1.55E-07	0.13	1.56E-07	1.2	1.88E-07	3259.07	3.04E-07	0%	
11/07	1633	60	254.43	35.88	1.55E-07	0.00	1.56E-07	1.2	1.87E-07	3259.07	3.04E-07	0%	Refill
11/08	857	59040	270.83	34.19	1.55E-07	0.00	1.55E-07	1.25	1.94E-07	3374.52	2.98E-07	2%	Dry refill
11/08	1328	16260	275.34	9.25	1.44E-07	-1.00	1.38E-07	1.2	1.65E-07	3454.76	2.95E-07	1%	
11/08	1329	60	275.36	35.81	1.44E-07	0.00	1.38E-07	1.2	1.66E-07	3454.76	2.95E-07	0%	Refill
11/08	1630	10860	278.38	18.50	1.45E-07	0.19	1.47E-07	1.2	1.76E-07	3510.46	2.94E-07	0%	
11/08	1631	60	278.39	35.86	1.45E-07	0.00	1.47E-07	1.2	1.76E-07	3510.46	2.94E-07	0%	Refill
11/09	736	54420	293.51	34.13	1.45E-07	0.00	1.47E-07	1.2	1.76E-07	3625.91	2.88E-07	2%	Dry refill
11/09	1347	22140	299.66	3.06	1.34E-07	-0.32	1.33E-07	1.2	1.59E-07	3725.86	2.85E-07	1%	
11/09	1348	60	299.66	35.63	1.34E-07	0.00	1.33E-07	1.2	1.60E-07	3725.86	2.85E-07	0%	Refill
11/09	1649	10860	302.69	18.00	1.46E-07	0.13	1.49E-07	1.2	1.79E-07	3762.81	2.84E-07	0%	
11/09	1650	60	302.71	35.50	1.46E-07	0.00	1.49E-07	1.2	1.79E-07	3762.81	2.84E-07	0%	Refill
11/10	751	54060	317.73	34.83	1.46E-07	0.00	1.49E-07	1.2	1.79E-07	3896.83	2.79E-07	2%	Dry Refill
11/10	1354	21780	323.76	4.56	1.31E-07	-0.25	1.30E-07	1.2	1.56E-07	3993.59	2.77E-07	1%	
11/10	1356	120	323.81	35.56	1.31E-07	0.00	1.30E-07	1.2	1.56E-07	3993.59	2.77E-07	0%	Refill
11/10	1645	10140	326.63	20.25	1.37E-07	-0.06	1.36E-07	1.2	1.63E-07	4042.85	2.76E-07	0%	
11/10	1646	60	326.64	36.00	1.37E-07	0.00	1.36E-07	1.2	1.63E-07	4042.85	2.76E-07	0%	Refill
11/11	747	54060	341.86	34.75	1.37E-07	0.00	1.36E-07	1.2	1.63E-07	4156.86	2.71E-07	2%	Dry Refill
11/11	930	6180	343.38	25.44	1.35E-07	-0.02	1.35E-07	1.2	1.61E-07	4166.84	2.70E-07	0%	
11/11	936	360	343.46	26.86	1.35E-07	0.00	1.35E-07	1.2	1.62E-07	4166.84	2.70E-07	0%	DYE Refill
11/11	1408	16320	348.01	6.06	1.23E-07	-0.06	1.23E-07	1.2	1.47E-07	4255.83	2.89E-07	1%	
11/11	1412	240	348.08	35.56	1.23E-07	0.00	1.23E-07	1.2	1.46E-07	4255.83	2.89E-07	0%	END TEST (Refill)

END OF TEST TSB-9 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-10 STAGE TWO
Geometric factor - G = 0.006634"
Depth factor = 165.25"
TC values from Replacement TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	RL	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/27	915	0	0.00	33.00	-	-	-	-	-	0	-	-	START
10/27	1410	17700	4.92	27.63	2.37E-08	-0.31	2.23E-08	1.1	2.46E-08	17.28	2.46E-08	200%	
10/27	1555	8300	6.87	24.00	4.60E-08	0.13	4.77E-08	1.1	5.24E-08	26.98	3.19E-08	26%	
10/28	805	58200	22.83	33.50	4.60E-08	0.00	4.77E-08	1.2	5.72E-08	106.16	4.98E-08	44%	Dry Refill
10/28	1332	19620	28.28	15.56	7.35E-08	-0.06	7.32E-08	1.1	8.06E-08	163.90	5.58E-08	11%	
10/28	1736	14640	32.35	4.44	6.56E-08	0.25	6.71E-08	1.1	7.38E-08	199.86	5.80E-08	4%	
10/28	1740	240	32.42	35.00	6.56E-08	0.00	6.71E-08	1.1	7.38E-08	199.86	5.81E-08	0%	Refill
10/29	820	52800	47.08	35.31	6.56E-08	0.00	6.71E-08	1.1	7.38E-08	312.30	6.30E-08	8%	Dry Refill
10/29	1148	12480	50.55	22.88	7.83E-08	0.00	7.83E-08	1.1	8.62E-08	352.29	6.46E-08	2%	
10/29	1625	16620	55.17	12.50	5.19E-08	0.06	5.22E-08	1.1	5.74E-08	365.69	6.40E-08	1%	
10/29	1628	180	55.22	35.63	5.19E-08	0.00	5.22E-08	1.1	5.74E-08	365.69	6.39E-08	0%	Refill
10/30	836	58080	71.35	32.81	5.19E-08	0.00	5.22E-08	1.2	6.26E-08	500.33	6.37E-08	0%	Dry Refill
10/30	1216	13200	75.02	15.75	1.04E-07	-0.19	1.03E-07	1.2	1.23E-07	555.23	6.66E-08	4%	
10/30	1220	240	75.08	32.81	1.04E-07	0.00	1.03E-07	1.2	1.24E-07	555.23	6.66E-08	0%	Refill
10/30	1615	14100	79.00	15.94	9.62E-08	0.00	9.62E-08	1.1	1.06E-07	609.51	6.86E-08	3%	
10/30	1627	720	79.20	34.75	9.62E-08	0.00	9.62E-08	1.1	1.06E-07	609.51	6.87E-08	0%	Refill
10/31	746	55140	94.52	31.25	9.62E-08	0.00	9.62E-08	1.1	1.06E-07	721.32	7.47E-08	8%	Dry Refill
10/31	1158	15120	98.72	15.06	8.66E-08	-0.12	8.60E-08	1.1	9.45E-08	773.41	7.55E-08	1%	
10/31	1205	420	98.83	35.38	8.66E-08	0.00	8.60E-08	1.1	9.46E-08	773.41	7.55E-08	0%	Refill
10/31	1527	12120	102.20	21.06	9.33E-08	0.00	9.33E-08	1.1	1.03E-07	819.49	7.64E-08	1%	
10/31	1535	480	102.33	35.63	9.33E-08	0.00	9.33E-08	1.1	1.03E-07	819.49	7.65E-08	0%	Refill
11/01	1002	66420	120.78	35.81	9.33E-08	0.00	9.33E-08	1.1	1.03E-07	934.13	8.05E-08	5%	Dry refill
11/01	1526	19440	126.18	18.13	7.23E-08	0.00	7.23E-08	1.1	7.95E-08	991.02	8.04E-08	0%	
11/02	837	61860	143.37	31.44	7.23E-08	0.00	7.23E-08	1.1	7.95E-08	1049.36	8.03E-08	0%	Dry Refill
11/02	1335	17880	148.33	16.63	6.67E-08	-0.07	6.64E-08	1.2	7.97E-08	1097.01	8.03E-08	0%	
11/02	1600	8700	150.75	10.88	5.60E-08	0.13	5.73E-08	1.2	6.87E-08	1115.51	8.01E-08	0%	
11/02	1603	180	150.80	35.25	5.60E-08	0.00	5.73E-08	1.2	6.88E-08	1115.51	8.01E-08	0%	Refill
11/03	838	59700	167.38	35.81	5.60E-08	0.00	5.73E-08	1.2	6.88E-08	1228.93	7.90E-08	1%	Dry refill
11/03	1056	8400	169.72	28.19	7.04E-08	0.00	7.04E-08	1.2	8.44E-08	1253.45	7.91E-08	0%	
11/03	1548	17400	174.55	13.75	6.78E-08	0.32	6.94E-08	1.2	8.33E-08	1299.91	7.92E-08	0%	
11/03	1550	120	169.75	35.75	6.78E-08	0.00	6.94E-08	1.2	8.33E-08	1299.91	7.91E-08	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-10 STAGE TWO
Geometric factor - G = 0.006634"
Depth factor = 185.25"
TC values from Replacement TEG-1

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tws)	RPD (K1ws)	Comments
11/04	858	61680	166.88	34.06	6.78E-08	0.00	6.94E-08	1.2	8.33E-08	1414.94	7.94E-08	0%	Dry refill
11/04	1231	12780	190.43	22.83	7.06E-08	-0.06	7.02E-08	1.2	8.42E-08	1451.72	7.95E-08	0%	
11/04	1626	14100	194.35	11.56	6.54E-08	0.13	6.62E-08	1.2	7.94E-08	1487.34	7.95E-08	0%	
11/04	1628	120	194.38	34.81	6.54E-08	0.00	6.62E-08	1.2	7.94E-08	1487.34	7.95E-08	0%	Refill
11/05	825	57420	210.33	35.31	6.54E-08	0.00	6.62E-08	1.2	7.94E-08	1599.34	7.95E-08	0%	Dry refill
11/05	1347	19320	215.70	18.69	6.83E-08	0.00	6.83E-08	1.2	8.20E-08	1652.82	7.96E-08	0%	
11/05	1644	10620	218.65	11.06	6.05E-08	0.12	6.15E-08	1.2	7.38E-08	1677.37	7.95E-08	0%	
11/05	1645	120	218.68	35.50	6.05E-08	0.00	6.15E-08	1.2	7.38E-08	1677.37	7.95E-08	0%	Refill
11/06	823	56220	234.30	35.75	6.05E-08	0.00	6.15E-08	1.2	7.38E-08	1791.59	7.91E-08	0%	Dry refill
11/06	1416	21180	240.18	18.44	6.49E-08	-0.06	6.47E-08	1.2	7.76E-08	1847.29	7.91E-08	0%	
11/06	1703	10020	242.97	11.00	6.26E-08	0.00	6.26E-08	1.2	7.51E-08	1871.23	7.90E-08	0%	
11/06	1704	60	242.98	35.56	6.26E-08	0.00	6.26E-08	1.2	7.51E-08	1871.23	7.90E-08	0%	Refill
11/07	852	56880	258.78	36.00	6.26E-08	0.00	6.26E-08	1.2	7.51E-08	1985.85	7.86E-08	0%	Dry refill
11/07	1417	19500	264.20	23.25	5.13E-08	-0.38	4.97E-08	1.2	5.97E-08	2026.87	7.84E-08	0%	
11/07	1635	8280	266.50	18.83	4.56E-08	0.13	4.69E-08	1.2	5.63E-08	2041.54	7.82E-08	0%	
11/07	1636	60	266.52	36.00	4.56E-08	0.00	4.69E-08	1.2	5.63E-08	2041.54	7.82E-08	0%	Refill
11/08	853	58620	282.80	3.50	4.57E-08	0.18	4.59E-08	1.25	5.74E-08	2146.11	7.70E-08	2%	
11/08	854	60	282.82	35.50	4.57E-08	0.00	4.59E-08	1.25	5.74E-08	2146.11	7.70E-08	0%	Refill
11/08	1331	16620	287.43	25.56	4.87E-08	-1.00	4.19E-08	1.2	5.03E-08	2176.09	7.56E-08	1%	
11/08	1632	10860	290.45	20.00	4.15E-08	0.19	4.29E-08	1.2	5.15E-08	2195.98	7.63E-08	0%	
11/08	1633	60	290.47	35.63	4.15E-08	0.00	4.29E-08	1.2	5.15E-08	2195.98	7.63E-08	0%	Refill
11/09	739	54360	305.57	8.56	4.05E-08	0.13	4.07E-08	1.2	4.89E-08	2283.08	7.50E-08	2%	
11/09	741	120	305.60	36.00	4.05E-08	0.00	4.07E-08	1.2	4.88E-08	2283.08	7.50E-08	0%	Refill
11/09	1651	33000	314.77	19.31	4.00E-08	-0.19	3.96E-08	1.2	4.75E-08	2336.78	7.42E-08	1%	
11/09	1652	60	314.78	36.00	4.00E-08	0.00	3.96E-08	1.2	4.75E-08	2336.78	7.42E-08	0%	Refill
11/10	752	54000	329.78	6.63	4.44E-08	0.06	4.45E-08	1.2	5.34E-08	2431.28	7.32E-08	1%	
11/10	753	60	329.80	36.00	4.44E-08	0.00	4.45E-08	1.2	5.34E-08	2431.28	7.32E-08	0%	Refill
11/10	1648	32100	338.72	17.13	4.68E-08	-0.31	4.60E-08	1.2	5.52E-08	2492.00	7.28E-08	1%	
11/10	1649	60	338.73	35.88	4.68E-08	0.00	4.60E-08	1.2	5.52E-08	2492.00	7.28E-08	0%	Refill
11/11	750	54060	353.75	9.31	3.99E-08	-0.06	3.98E-08	1.2	4.78E-08	2577.49	7.17E-08	1%	
11/11	751	60	353.77	36.00	3.99E-08	0.00	3.98E-08	1.2	4.76E-08	2577.49	7.17E-08	0%	Refill
11/11	1413	22920	360.13	24.38	3.97E-08	-0.06	3.95E-08	1.2	4.73E-08	2614.86	7.13E-08	1%	END TEST

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-11 STAGE TWO
Geometric factor - G = 0.006576"
Depth factor = 234.75"
TC values from Replacement TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (t,ws)	RPD (K1,ws)	Comments
10/27	859	0	0.00	35.25	-	-	-	-	-	0.00	-	-	START
10/27	1411	18720	5.20	31.56	1.23E-08	-0.13	1.18E-08	1.1	1.30E-08	11.87	1.30E-08	-	
10/27	1559	6480	7.00	30.13	1.39E-08	0.13	1.51E-08	1.1	1.67E-08	16.47	1.40E-08	7%	
10/28	800	57660	23.02	17.50	1.42E-08	0.06	1.42E-08	1.1	1.56E-08	57.11	1.51E-08	8%	
10/28	1335	20100	28.60	14.38	1.03E-08	-0.03	1.02E-08	1.1	1.13E-08	67.15	1.44E-08	5%	
10/28	1737	14520	32.63	12.19	1.02E-08	-0.12	9.80E-09	1.1	1.06E-08	74.20	1.39E-08	3%	
10/29	811	52440	47.20	4.38	1.02E-08	-0.13	1.01E-08	1.1	1.11E-08	99.33	1.30E-08	6%	
10/29	825	240	47.27	33.00	1.02E-08	0.00	1.01E-08	1.1	1.11E-08	99.33	1.30E-08	0%	Refill
10/29	1149	12240	50.67	30.69	1.16E-08	0.00	1.16E-08	1.1	1.30E-08	106.76	1.30E-08	0%	
10/29	1630	16860	55.35	27.63	1.15E-08	0.13	1.20E-08	1.1	1.32E-08	116.81	1.30E-08	0%	
10/30	838	58080	71.48	17.50	1.13E-08	0.00	1.13E-08	1.1	1.25E-08	149.20	1.29E-08	1%	
10/30	1215	13020	75.10	15.19	1.16E-08	-0.19	1.08E-08	1.1	1.19E-08	156.84	1.29E-08	0%	
10/30	1614	14340	79.08	12.75	1.14E-08	0.00	1.14E-08	1.1	1.26E-08	164.49	1.28E-08	0%	
10/30	1625	660	79.27	35.81	1.14E-08	0.00	1.14E-08	1.1	1.25E-08	164.83	1.28E-08	0%	Refill
10/31	745	58980	95.65	25.50	1.10E-08	-0.06	1.09E-08	1.1	1.20E-08	198.01	1.27E-08	1%	
10/31	1158	15180	99.87	21.56	1.68E-08	-0.13	1.62E-08	1.1	1.79E-08	210.66	1.29E-08	2%	
10/31	1528	12600	103.37	19.25	1.20E-08	0.00	1.20E-08	1.1	1.32E-08	218.12	1.29E-08	0%	
11/01	950	85520	121.57	8.19	1.13E-08	-0.19	1.12E-08	1.1	1.23E-08	253.70	1.28E-08	1%	
11/01	1006	960	121.83	35.75	1.13E-08	0.00	1.12E-08	1.1	1.23E-08	260.05	1.28E-08	0%	Dry refill
11/01	1525	19140	127.15	31.75	1.30E-08	0.07	1.32E-08	1.1	1.46E-08	292.92	1.29E-08	1%	
11/02	822	61020	144.10	20.63	1.17E-08	0.25	1.19E-08	1.1	1.31E-08	328.70	1.29E-08	0%	
11/02	1334	18720	149.30	17.38	1.14E-08	-0.07	1.12E-08	1.1	1.23E-08	339.16	1.29E-08	0%	
11/02	1605	9060	151.82	15.25	1.56E-08	0.13	1.66E-08	1.1	1.83E-08	346.01	1.30E-08	1%	
11/03	834	59340	168.30	5.00	1.16E-08	0.12	1.19E-08	1.1	1.31E-08	379.00	1.30E-08	0%	
11/03	840	360	168.40	35.63	1.16E-08	0.00	1.19E-08	1.1	1.31E-08	379.19	1.30E-08	0%	Refill
11/03	1100	8400	170.73	33.88	1.29E-08	0.00	1.29E-08	1.1	1.42E-08	384.82	1.30E-08	0%	
11/03	1553	17580	175.62	30.31	1.27E-08	0.25	1.36E-08	1.1	1.50E-08	396.31	1.31E-08	0%	
11/04	851	61080	192.58	18.38	1.26E-08	0.00	1.26E-08	1.1	1.39E-08	434.70	1.31E-08	1%	
11/04	1232	13260	196.27	15.88	1.25E-08	0.00	1.25E-08	1.1	1.38E-08	442.74	1.32E-08	0%	
11/04	1621	13740	200.08	13.25	1.28E-08	0.07	1.32E-08	1.1	1.45E-08	451.20	1.32E-08	0%	
11/05	819	57480	216.05	3.50	1.17E-08	0.00	1.17E-08	1.1	1.28E-08	482.58	1.32E-08	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-11 STAGE TWO
Geometric factor - G = 0.006576"
Depth factor = 234.75"
TC values from Replacement TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
11/05	827	480	216.16	35.56	1.17E-08	0.00	1.17E-08	1.1	1.29E-08	482.64	1.32E-08	0%	Refill
11/05	1349	19320	221.55	31.25	1.39E-08	0.00	1.39E-08	1.1	1.53E-08	496.70	1.32E-08	0%	
11/05	1649	10080	224.35	29.00	1.41E-08	0.08	1.45E-08	1.1	1.59E-08	503.94	1.32E-08	0%	
11/06	822	55980	239.90	17.56	1.32E-08	0.08	1.33E-08	1.1	1.46E-08	540.75	1.33E-08	1%	
11/06	1417	21300	245.82	13.56	1.25E-08	-0.06	1.23E-08	1.1	1.36E-08	553.82	1.33E-08	0%	
11/06	1707	10200	248.65	11.75	1.20E-08	0.00	1.20E-08	1.1	1.32E-08	559.45	1.33E-08	0%	
11/06	1708	60	248.67	35.50	1.20E-08	0.00	1.20E-08	1.1	1.32E-08	559.48	1.33E-08	0%	Refill
11/07	853	56700	264.42	23.31	1.36E-08	-0.06	1.35E-08	1.1	1.49E-08	598.70	1.34E-08	1%	
11/07	1418	19500	269.83	19.38	1.31E-08	-0.13	1.27E-08	1.1	1.40E-08	611.35	1.34E-08	0%	
11/07	1627	7740	271.98	17.88	1.28E-08	0.06	1.33E-08	1.1	1.46E-08	616.17	1.34E-08	0%	
11/08	851	59040	288.38	7.00	1.25E-08	0.07	1.25E-08	1.1	1.38E-08	651.18	1.35E-08	0%	
11/08	852	60	288.40	35.50	1.25E-08	0.00	1.25E-08	1.1	1.38E-08	651.22	1.35E-08	0%	Refill
11/08	1332	16800	293.07	31.56	1.46E-08	-0.69	1.20E-08	1.1	1.32E-08	663.89	1.35E-08	0%	
11/08	1635	10980	296.12	29.44	1.22E-08	0.12	1.26E-08	1.1	1.41E-08	670.72	1.35E-08	0%	
11/09	743	54480	311.25	18.75	1.27E-08	-0.07	1.26E-08	1.1	1.38E-08	705.11	1.35E-08	0%	
11/09	1654	33060	320.43	12.69	1.22E-08	-0.13	1.20E-08	1.1	1.32E-08	724.81	1.35E-08	0%	
11/09	1655	60	320.45	36.00	1.22E-08	0.00	1.20E-08	1.1	1.32E-08	724.85	1.35E-08	0%	Refill
11/10	755	54000	335.45	25.00	1.28E-08	0.00	1.28E-08	1.1	1.41E-08	760.04	1.35E-08	0%	
11/10	1650	32100	344.37	18.81	1.26E-08	-0.19	1.22E-08	1.1	1.34E-08	779.96	1.35E-08	0%	
11/11	752	54120	359.40	9.31	1.18E-08	0.00	1.18E-08	1.1	1.30E-08	810.52	1.35E-08	0%	
11/11	1414	22920	365.77	5.56	1.13E-08	0.00	1.13E-08	1.1	1.24E-08	822.59	1.35E-08	0%	END TEST

END OF TEST TSB-11 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-12 STAGE TWO
Geometric factor - G = 0.006401"
Depth factor = 266.00"
TC values from Replacement TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
10/26	1047	0	0.00	33.50	-	-	-	-	-	0.00	-	-	START
10/26	1130	2580	0.72	32.75	1.58E-08	-0.40	7.37E-09	1.1	8.11E-09	2.41	8.11E-09	-	
10/26	1500	12600	4.22	29.88	1.25E-08	-0.45	1.05E-08	1.1	1.15E-08	11.85	1.10E-08	30%	
10/26	1634	5640	5.78	27.75	2.08E-08	-0.50	1.59E-08	1.1	1.75E-08	16.50	1.27E-08	15%	
10/27	751	55020	21.07	0.69	2.86E-08	-0.25	2.83E-08	1.1	3.11E-08	105.57	2.61E-08	69%	
10/27	753	120	21.10	33.38	2.86E-08	0.00	2.83E-08	1.1	3.11E-08	105.76	2.61E-08	0%	Refill
10/27	1351	21480	27.07	16.69	3.81E-08	-0.13	3.77E-08	1.1	4.15E-08	153.03	2.95E-08	12%	
10/27	1612	9480	29.42	13.75	3.36E-08	0.13	3.45E-08	1.1	3.80E-08	166.92	3.02E-08	2%	
10/27	1627	300	29.50	34.50	3.36E-08	0.00	3.45E-08	1.1	3.80E-08	169.46	3.02E-08	0%	Refill
10/28	743	54960	44.77	1.25	3.47E-08	0.06	3.48E-08	1.1	3.82E-08	276.45	3.29E-08	9%	
10/28	820	2220	45.38	33.81	3.47E-08	0.00	3.48E-08	1.1	3.83E-08	280.80	3.30E-08	0%	Refill
10/28	1355	20100	50.97	20.13	3.78E-08	-0.03	3.77E-08	1.1	4.15E-08	324.62	3.39E-08	3%	
10/28	1716	12060	54.32	13.06	3.37E-08	-0.12	3.32E-08	1.1	3.65E-08	347.37	3.41E-08	0%	
10/28	1720	240	54.38	34.13	3.37E-08	0.00	3.32E-08	1.1	3.65E-08	347.81	3.41E-08	0%	Refill
10/29	740	51600	68.72	2.44	3.52E-08	-0.13	3.50E-08	1.1	3.85E-08	449.76	3.50E-08	3%	
10/29	835	3300	69.63	35.88	3.52E-08	0.00	3.50E-08	1.1	3.85E-08	455.91	3.51E-08	0%	Refill
10/29	1135	10800	72.63	26.00	3.96E-08	0.00	3.98E-08	1.1	4.38E-08	481.26	3.54E-08	1%	
10/29	1555	15600	76.97	16.06	3.56E-08	0.13	3.63E-08	1.1	4.00E-08	513.25	3.57E-08	1%	
10/29	1600	300	77.05	35.88	3.56E-08	0.00	3.63E-08	1.1	3.99E-08	513.85	3.57E-08	0%	Refill
10/30	800	57600	93.05	1.88	3.37E-08	0.00	3.37E-08	1.1	3.71E-08	623.25	3.59E-08	1%	
10/30	807	420	93.17	35.25	3.37E-08	0.00	3.37E-08	1.1	3.71E-08	624.04	3.59E-08	0%	Refill
10/30	1157	13800	97.00	25.81	3.75E-08	-0.19	3.67E-08	1.1	4.04E-08	654.41	3.61E-08	0%	
10/30	1545	13680	100.80	17.63	3.38E-08	0.00	3.38E-08	1.1	3.72E-08	680.73	3.61E-08	0%	
10/30	1549	240	100.87	35.38	3.38E-08	0.00	3.38E-08	1.1	3.72E-08	681.19	3.61E-08	0%	Refill
10/31	718	55740	116.35	2.75	3.34E-08	-0.06	3.34E-08	1.1	3.67E-08	786.18	3.62E-08	0%	
10/31	725	420	116.47	35.50	3.34E-08	0.00	3.34E-08	1.1	3.67E-08	786.96	3.62E-08	0%	Refill
10/31	1141	15360	120.73	25.06	3.73E-08	-0.13	3.68E-08	1.1	4.05E-08	820.55	3.64E-08	0%	
10/31	1501	12000	124.07	18.00	3.33E-08	0.00	3.33E-08	1.1	3.66E-08	843.27	3.64E-08	0%	
10/31	1509	480	124.20	35.38	3.33E-08	0.00	3.33E-08	1.1	3.66E-08	844.14	3.64E-08	0%	Refill
11/01	927	65880	142.50	33.00	3.33E-08	0.00	3.33E-08	1.1	3.66E-08	957.98	3.64E-08	0%	Dry refill
11/01	1456	19740	147.98	19.88	3.70E-08	0.07	3.72E-08	1.1	4.09E-08	1000.20	3.66E-08	0%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-12 STAGE TWO
Geometric factor - G = 0.006401"
Depth factor = 266.00"
TC values from Replacement TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	Ki	TC	KiC	visc. factor	KiCT	cumulative volume (cc)	K (twa)	RPD (Ktwa)	Comments
11/01	1507	660	148.17	35.44	3.70E-08	0.00	3.72E-08	1.1	4.09E-08	1001.56	3.66E-08	0%	Refill
11/02	754	60480	164.97	3.56	3.00E-08	0.25	3.03E-08	1.1	3.33E-08	1104.08	3.62E-08	1%	
11/02	802	480	165.10	35.36	3.00E-08	0.00	3.03E-08	1.1	3.33E-08	1104.88	3.62E-08	0%	Refill
11/02	1317	18900	170.35	24.00	3.31E-08	-0.07	3.29E-08	1.1	3.62E-08	1141.50	3.62E-08	0%	
11/02	1624	11220	173.47	16.19	2.93E-08	0.13	3.00E-08	1.1	3.30E-08	1160.19	3.62E-08	0%	
11/02	1628	240	173.53	35.63	2.93E-08	0.00	3.00E-08	1.1	3.30E-08	1160.59	3.62E-08	0%	Refill
11/03	755	55620	188.98	7.06	2.91E-08	0.12	2.92E-08	1.1	3.21E-08	1252.51	3.58E-08	1%	
11/03	800	300	189.07	35.88	2.91E-08	0.00	2.92E-08	1.1	3.21E-08	1253.01	3.58E-08	0%	Refill
11/03	1113	11580	192.28	29.50	3.00E-08	0.00	3.00E-08	1.1	3.30E-08	1273.53	3.58E-08	0%	
11/03	1503	13800	196.12	22.44	2.85E-08	0.25	2.95E-08	1.1	3.25E-08	1298.25	3.57E-08	0%	
11/04	805	61320	213.15	35.63	2.85E-08	0.00	2.85E-08	1.1	3.14E-08	1366.45	3.54E-08	1%	Dry refill
11/04	1215	15000	217.32	27.31	3.03E-08	0.00	3.03E-08	1.1	3.33E-08	1395.22	3.53E-08	0%	
11/04	1600	13500	221.07	20.69	2.75E-08	0.07	2.78E-08	1.1	3.06E-08	1416.52	3.53E-08	0%	
11/04	1650	3000	221.90	19.31	2.82E-08	0.07	2.75E-08	1.1	3.02E-08	1420.96	3.52E-08	0%	
11/04	1652	120	221.93	35.25	2.82E-08	0.00	2.75E-08	1.1	3.03E-08	1421.13	3.52E-08	0%	Refill
11/05	746	53640	236.83	10.06	2.65E-08	0.00	2.65E-08	1.1	2.91E-08	1502.19	3.49E-08	1%	
11/05	750	240	236.90	35.81	2.65E-08	0.00	2.65E-08	1.1	2.92E-08	1502.55	3.49E-08	0%	Refill
11/05	1332	20520	242.60	25.31	2.81E-08	0.00	2.81E-08	1.1	3.09E-08	1536.33	3.48E-08	0%	
11/05	1617	9900	245.35	20.88	2.52E-08	0.06	2.55E-08	1.1	2.81E-08	1550.59	3.47E-08	0%	
11/05	1618	60	245.37	35.88	2.52E-08	0.00	2.55E-08	1.1	2.81E-08	1550.67	3.47E-08	0%	Refill
11/06	755	56220	260.98	10.31	2.56E-08	0.06	2.57E-08	1.1	2.82E-08	1632.95	3.43E-08	1%	
11/06	758	180	261.03	35.56	2.56E-08	0.00	2.57E-08	1.1	2.83E-08	1633.21	3.43E-08	0%	Refill
11/06	1405	22020	267.15	24.75	2.70E-08	-0.06	2.66E-08	1.1	2.95E-08	1667.99	3.42E-08	0%	
11/06	1640	9300	269.73	20.69	2.46E-08	0.00	2.46E-08	1.1	2.70E-08	1681.05	3.41E-08	0%	
11/06	1642	120	269.77	35.75	2.46E-08	0.00	2.46E-08	1.1	2.71E-08	1681.22	3.41E-08	0%	Refill
11/07	825	56580	285.48	10.75	2.49E-08	-0.06	2.48E-08	1.1	2.73E-08	1761.66	3.37E-08	1%	
11/07	826	60	285.50	35.88	2.49E-08	0.00	2.48E-08	1.1	2.73E-08	1761.75	3.37E-08	0%	Refill
11/07	1358	19920	291.03	26.38	2.61E-08	-0.13	2.57E-08	1.1	2.83E-08	1792.31	3.36E-08	0%	
11/07	1640	5580	292.58	22.19	4.21E-08	0.06	4.27E-08	1.1	4.69E-08	1805.79	3.37E-08	0%	
11/07	1641	60	292.60	35.88	4.21E-08	0.00	4.27E-08	1.1	4.70E-08	1805.94	3.37E-08	0%	Refill
11/08	828	56820	308.38	12.19	2.34E-08	0.07	2.35E-08	1.1	2.58E-08	1882.16	3.33E-08	1%	
11/08	1315	17220	313.17	5.81	2.19E-08	-0.69	1.95E-08	1.1	2.15E-08	1902.69	3.31E-08	1%	

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-12 STAGE TWO
Geometric factor - G = 0.006401"
Depth factor = 266.00"
TC values from Replacement TEG-2

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (tws)	RPD (K1ws)	Comments
11/08	1316	60	313.16	36.00	2.19E-08	0.00	1.95E-08	1.1	2.15E-08	1902.76	3.31E-08	0%	Refill
11/08	1600	9840	315.92	31.83	2.41E-08	0.12	2.47E-08	1.1	2.72E-08	1916.82	3.31E-08	0%	
11/09	714	54840	331.15	10.44	2.19E-08	-0.07	2.18E-08	1.1	2.40E-08	1965.00	3.27E-08	1%	
11/09	715	60	331.17	35.94	2.19E-08	0.00	2.18E-08	1.1	2.40E-08	1965.08	3.27E-08	0%	Refill
11/09	1336	22860	337.52	25.94	2.40E-08	-0.19	2.35E-08	1.1	2.58E-08	2017.26	3.25E-08	0%	
11/09	1617	9660	340.20	22.13	2.21E-08	0.06	2.25E-08	1.1	2.47E-08	2029.51	3.25E-08	0%	
11/09	1618	60	340.22	35.75	2.21E-08	0.00	2.25E-08	1.1	2.48E-08	2029.59	3.25E-08	0%	Refill
11/10	721	54180	355.27	14.38	2.20E-08	0.00	2.20E-08	1.1	2.42E-08	2098.35	3.21E-08	1%	
11/10	723	120	355.30	35.81	2.20E-08	0.00	2.20E-08	1.1	2.42E-08	2098.50	3.21E-08	0%	Refill
11/10	1617	32040	364.20	22.63	2.27E-08	-0.19	2.23E-08	1.1	2.46E-08	2140.91	3.19E-08	1%	
11/10	1618	60	364.22	35.75	2.27E-08	0.00	2.23E-08	1.1	2.45E-08	2140.99	3.19E-08	0%	Refill
11/11	727	54540	379.37	14.56	2.14E-08	0.00	2.14E-08	1.1	2.35E-08	2208.14	3.16E-08	1%	
11/11	728	60	379.38	35.75	2.14E-08	0.00	2.14E-08	1.1	2.36E-08	2208.21	3.16E-08	0%	Refill
11/11	1338	22200	385.55	27.00	2.16E-08	0.00	2.16E-08	1.1	2.37E-08	2236.37	3.15E-08	0%	END TEST

END OF TEST TSB-12 STAGE TWO

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-13 STAGE TWO
Geometric factor - G = 0.006243"
Depth factor = 356.8"
TC values from TEG-3

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (t,wa)	RPD (K1,wa)	Comments
10/26	1130	0	0.00	33.56	-	-	-	1.1	-	0.00	-	-	START
10/26	1502	12720	3.53	19.38	4.61E-06	0.06	4.63E-06	1.1	5.10E-06	45.83	5.10E-06	-	
10/26	1634	5520	5.07	12.81	5.06E-06	-0.06	5.01E-06	1.1	5.52E-06	66.77	5.22E-06	2%	
10/26	1636	120	5.10	35.25	5.06E-06	0.00	5.01E-06	1.1	5.51E-06	67.21	5.23E-06	0%	Refill
10/27	754	55080	20.40	34.88	5.06E-06	0.00	5.01E-06	1.1	5.51E-06	160.84	5.44E-06	4%	Dry refill
10/27	1352	21480	26.37	14.25	3.99E-06	-0.13	3.97E-06	1.1	4.37E-06	247.01	5.20E-06	5%	
10/27	1613	9460	28.72	7.31	3.54E-06	0.19	3.54E-06	1.1	4.00E-06	269.34	5.10E-06	2%	
10/27	1628	900	28.97	34.63	3.54E-06	0.00	3.54E-06	1.1	4.00E-06	271.49	5.09E-06	0%	Refill
10/28	748	55080	44.27	31.00	3.54E-06	0.00	3.54E-06	1.1	4.00E-06	382.92	4.71E-06	8%	Dry refill
10/28	1318	19920	49.80	9.00	4.65E-06	-0.31	4.58E-06	1.1	5.04E-06	453.70	4.75E-06	1%	
10/28	1400	2520	50.50	6.56	4.21E-06	0.06	4.32E-06	1.1	4.75E-06	461.58	4.75E-06	0%	
10/28	1725	12300	53.92	32.75	4.21E-06	0.00	4.32E-06	1.1	4.75E-06	482.66	4.75E-06	0%	Dry refill
10/29	840	54900	69.17	32.81	4.21E-06	0.00	4.32E-06	1.1	4.75E-06	586.04	4.75E-06	0%	Dry refill
10/29	1135	10500	72.08	20.44	4.87E-06	-0.06	4.85E-06	1.1	5.33E-06	627.84	4.77E-06	0%	
10/29	1556	15660	76.43	4.25	4.44E-06	0.12	4.48E-06	1.1	4.92E-06	679.93	4.78E-06	0%	
10/29	1600	240	76.50	35.56	4.44E-06	0.00	4.48E-06	1.1	4.93E-06	680.72	4.78E-06	0%	Refill
10/30	805	57900	92.58	35.75	4.44E-06	0.00	4.48E-06	1.1	4.93E-06	795.14	4.81E-06	1%	Dry refill
10/30	1159	14040	96.48	17.75	5.30E-06	-0.13	5.26E-06	1.1	5.79E-06	853.05	4.85E-06	1%	
10/30	1547	13680	100.28	2.25	4.90E-06	-0.06	4.88E-06	1.1	5.37E-06	902.93	4.87E-06	0%	
10/30	1553	360	100.38	35.38	4.90E-06	0.00	4.88E-06	1.1	5.37E-06	904.21	4.87E-06	0%	Refill
10/31	719	55560	115.82	33.50	4.90E-06	0.00	4.88E-06	1.1	5.37E-06	1018.05	4.93E-06	1%	Dry refill
10/31	1142	15780	120.20	10.00	6.24E-06	0.00	6.24E-06	1.1	6.86E-06	1093.66	5.00E-06	1%	
10/31	1145	180	120.25	35.38	6.24E-06	0.00	6.24E-06	1.1	6.86E-06	1094.51	5.01E-06	0%	Refill
10/31	1502	11820	123.53	15.00	7.16E-06	0.00	7.16E-06	1.1	7.88E-06	1160.09	5.08E-06	2%	
10/31	1508	360	123.63	35.06	7.16E-06	0.00	7.16E-06	1.1	7.88E-06	1162.02	5.08E-06	0%	Refill
11/01	928	66000	141.97	35.00	7.16E-06	0.00	7.16E-06	1.1	7.88E-06	1274.83	5.44E-06	7%	Dry refill
11/01	1500	19920	147.50	5.31	6.27E-06	0.00	6.27E-06	1.1	6.90E-06	1370.36	5.50E-06	1%	
11/01	1505	300	147.58	35.56	6.27E-06	0.00	6.27E-06	1.1	6.90E-06	1371.78	5.50E-06	0%	Refill
11/02	754	60540	164.40	33.00	6.27E-06	0.00	6.27E-06	1.1	6.90E-06	1486.20	5.64E-06	3%	Dry refill
11/02	1318	19440	169.80	7.13	5.60E-06	-0.13	5.57E-06	1.1	6.13E-06	1569.44	5.66E-06	0%	
11/02	1321	180	169.85	34.88	5.60E-06	0.00	5.57E-06	1.1	6.13E-06	1570.20	5.66E-06	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-13 STAGE TWO
Geometric factor - G = 0.006243"
Depth factor = 356.8"
TC values from TEG-3

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
11/02	1625	11040	172.92	19.50	5.75E-08	0.13	5.80E-08	1.1	6.38E-08	1619.69	5.67E-08	0%	
11/02	1630	300	173.00	35.44	5.75E-08	0.00	5.80E-08	1.1	6.38E-08	1621.00	5.67E-08	0%	Refill
11/03	758	55680	186.47	34.31	5.75E-08	0.00	5.80E-08	1.1	6.38E-08	1735.03	5.73E-08	1%	Dry refill
11/03	1114	11760	191.73	19.56	5.18E-08	0.00	5.18E-08	1.1	5.70E-08	1782.49	5.73E-08	0%	
11/03	1504	13800	195.57	3.38	5.05E-08	0.18	5.11E-08	1.1	5.62E-08	1834.55	5.73E-08	0%	
11/03	1507	180	195.62	35.31	5.05E-08	0.00	5.11E-08	1.1	5.62E-08	1835.22	5.73E-08	0%	Refill
11/04	808	61260	212.63	34.06	5.05E-08	0.00	5.11E-08	1.1	5.62E-08	1948.83	5.72E-08	0%	Dry refill
11/04	1218	14880	216.77	15.38	5.22E-08	0.00	5.22E-08	1.1	5.74E-08	2008.94	5.72E-08	0%	
11/04	1605	13740	220.58	35.25	5.22E-08	0.00	5.22E-08	1.1	5.74E-08	2058.43	5.72E-08	0%	Dry refill
11/05	755	57000	236.42	33.50	5.22E-08	0.00	5.22E-08	1.1	5.74E-08	2171.85	5.72E-08	0%	Dry refill
11/05	1333	20280	242.05	9.50	4.96E-08	-0.12	4.94E-08	1.1	5.43E-08	2249.07	5.71E-08	0%	
11/05	1335	120	242.08	35.75	4.96E-08	0.00	4.94E-08	1.1	5.43E-08	2249.52	5.71E-08	0%	Refill
11/05	1620	9900	244.83	23.63	5.02E-08	0.16	5.10E-08	1.1	5.61E-08	2288.52	5.71E-08	0%	
11/05	1622	120	244.87	35.81	5.02E-08	0.00	5.10E-08	1.1	5.61E-08	2288.99	5.71E-08	0%	Refill
11/06	800	56280	260.50	33.38	5.02E-08	0.00	5.10E-08	1.1	5.61E-08	2404.21	5.71E-08	0%	Dry refill
11/06	1406	21960	266.60	7.56	4.94E-08	-0.06	4.93E-08	1.1	5.43E-08	2467.29	5.70E-08	0%	
11/06	1407	60	266.62	35.25	4.94E-08	0.00	4.93E-08	1.1	5.42E-08	2467.51	5.70E-08	0%	Refill
11/06	1643	9360	269.22	23.63	5.10E-08	0.06	5.12E-08	1.1	5.64E-08	2524.90	5.70E-08	0%	
11/06	1644	60	269.23	35.88	5.10E-08	0.00	5.12E-08	1.1	5.63E-08	2525.14	5.70E-08	0%	Refill
11/07	828	56640	284.97	34.38	5.10E-08	0.00	5.12E-08	1.1	5.63E-08	2640.59	5.70E-08	0%	Dry refill
11/07	1400	19920	290.50	11.06	4.89E-08	-0.13	4.86E-08	1.1	5.35E-08	2715.82	5.69E-08	0%	
11/07	1401	60	290.52	35.75	4.89E-08	0.00	4.86E-08	1.1	5.35E-08	2715.85	5.69E-08	0%	Refill
11/07	1645	9840	293.25	23.69	5.03E-08	0.07	5.06E-08	1.1	5.56E-08	2754.65	5.69E-08	0%	
11/07	1647	120	293.28	36.00	5.03E-08	0.00	5.06E-08	1.1	5.57E-08	2755.12	5.69E-08	0%	Refill
11/08	830	56580	309.00	33.63	5.03E-08	0.00	5.06E-08	1.1	5.57E-08	2870.95	5.68E-08	0%	Dry refill
11/08	1318	17280	313.80	12.75	5.04E-08	-0.19	5.00E-08	1.1	5.50E-08	2938.14	5.68E-08	0%	
11/08	1319	60	313.82	35.75	5.04E-08	0.00	5.00E-08	1.1	5.50E-08	2938.37	5.68E-08	0%	Refill
11/08	1602	9660	316.51	24.13	4.92E-08	-0.19	4.84E-08	1.1	5.32E-08	2975.76	5.68E-08	0%	
11/08	1603	60	316.52	35.88	4.92E-08	0.00	4.84E-08	1.1	5.32E-08	2975.99	5.68E-08	0%	Refill
11/09	718	54900	331.77	33.44	4.92E-08	0.00	4.84E-08	1.1	5.32E-08	3091.44	5.66E-08	0%	Dry refill
11/09	1337	22740	338.09	7.50	4.80E-08	-0.12	4.77E-08	1.1	5.25E-08	3174.90	5.65E-08	0%	
11/09	1338	60	338.11	35.75	4.80E-08	0.00	4.77E-08	1.1	5.25E-08	3175.12	5.65E-08	0%	Refill

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE TWO DATA

TSB-13 STAGE TWO
Geometric factor - G = 0.006243"
Depth factor = 356.8"
TC values from TEG-3

Date	Time	elapsed time seconds	cumulative elapsed time hours	Rt	K1	TC	K1C	visc. factor	K1CT	cumulative volume (cc)	K (twa)	RPD (K1wa)	Comments
11/09	1619	9660	340.79	24.13	4.93E-06	0.00	4.93E-06	1.1	5.43E-06	3212.51	5.85E-06	0%	
11/09	1620	60	340.81	36.00	4.93E-06	0.00	4.93E-06	1.1	5.42E-06	3212.74	5.85E-06	0%	Refill
11/10	725	54300	355.89	34.25	4.93E-06	0.00	4.93E-06	1.1	5.42E-06	3328.57	5.84E-06	0%	Dry refill
11/10	1341	22560	362.16	9.00	4.69E-06	-0.13	4.67E-06	1.1	5.13E-06	3409.82	5.83E-06	0%	
11/10	1342	60	362.17	35.88	4.69E-06	0.00	4.67E-06	1.1	5.14E-06	3410.03	5.83E-06	0%	Refill
11/10	1620	9480	364.81	25.13	4.64E-06	0.00	4.64E-06	1.1	5.11E-06	3444.82	5.83E-06	0%	
11/10	1621	60	364.82	35.75	4.64E-06	0.00	4.64E-06	1.1	5.10E-06	3444.84	5.83E-06	0%	Refill
11/11	730	54540	379.97	34.88	4.64E-06	0.00	4.64E-06	1.1	5.10E-06	3559.87	5.81E-06	0%	Dry refill
11/11	1340	22200	386.14	10.56	4.58E-06	0.06	4.59E-06	1.1	5.05E-06	3636.12	5.80E-06	0%	END TEST

END OF TEST TSB-13 STAGE TWO

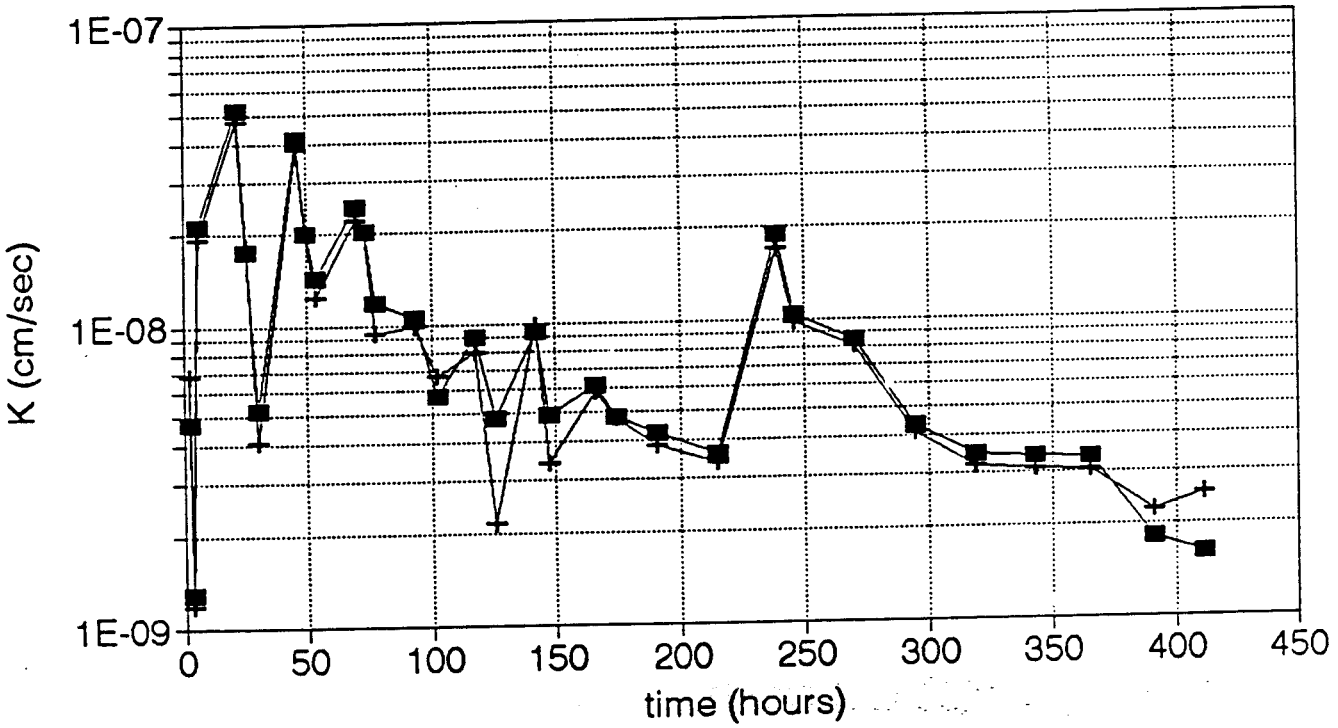
ATTACHMENT 3A

TSB DATA PLOTS

STAGE 1

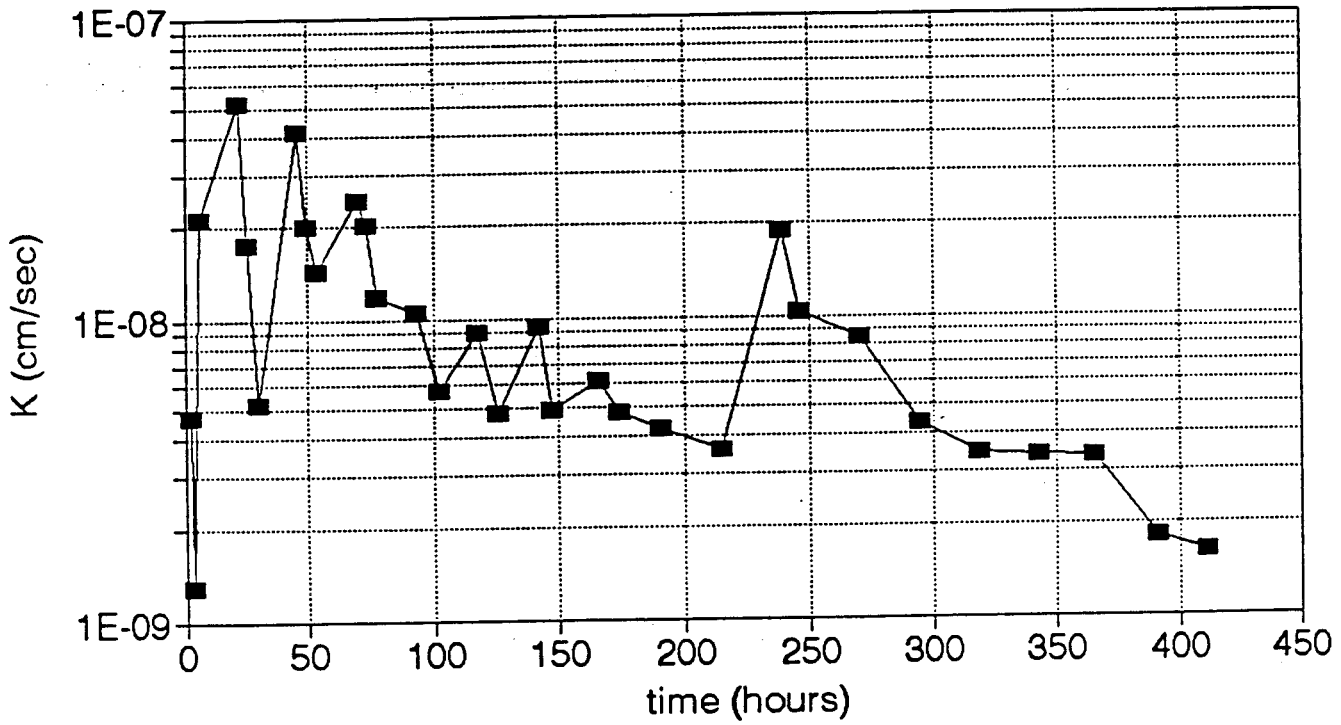
TSB-1 STAGE ONE

t vs. K



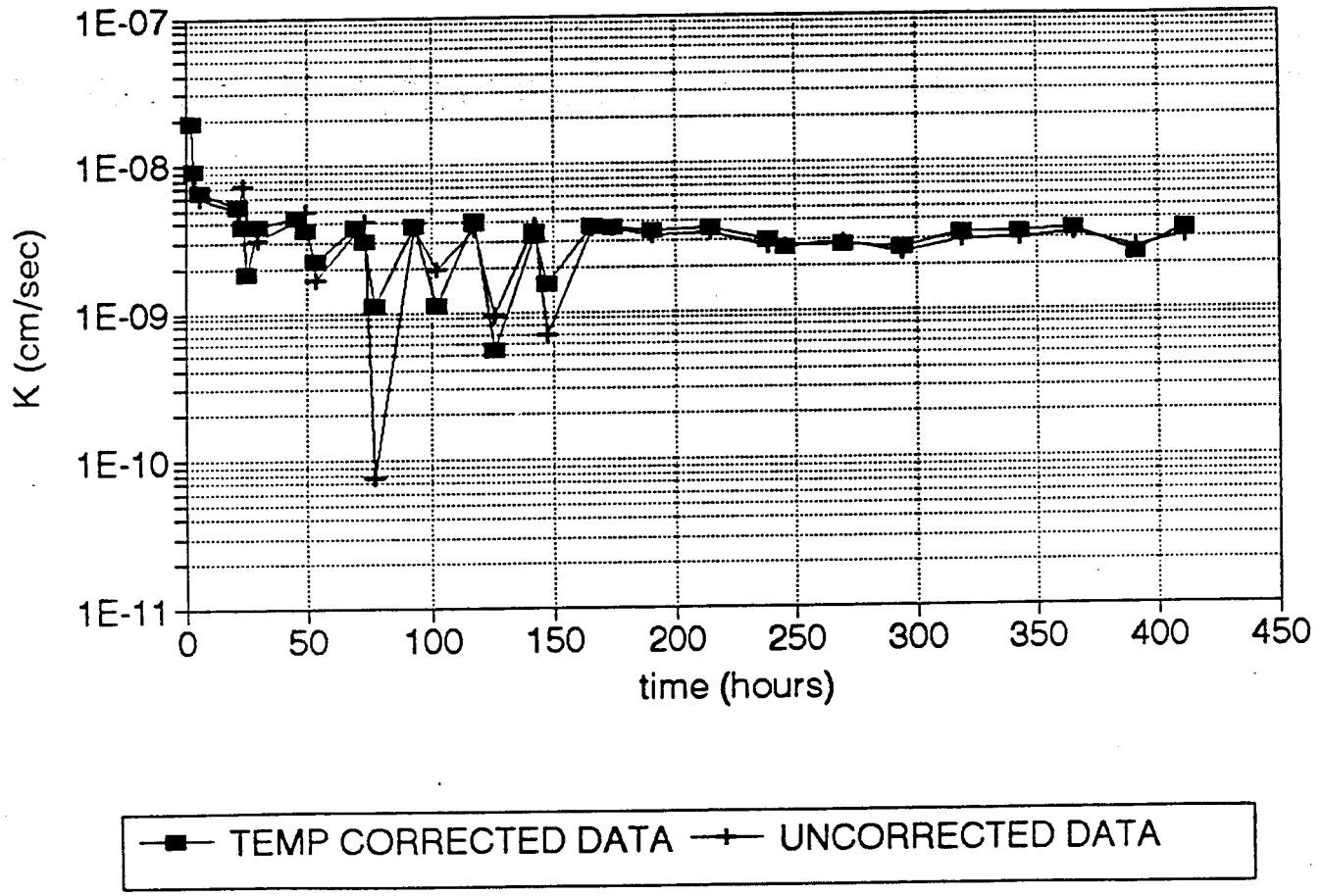
TSB-1 STAGE ONE

t vs. K



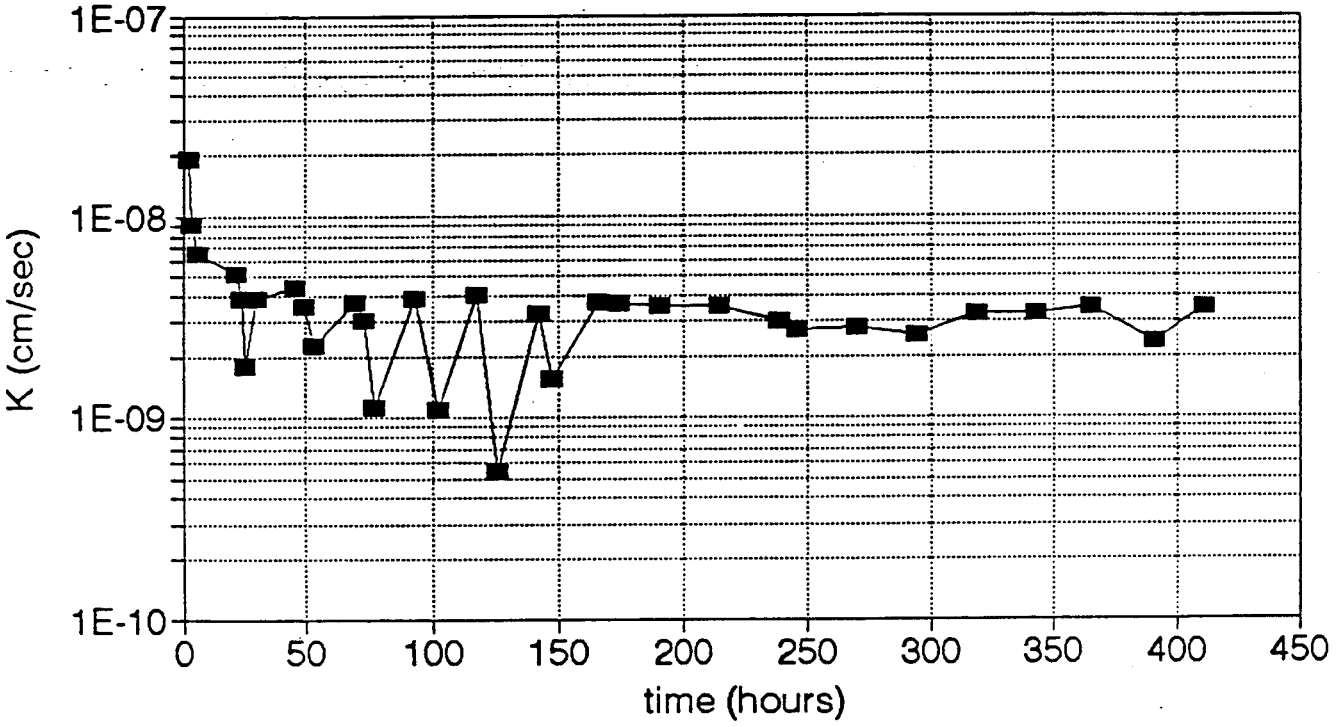
TSB-2 STAGE ONE

t vs. K



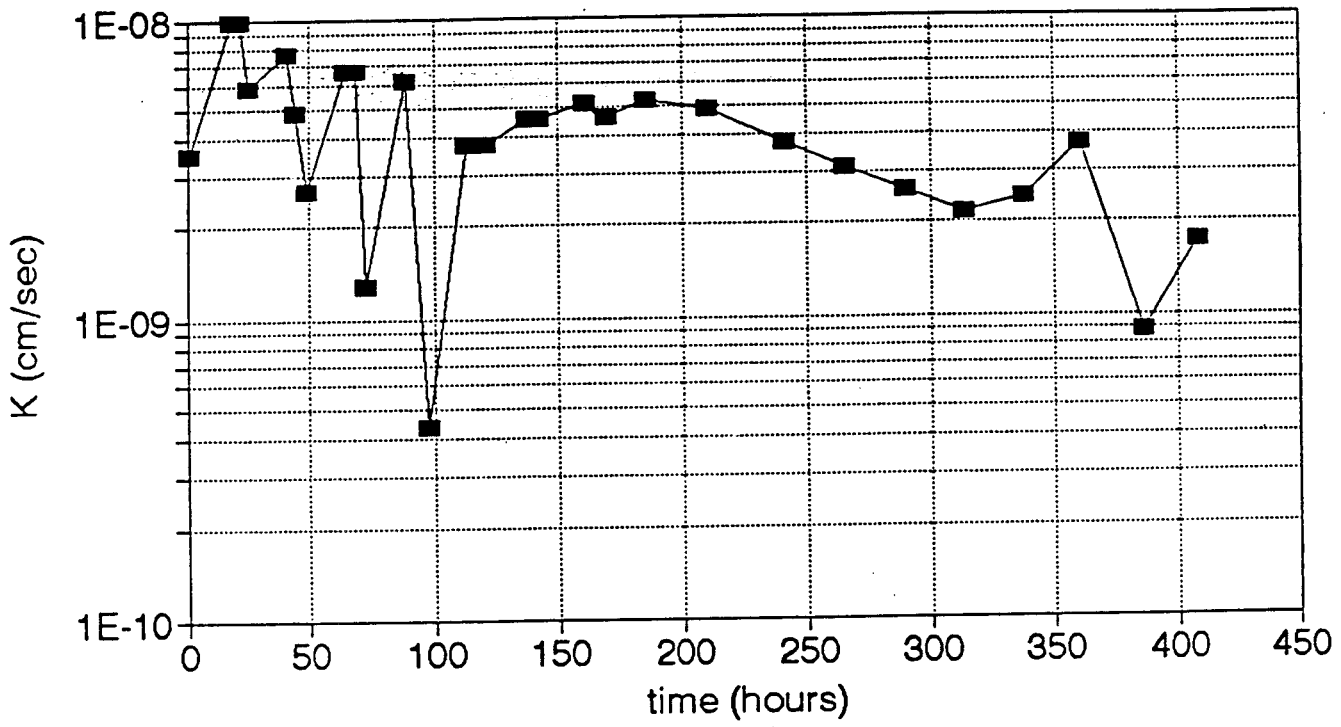
TSB-2 STAGE ONE

t vs. K



TSB-3 STAGE ONE

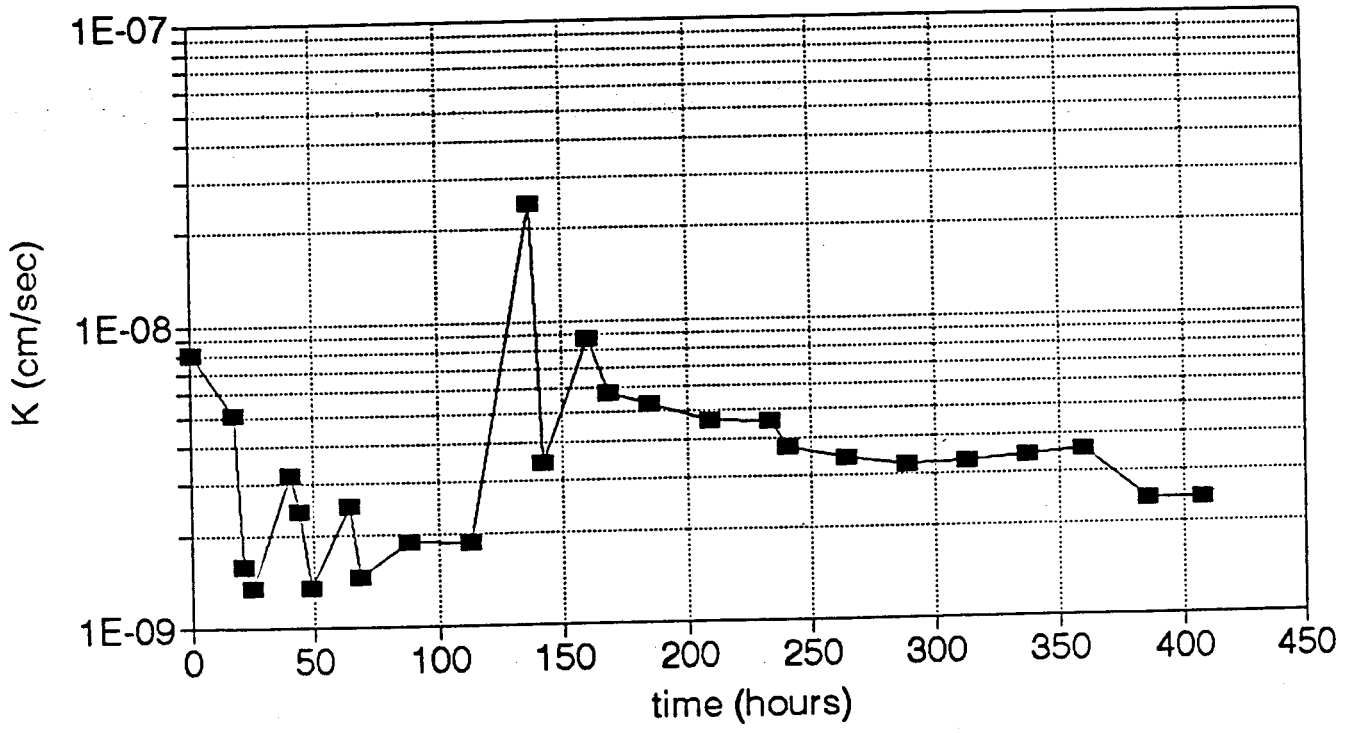
t vs. K



TEMP CORRECTED DATA

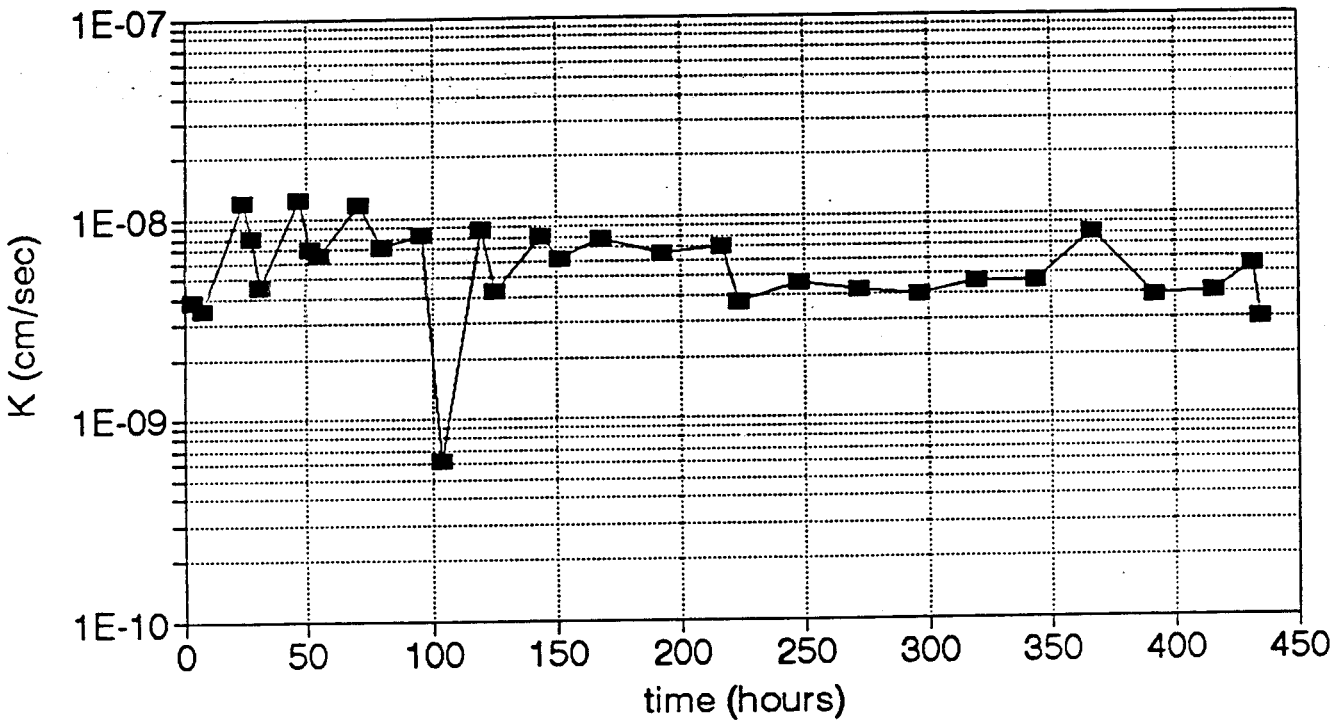
TSB-4 STAGE ONE

t vs. K



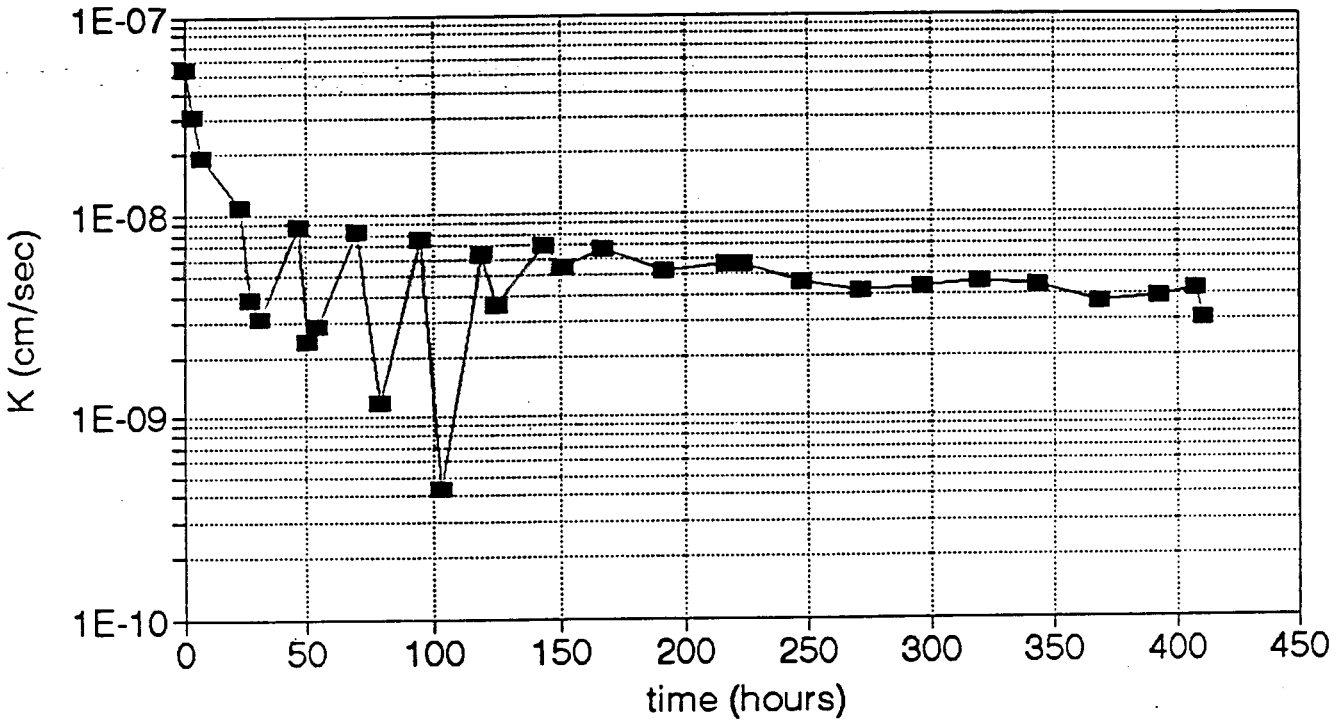
TSB-5 STAGE ONE

t vs. K



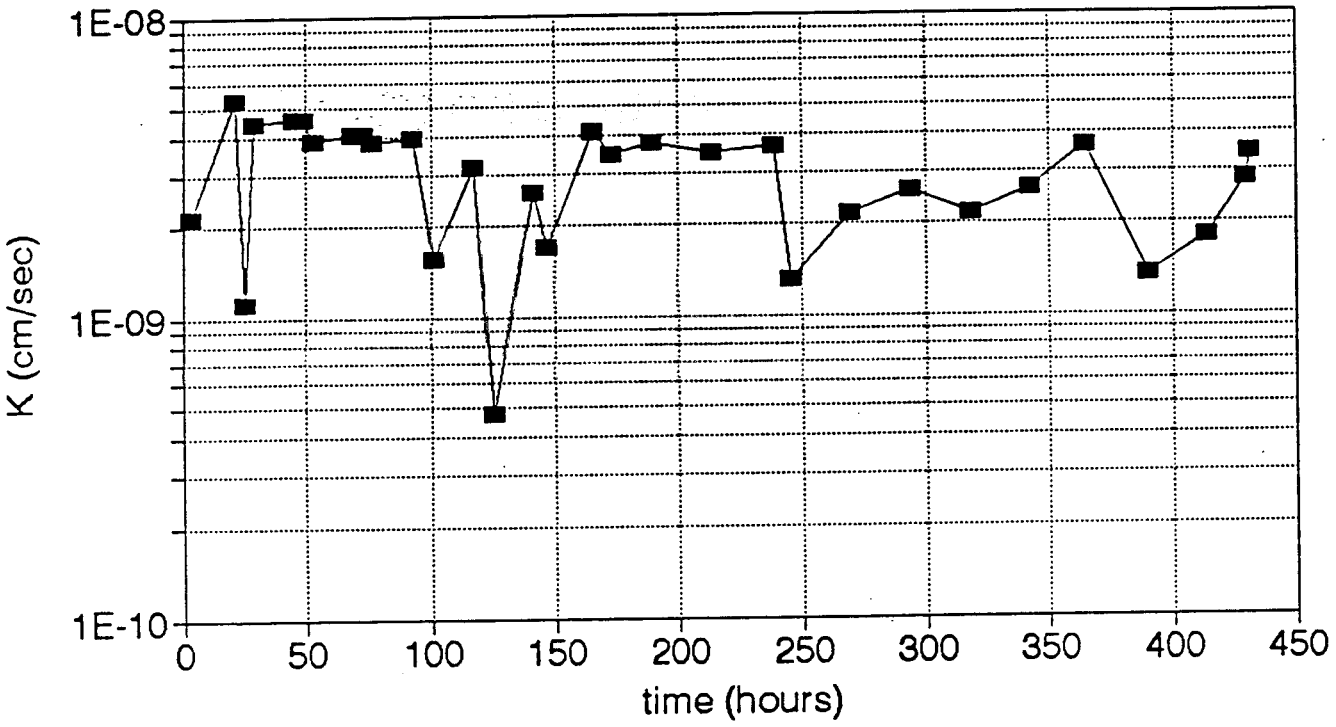
TSB-6 STAGE ONE

t vs. K



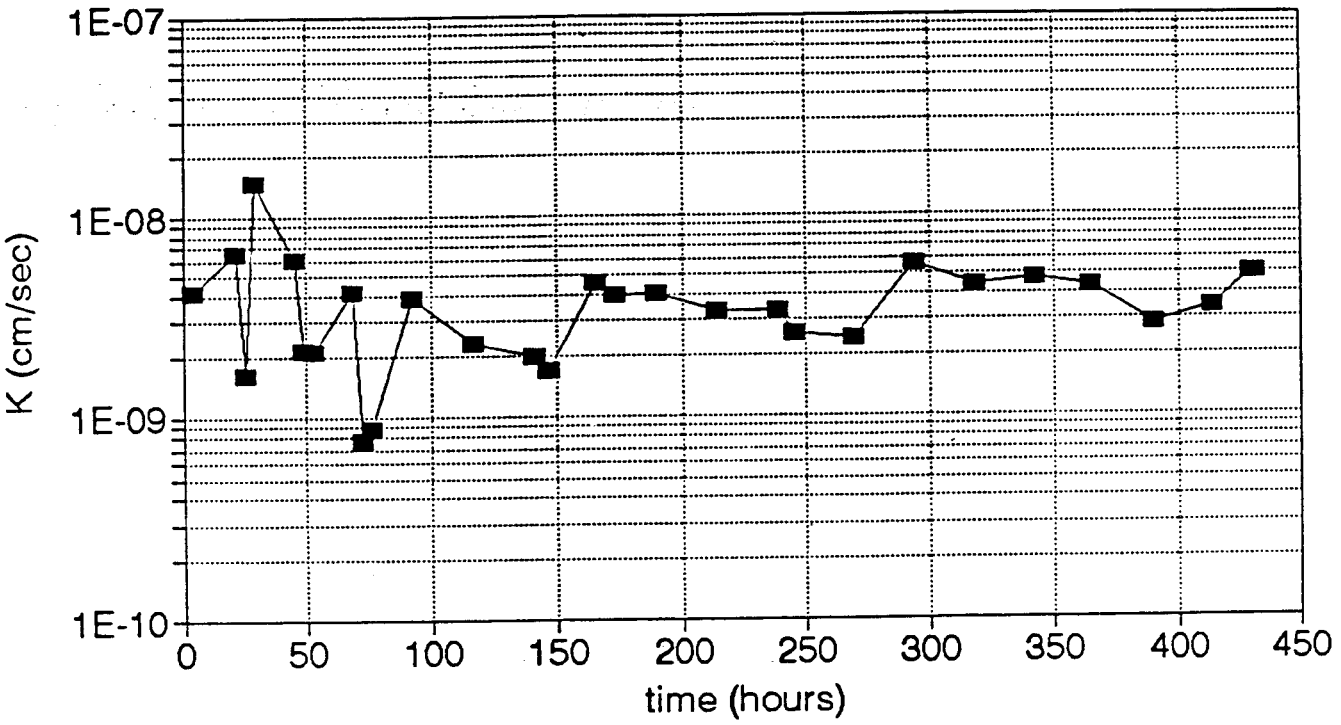
TSB-7 STAGE ONE

t vs. K



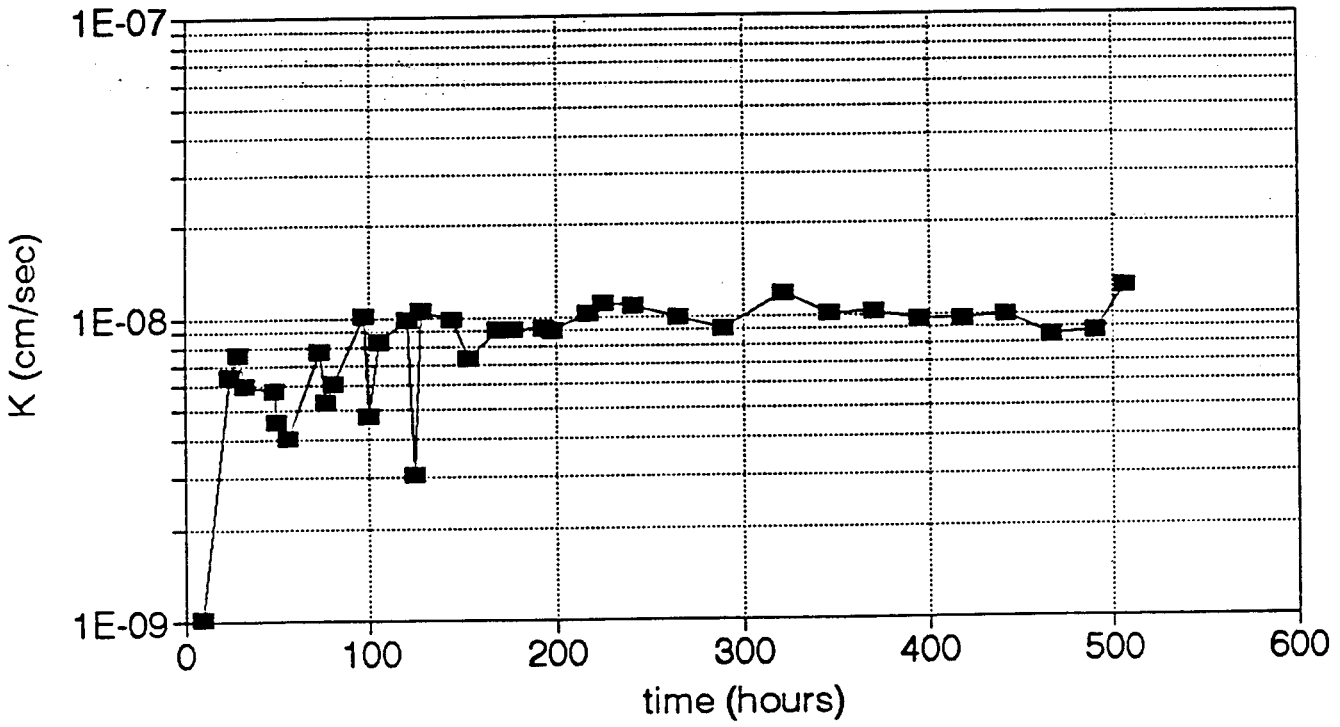
TSB-8 STAGE ONE

t vs. K



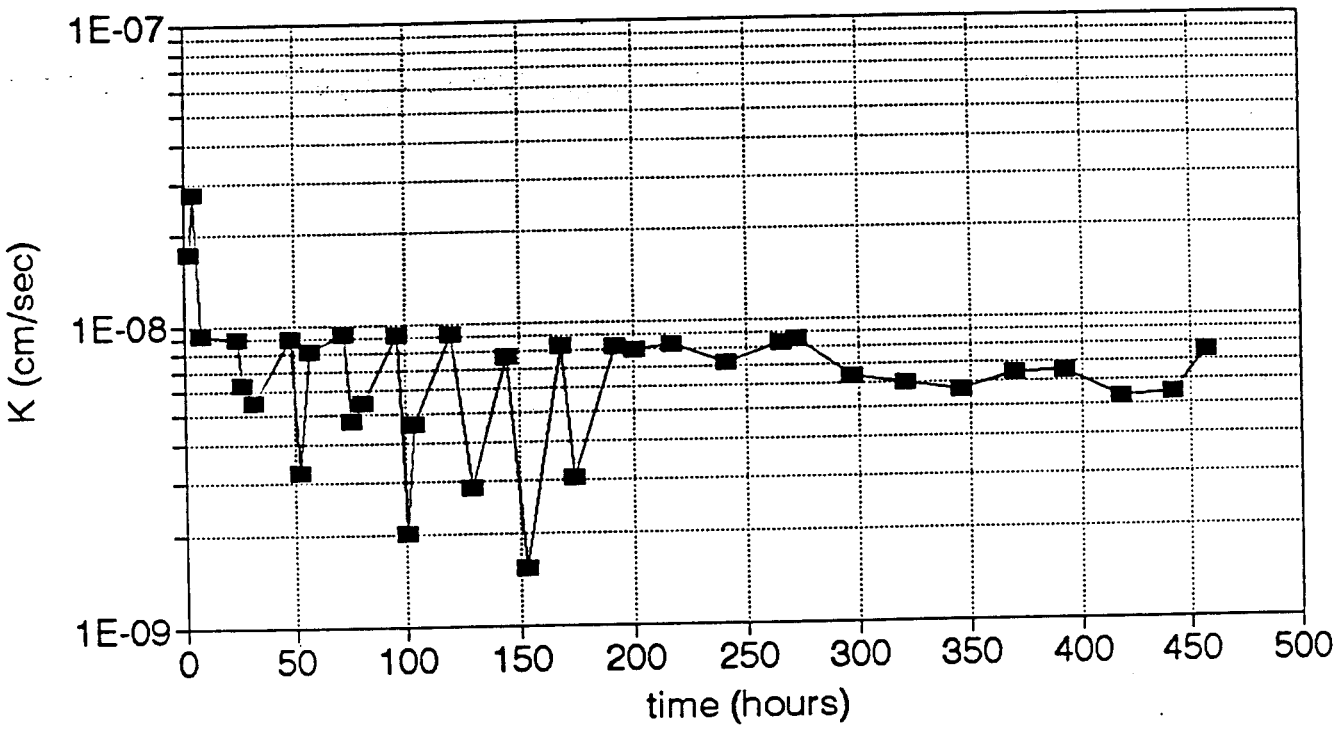
TSB-9 STAGE ONE

t vs. K



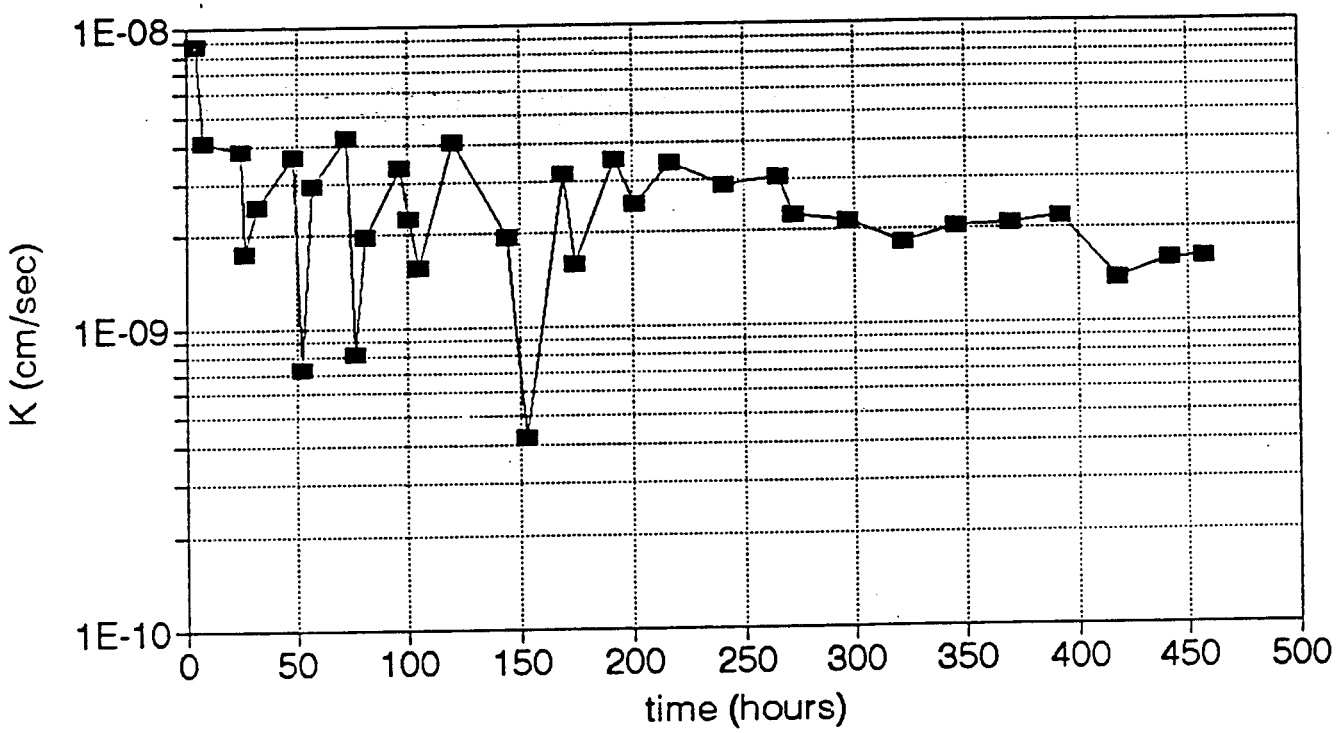
TSB-10 STAGE ONE

t vs. K



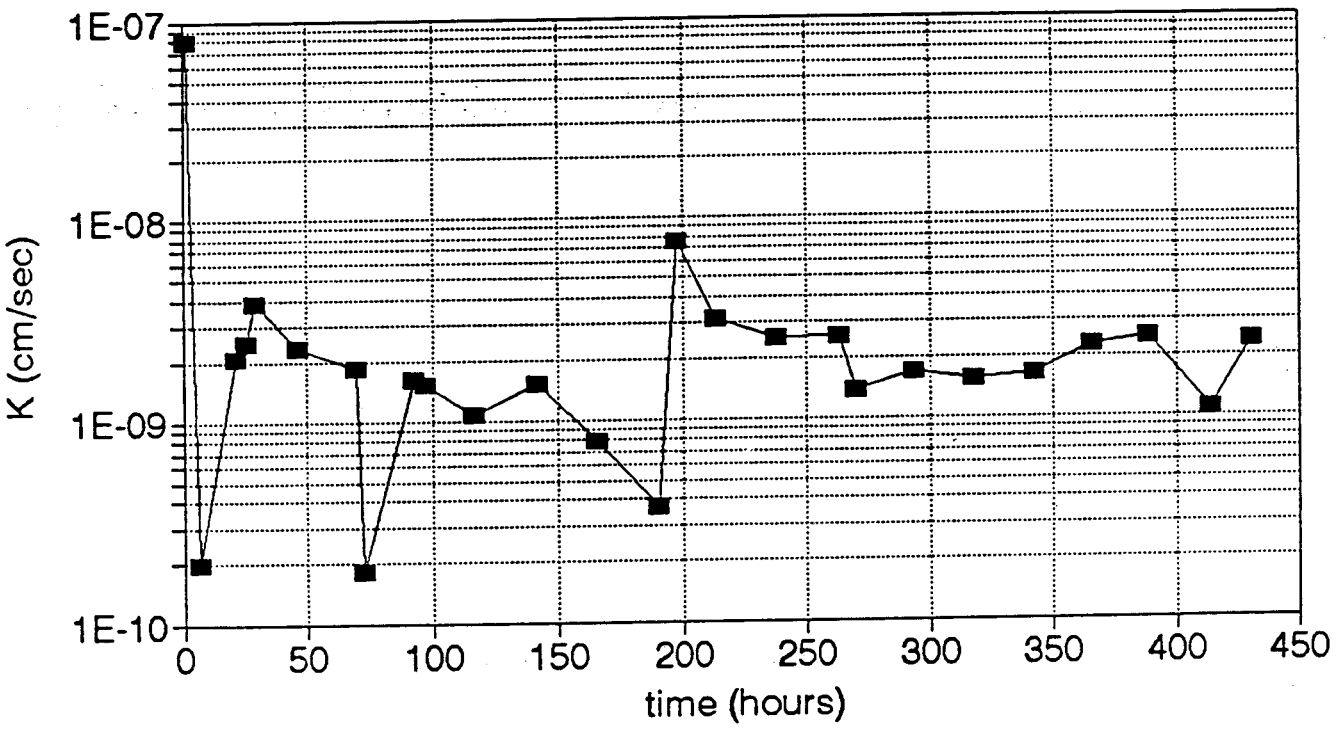
TSB-11 STAGE ONE

t vs. K



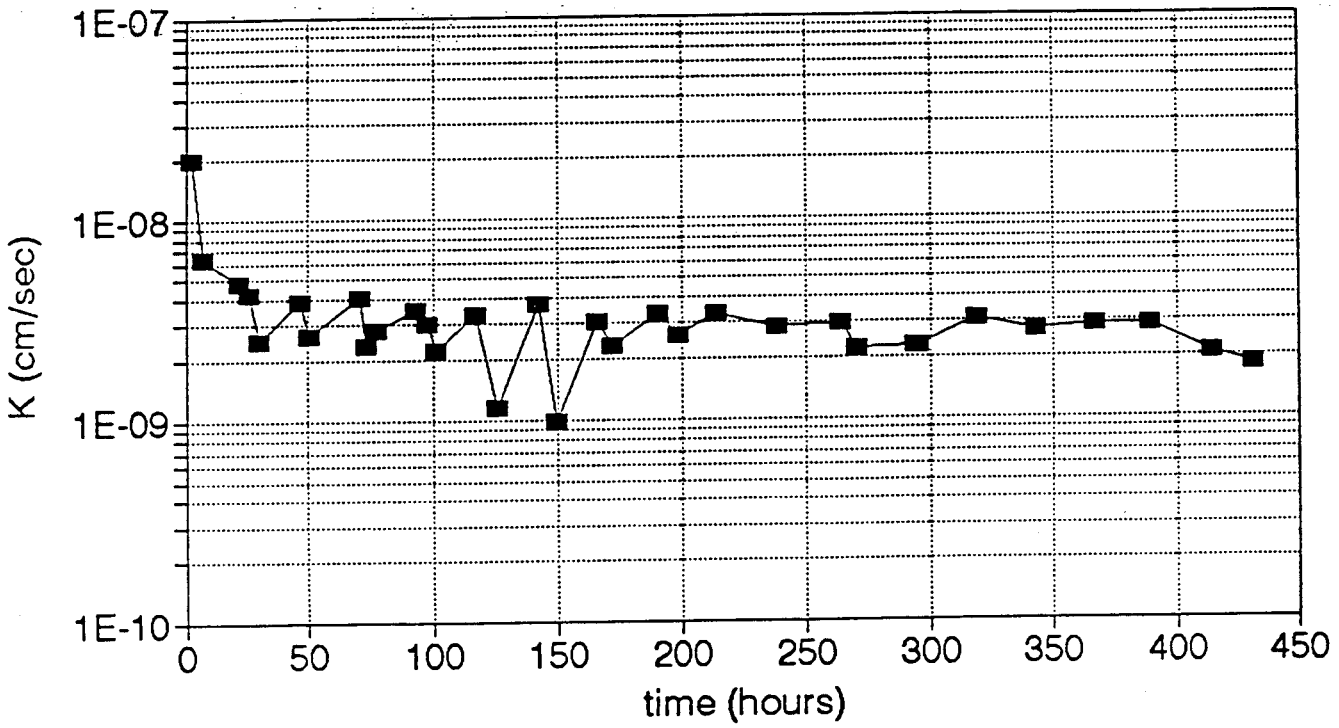
TSB-12 STAGE ONE

t vs. K



TSB-13 STAGE ONE

t vs. K



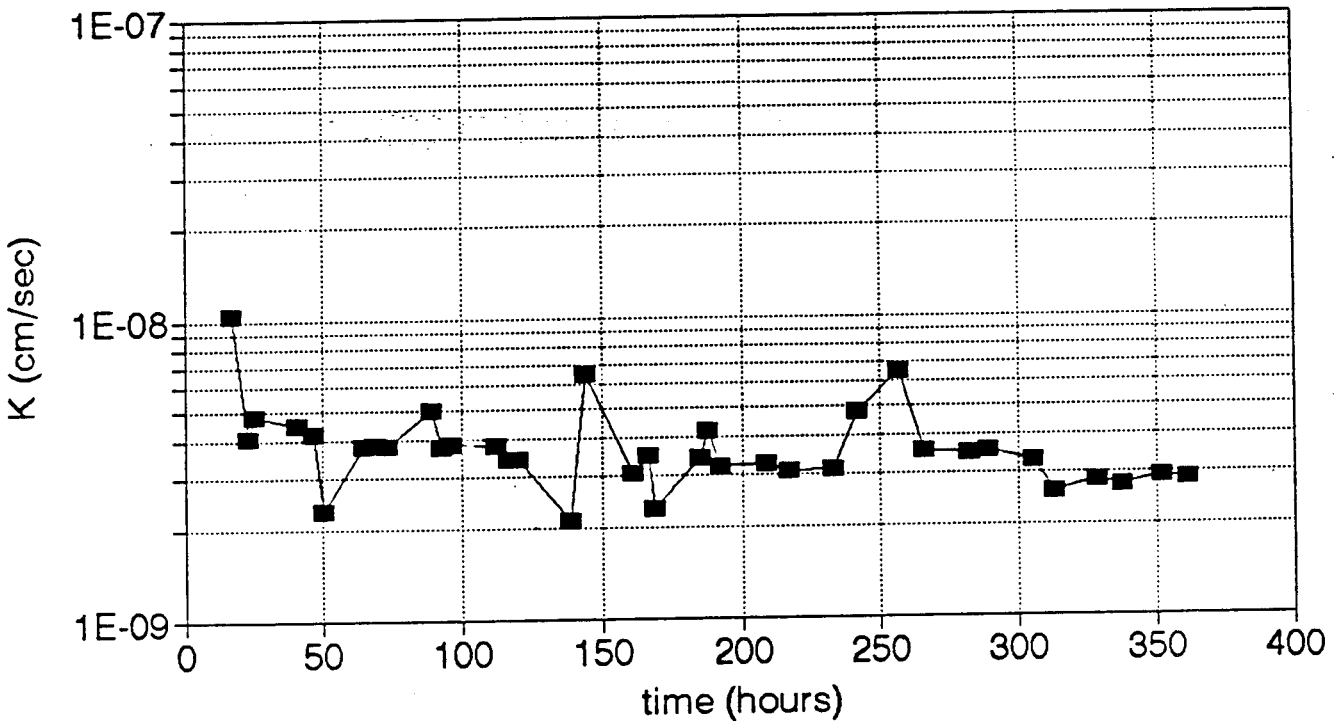
ATTACHMENT 3B

TSB DATA PLOTS

STAGE 2

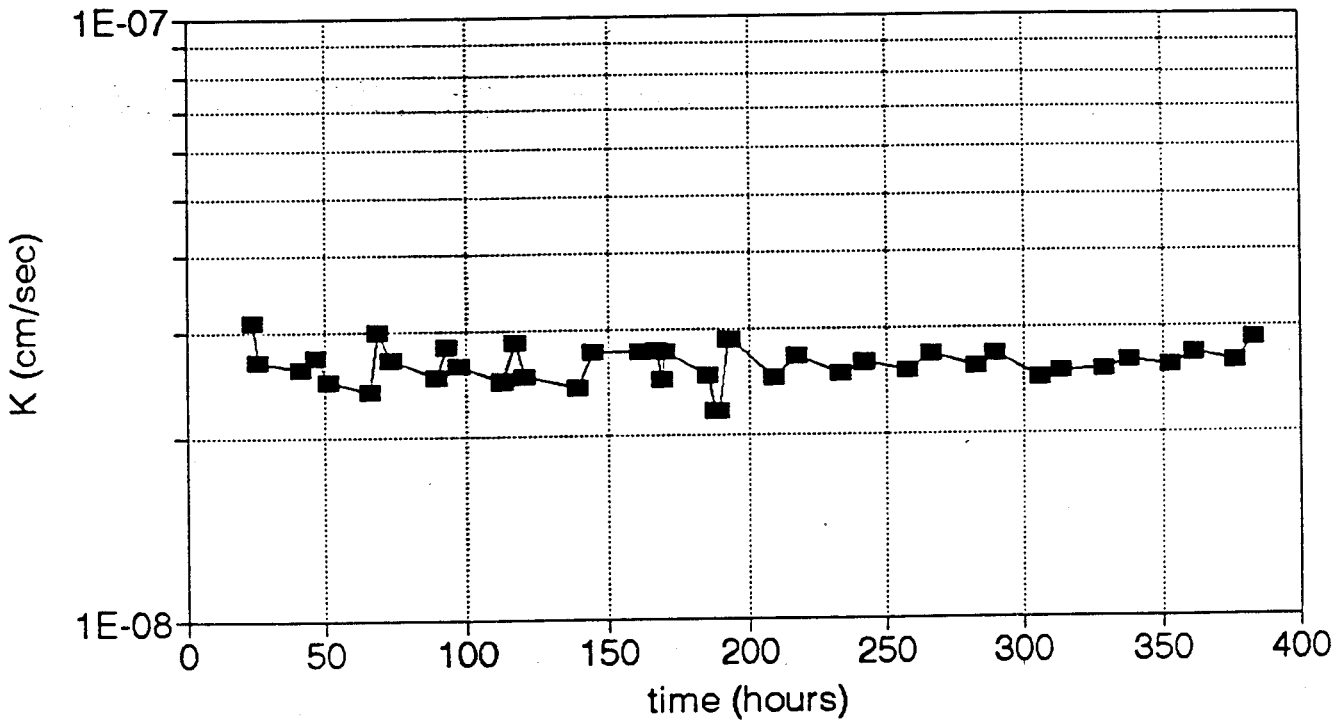
TSB-1 STAGE TWO

t vs. K



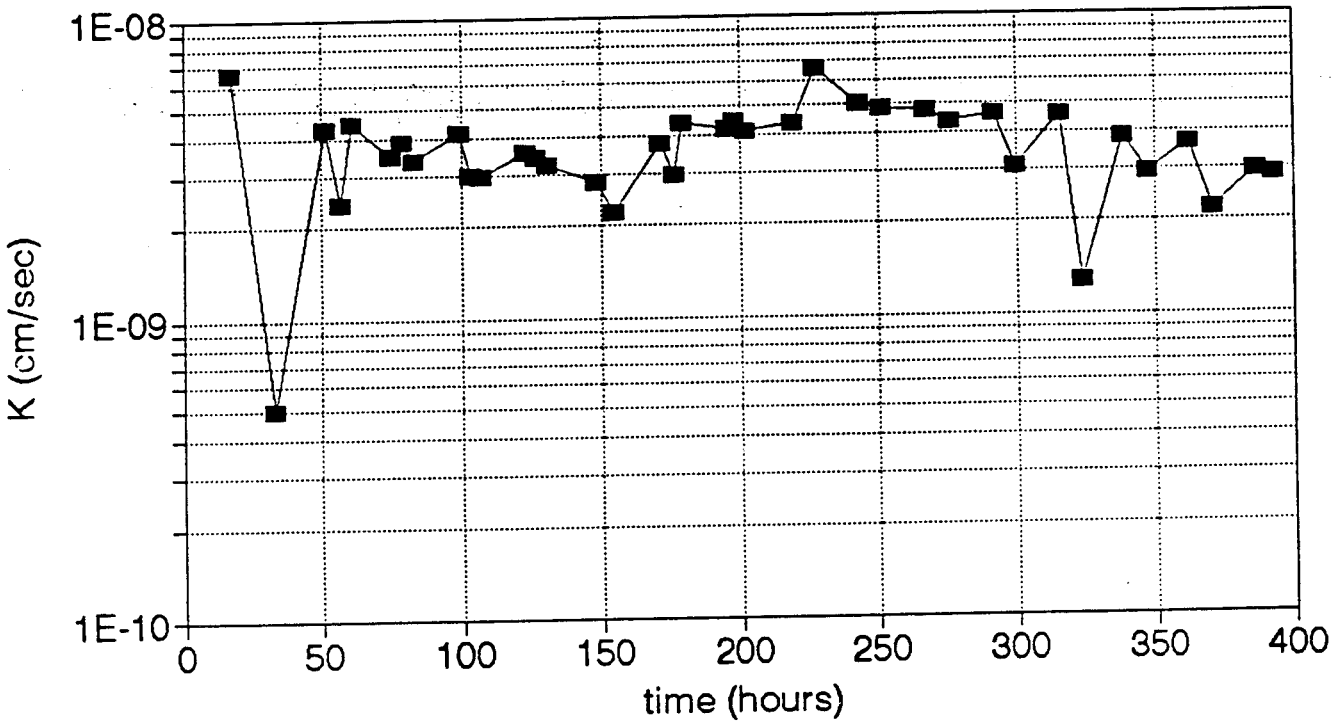
TSB-2 STAGE TWO

t vs. K



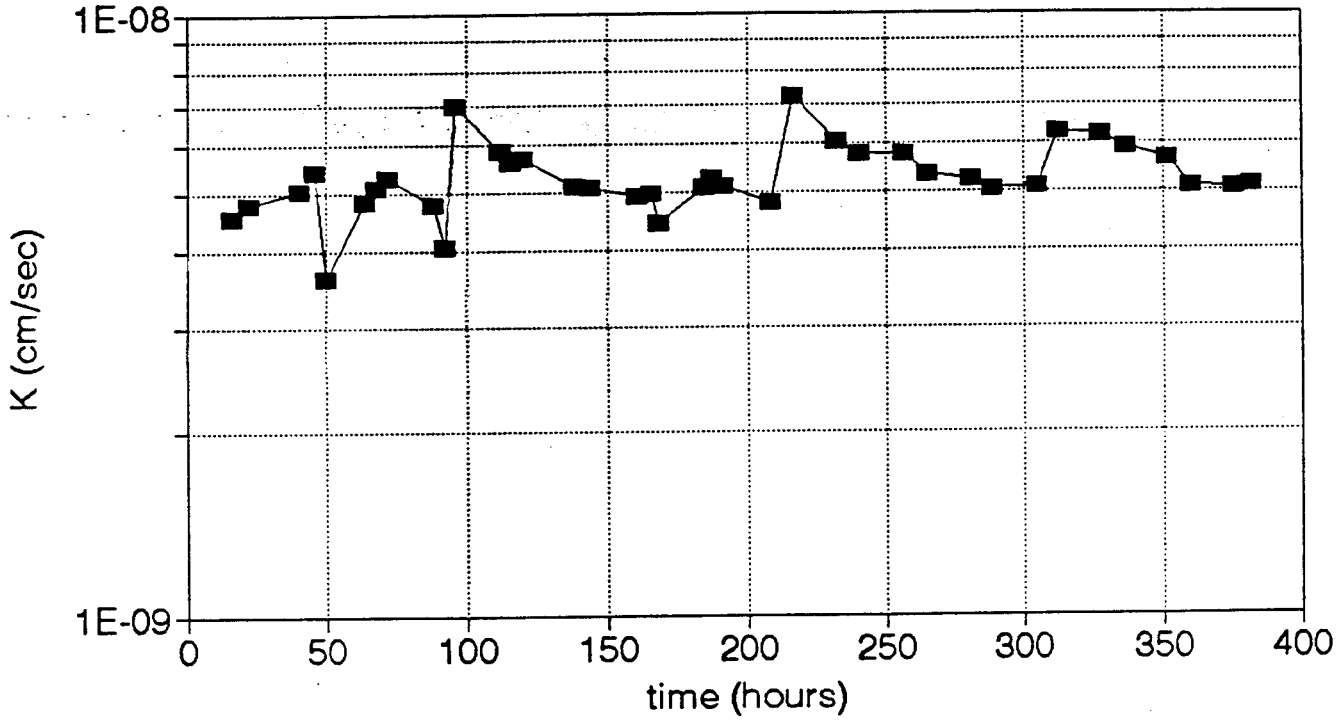
TSB-3 STAGE TWO

t vs. K



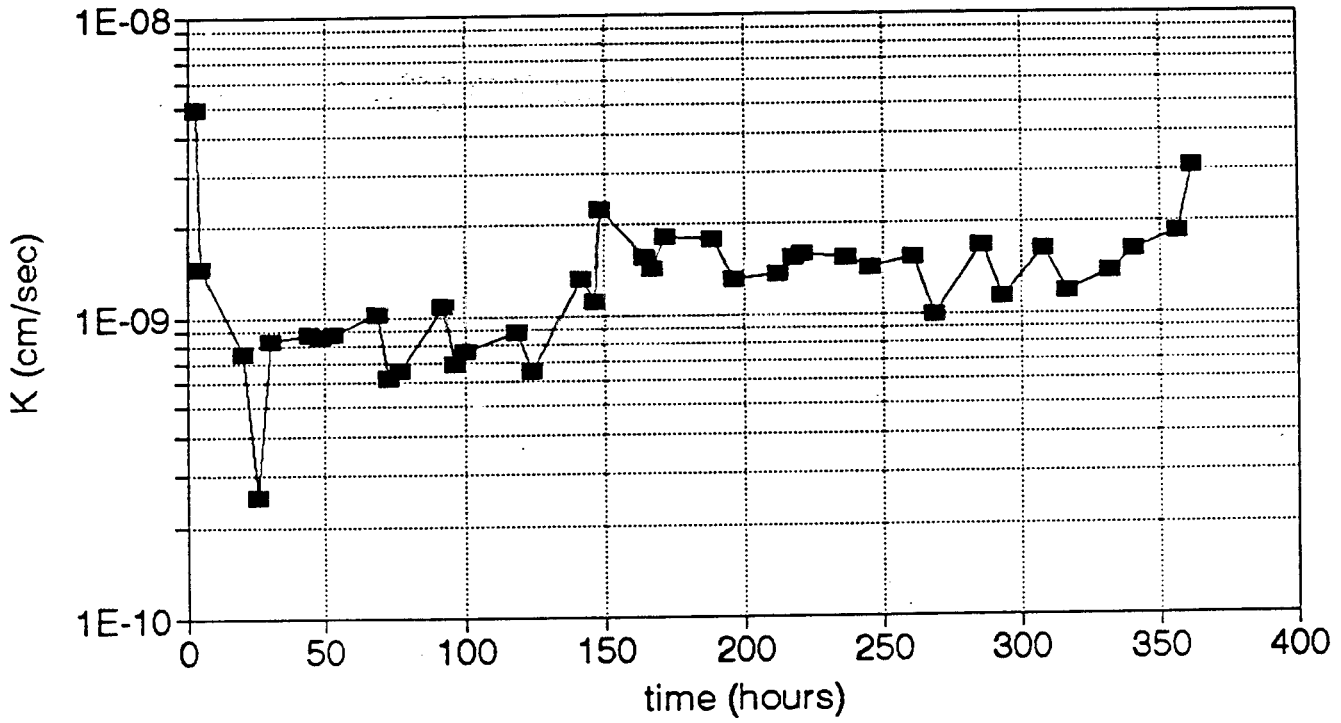
TSB-4 STAGE TWO

t vs. K



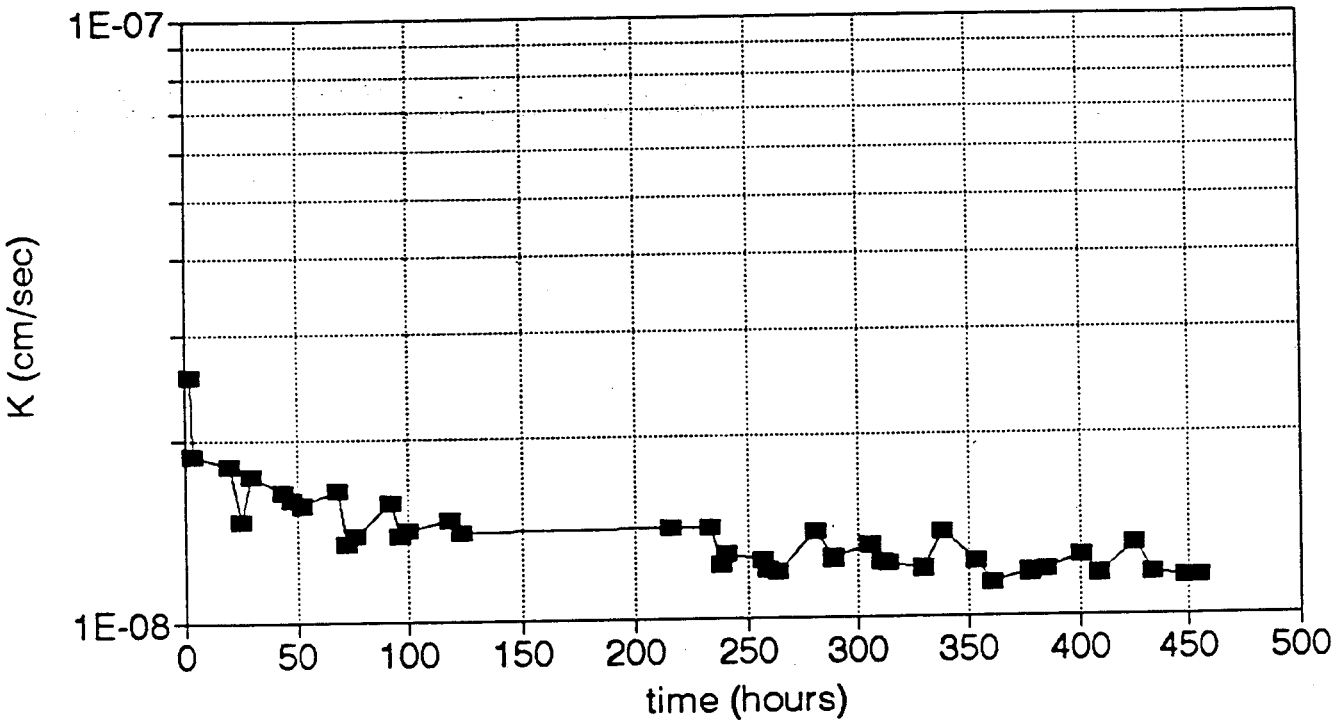
TSB-5 STAGE TWO

t vs. K



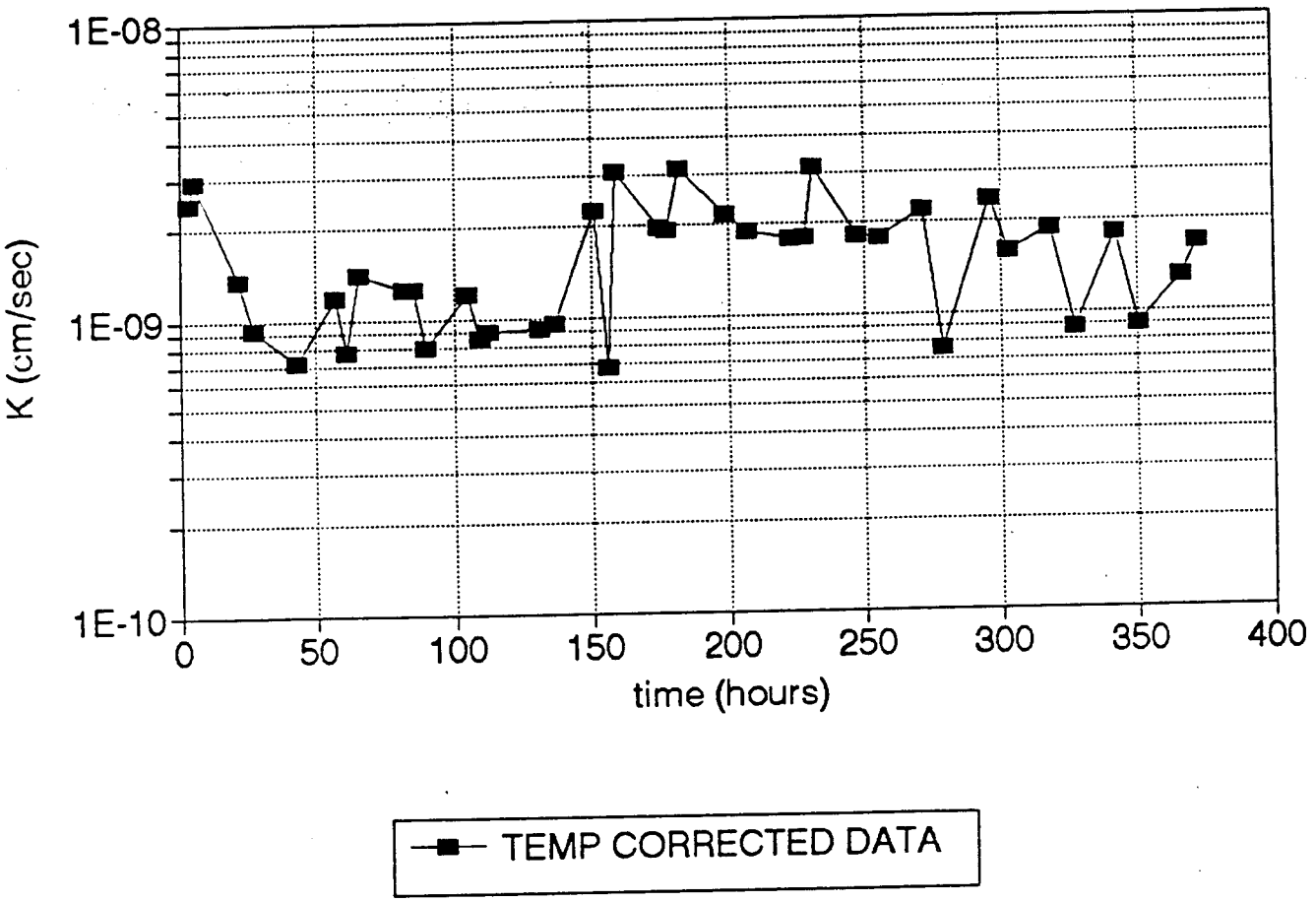
TSB-6 STAGE TWO

t vs. K



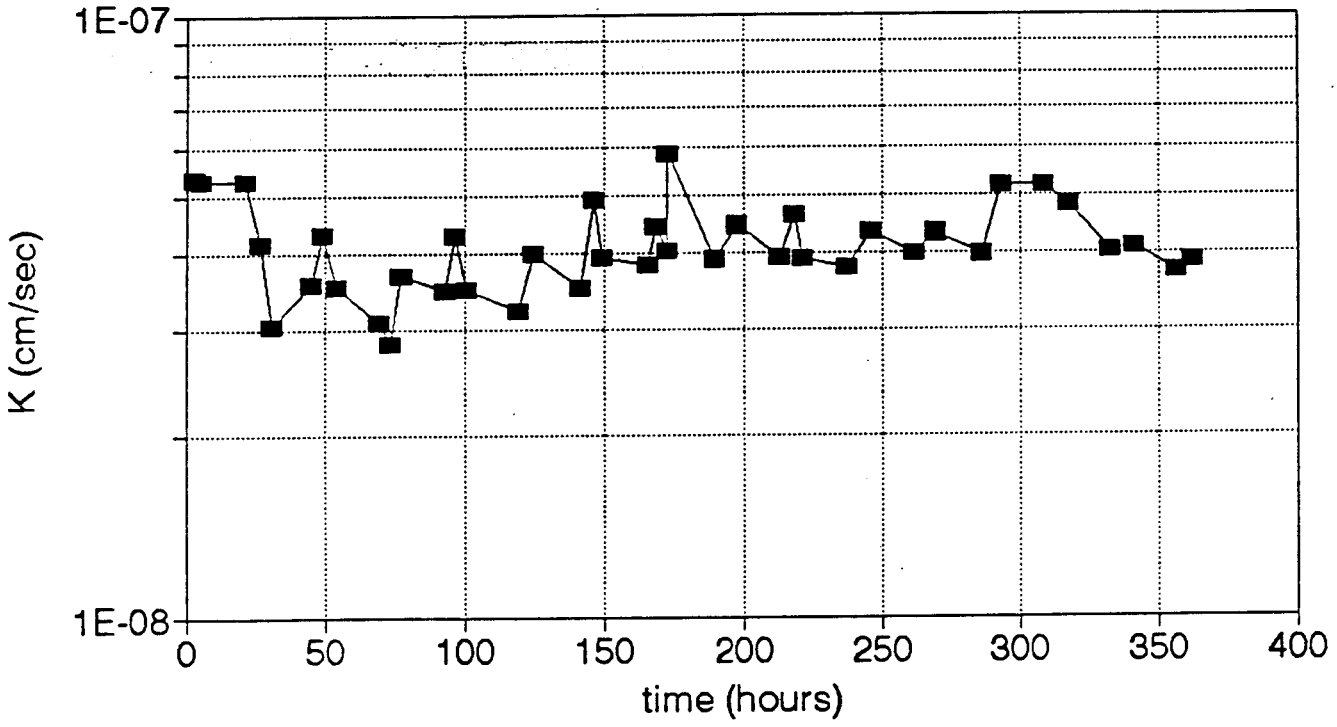
TSB-7 STAGE TWO

t vs. K



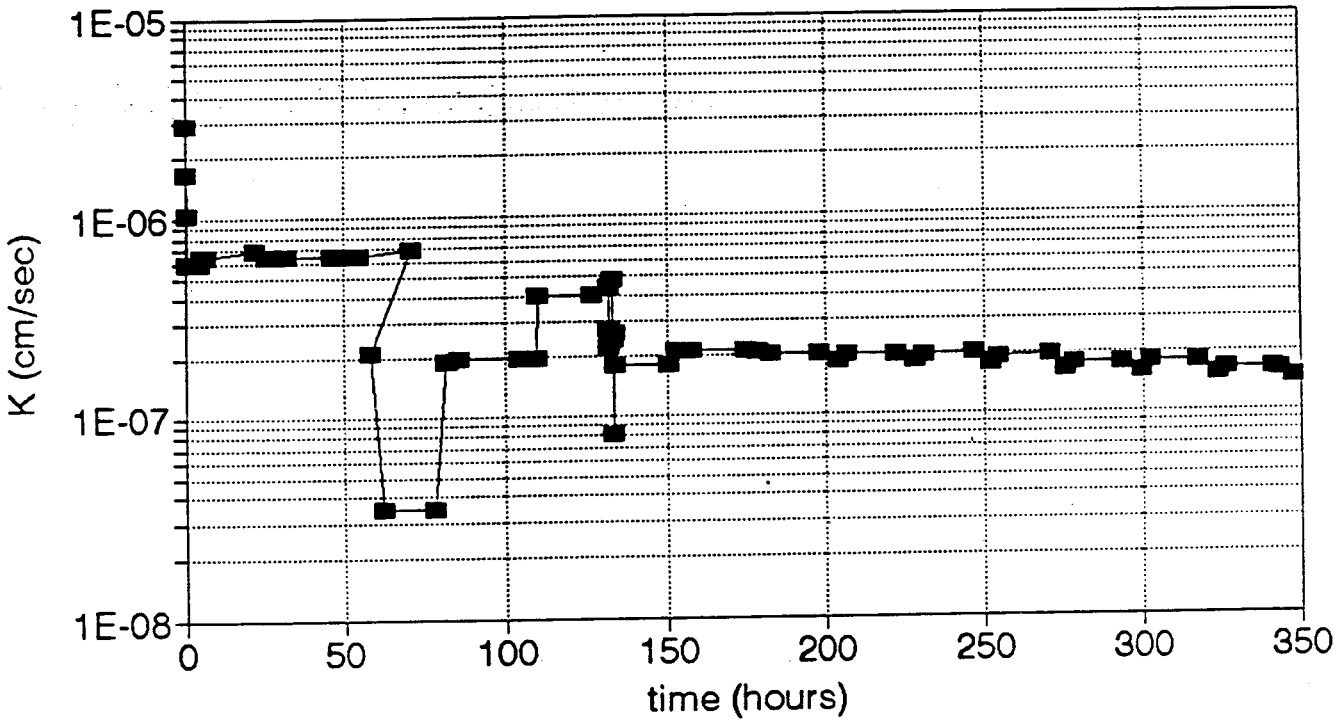
TSB-8 STAGE TWO

t vs. K



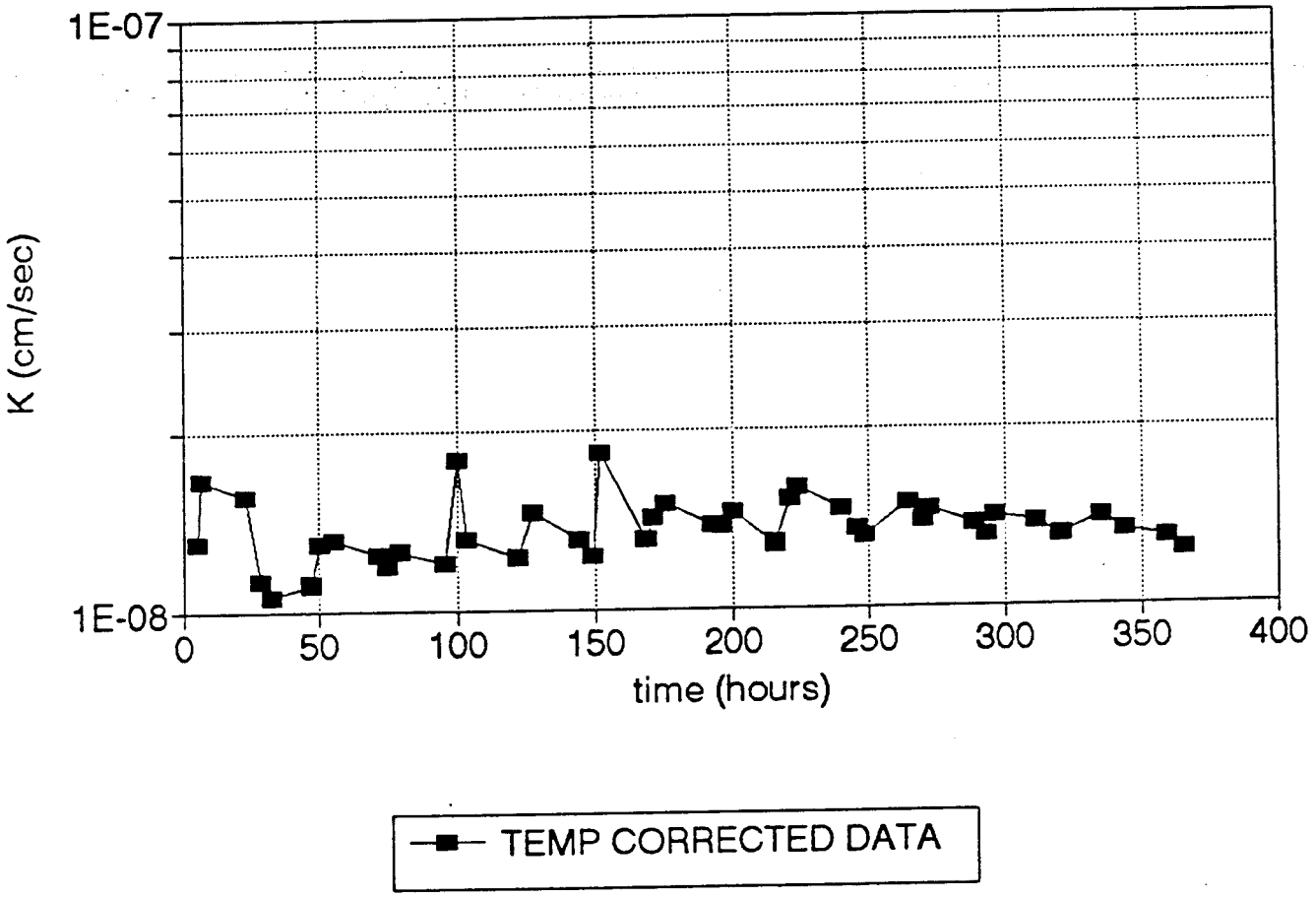
TSB-9 STAGE TWO

t vs. K



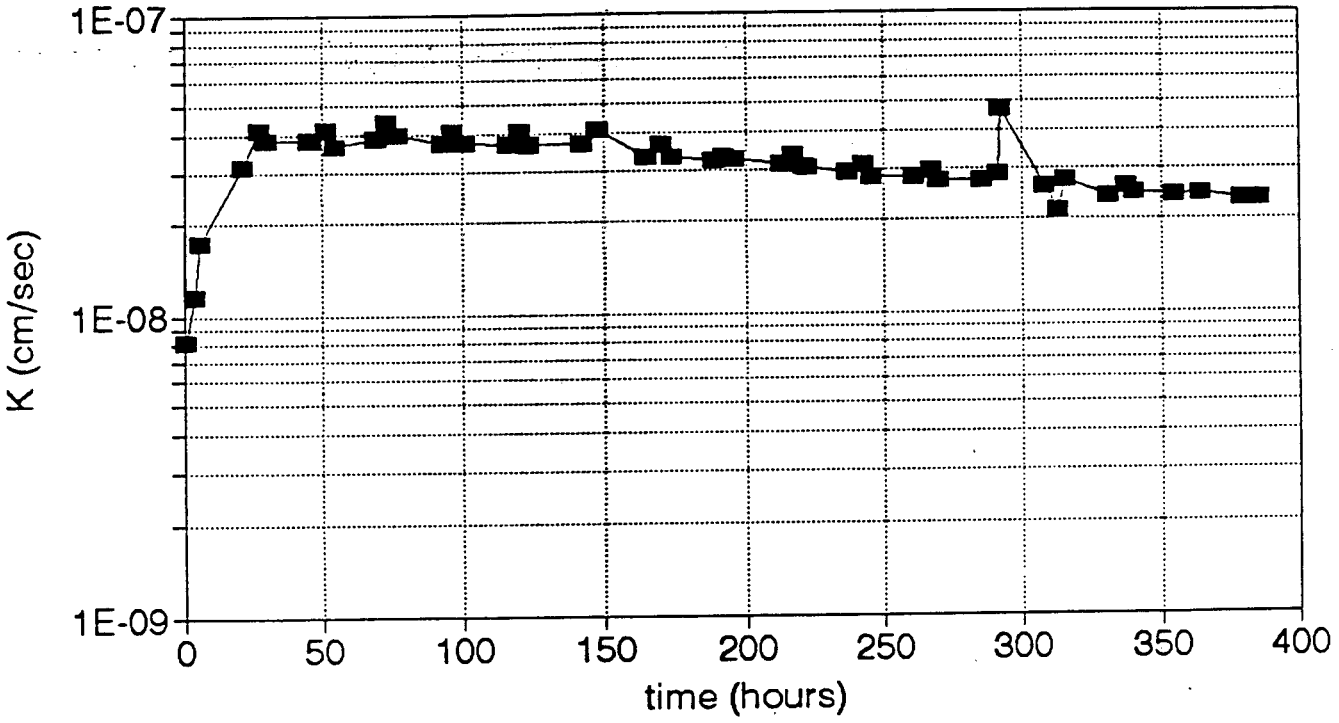
TSB-11 STAGE TWO

t vs. K



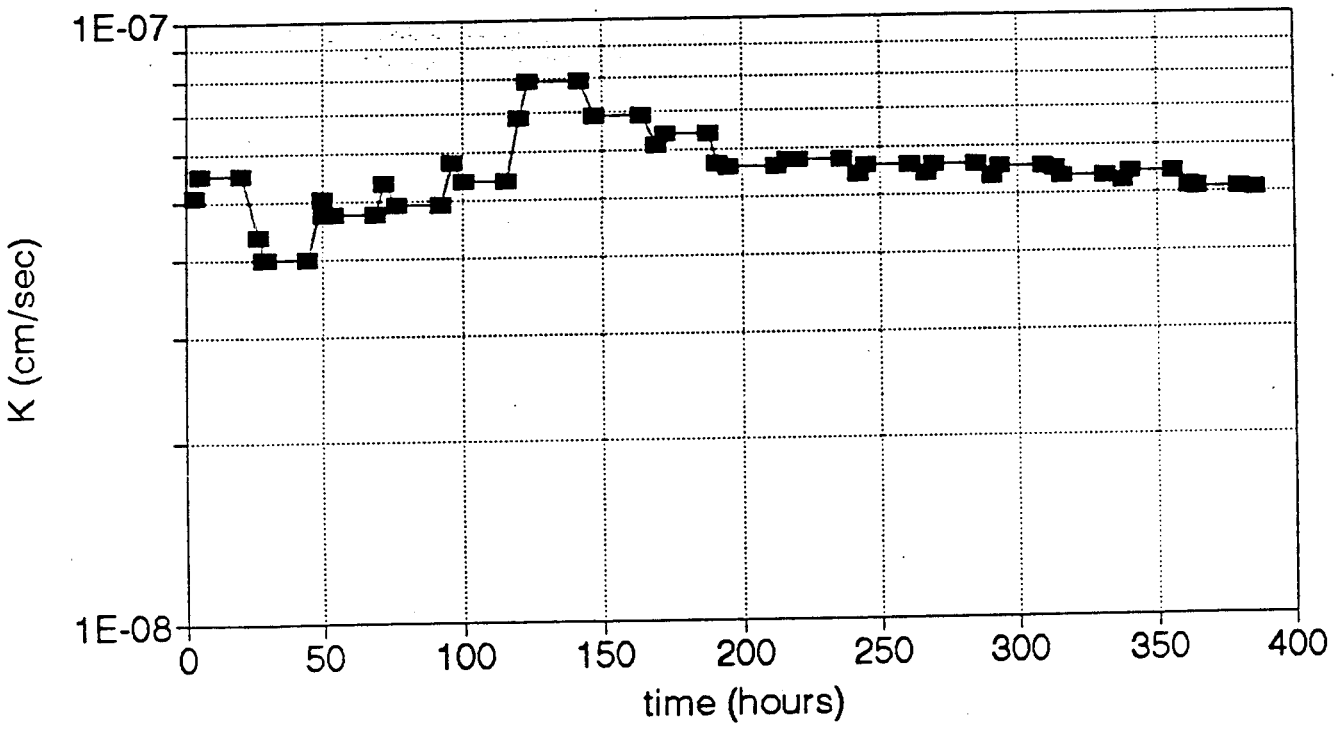
TSB-12 STAGE TWO

t vs. K



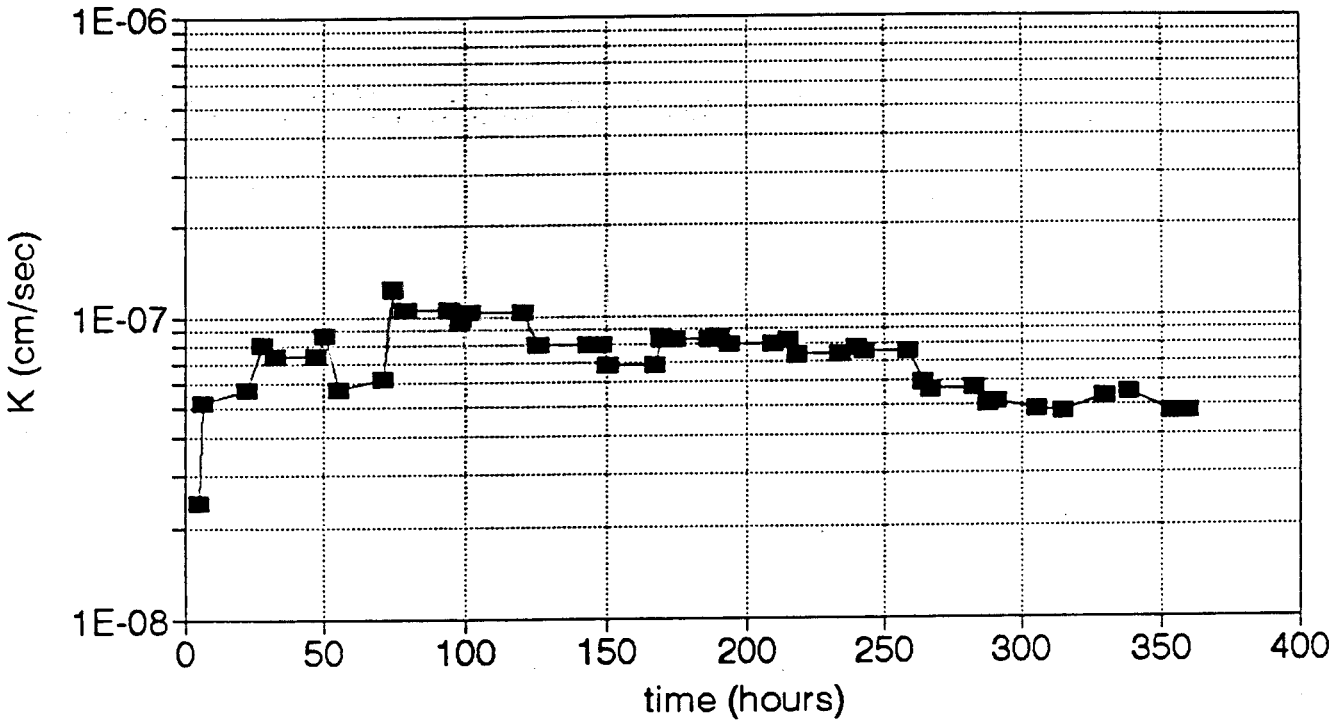
TSB-13 STAGE TWO

t vs. K



TSB-10 STAGE TWO

t vs. K



ATTACHMENT 4A

TSB CALCULATIONS

TIME-WEIGHTED AVERAGE

HYDRAULIC CONDUCTIVITY

K1'

SUBJECT STAGE I TSB FINAL VALUES SHEET 1/5

DATE 11-13-92 BY JDC CHKD. DE Comm JOB NO. 3940-827-01-903

FROM BAITWELL (1992):

$$K1' = \Sigma(K_i * T_i) / \Sigma(T_i)$$

WHERE:

$K1'$ = ARITHMETIC TIME WEIGHTED ALERAGE HYDRAULIC CONDUCTIVITY (CM/SEC)

T_i = TIME DURATION OF TEST INCREMENT (i) (SEC)

K_i = HYDRAULIC CONDUCTIVITY MEASURED DURING TEST INCREMENT (i) (CM/SEC) (TEMPERATURE CORRECTED VALUES · KCT)

1) USING LAST 6 MEASUREMENTS FROM TSB-1 WHERE $T_i > 1000$ s:

$$K1' = \frac{(1.4E-9 * 86400) + (3.49E-9 * 87900) + (3.38E-9 * 85020) + (3.35E-9 * 82560) + (1.84E-9 * 91320) + (1.62E-9 * 76500)}{86400 + 87900 + 85020 + 82560 + 91320 + 76500}$$

$$= \frac{1.54E-03}{509700} = \boxed{3.03E-09 \text{ cm/sec}}$$

2) USING THE LAST 6 MEASUREMENTS FROM TSB-2 WHERE $T_i > 1000$s

$$K1' = \frac{(2.55E-9 * 86280) + (3.22E-9 * 87660) + (3.25E-9 * 85140) + (3.47E-9 * 82500) + (2.37E-9 * 91380) + (3.51E-9 * 76200)}{86280 + 87660 + 85140 + 82500 + 91380 + 76200}$$

$$= 1.55E-03 / 509160 = \boxed{3.04E-09 \text{ cm/sec}}$$

SUBJECT STAGE 1 TSB FINAL VALUES SHEET 2/5

DATE 11-13-92 BY JDC CHKD. [illegible] JOB NO. 3840-827-01-903

3) USING LAST 6 MEASUREMENTS FROM $\boxed{\text{TSB-3}}$:

$$K1' = \frac{(2.58E-9 * 86580) + (2.18E-9 * 87660) + (2.43E-9 * 85080)}{86580 + 87660 + 85080}$$

$$\frac{+ (3.69E-9 * 82860) + (8.8E-10 * 91020) + (1.74E-9 * 83400)}{+ 82860 + 91020 + 83400}$$

$$= \frac{1.15E-3}{516600} = \boxed{2.23E-09 \text{ cm/sec}}$$

4) USING LAST 6 MEASUREMENTS FROM $\boxed{\text{TSB-4}}$:

$$K1' = \frac{(3.22E-9 * 86520) + (3.32E-9 * 87660) + (3.42E-9 * 85200) +}{86520 + 87660 + 85200}$$

$$\frac{(3.56E-9 * 82800) + (2.41E-9 * 91020) + (2.41E-9 * 82920)}{+ 82800 + 91020 + 82920}$$

$$= \frac{1.57E-03}{516120} = \boxed{3.05E-09 \text{ cm/sec}}$$

5) USING LAST 6 MEASUREMENTS FROM $\boxed{\text{TSB-5}}$:

$$K1' = \frac{(4.59E-9 * 85080) + (8.10E-9 * 82680) + (3.69E-9 * 91020)}{85080 + 82680 + 91020}$$

$$\frac{+ (4.08E-9 * 87600) + (5.52E-9 * 56400) + (2.99E-9 * 11100}{+ 87600 + 56400 + 11100}$$

$$= \frac{2.10E-03}{413880} = \boxed{5.07E-09 \text{ cm/sec}}$$

SUBJECT STAGE I TSB FINAL VALUES SHEET 3/5

DATE 11-13-92 BY JDC CHKD. O.E. JOB NO. 3943-827-01-903

6) USING LAST 6 MEASUREMENTS FROM TSB-6:

$$K1' = \frac{(4.6E-9*85020)+(4.47E-9*32860)+(3.68E-9*91080)}{85020+82860+91080}$$

$$\frac{(3.86E-9*87600)+(4.23E-9*56220)+(3.02E-9*12060)}{+87600+56220+12060}$$

$$= \frac{1.71E-03}{414840} = \boxed{4.12E-09 \text{ cm/sec}}$$

7) USING LAST 6 MEASUREMENTS FROM TSB-7:

$$K1' = \frac{(2.63E-9*85320)+(3.61E-9*82620)+(1.35E-9*90960)}{85320+82620+90960}$$

$$\frac{+(1.79E-9*87600)+(2.81E-9*56340)+(3.11E-9*4980)}{+87600+56340+4980}$$

$$= \frac{9.78E-04}{407820} = \boxed{2.40E-09 \text{ cm/sec}}$$

8) USING LAST 6 MEASUREMENTS FROM TSB-8 WHERE $T_i > 1000$ s:

$$K1' = \frac{(4.36E-9*82260)+(2.82E-9*91320)+(3.42E-9*87540)}{82260+91320+87540}$$

$$\frac{+(4.77E-9*85320)+(5.03E-9*56040)+(5.03E-9*5040)}{+85320+56040+5040}$$

$$= \frac{1.63E-3}{407520} = \boxed{4.00E-09 \text{ cm/sec}}$$

SUBJECT STAGE 1 TSB FINAL VALUES SHEET 4/5

DATE 11-13-92 BY JDC CHKD. J.C. Connor JOB NO. 3840-827-01-403

9) USING LAST 6 MEASUREMENTS FROM TSB-9 WHERE $T_i > 1000s$:

$$K1' = \frac{(9.63E-9 * 85320) + (9.89E-9 * 82800) + (8.48E-9 * 90900)}{85320 + 82800 + 90900 +}$$

$$\frac{+(8.72E-9 * 86100) + (9.56E-9 * 87660 + (1.22E-8 * 57000)}{86100 + 87660 + 57000}$$

$$= \frac{4.7E-3}{489780} = \boxed{9.59E-09 \text{ cm/sec}}$$

10) USING THE LAST 6 MEASUREMENTS FROM TSB-10:

$$K1' = \frac{(5.66E-9 * 87660) + (6.42E-9 * 85320) + (6.5E-9 * 82920)}{87660 + 85320 + 82920 +}$$

$$\frac{(5.32E-9 * 90780) + (5.47E-9 * 86040) + (7.52E-9 * 57180)}{90780 + 86040 + 57180}$$

$$= \frac{2.97E-3}{489900} = \boxed{6.06E-09 \text{ cm/sec}}$$

11) USING THE LAST 6 MEASUREMENTS FROM TSB-11:

$$K1' = \frac{(2.05E-9 * 87660) + (2.11E-9 * 85500) + (2.19E-9 * 82800) +}{87660 + 85500 + 82800}$$

$$\frac{(1.38E-9 * 90900) + (1.6E-9 * 85860) + (1.61E-9 * 57120)}{90900 + 85860 + 57120}$$

$$= \frac{8.96E-4}{489840} = \boxed{1.83E-09 \text{ cm/sec}}$$

CALC IV

SUBJECT STAGE I TSB FINAL VALUES SHEET 5/5

DATE 11-13-92 BY JDC CHKD. DE Conner JOB NO. 3940-877-01-903

12) USING LAST 6 MEASUREMENTS FROM $\boxed{\text{TSB-12}}$:

$$K1' = \frac{(1.55E-9 * 86160) + (1.64E-9 * 88200) + (2.23E-9 * 84840)}{86160 + 88200 + 84840 +}$$

$$\frac{+(2.45E-9 * 82800) + (1.10E-9 * 91260) + (2.36E-9 * 59580)}{82800 + 91260 + 59580}$$

$$= \frac{9.11E-4}{492840} = \boxed{1.85E-09 \text{ cm/sec}}$$

13) USING LAST 6 MEASUREMENTS FROM $\boxed{\text{TSB-13}}$:

$$K1' = \frac{(3.08E-9 * 82800) + (2.68E-9 * 87960) + (2.86E-9 * 85020) +}{82800 + 87960 + 85020}$$

$$\frac{(2.87E-9 * 82620) + (2.07E-9 * 91320) + (1.84E-9 * 59580)}{82620 + 91320 + 59580}$$

$$= \frac{1.27E-3}{489300} = \boxed{2.60E-09 \text{ cm/sec}}$$

ATTACHMENT 4B

TSB CALCULATIONS

TIME-WEIGHTED AVERAGE

HYDRAULIC CONDUCTIVITY

K2

CALCULATION NO. IV

SUBJECT STAGE 2 TSB FINAL VALUES SHEET 1/5

DATE 11-12-92 BY JDC CHKD. D E Conour JOB NO. 3840-827-01-903

FROM BOLTWELL (1992):

$$K2' = \Sigma (K_i \times T_i) / \Sigma (T_i)$$

WHERE: $K2'$ = ARITHMETIC TIME WEIGHTED AVERAGE HYDRAULIC CONDUCTIVITY (cm/sec)

T_i = TIME DURATION OF TEST INCREMENT (i) (sec)

K_i = HYDRAULIC CONDUCTIVITY MEASURED DURING TEST INCREMENT (i) (cm/sec) (TEMPERATURE CORRECTED VALUES - KCT)

1) USING LAST 5 MEASUREMENTS FROM TSB-1:

$$K2' = \frac{(2.91E-09 * 27000) + (2.82E-09 * 55020) + (2.73E-09 * 32580)}{27000 + 55020 + 32580}$$

$$\frac{+(2.91E-09 * 54300) + (2.84E-09 * 32040)}{+54300 + 32040} = \frac{5.63E-04}{200,940}$$

$$= 2.8E-09 \text{ cm/sec}$$

2) USING LAST 6 MEASUREMENTS FROM TSB-2 WHERE $T_i > 1000s$:

$$K2' = \frac{(2.55E-8 * 54900) + (2.64E-8 * 32520) + (2.59E-8 * 54240) +}{54900 + 32520 + 54240}$$

$$\frac{(2.71E-8 * 31680) + (2.39E-8 * 54480) + (2.86E-8 * 22080)}{+31680 + 54480 + 22080}$$

$$= \frac{6.46E-03}{249900} = 2.58E-08 \text{ cm/sec}$$

CALC No. IV

SUBJECT STAGE 2 TSB FINAL VALUES SHEET 2/5

DATE 11-12-92 BY JDC CHKD. D E Graves JOB NO. 3840-827-01-903

3) USING LAST 6 MEASUREMENTS FROM TSB 3 =

$$K2' = \frac{(3.82\text{-}09 * 55080) + (2.93E\text{-}09 * 32460) + (3.66E\text{-}09 * 51480) +}{55080 + 32460 + 51480}$$

$$\frac{(2.20E\text{-}09 * 31920) + (2.94E\text{-}09 * 54660) + (2.95E\text{-}09 * 22900)}{+ 31920 + 54660 + 22900}$$

$$= \frac{8.01E\text{-}04}{251400} = \boxed{3.19E\text{-}09 \text{ cm/sec}}$$

4) USING LAST 6 MEASUREMENTS FROM TSB-4 :

$$K2' = \frac{(6.20E\text{-}09 * 55080) + (5.93E\text{-}09 * 32460) + (5.65E\text{-}09 * 54480) +}{55080 + 32460 + 54480}$$

$$\frac{(5.10E\text{-}09 * 31920) + (5.06E\text{-}09 * 54660) + (5.12E\text{-}09 * 22800)}{+31920 + 54660 + 22800}$$

$$= \frac{1.4E\text{-}03}{251400} = \boxed{5.56E\text{-}09 \text{ cm/sec}}$$

5) USING LAST 6 VALUES FROM TSB-5 :

$$K2' = \frac{(1.65E\text{-}09 * 56280) + (1.19E\text{-}09 * 31260) + (1.38E\text{-}09 * 54360 +}{56280 + 31260 + 54360 +}$$

$$\frac{+ (1.62E\text{-}09 * 31920) + (1.86E\text{-}09 * 55980) + (3.05E\text{-}09 * 20940}{31920 + 55980 + 20940}$$

$$= \frac{3.13E\text{-}4}{250740} = \boxed{1.24E\text{-}09 \text{ cm/sec}}$$

$$\frac{4.25E\text{-}4}{250740} = 1.69E\text{-}09 \text{ cm/sec}$$

CALC No. IV

SUBJECT STAGE 2 TSB FINAL VALUES SHEET 3/5

DATE 11-13-92 BY JDC CHKD. [illegible] JOB NO. 3840-827-01-903

6) USING THE LAST 6 MEASUREMENTS FROM TSB-6 WHERE $T_i > 1000$ s:

$$K2' = \frac{(1.25E\text{-}8 * 56280) + (1.17E\text{-}8 * 31260) + (1.31E\text{-}08 * 54240) + (1.18E\text{-}08 * 31920) + (1.15E\text{-}09 * 55300) + (1.16E\text{-}08 * 21120)}{56280 + 31260 + 54240 + 31920 + 55800 + 21120}$$

$$= \frac{3.04E\text{-}3}{250620} = \boxed{1.21E\text{-}08 \text{ cm/sec}}$$

7) USING THE LAST 6 MEASUREMENTS FROM TSB-7:

$$K2' = \frac{(1.90E\text{-}9 * 55680) + (8.84E\text{-}10 * 31920) + (1.82E\text{-}09 * 54300) + (8.92E\text{-}10 * 31860) + (1.30E\text{-}09 * 55200) + (1.69E\text{-}9 * 21720)}{55680 + 31920 + 54300 + 31860 + 55200 + 21720}$$

$$= \frac{3.7E\text{-}04}{250680} = \boxed{1.47E\text{-}09 \text{ cm/sec}}$$

8) USING LAST 6 MEASUREMENTS FROM TSB 8 WHERE $T_i > 1000$ s:

$$K2' = \frac{(5.19E\text{-}8 * 55740) + (4.82E\text{-}8 * 31860) + (4.05E\text{-}8 * 54240) + (4.1E\text{-}8 * 31800) + (3.75E\text{-}8 * 55140) + (3.9E\text{-}8 * 21660)}{55740 + 31860 + 54240 + 31800 + 55140 + 21660}$$

$$= \frac{1.08E\text{-}2}{250440} = \boxed{4.33E\text{-}08 \text{ cm/sec}}$$

CALC No. IV

SUBJECT STAGE 2 TSB FINAL VALUES SHEET 4/5

DATE 11-13-92 BY JDC CHKD. D.E. Cowan JOB NO. 3840-827-01-963

9) USING THE LAST 6 MEASUREMENTS FROM TSB-9 WHERE $T_i > 1000s$

$$K2' = \frac{(1.79E-7 * 54060) + (1.56E-7 * 21780) + (1.63E-7 * 10140) + (1.63E-7 * 54060) + (1.61E-7 * 6180) + (1.62E-7 * 16560)}{54060 + 21780 + 10140 + 54060 + 6180 + 16560}$$

$$= \frac{2.72E-2}{162780} = \boxed{1.67E-07 \text{ cm/sec}}$$

10) USING LAST 6 MEASUREMENTS FROM TSB-10 WHERE $T_i > 1000s$:

$$K2' = \frac{(4.89E-8 * 54360) + (4.75E-8 * 33000) + (5.34E-8 * 54000) + (5.52E-8 * 32100) + (4.78E-8 * 54060) + (4.73E-8 * 22920)}{54360 + 33000 + 54000 + 32100 + 54060 + 22920}$$

$$= \frac{1.25E-2}{250440} = \boxed{5.01E-8 \text{ cm/sec}}$$

11) USING THE LAST 6 MEASUREMENTS FROM TSB-11:

$$K2' = \frac{(1.38E-8 * 54480) + (1.32E-8 * 33060) + (1.41E-8 * 54000) + (1.34E-8 * 32100) + (1.30E-8 * 54120) + (1.24E-8 * 22920)}{54480 + 33060 + 54000 + 32100 + 54120 + 22920}$$

$$= \frac{3.37E-3}{250680} = \boxed{1.34E-08 \text{ cm/sec}}$$

CALC No. IL

SUBJECT STAGE 2 TSB FINAL VALUES SHEET 5/5

DATE 11-13-92 BY JDC CHKD. QC Comm JOB NO. 3840-827-01-90

12) USING THE LAST 6 MEASUREMENTS FROM TSB 12 WHERE $T_i > 1000$s

$$K2' = \frac{(2.58E\text{-}8 * 22860) + (2.47E\text{-}8 * 9660) + (2.42E\text{-}8 * 54180)}{22860 + 9660 + 54180}$$

$$+ \frac{(2.46E\text{-}8 * 32040) + (2.35E\text{-}8 * 54540) + (2.37E\text{-}8 * 22200)}{+ 32040 + 54540 + 22200}$$

$$= \frac{4.74E\text{-}03}{195480} = \boxed{2.42E\text{-}08 \text{ cm/sec}}$$

13) USING THE LAST 6 MEASUREMENTS FROM TSB-13 WHERE $T_i > 1000$s

$$K2' = \frac{(5.43E\text{-}8 * 9660) + (5.42E\text{-}8 * 54300) + (5.13E\text{-}8 * 22560)}{9660 + 54300 + 22560 +}$$

$$+ \frac{+(5.11E\text{-}8 * 9480) + (5.10E\text{-}8 * 54540) + (5.05E\text{-}8 * 22200)}{9480 + 54540 + 22200}$$

$$= \frac{9.01E\text{-}03}{172740} = \boxed{5.22E\text{-}08 \text{ cm/sec}}$$

ATTACHMENT 5

SPREADSHEET CALCULATION SUMMARY

Kh AND Kv

TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST
STAGE ONE and STAGE TWO DATA REDUCTION
and CALCULATION of Kv and Kh VALUES
WSSRAP SUPPORTING STUDY 3A -
HYDRAULIC PROPERTIES OF UNDISTURBED SOILS

TSB INSTALLATION	K1' (cm/sec)	K2' (cm/sec)	K2'/K1'	p*	L (inches)	m**	Kv	Kh	Kh/Kv	Comments
TSB-01	3.03E-09	2.80E-09	0.9241	1	6.00	0.7410	4.09E-09	2.25E-09	0.5491	Best Kh & Kv
TSB-01	3.03E-09	2.80E-09	0.9241	2	6.00	0.9953	3.04E-09	3.02E-09	0.9906	
TSB-02	3.04E-09	2.58E-08	8.4868	1	6.25	30.7055	9.90E-11	9.33E-08	942.8277	
TSB-02	3.04E-09	2.58E-08	8.4868	***	6.25	3.3360	9.11E-10	1.01E-08	11.1289	Best Kh & Kv
TSB-03	2.23E-09	3.19E-09	1.4305	1	6.38	2.0560	1.08E-09	4.58E-09	4.2271	
TSB-04	3.05E-09	5.56E-09	1.8230	1	6.13	3.3360	9.14E-10	1.02E-08	11.1289	
TSB-05	5.07E-09	1.69E-09	0.3333	***	6.00	3.3360	1.52E-09	1.69E-08	11.1289	
TSB-06	4.12E-09	1.21E-08	2.9369	1	6.88	6.8060	6.05E-10	2.80E-08	46.3216	
TSB-06	4.12E-09	1.21E-08	2.9369	***	6.88	3.3360	1.24E-09	1.37E-08	11.1289	Best Kh & Kv
TSB-07	2.40E-09	1.48E-09	0.6167	10	5.88	1.1470	2.09E-09	2.75E-09	1.3156	Best Kh & Kv
TSB-07	2.40E-09	1.48E-09	0.6167	20	5.88	2.0630	1.16E-09	4.95E-09	4.2560	
TSB-08	4.00E-09	4.33E-08	10.8250	1	6.25	43.2103	9.26E-11	1.73E-07	1867.1300	
TSB-08	4.00E-09	4.33E-08	10.8250	***	6.25	3.3360	1.20E-09	1.33E-08	11.1289	Best Kh & Kv
TSB-09	9.59E-09	1.67E-07	17.4140	1	5.75	82.0455	1.17E-10	7.87E-07	6731.4641	
TSB-09	9.59E-09	1.67E-07	17.4140	****	5.75	1.1470	8.36E-09	1.10E-08	1.3156	Best Kh & Kv
TSB-10	6.06E-09	5.01E-08	8.2673	1	5.88	31.8615	1.90E-10	1.93E-07	1015.1552	
TSB-10	6.06E-09	5.01E-08	8.2673	*****	5.88	0.7410	8.18E-09	4.49E-09	0.5491	Best Kh & Kv
TSB-11	1.83E-09	1.34E-08	7.3224	1	6.00	26.9140	6.80E-11	4.93E-08	724.3634	
TSB-11	1.83E-09	1.34E-08	7.3224	***	6.00	3.3360	5.49E-10	6.10E-09	11.1289	Best Kh & Kv
TSB-12	1.85E-09	2.42E-08	13.0811	1	6.38	54.0530	3.42E-11	1.00E-07	2921.7268	
TSB-12	1.85E-09	2.42E-08	13.0811	****	6.38	1.1470	1.61E-09	2.12E-09	1.3156	
TSB-12	1.85E-09	2.42E-08	13.0811	*****	6.38	0.7410	2.50E-09	1.37E-09	0.5491	Best Kh & Kv
TSB-13	2.59E-09	5.22E-08	20.1544	1	6.75	88.7885	2.92E-11	2.30E-07	7883.3977	
TSB-13	2.59E-09	5.22E-08	20.1544	***	6.75	3.3360	7.76E-10	8.64E-09	11.1289	Best Kh & Kv

* Values for p from Table on Page 21 (Boutwell, 1992).
** From FORTRAN Program which solves for the given K2'/K1' using selected values for m
*** m value for these TSBs is from TSB-04, closest TSB in depth and unit tested, with a < 20 Kh/Kv ratio.
**** m value for these TSBs is from TSB-07.
***** m value for this TSB is from TSB-01.

ATTACHMENT 6

TSB METHOD REFERENCE

THE STEI TWO-STAGE BOREHOLE FIELD PERMEABILITY TEST

by: Gordon P. Boutwell, PhD, P.E.

Presented to

"CONTAINMENT LINER TECHNOLOGY AND SUBTITLE D"

Seminar Sponsored by
Geotechnical Committee
Houston Branch, ASCE

Houston, Texas - March 12, 1992

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SYNOPSIS

In 1991, the Texas Department of Health began requiring field verification of the hydraulic conductivity for the waste-retention barriers under its jurisdiction. The TDH has approved two procedures: the Two-Stage Borehole (TSB) method and the Sealed, Double-Ring Infiltrometer (SDRI) method. The TSB method is discussed herein.

It is a falling-head infiltration test conducted in a cased borehole, typically 4 inches in diameter. The first stage is performed with the bottom of the hole flush with the bottom of the casing for maximum effect of vertical permeability (k_v). After steady-state is achieved, the hole is advanced some 6 to 8 inches below the bottom of the casing so that horizontal permeability (k_h) has a greater effect. The two stages yield the following:

Stage 1 - The maximum possible value for (k_v).
Stage 2 - The minimum possible value for (k_h).
Stage 1 + Stage 2 - Constants for two equations which can then be solved for the real (k_h, k_v).

Procedures are available for reduction of the data in the cases of both above and below water table testing, and for the bottom boundary conditions of a material far more permeable, equally permeable, or far less permeable than the medium being tested. The test has been successful in evaluating both compacted and natural materials with permeabilities as low as 1x10(-9) cm/sec.

The major test precautions include proper sealing of the casing along the outside, accounting for temperature effects, and correcting for sidewall smear during the second stage. The test is quick, simple, and relatively inexpensive. It allows results in days, rather than months. Multiple installations are feasible so that statistical confidence can be achieved. It is recognized in the literature, including U.S. EPA publications, and accepted by many State regulatory authorities.

I. INTRODUCTION

Clay barriers are an important component of waste retention structures. Their primary geotechnical characteristic for this use is hydraulic conductivity, which must be verified during the Construction Quality Assurance program. Until recently, practice relied on laboratory testing of small (7 to 10 cm diameter) undisturbed samples taken from the barrier or a similarly constructed test pad. Day and Daniel (1985) reported conductivities measured in the field which were 3 to 4 orders of magnitude higher than they obtained with laboratory tests. While that study was justly criticized, the horse was out of the barn and regulators all over the country galloped into field testing for hydraulic conductivity evaluation at waste facilities.

From the regulatory standpoint, a test procedure should be accurate and avoid false positives, i.e., not indicate compliance with the specified conductivity when the liner or pad truly has a higher value. This normally means testing a large soil volume searching for the elusive "macropores" which are thought to evade, somehow, even numerous laboratory tests. The regulated community wants the accuracy and avoidance of false positives for their own protection, but also wants to minimize testing times (and costs), and to avoid false negatives, both for economy.

In about the last two years, two methods have become accepted as meeting these criteria to a satisfactory degree: the Sealed, Double-Ring Infiltrometer (SDRI) and the Two-Stage Borehole (TSB) procedure. Each has its stronger and weaker points (see Daniel, 1989).

II. BASIC CONCEPTS

The vertical conductivity (k_v) governs flow, even in sidewall liners if built in the preferred manner: lifts parallel to the slope. However, the horizontal conductivity (k_h) is greater than the vertical. All field tests are affected by this anisotropy, unless flow in the horizontal direction is artificially blocked; the effect is to increase the test conductivity by factors of 2 to 5 over the real (k_v) value. Equations for flow from various source geometries in a cross-anisotropic medium are available in Hvorslev (1951). However, each equation has two unknowns: (k_v) and ($m^2 = k_h/k_v$).

The TSB procedure combines four old concepts into one new idea to find (k_v). The field procedure is taken from long-established US Bureau of Reclamation methods: their flush-bottom borehole test (E-18) and borehole packer test (E-19). Computations are based on the Hvorslev equations adapted for various bottom boundary conditions by the three-dimensional Image Potential Technique (Carslaw and Jaeger, 1959). The new idea is performing both USBR tests in the same borehole, yielding two equations which can be solved for the two unknowns, (k_h) and (k_v).

The TSB is a field infiltration test, conducted in a cased borehole so that the geometry of the infiltrating zone can be controlled. It is normally conducted as a falling-head test. The basic idea is to vary the geometry of the infiltrating area so as to vary the relative effects of (k_h) and (k_v). In the first stage, the geometry is chosen so that (k_v) has its maximum effect. The second stage geometry is such that (k_h) has its maximum effect. The results of the two stages yield two equations in two unknowns (k_h, k_v), which can then be solved. This concept is illustrated on Figure 1, below:

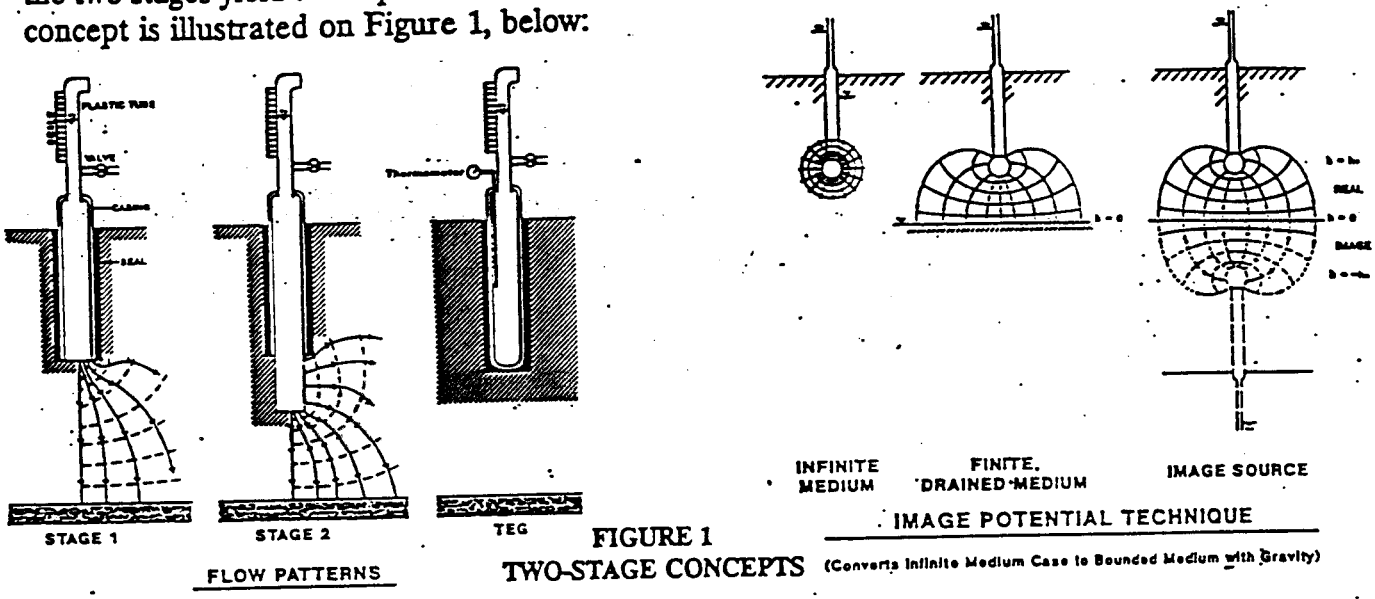

FIGURE 1
TWO-STAGE CONCEPTS

Stage 1 is normally conducted using a flat bottom flush with the base of the casing. Infiltration proceeds until a steady-state flow condition is achieved. Then, the borehole is advanced some 1.5 to 2 casing diameters (6 to 8 inches) below the bottom of the casing. The apparatus is refilled, and infiltration in this Stage 2 continues until it achieves steady-state flow.

During the test, the soil is assumed isotropic ($k_v = k_h$). Stage 1 then yields an apparent permeability (K1), and Stage 2 a different value (K2). The unknown ratio (k_h/k_v) is a unique function of the known test geometry and the known test ratio (K2/K1). When the former is determined, the real (k_v, k_h) can be computed from (K1) or (K2).

III. FIELD PROCEDURES

As is the case with virtually all field tests, and especially field permeability tests, the field procedures are of paramount importance. The most diligent office analyses cannot overcome all of the problems resulting from improper installation, inadequate monitoring, premature test termination, and the like.

3.1 Test Program Design. The test program should be designed to meet the conditions assumed in deriving the data reduction equations so that meaningful results can be obtained.

3.1.1 Vertical Boundaries. Certain clearances are required between the infiltrating surface and any boundaries, pervious or impervious. These can be summarized as:

a. **Minimum casing embedment below ground surface = 2.5D**
(Prevents uplift, minimizes hydraulic fracturing)

b. **Minimum thickness of tested material below bottom of Stage 2= 2.0D**
(Avoids violating boundary conditions of equations)

c. **Minimum recommended Stage 2 extension = 1.5D**
(Avoids theoretical problems at finite but small L/D)

D = Casing inside diameter
L = Length of Stage 2 extension

3.1.2 Horizontal Spacings. It is intuitively obvious that the tests must be spaced "far enough" apart so that their flows do not interfere with each other causing a falsely low permeability. Also, the presence of a drainage boundary (such as the edge of a test pad) which is "too close" to the test will increase the flow, yielding a falsely high permeability.

This can be avoided by maintaining at least the following clearances:

a. **Minimum horizontal distance between tests = 30D**
b. **Minimum horizontal distance to free surface = 30D**

3.1.3 Number and Size of Tests. The number of tests required for evaluation depends on the project, the acceptance criteria, and the variability of the stratum/fill being evaluated. As in virtually any other geotechnical testing, "the bigger the better".

However, the general practice has been to use 4-inch (ID) tests, with 5 tests for the typical liner or test pad.

The scale effect, if any, of test size has not been fully researched. Virtually all of the known tests have been conducted using 4-inch (10 cm) ID casings. These tests typically permeate a volume of some 0.4 - 1.1 cubic feet each, or 2 to 5 cubic feet for a 5-test group. Benson (pers. comm., 1991) indicates that the minimum representative volume for a permeability determination is on the order of 0.5 - 1.0 cubic foot. This is about the volume permeated by a typical TSB test.

3.1.4 Other Details. There are a few other details in test planning which should be considered. Among these are:

a. Protect the test area surface from desiccation, usually with clear or white plastic.
(Avoids heat-induced problems).

b. Use a "sock" to prevent collapse of the Stage 2 open hole in susceptible materials. The sock is a rigid cylinder of open-mesh plastic, lined with a filter geofabric. The cylinder is somewhat smaller in diameter than the casing ID (and thus the Stage 2 hole), and an inch or so longer than the extension for Stage 2. It is fitted with retrieving lines and not left in the hole after the test.

c. Minimize the distance (R_y) from the ground surface to the bottom of the measuring scale, especially for shallow tests. This also aids in having the longest possible reading time between standpipe refills and avoiding hydraulic fracturing.

d. Match the standpipe size to the flow rate so that accuracy is achieved but overnight readings are possible. For a 4-inch casing, this usually means a 0.5 - 0.75 inch ID standpipe.

3.2 Permeameter Installation. Proper installation and checking the permeameters are vital to obtaining a valid test. Various field techniques have been developed through experience which minimize problems. These techniques are discussed in this section.

3.2.1 Permeameter. A typical permeameter is illustrated on Figure 2. The apparatus is simple; the permeameter can be assembled with a visit to a water-well driller and a hardware store. The elements for a falling-head system are:

a. Casing. Typically 4-inch ID Schedule 40 PVC monitoring well pipe, flush-threaded, with "O"-Ring joint. Other casings can be used.

b. Cap. To fit casing, preferably domed, and drilled and/or tapped to receive the standpipe apparatus.

c. Standpipe. *Clear* Schedule 40 PVC or acrylic tube, 0.5 to 1.0 inch ID, with scale. Include elbow with cover (having air-vent) to prevent rain entry and minimize evaporation.

d. Fittings. The small fittings necessary to assemble the apparatus.

All joints which are not glued are assembled with PTFE Plumber's Tape and silicone grease (not sealant).

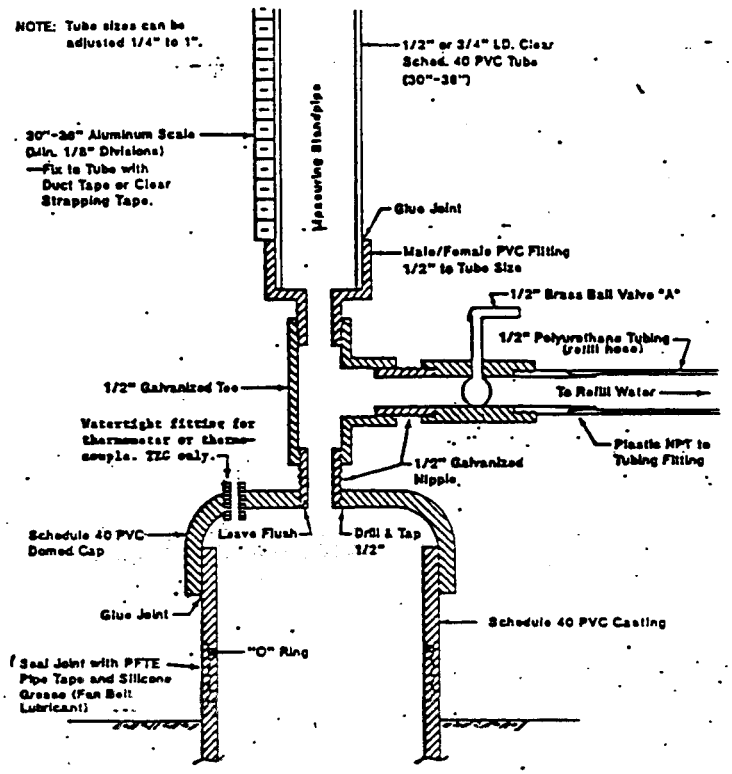

FIGURE 2
TYPICAL PERMEAMETER

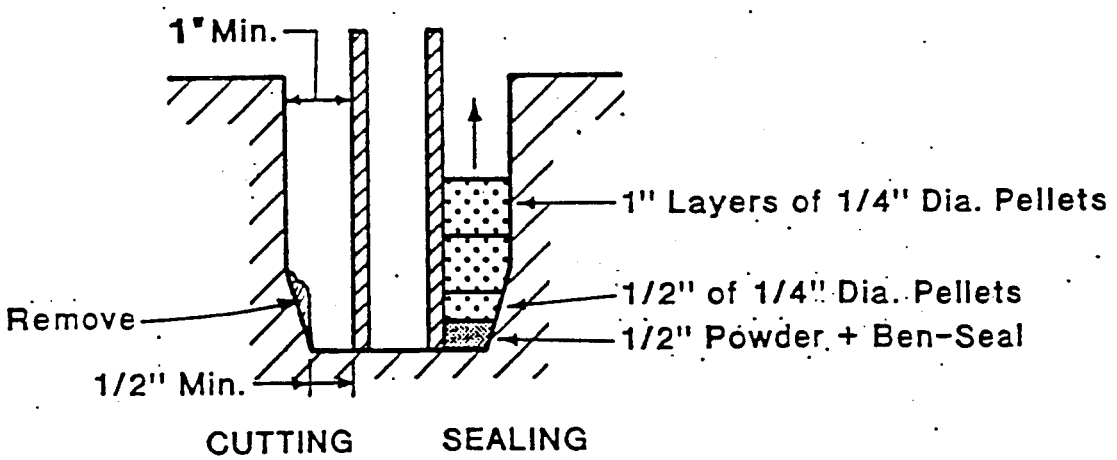

FIGURE 3
SEALING PROCEDURE

3.2.2 Borehole. The casing is set into a borehole. The holes have been drilled using rigs, power-operated hand equipment, and hand augers. The device depends on depth and hardness of material. The hole must have a large enough diameter to allow sealing the annular space between the borehole wall and the casing. Also, it must not disturb the soils below the casing bottom. The bottom must also be flat. Experience has shown the following to be acceptable:

a. Borehole diameter at least 2 inches greater than the casing OD. (To allow sealant to reach the bottom and for tamping).

b. Stop point of auger about 1 inch above proposed casing bottom. (To avoid testing in a disturbed material)

c. Ream bottom of borehole to final depth with a flat auger.

The bottom of the borehole should be flat and flush with the bottom of the casing in order to correspond with Hvorslev's (or H-I) Case "B" or "C" for Stage 1.

3.2.3 Sealing. This is the single most important step in installation. A poorly sealed test cannot be salvaged. The annular space between the casing and the wall of the borehole is sealed with bentonite. Best results have been attained using 1/4" (not 3/8" or larger) bentonite pellets or crushed bentonite (Baroid "Hole-Plug" or equivalent). The procedure, illustrated on Figure 3, is:

a. Crush sufficient pellets, "Ben-Seal", or "Hole-Plug" to fill about 1/2 inch of the annulus. This should have about 1/16" size fragments with some powder.

b. Place this material into the annular space.

c. Place about 1/2 inch of bentonite pellets or "Hole-Plug" into hole,

d. Tamp the bentonite pellets or "Hole Plug",

e. Add water until it shows above the bentonite,

f. Repeat the process (but using only the pellets or "Hole Plug") in 1 inch increments to the ground surface or a minimum of 6D above the casing bottom, whichever occurs first. Grouting above the 6D level is allowable.

g. Allow the bentonite (and grout) to hydrate at least overnight.

The casing must be steadied to prevent lateral motion while sealing. The bentonite seal is then allowed to hydrate overnight before any head is applied to the system.

3.2.4 Advancing for Stage 2. Upon completion of Stage 1, a borehole is advanced below the bottom of the casing to form the cylindrical infiltrating surface for Stage 2. The important points are:

a. **Do not disturb the casing - that can affect the seal.**

b. **Borehole diameter should equal casing ID.**

c. **Stop point of auger about 1 inch above proposed Stage 2 bottom. Ream flat and measure depth.**

d. **Roughen the sidewalls to minimize smear.**

This portion of the work is normally handled with hand equipment. The first step after removing the cap is to empty the casing of water (tests above groundwater level or where no seepage was noted during Stage 1 drilling and/or sealing). It is frequently useful to obtain an undisturbed sample during this process, using ASTM D2937 or D1587. However, undisturbed sampling should not be performed if the material being tested contains gravel-sized particles; they can disturb the sidewalls during the push or driving. After or in lieu of undisturbed sampling, the boring is augered until the point of the auger is about 1 inch above the desired bottom for Stage 2. The auger should be at least 1/2 inch in diameter smaller than the casing ID. The boring is then completed to depth and diameter with a flat-bottomed reamer.

The reamer is designed to minimize sidewall smear, having full casing ID only at the cutting edge. The sidewalls are then roughened with a wire brush or similar device, a procedure also recommended in USBR E-18. This step must not be omitted, since one of the significant problems encountered in Two-Stage testing has been artificially low values for Stage 2 due to smear. Equations to handle smear are included herein, but require some idea of the degree of smear.

After the borehole is completed and cleaned of cuttings, the depth is measured so that the correct length of the Stage 2 cylinder is known. For a typical test, a 1-inch depth error will yield the wrong Stage 2 permeability value by 7 to 8%. The cap is then reseated, and Stage 2 begins.

3.3 Ambient Condition Effects. Temperature changes cause the dominant effects of ambient conditions on this test, although there may be some contribution from barometric pressure changes. Temperature changes affect the test by:

- Volumetric changes in the water and apparatus.
- Viscosity changes with temperature.
- Freezing the test water.

The procedures for overcoming these effects are given below.

3.3.1 Volumetric Effects (TEG). At slow rates of flow, the field readings are affected by temperature, as has been noted on many such projects. Rising temperature causes the water column in the pressure/measurement standpipe to expand, so that the drop in water level is less than flow alone would produce. The net effect is a lower apparent permeability. Conversely, falling temperature produces a higher apparent permeability. A normal day's temperature variations can easily cause a 0.5 to 1 order of magnitude change in the apparent permeability of low-permeability materials.

Therefore, a complete "dummy" test setup is installed but with the bottom of the casing sealed with a cap which is normally glued on and pressure-tested. This dummy, or temperature effect gauge (TEG) is of the same construction and embedded to the same depth as the regular test setups. Since there is no flow from the TEG, any change in its readings must be due to changes in the ambient conditions (temperature and/or barometric pressure). Such changes would affect the regular test setups to exactly the same degree.

This correction is applied to the regular tests by:

- Reading the TEG at the same times as readings are taken on the regular tests.
- Determining any increase (decrease) in .water levels in the TEG between regular test readings.
- Subtracting any increase (adding any decrease) at the TEG from the readings at the regular tests for the ends of the same time increments.

3.3.2 Viscosity Effects of Temperature. Permeability is normally reported as the value for water at 20°C (68°F). The density and viscosity of liquids, including water, are affected by temperature. The effect on permeability is in direct ratio to the kinematic viscosity (U), which is the viscosity divided by the density. The kinematic viscosity decreases at higher temperatures. The net effect is that the apparent permeability is greater than the 68°F value at low temperatures. The reverse occurs with decreasing temperatures. The effects for ordinary conditions can be from -50% to +15% on the permeability value. The normal correction to the standard condition is given in ASTM D5084:

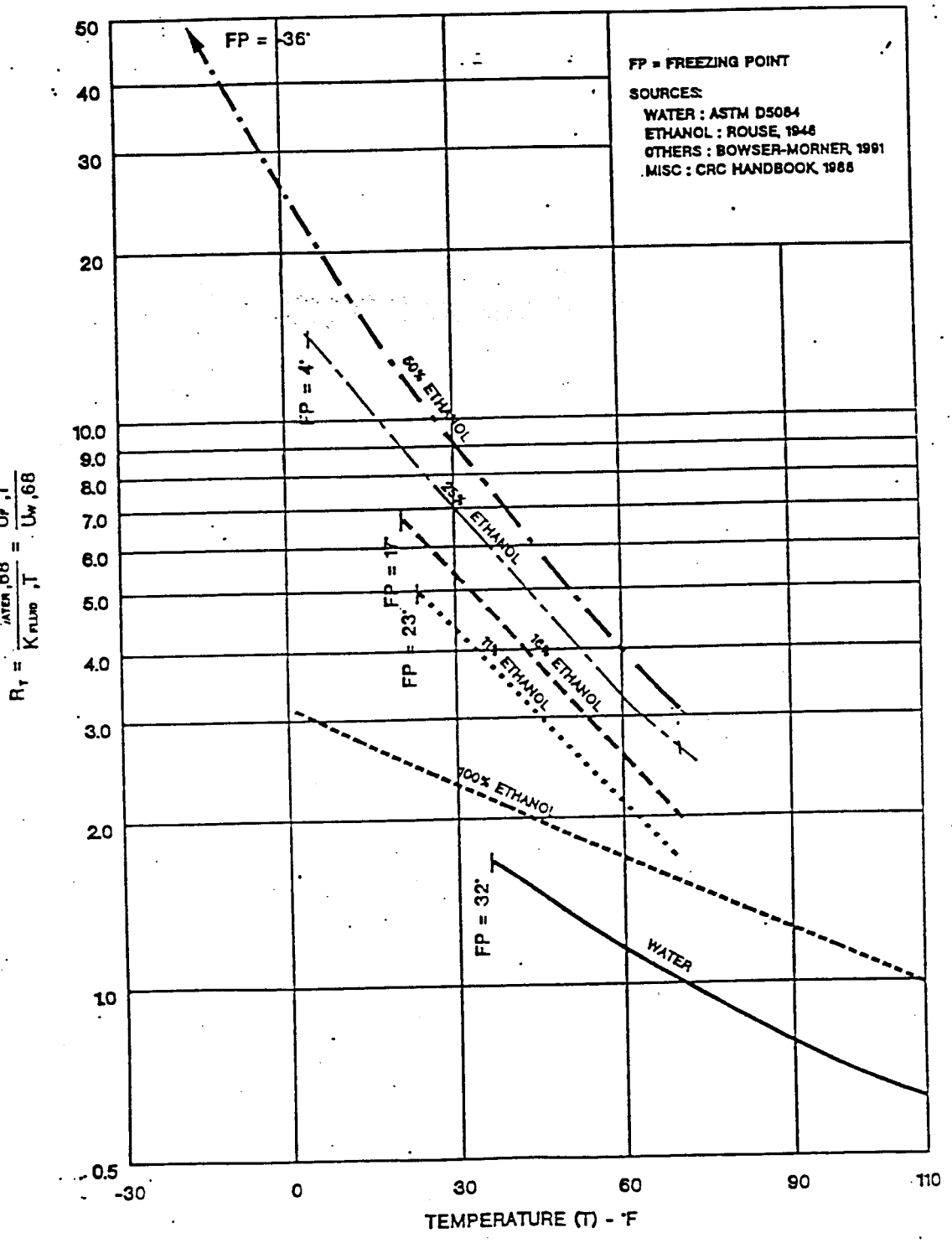

FIGURE 4
KINEMATIC VISCOSITY FACTORS

$$k_s/k_T = R_T = U_T/U_s \qquad (3.3.-1)$$

where:
k_s = Permeability for water at 68°F
k_T = Permeability observed in test
R_T = Correction Factor
U_T = Kinematic viscosity for test fluid at test temperature
U_s = Kinematic viscosity for water at 68°F

The factors (R_T) are given for water at temperatures between freezing and 120°F (0 to 49°C) in ASTM D5084. See also Figure 4 which reproduces that data.

The temperature of the exfiltrating water is measured by a thermometer or thermocouple in the TEG. It should extend to roughly the bottom of the casing. The thermometer or the leads for the thermocouple should have its own (sealed) port into the TEG cap or casing. Running either through the TEG standpipe could easily affect its function of volumetric correction.

3.3.3 Freezing Conditions. Unfortunately, field testing must sometimes proceed when the air temperatures are below freezing. Landfill operators often complete a test pad in late fall, so that they will have approval from the regulators for construction in the spring. Even if the ground temperatures stay above freezing, one cannot get decent readings from a frozen standpipe. Three procedures have been used:

a. Insulate the exposed test equipment, exposing only to make readings. (Only if mean daily air temperature exceeds freezing)

b. Use an antifreeze.
(Ethanol as Vodka is good, but needs its own R_T vs temperature graph. Does not attack clay at 25% or less alcohol).

c. Heat the test units.
(Potential for different temperatures - can invalidate the TEG).

3.4 Conducting the Test. The following discussion is applicable to both Stage 1 and Stage 2. Basically, the procedure is:

a. Fill and assemble permeameters.
(Use PTFE tape and silicone grease. Pour slowly to avoid bottom erosion).

b. **Read standpipe levels over time at the permeameter, plus level and temperature at the TEG.**
(Levels: to 1/16", temperature to 1°F).

c. **Convert these readings to apparent permeabilities.**

d. **Continue the test until these permeabilities remain steady.**

3.5 Field Calculations - Apparent Permeability. The data from each reading is converted into an apparent permeability, termed (K1) for Stage 1 and (K2) for Stage 2. Keeping up with the data in terms of a permeability has a physical meaning, and also yields a better "feel" for the behavior of the medium being tested. If that medium were isotropic ($k_h = k_v$), then (K1,K2) would be "the" permeability. Remember that the objective of most field permeability tests on regulated facilities is to determine that the vertical permeability (k_v) of the liner is not greater than some value, usually 1x10(-7) cm/sec, or to show that the horizontal permeability (k_h) of a drainage material is not less than some value, typically 1x10(-2) cm/sec. It can be shown that (K1) is the maximum possible value for (k_v) and that (K2) is the minimum possible value for (k_h). Hence, using these apparent permeabilities (K1,K2) frequently allows "pass-or-fail" determination early in the testing process. For example, (K1<Spec) within 24 hours in 90% of tests where (k_v/Spec<0.6), and 70% of all tests.

The equations for both Stage 1 and Stage 2 follow the generic falling-head test format:

$$k = R_T G \, \mathrm{Ln}(H_1/H_2)/(t_2-t_1) \qquad (3.5\text{-}1)$$

where:

k	=	Permeability
H_1	=	Initial head (at $t=t_1$)
H_2	=	Final head (at $t=t_2$)
t_1	=	Initial time
t_2	=	Final time
G	=	Geometric Constant, depends on test geometry
R_T	=	Kinematic viscosity correction to water at 68°F

In both Stages, the head is taken as the distance from the level in the standpipe to the groundwater level. The distance from the bottom of the casing to the groundwater level is limited for calculation purposes (only) to no more than 20 times the casing ID. If the depth to groundwater is less than 20 times the casing ID, the true depth is used in the calculations. However, where the depth to groundwater exceeds this criterion, it is considered to be at this 20-diameter depth in the calculations. This limitation is derived by 3-dimensional analogy with the two-dimensional "effective radius" of a well. The volumetric effects of temperature are accounted for using a corrected final head, replacing (H_2) by (H_2'), where:

$$H_2' = H_2 - c \qquad (3.5\text{-}2)$$

where: c = Increase in TEG standpipe water level during time period from t_1 to t_2

If the TEG standpipe water level goes up between readings, (c) is positive and ($H_2' < H_2$). Conversely, (c) is negative and ($H_2' > H_2$) if the TEG standpipe level drops between readings. This step is not theoretically precise, but is close enough for test purposes. The theoretical solution yields a complex implicit equation in which the true permeability is a function of its own logarithm. However, for the geometry of the test setups and the observed magnitudes of increases/decreases, the apparent permeabilities calculated in this manner differ from the true permeabilities by no more than 2 to 5 percent. The net result is to "smooth" the apparent permeabilities. This smoothing is most apparent (and most useful) when the soil's apparent permeability is less than about 2 to 5x10(-7) cm/sec and especially for small-diameter standpipes.

The kinematic viscosity factor (R_T) used in the calculation is that for the average test water temperature during the period from (t_1) to (t_2).

3.5.1 Stage 1. The nomenclature for the various terms of the Stage 1 calculations is illustrated on Figure 5. The proper equation is given below; it is the solution for (k_v) for an isotropic medium ($k_h/k_v = 1$).

$$K1 = R_T(\pi d^2/11D_1)[1+a(D_1/4b_1)]Ln(H_1/H_2')/(t_2-t_1) \qquad (3.5\text{-}3)$$

where:
- d = ID of Standpipe
- D_1 = Effective diameter of Stage 1 (Casing ID or OD)
- b_1 = Depth of tested medium below bottom of casing
- a = +1 for impervious lower boundary
- a = 0 for infinite depth of tested medium ($b_1 = \infty$)
- a = -1 for pervious lower boundary

And the other terms are as defined above. For field use, the geometric terms are combined into a single constant:

$$K1 = R_T\, G1\, Ln(H_1/H_2')/(t_2-t_1) \qquad (3.5\text{-}4)$$

where: $G1 = (\pi d^2/11D_1)[1+a(D_1/4b_1)]$

A complete example is given in the Sample Calculations, Appendix A.

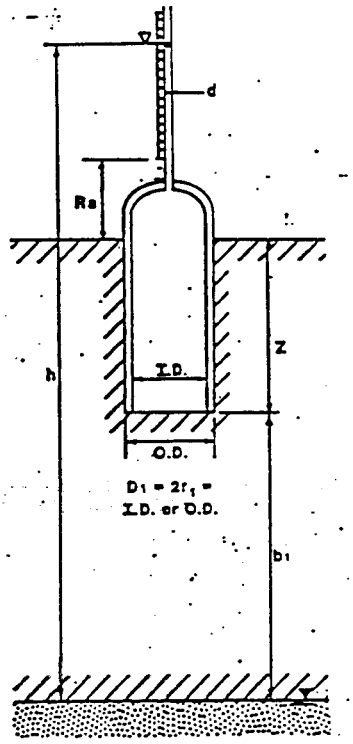

FIGURE 5
STAGE 1 NOMENCLATURE

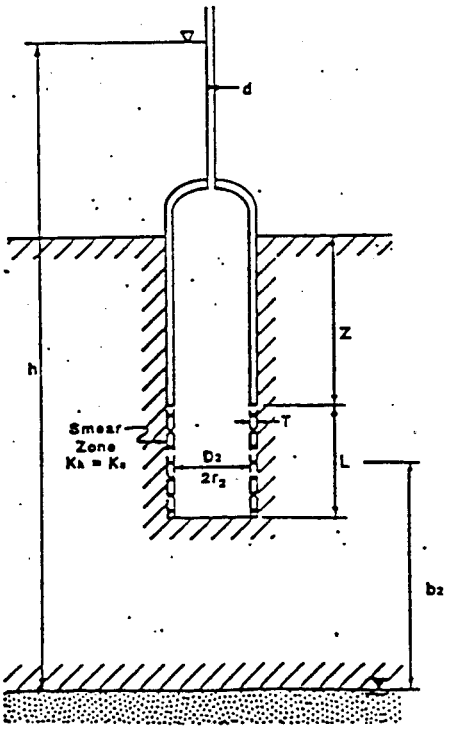

FIGURE 6
STAGE 2 NOMENCLATURE

3.5.2 Stage 2. The nomenclature for the various terms of the Stage 2 calculations is illustrated on Figure 6. The proper equation is that given below; it is the solution for (k_v) with the assumption that ($k_h/k_v=1$).

$$K2 = R_T\,(d^2/16Lf)\,\{Ln[u(1,r_o,o)]+a\,Ln[u(1,r_o,2b_2)]\}\,Ln(H_1/H_2')/(t_2-t_1) \qquad (3.5\text{-}5)$$

where:

$f = 1\text{-}0.5623\,Exp(-1.566\,L/D)$

L = Length of Stage 2 cylinder below casing

$u(1,r_o,o) = \{L/D_2 + \sqrt{1+(L/D_2)^2}\}^2$

$u(1,r_o,2b_2) = \dfrac{4b_2/D_2+L/D_2+\sqrt{1+(4b_2/D_2+L/D_2)^2}}{4b_2/D_2-L/D_2+\sqrt{1+(4b_2/D_2-L/D_2)^2}}$

D_2 = Diameter of Stage 2 extension (normally casing ID)

b_2 = Distance from center of Stage 2 extension to underlying boundary

And the other terms are as defined previously. The factor (f) was introduced to account for the non-convergence of the Hvorslev equations as ($L \rightarrow 0$). For field use, the geometric terms are combined into a single constant:

$$K2 = R_T\,G2\,Ln(H_1/H_2')/(t_2-t_1) \qquad (3.5\text{-}6)$$

where: $G2 = (d^2/16Lf)\,\{Ln[u(1,r_o,o)]+a\,Ln[u(1,r_o,2b_2)]\}$

A complete example is given in the Sample Calculation, Appendix A.

3.5.3 Time-Weighted Averaging. Whether one uses the Laplacian or the Green-Ampt model for groundwater flow, there are still transient effects at the beginning of every type of field or laboratory permeability test. The observed effect is to indicate a high permeability, gradually decreasing to some relatively constant value corresponding to a steady-state flow condition. Such an effect is usually noted in the TSB. Therefore, the test must be conducted "long enough" to achieve virtually the steady-state condition or the results will be not only too high but also erratic. In addition, a single value each of (K1) and (K2) must be used in the final data reduction (Section IV).

There is no reliable method for pre-calculating the length of time required to achieve steady-state. Rather, the observational method is used. The appropriate apparent permeability (K1 or K2) is calculated for each time-increment, and/or over longer periods of time; when these appear to be stable, they are checked using arithmetic time - weighted averages, e.g.,

$$K' = \Sigma (TiKi)/\Sigma (Ti) \qquad (3.5\text{-}7)$$

where: K' = Arithmetic Time-Weighted Average (ATWA) Permeability
Ti = Time Duration of Test Increment (i)
Ki = Permeability Measured during Test Increment (i)

This is theoretically exact for a single run (between refills). Time - weighted averaging also provides a rational basis for smoothing the (often) slightly erratic individual (K1,K2) values from the various time increments. An example of time-weighted averaging is given in the Sample Calculations, Appendix A.

3.5.4 Termination Criteria. Infiltration theory indicates that the apparent permeabilities (K1,K2) should forever decrease at an ever-and-ever decreasing rate. Observations in over 200 of these tests show that a steady-state condition or a close approximation of it is achieved in reasonable testing periods. A log-log plot of apparent permeability versus time is useful in determining when steady-state is achieved. Eventually, the (K1,K2) plots fluctuate about stable values. An example of such a plot is given in the Sample Calculation, Appendix A. This plot illustrates the importance of fairly closely spaced readings at the beginning of each stage, which allow separating the long-term behavior from the short-term fluctuations, i.e., enhance the "signal-to-noise" ratio.

In most tests, time-weighted averages become quite stable, often to within 1 to 5%. A reasonable set of criteria for terminating a stage is as follows:

* The time-weighted averages do not show an upwards or downwards trend with time,

and

* Do not fluctuate more than 10 to 20% among themselves,

and

* Maintain this behavior over a "sufficiently long" time, 12 - 72 hours depending on permeability.

IV.- DATA REDUCTION

4.1 Basic Procedure. In some cases, the (K1') or (K2') values may be adequate for the purpose of the test. More generally, the test is performed to determine the actual (k_h,k_v). This section outlines how to convert the (K1',K2') values calculated as outlined in Paragraphs (3.5.1) and (3.5.2) into the real permeabilities (k_h,k_v). Details for the common case are covered below.

4.1.1 Simultaneous Equations. The equations presented earlier for determining (K1,K2) are special cases of more general relationships. These more general equations define the degree of anisotropy by the parameter:

$$m = \sqrt{k_h/k_v} \qquad (4.1\text{-}1)$$

This parameter affects the geometric terms of the various equations. Each stage has its own equation with a different effect of (m). In a general sense, these can be written as:

Stage 1: $k_v = G1_m \, Ln(H_1/H_2')(t_2-t_1)$
$K1 = G1 \, Ln(H_1/H_2')(t_2-t_1)$

or $k_v = K1 \, (G1_m/G1)$ (4.1-2)

where: $G1_m$ = Geometric factor including (m)

Similarly, for Stage 2,

$$k_v = K2' \, (G2_m/G2) \qquad (4.1\text{-}3)$$

If the soil medium being tested is homogeneous (although cross-anisotropic and possibly bounded), the vertical permeability (k_v) must be the same in both stages. Hence, (4.1-2) and (4.1-3) provide two equations in the two unknowns ($m = \sqrt{k_h/k_v}$) and (k_v). The resulting equation is:

$$K1'(G1_m/G1) = k_v = K2'(G2_m/G2)$$

or $K2'/K1' = (G1_m/G1)(G2/G2_m)$ (4.1-4)

The standpipe area (A_p) cancels for each individual stage in (4.1-2 and 4.1-3), even though different (A_p) values may have been used for Stage 1 and Stage 2, and even for different portions of either stage. The actual equations for the geometric constants involving (m) are given in Paragraph (4.2).

The ratio (K2'/K1') is known from the test; the actual values introduced are the long-term time-weighted averages, (K1' and K2'). The geometric terms are also known. Therefore, Equation (4.1-4) is satisfied only for one value of (m). Due to the complex nature of (4.1-4), trial-and-error or graphical solution works best for specific problems.

4.1.2 Calculating (k_h) and (k_v). The value for (m) is obtained as outlined above in Paragraph (4.1.1). When (m) is known, (k_v) can be calculated directly from Equation (4.1-2), and, by the definition of (m) in Equation (4.1-1).

$$k_h = m^2 k_v \qquad (4.1\text{-}5)$$

4.1.3 Stage 1 Only Method. In some individual tests, the ratio (K2'/K1') is so low that Equation (4.1-4) fails to converge. Others may have so large a (K2'/K1') ratio that the permeability values are obviously in error: (k_v) is far too low and (k_h) is far too high. This is usually due to inhomogeneity of the tested material. Advancing Stage 2 into a zone of lower permeability will cause a low (K2'/K1'). Conversely, advancing into a zone of higher permeability (such as a poor lift joint in fill or a silt/sand seam in natural materials) yields a very high (K2'/K1').

These events are handled by using a conservative (m) from the best-behaved tests and introducing that value into Equation (4.1-2).

4.2 Image Equation with Smear. The basic Hvorslev equations apply most directly to masses of infinite depth and below the groundwater level. Neither test pads nor liners often meet these criteria. Therefore, results calculated by using the Hvorslev equations directly for such cases will not be correct. For a given permeability, both proximity to a drainage zone and the vertical gradient due to gravity cause the flow to be greater than the basic Hvorslev equations would predict. The basic Hvorslev equations therefore predict a higher permeability than the material really has. The vertical gradient effect can be overcome by using the head as from the top of the standpipe to the groundwater level. A method for accounting for the proximity effect and proving the previous assertion was needed.

The method of image wells has been used in geohydrology for years. The classic example is the solution for a well near a river, found in many textbooks. However, the method is not limited to two-dimensional situations such as this illustration. Any solution for an infinite or semi-infinite medium which describes the potential field (head distribution) can be converted to a solution for a finite medium bounded by a plane by using the Image Potential technique (Carslaw & Jaeger, 1959).

The basic idea is that halfway between a source and a sink of equal but opposite strength will be a plane of zero potential. So, if there is a plane of zero potential (head), its effect can be replaced by an "image" source/sink located twice as far away from the sink/source as is the midway plane. If the test (source) is set a distance (b) above the drainage blanket, the flow field will be the same as if there were no blanket but there was an image test (sink) with negative head at a distance of (2b) below the real test. Since the drainage blanket is at zero head, the head at the test is taken as the total head lost: (b) plus the excess pressure (ht) applied at the infiltration point of the test.

Consider also the case where both the real and image sources have equal strengths and both are sources (positive head) or both are sinks (negative head). By the same logic as given above, the midway plane will be a no-flow boundary, corresponding to an impermeable bottom boundary located at a depth (b) below the real test.

4.2.1 Stage 1. The Hvorslev-Image equation (Case "C") for the flush-bottomed portion of the test is given by:

$$k_v = (\pi d^2/11mD_1)[1+a(D_1/4mb_1)]Ln(H_1/H_2')/(t_2-t_1) \qquad (4.2\text{-}1)$$

where:

d	=	ID of Standpipe
D_1	=	Test diameter for Stage 1
b_1	=	Thickness of test medium below base of casing
H_1	=	Initial head ($t=t_1$)
H_2'	=	Corrected final head = H_2-c (see Paragraph 3.5)
t_2	=	Final time
t_1	-	Initial time
a	=	-1 for permeable bottom boundary
a	=	0 for infinite depth to bottom boundary
a	=	+1 for impermeable bottom boundary

Equation (4.2-1) can also be written as:

$$k_v = G1_m\, Ln(H_1/H_2')/(t_2-t_1) \qquad (4.2\text{-}2)$$
$$G1_m = (\pi d^2/11mD_1)[1+a(D_1/4mb_1)]$$

4.2.2 Stage 2. Similarly, for the cylindrical case (Hvorslev "G"), the Image equation (with sidewall smear) is that given by:

$$k_v = (d^2/16Lfm^2)\{Ln[u(m,r_o+T,o)] + a\, Ln[u(m,r_o,2b_2)] + p\, Ln[u(m,r_o,o)/u(m,r_o+T,o)]\}\, Ln(H_1/H_2')/(t_2-t_1) \qquad (4.2\text{-}3)$$

where: L = Length of Stage 2 extension

f = $1-0.5623\ \mathrm{Exp}(-1.566\ L/D)$

$u(m,r_o,o)$ = $[mL/D_2 + \sqrt{1+(mL/D_2)^2}]^2$

$u(m,r_o,2b_2)$ = $\dfrac{4mb_2/D_2+mL/D_2+\sqrt{1+(4mb_2/D_2+mL/D_2)^2}}{4mb_2/D_2-mL/D_2+\sqrt{1+(4mb_2/D_2-mL/D_2)^2}}$

$u(m,r_o+T,o)$ = $\{mL/(D_2+2T) + \sqrt{1+[mL/(D_2+2T)]^2}\}^2$

p = k_h/k_s

k_s = Permeability of smeared zone

T = Thickness of smeared zone (0.6cm=0.25in)

D_2 = Diameter of Stage 2 extension

b_2 = Distance from center of Stage 2 cylinder to underlying boundary

And the other terms are as defined above for Stage 1. Equation (4.2-3) can be written in the generic format as:

$$k_v = G2S\ \mathrm{Ln}(H_1/H_2')/(t_2-t_1) \qquad (4.2\text{-}4)$$

where: $G2S = (d^2/16Lfm^2)\{\mathrm{Ln}[u(m,r_o+T,o)] + a\ \mathrm{Ln}[u(m,r_o,2b_2) + p\ \mathrm{Ln}[u(m,r_o,o)/u(m,r_o+T,o)]\}$

The generic expression for (K2'/K1') as a function of the test geometry is Equation (4.1-4). Following the steps outlined in Paragraph (4.1.1),

$$K2'/K1' = (G1_m/G1) \bullet (G2/G2S) \qquad (4.2\text{-}5)$$

where:

$(G1_m/G1)$ = $(1/m)\ [1+a(D_1/4mb_1)]/[1+a(D_1/4b_1)]$

$(G2/G2S)$ = $\dfrac{m^2\{\mathrm{Ln}[u(1,r_o,o)]+a\mathrm{Ln}[u(1,r_o,2b_2)]}{\mathrm{Ln}[u(m,r_o+T,o)]+a\mathrm{Ln}[u(m,r_o,2b_2)]+p\mathrm{Ln}[u(m,r_o,o)/u(m,r_o+T,o)]}$

Equation (4.2-5) is solved by taking an appropriate (p) and determining (m) by trial-and-error or by a graphical solution such as Figure 7.

The value of (p) is not determined in the test. The normal range of (p) is from 2 to 20; (p=1) indicates no smear. The following values for (p) have yielded satisfactory results, consistent with apparently non-smeared tests on the same tested units:

K2'/K1'	p
>1.1	1
0.9 - 1.1	1,2
0.8 - 0.9	2,5
0.7 - 0.8	5,10
0.6 - 0.7	10,20
0.4 - 0.6	15,20
0.4>	*

* Use Stage 1 Only Approach - Paragraph (4.1.3).

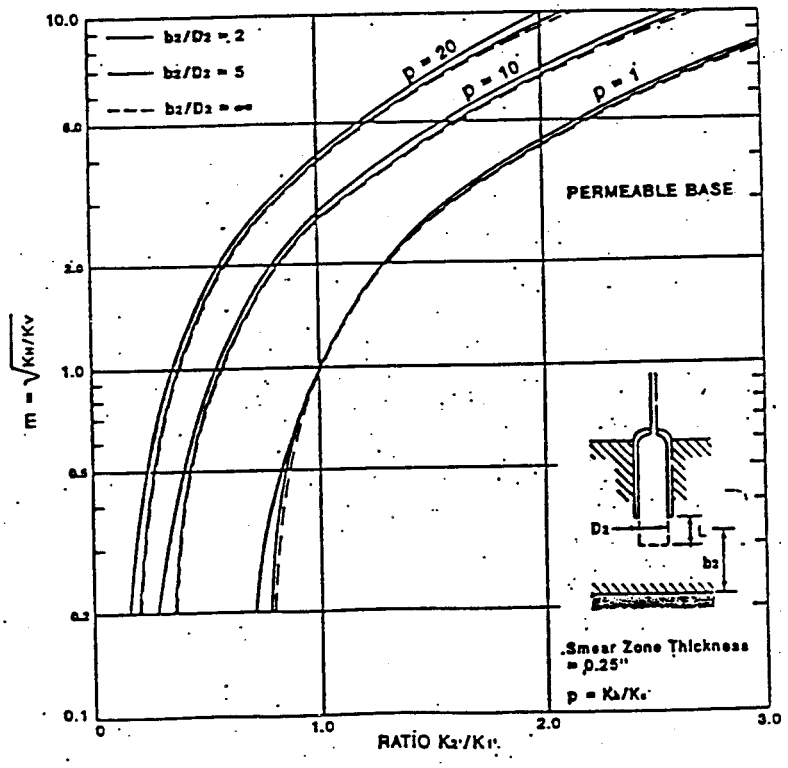

FIGURE 7
GRAPH FOR (m) - (L/D=1.5)

4.3 Non-Saturated Media. Field permeability tests are frequently performed on materials which are not fully saturated. Such materials affect the tests in two ways:

- The hydraulic head is dissipated over the (changing) distance from the point of inflow into the soil to the "wetting front", where the soil is considered fully saturated (Green-Ampt Model).
- Unsaturated clays exhibit "soil suction", which effectively adds to the hydraulic head.

In the Two-Stage test, infiltration into the soil is three-dimensional. The majority of the head loss occurs close to the inflow surface, even in a fully saturated material. About 50% of the loss occurs within one test radius of the inflow surface. For a typical Two-Stage test, disregarding wetting front distance theoretically yields a permeability 10 to 50% too high.

The effect of soil suction is roughly proportional to the ratio of suction to applied head. The effect of suction alone on a permeability test can be expressed as:

$$k_a/k_t = (1 + S/h_o) \qquad (4.3\text{-}1)$$

where:
k_a = Observed permeability
k_t = True saturated permeability
S = Soil suction
h_o = Applied head

The Two-Stage test normally operates with heads 3 to 6 times those of other test methods, minimizing the relative effect of suction.

These two effects can be handled using the graph presented on Figure 8. That figure is based on numerical solutions for the equipotential surfaces in an infinite medium (a=0). However, for the typical real test, the dimensionless flow volume is such that the equipotentials do not vary significantly from the ellipsoids in either the permeable-base (a=-1) or impermeable-base (a=+1) cases. The actual volume, which includes an allowance for the impermeable casing, has been included on Figure 8.

When using Figure 8, the initial volume (V_o) is taken as:

- Stage 1 - The volume of a hemi-ellipsoid having the diameter (D_1) and height ($D_1/4$).

$$V_{o1} = (\pi/24)\, D_1^3 \qquad (4.3\text{-}2)$$

- Stage 2 - The volume of the Stage 2 cylinder.

$$V_{o2} = (\pi/4)\, D_2^3\, (L/D_2) \qquad (4.3\text{-}3)$$

WE ALMOST NEVER USE NON-SAT EFFECTS.

The term (V_w) is the total volume of water which has infiltrated into the soil through the end of each stage, allowing for that removed in the Stage 2 extension. The (n_a) term is the soil's air porosity.

Figure 8 is applied first to the individual (K1) values from Stage 1:

$$K1_t = K1/[R(1+s/H_o)] \qquad (4.3\text{-}4)$$

where: $K1_t$ = K1 corrected for suction and wetting front
R = Permeability ratio from Figure 8

Then, Figure 8 is similarly applied to the individual (K2) values from Stage 2:

$$K2_t = K2/[R(1+s/H_o)] \qquad (4.3\text{-}5)$$

where: $K2_t$ = K2 corrected for suction and wetting front

Thereafter, ($K1_t$,$K2_t$) are used in Equation (3.5-7) for the average values ($K1'_t$,$K2'_t$). These are then introduced into Equations (4.2-5) for (m) then (4.1-2) for (k_v), and finally (4.1-5) for (k_h).

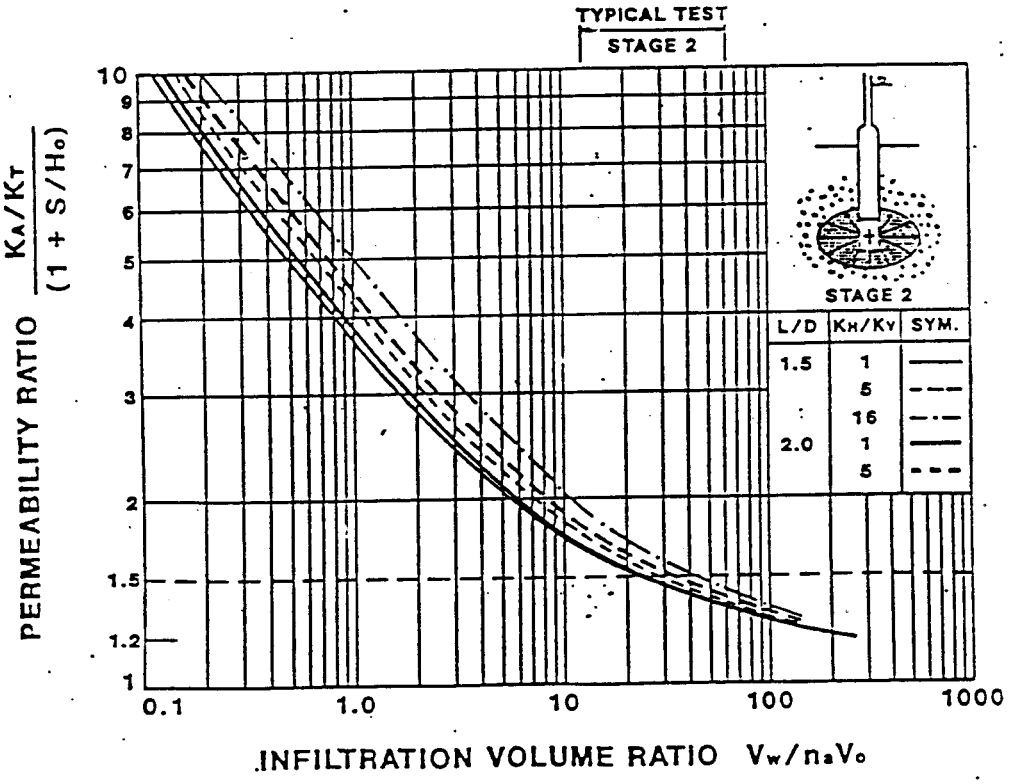

FIGURE 8
NON-SATURATION EFFECTS

V. EXPERIENCE WITH TSB TESTS

As of January, 1992, STEI alone has been involved in some 200 tests (40+ projects) on recompacted materials and 90 tests (6 projects) in natural materials. These have generally been of relatively low permeability [10(-6) to 10(-9) cm/sec]. Some conclusions from this experience are given below.

5.1 Types of Projects. The test has been successful in many types of soils:

5.1.1 Test Pads and Liners. It has been used in such conditions for test units from 20 to 60 inches thick. Materials have ranged from CH-OH (Liquid Limit 100+, clay content 70%+) to SC/GC (Liquid Limit 30-, gravel content up to 30%, clay content 12%). Vertical permeabilities have been successfully measured from the mid 10(-7)'s to the low 10(-9)'s (values in cm/sec).

5.1.2 "Natural" Deposits. It has been very successful in clays to depths of 10 to 15 feet. Where the clay does not make water, it has also been successful to about 20 to 25 feet. The test was moderately successful in soft, highly layered mine tailings clay at depths up to 30 feet. It has been used up to 7 feet deep in shales. Measured vertical permeabilities have been in the same ranges mentioned above.

5.2 Comparisons with Other Methods. The accuracy and lack of false negatives of the TSB can be evaluated by the comparisons with SDRI data shown on Figure 9 and with laboratory data from undisturbed samples given on Figure 10. Of the 11 known cases where both field methods were used on the same test pads/liners the mean ratio of their conductivities was 1.1 (TSB higher). In three known cases, the TSB proved failure defects in test pads that laboratory tests did not show, indicating the TSB avoids false positives. Experience to date can be summarized as:

5.2.1 Recompacted Clays. The vertical permeability (k_v) as obtained from laboratory tests, the TSB, and the SDRI generally agree quite well on test pads/liners (11 cases) which have had proper CQA. The laboratory tests tend to underestimate the horizontal permeability.

5.2.2 Natural Clays. Comparisons have only been made with small-scale laboratory tests. In general, there is good agreement with the TSB for vertical permeability, while laboratory tests again underestimate the horizontal permeability.

5.3 Speed. As soon as the test begins, so does the question from the client, "Does it Pass?" It is usual that (k_v) must be less than some specified value (Spec), or that (k_h) must be greater than a different (Spec). Since the maximum possible value for (k_v) is (K1), as soon as (K1<Spec), one knows the test for (k_v) must pass. Likewise, since (K2) is the minimum possible value for (k_h), if the long-term (K2) is greater than (Spec), the test for (k_h) must pass.

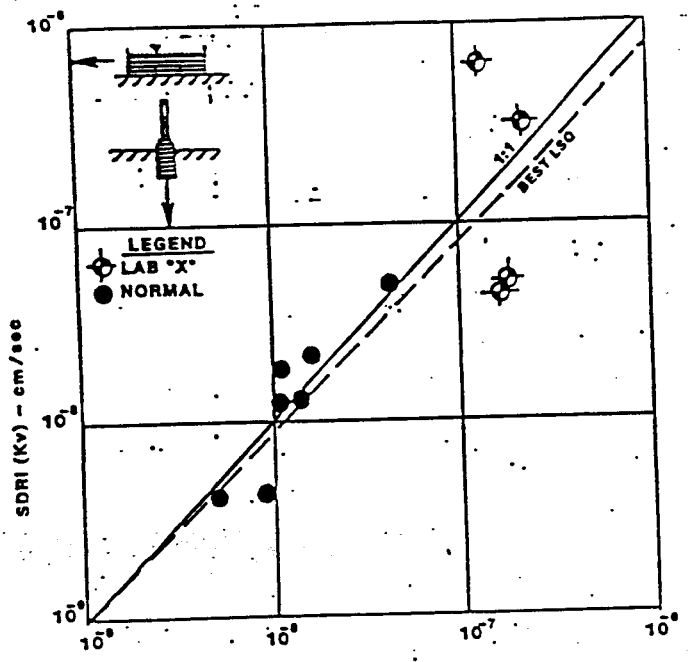

FIGURE 9
TSB AND SDRI RESULTS
(Tests on Same Liners/Test Pads)

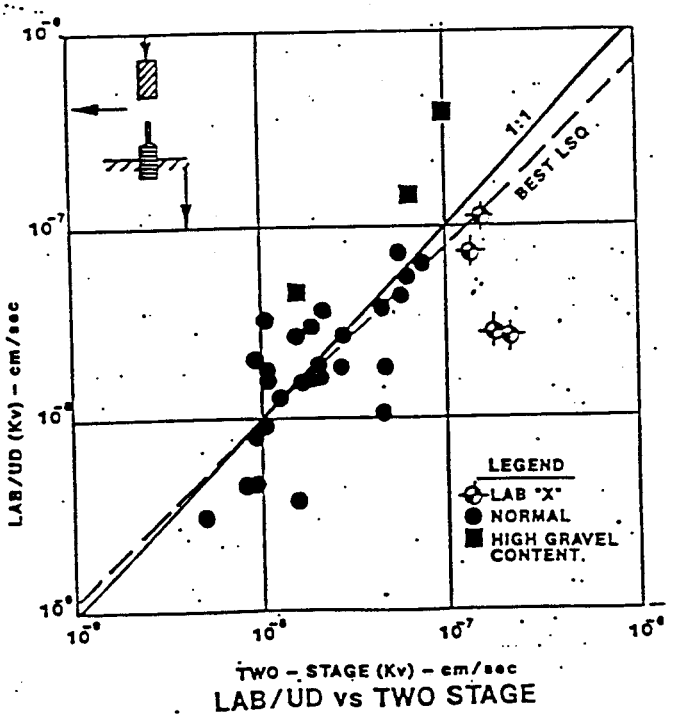

FIGURE 10
TSB AND LAB (k_v) RESULTS
(Tests on Same Liners/Test Pads)

Most of the TSB tests to date in test pads/liners have been for (k_v). The better the pad, i.e., the higher the (Spec/k_v) ratio, the sooner (K1<Spec). In 90% of the tests where (Spec/k_v>1.7), passing was indicated in 24 hours or less. Some 75% of all tests have indicated passing within 72 hours. A marginal test unit, whose (k_v) is just below (Spec), will require completing Stage 2. In general, each Stage lasts 4 to 14 days, the longer times being required to complete a test in lower permeability materials.

5.4 Volume Tested. A single typical TSB test permeates a volume around 0.6 to 1.1 cubic feet, or 60 to 200 times the volume of a typical plug tested in the laboratory (3 inch diameter, 3 inch height). The usual 5-test program thus tests about 10 to 20% the volume of an SDRI, yet yields about the same values. The TSB has a good balance of soil volume tested and speed.

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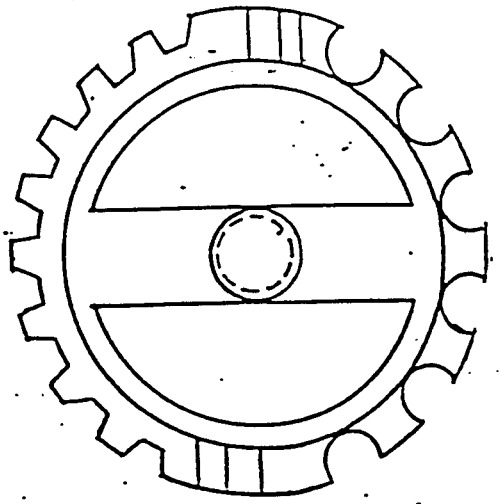
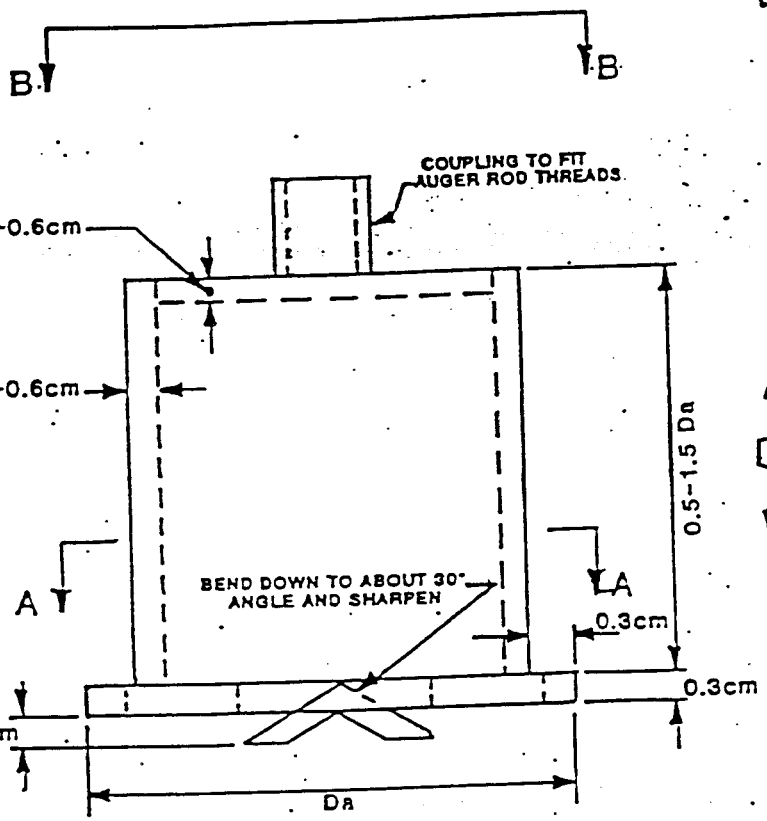
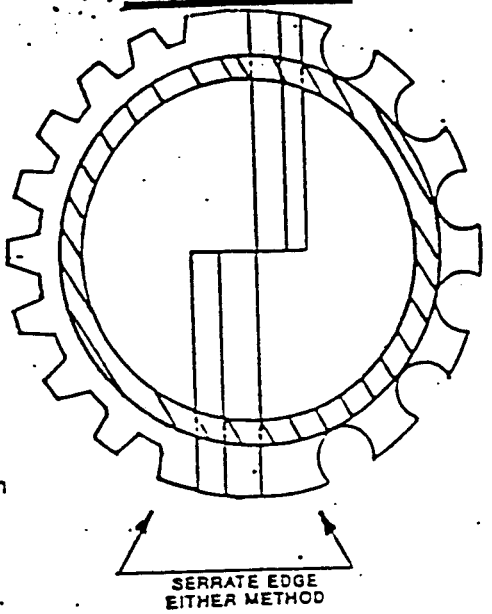


SECTION B-B



ELEVATION



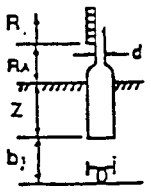
SECTION A-A

not to scale

NOTE: FOR FLAT AUGER, Da=D+5cm
FOR REAMER, Da=D -0.1 cm

FLAT BOTTOM REAMING AUGER

STAGE 1 CALCULATIONS



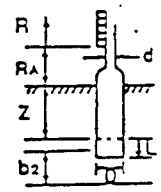
d = 1.27 cm
D = 11.43 cm
Z = 61.0 cm
RA = 22.9 cm
b1 = 61.0 cm

ΔV = 1.27 Δhc
H = 144.8 +R
K1 = 0.0384 / LN (H1/H2) / t2−t1

Ground Elev.: _____ Project: _____
TOC Elev.: _____ (before) File No.: _____
_____ (after)
Site Coords: _____ Test No.: _____
_____ Page: _____

Date	Time	Δt (hrs.)	Δt (sec.)	R (cm)	H1 (cm)	H2 (cm)	K1 (cm/sec)	C (cm)	H2' (cm)	K1' (cm/sec)	Temp. (°C)	R Factor	K1' (cm/sec)	Cum Vol. (cc)	Cum. Hrs.	Remarks
8/01	0800	—	—	64.8	—	209.6	—	0.0	—	—	21	—	—	0.0	0.0	START
	0830	0.50	1800	47.8	209.6	192.6	1.80E-06	0.0	192.6	1.80E-06	21	0.97	1.76E-06	21.5	0.5	
	0900	0.50	1800	36.3	192.6	181.1	1.31E-06	0.0	181.1	1.31E-06	21	0.97	1.27E-06	36.0	1.0	
	1000	1.00	3600	19.7	181.1	164.5	1.03E-06	0.2	164.3	1.04E-06	22	0.96	9.99E-07	57.1	2.0	END RUN
	1001	-	-	66.7	-	211.5	—	0.0	—	—	22	—	—	—	2.0	REFILL
	1200	1h+59m	7140	47.0	211.5	191.8	5.26E-07	0.6	191.2	5.44E-07	23	0.94	5.09E-07	82.0	4.0	
								etc.								
8/05	1700			50.0		194.8					26				105.0	
8/06	0800	15.00	54000	38.1	194.8	182.9	4.49E-08	-2.8	185.7	3.39E-08	19	0.94	3.20E-08	205.5	120.0	STOP

STAGE 2 CALCULATIONS



d = 1.27 cm
D = 10.16 cm
Z = 61.0 cm
RA = 22.9 cm
b2 = 53.3 cm

L = 15.2 cm
ΔV = 1.27 Δhc
H = 144.8 +R
K2 = 0.01570 LN (H1/H2) / t2−t1

Ground Elev.: _____ Project: _____
TOC Elev.: _____ (before) File No.: _____
_____ (after)
Site Coords: _____ Test No.: _____
_____ Page: _____

Date	Time	Δt (hrs.)	Δt (sec.)	R (cm)	H1 (cm)	H2 (cm)	K2 (cm/sec)	C (cm)	H2' (cm)	K2' (cm/sec)	Temp. (°C)	R Factor	K2' (cm/sec)	Cum Vol. (cc)	Cum. Hrs.	Remarks
8/06	0930	—	—	65.4	—	210.2	—	—	—	—	20	—	—	0.0	0.0	START
	1000	0.5	1800	59.4	210.2	204.2	2.52E-07	0.0	204.2	2.52E-07	21	0.99	2.49E-07	7.6	0.5	
	1030	0.5	1800	54.3	204.2	199.1	2.21E-07	+0.2	198.9	2.28E-07	22	0.96	2.19E-07	14.1	1.0	
	1130	1.0	3600	45.7	199.1	190.5	1.92E-07	+0.3	190.2	2.00E-07	23	0.94	1.87E-07	24.9	2.0	
	1330	2.0	7200	33.3	190.5	178.1	1.47E-07	+1.3	176.8	1.62E-07	24	0.91	1.48E-07	40.6	4.0	
							etc.									
8/09	0730			21.3		166.1					16			-	70.0	
	1600	8.5	30600	9.2	166.1	154.0	3.88E-08	+1.1	152.9	4.25E-08	19	1.07	4.56E-08	267.9	78.5	STOP

FIGURE 3

APPENDIX A

SAMPLE CALCULATION
FOR
2-STAGE FIELD PERMEABILITY TEST

NOTE: This is an idealized case exhibiting virtually perfect behavior, and is not to be considered representative of field behavior.

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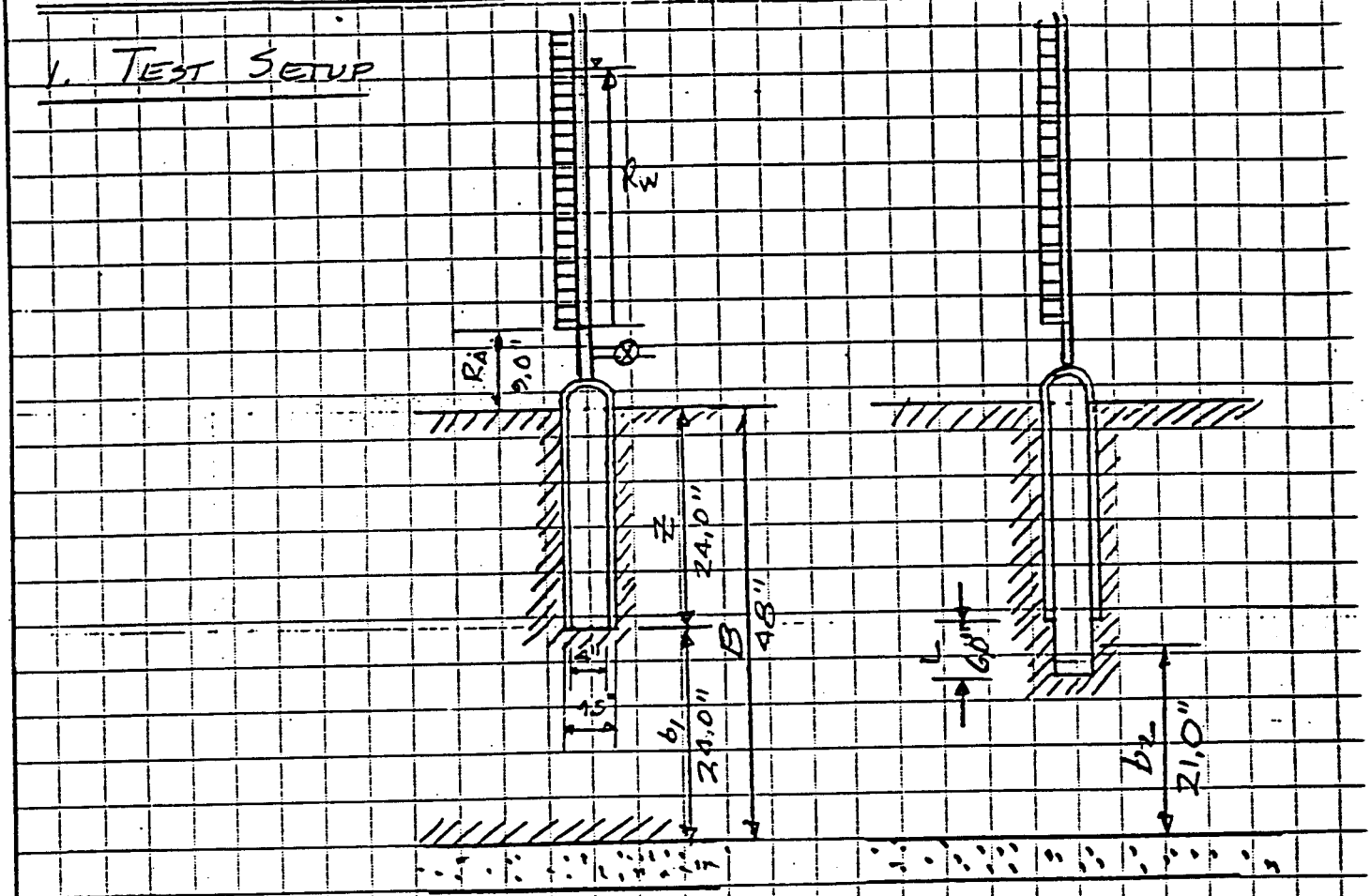
SAMPLE 2-STAGE CALCULATION – HYPOTHETICAL TEST "A"

1. TEST SETUP



STAGE 1 STAGE 2

Note: Water seeped into casing during bentonite sealing. Therefore, use casing OD = 4.5" for Stage 1 Only.

TO AVOID HYDRAULIC FRACTURING:

HEAD < 1.25 × OVERBURDEN FT. CASING BOTTOM

$62.4 \frac{LB}{FT^3} H_{FT} < 1.25 \times 2.0^{FT} \times 124.8 \, LB/FT^2$

$H_{FT} < 5.0 \, FT$

OR $R_W < 5.0 - 2.0 - 0.75 = 2.25 \, FT = 27.0^{IN}$

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2. TEST DATA

STAGE 1 DATA

Date	Time	RW (in.)	ΔC (in.)	Temp. (°F)	TEG (in.)
8/01	08:00	25.50	—	70	13.00
	0830	18.81	0	70	13.00
	0900	14.31	0	70	13.00
	1000	7.75	+0.06	72	13.06
Rf.	1001	26.25	—	72	13.06
	1200	18.50	+0.25	74	13.31
	1600	13.88	+1.00	80	14.31
Rf.	1601	26.00	—	80	14.31
8/02	0800	15.81	-1.50	65	12.81
	1700	14.06	+1.31	74	14.12
8/03	0800	9.06	-1.25	68	12.87
	1600	8.38	+1.06	76	13.93
8/04	0800	3.75	-1.44	62	12.49
Rf.	1801	26.50	—	62	12.49
	1701	24.88	+0.50	71	13.00
8/05	0700	20.88	-0.62	66	12.37
	1700	19.69	+1.25	78	13.62
8/06	0800	15.00	-1.12	67	12.50

READ FROM TEG

CALCULATED FROM TEG LEVELS

STAGE 2 DATA

Date	Time	RW (in.)	ΔC (in.)	Temp. (°F)	TEG (in.)
8/06	0930	25.75	—	68	12.56
	1000	23.39	0.00	70	12.56
	1030	21.38	+0.06	72	12.62
	1130	18.00	+0.13	74	12.75
	1330	13.12	+0.50	76	13.25
	1700	7.12	+0.69	80	13.94
R	1701	26.56	-	80	13.94
8/07	0700	6.06	-1.12	70	12.82
R	0701	25.25	—	70	12.82
	1200	19.88	+0.31	74	13.03
	1700	15.94	+0.56	78	13.59
8/08	0800	3.81	-1.50	62	12.09
R	0802	26.31	-	62	12.09
	1700	20.56	+1.69	74	13.78
8/09	0730	8.38	-1.56	60	12.22
	1600	3.62	+0.44	66	12.66

READ FROM TEG

CALCULATE FROM TEG LEVELS

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3. STAGE 1

A. CALCULATE FACTOR [Eq. 3.5-4]

$$K1 = F_1 \frac{Ln(H_1'/H_2')}{t_2 - t_1} \quad \text{where } F_1 = \frac{\pi d^2}{11 D}\left(1 - \frac{D}{4b_1}\right)$$

$d = 0.50" = 1.27$ cm (See sketch on p. 1)
$D = 4.50" = 11.43$ cm (See note on p. 1)
$b_1 = 24.0" = 60.96$ cm (See sketch on p. 1)

$$F_1 = \frac{\pi (1.27)^2}{11 \times 11.43}\left(1 - \frac{11.43}{4 \times 60.96}\right)$$

$$\boxed{F_1 = 0.03841 \text{ cm}}$$

B. CALCULATIONS

i. $H1 = B + R_A + R_{W1} = 48.00 + 0.00 + R_{W1} = 57.00 + R_{W1}$
$H2' = B + R_A + R_{W2} - C = 48.00 + 0.00 + (R_{W2} - C) = 57.00 + (R_{W2} - C)$

ii. Period 1700 08/02 – 0800 08/03

$$K1 = .03841 \frac{Ln[(57.00 + R_{W1})/(57.00 + R_{W2} + C)]}{\Delta t \text{ (sec)}}$$

$H1 = 57.00 + 14.06 = 71.06$
$H2' = 57.00 + 9.06 + 1.25 = 67.31$

Note: TEG fell 1.25" in this period. 1.25' of the Test drop is purely temp.

$\Delta t = 15 hrs \times 3600 \text{ s/hr} = 54000$ sec.

$$K1 = 0.03841 \text{ cm} \frac{Ln(71.06/67.31)}{54000 \text{ sec}} = 3.86 \times 10(-8)$$

Now, apply viscosity correction
Temp $= \frac{1}{2}(74 + 68) = 71°$
From chart, Viscosity Factor $= 0.96 = R_T$

$$K1_2 = R_T \cdot K1c = 0.96 \times [3.86 \times 10(-8)] = 3.71 \times 10(-8) \frac{cm}{sec}$$

See p. 6 for Tabulation of all points

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A. STAGE 2

A. CALCULATE FACTOR [Eq. 3.5-5, with a = -1]

$$K2 = F \frac{L_N(H_1/H_2)}{z_2 - z_1}$$

where: $F = \left(\frac{1}{f}\right)\left(\frac{d^2}{16L}\right) L_N \left[\frac{U(D,0)}{U(D,2b_2)}\right]$

$f = 1 - 0.5623\, e^{-1.566(L/D)}$

L = Extension below Casing (6 inches = 15.24 cm)

D = Borehole diameter = ID of Casing (4 inches)

$r_2 = D/2$

$b_2 = B - Z + L/2 = 48.00" - 24.00" - 6.00"/2 = 21.00"$

$$U(1,D,z) = \frac{(23/D + L/D) + \sqrt{1 + [23/D + L/D]^2}}{23/D - L/D + \sqrt{1 + [23/D - L/D]^2}}$$

$L/D = 6"/4" = 1.5$

$\therefore f = 1 - 0.5623\, e^{-1.566(1.5)}$

$= 0.9463$

$$U(1,r_0,0) = U(1,D,0) = \frac{(0+1.5) + \sqrt{1 + [0+1.5]^2}}{(0-1.5) + \sqrt{1 + [0-1.5]^2}} = \frac{1.5 + \sqrt{1+1.5^2}}{-1.5 + \sqrt{1+1.5^2}}$$

[U(1,r0,0) Eq. 3.5-5]

$= [1.5 + \sqrt{1+1.5^2}]^2$

$= 10.9083$

$2b_2 = 2 \times 21 = 42"$

$$U(1,r_0,2b_2) = U(1,D,42) = \frac{(84/4 + 1.5) + \sqrt{1 + [84/4 + 1.5]^2}}{(84/4 - 1.5) + \sqrt{1 + [84/4 - 1.5]^2}} = \frac{22.5 + \sqrt{1 + 22.5^2}}{19.5 + \sqrt{1 + 19.5^2}}$$

[U(1,r0,2b2) Eq. 3.5-5]

$= 1.1537$

$\therefore F = \frac{1}{0.9463} \times \frac{1.27^2\ cm^2}{16 \times 15.24\ cm} L_N (10.9083 / 1.1537)$

$$\boxed{F = 0.01570\ cm}$$

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5.B. Calculation for K2' (See p. 7 for the data points)

This is virtually the same calculation as on p. 8

Period (hrs)	Calculation		K2'
0.0 – 2.0	$\frac{24.9\times1.80+21.9\times1.80+18.7\times3.60}{1.80+1.80+3.60}$	$=\frac{151.56}{7.20}=21.05\times10(-8)$	$2.11\times10(-7)$
2.0 – 21.5	$\frac{14.8\times7.20+11.0\times12.60+1.52\times50.34}{7.20+12.60+50.34}$	$=\frac{623.12}{70.14}=8.89\times10(-8)$	$8.89\times10(-8)$
21.5 – 31.5	$\frac{5.94\times17.94+4.14\times18.00}{17.94+18.00}$	$=\frac{191.88}{35.94}=5.34\times10(-8)$	$5.34\times10(-8)$
31.5 – 55.5	$\frac{4.46\times54.00+4.55\times32.28}{54.00+32.28}$	$=\frac{387.11}{86.28}=4.49\times10(-8)$	$4.49\times10(-8)$
55.5 – 78.5	$\frac{4.49\times52.20+4.56\times30.60}{52.20+30.60}$	$=\frac{373.91}{82.80}=4.52\times10(-8)$	$4.52\times10(-8)$

The last two periods are virtually identical and last some 24 hours each (appropriate for this permeability level)

$$\text{i.e. } K2' = \frac{387.11+373.91}{86.28+82.80} = \frac{761.62}{169.08} = 4.50\times10(-8)$$

$$\boxed{K2' = 4.50\times10^{-8}\ \text{cm/sec}}$$

6.0 Calculate Kv and Kh

A. Smear.

Check by K2/K1 ratio needed for next step

$$K2'/K1' = \frac{4.50\times10(-8)}{3.21\times10(-8)} = 1.40$$

Probably no smear since > 1.0

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B. EQUATION (FOR SHORTCUT, SEE p. 12)

$$K2'/K1' = \left(\frac{G1m}{G1}\right)\left(\frac{G2}{G2S}\right) \qquad [\text{Eq. } 4.2\text{-}5]$$

where $G1m/G1 = (1/m)\left[1 + a(D_1/4mb_1)\right] / \left[1 + a(D_1/4b_1)\right]$

but, $D_1 = 11.43$ cm (p. 3) $\quad a = -1$ (Perm. Base)

$b_1 = 26.924$ cm (p. 3)

$$G1m/G1 = (1/m)\left[1 - \frac{11.43}{4(m)(26.96)}\right] / \left[1 - \frac{11.43}{4(26.96)}\right]$$

$$= (1/m)\left(\frac{1}{.9464}\right)\left(1 - \frac{1}{21.33m}\right)$$

$$G2/G2S = \frac{m^2\left\{Ln\left[v(1,r_0,0)\right] + a\,Ln\left[v(1,r_0,2b_2)\right]\right\}^2}{Ln\left[v(m,r_0+r,0)\right] + a\,Ln\left[v(m,r_0,2b_2)\right] + p\,Ln\left[v(n,r_0,0)/v(m,r_0+r,0)\right]}$$

$a = -1$

$p = 1$

$$\text{Thus } G2/G2S = \frac{m^2\,Ln\left[v(1,r_0,0)/v(1,r_0,2b_2)\right]}{Ln\left[v(m,r_0,0)/v(m,r_0,2b_2)\right]}$$

$$v(1,r_0,0) = \left[L/D + \sqrt{1+(L/D)^2}\right]^2 = \left[1.5 + \sqrt{1+1.5^2}\right]^2 = 10.90833$$

$$v(1,r_0,2b_2) = \frac{4b_2/D_2 + L/D_2 + \sqrt{1+(4b_2/D_2 + L/D_2)^2}}{4b_2/D_2 - L/D_2 + \sqrt{1+(4b_2/D_2 - L/D_2)^2}}$$

$b_2 = 21''$ (See p. 1)

$D_2 = 4.0''$ (See p. 1)

$$= \frac{4(21/4) + 6/4 + \sqrt{1+(4\times 21/4 + 6/4)^2}}{4(21/4) - 6/4 + \sqrt{1+(4\times 21/4 - 6/4)^2}} = \frac{45.6622}{37.0256}$$

$$v(1,r_0,2b_2) = 1.15366$$

$$G2/G2S = \frac{m^2\,Ln\left[10.90833/1.15366\right]}{Ln\left[v(m,r_0,0)/v(m,r_0,2b_2)\right]} = \frac{2.24659\,m^2}{Ln\left[v(m,r_0,0)/v(m,r_0,2b_2)\right]}$$

$$K2'/K1' = \frac{1}{m}\cdot\frac{1}{.9464}\left(1 - \frac{1}{21.33m}\right)\cdot\frac{2.24659\,m^2}{Ln\left[v(m,r_0,0)/v(m,r_0,2b_2)\right]}$$

$$= 2.3738\,m\left(1 - \frac{1}{21.33m}\right)\frac{1}{Ln\left[v(m,r_0,0)/v(m,r_0,2b_2)\right]}$$

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JOB SAMPLE – A
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(i) Try $m = 2.0$

$$u(m, r_o, o) = \left[mL/D_2 + \sqrt{1 + (mL/D_2)^2} \right]^2$$

$$= \left[1.5m + \sqrt{1 + (1.5m)^2} \right]^2$$

$$u(2, r_o, o) = \left[1.5 \times 2 + \sqrt{1 + (1.5 \times 2)^2} \right]^2 = 6.1623^2$$

$$= 37.9737$$

$$u(m, r_o, 2b_2) = \frac{4mb_2/D_2 + mL/D + \sqrt{1 + (4mb_2/D_2 + mL/D_2)^2}}{4mb_2/D_2 - mL/D + \sqrt{1 + (4mb_2/D_2 - mL/D_2)^2}}$$

$$= \frac{4m\,21/4 + m\,6/4 + \sqrt{1 + (4m\,21/4 + m\,6/4)^2}}{4m\,21/4 - m\,6/4 + \sqrt{1 + (4m\,21/4 - m\,6/4)^2}}$$

$$= \frac{22.5m + \sqrt{1 + (22.5m)^2}}{10.5m + \sqrt{1 + (10.5m)^2}}$$

$$u(2, r_o, 2b_2) = \frac{22.5 \times 2 + \sqrt{1 + (22.5 \times 2)^2}}{10.5 \times 2 + \sqrt{1 + (10.5 \times 2)^2}} = \frac{90.0111}{78.0128} = 1.1538$$

$$K_2'/K_1' = 1.40 \stackrel{?}{=} 2378(2.0)\left(1 - \frac{1}{2.33 \times 2}\right) \frac{1}{\ln\left[37.2737/1.1538\right]}$$

$$\stackrel{?}{=} 4.7476\,(.9766)\,\frac{1}{3.4738}$$

$$1.40 > 1.327$$

∴ need larger m

ii. Try $m = 2.4$

$$u(2, r_o, o) = \left[1.5 \times 2.4 + \sqrt{1 + (1.5 \times 2.4)^2} \right]^2 = 53.8214$$

$$u(2, r_o, 2b_2) = \frac{22.5 \times 2.4 + \sqrt{1 + (22.5 \times 2.4)^2}}{10.5 \times 2.4 + \sqrt{1 + (10.5 \times 2.4)^2}} = 1.1538$$

$$K_2'/K_1' = 1.40 \stackrel{?}{=} 2.3738\,(2.4)\left[1 - \frac{1}{2.33 \times 2.4}\right] \frac{1}{\ln\left[53.8214/1.1538\right]}$$

$$\stackrel{?}{=} 5.6972\,(.9805)\,(1/3.8426)$$

$$1.40 < 1.454$$

∴ need smaller m

Successive trial-and-error yields $m = 2.27$

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C. CALCULATE K_v, K_h

Note: ONE CAN AVOID THE CALCULATIONS of pp. 10 and 11 BY USING THE ATTACHED NOMOGRAPH (Fig. 7 - Text)

The easiest calculation is using THE STRIP EQUATION:

$$K_v = \frac{G_{lm}}{G_l}\, K_1' = \frac{1}{m}\left[\frac{1 - D_1/4m b_1}{1 - D_1/4b_1}\right] K_1' \qquad \text{[Eq. 4.1-2]}$$

with $D_1 = 4.50''$
$b_1 = 24.0''$
$m = 2.27$

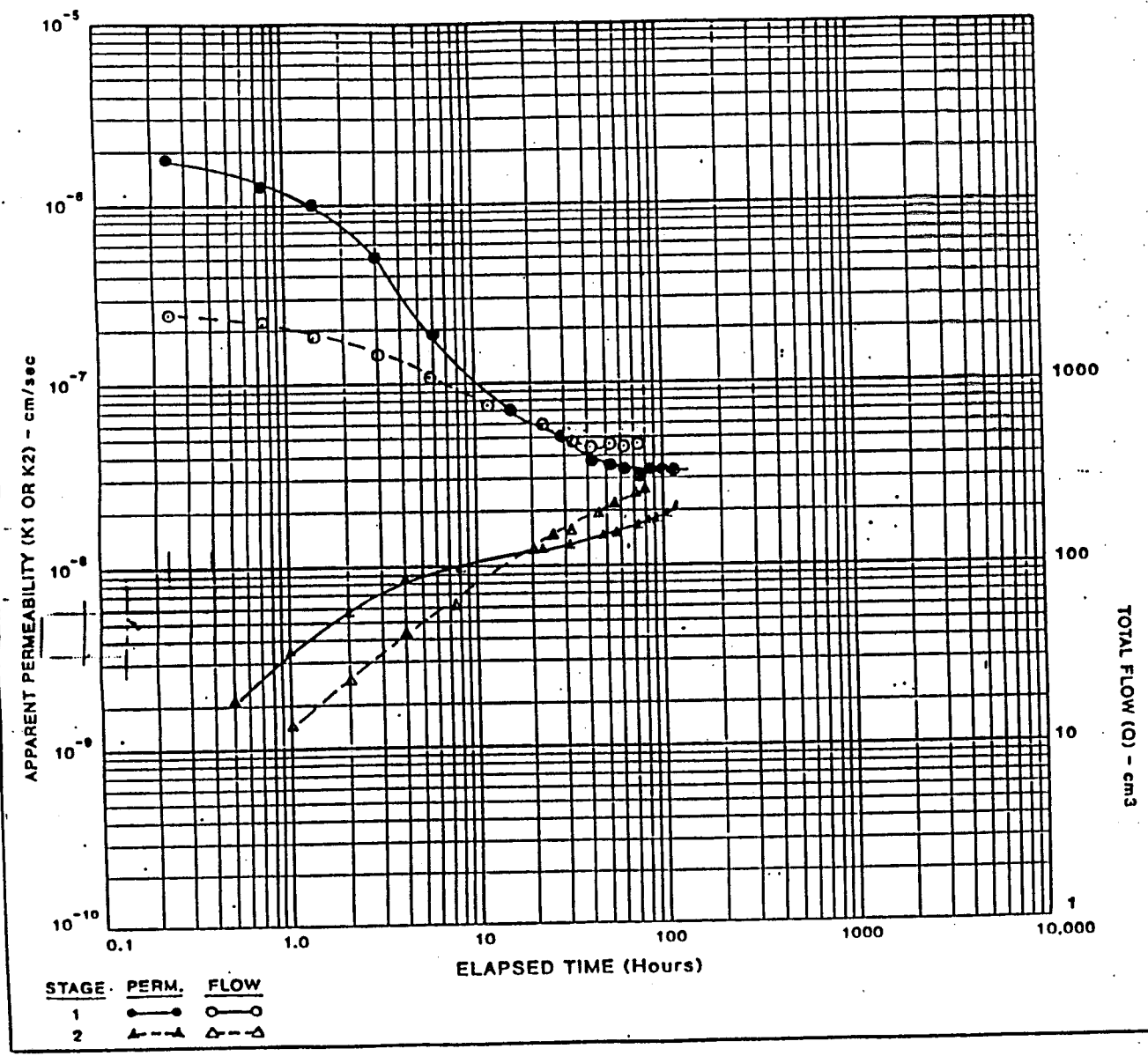
$$K_v = \frac{1}{2.27}\left[\frac{1 - \frac{4.5}{4(2.27)(24)}}{1 - \frac{4.5}{4(24)}}\right] \times [3.21 \times 10(-8)]$$

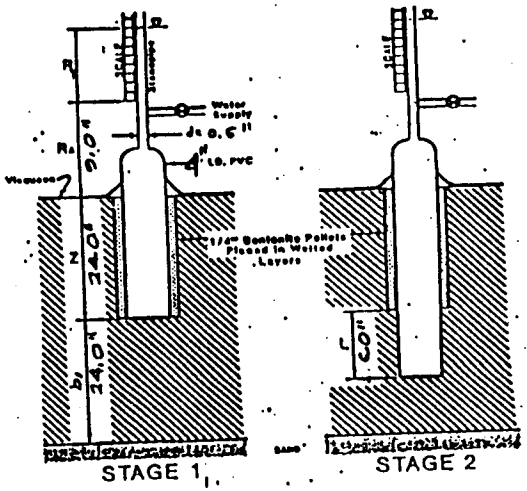
$$= \frac{1}{2.27}\left[\frac{.9762}{.9464}\right] 3.21 \times 10(-8)$$

$$\boxed{K_v = 1.45 \times 10(-8) \text{ cm/sec}}$$

$$K_h = m^2 K_v \qquad \text{[Eq. 4.1-5]}$$
$$= 2.27^2 [1.45 \times 10(-8)]$$

$$\boxed{K_h = 7.47 \times 10(-8)}$$





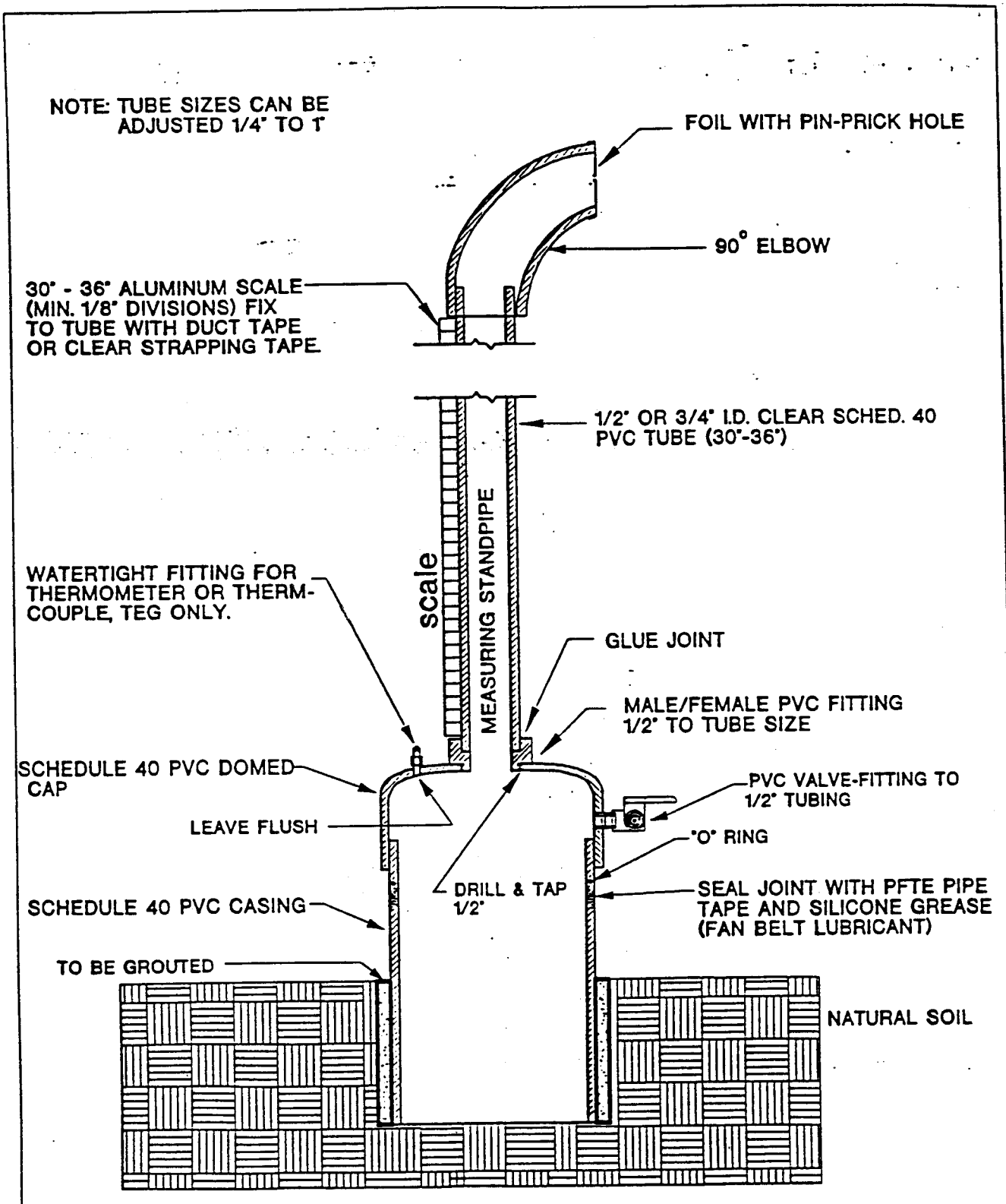
TWO – STAGE
FIELD PERMEABILITY TEST
SUBBASE TEST PAD

1. SAMPLE TEST "A"
EREWHON, CALIVANIA

GEOTECHNICAL SERVICES BY
SOIL TESTING ENGINEERS, INC.
Baton Rouge, LA Lake Charles, LA

Project Engineer:	Drawn by:	Checked by:
G.P. BOUTWELL	SJT	C.N.TSAI
File No.: 91-081	Date:	Figure No.:

Title:
BEHAVIOR OF TEST FP- "A"



TYPICAL PERMEAMETER

1450 10-6-92

TEG 1 FILLED 32.3/8

1508

TEG 2 FILLED 33 15/16"

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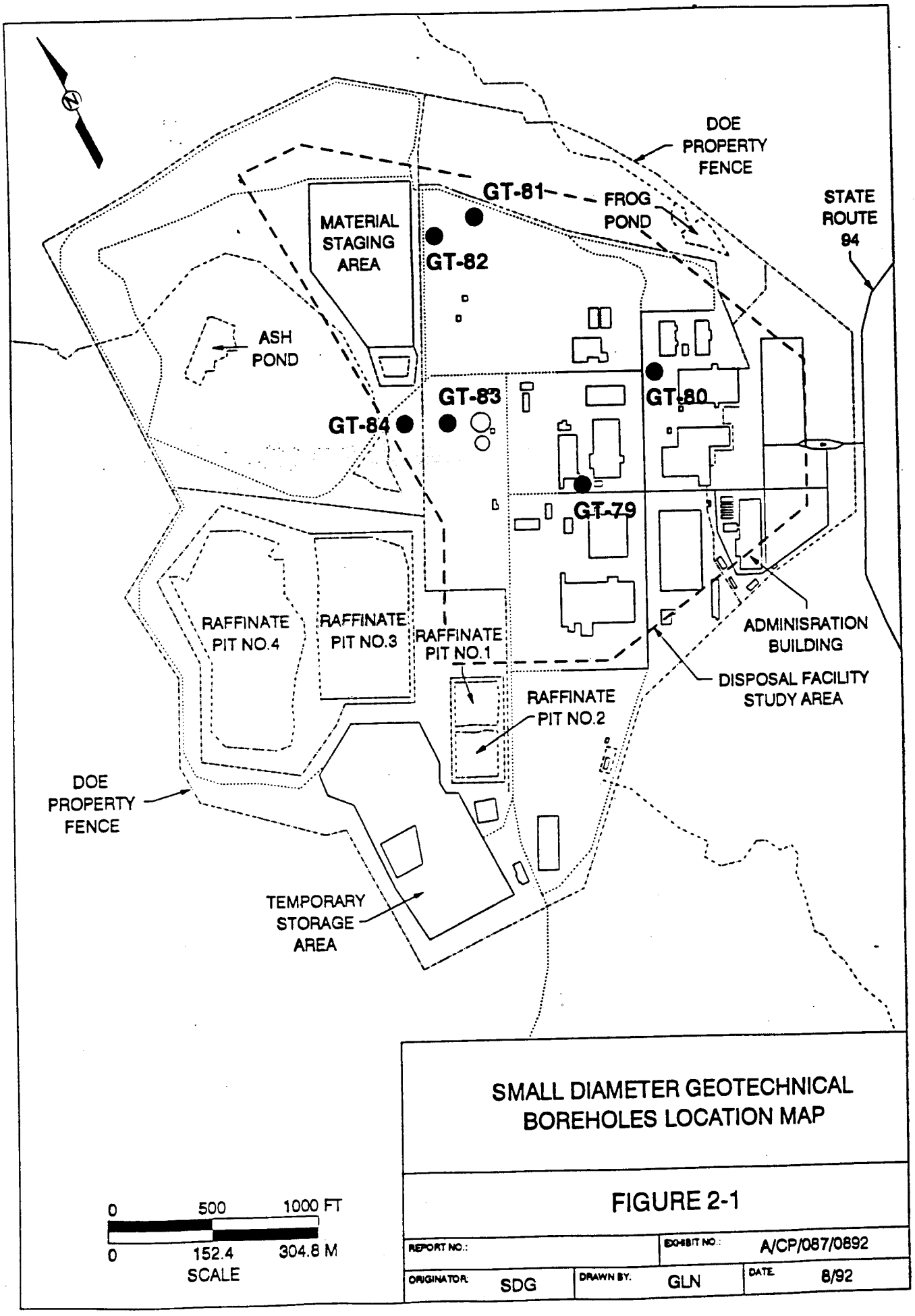
ATTACHMENT 7

LOCATIONS OF WATER/LEACHATE PERMEABILITY TESTING SAMPLES



SMALL DIAMETER GEOTECHNICAL BOREHOLES LOCATION MAP

FIGURE 2-1

REPORT NO.:		EXHIBIT NO.:	A/CP/087/0892
ORIGINATOR:	SDG	DRAWN BY: GLN	DATE: 8/92

ATTACHMENT 8
SUMMARY OF LEACHATE SYNTHESIS METHODOLOGY

Permeability testing was accomplished by obtaining undisturbed samples of site soils (Ferrelview Formation and Clay Till) and subjecting these samples to triaxial permeability testing (ASTM Method D-5084). Samples were initially tested with water as a permeant, then the same samples were tested with leachate permeant.

The leachate was generated by mixing liquids generated by modified batch leach testing of chemically stabilized/solidified raffinate sludge (CSS Sludge), untreated radioactive soils, and untreated chemically contaminated soils. The liquids from these leaching tests were combined at the following ratio in order to provide a representative leachate:

2:1:1 (CSS Treated Sludge:Untreated Radioactive Soils:Untreated Chemical Contaminated Soils)

This ratio of materials is based upon proposed waste quantities including bulking factors for treated wastes. These quantities are found in the latest version of the PMC's Waste Management Quarterly Report.

Additional details relating to the leaching methodology and associated sampling of waste materials are presented in the pertinent references listed in Attachment 10.

ATTACHMENT 9

COMPARATIVE CALCULATIONS

TRAVEL TIME AND PERMITTIVITY

COMPARISON OF HYDRAULIC CONDUCTIVITY DATA

DATA SET	HYDRAULIC CONDUCTIVITY [K] (cm/sec)	POROSITY [n] ([6])	EFFECTIVE POROSITY [n_e] ([7])	FORMATION THICKNESS [b] (ft)	SEEPAGE VELOCITY [P] (cm/sec) ([8])	PERMITTIVITY [t] (sec^{-1}) ([9])	TRAVEL TIME [V] (YEARS) ([10])
10 CSR 25-7[1]	1.0E-07	0.40		30	2.5E-07	1.1E-10	116
			0.08	30	1.25E-06		23
MKF & JEG 1991 [2]	3.1E-08	0.40		20	7.7E-08	5.1E-11	250
			0.08	20	3.9E-07		50
TSB[3]	1.28E-08	0.40		20	3.2E-08	2.1E-11	604
			0.08	20	1.6E-07		121
1992 LAB (H_2O) [4]	1.5E-08	0.40		20	3.8E-08	2.5E-11	516
			0.08	20	1.9E-07		103
1992 LAB (LEACH) [5]	2.7E-09	0.40		20	6.8E-09	4.4E-12	2865
			0.08	20	3.4E-08		573

EXPLANATION:

1 10 CSR 25-7 - Basic regulatory criteria are 30 ft of soil with K= 1.0E-07 cm/sec.

2 Site suitability data on potential location of a disposal facility: Collapse potential and permeability.

3 Largest logarithmic mean value from Table 2.

4 Largest measured value for water from Table 3.

5 Largest measured value for leachate from Table 3.

6 Average total porosity from unpublished data - MKF & JEG 1992 Draft.

7 Estimated average effective porosity from [6].

8 Seepage velocity - V= Ki/n

9 Permittivity - P = Average hydraulic conductivity + thickness (Koerner, R.M. 1990. Designing with geosynthetics. Prentic-Hall.)

10 Travel time - t = 6/V

ATTACHMENT 10

LIST OF PERTINENT REFERENCE DOCUMENTS

The following documents are listed for reference in describing background and support activities associated with this effort. Copies of these reports have been submitted under separate cover:

Modified batch leach testing is described in the "Batch Leach Testing Plan", MK-JEG, Rev. 1, Nov. 92.

The chemical soil samples were collected in accordance with the "Soil Sampling Plan for Column Leach and Batch Tests and TCLP Analysis", Rev. 0, May 92.

The radioactive site soils were collected in accordance with the "Stabilization /Solidification/Dewatering Sampling Plan", MK-JEG, Rev. 0, May 91.

The undisturbed soil samples were obtained in accordance with the "Sampling Plan for Determination of Hydraulic Properties of Undisturbed Soils in the Weldon Spring Disposal Facility Study Area", Rev. 1, MK-JEG, Oct. 92.

CHEMICAL PLANT
202-1.16

DOCUMENT CONTROL SYSTEM - CORRESPONDENCE FILE

WELDON SPRING SITE REMEDIAL ACTION PROJECT
MK-FERGUSON CO., INC. WO 3589 (314) 441-8086
7295 Highway 94 South
St. Charles, MO 63303

Document Number: _____

Document Type: LR-MDNR-DOE

Originators DCN: 009204

SUBJECT Summaries of analytical data on 60 private drinking water wells in vicinity of WSS

AUTHOR Bedan, D. C. TO H.C. Cracken, S. DATE 1/8/92

SUBJECT CODE/WORK PACKAGE NUMBER 1.3000

REFERENCED DOCUMENT(S) _____

THIS IS A RESPONSE TO COMMUNICATION: NUMBER _____ DATED _____

ACTION ITEM TRACKING

INITIATE ACTION ITEM

INDIVIDUAL ASSIGNED TO ACTION _____ DEPARTMENT _____

ACTION REQUIRED _____

DUE DATE / / ACTION ITEM LOG NUMBER _____

IF ADDITIONAL ACTION ITEMS ARE ATTACHED, HOW MANY? _____ _____

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STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF ENVIRONMENTAL QUALITY
P.O. Box 176
Jefferson City, MO 65102

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Divisionof Parks, Recreation,
and Historic Preservation

January 8, 1992

Mr. Steve McCracken
Project Manager
U.S. Department of Energy
Weldon Spring Site
Remedial Action Project
7295 Highway 94 South
St. Charles, Missouri 63303

Dear Mr. McCracken:

Attached for your information and review are the summaries of analytical data on 60 private drinking water wells in the vicinity of the Weldon Spring Site. This work has been carried out by the Missouri Department of Health. These data are complete through 1991.

I suggest that these data be considered and referenced in your update of the baseline assessment for the site.

Sincerely yours,

DIVISION OF ENVIRONMENTAL QUALITY

David E. Bedan
Radioactive Waste Cleanup Coordinator

Attachment

cc: Ron Kucera, DNR
John Young, DEQ
Nick DiPasquale, HWP
Jerry Lane, PDWP
Ed Knight, HWP/SPF
Jim Williams, DGLS
Mimi Garstang, DGLS
Dan Wall, US EPA, Region VII
Dan Bauer, USGS

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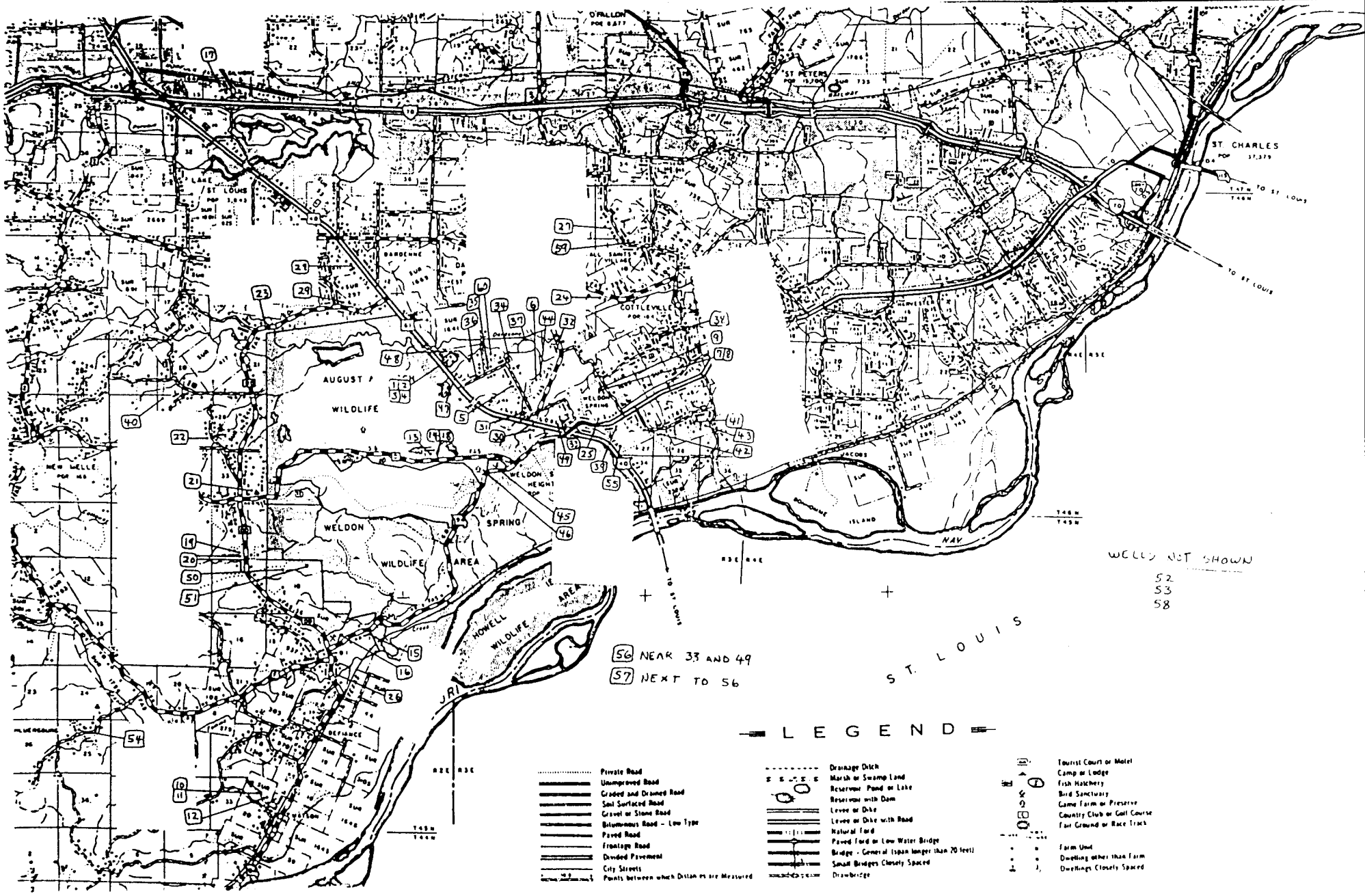

ST. CHARLES
ST. PETERS
O'FALLON
LAKE ST. LOUIS
BARDENNE
COTTLEVILLE
ALL SAINTS VILLAGE
AUGUST A WILDLIFE
WELDON SPRING
WELDON SPRING HEIGHTS
WELDON WILDLIFE AREA
HOWELL WILDLIFE AREA
NEW MELLE
DEFIANCE
JACOBS
BONHOMME ISLAND
NAV
ST. LOUIS
TO ST. LOUIS
WELLS NOT SHOWN
52
53
58
56 NEAR 33 AND 49
57 NEXT TO 56
LEGEND
Private Road
Unimproved Road
Graded and Drained Road
Soil Surfaced Road
Gravel or Stone Road
Bituminous Road - Low Type
Paved Road
Frontage Road
Divided Pavement
City Streets
Points between which Distances are Measured
Drainage Ditch
Marsh or Swamp Land
Reservoir Pond or Lake
Reservoir with Dam
Levee or Dike
Levee or Dike with Road
Natural Ford
Paved Ford or Low Water Bridge
Bridge - General (span longer than 20 feet)
Small Bridges Closely Spaced
Drawbridge
Tourist Court or Motel
Camp or Lodge
Fish Hatchery
Bird Sanctuary
Game Farm or Preserve
Country Club or Golf Course
Fair Ground or Race Track
Farm Unit
Dwelling other than Farm
Dwellings Closely Spaced

Missouri Department of HEALTH

MEMO

TO: Dave Bedan
Radioactive Waste Site Coordinator
Department of Natural Resources
205 Jefferson
12th Floor, Jefferson State Office Bldg.
Jefferson City, Missouri 65102

FROM: Daryl W. Roberts
Chief
Missouri Department of Health
Bureau of Environmental Epidemiology

DATE: December 23, 1991

SUBJECT: Weldon Spring Well Data

Attached is a list of test results from the private drinking water wells that the MDOH is monitoring around the Weldon Spring site. The data is complete through 1991.

If you have any questions, please contact Dick Gnaedinger at 751-6102.

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Attachment

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WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	111	12/21/82	1.4	*	*	*	0.8	*	*	0.81	<10	350		6
1	111	07/25/83	2.0	<1.0	*	*	*	*	*	*	*	*	*	*
1	111	02/23/84	2.0	2.6	*	*	*	*	*	*	*	*	*	*
1	111	10/16/85	1.2	1.4	*	*	*	*	*	*	*	*	*	*
1	111	09/24/86	3.2	1.1	*	*	*	*	*	<0.05	<10	337	<0.05	*
1	111	04/10/87	*	*	*	*	*	*	*	*	*	*	<0.05	*
1	111	05/05/87	1.9	2.0	0.4	<1	*	*	*	0.06	13	325	<0.05	*
1	111	08/27/87	*	*	*	*	*	*	*	0.51	18	331	<0.05	*
1	111	11/10/87	*	*	*	*	*	*	*	0.47	10	334	<0.05	*
1	111	03/14/88	*	*	*	*	*	*	*	0.40	23	327	<0.05	5
1	111	06/27/88	*	*	*	*	*	*	*	0.46	17	245	<0.05	4
1	111	11/07/88	3.4	1.7	*	*	*	*	*	0.56	13	325	<0.05	5
1	111	01/02/89	*	*	*	*	*	*	*	*	*	*	*	*
1	111	01/30/89	*	*	*	*	*	*	*	0.55	10	311	<0.05	4
1	111	02/07/89	*	*	*	*	*	*	*	*	*	*	*	*
1	111	02/23/89	*	*	*	*	*	*	*	*	*	*	*	*
1	111	03/30/89	*	*	*	*	*	*	*	*	*	*	*	*
1	111	05/01/89	*	*	*	*	*	*	*	0.55	14	329	<0.05	4
1	111	07/31/89	3.2	2.7	*	*	*	*	*	0.07	17	388	<0.05	3
1	111	02/20/90	*	*	*	*	*	*	*	<0.05	15	317	<0.05	3
1	111	05/14/90	*	*	*	*	*	*	*	0.20	12	322	<0.05	7
1	111	08/06/90	4.2	1.9	*	*	*	*	*	<.05	18	355	<.05	13
1	111	01/21/91	*	*	*	*	*	*	*	<.05	16	289	<.05	3

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
2	630	09/24/86	3.2	2.7	*	*	*	*	*	<0.05	15	282	<0.05	0
2	630	03/14/88	*	*	*	*	*	*	*	<0.05	23	305	<0.05	4
2	630	03/30/89	*	*	*	*	*	*	*	*	*	*	*	*

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
3	220	09/24/86	6.4	7.4	2.1	*	*	*	*	0.17	12	346	<0.05	0
3	220	11/10/87	*	*	*	*	*	*	*	0.66	14	326	<0.05	0
3	220	03/14/88	*	*	*	*	*	*	*	0.76	23	337	<0.05	4
3	220	06/27/88	*	*	*	*	*	*	*	0.80	17	355	<0.05	4
3	220	11/07/88	3.5	2.0	*	*	*	*	*	0.73	15	318	<0.05	4
3	220	01/02/89	*	*	*	*	*	*	*	*	*	*	*	*
3	220	02/23/89	*	*	*	*	*	*	*	*	*	*	*	*
3	220	03/30/89	*	*	*	*	*	*	*	*	*	*	*	*
3	220	05/02/89	*	*	*	*	*	*	*	0.81	17	341	<0.05	4
3	220	07/31/89	2.1	<1	*	*	*	*	*	0.90	18	372	<0.05	4
3	220	02/20/90	*	*	*	*	*	*	*	0.87	19	322	<0.05	4
3	220	05/14/90	*	*	*	*	*	*	*	0.91	16	301	<0.05	3
3	220	08/06/90	1.1	1.7	*	*	*	*	*	0.99	18	336	<.05	11
3	220	01/21/91	*	*	*	*	*	*	*	0.87	16	296	<.05	4
3	220	04/29/91	*	*	*	*	*	*	*	<.05	12	309	<.05	<2
3	220	07/29/91	1.6	<1	*	*	*	*	*	0.18	14	299	<.05	3

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
4	*	04/10/87	*	*	*	*	*	*	*	*	*	*	<0.05	*
4	*	11/10/87	4.5	3.7	*	*	*	*	*	<0.05	14	313	<0.05	*
4	*	06/27/88	*	*	*	*	*	*	*	<0.05	17	354	<0.05	2
4	*	11/07/88	2.5	1.9	*	*	*	*	*	<0.05	13	316	<0.05	3
4	*	01/30/89	*	*	*	*	*	*	*	<0.05	14	295	<0.05	2
4	*	02/07/89	*	*	*	*	*	*	*	*	*	*	*	*
4	*	02/23/89	*	*	*	*	*	*	*	*	*	*	*	*
4	*	03/30/89	*	*	*	*	*	*	*	*	*	*	*	*
4	*	05/01/89	*	*	*	*	*	*	*	0.08	14	334	####	<2
4	*	07/31/89	2.6	1.4	*	*	*	*	*	0.86	17	391	<0.05	4
4	*	02/02/90	*	*	*	*	*	*	*	<0.05	17	292	<0.05	2
4	*	05/14/90	*	*	*	*	*	*	*	1.20	13	299	<0.05	6
4	*	08/06/90	<1.0	1.6	*	*	*	*	*	<.05	14	286	<.05	<2
4	*	01/21/91	*	*	*	*	*	*	*	<.05	13	260	<.05	<2
4	*	04/29/91	*	*	*	*	*	*	*	<.05	15	302	<.05	<2
4	*	07/29/91	<1	1.2	*	*	*	*	*	<.05	15	283	<.05	<2

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
5	116	12/21/82	1.9	*	*	*	*	*	*	*	*	*	*	*
5	116	07/25/83	1.0	1.9	*	*	*	*	*	*	*	*	*	*
5	116	02/23/84	1.9	2.4	*	*	*	*	*	*	*	*	*	*
5	116	10/16/85	2.2	2.6	*	*	*	*	*	*	*	*	*	*
5	116	09/24/86	2.3	1.2	*	*	*	*	*	0.33	49	488	<0.05	*
5	116	08/27/87	*	*	*	*	*	*	*	0.12	54	414	<0.05	2
5	116	03/14/88	*	*	*	*	*	*	*	0.90	44	491	<0.05	5
5	116	11/08/88	5.5	3.7	0.2	<1	*	*	*	0.07	40	468	<0.05	3
5	116	01/30/89	*	*	*	*	*	*	*	0.27	42	441	<0.05	4
5	116	07/31/89	2.5	3.1	*	*	*	*	*	0.38	58	518	<0.05	3
5	116	08/06/90	1.9	2.0	*	*	*	*	*	0.74	56	450	<.05	5
5	116	07/29/91	2.1	1.9	*	*	*	*	*	1.20	55	434	<.05	6

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
6	225	12/21/82	1.9	*	*	*	*	*	*	*	*	*	*	*
6	225	07/25/83	1.4	1.9	*	*	*	*	*	*	*	*	*	*
6	225	02/23/84	<1	3.9	*	*	*	*	*	*	*	*	*	*
6	225	10/16/85	<1	1.5	*	*	*	*	*	*	*	*	*	*
6	225	09/24/86	1.4	4.2	*	*	*	*	*	0.10	38	127	<0.05	*
6	225	08/27/87	*	*	*	*	*	*	*	0.11	38	35	<0.05	4
6	225	11/10/87	*	*	*	*	*	*	*	0.12	35	345	<0.05	*
6	225	03/14/88	*	*	*	*	*	*	*	0.36	42	372	<0.05	7
6	225	07/05/88	*	*	*	*	*	*	*	0.15	36	322	<0.05	7
6	225	11/07/88	4.3	3.5	*	*	*	*	*	0.09	32	342	<0.05	5
6	225	01/30/89	*	*	*	*	*	*	*	0.20	45	345	<0.05	5
6	225	05/01/89	*	*	*	*	*	*	*	0.40	54	375	<0.05	8
6	225	07/31/89	<1	1.2	*	*	*	*	*	0.18	41	403	<0.05	6
6	225	02/20/90	*	*	*	*	*	*	*	<0.05	42	322	<0.05	6
6	225	05/14/90	*	*	*	*	*	*	*	0.11	47	317	<0.05	7
6	225	08/06/90	1.2	1.3	*	*	*	*	*	0.13	46	335	<.05	6
6	225	01/21/91	*	*	*	*	*	*	*	0.16	42	299	<.05	6
6	225	04/29/91	*	*	*	*	*	*	*	0.47	56	362	<.05	8
6	225	07/29/91	<1	<1	*	*	*	*	*	0.20	48	316	<.05	7

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
7	65	12/21/82	<1	*	*	*	*	*	*	*	*	*	*	*
7	65	08/17/83	2.9	2.0	*	*	*	*	*	*	*	*	*	*
7	65	02/23/84	<1	3.5	*	*	*	*	*	*	*	*	*	*
7	65	10/17/85	1.7	5.2	*	*	*	*	*	*	*	*	*	*
7	65	09/29/86	<1	7.4	*	*	*	*	*	<0.05	<10	79	<0.05	*
7	65	08/27/87	*	*	*	*	*	*	*	0.07	18	336	<0.05	*
7	65	11/11/87	*	*	*	*	*	*	*	0.09	14	332	<0.05	*
7	65	03/14/88	*	*	*	*	*	*	*	0.17	27	352	<0.05	4
7	65	11/07/88	3.7	2.1	*	*	*	*	*	0.16	17	322	<0.05	4
7	65	01/30/89	*	*	*	*	*	*	*	0.48	20	356	<0.05	7
7	65	05/01/89	*	*	*	*	*	*	*	0.41	19	368	<0.05	4
7	65	07/31/89	*	1.6	*	*	*	*	*	0.31	21	405	<0.05	6
7	65	02/20/90	*	*	*	*	*	*	*	0.28	20	306	<0.05	6
7	65	05/14/90	*	*	*	*	*	*	*	0.19	15	315	<0.05	4
7	65	08/06/90	1.6	1.4	*	*	*	*	*	0.21	18	324	<0.5	5
7	65	01/21/91	*	*	*	*	*	*	*	0.20	16	321	<.05	4
7	65	04/29/91	*	*	*	*	*	*	*	0.22	17	341	<.05	4
7	65	07/29/91	1.2	1.9	*	*	*	*	*	0.15	20	306	<.05	4

WELL	DEPTH	DATE	ALPHA	BETA	F.A-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	Ca
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
8	245	09/29/86	1.0	<1	*	*	*	*	*	*	*	*	*	*
8	245	05/05/87	2.4	1.6	0.4	<1	*	*	*	0.22	16	342	<0.05	*

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
9	385	12/21/82	<1	*	*	*	*	*	*	*	*	*	*	*
9	385	07/25/83	<1	1.1	*	*	*	*	*	*	*	*	*	*
9	385	02/23/84	<1	1.1	*	*	*	*	*	*	*	*	*	*
9	385	10/16/85	1.0	1.7	*	*	*	*	*	*	*	*	*	*

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
10	245	12/21/82	2.9	*	*	*	*	*	*	*	*	*	*	*
10	245	07/25/83	<1	<1	*	*	*	*	*	*	*	*	*	*
10	245	02/23/84	<1	2.1	*	*	*	*	*	*	*	*	*	*
10	245	10/17/85	2.0	3.1	*	*	*	*	*	*	*	*	*	*
10	245	09/25/86	3.0	2.7	*	*	*	*	*	1.60	21	450	<0.05	*
10	245	11/10/87	2.9	2.6	*	*	*	*	*	1.10	20	437	<0.05	*
10	245	06/27/88	5.0	4.0	<0.5	<0.5	*	*	*	0.45	19	410	<0.05	5
10	245	05/01/89	1.7	2.3	*	*	*	*	*	0.26	31	353	<0.05	9
10	245	05/14/90	1.3	1.2	*	*	*	*	*	1.40	31	435	<0.05	12
10	245	01/21/91	2.8	2.5	*	*	*	*	*	*	*	*	*	*
10	245	04/29/91	3.8	2.3	*	*	*	*	*	0.43	20	397	<.05	4

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
11	*	12/21/82	3.5	*	*	*	*	*	*	*	*	*	*	*
11	*	07/25/83	1.4	<1	*	*	*	*	*	*	*	*	*	*
11	*	02/23/84	14.5	11.7	4.2	4.0	*	*	*	*	*	*	*	*
11	*	10/17/85	1.1	1.7	*	*	*	*	*	*	*	*	*	*
11	*	09/25/86	2.3	2.5	*	*	*	*	*	<0.05	21	93	<0.05	0
11	*	11/10/87	1.0	2.1	*	*	*	*	*	<0.05	16	322	<0.05	0
11	*	06/27/88	2.5	3.1	*	*	*	*	*	0.19	28	388	<0.05	6
11	*	05/02/89	3.7	2.3	*	*	*	*	*	1.60	31	445	<0.05	14
11	*	02/20/90	11.8	11.7	*	*	*	*	*	*	*	*	*	*
11	*	05/14/90	1.2	2.3	*	*	*	*	*	0.39	29	284	<0.05	8

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
12	630	12/21/82	2.8	*	*	*	*	*	*	*	*	*	*	*
12	630	07/25/83	4.1	1.0	*	*	*	*	*	*	*	*	*	*
12	630	02/23/84	4.1	4.8	*	*	*	*	*	*	*	*	*	*
12	630	10/17/85	2.6	1.3	*	*	*	*	*	0.11	<10	114	<0.05	*
12	630	09/25/86	3.6	4.3	*	*	*	*	*	0.15	14	350	<0.05	*
12	630	11/10/87	3.4	3.4	<0.5	0.9	*	*	*	0.08	11	373	<0.05	2
12	630	06/27/88	5.3	4.1	<0.5	<0.5	*	*	*	0.13	16	359	<0.05	<2
12	630	05/01/89	3.8	3.2	*	*	*	*	*	0.11	<10	322	<0.05	<2
12	630	02/20/90	*	*	*	*	*	*	*	0.11	14	327	<0.05	<2
12	630	05/14/90	6.3	3.8	0.4	1.4	*	*	*					
12	WELL	CLOSED NOV. 90-		NEW	WELL	DRILLED	NEARBY.							
12	NEW	WELL IS	240 FT											
12	240	01/21/91	4.2	3.3	*	*	*	*	*	0.05	<10	262	<.05	<2
12	240	04/29/91	4.9	2.8	*	*	*	*	*	0.09	11	347	<.05	<2

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
13	360	01/07/83	3.6	*	*	*	*	*	*	*	*	*	*	*
13	360	07/25/83	2.0	2.7	*	*	*	*	*	*	*	*	*	*
13	360	07/23/84	4.0	2.9	*	*	*	*	*	*	*	*	*	*
13	360	10/17/85	3.0	3.2	*	*	*	*	*	*	*	*	*	*
13	360	09/24/86	3.4	2.4	*	*	*	*	*	<0.05	12	91	<0.05	*
13	360	05/05/87	2.2	3.2	0.8	<1	*	*	*	0.05	18	325	<0.05	*
13	360	08/27/87	2.3	2.5	*	*	*	*	*	0.53	21	323	<0.05	<2
13	360	11/10/87	*	*	*	*	*	*	*	<0.05	20	331	<0.05	*
13	360	03/14/88	2.2	1.9	*	*	*	*	*	<0.05	30	345	<0.05	2
13	360	06/27/88	*	*	*	*	*	*	*	<0.05	19	350	<0.05	2
13	360	11/07/88	*	*	*	*	*	*	*	0.12	20	326	<0.05	2
13	360	02/07/89	1.8	2.3	*	*	*	*	*	0.12	22	336	<0.05	2
13	360	05/02/89	*	*	*	*	*	*	*	0.07	19	328	<0.05	<2
13	360	07/31/89	*	*	*	*	*	*	*	0.10	22	347	<0.05	<2

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
14	260	01/07/83	<1	*	*	*	*	*	*	*	*	*	<0.05	*
14	260	07/25/83	1.1	<1	*	*	*	*	*	*	*	*	*	*
14	260	02/23/84	<1	1.8	*	*	*	*	*	*	*	*	*	*
14	260	09/24/86	3.4	2.4	*	*	*	*	*	*	*	*	*	*

WELL #	DEPTH ft.	DATE	ALPHA pCi/L	BETA pCi/L	RA-226 pCi/L	RA-228 pCi/L	URANUM pCi/L	TH-230 pCi/L	TH-232 pCi/L	NITRAT mg/L	SULFAT mg/L	T.D.S. mg/L	LITH mg/L	CL mg/L
15	285	01/07/83	2.8	*	*	*	*	*	*	*	*	*	*	*
15	285	07/25/83	4.9	6.9	*	*	*	*	*	*	*	*	*	*
15	285	02/23/84	4.5	7.2	*	*	*	*	*	*	*	*	*	*
15	285	09/25/86	4.7	4.4	*	*	*	*	*	0.05	<10	338	<0.05	0

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
16	180	01/07/83	4.1	•	•	•	•	•	•	•	•	•	•	•
16	180	08/18/83	4.5	5.9	•	•	•	•	•	•	•	•	•	•
16	180	02/23/84	4.8	5.2	•	•	•	•	•	•	•	•	•	•
16	180	10/23/85	3.6	3.2	•	•	•	•	•	•	•	•	•	•
16	180	09/25/86	2.8	3.7	•	•	•	•	•	0.17	12	372	<0.05	0
16	180	06/27/88	5.1	4.6	<0.5	<0.5	•	•	•	0.47	17	385	<0.05	3
16	180	11/07/88	•	•	•	•	•	•	•	•	•	•	•	•
16	180	05/01/89	5.2	4.2	•	•	•	•	•	0.35	<10	356	<0.05	3
16	180	05/14/90	4.4	3.6	•	•	•	•	•	1.10	12	347	<0.05	3
16	180	04/29/91	4.8	4.2	•	•	•	•	•	0.85	13	340	<.05	<2

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
17	485	01/18/83	5.7	4.4	•	•	•	•	•	•	•	•	•	•
17	485	02/07/83	4.9	•	1.3	<1	•	•	•	•	•	•	•	•
17	485	07/25/83	5.6	6.9	•	•	•	•	•	•	•	•	•	•
17	485	08/17/83	•	•	1.5	<1	•	•	•	•	•	•	•	•
17	485	02/23/84	6.7	7.0	1.7	•	•	•	•	•	•	•	•	•
17	485	10/16/85	4.8	3.2	•	•	•	•	•	•	•	•	•	•
17	485	09/25/86	3.9	4.1	•	•	•	•	•	<0.05	27	383	<0.05	0
17	485	11/10/87	5.0	7.7	2.6	<0.5	•	•	•	0.09	30	403	<0.05	0
17	485	06/28/88	5.4	6.8	2.2	1.3	•	•	•	<0.05	26	406	<0.05	5
17	485	05/01/89	6.6	7.9	2.0	0.8	•	•	•	0.07	64	513	<0.05	59
17	485	02/26/90	8.1	6.5	1.4	0.2	•	•	•	•	•	•	•	•
17	485	05/14/90	7.8	6.4	1.2	0.4	•	•	•	0.18	61	478	<0.05	61
17	485	01/28/91	4.3	6.0	•	•	•	•	•	•	•	•	•	•
17	485	04/29/91	7.8	6.8	1.4	0.8	•	•	•	<.05	63	472	<.05	74

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
18	50	01/18/83	<1	5.1	*	*	*	*	*	*	*	*	*	*
18	50	07/25/83	3.2	6.0	*	*	*	*	*	*	*	*	*	*
18	50	02/23/84	4.7	2.3	*	*	*	*	*	*	*	*	*	*

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
19	700	01/18/83	2.8	2.1	*	*	*	*	*	*	*	*	*	*
19	700	08/17/83	4.0	3.2	*	*	*	*	*	*	*	*	*	*
19	700	02/23/84	3.9	3.6	*	*	*	*	*	*	*	*	*	*
19	700	10/23/85	4.6	5.3	*	*	*	*	*	*	*	*	*	*
19	700	09/25/86	3.3	3.1	*	*	*	*	*	0.06	<10	327	<0.05	*
19	700	06/27/88	4.5	3.3	1.0	<0.5	*	*	*	0.07	14	351	<0.05	2
19	700	05/01/89	4.8	3.7	*	*	*	*	*	0.70	12	335	<0.05	<2
19	700	05/14/90	5.5	3.7	1.6	0.6	*	*	*	0.07	12	299	<0.05	2
19	700	04/29/91	5.2	3.2	1.5	0.3	*	*	*	0.06	12	294	<.05	<2

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
20	365	01/18/83	3.0	2.4	*	*	*	*	*	*	*	*	*	*
20	365	08/17/83	5.2	4.9	*	*	*	*	*	*	*	*	*	*
20	365	10/20/83	*	*	1.6	<1	*	*	*	*	*	*	*	*
20	365	02/23/84	3.6	3.6	*	*	*	*	*	*	*	*	*	*
20	365	10/23/85	3.3	1.6	*	*	*	*	*	*	*	*	*	*
20	365	09/29/86	4.2	1.2	*	*	*	*	*	0.08	<10	3.5	<0.05	*
20	365	11/11/87	3.7	3.6	1.1	<0.5	*	*	*	0.11	14	366	<0.05	*
20	365	06/27/88	4.1	3.1	1.1	<0.5	*	*	*	0.12	17	411	<0.05	5
20	365	05/01/89	4.6	4.1	*	*	*	*	*	0.11	<10	375	<0.05	6
20	365	02/20/90	4.2	2.9	*	*	*	*	*	*	*	*	*	*
20	365	05/14/90	5.1	4.2	1.5	0.4	*	*	*	0.08	13	342	<0.05	5
20	365	01/21/91	5.3	3.8	1.7	0.8	*	*	*	*	*	*	*	*
20	365	04/29/91	5.9	4.7	2.1	0.3	*	*	*	0.10	13	348	<.05	4

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCI/L	pCI/L	pCI/L	pCI/L	pCI/L	pCI/L	pCI/L	mg/L	mg/L	mg/L	mg/L	mg/L
21	330	01/18/83	2.6	3.3	*	*	*	*	*	*	*	*	*	*
21	330	08/17/83	5.3	4.4	*	*	*	*	*	*	*	*	*	*
21	330	10/20/83	*	*	2.2	<0.1	*	*	*	*	*	*	*	*
21	330	02/23/84	8.1	4.9	2.6	*	*	*	*	*	*	*	*	*
21	330	10/23/85	1.6	4.4	*	*	*	*	*	*	*	*	*	*
21	330	10/29/85	2.7	2.6	*	*	*	*	*	*	*	*	*	*
21	330	09/29/86	4.1	2.1	*	*	*	*	*	0.82	*	*	<0.05	*
21	330	04/10/87	*	*	*	*	*	*	*	*	*	*	<0.05	*
21	330	06/27/88	5.6	4.3	0.9	<0.1	*	*	*	0.21	37	429	<0.05	12
21	330	05/01/89	5.0	3.4	*	*	*	*	*	0.29	38	391	<0.05	16
21	330	05/14/90	<1	3.5	*	*	*	*	*	0.33	114	273	<0.05	19
21	330	04/29/91	1.4	2.1	*	*	*	*	*	2.00	24	353	<.05	16

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
22	130	01/18/83	2.2	1.4	*	*	*	*	*	*	*	*	*	*
22	130	08/17/83	1.7	1.0	*	*	*	*	*	*	*	*	*	*
22	130	02/23/84	3.7	2.7	*	*	*	*	*	*	*	*	*	*
22	130	10/23/85	2.5	1.0	*	*	*	*	*	*	*	*	*	*
22	130	09/29/86	2.1	2.1	*	*	*	*	*	1.70	<10	375	<0.05	0
22	130	02/20/90	2.4	1.0	*	*	*	*	*	1.50	11	369	<0.05	9
22	130	01/21/91	2.8	2.2	*	*	*	*	*	3.00	12	353	<.05	11

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
23	385	01/18/83	2.1	1.4	*	*	*	*	*	*	*	*	*	*
23	385	08/17/83	<1	<1	*	*	*	*	*	*	*	*	*	*
23	385	02/23/84	1.4	1.9	*	*	*	*	*	*	*	*	*	*
23	385	10/23/85	2.3	2.1	*	*	*	*	*	*	*	*	*	*
23	385	11/10/86	2.3	<1	*	*	*	*	*	0.13	<10	348	<0.05	0
23	385	02/20/90	2.1	1.2	*	*	*	*	*	0.14	<10	294	<0.05	<2
23	385	01/21/91	1.9	1.4	*	*	*	*	*	0.11	<10	308	<.05	<2

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
24	125	01/18/83	<1	1.8	*	*	*	*	*	*	*	*	*	*
24	125	08/17/83	1.4	<1	*	*	*	*	*	*	*	*	*	*
24	125	02/23/84	1.7	<1	*	*	*	*	*	*	*	*	*	*
24	125	10/16/85	1.2	3.1	*	*	*	*	*	3.40	11	377	<0.05	0
24	125	11/10/86	1.8	3.1	*	*	*	*	*	3.20	18	382	<0.05	0
24	125	08/27/87	*	*	*	*	*	*	*	3.06	24	383	<0.05	7
24	125	03/14/88	*	*	*	*	*	*	*	3.30	15	362	<0.05	7
24	125	11/07/88	3.2	<1	*	*	*	*	*	3.30	15	371	<0.05	7
24	125	01/30/89	*	*	*	*	*	*	*	3.30	12	805	<0.05	7
24	125	07/31/89	<1	2.5	*	*	*	*	*	3.20	14	365	<.05	8
24	125	08/06/90	<1.0	2.0	*	*	*	*	*	3.30	15	345	<.05	8
24	125	07/29/91	1.5	<1	*	*	*	*	*					

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
25	16	01/18/83	<1	2.3	*	*	*	*	*	*	*	*	*	*
25	16	07/25/83	<1	1.3	*	*	*	*	*	*	*	*	*	*
25	16	02/23/84	<1	2.9	*	*	*	*	*	*	*	*	*	*
25	16	10/16/85	<1	3.1	*	*	*	*	*	*	*	*	*	*
25	16	09/25/86	<1	3.9	*	*	*	*	*	4.00	32	361	<0.05	*
25	16	08/27/87	*	*	*	*	*	*	*	3.90	35	435	<0.05	74
25	16	03/14/88	*	*	*	*	*	*	*	3.21	36	384	<0.05	70
25	16	07/05/88	1.8	4.6	*	*	*	*	*	3.84	36	468	<0.05	71
25	16	11/07/88	3.2	4.4	*	*	*	*	*	2.70	29	411	<0.05	74
25	16	01/30/89	*	*	*	*	*	*	*	3.20	26	311	<0.05	56
25	16	05/09/89	*	*	*	*	*	*	*	3.10	33	351	<0.05	74
25	16	02/20/90	*	*	*	*	*	*	*	4.80	31	445	<0.05	118
25	16	05/21/90	*	*	*	*	*	*	*	2.00	35	281	<0.05	46
25	16	07/31/90	1.6	4.4	*	*	*	*	*	4.40	27	772	<0.05	77
25	16	08/13/90	6.3	4.2	1.9	0.3	*	*	*	*	*	*	*	*
25	16	01/21/91	*	*	*	*	*	*	*	2.90	31	330	<.05	65
25	16	04/29/91	*	*	*	*	*	*	*	3.40	35	359	<.05	71
25	16	07/29/91	1.5	3.8	*	*	*	*	*	3.10	31	354	<.05	53

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
26	225	02/07/83	9.2	6.7	•	•	•	•	•	•	•	•	•	•
26	225	03/15/83	9.7	•	3.2	<1	•	•	•	•	•	•	•	•
26	225	07/25/83	10.7	12.5	•	•	•	•	•	•	•	•	•	•
26	225	08/17/83	•	•	3.1	1.3	•	•	•	•	•	•	•	•
26	225	02/23/84	9.2	12.0	3.6	1.7	•	•	•	•	•	•	•	•
26	225	10/23/85	8.5	5.5	3.1	<1	•	•	•	•	•	•	•	•
26	225	09/25/86	6.4	7.5	3.2	•	•	•	•	<0.05	18	283	<0.05	0

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
27	711	02/07/83	4.3	3.0	*	*	*	*	*	*	*	*	*	*
27	711	08/17/83	6.2	5.1	*	*	*	*	*	*	*	*	*	*
27	711	10/20/83	*	*	1.6	<1	*	*	*	*	*	*	*	*
27	711	02/23/84	7.0	7.5	*	*	*	*	*	*	*	*	*	*
27	711	10/23/85	9.9	6.3	3.1	<1	*	*	*	*	*	*	*	*
27	711	11/10/86	12.8	5.6	3.6	*	*	*	*	0.06	21	300	<0.05	0
27	711	03/14/88	15.9	7.1	5.0	<1	*	*	*	0.17	27	315	<0.05	3
27	711	04/13/88	12.4	6.9	1.9	*	1.9	*	*	*	*	*	*	*
27	711	11/07/88	28.5	14.0	2.8	0.9	2.8	6.4	5.1	0.09	20	307	<0.05	3
27	711	01/30/89	22.8	12.0	3.7	0.5	0.0	0.0	*	0.09	15	299	<0.05	3
27	711	07/31/89	22.0	13.1	5.1	0.8	0.0	0.0	*	0.16	17	565	<0.05	2
27	711	08/06/90	22.4	12.0	4.5	0.8	*	*	*	0.23	18	276	<.05	3
27	711	08/12/91	20.0	10.1	5.2	0.7	*	*	*	0.21	18	303	<.05	3

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
28	140	02/07/83	<1	3.5	*	*	*	*	*	*	*	*	*	*
28	140	08/17/83	1.1	1.1	*	*	*	*	*	*	*	*	*	*
28	140	02/23/84	<1	3.2	*	*	*	*	*	*	*	*	*	*
28	140	10/16/85	<1	1.7	*	*	*	*	*	*	*	*	*	*
28	140	09/25/86	<1	<1	*	*	*	*	*	2.20	<10	287	<0.05	*
28	140	02/20/90	<1	2.3	*	*	*	*	*	2.50	<10	315	<0.05	3
28	140	01/28/91	<1	2.6	*	*	*	*	*	2.50	<10	323	<.05	3

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
29	125	02/07/83	<1	3.2	*	*	*	*	*	*	*	*	*	*
29	125	08/17/83	2.8	3.8	*	*	*	*	*	*	*	*	*	*
29	125	02/23/84	1.5	2.9	*	*	*	*	*	*	*	*	*	*
29	125	10/16/85	<1.3	<1	*	*	*	*	*	*	*	*	*	*
29	125	09/29/86	<1.3	<1	*	*	*	*	*	*	*	*	*	*
29	125	02/20/90	3.1	2.1	*	*	*	*	*	1.20	18	302	<0.05	7
29	125	01/28/91	<1	1.2	*	*	*	*	*	0.13	<10	271	<.05	<2

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
30	350	09/29/86	2.4	3.2	*	*	*	*	*	0.11	<10	269	<0.05	*
30	350	05/05/87	2.4	1.1	0.3	<1	*	*	*	0.30	8	328	<0.05	*
30	350	08/27/87	*	*	*	*	*	*	*	<0.05	15	359	<0.05	- 2
30	350	03/14/88	*	*	*	*	*	*	*	0.14	24	360	<0.05	2
30	350	11/07/88	2.4	1.3	*	*	*	*	*	<0.05	13	401	<0.05	- 2
30	350	02/06/89			*	*	*	*	*	<0.05	13	383	<0.05	3
30	350	07/31/89	2.3	1.1	*	*	*	*	*	<0.05	10	618	<0.05	3
30	350	08/06/90	1.2	<1.0	*	*	*	*	*	<0.05	11	313	<.05	<2
30	350	05/23/89	TESTED	POS.	FOR	CHLORDAN	BY	ARMY						
30	350	10/31/90	TESTED	POS.	FOR	CHLORDAN	BY	MDOH						
30	WELL	CLOSED '90												

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
31	150	09/29/86	3.2	1.2	*	*	*	*	*	<0.05	14	332	<0.05	*
31	150	05/05/87	2.2	<1	0.2	1.0	*	*	*	4.50	30	422	<0.05	*
31	150	08/27/87	*	*	*	*	*	*	*	1.40	30	380	<0.05	9
31	150	11/10/87	*	*	*	*	*	*	*	<0.05	20	345	<0.05	*
31	150	02/06/88	*	*	*	*	*	*	*	1.40	17	368	<0.05	10
31	150	03/14/88	*	*	*	*	*	*	*	4.05	33	432	<0.05	19
31	150	06/27/88	*	*	*	*	*	*	*	1.80	28	401	<0.05	12
31	150	11/07/88	7.6	3.9	0.2	0.2	*	*	*	<0.05	13	324	<0.05	4
31	150	05/09/89	*	*	*	*	*	*	*	3.50	28	401	<0.05	20
31	150	07/31/89	2.1	1.1	*	*	*	*	*	1.70	16	695	<0.05	12
31	150	02/26/90	*	*	*	*	*	*	*	<0.05	<10	300	<0.05	4
31	150	05/21/90	*	*	*	*	*	*	*	3.60	32	395	<0.05	21
31	150	08/06/90	1.5	.3	*	*	*	*	*	3.50	32	4.2	<.05	24
31	150	01/21/91	*	*	*	*	*	*	*	3.50	31	399	<.05	24
31	150	04/29/91	*	*	*	*	*	*	*	3.30	34	394	<.05	24
31	150	07/29/91	1.6	<1	*	*	*	*	*	3.20	37	426	<.05	28

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
32	167	09/29/86	3.4	2.8	*	*	*	*	*	4.00	36	604	<0.05	*
32	167	05/05/87	1.3	2.0	0.3	<1	*	*	*	3.60	35	720	<0.05	*
32	167	08/27/87	*	*	*	*	*	*	*	4.30	38	718	<0.05	100
32	167	11/11/87	*	*	*	*	*	*	*	0.45	64	707	<0.05	*
32	167	03/14/88	*	*	*	*	*	*	*	4.29	39	730	<0.05	129
32	167	07/05/88	*	*	*	*	*	*	*	4.50	36	769	<0.05	126
32	167	11/07/88	9.8	2.9	0.3	0.4	*	*	*	0.22	64	708	<0.05	114
32	167	02/06/89	*	*	*	*	*	*	*	4.90	37	679	<0.05	100
32	167	05/09/89	*	*	*	*	*	*	*	4.00	35	806	<0.05	175
32	167	07/31/89	4.7	1.2	*	*	*	*	*	4.80	38	1427	<0.05	114
32	167	02/26/90	*	*	*	*	*	*	*	0.28	59	602	<0.05	83
32	167	05/21/90	*	*	*	*	*	*	*	4.80	76	813	<0.05	134
32	167	08/06/90	1.3	1.8	*	*	*	*	*	4.60	52	759	<.05	157
32	167	01/28/91	*	*	*	*	*	*	*	4.20	55	770	<.05	178
32	167	05/06/91	*	*	*	*	*	*	*	3.30	41	813	<.05	168
32	167	07/29/91	<1	1.6	*	*	*	*	*	4.10	42	669	<.05	140

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCI/L	pCI/L	pCI/L	pCI/L	pCI/L	pCI/L	pCI/L	mg/L	mg/L	mg/L	mg/L	mg/L
33	170	08/27/87	2.7	3.7	*	*	*	*	*	3.40	40	570	<0.05	65
33	170	11/09/87	*	*	*	*	*	*	*	3.50	33	543	<0.05	0
33	170	03/14/88	<1	1.8	*	*	*	*	*	3.33	36	559	<0.05	65
33	170	07/05/88	*	*	*	*	*	*	*	3.51	36	566	<0.05	64
33	170	01/30/89	<1	2.2	*	*	*	*	*	3.50	26	498	<0.05	64
33	170	05/02/89	*	*	*	*	*	*	*	3.70	36	520	<0.05	68
33	170	08/08/89	*	*	*	*	*	*	*	3.40	29	547	<0.05	67
33	170	02/26/90	*	*	*	*	*	*	*	3.10	31	482	<0.05	59
33	170	05/21/90	*	*	*	*	*	*	*	3.20	33	426	<0.05	58
33	170	08/13/90	*	*	*	*	*	*	*	3.70	36.3	518	<.05	62.5
33	170	01/28/91	*	*	*	*	*	*	*	3.70	32	491	<.05	63
33	170	07/29/91	*	*	*	*	*	*	*	3.50	40	510	<.05	60

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
34	100	11/10/86	2.8	2.0	*	*	*	*	*	0.33	36	498	<0.05	3
34	100	08/27/87	5.8	3.8	0.3	*	*	*	*	0.25	36	483	<0.05	*
34	100	11/11/87	*	*	*	*	*	*	*	0.12	34	478	<0.05	*
34	100	03/14/88	3.2	2.4	*	*	*	*	*	0.51	33	566	<0.05	8
34	100	07/05/88	*	*	*	*	*	*	*	0.07	33	493	<0.05	4
34	100	11/07/88	*	*	*	*	*	*	*	<0.05	30	483	<0.05	4
34	100	05/09/89	2.5	3.6	*	*	*	*	*	0.27	40	508	<0.05	8
34	100	08/08/89	*	*	*	*	*	*	*	0.10	39	467	<0.05	4
34	100	02/26/90	*	*	*	*	*	*	*	<0.05	37	327	<0.05	3
34	100	05/21/90	*	*	*	*	*	*	*	0.32	45	457	<0.05	8
34	100	08/13/90	*	*	*	*	*	*	*	0.11	42.8	457	<0.5	3.2
34	100	01/28/91	*	*	*	*	*	*	*	0.13	41	466	<.05	6
34	100	05/06/91	*	*	*	*	*	*	*	0.31	45	521	<.05	7
34	100	07/29/91	*	*	*	*	*	*	*	0.23	42	484	<.05	7

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
35	325	11/25/86	3.8	2.7	*	*	*	*	*	<0.05	34	380	<0.05	*
35	325	08/27/87	3.9	4.2	*	*	*	*	*	<0.05	23	345	<0.05	*
35	325	03/14/88	4.6	3.9	*	*	*	*	*	<0.05	30	365	<0.05	3
35	325	11/07/88	*	*	*	*	*	*	*	<0.05	25	365	<0.05	3
35	325	02/06/89	3.1	3.1	*	*	*	*	*	<0.05	30	378	<0.05	2
35	325	08/08/89	*	*	*	*	*	*	*	0.05	39	387	<0.05	2
35	325	08/13/90	*	*	*	*	*	*	*	0.07	25.7	361	<.05	<2
35	325	08/12/91	*	*	*	*	*	*	*	<.05	25	311	<.05	2

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
36	325	11/10/86	2.4	2.1	*	*	*	*	*	<0.05	10	373	<0.05	*
36	325	05/05/87	2.5	2.5	*	*	*	*	*	<0.05	13	388	<0.05	*
36	325	08/27/87	1.3	<2	*	*	*	*	*	<0.05	18	397	<0.05	- 2
36	325	11/11/87	*	*	*	*	*	*	*	<0.05	23	376	<0.05	2
36	325	03/14/88	<1	<1	*	*	*	*	*	<0.05	20	374	<0.05	2
36	325	07/05/88	*	*	*	*	*	*	*	<0.05	20	374	<0.05	2
36	325	11/07/88	*	*	*	*	*	*	*	<0.05	19	377	<0.05	2
36	325	02/06/89	<1	1.3	*	*	*	*	*	<0.05	13	400	<0.05	2
36	325	05/09/89	*	*	*	*	*	*	*	<0.05	14	372	<0.05	<2
36	325	08/08/89	*	*	*	*	*	*	*	<0.05	14	353	<0.05	<2
36	325	02/26/90	*	*	*	*	*	*	*	<0.05	15	350	<0.05	2
36	325	05/21/90	*	*	*	*	*	*	*	<0.05	14	339	<0.05	2
36	325	08/13/90	*	*	*	*	*	*	*	0.05	12.9	367	<.05	<2
36	325	01/28/91	*	*	*	*	*	*	*	<.05	18	363	<.05	<2
36	325	05/06/91	*	*	*	*	*	*	*	<.05	15	381	<.05	<2
36	325	08/12/91	*	*	*	*	*	*	*	<.05	14	356	<.05	<2

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
37	390	11/10/86	3.6	2.1	*	*	*	*	*	<0.05	13	326	<0.05	*
37	390	08/27/87	2.5	2.1	*	*	*	*	*	<0.05	18	318	<0.05	2
37	390	03/14/88	7.1	5.4	0.6	0.8	*	*	*	<0.05	23	322	<0.05	2
37	390	11/07/88	11.5	6.1	0.7	0.7	*	*	*	<0.05	20	306	<0.05	2
37	390	02/06/89	4.2	3.3	*	*	*	*	*	<0.05	17	321	<0.05	2
37	390	08/08/89	*	*	*	*	*	*	*	<0.05	15	297	<0.05	2
37	390	08/13/90	*	*	*	*	*	*	*	<.05	15.6	295	<.05	<2
37	390	08/12/91	*	*	*	*	*	*	*	<.05	16	305	<.05	<2

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
38	120	11/25/86	1.3	4.0	*	*	*	*	*	0.29	62	229	<0.05	*
38	120	08/27/87	1.0	<2	*	*	*	*	*	3.40	61	520	<0.05	23
38	120	03/14/88	1.1	1.0	*	*	*	*	*	7.40	47	469	<0.05	16
38	120	11/07/88	*	*	*	*	*	*	*	2.90	57	515	<0.05	37
38	120	02/06/89	<1	1.3	*	*	*	*	*	6.70	48	477	<0.05	31
38	120	08/08/89		0.0	*	*	*	*	*	3.60	61	572	<0.05	78
38	120	08/13/90	*	*	*	*	*	*	*	4.90	58.9	542	<.05	55
38	120	08/12/91	*	*	*	*	*	*	*	3.70	69	528	<.05	47

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/l.	mg/L	mg/L
39	200	11/10/86	1.7	2.1	*	*	*	*	*	0.10	<10	354	<0.05	*
39	200	08/27/87	1.3	2.0	*	*	*	*	*	<0.05	15	360	<0.05	<2
39	200	03/14/88	1.6	1.2	*	*	*	*	*	0.06	17	355	<0.05	2
39	200	11/07/88	*	*	*	*	*	*	*	*	*	*	*	*
39	200	02/06/89	<1	1.3	*	*	*	*	*	0.05	<10	361	<0.05	2

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
40	450	11/25/86	27.4	15.1	10.3	*	*	*	*	<0.05	<10	300	<0.05	*
40	450	08/26/87	27.9	19.3	8.8	<1	*	*	*	<0.05	12	302	<0.05	2
40	450	03/14/88	23.9	14.6	9.3	<1	*	*	*	0.05	33	313	<0.05	3
40	450	11/07/88	57.4	28.6	6.5	0.7	0.9	45.1	8.4	0.05	*	*	*	*
40	450	01/30/89	34.6	18.2	7.2	0.6	*	*	*	<0.05	<10	277	<0.05	2
40	450	08/08/89	31.1	20.7	6.1	1.1	*	*	*	*	*	*	*	*
40	450	08/06/90	42.5	23.7	9.5	1.0	*	*	*	*	*	*	*	*
40	450	08/12/91	31.8	18.3	9.5	0.7	*	*	*	*	*	*	*	*

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
41	340	11/25/86	<1	2.2	*	*	*	*	*	<0.05	61	491	<0.05	*
41	340	08/26/87	64.7	21.5	*	2.3	*	*	*	0.06	52	452	<0.05	*
41	340	09/14/87	1.3	1.3	<1	<1	*	*	*	*	*	*	*	*
41	340	03/14/88	2.1	1.7	*	*	*	*	*	0.30	54	533	<0.05	28
41	340	11/07/88	*	*	*	*	*	*	*	*	*	*	*	*
41	340	02/06/89	1.9	2.6	*	*	*	*	*	0.24	58	530	<0.05	42

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
42	225	11/25/86	1.4	2.6	*	*	*	*	*	<0.05	12	393	<0.05	0
42	225	02/26/90	2.1	1.1	*	*	*	*	*	<0.05	11	262	<0.05	3
42	225	01/28/91	1.8	1.4	*	*	*	*	*	<.05	14	350	<.05	2

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
43	140	11/25/86	4.4	2.2	*	*	*	*	*	12.00	122	677	<0.05	*
43	140	05/05/87	2.3	1.1	0.6	1.0	*	*	*	16.30	35	571	<0.05	*
43	140	05/26/87	*	*	*	*	*	*	*	0.40	*	*	*	*
43	140	05/06/88	3.9	2.9	*	*	*	*	*	27.50	66	759	<0.05	54
43	140	05/09/89	4.1	1.9	*	*	*	*	*	20.00	43	602	<0.05	45
43	140	02/26/90	3.2	2.6	*	*	*	*	*	12.00	66	531	<0.05	36
43	140	05/22/90	3.1	2.0	*	*	*	*	*	0.70	25	382	<0.05	7
43	140	01/28/91	2.5	1.6	*	*	*	*	*	12.00	35	493	<.05	28
43	140	05/06/91	1.8	2.6	*	*	*	*	*	14.00	38	562	<.05	31

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
44	300	11/25/86	<1	<1	*	*	*	*	*	<0.05	21	3.6	<0.05	*
44	300	08/27/87	0.5	-2.0	*	*	*	*	*	<0.05	18	517	<0.05	*
44	300	11/10/87	*	*	*	*	*	*	*	<0.05	15	278	<0.05	*
44	300	03/14/88	<1	<1	*	*	*	*	*	<0.05	17	298	<0.05	2
44	300	07/05/88	*	*	*	*	*	*	*	0.06	22	332	<0.05	2
44	300	11/07/88	*	*	*	*	*	*	*	<0.05	19	289	<0.05	2
44	300	02/06/89	16.9	9.4	<1	<1	*	*	*	<0.05	12	286	<0.05	2
44	300	05/09/89	*	*	*	*	*	*	*	<0.05	14	304	<0.05	<2
44	300	08/08/89	*	*	*	*	*	*	*	<0.05	12	309	<0.05	<2
44	300	02/20/90	*	*	*	*	*	*	*	<0.05	12	263	<0.05	2
44	300	05/21/90	*	*	*	*	*	*	*	<0.05	<10	292	<0.05	<2
44	300	08/13/90	<1.0	<1.0	*	*	*	*	*	0.67	11.9	319	<.05	<2
44	300	01/28/91	*	*	*	*	*	*	*	<.05	14	272	<.05	<2
44	300	05/06/91	*	*	*	*	*	*	*	<.05	14	315	<.05	<2
44	300	08/12/91	*	*	*	*	*	*	*	<.05	13	295	<.05	<2

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
45	*	10/23/85	1.1	4.7	*	*	*	*	*	*	*	*	*	*
45	*	11/11/87	1.0	3.8	*	*	*	*	*	0.38	10	217	<0.05	*
45	*	06/27/88	<1	4.0	*	*	*	*	*	0.34	70	267	<0.05	14
45	*	05/09/89	<1	3.6	*	*	*	*	*	0.25	87	252	<0.05	18
45	*	02/26/90	1.1	4.2	*	*	*	*	*	0.34	94	335	<0.05	17
45	*	05/21/90	<1	4.8	*	*	*	*	*	0.29	130	265	<0.05	20
45	*	01/28/91	<1	5.9	*	*	*	*	*	0.30	99	259	<.05	18
45	*	05/06/91	<1	3.8	*	*	*	*	*	0.32	81	266	<.05	14

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
46	*	10/23/85	<1	3.6	*	*	*	*	*	*	*	*	*	*

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
47	*	04/10/87	*	*	*	*	*	*	*	*	*	*	<0.05	*
47	*	05/05/87	1.5	1.5	0.3	<1	*	*	*	<0.05	8	343	<0.05	*

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
48	305	04/10/87	*	*	*	*	*	*	*	*	*	*	<0.05	*
48	305	05/05/87	2.8	2.5	0.6	1.1	*	*	*	5.00	30	477	<0.05	*
48	305	07/05/88	4.4	3.4	*	*	*	*	*	1.56	34	493	<0.05	13
48	305	05/09/89	4.1	4.7	*	*	*	*	*	0.68	29	369	<0.05	12
48	305	02/26/90	*	*	*	*	*	*	*	3.10	24	380	<0.05	11
48	305	05/21/90	1.6	2.0	*	*	*	*	*	2.80	25	384	<0.05	8
48	305	01/28/91	*	*	*	*	*	*	*	0.64	16	314	<.05	4
48	305	05/06/91	3.3	3.2	*	*	*	*	*	0.40	16	335	<.05	<2

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
49	100	11/09/87	7.3	4.0	0.5	1.0	*	*	*	1.50	23	939	<0.05	*
49	100	03/14/88	*	*	*	*	*	*	*	1.93	31	841	<0.05	236
49	100	07/05/88	*	*	*	*	*	*	*	1.52	25	1152	<0.05	250
49	100	11/07/88	9.8	4.3	0.3	-0.1	*	*	*	1.40	23	1012	<0.05	280
49	100	02/06/89	*	*	*	*	*	*	*	1.90	16	859	<0.05	258
49	100	05/09/89	*	*	*	*	*	*	*	1.60	21	969	<0.05	285
49	100	08/08/89	8.8	4.5	0.4	1.0	0.0	0.0	*	1.20	21	920	<0.05	285
49	100	02/26/90	*	*	*	*	*	*	*	1.60	21	828	<0.05	297
49	100	05/21/90	*	*	*	*	*	*	*	1.20	25	770	<0.05	225
49	100	08/13/90	5.8	2.9	0.3	0.5	*	*	*	1.20	20.8	709	<.05	198
49	100	05/06/91	*	*	*	*	*	*	*	1.20	25	641	<.05	184
49	100	08/12/91	6.9	2.1	0.3	<.1	*	*	*	0.90	25	676	<.05	182

WELL #	DEPTH ft.	DATE	ALPHA pCi/L	BETA pCi/L	RA-226 pCi/L	RA-228 pCi/L	URANUM pCi/L	TH-230 pCi/L	TH-232 pCi/L	NITRAT mg/L	SULFAT mg/L	T.D.S. mg/L	LITH mg/L	CL mg/L
50	300	11/11/87	20.8	24.3	8.7	1.1	0.7	•	•	0.39	14	301	<0.05	•
50	300	06/27/88	25.2	18.0	8.2	1.2	•	•	•	0.40	17	333	<0.05	4
50	300	11/07/88	49.7	22.7	6.2	0.6	0.2	5.2	7.2	•	•	•	•	•
50	300	02/07/89	4.1	3.8	•	•	•	•	•	•	•	•	•	•
50	300	05/01/89	29.5	17.8	7.1	1.1	•	•	•	0.52	18	302	<0.05	7
50	300	05/01/89	<1	1.6	•	•	•	•	•	•	•	•	•	•
50	300	08/08/89	28.6	18.0	7.1	0.2	0.5	3.5	0.3	•	•	•	•	•
50	300	02/26/90	18.2	12.1	8.9	0.4	•	•	•	0.39	11	263	<0.05	5
50	300	05/21/90	20.3	11.4	5.7	0.6	•	•	•	1.40	19	320	<0.05	24
50	300	01/28/91	24.3	11.8	7.3	1.1	•	•	•	1.20	16	302	<.05	20
50	300	05/06/91	21.0	12.8	7.0	0.9	•	•	•	0.93	16	317	<.05	13
50	300	08/12/91	23.2	15.6	7.5	1.8	<.1	0.2	<.1	•	•	•	•	•

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
51	425	11/11/87	15.1	7.4	2.4	0.8	1.5	•	•	0.15	18	266	<0.05	•
51	425	06/27/88	13.2	10.7	4.7	<1	•	•	•	<0.05	28	324	<0.05	4
51	425	11/07/88	28.0	14.5	3.7	<0.1	0.9	3.0	8.5	•	•	•	•	•
51	425	05/01/89	11.5	7.7	3.0	0.3	•	•	•	0.10	24	290	<0.05	5
51	425	08/08/89	21.5	11.8	5.7	0.7	•	6.1	0.6	•	•	•	•	•
51	425	02/26/90	13.6	7.7	5.3	0.5	•	•	•	0.12	28	271	<0.05	5
51	425	05/21/90	12.1	6.9	2.5	0.4	•	•	•	0.12	22	248	<0.05	5
51	425	08/13/90	8.4	6.4	4.1	1.1	0.7	2.4	0.3	•	•	•	•	•
51	425	01/28/91	11.1	7.2	3.8	0.6	•	•	•	0.13	17	263	<.05	10
51	425	05/06/91	11.2	7.2	4.3	0.7	•	•	•	0.13	17	285	<.05	7
51	425	08/12/91	18.5	10.5	5.0	0.7	0.4	0.5	<.1	•	•	•	•	•

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
52														

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCI/L	pCI/L	pCI/L	pCI/L	pCI/L	pCI/L	pCI/L	mg/L	mg/L	mg/L	mg/L	mg/L
53														

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
54	85	06/01/88	*	*	*	*	*	*	*	4.80	39	349	<0.05	7

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
55	700	07/05/88	2.3	3.0	*	*	*	*	*	<0.05	25	382	<0.05	2
55	700	05/09/89	1.3	<1	*	*	*	*	*	<0.05	21	402	<0.05	3
55	700	05/21/90	<1	1.9	*	*	*	*	*	<0.05	21	376	<0.05	2
55	700	05/06/91	1.5	2.0	*	*	*	*	*	<.05	18	403	<.05	<2

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
56	230	11/07/88	3.4	2.3	*	*	*	*	*	1.20	19	498	<0.05	70

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCI/L	pCI/L	pCI/L	pCI/L	pCI/L	pCI/L	pCI/L	mg/L	mg/L	mg/L	mg/L	mg/L
57	230	11/07/88	3.5	1.7	*	*	*	*	*	1.80	17	548	<0.05	67

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
58	400	02/14/89	2.8	3.1	*	*	*	*	*	*	*	*	*	*

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
59	120	01/30/89	<1	1.6	*	*		*	*	7.00	47	326	<0.05	20

WS WELL DATA

WELL	DEPTH	DATE	ALPHA	BETA	RA-226	RA-228	URANUM	TH-230	TH-232	NITRAT	SULFAT	T.D.S.	LITH	CL
#	ft.		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	mg/L	mg/L	mg/L
60	325	08/13/90	*	*	*	*	*	*	*	<0.05	22.5	360	<.05	<2
60	325	08/12/91	*	*	*	*	*	*	*	<.05	25	353	<.05	<2

CHEMICAL PLANT
202-1.17

DOE/OR/21548-364
CONTRACT NO. DE-AC05-86OR21548

QUARTERLY ENVIRONMENTAL DATA SUMMARY - THIRD QUARTER 1992

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

DECEMBER 1992 **REV. 0**

U.S. Department of Energy
Oak Ridge Field Office
Weldon Spring Site Remedial Action Project

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Department Manager — Date 12/1/92

Quality Assurance Manager — Date

Deputy Project Director — Date 12 3 92

Project Director — Date 12/4/92

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Weldon Spring Site Remedial Action Project

Quarterly Environmental Data Summary - Third Quarter 1992

Revision 0

December 1992

Prepared by

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U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

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ABSTRACT

The purpose of this *Quarterly Environmental Data Summary* is to provide to the public preliminary data acquired as part of the Weldon Spring Site Remedial Action Project (WSSRAP) environmental monitoring program. The document summarizes the preliminary environmental data, highlights any potentially significant findings, and offers tentative interpretations. Validated data and final interpretations will appear in the 1992 annual site environmental report.

This report includes preliminary data from environmental monitoring activities at the Weldon Spring site (WSS) during the third quarter of 1992. Groundwater, surface water, and air samples were collected in order to monitor potential exposure pathways. Analytical parameters included radionuclides, nitroaromatic compounds, inorganic anions, and direct gamma exposure. The results are used to evaluate possible exposure scenarios and assess the impact of the contaminants at the site on potentially exposed populations.

In summary, off-site exposures during the third quarter of 1992 did not differ significantly from exposures calculated in previous quarters. Contaminated groundwater did not affect the St. Charles County well field.

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1 INTRODUCTION

This quarterly report summarizes the findings from the routine environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). These quarterly reports supplement the annual site environmental report (ASER) by providing interested outside agencies and organizations with more frequent access to WSSRAP data. They provide data resulting from routine environmental sampling as described in the WSSRAP *Environmental Monitoring Plan* (EMP) (MKF and JEG 1992a) and a brief interpretation of that data.

It is the goal of this document to summarize and briefly discuss the data, highlighting data that differ significantly from historical observations. The full interpretation of these data (as well as data in other quarterly summaries) will be undertaken in the 1992 ASER. It is recommended that interested readers refer to previous EMPs, ASERs, and project documents for more information on existing site conditions, site history, transport mechanisms, and quantified contaminant levels. The monitoring scheme for every calendar year is established prior to that year in the annual EMP. Each sampling location to be monitored during the upcoming year is identified in the EMP and the schedule of analytical parameters is tabulated for easy reference. These reports may be obtained by visiting the WSSRAP reading room or contacting the WSSRAP Community Relations Manager at (314) 441-8086.

These quarterly reports are intended to include data from all quarterly environmental monitoring programs conducted at the WSSRAP including groundwater, springs, surface water, National Pollutant Discharge Elimination System (NPDES), radon gas, gamma radiation, and air particulates (including asbestos and radioactive particulates). This document summarizes the preliminary environmental data, highlights any potentially significant findings, and offers tentative interpretations. Validated data and final interpretations will appear in the 1992 annual site environmental report. Because standard turnaround time to receive data from the laboratories is 45 days, not all third quarter data are available for reporting. These data will be reported in the 1992 ASER. Sludges and soils are not sampled on a routine basis; therefore, analytical results for these parameters are not included in this report. Trend analyses are being prepared from historical data for surface water, groundwater, and air pathways. These analyses will be presented in the 1992 ASER. Quality control (QC) data for the third quarter and fourth bimonthly periods, along with all other periods, will be presented in the 1992 ASER.

2 GROUNDWATER MONITORING

The groundwater is sampled regularly at both the Weldon Spring Chemical Plant/raffinate pits/vicinity properties (WSCP/RP/VP) and the Weldon Spring Quarry (WSQ). Due to differences in the environmental settings and sources of contaminants, separate monitoring schedules are followed. Therefore, results of groundwater monitoring at the WSCP/RP/VP and WSQ will be discussed separately.

2.1 Chemical Plant/Raffinate Pits/Vicinity Properties

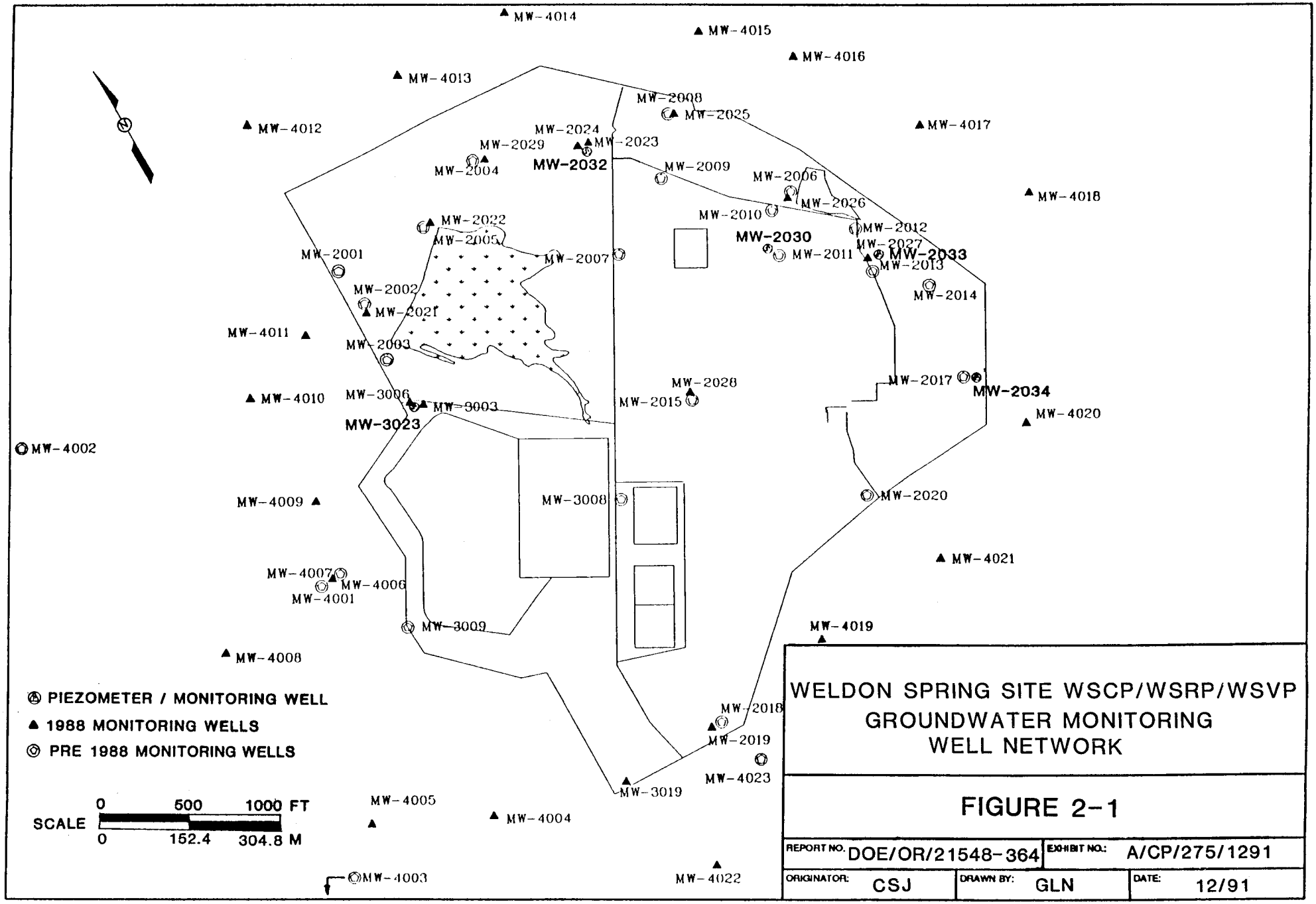
Groundwater at the chemical plant/raffinate pits/vicinity properties area is monitored on a quarterly or semiannual basis (specific to each well as prescribed in the 1992 *Environmental Monitoring Plan* (MKF and JEG 1992a). Locations are given in Figure 2-1. The number of quarterly sampled wells has increased substantially; a complete list of wells scheduled for quarterly and semiannual sampling is given in the 1992 EMP. Total uranium, inorganic anions, and nitroaromatic compounds are measured during each monitoring period for both quarterly and semiannual wells. Other radiological parameters are measured annually during the first period for all wells.

2.1.1 Nitroaromatic Results

Table 2-1 contains nitroaromatic data from samples collected from the quarterly monitored groundwater wells. Nitroaromatic compounds were detected in 16 of the 32 locations for which data are currently available. Concentration levels for these compounds are within their historical range, with the following exceptions: new 2,4,6-trinitrotoluene (TNT) highs were recorded in wells MW-2030, MW-2032, MW-2033, a new 2,4-dinitrotoluene (DNT) high was recorded in MW-3023, and new 1,3,5-trinitrobenzene (TNB) highs were recorded in MW-2030, MW-2033, and MW-4001. A new 1,3,5-TNB low was measured in MW-4013.

2.1.2 Radiological Results

The upper bound for natural uranium background concentration in groundwater at the WSCP/RP/VP has been determined to be 3.4 pCi/l (0.13 Bq/l) (MKF and JEG 1989). The



WELDON SPRING SITE WSCP/WSRP/WSVP GROUNDWATER MONITORING WELL NETWORK

FIGURE 2-1

REPORT NO.	DOE/OR/21548-364	EXHIBIT NO.:	A/CP/275/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91

TABLE 2-1 Third Quarter Nitroaromatic Results for Groundwater at the WSCP/RP/VP

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-2001-Q392	ND	ND	0.087	0.060	ND	0.035
GW-2002-Q392	ND	ND	0.063	0.39	ND	ND
GW-2003-Q392	ND	ND	0.15	0.80	ND	ND
GW-2030-Q392	ND	ND	0.14	10.0	14.0	9.5
GW-2032-Q392	ND	ND	0.15	4.0	9.0	3.2
GW-2033-Q392	ND	ND	0.34	8.0	3.2	12.0
GW-3003-Q392	ND	ND	0.061	0.13	ND	ND
GW-3006-Q392	ND	ND	ND	ND	ND	ND
GW-3008-Q392	NA	NA	NA	NA	NA	NA
GW-3009-Q392	ND	ND	0.20	0.057	ND	0.14
GW-3023-Q392	ND	ND	8.5	8.4	ND	ND
GW-4001-Q392	ND	0.11	3.2	5.8	1.7	72
GW-4002-Q392	ND	ND	ND	0.19	0.22	0.32
GW-4003-Q392	ND	ND	ND	ND	ND	ND
GW-4004-Q392	ND	ND	ND	ND	ND	ND
GW-4005-Q392	ND	ND	ND	ND	ND	ND
GW-4006-Q392	0.037	ND	0.091	4.4	ND	10.0
GW-4007-Q392	ND	ND	ND	ND	ND	ND
GW-4008-Q392	ND	ND	ND	ND	ND	ND
GW-4009-Q392	ND	ND	ND	ND	ND	ND
GW-4010-Q392	ND	ND	ND	ND	ND	ND
GW-4011-Q392	ND	ND	ND	ND	ND	ND
GW-4012-Q392	ND	ND	ND	ND	ND	ND
GW-4013-Q392	ND	ND	0.056	0.84	0.040	32
GW-4014-Q392	ND	ND	ND	0.052	0.031	0.40
GW-4015-Q392	ND	ND	0.048	0.59	ND	0.34
GW-4016-Q392	ND	ND	ND	ND	ND	ND
GW-4017-Q392	ND	ND	ND	ND	ND	ND
GW-4018-Q392	ND	ND	ND	ND	ND	ND

TABLE 2-1 Third Quarter Nitroaromatic Results for Groundwater at the WSCP/RP/VP (Continued)

Sample ID	NB (μg/l)	1,3-DNB (μg/l)	2,4-DNT (μg/l)	2,6-DNT (μg/l)	2,4,6-TNT (μg/l)	1,3,5-TNB (μg/l)
GW-4019-Q392	ND	ND	ND	ND	ND	ND
GW-4020-Q392	ND	ND	ND	ND	ND	ND
GW-4021-Q392	ND	ND	ND	ND	ND	ND
GW-4022-Q392	ND	ND	ND	ND	ND	ND
GW-4023-Q392	ND	ND	0.076	0.039	ND	0.14

NA - Not Available
ND - Not Detected

U.S. Environmental Protection Agency (EPA) has not yet established a drinking water standard for uranium; however, the proposed maximum contaminant level (MCL) is 20 μg/l, which converts to 13.6 pCi/l (0.50 Bq/l) using a new site-specific conversion factor of 0.68 pCi/μg (assuming isotopic equilibrum). The increase to 13.6 pCi/l (0.50 Bq/l) from the previously reported value of 12 pCi/l (0.44 Bq/l) reflects improved quantification of the average U-234/U-238 activity ratios for uranium present at the Weldon Spring Site Remedial Action Project (WSSRAP). The U.S. Department of Energy (DOE) has a health-based, derived concentration guideline (DCG) of 600 pCi/l (22.2 Bq/l) in surface water effluent.

Total uranium results for samples from the quarterly monitored wells at the WSCP/RP/VP are presented in Table 2-2. Uranium concentrations remained within historical ranges at all locations for which data are presently available.

2.1.3 Sulfate and Nitrate Results

Sulfate and nitrate concentrations are measured during each monitoring period. Results from the quarterly monitored wells are shown in Table 2-2. Third quarter results are within historical ranges with the exception of a new nitrate high in MW-3023 and a nitrate low in MW-3009. A new sulfate high was recorded in MW-2033 and a new low in MW-2003. These extreme values are thought to reflect natural fluctuation in these wells.

TABLE 2-2 Third Quarter Uranium and Inorganic Anion Results for Groundwater at the WSCP/RP/VP

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-2001-Q392	30.6	8.70	ND
GW-2002-Q392	264	118	ND
GW-2003-Q392	229	92.7	ND
GW-2030-Q392	1.40	39.5	9.80
GW-2032-Q392	55.0	55.0	ND
GW-2033-Q392	0.74	28.4	NA
GW-3003-Q392	338	152	18
GW-3006-Q392	0.07	22.7	ND
GW-3008-Q392	NA	NA	NA
GW-3009-Q392	60.8	84.9	NA
GW-3023-Q392	495	305	8.30
GW-4001-Q392	32.6	65.6	ND
GW-4002-Q392	6.00	15.3	ND
GW-4003-Q392	0.91	34.0	ND
GW-4004-Q392	0.94	19.9	2.0
GW-4005-Q392	2.00	20.6	ND
GW-4006-Q392	4.40	28.4	ND
GW-4007-Q392	0.25	12.8	2.5
GW-4008-Q392	0.03	14.0	ND
GW-4009-Q392	0.17	16.2	5.4
GW-4010-Q392	0.16	22.3	3.7
GW-4011-Q392	28.9	54.8	6.4
GW-4012-Q392	0.06	46.7	0.82
GW-4013-Q392	49.7	39.7	ND
GW-4014-Q392	0.02	26.8	ND
GW-4015-Q392	1.40	7.10	ND
GW-4016-Q392	ND	17.6	3.7
GW-4017-Q392	0.45	5.60	ND

TABLE 2-2 Third Quarter Uranium and Inorganic Anion Results for Groundwater at the WSCP/RP/VP (Continued)

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-4018-Q392	2.40	6.50	ND
GW-4019-Q392	0.41	6.30	1.7
GW-4020-Q392	2.80	129	12.0
GW-4021-Q392	0.12	264	6.9
GW-4022-Q392	0.38	37.8	4.8
GW-4023-Q392	4.00	68.2	ND

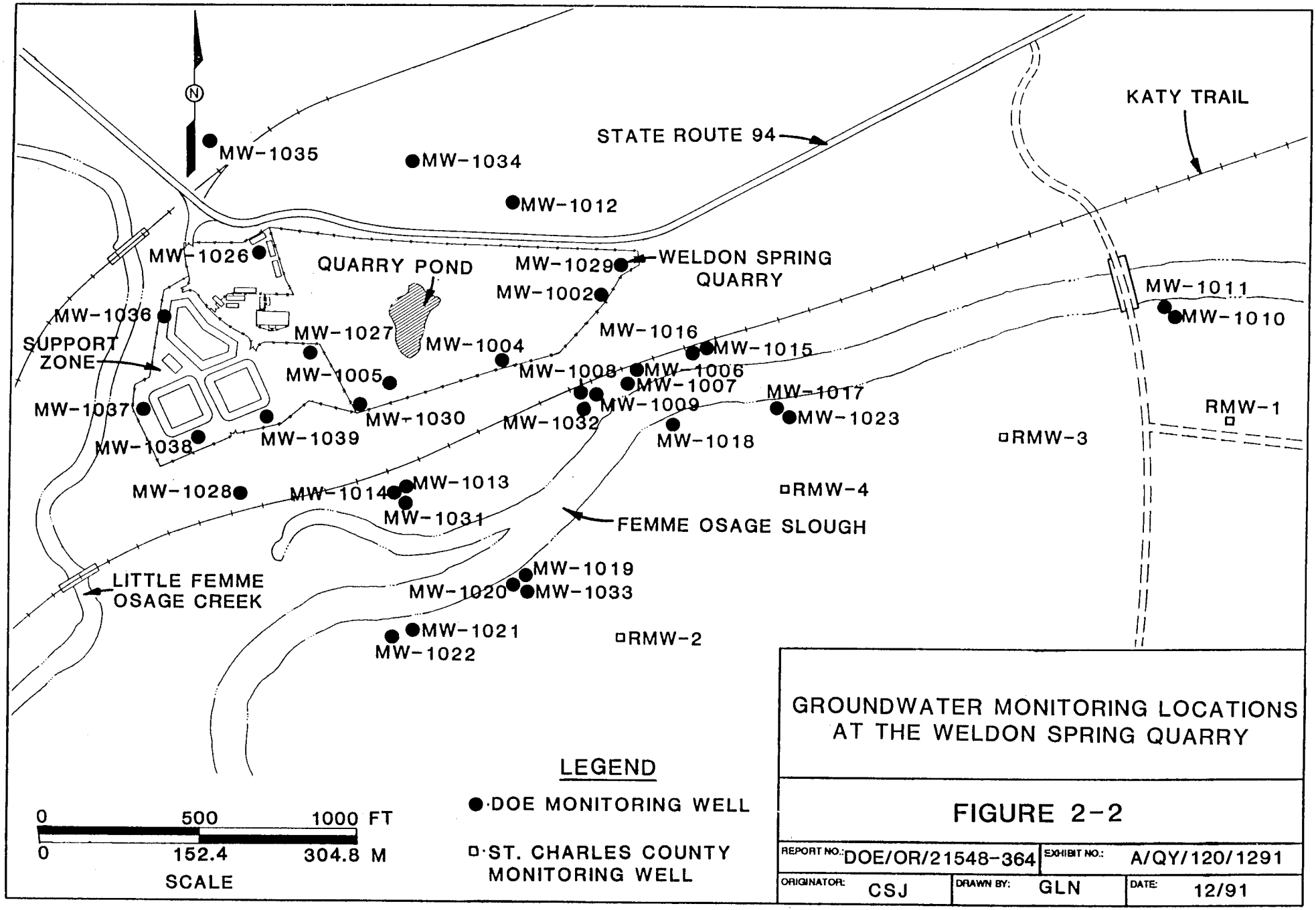
ND - Not Detected
NA - Not Available

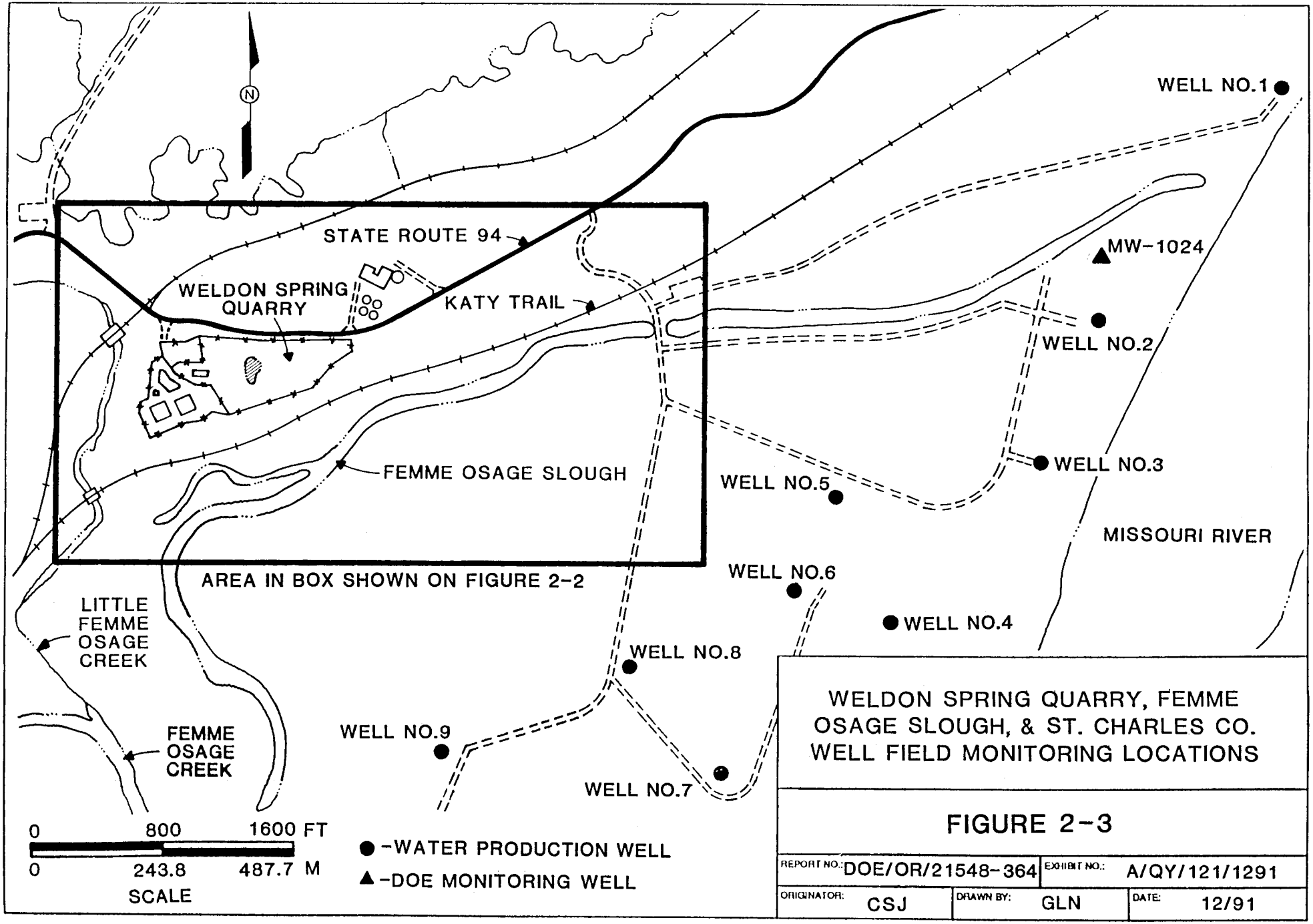
2.2 Weldon Spring Quarry

Groundwater at the WSQ has become radiologically and chemically contaminated as a result of contact with, or migration from, wastes present in the WSQ. Monitoring of the groundwater at and near the WSQ is of particular concern because of the proximity of the St. Charles County well field. The well field is located approximately 0.8 km (0.5 mi) to the south of the WSQ. Monitoring of contaminants in groundwater and the protection of the well field is a top priority at the WSSRAP.

Groundwater is currently being monitored at 48 wells located in and around the quarry area. Thirty-six monitoring wells installed by the DOE are currently utilized in or near the quarry. Four monitoring wells were installed by St. Charles County in 1986 and are currently included in the DOE's monitoring program. Eight St. Charles County municipal wells, and the treated and untreated water from the St. Charles County water treatment plant, are also monitored for the presence of these contaminants. All monitoring well locations are shown in Figures 2-2 and 2-3. These wells monitor groundwater in both the bedrock and alluvial aquifers associated with the WSQ.

Two separate groundwater monitoring programs have been developed for the WSQ area. The first program is a bimonthly sampling of all wells north of the Femme Osage Slough and MW-1010 and MW-1011 located south of the slough. In addition, wells MW-1035, MW-1036,


N
MW-1035
MW-1034
STATE ROUTE 94
KATY TRAIL
MW-1012
MW-1026
QUARRY POND
MW-1029
WELDON SPRING QUARRY
MW-1002
MW-1011
MW-1010
MW-1036
SUPPORT ZONE
MW-1027
MW-1004
MW-1016
MW-1015
MW-1005
MW-1008
MW-1006
MW-1007
MW-1017
MW-1037
MW-1030
MW-1009
RMW-1
MW-1032
MW-1023
MW-1039
MW-1018
RMW-3
MW-1038
MW-1028
MW-1014
MW-1013
RMW-4
MW-1031
FEMME OSAGE SLOUGH
MW-1019
LITTLE FEMME OSAGE CREEK
MW-1020
MW-1033
MW-1021
RMW-2
MW-1022
0
500
1000 FT
0
152.4
304.8 M
SCALE
LEGEND
DOE MONITORING WELL
ST. CHARLES COUNTY MONITORING WELL
GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING QUARRY
FIGURE 2-2
REPORT NO.: DOE/OR/21548-364
EXHIBIT NO.: A/QY/120/1291
ORIGINATOR: CSJ
DRAWN BY: GLN
DATE: 12/91



WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, & ST. CHARLES CO. WELL FIELD MONITORING LOCATIONS

FIGURE 2-3

REPORT NO.:	DOE/OR/21548-364	EXHIBIT NO.:	A/QY/121/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91

MW-1037, MW-1038, and MW-1039 will be sampled bimonthly until operation of the Weldon Spring Quarry water treatment plant is initiated. The second program is the quarterly sampling of all wells south of the Femme Osage Slough, excluding MW-1010 and MW-1011, but including the St. Charles County well field. Both the raw and treated waters from the St. Charles County water treatment plant are also sampled quarterly.

2.2.1 Radiological Results

Radiological data are presented in Tables 2-3 and 2-4 for samples collected for the fourth bimonthly period and the third quarter. The results show typical fluctuations near the average levels in the WSQ area. Last quarter the uranium concentration in MW-1032 exceeded the historic average; results for this quarter are slightly below the results for the second quarter. Continued monitoring will be performed to determine whether this is a trend. Detectable concentrations of uranium were indicated from the St. Charles County RMW-series wells. In addition to being within historic averages and representative of background levels, these levels are the results of lower detection limits for uranium during analytical testing. The results for the St. Charles County production wells (PWOX series) were not available from the laboratory at the time of this report.

The St. Charles County RMW-series and production wells are sampled annually for gross alpha. The results of this analysis are presented in Table 2-4. The results for the St. Charles County production wells were not made available at the time of this report. The concentrations in the RMW-series wells are consistent with background values of waters in or near the WSQ.

2.2.2 Nitroaromatic Compounds Results

Analytical results for the fourth bimonthly period and the third quarter for nitroaromatic compounds are presented in Tables 2-5 and 2-6. No monitoring wells south of the Femme Osage Slough showed detectable concentrations of nitroaromatic compounds during the third quarter of 1992. The elevated levels of nitroaromatic compounds detected in rim well MW-1004 remain consistent with the second and third bimonthly results. Nitroaromatic levels have increased in bedrock monitoring well MW-1027. The distribution and magnitude of nitroaromatic contamination in the remainder of the wells near the quarry remain consistent with historical levels.

TABLE 2-3 Fourth Bimonthly (July/August) Uranium and Inorganic Anion Results for Groundwater at the WSQ

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-1002-B492	0.34	54.2	ND
GW-1004-B492	0.56	372	6100
GW-1005-B492	ND	170	2200
GW-1006-B492	0.14	426	4100
GW-1007-B492	ND	61.6	59
GW-1008-B492	ND	279	4800
GW-1009-B492	ND	275	10
GW-1010-B492	0.38	ND	ND
GW-1011-B492	WELL DRY		
GW-1012-B492	0.99	65.9	2.4
GW-1013-B492	ND	97.9	920
GW-1014-B492	ND	108	1100
GW-1015-B492	1.80	352	1500
GW-1016-B492	1.30	271	690
GW-1026-B492	ND	0.92	ND
GW-1027-B492	0.12	100	900
GW-1028-B492	ND	71.4	ND
GW-1029-B492	ND	76.9	ND
GW-1030-B492	ND	105	3.3
GW-1031-B492	ND	35.8	26
GW-1032-B492	ND	254	1600
GW-1034-B492	0.41	71.5	0.58
GW-1035-B492	0.20	35.3	ND
GW-1036-B492	ND	58.4	4.6
GW-1037-B492	ND	15.1	ND
GW-1038-B492	ND	45.1	2.4
GW-1039-B492	ND	54.6	0.72

ND - Not Detected
NA - Not Available

TABLE 2-4 Third Quarter Uranium and Inorganic Anion Results for Groundwater at the WSQ

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)	Gross Alpha (pCi/l)
GW-1017-Q392	ND	ND	0.2	NR
GW-1018-Q392	ND	100.0	0.61	NR
GW-1019-Q392	ND	0.85	NA	NR
GW-1020-Q392	0.17	41.9	NA	NR
GW-1021-Q392	ND	1.80	NA	NR
GW-1022-Q392	0.12	0.33	NA	NR
GW-1023-Q392	ND	4.00	0.2	NR
GW-1024-Q392	ND	3.10	ND	3.0
GW-1033-Q392	ND	10.0	NA	NA
GW-RMW1-Q392	ND	27.2	0.82	7.7
GW-RMW2-Q392	ND	12.3	NA	NA
GW-RMW3-Q392	ND	5.10	0.2	7.4
GW-RMW4-Q392	ND	23.4	1.4	3.9
GW-PW02-Q392	NR	NR	NA	NA
GW-PW03-Q392	NR	NR	NA	NA
GW-PW04-Q392	NR	NR	NA	NA
GW-PW05-Q392	NR	NR	NA	NA
GW-PW06-Q392	NR	NR	NA	NA
GW-PW07-Q392	NR	NR	NA	NA
GW-PW08-Q392	NR	NR	NA	NA
GW-PW09-Q392	NR	NR	NA	NA
GW-RAWW-Q392	NR	NR	NA	NA
GW-FINW-Q392	NR	NR	NA	NA

ND - Not Detected
NA - Not Available
NR - Not Required for third quarter

TABLE 2-5 Fourth Bimonthly (July/August) Nitroaromatic Results for Groundwater at the WSQ

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1002-B492	ND	0.21	0.078	11	46	280
GW-1004-B492	ND	ND	4.2	5.7	22	7.0
GW-1005-B492	ND	ND	0.098	0.034	ND	ND
GW-1006-B492	ND	ND	0.40	6.0	24	140
GW-1007-B492	ND	ND	ND	ND	ND	ND
GW-1008-B492	ND	ND	ND	0.10	ND	ND
GW-1009-B492	ND	ND	ND	ND	ND	ND
GW-1010-B492	ND	ND	ND	ND	ND	ND
GW-1011-B492	WELL DRY					
GW-1012-B492	ND	ND	ND	ND	ND	ND
GW-1013-B492	ND	ND	0.035	0.014	ND	ND
GW-1014-B492	ND	ND	ND	ND	ND	ND
GW-1015-B492	ND	0.093	0.066	0.88	32	230
GW-1016-B492	ND	ND	ND	0.20	5.0	27
GW-1026-B492	ND	ND	ND	ND	ND	ND
GW-1027-B492	ND	ND	7.5	5.3	38	0.086
GW-1028-B492	ND	ND	ND	ND	ND	ND
GW-1029-B492	ND	ND	ND	ND	ND	ND
GW-1030-B492	ND	ND	0.033	ND	ND	ND
GW-1031-B492	ND	ND	ND	ND	ND	ND
GW-1032-B492	ND	ND	0.096	0.084	0.060	ND
GW-1034-B492	ND	ND	ND	ND	ND	ND
GW-1035-B492	ND	ND	ND	ND	ND	ND
GW-1036-B492	ND	ND	ND	ND	ND	ND
GW-1037-B492	ND	ND	ND	ND	ND	ND
GW-1038-B492	ND	ND	ND	ND	ND	ND
GW-1039-B492	ND	ND	ND	ND	ND	ND

NA - Not Available
ND - Not Detected

TABLE 2-6 Third Quarter Nitroaromatic Results for Groundwater at the WSQ

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1017-Q392	ND	ND	ND	ND	ND	ND
GW-1018-Q392	ND	ND	ND	ND	ND	ND
GW-1019-Q392	ND	ND	ND	ND	ND	ND
GW-1020-Q392	ND	ND	ND	ND	ND	ND
GW-1021-Q392	ND	ND	ND	ND	ND	ND
GW-1022-Q392	ND	ND	ND	ND	ND	ND
GW-1023-Q392	ND	ND	ND	ND	ND	ND
GW-1024-Q392	ND	ND	ND	ND	ND	ND
GW-1033-Q392	ND	ND	ND	ND	ND	ND
GW-RMW1-Q392	ND	ND	ND	ND	ND	ND
GW-RMW2-Q392	ND	ND	ND	ND	ND	ND
GW-RMW3-Q392	ND	ND	ND	ND	ND	ND
GW-RMW4-Q392	ND	ND	ND	ND	ND	ND
GW-PW02-Q392	ND	ND	ND	ND	ND	ND
GW-PW03-Q392	ND	ND	ND	ND	ND	ND
GW-PW04-Q392	ND	ND	ND	ND	ND	ND
GW-PW05-Q392	ND	ND	ND	ND	ND	ND
GW-PW06-Q392	ND	ND	ND	ND	ND	ND
GW-PW07-Q392	ND	ND	ND	ND	ND	ND
GW-PW08-Q392	ND	ND	ND	ND	ND	ND
GW-PW09-Q392	ND	ND	ND	ND	ND	ND
GW-RAWW-Q392	ND	ND	ND	ND	ND	ND
GW-FINW-Q392	ND	ND	ND	ND	ND	ND

NA - Not Available
ND - Not Detected

2.2.3 Inorganic Anions Results

Two inorganic anions, nitrate and sulfate, are sampled in all of the wells monitored at the WSQ. The analytical results for the fourth bimonthly period and the third quarter are presented in Tables 2-3 and 2-4. An elevated level of sulfate was detected in rim well MW-1005 and alluvial well MW-1010. The results for the remainder of the monitoring wells are consistent with data reported in the previous environmental monitoring reports. The WSQ groundwater samples continue to indicate that there is no significant nitrate contamination of the groundwater. The results indicate that elevated sulfate levels are present in groundwater within the WSQ and north of the Femme Osage Slough.

2.2.4 Metals Results

All wells in the WSQ monitoring program are sampled for arsenic and barium. The results for the fourth bimonthly period and the third quarter are presented in Tables 2-7 and 2-8. Arsenic levels were consistent with historical values for groundwater in the vicinity of the WSQ. Barium levels have remained elevated in the wells in the vicinity of the Femme Osage Slough. Elevated barium levels indicated in the second and third bimonthly periods for rim well MW-1002 have remained unchanged.

2.3 Springs

Five springs near the Weldon Spring site (WSS), which are measurably influenced by site-related contaminants, were sampled during the third quarter (see Figure 2-4). During the third quarter, spring samples were analyzed for uranium and inorganic anions. Results are presented in Table 2-9. SP-6301 and SP-6306 were sampled during high and low flow to evaluate the groundwater (which is thought to predominate low flow) and surface water (which is thought to dominate high flow) components of flow. In comparison to the high flow sample from SP-6301, the low flow sample had higher levels of nitrate and sulfate, but a similar level of uranium. There was little difference between the high and low flow samples from SP-6306.

TABLE 2-7 Fourth Bimonthly (July/August) Metal Results for Groundwater at the WSQ

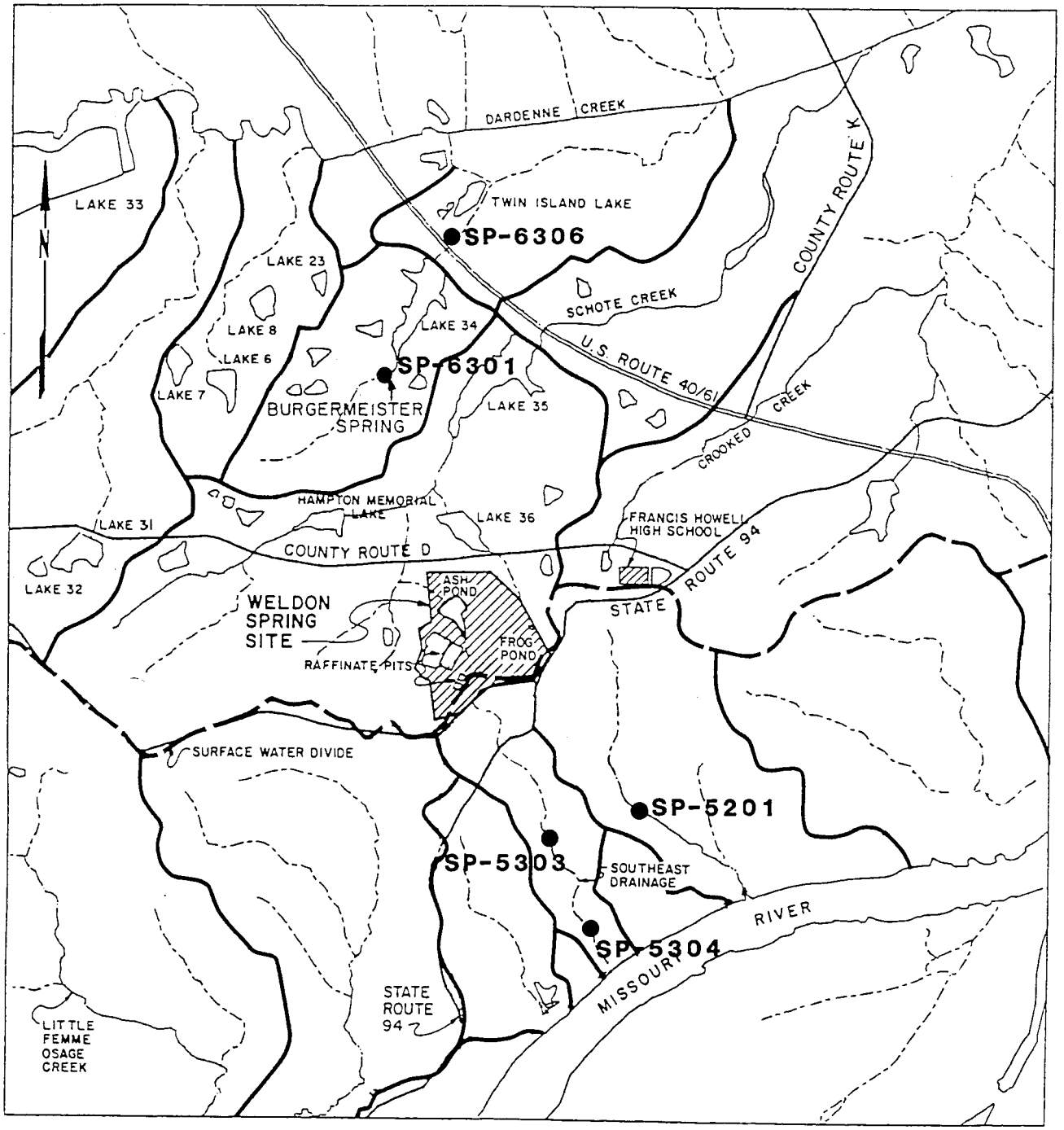
Sample ID	Arsenic (µg/l)	Barium (µg/l)
GW-1002-B492	ND	127
GW-1004-B492	ND	43.3
GW-1005-B492	ND	54.3
GW-1006-B492	ND	56.7
GW-1007-B492	25.2	336
GW-1008-B492	ND	50.2
GW-1009-B492	2.29	482
GW-1010-B492	103	407
GW-1011-B492	WELL DRY	
GW-1012-B492	ND	124
GW-1013-B492	2.70	142
GW-1014-B492	ND	158
GW-1015-B492	ND	109
GW-1016-B492	ND	119
GW-1026-B492	20.6	360
GW-1027-B492	ND	92.6
GW-1028-B492	5.90	303
GW-1029-B492	ND	118
GW-1030-B492	ND	132
GW-1031-B492	ND	94.1
GW-1032-B492	ND	93.3
GW-1034-B492	ND	154
GW-1035-B492	ND	200
GW-1036-B492	ND	264
GW-1037-B492	ND	639
GW-1038-B492	ND	199
GW-1039-B492	ND	425

ND - Not Detected
NA - Not Available

TABLE 2-8 Third Quarter Metal Results for Groundwater at the WSQ

Sample ID	Arsenic (µg/l)	Barium (µg/l)
GW-1017-Q392	144.0	1000
GW-1018-Q392	127.0	719
GW-1019-Q392	69.2	852
GW-1020-Q392	20.5	398
GW-1021-Q392	52.0	803
GW-1022-Q392	138	524
GW-1023-Q392	68.0	323
GW-1024-Q392	7.90	508
GW-1033-Q392	ND	398
GW-RMW1-Q392	4.80	474
GW-RMW2-Q392	14.2	319
GW-RMW3-Q392	26.10	727
GW-RMW4-Q392	26.10	231
GW-PW02-Q392	ND	321
GW-PW03-Q392	ND	249
GW-PW04-Q392	ND	283
GW-PW05-Q392	ND	398
GW-PW06-Q392	ND	328
GW-PW07-Q392	ND	470
GW-PW08-Q392	2.30	464
GW-PW09-Q392	3.20	528
GW-RAWW-Q392	ND	372
GW-FINW-Q392	ND	134

ND - Not Detected
NA - Not Available



● SPRING

0 3200 6400 FT

0 975.4 1950.7 M

SCALE

SPRINGS IN THE VICINITY OF THE WSS

FIGURE 2-4

REPORT NO.:	DOE/OR/21548-364	EXHIBIT NO.:	A/VP/040/0592		
ORIGINATOR:	MGT	DRAWN BY:	GLN	DATE:	5/92

TABLE 2-9 Third Quarter Uranium and Inorganic Anion Results for Springs Near the Weldon Spring Site

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
SP-6301-Q392-H	1.60	52.0	81.0
SP-6301-Q392-L	56.1	66.8	80.0
SP-6306-Q392-H	0.28	6.40	ND
SP-6306-Q392-L	0.32	5.70	0.96
SP-5303-Q392	0.65	62.1	160
SP-5304-Q392	0.76	50.7	140
SP-5201-Q392	0.18	57.8	0.75

ND - Not Detected
NA - Not Available

3 SURFACE WATER MONITORING

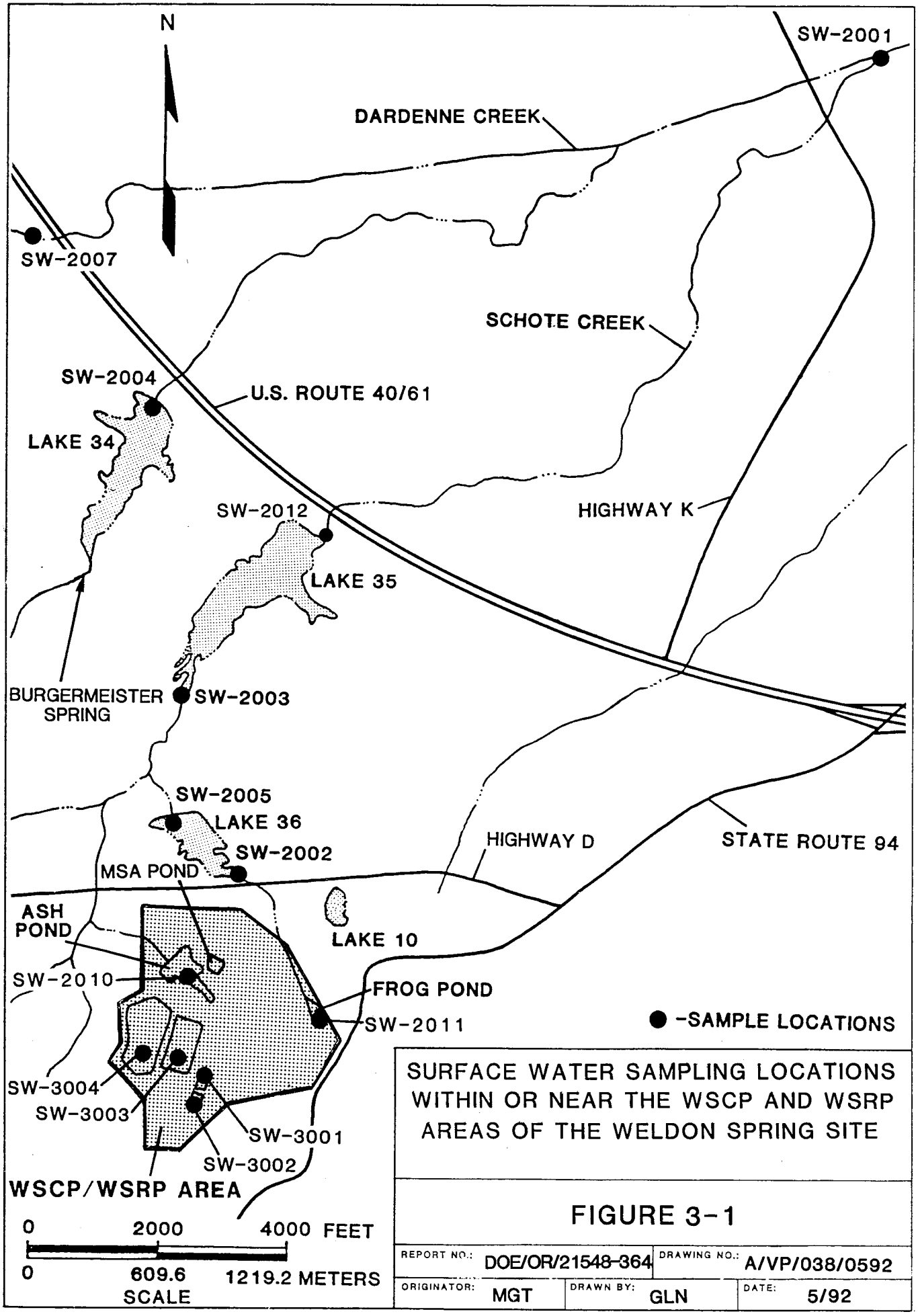
Routine samples were collected during the third quarter of 1992 from both on-site and off-site surface water locations. All surface water samples were analyzed without filtering, unless a specific comparison of dissolved versus total contaminant concentrations was desired. Some analytical results are not available at this time; however, they will be presented in the 1992 annual site environmental report (ASER).

3.1 Chemical Plant/Raffinate Pits/Vicinity Properties

During the third quarter, surface water samples were collected from 11 of the 15 surface water sampling locations shown in Figure 3-1 and analyzed for uranium, radium, thorium, gross alpha, and gross beta. Monitoring point SW-2016, not shown in Figure 3-1, is located at the intersection of Dardenne Creek and County Highway N. This is now the furthest location downstream at which to measure contaminant levels in Dardenne Creek after it has received the Schote Creek contribution. The results, presented in Table 3-1, indicated that conditions at sampling locations remain consistent with historical values.

3.2 Weldon Spring Quarry

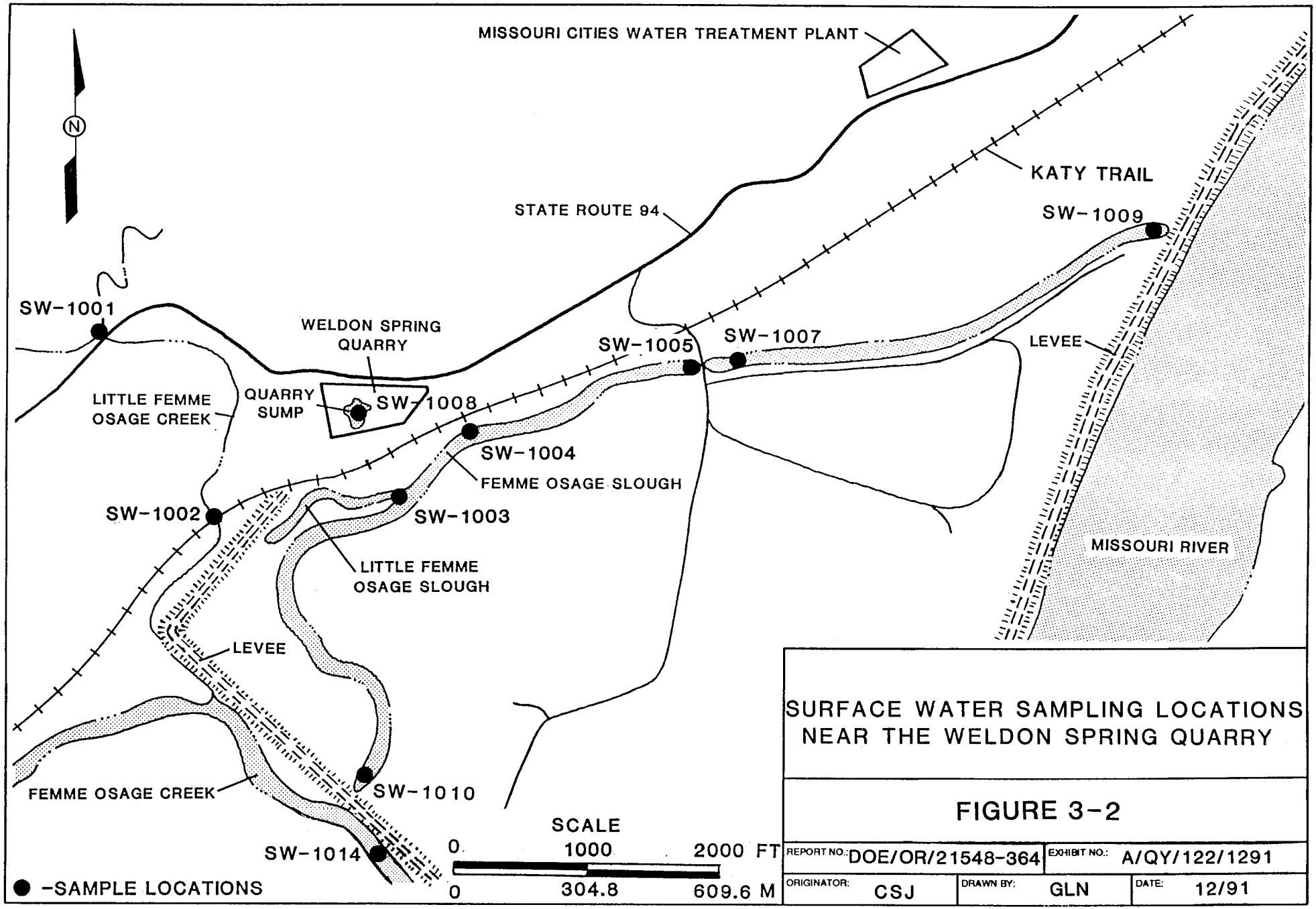
Monitoring locations SW-1001, SW-1002, and SW-1014 (Figure 3-2) monitor the Little Femme Osage Creek at points upstream and downstream of the Weldon Spring Quarry (WSQ). Six sampling locations, SW-1003 through SW-1005, SW1007, SW-1009, and SW-1010, are distributed along the Femme Osage Slough in the vicinity of the WSQ. These locations were chosen to provide the most representative data for areas potentially impacted by the quarry contamination. Location SW-1008 monitors the ponded water within the WSQ and provides a rough determination of the concentrations of the various contaminants in the WSQ pond, which may migrate to groundwater. Locations SW-1011 through SW-1013 (Figure 3-3) and SW-1015 (Howard Bend) provide baseline water quality data for the Missouri River at points both upstream and downstream from the WSQ and the Southeast Drainage (5300) easement.



SURFACE WATER SAMPLING LOCATIONS WITHIN OR NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

FIGURE 3-1

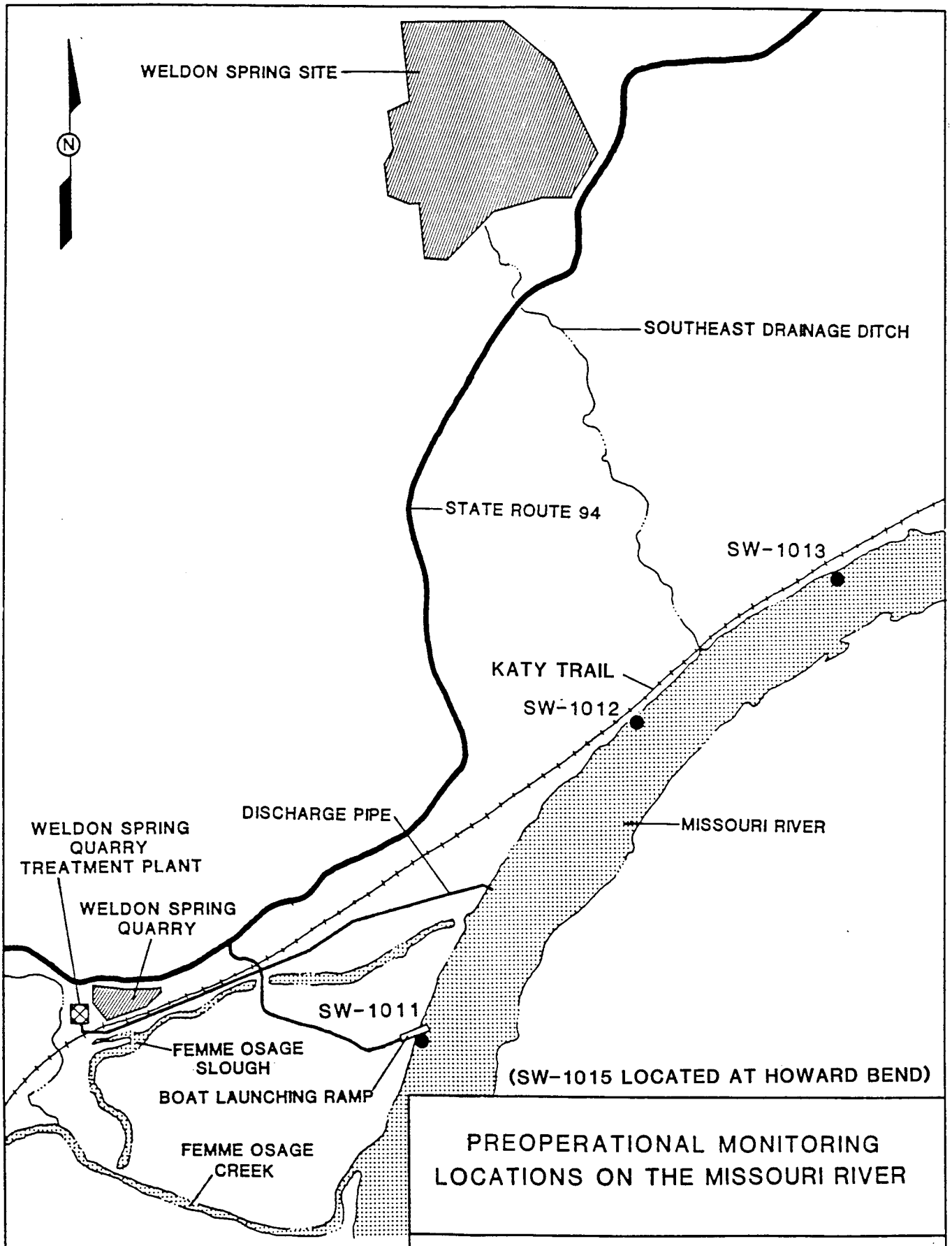
REPORT NO.: DOE/OR/21548-364	DRAWING NO.: A/VP/038/0592	
ORIGINATOR: MGT	DRAWN BY: GLN	DATE: 5/92



SURFACE WATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 3-2

REPORT NO.: DOE/OR/21548-364	EXHIBIT NO.: A/QY/122/1291	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 12/91



PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

FIGURE 3-3

REPORT NO.	EXHIBIT NO.	
DOE/OR/21548-364	A/VP/193/1291	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 12/91

TABLE 3-1 Third Quarter Radiological Results for Groundwater at the WSCP/RP/VP

Sample ID	Gross Alpha (pCi/l)	Gross Beta (pCi/l)	Ra-226 (pCi/l)	Ra-228 (pCi/l)	Th-228 (pCi/l)	Th-230 (pCi/l)	Th-232 (pCi/l)	Uranium (pCi/l)
SW-2001-Q392	ND	ND	ND	3.4	ND	0.8	ND	ND
SW-2002-Q392	ND	ND	ND	ND	ND	0.9	ND	23
SW-2003-Q392	ND	ND	ND	ND	ND	ND	ND	6.1
SW-2004-Q392	ND	ND	ND	ND	ND	2.1	0.8	11
SW-2005-Q392	ND	ND	ND	ND	ND	0.8	ND	21
SW-2007-Q392	ND	ND	ND	ND	ND	2.8	ND	ND
SW-2010-Q392	NA	NA	NA	NA	NA	NA	NA	NA
SW-2011-Q392	NA	NA	NA	NA	NA	NA	NA	NA
SW-2012-Q392	NA	NA	NA	NA	NA	NA	NA	NA
SW-2016-Q392	ND	ND	ND	ND	ND	1.0	ND	ND
SW-3001	NR	NR	NR	NR	NR	NR	NR	NR
SW-3002	NR	NR	NR	NR	NR	NR	NR	NR
SW-3003	NR	NR	NR	NR	NR	NR	NR	NR
SW-3004	NR	NR	NR	NR	NR	NR	NR	NR
SW-5311-Q392	109	64.4	2.0	ND	ND	0.9	ND	110

ND - Not Detected
NA - Not Available
NR - Not required during Third Quarter

3.2.1 Radiological Results

Surface water samples were collected for radiological analyses from the 13 locations shown in Figures 3-2 and 3-3. The uranium results for the fourth bimonthly period are presented in Table 3-2. Fourth bimonthly uranium concentrations for the sampling locations in the Femme Osage Slough and Little Femme Osage Creek remain within historical ranges.

3.2.2 Weldon Spring Quarry Pond Results

A summary of the analytical results for the fourth bimonthly sampling period is presented in Table 3-3. This sampling location is summarized separately to characterize the surface waters in the WSQ which may migrate and effect groundwater. The results for this bimonthly period are within historic ranges for all parameters analyzed.

TABLE 3-2 Fourth Bimonthly (July/August) Uranium Results in Surface Water at the WSQ

Sample ID	Total Uranium (pCi/l)
SW-1001-B492	ND
SW-1002-B492	ND
SW-1003-B492	44
SW-1004-B492	51
SW-1005-B492	41
SW-1007-B492	11
SW-1008-B492	NA
SW-1009-B492	7.2
SW-1010-B492	71
SW-1011-B492	2.4
SW-1012-B492	ND
SW-1013-B492	ND
SW-1014-B492	0.5

ND - Not Detected
NA - Not Available

TABLE 3-3 Fourth Bimonthly (July/August) Results for SW-1008

Parameter	Concentration	Units
Ra-226	NA	pCi/l
Ra-228	NA	pCi/l
Th-228	NA	pCi/l
Th-230	NA	pCi/l
Th-232	NA	pCi/l
Gross Alpha	NA	pCi/l
Gross Beta	NA	pCi/l
Nitrate	ND	mg/l
Sulfate	57.8	mg/l
Nitrobenzene	ND	µg/l
1,3-DNB	ND	µg/l
2,4-DNT	18	µg/l
2,6-DNT	1.1	µg/l
2,4,6-TNT	4.2	µg/l
1,3,5-TNB	0.049	µg/l

ND - Not Detected
NA - Not Available

4 EFFLUENT MONITORING

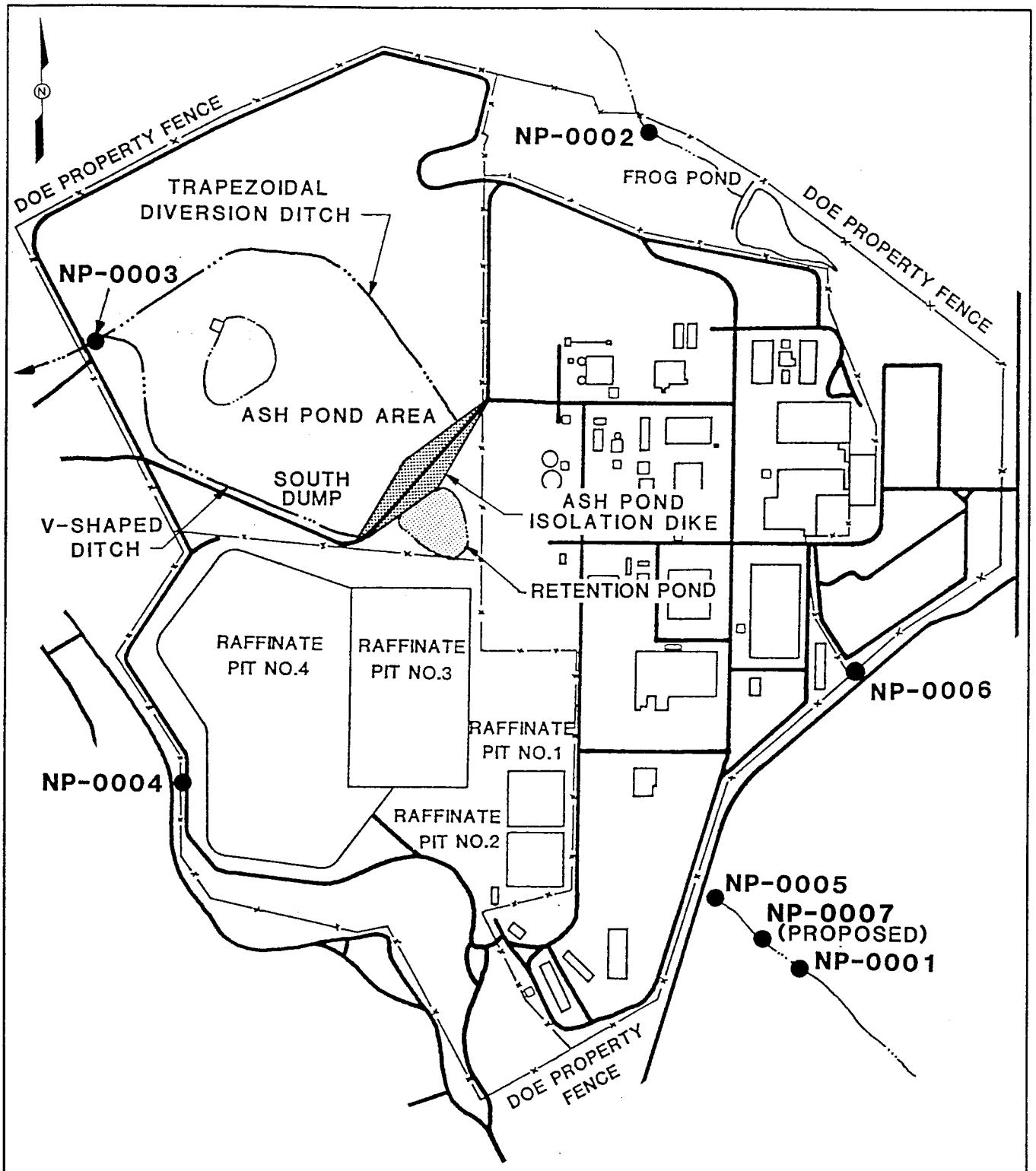
The National Pollutant Discharge Elimination System (NPDES) permit process is authorized by Section 402(a)(1) of the *Clean Water Act of 1977.* The authority to issue permits is delegated to the State of Missouri by the U.S. Environmental Protection Agency (EPA). The State of Missouri has issued four NPDES permits to the U.S. Department of Energy (DOE) allowing the discharge of storm water, hydrostatic test water, and treated wastewater to waters of the state. The permits require that samples of the wastewater be collected periodically and the results reported to the Missouri Department of Natural Resources. The following sections contain the analytical results for samples collected during July, August, and September of 1992.

4.1 National Pollutant Discharge Elimination System Data Review

Effluent samples were collected and analyzed in compliance with the Weldon Spring site NPDES permits. Permit No. MO-0107701 was issued on October 1, 1990, and currently addresses the five storm water and two wastewater discharges shown in Figure 4-1. Outfalls NP-0001 through NP-0005 represent storm water discharges; Outfall NP-0006 represents the treated wastewater discharge associated with the administration building sanitary wastewater treatment plant; and Outfall NP-0007 represents the site water treatment plant, which is under construction, but not yet completed. There was no discharge from Outfall NP-0007. Outfalls NP-0006 and NP-0007 have effluent limitations. The five storm water outfalls have "monitoring only" requirements for permitted parameters. Third quarter 1992 analytical data for each outfall are presented in Table 4-1.

Permit No. MO-0108987 was issued on May 5, 1989, for Outfall NP-1001 of the Weldon Spring Quarry water treatment plant. The plant construction is completed, but no discharge took place during the third quarter of 1992.

NPDES permit No. MO-G680001 was issued on December 19, 1991. This permit is for discharge of uncontaminated water used for new tank and basin hydrostatic testing at the quarry water treatment plant. Third quarter 1992 analytical data are presented in Table 4-2. Waters discharged from hydrostatic testing at the quarry water treatment plant were in compliance with permitted limits, with the exception of the following occurrence.



SCALE 0 500 1000 FT
0 152.4 304.8 M

NPDES SURFACE WATER SAMPLING LOCATIONS AT THE WSCP/RP

FIGURE 4-1

REPORT NO.:	DOE/OR/21548-364	EXHIBIT NO.:	A/CP/050/0592		
ORIGINATOR:	TW	DRAWN BY:	GLN	DATE:	5/92

TABLE 4-1 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006

Outfall NP-0001 NPDES data for Q3 1992

Date Sampled	Flow	Susp. Solids	Set. Solids	Nitrate	pH	Lithium	Gross Alpha	Total Uranium	
Units	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
July 21	22,000	59.0	<0.1	0.543	7.02	ND (0.009)	404	0.669	455
August 10	22,000	21.0	<0.1	0.246	6.93	ND (0.009)	432	0.656	446

Outfall NP-0002 NPDES data for Q3 1992

Date Sampled	Flow	Susp. Solids	Set. Solids	Nitrate	pH	Lithium	Gross Alpha	Total Uranium	
Units	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
July 7	2,100	148	<0.1	0.26	7.38	ND (0.023)	183	0.289	197
August 10	32,700	10.0	<0.1	0.044	7.68	ND (0.009)	96.7	0.156	106
September 1	9,000	ND (2.0)	<0.1	0.12	7.61	ND (0.009)	*	0.353	240

Outfall NP-0003 NPDES data for Q3 1992

Date Sampled	Flow	Susp. Solids	Set. Solids	Nitrate	pH	Lithium	Gross Alpha	Total Uranium	
Units	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
July 13	28,800	3.00	<0.1	0.26	7.05	ND (0.006)	58.0	0.0946	64.3
August 27	2,900	32.0	<0.1	0.45	7.51	ND (0.010)	0.369	0.426	290
September 8	80,000	ND (5.0)	<0.1	0.27	6.85	ND (0.024)	39.0	0.0956	65.0

TABLE 4-1 Results of Monthly NPDES Monitoring for NP-0001 through NP-0006 (Continued)

Outfall NP-0004 NPDES data for Q3 1992

Date Sampled	Flow	Susp. Solids	Set. Solids	Nitrate	pH	Lithium	Gross Alpha	Total Uranium	
Units	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
No Discharge	--	--	--	--	--	--	--	--	--

Outfall NP-0005 NPDES data for Q3 1992

Date Sampled	Flow	Susp. Solids	Set. Solids	Nitrate	pH	Lithium	Gross Alpha	Total Uranium	
Units	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
July 7	184,700	112.0	<0.1	0.81	7.43	ND (0.023)	5.67	0.00199	1.36
August 27	285,600	432.0	<0.1	0.96	7.46	0.0131	177.0	0.25	170
September 8	9,000	57.0	<0.1	0.43	6.74	0.0282	70.20	0.206	140

Outfall NP-0006 NPDES data for Q3 1992

Date Sampled	Flow	Susp. Solids	BOD	Fecal Coliform	pH
Units	GPD**	mg/l	mg/l	Colonies/100 ml	pH units
July 6	6,000	10	2	0	7.5
August 5	5,000	6	3	0	8.5
September 2	5,000	2	8	0	8.0

* Data not yet received from contract laboratory.
** Indicates flow rate at time of sample collection.
ND Not detected, detection limit is in parentheses.
-- Indicates analysis not done on this parameter.

TABLE 4-2 Results of NPDES Monitoring for Permit MO-G680001

Date Sampled	Flow	Oil and Grease*	Susp. Solids*	pH
Units	Gallons	mg/l	mg/l	
July 29	1,000	ND (5.0)	ND (5.0)	8.01
September 14	200,000	ND (5.0)	69	8.58
September 16	4,000	ND (5.0)	9	7.38
September 18	500	ND (5.0)	ND (5.0)	6.84

* Detection limit.

On September 14, 1992, storm water that accumulated in the quarry water treatment plant Effluent Pond 1 was pumped to the Little Femme Osage Creek. Water sampled from this event demonstrated a total suspended solids level of 69 mg/l, which is above the permitted limit of 50 mg/l. It is believed that a small amount of algae or sediment caused this elevated solids level.

NPDES permit No. MO-G680002 was issued on February 7, 1992. This permit is for discharge of uncontaminated water used for new tank and basin hydrostatic testing at the site water treatment plant. Third quarter 1992 analytical data are presented in Table 4-3. Waters discharged from hydrostatic testing at the site water treatment plant were in compliance with permitted limits with the exception of the following occurrence.

On August 25, 1992, a sample of water being pumped from the site water treatment plant sump into the adjacent siltation basin demonstrated a total suspended solids level of 219 mg/l, which exceeds the permitted limit of 50 mg/l. This concentration is believed to have resulted from the method used to discharge the water, and not from the tanks themselves. The method used involved discharging potable water from the tanks to a concrete floor drain and collection sumps, both of which are believed to have developed an accumulation of dust and sediment from previous building construction activities.

In the future, actions will be taken to ensure that discharged waters from hydrostatic testing meet permit limits. Hydrostatic test water will no longer be discharged to secondary containments such as floor sumps. Pretesting and/or pretreating the effluent by the mobile sump treatment system prior to discharge may be a viable option. In addition, engineering controls such as effluent filtering may be used to reduce suspended solids discharge.

TABLE 4-3 Results of NPDES Monitoring for Permit MO-680002

Date Sampled	Flow	Oil and Grease*	Susp. Solids*	pH
Units	Gallons	mg/l	mg/l	
August 25	1,500	(a)	219	7.08
August 26	1,750	ND (5.0)	13	7.02
September 3	200,000	ND (5.0)	19	9.4

* Detection limit.
(a) Sample bottle was broken during shipment. No analysis was performed.

4.1.1 Radiological Analysis

Gross alpha and uranium analyses corresponded well with past data. The storm water outfalls had the following ranges of uranium concentrations. The process sewer outfall NP-0001, had two sample values of 455 pCi/l (0.669 mg/l) and 446 pCi/l (0.656 mg/l). Frog Pond outfall, NP-0002, had values from 106 pCi/l (0.156 mg/l) to 240 pCi/l (0.353 mg/l). The Ash Pond outfall, NP-0003, had values from 64.3 pCi/l (0.0946 mg/l) to 290 pCi/l (0.426 mg/l). There was no discharge from NP-0004 during the periods specified for monitoring in the permit, in the third quarter. The Southeast Drainage outfall, NP-0005, had values from 1.36 pCi/l (0.00199 mg/l) to 170 pCi/l (0.25 mg/l). These values were all below the derived concentration guideline (DCG) of 600 pCi/l.

4.1.2 Other Analysis

Other analyses for NP-0001 through NP-0005 include physical analyses (settleable solids and total suspended solids) and chemical analyses (nitrate, pH, and lithium). Third quarter 1992 values correspond well with past values for all parameters, and are displayed in Table 4-1.

The permit for the discharge from the administration building treatment plant at outfall NP-0006 has effluent limitations and a requirement to monitor once per quarter. Flow must be measured once a month. The Subcontractor monitors the effluent once a month to assess plant performance, thus generating two additional sample analyses a quarter. The NPDES permit specifies effluent limitations for biochemical oxygen demand (BOD), total suspended solids

(TSS), pH, and fecal coliform at this outfall. The limits for BOD are 10 mg/l monthly average and 15 mg/l weekly average; for TSS, 15 mg/l monthly average and 20 mg/l weekly average; for fecal coliform, 400 colonies per 100 ml monthly average and 1,000 colonies per 100 ml daily maximum. The Subcontractor is continuing to make operational changes to improve plant performance. Effluent from the administration building treatment plant was well within these limits during the third quarter 1992. In addition, a flow equalization system is being added to the treatment plant and should become operational during the fourth quarter of 1992. The equalization of flow should greatly improve the operation of the plant.

5 AIR MONITORING

5.1 Radon Gas

The radon gas monitoring program utilizes a pair of alpha track radon detectors at each of the 25 permanent locations; each detector is exchanged quarterly. These detectors are deployed at six locations at the Weldon Spring Chemical Plant, eight locations at the Weldon Spring Quarry, four locations at the Weldon Spring raffinate pits, and at seven off-site locations. Radon monitoring locations are shown in Figures 5-1, 5-2, and 5-3. On-site detectors are distributed around the perimeter fences to ensure adequate detection of radon dispersing from the properties under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005, RD-4006, and RD-4007 monitor background levels near the site.

Landauer Type F track etch detectors were used for radon monitoring during the third quarter of 1992. The Type F detector is designed especially for outdoor monitoring of airborne radon concentrations. The detection mechanism consists of counting tracks generated by alpha particles in detector media to determine the radon concentration.

Table 5-1 summarizes the third quarter 1992 radon concentrations detected at all site perimeter and off-site monitoring locations. These concentrations represent the average of the two radon detectors placed at each location. Also contained in the third column of Table 5-1 is a comparison of the measured concentration with the Federally permitted radon concentration (for unrestricted areas) of 3 pCi/l (111 Bq/m^3)[1] above background as authorized by DOE Order 5400.5.

An average ambient background concentration was determined by calculating the arithmetic average for the five background locations. These data yielded an average ambient background radon concentration of 0.24 pCi/l (8.88 Bq/m^3) for the third quarter of 1992. This concentration was then subtracted from the concentration for each monitoring station, and compared to the U.S. Department of Energy (DOE) guideline of 3 pCi/l (111 Bq/m^3) above background.

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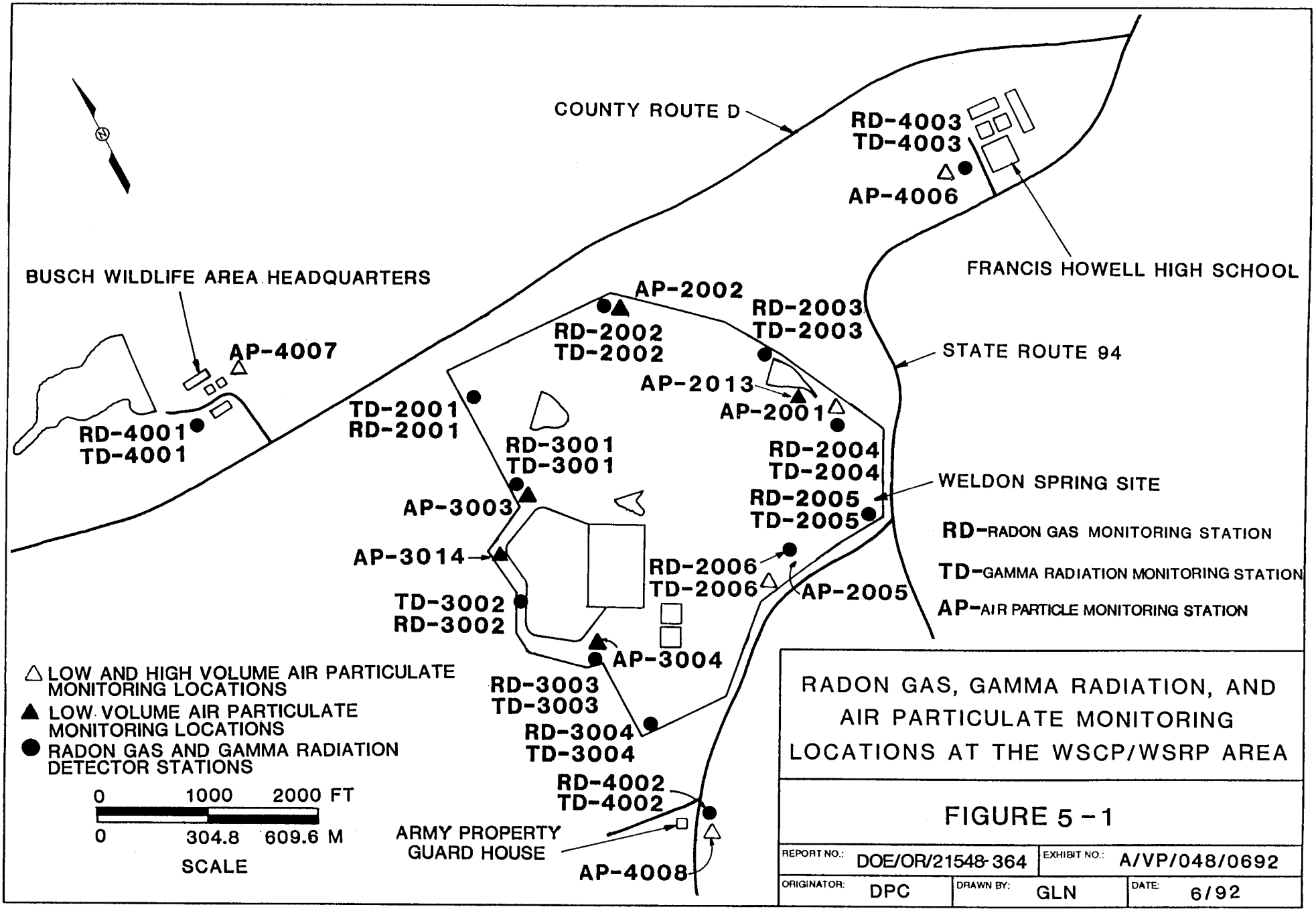
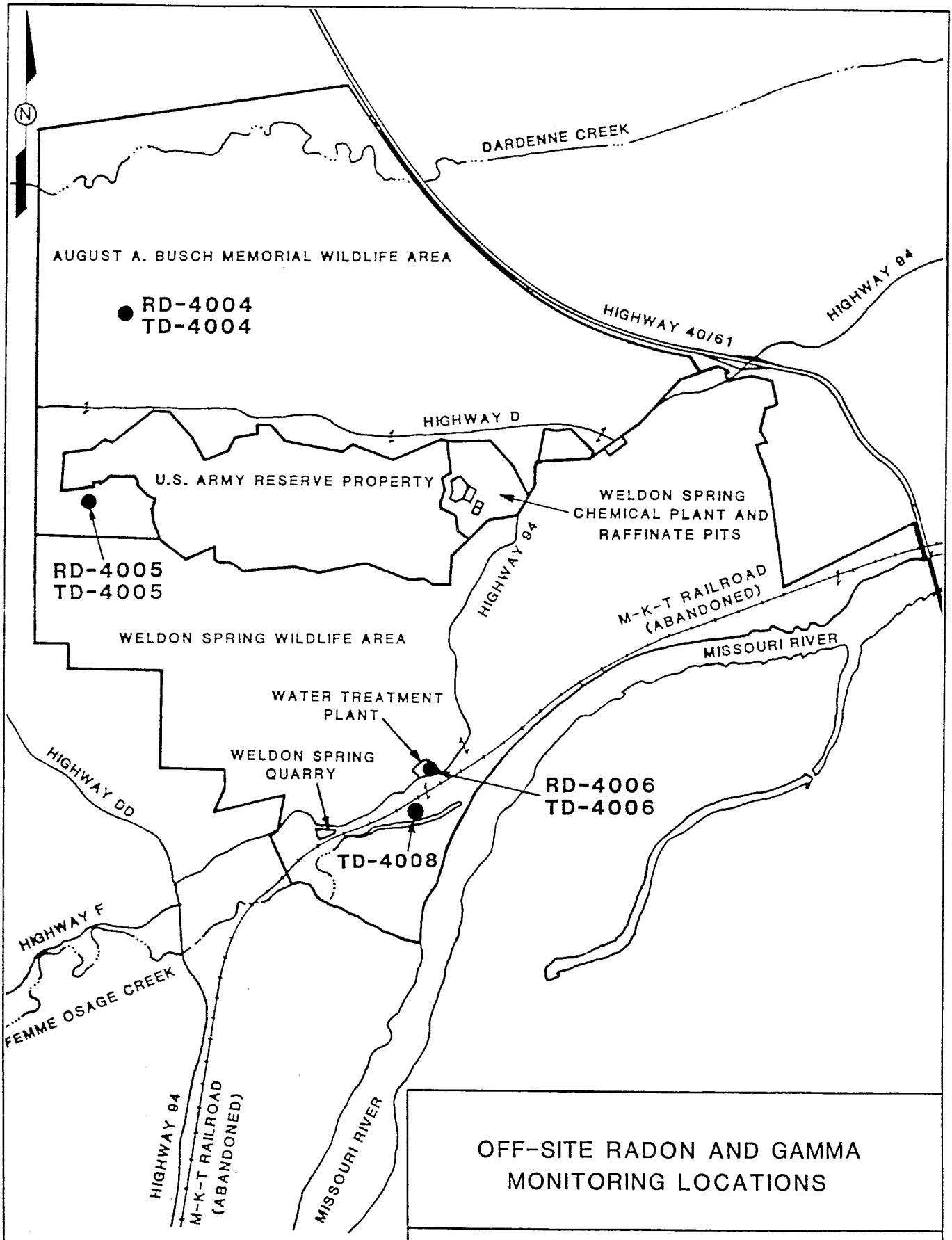
1 To convert μCi/ml to Bq/m^3, multiply by 3.7E10.



RADON GAS, GAMMA RADIATION, AND AIR PARTICULATE MONITORING LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 5-1

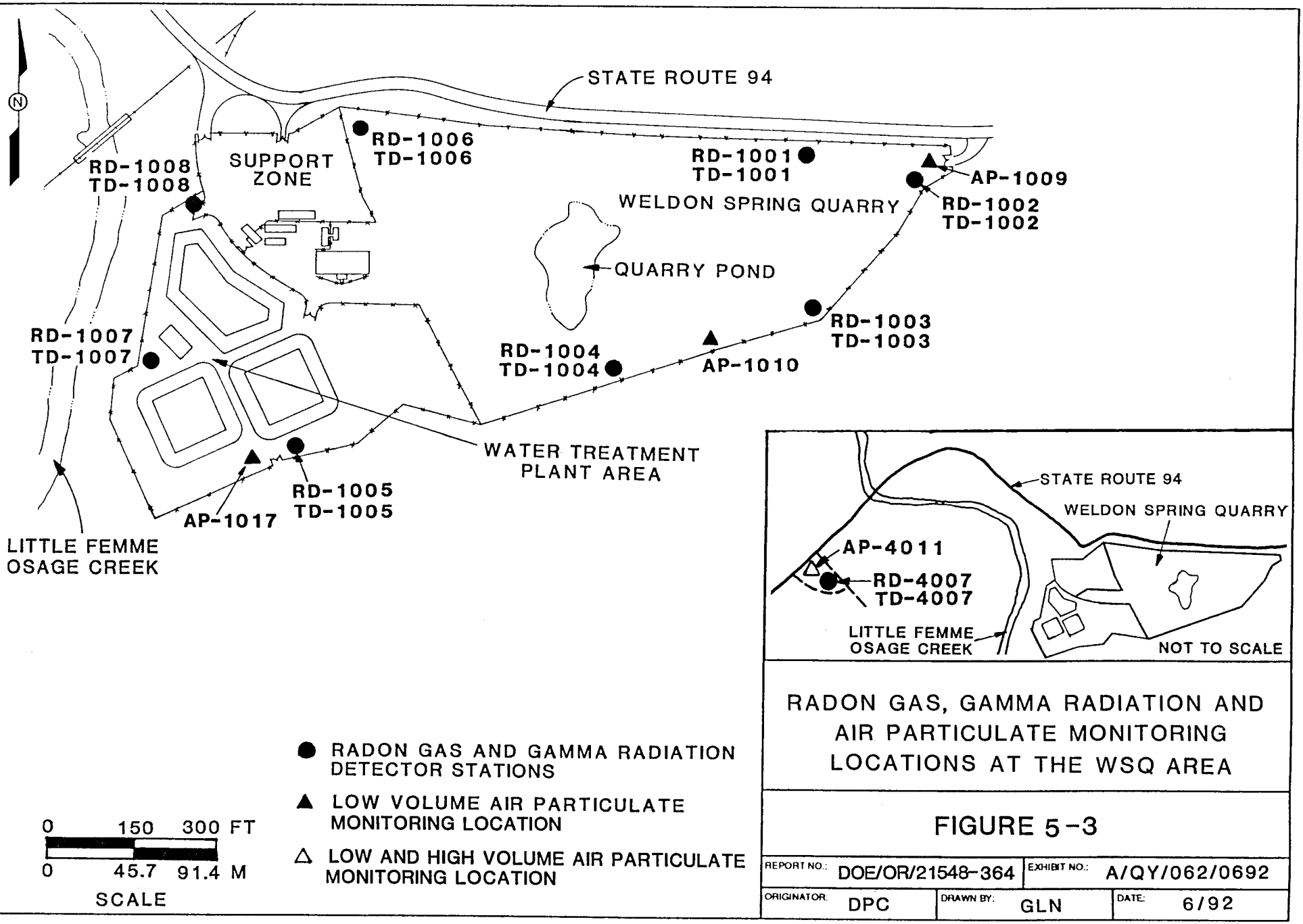
REPORT NO.:	DOE/OR/21548-364	EXHIBIT NO.:	A/VP/048/0692		
ORIGINATOR:	DPC	DRAWN BY:	GLN	DATE:	6/92



OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

FIGURE 5-2

REPORT NO.:	DOE/OR/21548-364	EXHIBIT NO.:	A/VP/042/0592		
ORIGINATOR:	DPC	DRAWN BY:	GLN	DATE:	5/92



RADON GAS, GAMMA RADIATION AND AIR PARTICULATE MONITORING LOCATIONS AT THE WSQ AREA

FIGURE 5-3

REPORT NO.:	DOE/OR/21548-364	EXHIBIT NO.:	A/QY/062/0692		
ORIGINATOR:	DPC	DRAWN BY:	GLN	DATE:	6/92

TABLE 5-1 Third Quarter 1992 Track Etch Radon Monitoring Results[a]

Location ID	3rd Quarter pCi/l	Percent of Guideline [b]
WSQ		
RD-1001	1.7	50
RD-1002	1.6	47
RD-1003	0.7	17
RD-1004	0.3	3
RD-1005	0.3	3
RD-1006	0.3	3
RD-1007	0.2	0
RD-1008	0.2	0
WSCP		
RD-2001	0.3	3
RD-2002	0.4	7
RD-2003	0.1	0
RD-2004	0.2	0
RD-2005	0.2	0
RD-2006	0.3	3
WSRP		
RD-3001	0.4	7
RD-3002	0.4	7
RD-3003	0.2	0
RD-3004	0.3	3

TABLE 5-1 Third Quarter 1992 Track Etch Radon Monitoring Results[a] (Continued)

Location ID	3rd Quarter pCi/l	Percent of Guideline [b]
OFF-SITE		
RD-4001*	0.2	NA
RD-4002	0.1	0
RD-4003	0.3	3
RD-4004*	0.3	NA
RD-4005*	0.2	NA
RD-4006*	0.3	NA
RD-4007*	0.2	NA

(a) Results include natural background.

(b) Percent of guideline calculated by taking the quarterly average minus the average of the background stations divided by the DOE concentration guideline for Rn-222 which is 3 pCi/l (111 Bq/m^3)(Annual average above background) for uncontrolled areas.

* Denotes Background Station; therefore, percent of guideline not applicable (NA).

Radon concentrations at the site and quarry perimeters and at off-site locations for the third quarter of 1992 were within the typical range expected during periods of normal precipitation. The quarterly radon concentrations at the Weldon Spring Chemical Plant/raffinatepit (WSCP/RP) area averaged 0.3 pCi/l (11.1 Bq/m^3), while the quarterly radon concentrations at the Weldon Spring Quarry (WSQ) averaged 0.7 pCi/l (25.9 Bq/m^3). The quarterly radon
concentrations from each individual detector (background included) ranged from less than the detection limit of 0.07 pCi/l (1.11 Bq/m^3) to 1.8 pCi/l (66.6 Bq/m^3).

Radon concentrations found at the quarry are higher than concentrations measured at other locations, because the radium concentrations in quarry wastes are typically higher than in other areas. Also, the quarry is a large depression with side walls ranging from 3 m to 15 m (10 ft to 50 ft) high, which tends to trap emanating radon within the quarry and raise the concentrations along the quarry perimeter.

5.2 Gamma Radiation Exposure

To monitor exposure from gamma radiation, environmental thermoluminescent dosimeters (TLDs) were deployed at 26 locations. The gamma monitoring locations are identified in Figures 5-1, 5-2, and 5-3 with a prefix TD-.

Table 5-2 summarizes the third quarter results of total gamma radiation monitoring at the 18 Weldon Spring site perimeter monitoring stations, Francis Howell High School (FHHS), the Weldon Spring Army Reserve Training Area, and at the six background monitoring stations.

The Weldon Spring Site Remedial Action Project changed TLD vendors starting with the third quarter of 1992. During the second quarter of 1992, duplicate TLDs, one from the old vendor and one from the new vendor, were deployed at four monitoring locations. The results from the new vendor TLDs appeared to be consistent with historical data.

The results from the third quarter of 1992 (average of 12.0 mrem) appear to be lower than would be expected when compared to the third quarter of 1991 (average 16.0 mrem). The lower than expected results for the third quarter of 1992 may be related to the results of the control TLD, which was subtracted from the results of TLDs deployed at the monitoring locations. The control TLD is used to exclude any exposures recieved by the monitoring location TLDs during transit to and from the vendor, and during storage prior to and after deployment. The lower than expected third quarter results will continue to be investigated and the outcome will be reported in the annual site environmental report.

5.3 Radioactive Air Particulates

Fourteen low volume air particulate samplers continuously monitor the Weldon Spring site. Five of these (AP-2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the Weldon Spring Chemical Plant (WSCP) perimeter and two are located around the quarry perimeter. There are five critical receptor monitoring stations, AP-4006, AP-4008, AP-2001, AP-2005 and AP-4011, located off-site at the Francis Howell high School, the Army Reserve property, the highway maintenance facility, the Weldon Spring Site Remedial Action Project (WSSRAP) administration building, and near a residential site west of the quarry, respectively. Three new monitoring stations were recently added during the second quarter of 1992. Two of the new monitoring stations, AP-2013 and AP-3014, were installed at the WSCP perimeter. The

TABLE 5-2 Third Quarter 1992 Environmental TLD Monitoring Results[a]

Location ID	3rd Quarter mrem
WSQ	
TD-1001	14.1
TD-1002	16.3
TD-1003	12.9
TD-1004	14.4
TD-1005	--
TD-1006	12.3
TD-1007	14.3
TD-1008	13.4
WSCP	
TD-2001	11.9
TD-2002	12.4
TD-2003	11.8
TD-2004	15.5
TD-2005	--
TD-2006	12.1
WSRP	
TD-3001	13.1
TD-3002	--
TD-3003	12.2
TD-3004	10.1
OFF-SITE	
TD-4001*	--
TD-4002	6.5
TD-4003	6.2
TD-4004*	13.3

TABLE 5-2 Third Quarter 1992 Environmental TLD Monitoring Results[a] (Continued)

Location ID	3rd Quarter mrem
TD-4005*	9.6
TD-4006*	10.8
TD-4007*	9.6
TD-4008*	--

(a) Results include natural background.
- Denotes lost or damaged TLD.
* Denotes background station.

other new station, AP-1017, was installed at the WSQ perimeter. The monitoring station at the August A. Busch Wildlife Area (AP-4007) is used to monitor background levels in the vicinity of the WSCP. The air particulate monitoring station locations are shown in Figures 5-1 and 5-3.

The background sampling station AP-4007, is approximately 0.8 km (0.5 mile) from the WSCP perimeter in a northwestern direction. The terrain between the WSCP and this sampling station is hilly and forested, providing a significant physical barrier to airborne particulates originating from the WSCP/WSRP area.

Table 5-3 summarizes the quarterly average concentrations and the standard deviations for the 14 air monitoring locations. The quarterly average concentration for each monitoring location was calculated by averaging all weekly air particulate analysis results including results lower than the instruments lower limit of detection (LLD). The corresponding standard deviation for each monitoring location was also calculated using all weekly air particulate analysis results. Due to maintenance and installation of new samplers, all samplers were not operating the entire 13 weeks, as indicated in the fourth column of Table 5-3. The WSSRAP has deployed high volume air samplers, as well as low volume air samplers, at critical receptor locations. These high volume samplers are used in accordance with the *Plan for Monitoring Radionuclide Emissions Other Than Radon at the Weldon Spring Site Critical Receptors* (MKF and JEG 1992b). The high volume monitoring results will be presented in the 1992 annual site environmental report.

TABLE 5-3 Third Quarter 1992 Radiological Air Particulate Monitoring Results

Monitor Identification Number	Quarterly Avgerage Gross Alpha Concentration (μCi/ml)	Standard Deviation (μCi/ml)	Number of Weeks Collected	Number of Values Above LLD
AP-2001	1.28E-15	5.46E-16	13	11
AP-2002	1.26E-15	4.94E-16	13	12
AP-3003	1.15E-15	5.28E-16	12	12
AP-3004	1.31E-15	6.72E-16	13	12
AP-2005	1.27E-15	4.91E-16	12	12
AP-4006	1.08E-15	3.23E-16	13	13
AP-4007	1.28E-15	4.93E-16	13	13
AP-4008	1.02E-15	3.38E-16	13	13
AP-1009	1.52E-15	6.91E-16	13	11
AP-1010	1.47E-15	7.33E-16	13	12
AP-4011	1.31E-15	5.15E-16	13	12
AP-2013	1.02E-15	3.41E-16	13	13
AP-3014	1.24E-15	6.91E-16	13	12
AP-1017	1.01E-15	5.34E-16	12	9

* Indicates background monitor station.

The third quarter average long-lived gross alpha concentrations ranged from 1.01×10^{-15} μCi/ml to 1.52×10^{-15} μCi/ml for perimeter and off site locations. The average background concentration measured at AP-4007 was 1.28×10^{-15} μCi/ml.

5.4 Asbestos

In accordance with the *Environmental Monitoring Plan* (MKF and JEG 1992a) the WSSRAP collected environmental airborne asbestos samples. These samples were collected at both the FHHS and the WSSRAP perimeter during bulk asbestos removal operations.

The samples collected at the perimeter locations all showed results of 0.003 fibers/cc or less. Fourteen samples were collected at the perimeter of which nine had measured concentrations below the detection limit.

The samples collected at the FHHS all showed results of 0.004 fibers/cc or less. Thirty-two samples were collected at the FHHS of which 10 were less than the detection limit.

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QUARTERLY ENVIRONMENTAL DATA SUMMARY — FOURTH QUARTER 1992

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

MARCH 1993 **REV. 0**

U.S. Department of Energy
Oak Ridge Field Office
Weldon Spring Site Remedial Action Project

MK-FERGUSON A MORRISON KNUDSEN COMPANY	
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Weldon Spring Site Remedial Action Project

Quarterly Environmental Data Summary - Fourth Quarter 1992

Revision 0

March 1993

Prepared by

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for the

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ABSTRACT

The purpose of this *Quarterly Environmental Data Summary* is to provide to the public preliminary data acquired as part of the Weldon Spring Site Remedial Action Project (WSSRAP) environmental monitoring program. The document summarizes the preliminary environmental data, highlights any potentially significant findings, and offers tentative interpretations. Validated data and final interpretations will appear in the 1992 annual site environmental report.

This report includes preliminary data from environmental monitoring activities at the Weldon Spring site (WSS) during the fourth quarter of 1992. Groundwater, surface water, and air samples were collected in order to monitor potential exposure pathways. Analytical parameters included radionuclides, nitroaromatic compounds, metals, inorganic anions, and direct gamma exposure. The results are used to evaluate possible exposure scenarios and assess the impact of the contaminants at the site on potentially exposed populations.

Contaminated ground water did not affect the St. Charles County well field.

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1 INTRODUCTION

This quarterly report summarizes the findings from the routine environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). These quarterly reports supplement the annual site environmental report (ASER) by providing interested outside agencies and organizations with more frequent access to WSSRAP data (Appendix A). They provide data resulting from routine environmental sampling as described in the WSSRAP *Environmental Monitoring Plan* (EMP) (MKF and JEG 1992a) and a brief interpretation of that data.

It is the goal of this document to summarize and briefly discuss the data, highlighting data that differ significantly from historical observations. The full interpretation of these data (as well as data in other quarterly summaries) will be undertaken in the 1992 ASER. It is recommended that interested readers refer to previous EMPs, ASERs, and project documents for more information on existing site conditions, site history, transport mechanisms, and quantified contaminant levels. The monitoring scheme for every calendar year is established prior to that year in the annual EMP. Each sampling location to be monitored during the upcoming year is identified in the EMP and the schedule of analytical parameters is tabulated for easy reference. These reports may be obtained by visiting the WSSRAP reading room or contacting the WSSRAP Community Relations Manager at (314) 441-8086.

These quarterly reports are intended to include data from all environmental monitoring programs conducted at the WSSRAP including groundwater, springs, surface water, National Pollutant Discharge Elimination System (NPDES), radon gas, gamma radiation, and air particulates (including asbestos and radioactive particulates). This document summarizes the preliminary environmental data, highlights any potentially significant findings, and offers tentative interpretations. Validated data and final interpretations will appear in the 1992 annual site environmental report. Because standard turnaround time to receive data from the laboratories is 45 days, not all fourth quarter data are available for reporting. These data will be reported in the 1992 ASER. Sludges and soils are not sampled on a routine basis; therefore, analytical results for these parameters are not included in this report. Trend analyses are being prepared from historical data for surface water, groundwater, and air pathways. These analyses will be presented in the 1992 ASER. Quality control (QC) data for the fourth quarter and fifth and sixth bimonthly periods, along with all other periods, will be presented in the 1992 ASER.

2 GROUNDWATER MONITORING

The groundwater is sampled regularly at both the Weldon Spring Chemical Plant/raffinate pits/vicinity properties (WSCP/WSRP/VP) and the Weldon Spring Quarry (WSQ). Due to differences in the environmental settings and sources of contaminants, separate monitoring schedules are followed. Therefore, results of groundwater monitoring at the WSCP/WSRP/VP and WSQ will be discussed separately.

2.1 Chemical Plant/Raffinate Pits/Vicinity Properties

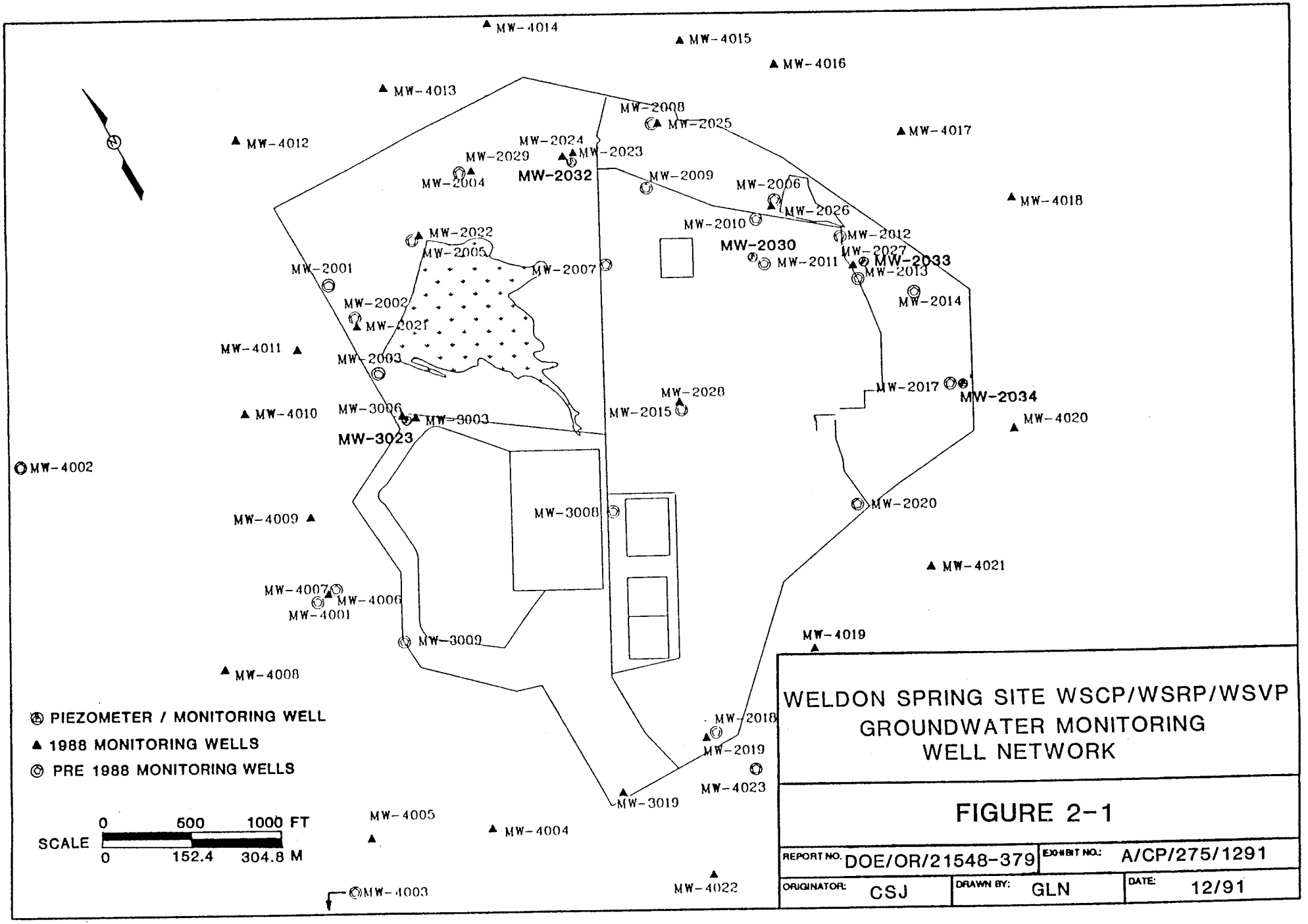
Groundwater at the WSCP/WSRP/VP area is monitored on a quarterly or semiannual basis. Locations are given in Figure 2-1. The number of wells sampled quarterly has increased substantially; a complete list of wells scheduled for quarterly and semiannual sampling is given in the 1992 *Environmental Monitoring Plan* (MKF and JEG 1992a). Total uranium, inorganic anions, and nitroaromatic compounds are measured during each monitoring period for both quarterly and semiannual wells. Other radiological parameters are measured annually during the first period for all wells.

2.1.1 Nitroaromatic Results

Table 2-1 contains nitroaromatic data from samples collected from the groundwater wells monitored quarterly. Nitroaromatic compounds were detected in 15 of the 34 locations. Table 2-2 contains nitroaromatic data from samples collected from the groundwater wells monitored semi-annually. Nitroaromatic compounds were detected in 9 of the 27 locations. Concentration levels for these compounds are within their historical range, with the following exceptions: a new 2,4,6-trinitrotoluene (TNT) high is recorded in well MW-2006 and a new 1,3,5-trinitrobenzene (TNB) low was measured in MW-4013.

2.1.2 Radiological Results

The upper bound for natural uranium background concentration in groundwater at the WSCP/WSRP/VP has been determined to be 3.4 pCi/l (0.13 Bq/l) (MKF and JEG 1989). The U.S. Environmental Protection Agency (EPA) has not yet established a drinking water standard for uranium; however, the proposed maximum contaminant level (MCL) is 20 μg/l, which



WELDON SPRING SITE WSCP/WSRP/WSVP GROUNDWATER MONITORING WELL NETWORK

FIGURE 2-1

REPORT NO. DOE/OR/21548-379		EXHIBIT NO.: A/CP/275/1291	
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 12/91	

TABLE 2-1 Fourth Quarter Nitroaromatic Results for Groundwater at the WSCP/WSRP/VP

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-2001-Q492	ND	ND	0.098	0.051	ND	0.034
GW-2002-Q492	ND	ND	0.11	0.51	ND	ND
GW-2003-Q492	ND	ND	0.19	1.2	ND	ND
GW-2030-Q492	ND	ND	0.15	12	14	10
GW-2032-Q492	NA	NA	NA	NA	NA	NA
GW-2033-Q492	ND	ND	3.8	7.8	2.9	9.4
GW-3003-Q492	ND	ND	0.058	0.098	ND	ND
GW-3006-Q492	ND	ND	ND	ND	ND	ND
GW-3008-Q492	ND	ND	0.12	0.29	ND	ND
GW-3009-Q492	ND	ND	0.30	0.17	ND	0.36
GW-3023-Q492	ND	ND	7.0	7.1	0.040	ND
GW-4001-Q492	ND	0.13	6.5	3.9	1.3	48
GW-4002-Q492	NA	NA	NA	NA	NA	NA
GW-4003-Q492	ND	ND	ND	ND	ND	ND
GW-4004-Q492	ND	ND	ND	ND	ND	ND
GW-4005-Q492	ND	ND	ND	ND	ND	ND
GW-4006-Q492	ND	ND	0.15	3.3	ND	17
GW-4007-Q492	NA	NA	NA	NA	NA	NA
GW-4008-Q492	ND	ND	ND	ND	ND	ND
GW-4009-Q492	NA	NA	NA	NA	NA	NA
GW-4010-Q492	ND	ND	ND	ND	ND	ND
GW-4011-Q492	ND	ND	ND	ND	ND	ND
GW-4012-Q492	ND	ND	ND	ND	ND	ND
GW-4013-Q492	ND	ND	0.051	0.63	0.032	28
GW-4014-Q492	ND	ND	ND	0.076	0.036	0.50
GW-4015-Q492	ND	ND	0.084	0.90	ND	0.85
GW-4016-Q492	ND	ND	ND	ND	ND	ND
GW-4017-Q492	ND	ND	ND	ND	ND	ND
GW-4018-Q492	NA	NA	NA	NA	NA	NA

TABLE 2-1 Fourth Quarter Nitroaromatic Results for Groundwater at the WSCP/WSRP/VP (Continued)

Sample ID	NB (μg/l)	1,3-DNB (μg/l)	2,4-DNT (μg/l)	2,6-DNT (μg/l)	2,4,6-TNT (μg/l)	1,3,5-TNB (μg/l)
GW-4019-Q492	NA	NA	NA	NA	NA	NA
GW-4020-Q492	ND	ND	ND	ND	ND	ND
GW-4021-Q492	ND	ND	ND	ND	ND	ND
GW-4022-Q492	ND	ND	ND	ND	ND	ND
GW-4023-Q492	ND	ND	0.087	0.042	ND	0.16

NA - Not Available
ND - Not Detected

converts to 13.6 pCi/l (0.50 Bq/l) using a new site-specific conversion factor of 0.68 pCi/μg (assuming isotopic equilibrium). The increase to 13.6 pCi/l (0.50 Bq/l) from the previously reported value of 12 pCi/l (0.44 Bq/l) reflects improved quantification of the average U-234/U-238 activity ratios for uranium present at the Weldon Spring Site Remedial Action Project (WSSRAP).

Total uranium results for samples from the wells monitored quarterly and semi-annually at the WSCP/WSRP/VP are presented in Tables 2-3 and 2-4. Uranium concentrations remained within historical ranges at locations for which data are presently available except for wells MW-3003 and MW-2030, where a new high and low were recorded, respectively.

2.1.3 Sulfate and Nitrate Results

Sulfate and nitrate concentrations are measured during each monitoring period. Results from the wells monitored quarterly are shown in Tables 2-3 and 2-4. Fourth quarter and semi-annual results are within historical ranges with the exception of a new nitrate low in MW-2003. The nitrate level in MW-3003 and sulfate level in MW-4023 were the highest recorded values in these wells since 1989. These values are thought to reflect natural fluctuation in these wells.

TABLE 2-2 Semi-annual Nitroaromatic Results for Groundwater at the WSCP/WSRP/VP

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-2004-S292	ND	ND	ND	ND	ND	ND
GW-2005-S292	ND	ND	0.082	0.14	ND	ND
GW-2006-S292	ND	ND	ND	3.02	2.18	8.53
GW-2007-S292	ND	ND	ND	ND	ND	ND
GW-2008-S292	ND	ND	0.080	1.0	ND	0.85
GW-2009-S292	NA	NA	NA	NA	NA	NA
GW-2010-S292	ND	ND	0.079	0.53	0.40	0.17
GW-2011-S292	0.042	ND	0.10	1.6	ND	0.42
GW-2012-S292	ND	ND	0.30	2.4	0.68	2.8
GW-2013-S292	ND	0.22	0.30	9.1	0.76	5.8
GW-2014-S292	0.033	ND	0.17	0.90	ND	2.2
GW-2015-S292	ND	ND	ND	ND	ND	ND
GW-2017-S292	ND	ND	ND	ND	ND	ND
GW-2018-S292	ND	ND	ND	ND	ND	ND
GW-2019-S292	ND	ND	ND	ND	ND	ND
GW-2020-S292	ND	ND	0.031	ND	ND	ND
GW-2021-S292	ND	ND	ND	ND	ND	ND
GW-2022-S292	ND	ND	ND	ND	ND	ND
GW-2023-S292	ND	ND	ND	ND	ND	ND
GW-2024-S292	ND	ND	ND	ND	ND	ND
GW-2025-S292	ND	ND	ND	ND	ND	ND
GW-2026-S292	ND	ND	ND	ND	ND	ND
GW-2027-S292	ND	ND	ND	ND	ND	ND
GW-2028-S292	ND	ND	ND	ND	ND	ND
GW-2029-S292	ND	ND	ND	ND	ND	ND
GW-2034-S292	ND	ND	ND	ND	ND	ND
GW-3019-S292	ND	ND	ND	ND	ND	ND

NA - Not Available
ND - Not Detected

TABLE 2-3 Fourth Quarter Uranium and Inorganic Anion Results for Groundwater at the WSCP/WSRP/VP

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-2001-Q492	34.6	8.60	0.68
GW-2002-Q492	450	126	ND
GW-2003-Q492	209	137	1.2
GW-2030-Q492	0.84	42.7	8.0
GW-2032-Q492	111	60.3	4.8
GW-2033-Q492	1.00	28.7	1.8
GW-3003-Q492	467	172	23
GW-3006-Q492	0.24	22.4	0.2
GW-3008-Q492	698	82.8	3.3
GW-3009-Q492	236	20.7	6.7
GW-3023-Q492	454	323	7.6
GW-4001-Q492	31.8	59.4	0.95
GW-4002-Q492	2.70	19.6	0.95
GW-4003-Q492	0.79	31.9	1.5
GW-4004-Q492	0.76	19.1	3.1
GW-4005-Q492	9.70	25.5	0.88
GW-4006-Q492	4.90	27.5	ND
GW-4007-Q492	0.10	11.2	1.8
GW-4008-Q492	ND	13.8	1.6
GW-4009-Q492	0.13	13.3	4.4
GW-4010-Q492	0.16	21.9	2.4
GW-4011-Q492	46.7	59.4	5.8
GW-4012-Q492	0.30	47.2	0.3
GW-4013-Q492	62.8	51.7	ND
GW-4014-Q492	5.30	27.0	ND
GW-4015-Q492	1.60	13.2	0.68
GW-4016-Q492	37.0	21.4	3.2
GW-4017-Q492	0.48	7.60	1.4

TABLE 2-3 Fourth Quarter Uranium and Inorganic Anion Results for Groundwater at the WSCP/WSRP/VP (Continued)

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-4018-Q492	2.10	7.70	0.4
GW-4019-Q492	0.28	9.20	1.6
GW-4020-Q492	ND	119	13
GW-4021-Q492	ND	245	3.6
GW-4022-Q492	0.24	37.5	3.9
GW-4023-Q492	4.40	145	2.0

ND - Not Detected
NA - Not Available

TABLE 2-4 Semi-annual Uranium and Inorganic Anion Results for Groundwater at the WSCP/WSRP/VP

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-2004-S292	0.26	1.90	0.89
GW-2005-S292	62.8	25.6	0.66
GW-2006-S292	1.00	32.2	ND
GW-2007-S292	ND	14.7	ND
GW-2008-S292	0.84	38.0	0.68
GW-2009-S292	NA	NA	NA
GW-2010-S292	0.77	30.7	0.68
GW-2011-S292	4.90	13.0	0.5
GW-2012-S292	0.37	67.1	0.8
GW-2013-S292	0.60	20.2	0.4
GW-2014-S292	0.82	33.3	0.81
GW-2015-S292	0.15	125	ND
GW-2017-S292	0.28	701	8.0
GW-2018-S292	0.40	9.70	0.88
GW-2019-S292	ND	41.7	2.5
GW-2020-S292	0.23	139	3.1
GW-2021-S292	ND	14.0	1.1
GW-2022-S292	ND	14.0	ND
GW-2023-S292	0.11	14.4	2.4
GW-2024-S292	0.10	28.7	ND
GW-2025-S292	0.08	15.8	0.95
GW-2026-S292	ND	14.0	NA
GW-2027-S292	NA	NA	0.2
GW-2028-S292	NA	NA	1.3
GW-2029-S292	0.31	24.5	1.3
GW-2034-S292	0.13	645	15
GW-3019-S292	ND	6.40	2.0

ND - Not Detected
NA - Not Available

2.2 Weldon Spring Quarry

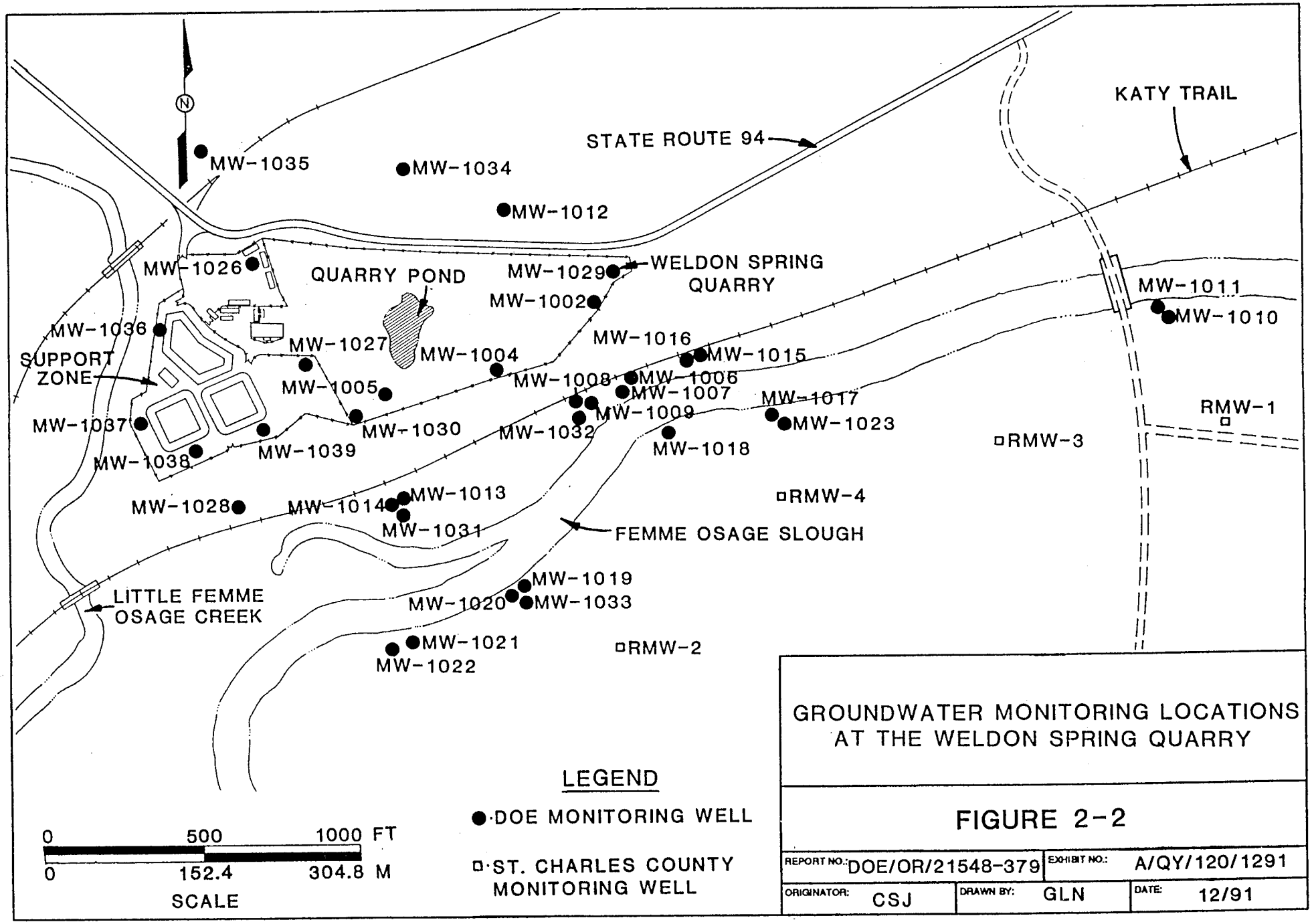
Groundwater at the WSQ has become radiologically and chemically contaminated as a result of contact with, or migration from, wastes present in the WSQ. Monitoring of the groundwater at and near the WSQ is of particular concern because of the proximity of the St. Charles County well field. The well field is located approximately 0.8 km (0.5 mi) to the south of the WSQ. Monitoring of contaminants in groundwater and the protection of the well field is a priority at the WSSRAP.

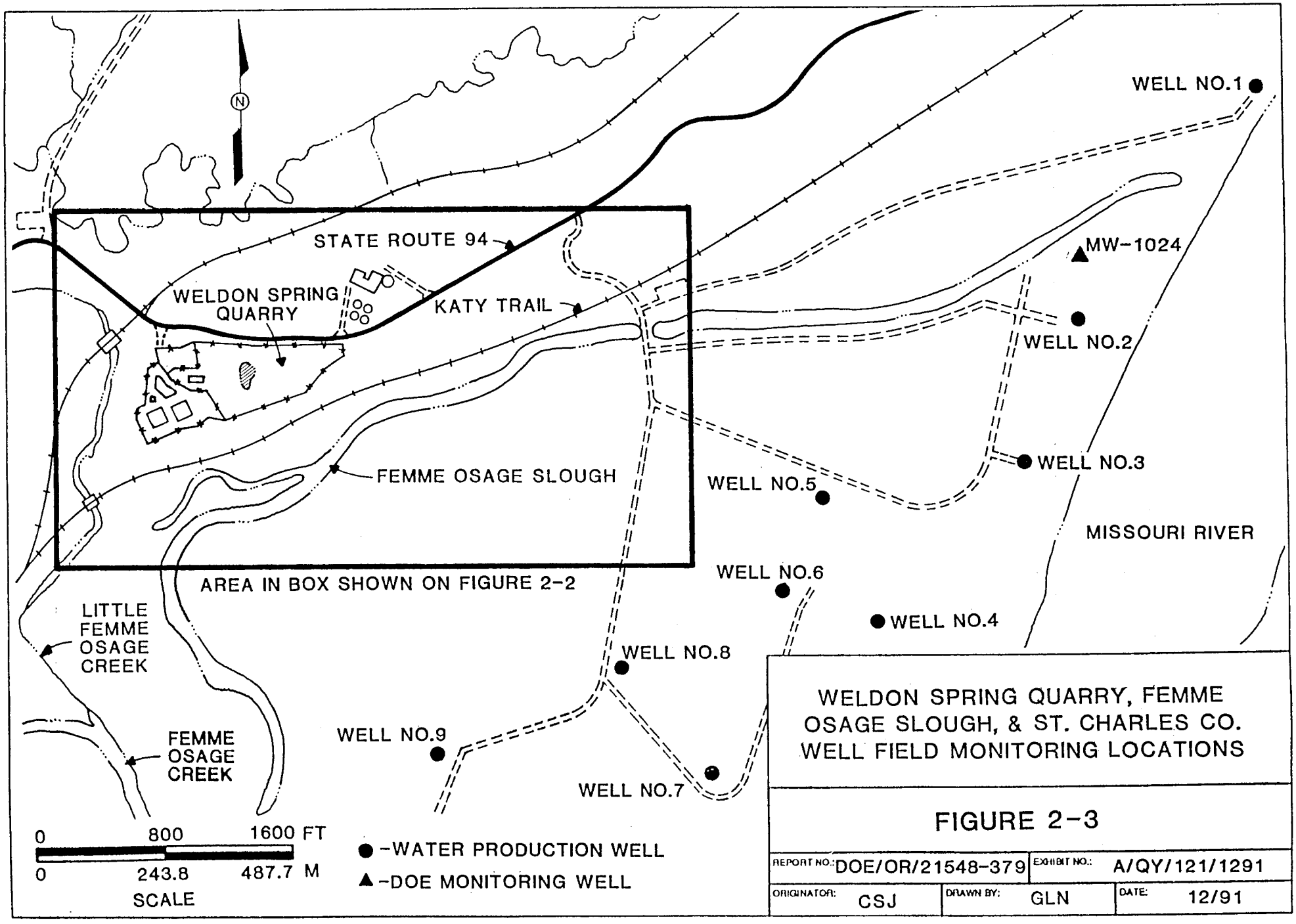
Groundwater is currently being monitored at 48 wells located in and around the quarry area. Groundwater at the WSQ and surrounding areas is monitored on a bimonthly or quarterly basis as detailed in the 1992 *Environmental Monitoring Plan* (MKF and JEG 1992a). All monitoring well locations are shown in Figures 2-2 and 2-3. These wells monitor groundwater in both the bedrock and alluvial aquifers associated with the WSQ.

2.2.1 Radiological Results

Radiological data are presented in Tables 2-5 through 2-7 for samples collected for the fifth and sixth bimonthly periods and the fourth quarter. The results show typical fluctuations near the average levels in the WSQ area, except for an elevated uranium level that was reported in the sixth bimonthly period in MW-1028 (1,000 pCi/l). This value is considered to be an erroneous laboratory value based on historic averages and has been submitted for validation. Detectable concentrations of uranium were indicated from the St. Charles County RMW-series and production wells. In addition to being within historic averages and representative of background levels, these levels are the result of lower detection limits for uranium during analytical testing.

The St. Charles County RMW-series and production wells are also sampled annually for gross alpha. The results of this analysis are presented in Table 2-7. The concentrations in the St. Charles County well field are consistent with background values of waters in or near the WSQ.


N
MW-1035
MW-1034
STATE ROUTE 94
KATY TRAIL
MW-1012
MW-1026
QUARRY POND
MW-1029
WELDON SPRING QUARRY
MW-1002
MW-1011
MW-1010
MW-1036
MW-1027
MW-1004
MW-1016
MW-1015
SUPPORT ZONE
MW-1005
MW-1008
MW-1006
MW-1007
MW-1017
RMW-1
MW-1037
MW-1030
MW-1009
MW-1032
MW-1023
MW-1039
MW-1018
RMW-3
MW-1038
MW-1028
MW-1014
MW-1013
RMW-4
MW-1031
FEMME OSAGE SLOUGH
MW-1019
LITTLE FEMME OSAGE CREEK
MW-1020
MW-1033
MW-1021
RMW-2
MW-1022
0 500 1000 FT
0 152.4 304.8 M
SCALE
LEGEND
DOE MONITORING WELL
ST. CHARLES COUNTY MONITORING WELL
GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING QUARRY
FIGURE 2-2
REPORT NO.: DOE/OR/21548-379
EXHIBIT NO.: A/QY/120/1291
ORIGINATOR: CSJ
DRAWN BY: GLN
DATE: 12/91



WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, & ST. CHARLES CO. WELL FIELD MONITORING LOCATIONS

FIGURE 2-3

REPORT NO.:	DOE/OR/21548-379	EXHIBIT NO.:	A/QY/121/1291		
ORIGINATOR:	CSJ	DRAWN BY:	GLN	DATE:	12/91

TABLE 2-5 Fifth Bimonthly (Sept/Oct) Uranium and Inorganic Anion Results for Groundwater at the WSQ

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-1002-B592	0.57	40.7	2.2
GW-1004-B592	0.30	238	3800
GW-1005-B592	ND	180	2100
GW-1006-B592	0.22	208	2300
GW-1007-B592	0.21	126	140
GW-1008-B592	ND	270	3700
GW-1009-B592	ND	271	4.7
GW-1010-B592	ND	0.49	ND
GW-1011-B592	ND	19.7	15
GW-1012-B592	0.80	62.4	4.1
GW-1013-B592	0.22	106	750
GW-1014-B592	0.22	102	870
GW-1015-B592	0.32	297	1300
GW-1016-B592	0.15	242	480
GW-1026-B592	ND	0.69	0.41
GW-1027-B592	0.22	109	540
GW-1028-B592	ND	81.7	1.30
GW-1029-B592	0.15	69.2	2.4
GW-1030-B592	0.52	81.4	NA
GW-1031-B592	ND	30.8	23
GW-1032-B592	ND	246	1300
GW-1034-B592	0.95	73.1	2.2
GW-1035-B592	0.17	40.5	0.75
GW-1036-B592	ND	55.0	5.6
GW-1037-B592	ND	16.7	0.6
GW-1038-B592	ND	42.9	2.7
GW-1039-B592	ND	52.0	1.2

ND - Not Detected
NA - Not Available

TABLE 2-6 Sixth Bimonthly (Nov/Dec) Uranium and Inorganic Anion Results for Groundwater at the WSQ

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
GW-1002-B692	1.50	60.8	2.7
GW-1004-B692	0.29	238	2700
GW-1005-B692	0.15	164	1600
GW-1006-B692	ND	406	3300
GW-1007-B692	1.10	80.3	300
GW-1008-B692	ND	228	6000
GW-1009-B692	ND	257	0.82
GW-1010-B692	ND	1.20	ND
GW-1011-B692	ND	43.3	9.5
GW-1012-B692	1.10	63.8	2.3
GW-1013-B692	NA	NA	830
GW-1014-B692	NA	NA	930
GW-1015-B692	1.00	251	880
GW-1016-B692	0.45	243	470
GW-1026-B692	ND	0.71	ND
GW-1027-B692	0.34	111	410
GW-1028-B692	NA	NA	1000
GW-1029-B692	ND	67.9	1.8
GW-1030-B692	0.76	70.1	8.8
GW-1031-B692	ND	29.0	17
GW-1032-B692	ND	241	980
GW-1034-B692	0.93	62.9	2.2
GW-1035-B692	0.12	40.1	ND
GW-1036-B692	ND	55.2	4.5
GW-1037-B692	ND	58.0	0.95
GW-1038-B692	ND	64.3	3.1
GW-1039-B692	ND	17.3	1.3

ND - Not Detected
NA - Not Available

TABLE 2-7 Fourth Quarter Uranium, Gross Alpha and Inorganic Anion Results for Groundwater at the WSQ

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)	Gross Alpha (pCil)
GW-1017-Q492	ND	0.51	ND	NR
GW-1018-Q492	ND	96.0	ND	NR
GW-1019-Q492	ND	0.39	ND	NR
GW-1020-Q492	ND	11.0	ND	NR
GW-1021-Q492	ND	1.50	0.54	NR
GW-1022-Q492	ND	0.43	ND	NR
GW-1023-Q492	ND	3.90	ND	NR
GW-1024-Q492	0.15	3.30	ND	ND
GW-1033-Q492	ND	9.60	1.2	NA
GW-RMW1-Q492	0.15	16.2	1.4	3.5
GW-RMW2-Q492	0.19	23.2	5.1	8.7
GW-RMW3-Q492	0.16	10.5	0.3	7.4
GW-RMW4-Q492	1.10	24.7	1.3	ND
GW-PW02-Q492	NR	NR	ND	ND
GW-PW03-Q492	NR	NR	0.6	ND
GW-PW04-Q492	NR	NR	ND	ND
GW-PW05-Q492	NR	NR	ND	2.5
GW-PW06-Q492	NR	NR	ND	ND
GW-PW07-Q492	NR	NR	0.2	ND
GW-PW08-Q492	NR	NR	0.2	2.2
GW-PW09-Q492	NR	NR	ND	ND
GW-RAWW-Q492	NR	NR	ND	ND
GW-FINW-Q492	NR	NR	0.2	ND

ND - Not Detected
NA - Not Available
NR - Sampling Not Required During Fourth Quarter

2.2.2 Nitroaromatic Compounds Results

Analytical results for the fifth and sixth bimonthly periods and the fourth quarter for nitroaromatic compounds are presented in Tables 2-8 through 2-10. No monitoring locations south of the Femme Osage Slough showed detectable concentrations of nitroaromatic compounds during the fourth quarter of 1992. Nitroaromatic levels have increased in the sixth period monitoring well MW-1002 located on the quarry rim. The distribution and magnitude of nitroaromatic contamination in the remainder of the wells near the quarry remain consistent with historical levels.

2.2.3 Inorganic Anions Results

Two inorganic anions, nitrate and sulfate, are sampled in all of the wells monitored at the WSQ. The analytical results for the fifth and sixth bimonthly periods and the fourth quarter are presented in Tables 2-5 through 2-7. The nitrate and sulfate results for the WSQ groundwater samples continue to be within historic ranges. The results continue to indicate that elevated sulfate levels are present in groundwater within the WSQ and north of the Femme Osage Slough.

2.2.4 Metals Results

All wells in the WSQ monitoring program are sampled for arsenic and barium. The results for the fifth and sixth bimonthly periods and the fourth quarter are presented in Tables 2-11 through 2-13. Arsenic levels were consistent with historical and background values for groundwater in the vicinity of the WSQ. Barium levels have remained elevated, but within historical ranges in the wells in the vicinity of the Femme Osage Slough. Elevated metal concentrations have been indicated in monitoring well MW-1010 located adjacent to the Femme Osage Slough. An elevated concentration of barium has been detected in monitoring well MW-1037 during the sixth bimonthly period and is considered to be erroneous based on the historic average for this and surrounding monitoring wells.

TABLE 2-8 Fifth Bimonthly (Sept/Oct) Nitroaromatic Results for Groundwater at the WSQ

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1002-B592	ND	0.33	0.10	8.3	30	200
GW-1004-B592	ND	ND	3.5	4.3	12	6.2
GW-1005-B592	ND	ND	0.092	0.028	ND	ND
GW-1006-B592	ND	ND	0.080	0.63	1.7	6.0
GW-1007-B592	ND	ND	ND	ND	ND	ND
GW-1008-B592	ND	ND	ND	ND	ND	ND
GW-1009-B592	ND	ND	ND	ND	ND	ND
GW-1010-B592	ND	ND	ND	ND	ND	ND
GW-1011-B592	ND	ND	ND	ND	ND	ND
GW-1012-B592	ND	ND	ND	ND	ND	ND
GW-1013-B592	ND	ND	ND	ND	ND	ND
GW-1014-B592	ND	ND	0.036	ND	ND	ND
GW-1015-B592	ND	0.22	0.062	0.64	20	120
GW-1016-B592	ND	ND	ND	0.12	1.8	9.0
GW-1026-B592	ND	ND	ND	ND	ND	ND
GW-1027-B592	ND	ND	19	5.8	6.5	ND
GW-1028-B592	ND	ND	ND	ND	ND	ND
GW-1029-B592	ND	ND	ND	ND	ND	ND
GW-1030-B592	ND	ND	0.044	ND	ND	ND
GW-1031-B592	ND	ND	ND	ND	ND	ND
GW-1032-B592	ND	ND	0.15	0.24	0.38	ND
GW-1034-B592	ND	ND	ND	ND	ND	ND
GW-1035-B592	ND	ND	ND	ND	ND	ND
GW-1036-B592	ND	ND	ND	ND	ND	ND
GW-1037-B592	ND	ND	ND	ND	ND	ND
GW-1038-B592	ND	ND	ND	ND	ND	ND
GW-1039-B592	ND	ND	ND	ND	ND	ND

NA - Not Available
ND - Not Detected

TABLE 2-9 Sixth Bimonthly (Nov/Dec) Nitroaromatic Results for Groundwater at the WSQ

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1002-B692	ND	0.47	0.26	42	120	680
GW-1004-B692	ND	ND	3.2	3.5	9.5	5.8
GW-1005-B692	ND	ND	0.11	0.026	ND	ND
GW-1006-B692	ND	ND	0.12	0.68	1.2	5.5
GW-1007-B692	ND	ND	ND	ND	ND	ND
GW-1008-B692	ND	ND	ND	0.051	0.26	0.041
GW-1009-B692	ND	ND	ND	ND	ND	ND
GW-1010-B692	ND	ND	ND	ND	ND	ND
GW-1011-B692	ND	ND	ND	ND	ND	ND
GW-1012-B692	ND	ND	ND	ND	ND	ND
GW-1013-B692	ND	ND	0.030	ND	ND	ND
GW-1014-B692	ND	ND	0.044	ND	ND	ND
GW-1015-B692	ND	0.45	0.062	0.46	15	75
GW-1016-B692	ND	ND	ND	0.096	1.4	5.8
GW-1026-B692	ND	ND	ND	ND	ND	ND
GW-1027-B692	ND	ND	1.6	1.3	9.5	0.058
GW-1028-B692	ND	ND	ND	ND	ND	ND
GW-1029-B692	ND	ND	ND	ND	ND	ND
GW-1030-B692	ND	ND	0.045	ND	ND	ND
GW-1031-B692	ND	ND	ND	ND	ND	ND
GW-1032-B692	ND	ND	0.11	0.11	0.098	ND
GW-1034-B692	ND	ND	ND	ND	ND	ND
GW-1035-B692	ND	ND	ND	ND	ND	ND
GW-1036-B692	ND	ND	ND	ND	ND	ND
GW-1037-B692	ND	ND	ND	ND	ND	ND
GW-1038-B692	ND	ND	ND	ND	ND	ND
GW-1039-B692	ND	ND	ND	ND	ND	ND

NA - Not Available
ND - Not Detected

TABLE 2-10 Fourth Quarter Nitroaromatic Results for Groundwater at the WSQ

Sample ID	NB (µg/l)	1,3-DNB (µg/l)	2,4-DNT (µg/l)	2,6-DNT (µg/l)	2,4,6-TNT (µg/l)	1,3,5-TNB (µg/l)
GW-1017-Q492	ND	ND	ND	ND	ND	ND
GW-1018-Q492	ND	ND	ND	ND	ND	ND
GW-1019-Q492	ND	ND	ND	ND	ND	ND
GW-1020-Q492	ND	ND	ND	ND	ND	ND
GW-1021-Q492	ND	ND	ND	ND	ND	ND
GW-1022-Q492	ND	ND	ND	ND	ND	ND
GW-1023-Q492	ND	ND	ND	ND	ND	ND
GW-1024-Q492	ND	ND	ND	ND	ND	ND
GW-1033-Q492	ND	ND	ND	ND	ND	ND
GW-RMW1-Q492	ND	ND	ND	ND	ND	ND
GW-RMW2-Q492	ND	ND	ND	ND	ND	ND
GW-RMW3-Q492	ND	ND	ND	ND	ND	ND
GW-RMW4-Q492	ND	ND	ND	ND	ND	ND
GW-PW02-Q492	ND	ND	ND	ND	ND	ND
GW-PW03-Q492	ND	ND	ND	ND	ND	ND
GW-PW04-Q492	ND	ND	ND	ND	ND	ND
GW-PW05-Q492	ND	ND	ND	ND	ND	ND
GW-PW06-Q492	ND	ND	ND	ND	ND	ND
GW-PW07-Q492	ND	ND	ND	ND	ND	ND
GW-PW08-Q492	ND	ND	ND	ND	ND	ND
GW-PW09-Q492	ND	ND	ND	ND	ND	ND
GW-RAWW-Q492	ND	ND	ND	ND	ND	ND
GW-FINW-Q492	ND	ND	ND	ND	ND	ND

NA - Not Available
ND - Not Detected

TABLE 2-11 Fifth Bimonthly (Sept/Oct) Metal Results for Groundwater at the WSQ

Sample ID	Arsenic (µg/l)	Barium (µg/l)
GW-1002-B592	ND	118
GW-1004-B592	ND	33.3
GW-1005-B592	ND	61.7
GW-1006-B592	3.70	83.4
GW-1007-B592	11.4	324
GW-1008-B592	ND	55.6
GW-1009-B592	ND	337
GW-1010-B592	120	439
GW-1011-B592	ND	271
GW-1012-B592	ND	125
GW-1013-B592	2.60	151
GW-1014-B592	ND	161
GW-1015-B592	ND	104
GW-1016-B592	ND	133
GW-1026-B592	19.6	401
GW-1027-B592	ND	134
GW-1028-B592	ND	278
GW-1029-B592	ND	107
GW-1030-B592	ND	82.0
GW-1031-B592	ND	110
GW-1032-B592	ND	105
GW-1034-B592	ND	144
GW-1035-B592	ND	203
GW-1036-B592	ND	279
GW-1037-B592	ND	673
GW-1038-B592	ND	254
GW-1039-B592	ND	488

ND - Not Detected
NA - Not Available

TABLE 2-12 Sixth Bimonthly (Nov/Dec) Metal Results for Groundwater at the WSQ

Sample ID	Arsenic (μg/l)	Barium (μg/l)
GW-1002-B692	ND	119
GW-1004-B692	ND	30.4
GW-1005-B692	ND	61.4
GW-1006-B692	ND	84.0
GW-1007-B692	17.2	370
GW-1008-B692	ND	45.0
GW-1009-B692	9.09	481
GW-1010-B692	130	503
GW-1011-B692	ND	295
GW-1012-B692	ND	138
GW-1013-B692	NA	NA
GW-1014-B692	NA	NA
GW-1015-B692	ND	98.1
GW-1016-B692	ND	133
GW-1026-B692	19.4	434
GW-1027-B692	ND	98.5
GW-1028-B692	NA	NA
GW-1029-B692	ND	152
GW-1030-B692	ND	122
GW-1031-B692	ND	103
GW-1032-B692	ND	89.9
GW-1034-B692	ND	156
GW-1035-B692	ND	198
GW-1036-B692	ND	315
GW-1037-B692	ND	569
GW-1038-B692	ND	250
GW-1039-B692	ND	489

ND - Not Detected
NA - Not Available

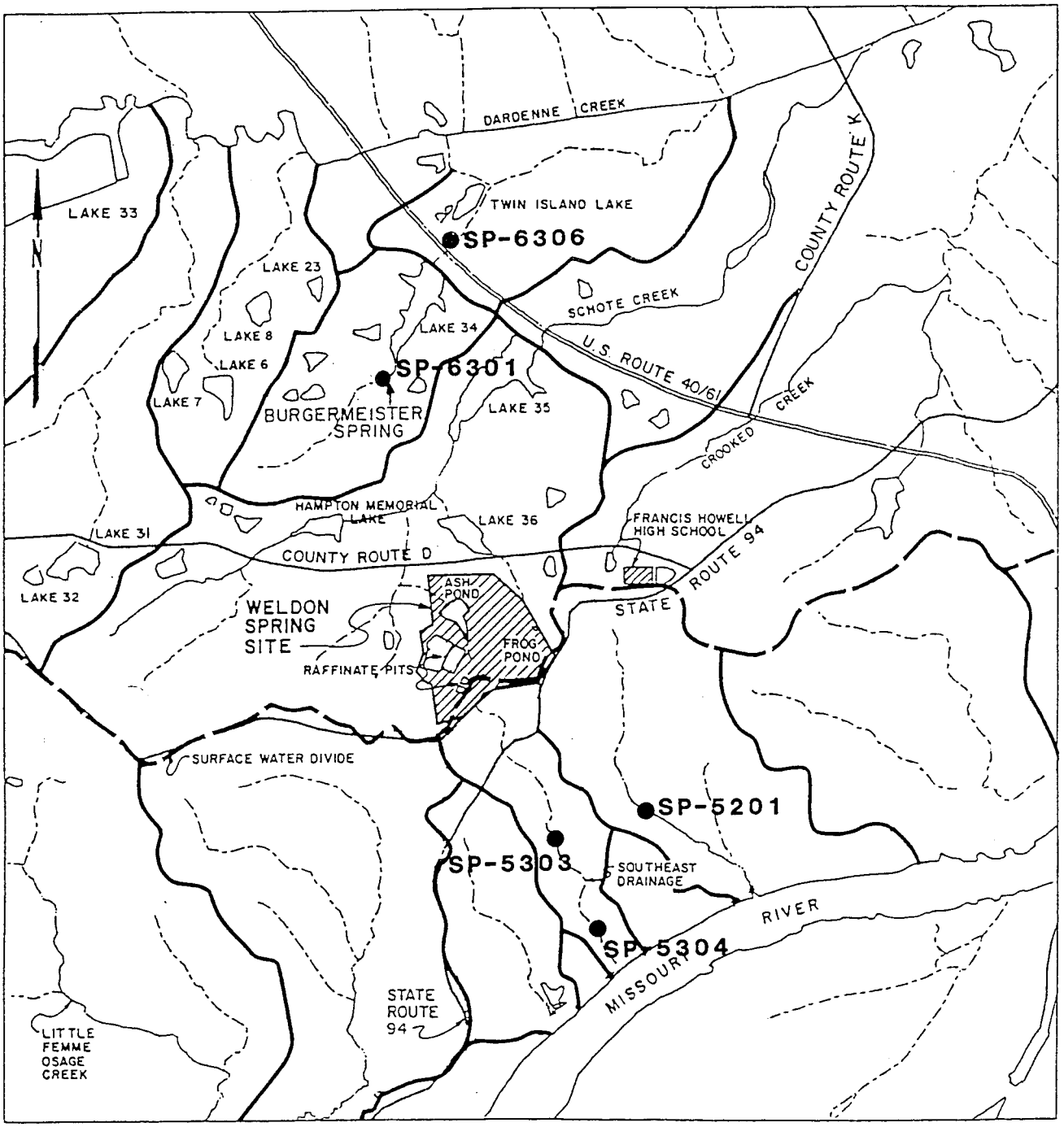
TABLE 2-13 Fourth Quarter Metal Results for Groundwater at the WSQ

Sample ID	Arsenic (μg/l)	Barium (μg/l)
GW-1017-Q492	179	950
GW-1018-Q492	103	674
GW-1019-Q492	79	842
GW-1020-Q492	22.2	411
GW-1021-Q492	78.2	761
GW-1022-Q492	169	567
GW-1023-Q492	71.2	320
GW-1024-Q492	7.00	513
GW-1033-Q492	ND	596
GW-RMW1-Q492	5.40	542
GW-RMW2-Q492	15.5	260
GW-RMW3-Q492	28.3	640
GW-RMW4-Q492	8.40	167
GW-PW02-Q492	ND	304
GW-PW03-Q492	ND	284
GW-PW04-Q492	ND	311
GW-PW05-Q492	ND	341
GW-PW06-Q492	ND	322
GW-PW07-Q492	ND	346
GW-PW08-Q492	2.98	462
GW-PW09-Q492	4.98	519
GW-RAWW-Q492	ND	349
GW-FINW-Q492	ND	90

ND - Not Detected
NA - Not Available

2.3 Springs

Five springs near the Weldon Spring site (WSS), which are measurably influenced by site-related contaminants, were sampled during the fourth quarter (see Figure 2-4). During the fourth quarter, spring samples were analyzed for uranium and inorganic anions. Results are presented in Table 2-14. SP-6301 and SP-6306 were sampled during high and low flow to evaluate the groundwater (which is thought to dominate low flow) and surface water (which is thought to dominate high flow) components of flow. Results for the fourth quarter remain consistent with historical values.



● SPRING

0 3200 6400 FT

0 975.4 1950.7 M

SCALE

SPRINGS IN THE VICINITY OF THE WSS

FIGURE 2-4

REPORT NO.: DOE/OR/21548-379		EXHIBIT NO.:	A/VP/040/0592
ORIGINATOR: MGT	DRAWN BY: GLN	DATE:	5/92

TABLE 2-14 Fourth Quarter Uranium and Inorganic Anion Results for Springs Near the Weldon Spring Site

Sample ID	Nitrate (mg/l)	Sulfate (mg/l)	Uranium (pCi/l)
SP-6301-Q492-H	21.8	73.1	110
SP-6301-Q492-L	73.2	59.2	79
SP-6306-Q492-H	ND	5.20	2.0
SP-6306-Q492-L	0.23	13.3	2.0
SP-5303-Q492	0.50	64.0	73
SP-5304-Q492	0.81	52.3	88
SP-5201-Q492	0.30	56.5	0.82

3 SURFACE WATER MONITORING

Routine samples were collected during the fourth quarter and fifth and sixth bimonthly periods of 1992 from both on-site and off-site surface water locations. All surface water samples were analyzed without filtering, unless a specific comparison of dissolved versus total contaminant concentrations was desired. Some analytical results are not available at this time; however, they will be presented in the 1992 annual site environmental report (ASER).

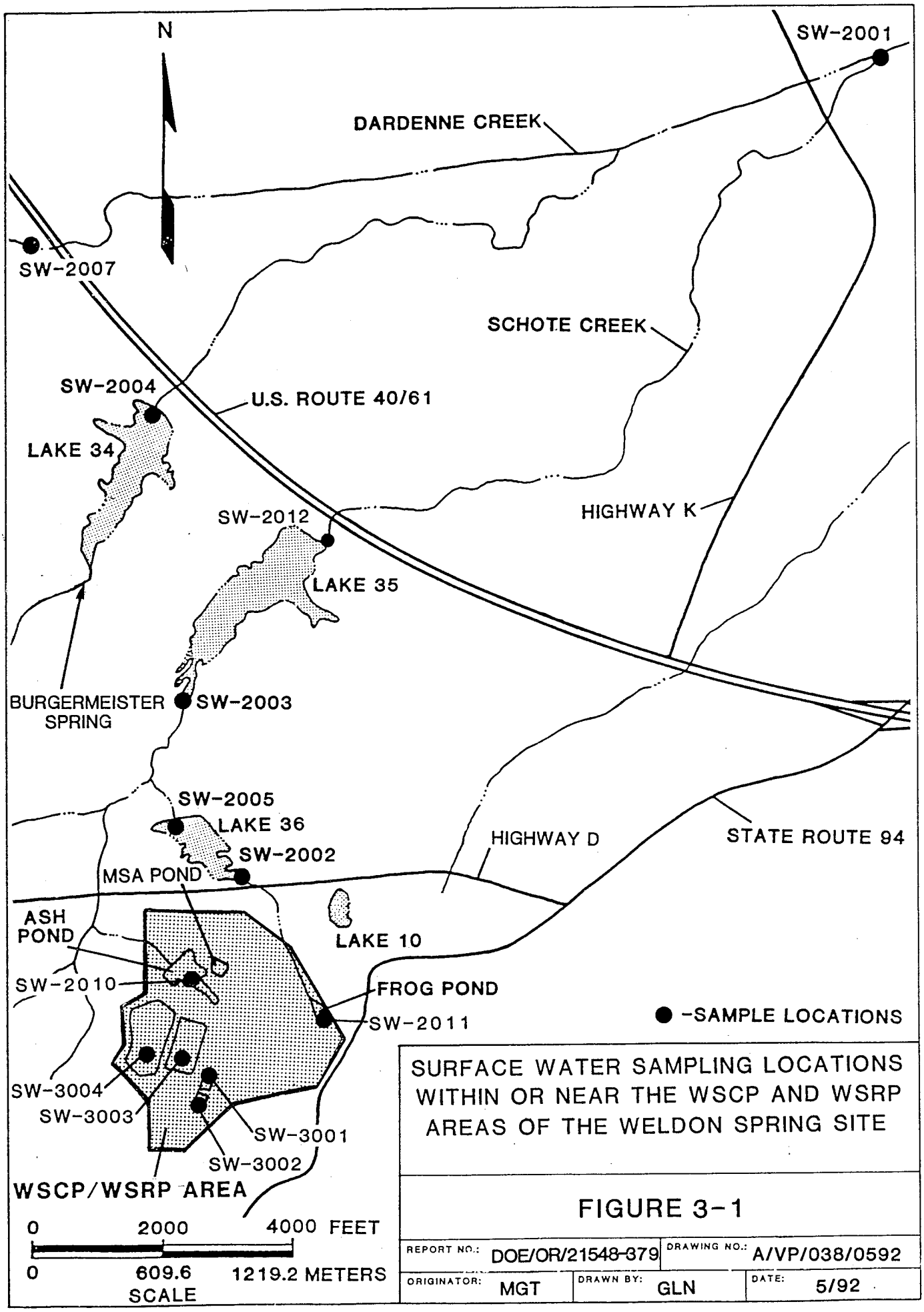
3.1 Chemical Plant/Raffinate Pits/Vicinity Properties

During the fourth quarter, surface water samples were collected from the 15 surface water sampling locations and analyzed for uranium (Figure 3-1). Monitoring points SW-2016 and SW-5311 are not shown in Figure 3-1. Location SW-2016 is located at the intersection of Dardenne Creek and County Highway N. This is the furthest location downstream at which contaminants are sampled for in Dardenne Creek after it has received the Schote Creek contribution. Location SW-5311 is located just above the confluence of the Southeast Drainage to the Missouri River. The results, presented in Table 3-1, indicated that conditions at sampling locations remain consistent with historical values.

3.2 Weldon Spring Quarry

During fifth and sixth bimonthly periods, surface water samples were collected from 13 locations shown in Figures 3-2 and 3-3 and analyzed for uranium. Results remain within historical ranges and are presented in Tables 3-2 and 3-3.

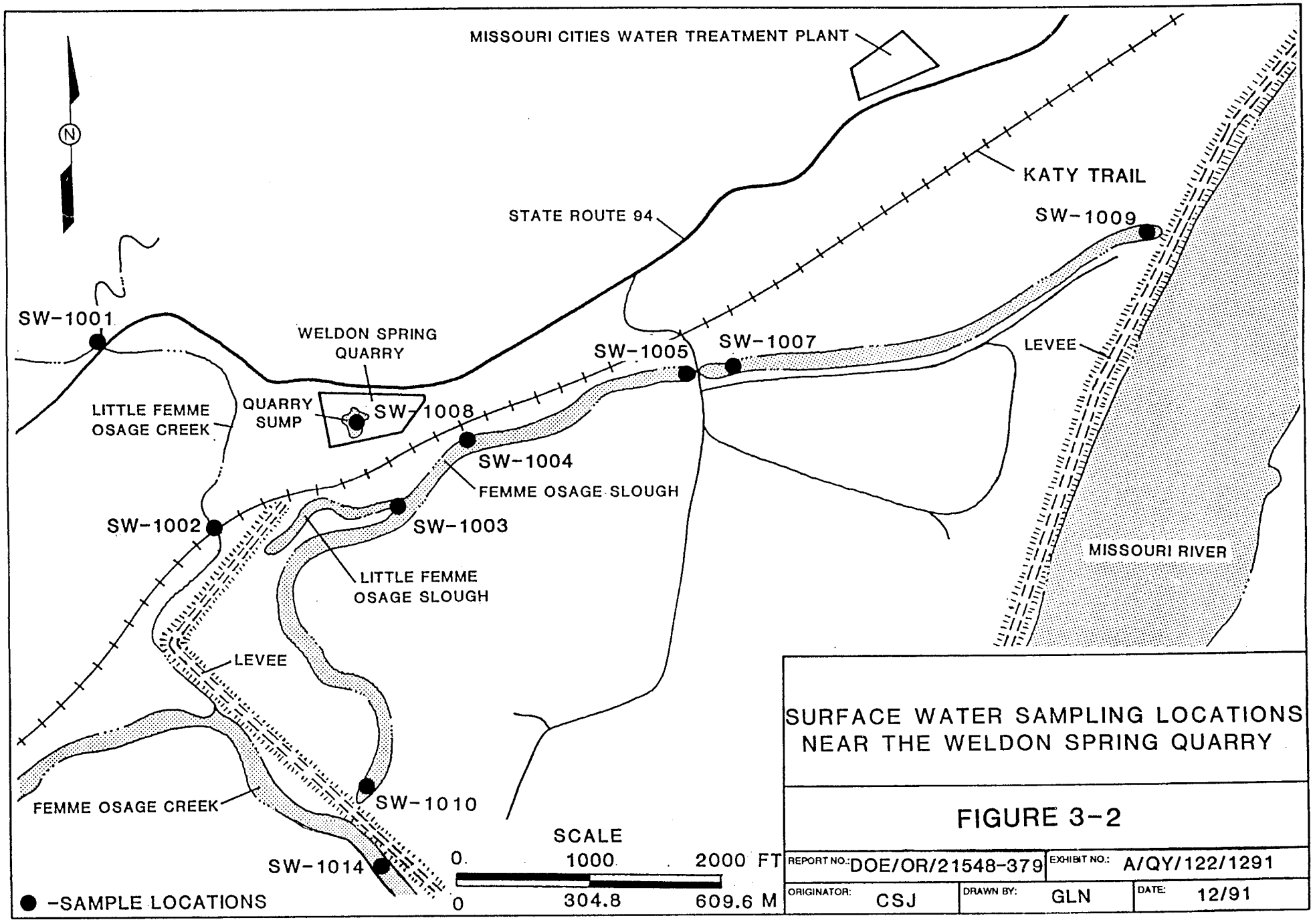
In addition to uranium samples, the Weldon Spring Quarry pond was sampled for nitroaromatics, isotopic radium, isotopic thorium, and inorganic anions during the fifth and sixth bimonthly periods. The results for fifth and sixth bimonthly periods are within historic ranges for all parameters analyzed and are presented in Table 3-4.



SURFACE WATER SAMPLING LOCATIONS WITHIN OR NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

FIGURE 3-1

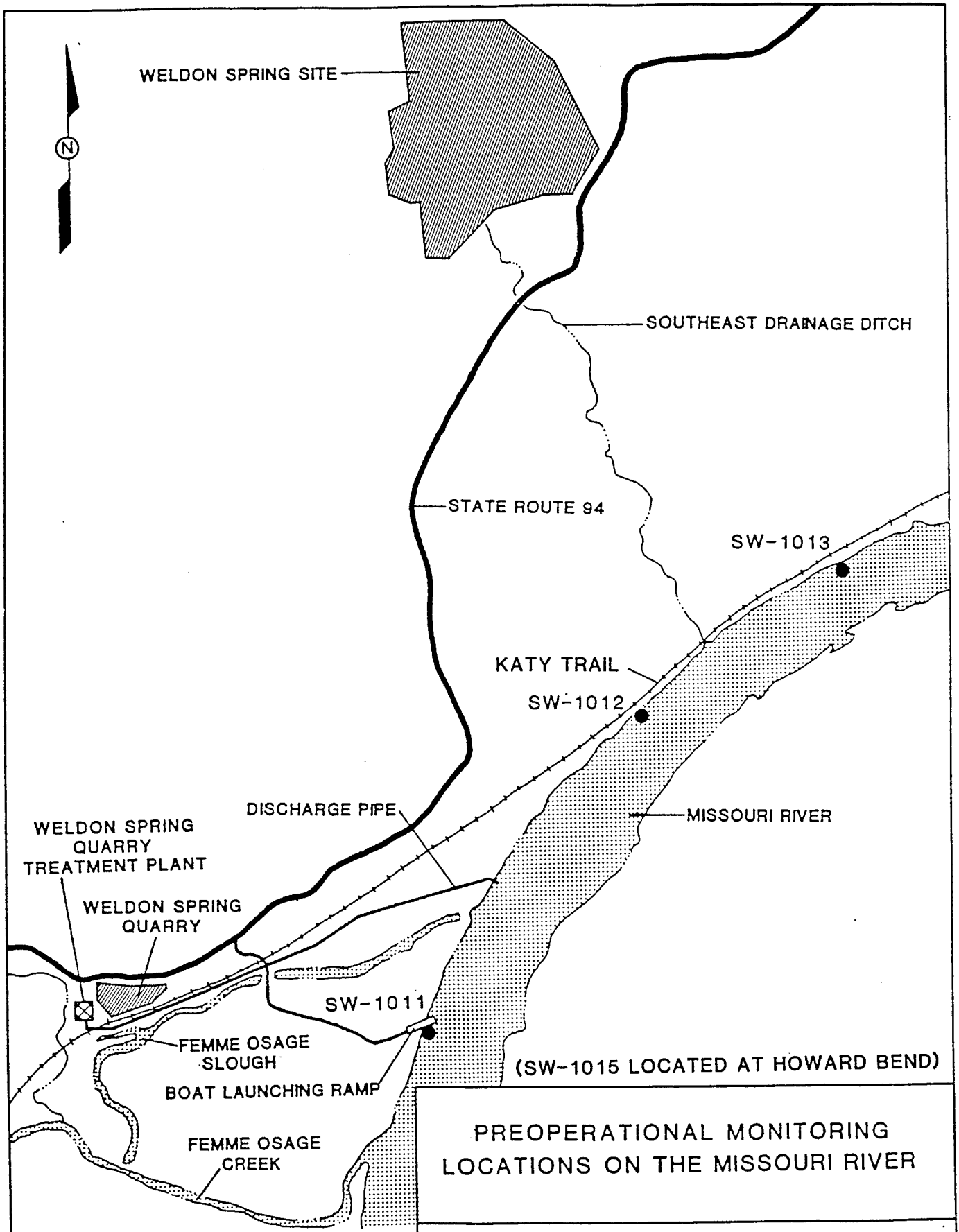
REPORT NO.: DOE/OR/21548-379	DRAWING NO.: A/VP/038/0592	
ORIGINATOR: MGT	DRAWN BY: GLN	DATE: 5/92



SURFACE WATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 3-2

REPORT NO.: DOE/OR/21548-379			EXHIBIT NO.: A/QY/122/1291		
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 12/91			



PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

FIGURE 3-3

REPORT NO.: DOE/OR/21548-379	EXHIBIT NO.: A/VP/193/1291		
ORIGINATOR: CSJ	DRAWN BY: GLN	DATE: 12/91	

TABLE 3-1 Fourth Quarter Uranium Results in Surface Water at the WSCP/WSRP

Sample ID	Uranium (pCi/l)
SW-2001-Q492	0.68
SW-2002-Q492	80
SW-2003-Q492	NA
SW-2004-Q492	14
SW-2005-Q492	24
SW-2007-Q492	ND
SW-2010-Q492	NA
SW-2011-Q492	270
SW-2012-Q492	NA
SW-2016-Q492	2.8
SW-3001-Q492	55
SW-3002-Q492	920
SW-3003-Q492	170
SW-3004-Q492	1000
SW-5311-Q492	NA

NA - Not Available
ND - Not Detected

TABLE 3-2 Fifth Bimonthly (Sept/Oct) Uranium Results in Surface Water at the WSQ

Sample ID	Uranium (pCi/l)
SW-1001-B592	1.6
SW-1002-B592	ND
SW-1003-B592	8.2
SW-1004-B592	18
SW-1005-B592	10
SW-1007-B592	11
SW-1008-B592	58
SW-1009-B592	5.7
SW-1010-B592	22
SW-1011-B592	4.2
SW-1012-B592	4.0
SW-1013-B592	4.5
SW-1014-B592	1.8

ND - Not Detected

TABLE 3-3 Sixth Bimonthly (Nov/Dec) Uranium Results in Surface Water at the WSQ

Sample ID	Uranium (pCi/l)
SW-1001-B692	1.7
SW-1002-B692	1.4
SW-1003-B692	45
SW-1004-B692	44
SW-1005-B692	18
SW-1007-B692	15
SW-1008-B692	470
SW-1009-B692	3.6
SW-1010-B692	32
SW-1011-B692	3.8
SW-1012-B692	2.2
SW-1013-B692	2.1
SW-1014-B692	0.82

TABLE 3-4 Fifth and Sixth Bimonthly Results for SW-1008

Parameter	Fifth Bimonthly Concentrations	Sixth Bimonthly Concentrations
1,3,5-Trinitrobenzene (μg/l)	0.079	0.031
1,3-Dinitrobenzene (μg/l)	ND	ND
2,4,6-TNT (μg/l)	10	16
2,4-DNT (μg/l)	7	10
2,6-DNT (μg/l)	0.66	0.50
Nitrobenzene (μg/l)	ND	ND
Uranium (pCi/l)	58	470
Ra-226 (pCi/l)	0.7	0.1
Ra-228 (pCi/l)	ND	0.9
Th-228 (pCi/l)	NA	ND
Th-230 (pCi/l)	0.9	ND
Th-232 (pCi/l)	ND	ND
Nitrate (mg/l)	ND	ND
Sulfate (mg/l)	67.9	57.0

ND - Not Detected

4 EFFLUENT MONITORING

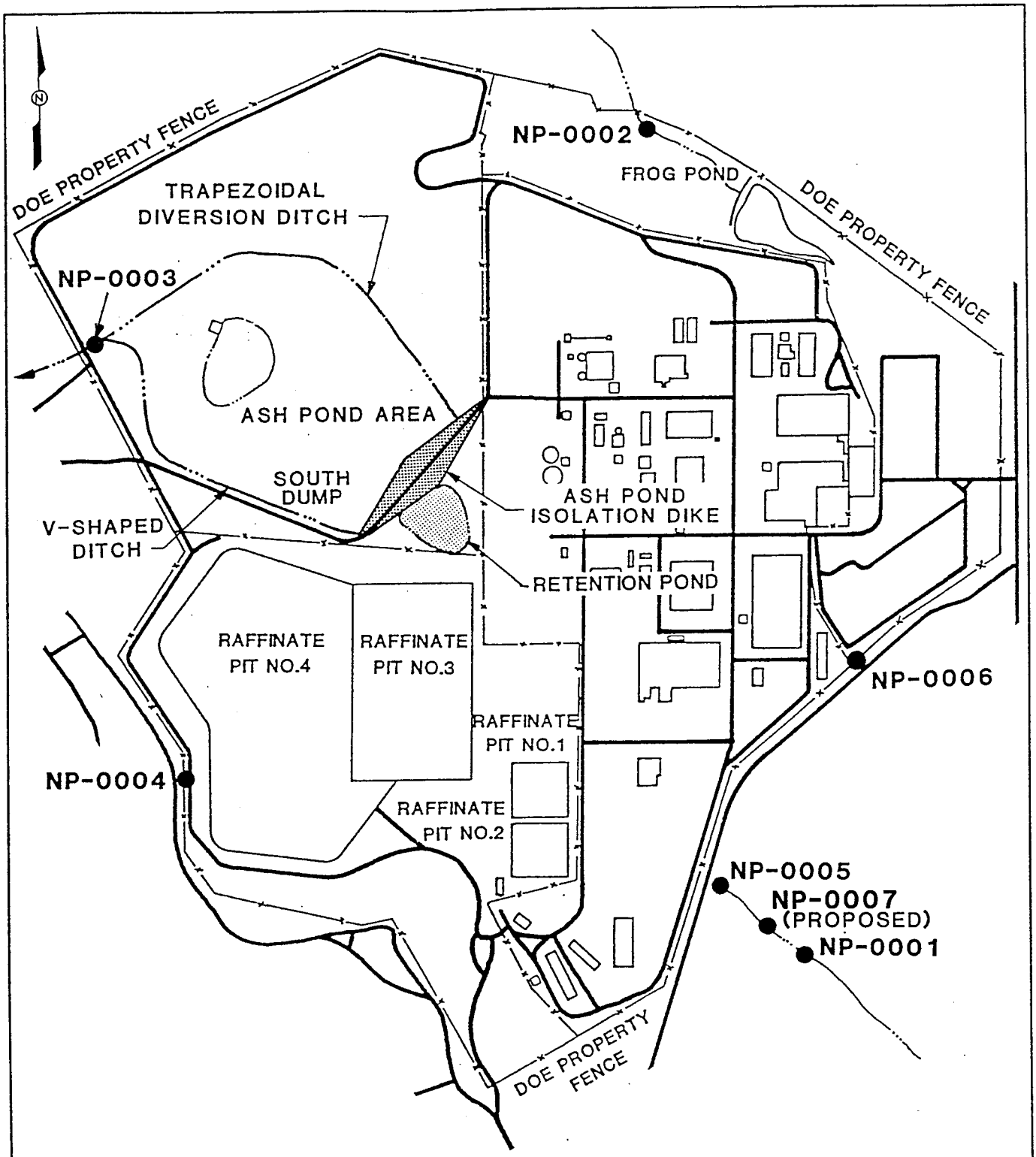
The National Pollutant Discharge Elimination System (NPDES) permit process is authorized by Section 402(a)(1) of the *Clean Water Act of 1977.* The authority to issue permits is delegated to the State of Missouri by the U.S. Environmental Protection Agency (EPA). The State of Missouri has issued seven NPDES permits to the U.S. Department of Energy (DOE) allowing the discharge of storm water, hydrostatic test water, and treated wastewater to waters of the state. The permits require that samples of the water be collected periodically and the results reported to the Missouri Department of Natural Resources. The following sections contain the analytical results for samples collected during October, November, and December of 1992. No NPDES permit limits were violated during the fourth quarter 1992.

4.1 National Pollutant Discharge Elimination System Data Review

Effluent samples were collected and analyzed in compliance with the Weldon Spring site NPDES permits. Permit No. MO-0107701 was issued on October 1, 1990, and currently addresses the five storm water and two wastewater discharges shown in Figure 4-1. Outfalls NP-0001 through NP-0005 represent storm water discharges; Outfall NP–0006 represents the treated wastewater discharge associated with the administration building sanitary wastewater treatment plant; and Outfall NP-0007 represents the site water treatment plant, which is under construction, and nearing completion. There was no discharge from Outfall NP-0007. Outfalls NP-0006 and NP-0007 have effluent limitations. The five storm water outfalls have "monitoring only" requirements for permitted parameters. Fourth quarter 1992 analytical data for each outfall are presented in Table 4-1.

In addition, storm water was pumped from the temporary storage area (TSA) basin to an area just west of the TSA itself. The location of the basin prevented the water from being pumped through a permitted outfall. Under the direction of the Missouri Department of Natural resources, this water was sampled as if it were flowing from the site through a permitted outfall. These results are included in Table 4-1.

Permit No. MO-0108987 was issued on May 5, 1989, for Outfall NP-1001 of the Weldon Spring Quarry water treatment plant. The first batch (approximately 541,000 gallons) of water from the Weldon Spring Quarry was treated in November 1992. Comprehensive sampling of the treated water was conducted on November 19, 1992. The *Discharge Monitoring Report —*



NPDES SURFACE WATER SAMPLING LOCATIONS AT THE WSCP/RP

FIGURE 4-1

SCALE 0 500 1000 FT
0 152.4 304.8 M

REPORT NO.:	DOE/OR/21548-379	EXHIBIT NO.:	A/CP/050/0592		
ORIGINATOR:	TW	DRAWN BY:	GLN	DATE:	5/92

TABLE 4-1 Results of NPDES Monitoring for NP-0001 through NP-0006

Outfall NP-0001 NPDES data for Q4 1992

Date Sampled	Flow	Susp. Solids	Set. Solids	Nitrate	pH	Lithium	Gross Alpha	Total Uranium	
Units	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
October 30	22,000	64.0	<0.1	0.63	7.38	ND (0.027)	306	0.692	471

Outfall NP-0002 NPDES data for Q4 1992

Date Sampled	Flow	Susp. Solids	Set. Solids	Nitrate	pH	Lithium	Gross Alpha	Total Uranium	
Units	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
October 20	17,000	7.0	<0.1	0.66	7.47	ND (0.024)	240	0.381	259
November 3	163,500	26.00	<0.1	0.40	8.26	ND (0.027)	220	0.312	212
December 9	1,500	11.0	<0.1	60.5	8.27	ND (0.009)	300	0.407	277

Outfall NP-0003 NPDES data for Q4 1992

Date Sampled	Flow	Susp. Solids	Set. Solids	Nitrate	pH	Lithium	Gross Alpha	Total Uranium	
Units	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
October 30	14,000	27.0	<0.1	0.38	7.95	ND (0.027)	120	0.2	136
November 3	184,700	25.0	<0.1	0.96	7.98	ND (0.027)	30	0.0787	54
December 10	26,000	9.0	<0.1	1.30	7.61	ND (0.027)	510	0.889	604

TABLE 4-1 Results of NPDES Monitoring for NP-0001 through NP-0006 (Continued)

Outfall NP-0004 NPDES data for Q4 1992

Date Sampled	Flow	Susp. Solids	Set. Solids	Nitrate	pH	Lithium	Gross Alpha	Total Uranium	
Units	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
December 9	1,500	41.0	<0.1	562	8.56	ND (0.009)	20	0.0178	12

Outfall NP-0005 NPDES data for Q4 1992

Date Sampled	Flow	Susp. Solids	Set. Solids	Nitrate	pH	Lithium	Gross Alpha	Total Uranium	
Units	GPD**	mg/l	ml/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
October 30	3,000	65.0	<0.1	0.58	7.31	ND (0.027)	320	0.571	388
November 3	258,000	197	1.1	0.17	8.13	ND (0.027)	270	0.372	253
November 10	231,900	600	<0.1	0.84	6.89	0.039	250	0.343	233
December 8	7,200	38.0	0.1	0.41	7.63	ND (0.027)	230	0.339	231

Outfall NP-0006 NPDES data for Q4 1992

Date Sampled	Flow	Susp. Solids	BOD	Fecal Coliform	pH
Units	GPD**	mg/l	mg/l	Colonies/100 ml	pH units
October	a	a	a	a	a
November	a	a	a	a	a
December	a	a	a	a	a

TABLE 4-1 Results of NPDES Monitoring for NP-0001 through NP-0006 (Continued)

Outfall Near Temporary Storage Area Basin Data for Q4 1992

Date Sampled	Total Flow	Susp. Solids	Oil and Grease	Settleable Solids	Nitrate	pH	Lithium	Gross Alpha	Total Uranium	
Units	GPD	mg/l	mg/l	mg/l/hr	mg/l	pH units	mg/l	pCi/l	mg/l	pCi/l
October 3	1,000	24.0	NS	0.2	0.25	8.33	ND(0.024)	2.8	0.0035	2.38
October 8	50,000	165.0	NS	<0.1	0.89	7.44	ND(0.024)	9.7	0.0070	4.76
November 12	700,000	30.0	NS	NS	3.46	6.43	ND(0.009)	5.4	0.0074	5.03
November 25	50,000	19.0	ND (5.0)	<0.1	1.30	7.43	ND(0.027)	1.4	0.0039	2.65
December 7	100,000	ND(5.0)	ND (5.0)	<0.1	1.80	7.52	ND(0.027)	2.2	0.0094	6.4
December 10	25,000	11.0	ND (5.0)	<0.1	2.3	7.96	ND(0.027)	1.2	0.0044	3.0
December 16	50,000	35.0	NS	<0.1	1.48	8.08	0.009	2.1	0.0014	0.952

* Data not yet received from contract laboratory.

** Indicates flow rate at time of sample collection.

ND Not detected, detection limit is in parentheses.

[a] No effluent discharge due to construction improvements to treatment plant. Influent sewage was removed daily by Ace Septic Service -- Approximately 4,000 gallons per day.

NS Not sampled.

Fourth Quarter 1992 contains all results of the treated water sampling and has been transmitted to the Missouri Department of Natural Resources. The treated water was in compliance with all applicable limits and was discharged to the Missouri River on January 7, 1992, and January 8, 1992. Analytical results for the treated water are presented in Table 4-2.

Under the NPDES permits MO-G680001, MO-G680002, MO-680004, and MO-680005, potable water used to hydrostatically test vessels, basins, and pipelines at the quarry and site water treatment plants, was discharged a total of 23 times during the fourth quarter of 1992. All discharges were within NPDES permit limits. Analytical results of these discharges will be included in the 1992 site environmental report.

4.1.1 Radiological Analysis

Gross alpha and uranium analyses corresponded well with past data with the following exception. Analysis of the December 9, 1992, sample at NP-0004 demonstrated a uranium concentration of 12 pCi/l. This concentration is slightly above the previous highest concentration at NP-0004.

The other storm water outfalls had the following ranges of uranium concentrations. The process sewer outfall NP-0001 had a sample value of 471 pCi/l (0.692 mg/l). Frog Pond outfall, NP-0002, had values from 259 pCi/l (0.381 mg/l) to 277 pCi/l (0.407 mg/l). Ash Pond outfall, MP-0003, had values from 54 pCi/l (0.0787) to 604 pCi/l (0.889 mg/l). The southeast drainage outfall, NP-0005, had values from 231 pCi/l (0.339 mg/l) to 388 pCi/l (0.571 mg/l).

4.1.2 Other Analysis

Other analyses for NP-0001 through NP-0005 include physical analyses (settleable solids and total suspended solids) and chemical analyses (nitrate, lithium, and pH). Fourth quarter 1992 values are displayed in Table 4-1 and correspond well with past values for all parameters with the following two exceptions.

Laboratory analysis demonstrated an elevated nitrate concentration of 60.5 mg/l for the December 9, 1992, sample at NP-0002. Also on December 9, 1992, laboratory analysis demonstrated a nitrate concentration of 562 mg/l at NP-0004. Previous and subsequent samples

TABLE 4-2 Results of Treated Quarry Water Analysis

Parameter	Permit Limit	Concentration in Treated Quarry Water
Chemical Oxygen Demand (mg/l)	60	1.0
Total Suspended Solids (mg/l)	30	ND(2.00)
pH (Standard Units)	6-9	6.8
2,4 DNT (μg/l)	0.22	ND (0.019)
Cyanide, Total (mg/l)	0.0075	ND (0.005)
Arsenic (mg/l)	0.10	ND (0.020)
Barium (mg/l)	1.5	0.003
Cadmium (mg/l)	0.02	ND (0.005)
Chromium (mg/l)	0.10	ND (0.006)
Copper (mg/l)	1.0	ND (0.017)
Iron (mg/l)	0.6	0.126
Lead (mg/l)	0.10	0.030
Manganese (mg/l)	0.10	0.008
Mercury (mg/l)	0.004	ND (0.001)
Selenium (mg/l)	0.02	ND (0.010)
Silver (mg/l)	0.10	ND (0.001)
Zinc (mg/l)	5.0	ND (0.015)
Fluoride (mg/l)	4.0	ND (0.050)
Sulfate (mg/l)	500	28.0
Whole Effluent Toxicity	10% Mortality	0% Mortality
Asbestos (MAS/l)	Monitor	ND (0.16)
Nitrate - N (mg/l)	Monitor	ND (0.020)
Chloride (mg/l)	Monitor	29.3
Gross Alpha (pCi/l)	Monitor	ND (2.0)
Gross Beta (pCi/l)	Monitor	7.0
Uranium, Total (pCi/l)	Monitor	ND (0.0003)

TABLE 4-2 Results of Treated Quarry Water Analysis (Continued)

Parameter	Permit Limit	Concentration in Treated Quarry Water
Radium 226 (pCi/l)	Monitor	ND (0.3)
Radium 228 (pCi/l)	Monitor	1.1
Thorium 230 (pCi/l)	Monitor	ND (0.4)
Thorium 232 (pCi/l)	Monitor	ND (0.4)
Priority Pollutants*	Monitor	ND

ND Not detected. Detection limit is in parentheses.
* Results of all "priority pollutants" were non-detect.

at both locations show substantially lower nitrate levels. These two data points are under investigation and data from these locations will be closely reviewed.

The permit for the discharge from the administration building treatment plant at outfall NP-0006 has effluent limitations and a requirement to monitor once per quarter. There was no discharge from the administration building's sewage treatment plant during the fourth quarter of 1992 because construction activities were taking place during this time to improve the new flow equalization system that was recently added to the plant. During this time, all sewage was collected from the plant and disposed of by Ace Septic Services of O'Fallon, Missouri.

5 AIR MONITORING

5.1 Radon Gas

The radon gas monitoring program utilizes a pair of alpha track radon detectors at each of the 28 permanent locations; each detector is exchanged quarterly. These detectors are deployed at seven locations at the Weldon Spring Chemical Plant, eight locations at the Weldon Spring Quarry, five locations at the Weldon Spring raffinate pits, and at eight off-site locations. Radon monitoring locations are shown in Figures 5-1, 5-2, and 5-3. On-site detectors are distributed around the perimeter fences to ensure adequate detection of radon dispersing from the properties under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005, RD-4006, and RD-4007 monitor background levels near the site.

Landauer Type F track etch detectors were used for radon monitoring during the fourth quarter of 1992. The Type F detector is designed especially for outdoor monitoring of airborne radon concentrations. The detection mechanism consists of counting tracks generated by alpha particles in detector media to determine the radon concentration.

Table 5-1 summarizes the fourth quarter 1992 radon concentrations detected at all site perimeter and off-site monitoring locations. These concentrations represent the average of the two radon detectors placed at each location. Also contained in the third column of Table 5-1 is a comparison of the measured concentration with the Federally permitted radon concentration (for unrestricted areas) of 3 pCi/l (111 Bq/m^3)[1] above background as authorized by DOE Order 5400.5.

Three stations RD-3005, RD-2007, and RD-4008, were added to the radon track etch detector network for the fourth quarter of 1992. RD-2007 and RD-3005 were placed at the WSCP perimeter. RD-4008 was placed near the Femme Osage Slough where low levels of radiological contamination is known to exist.

An average ambient background concentration was determined by calculating the arithmetic average for the five background locations. These data yielded an average ambient background radon concentration of 0.14 pCi/l (5.18 Bq/m^3) for the fourth quarter of 1992. This

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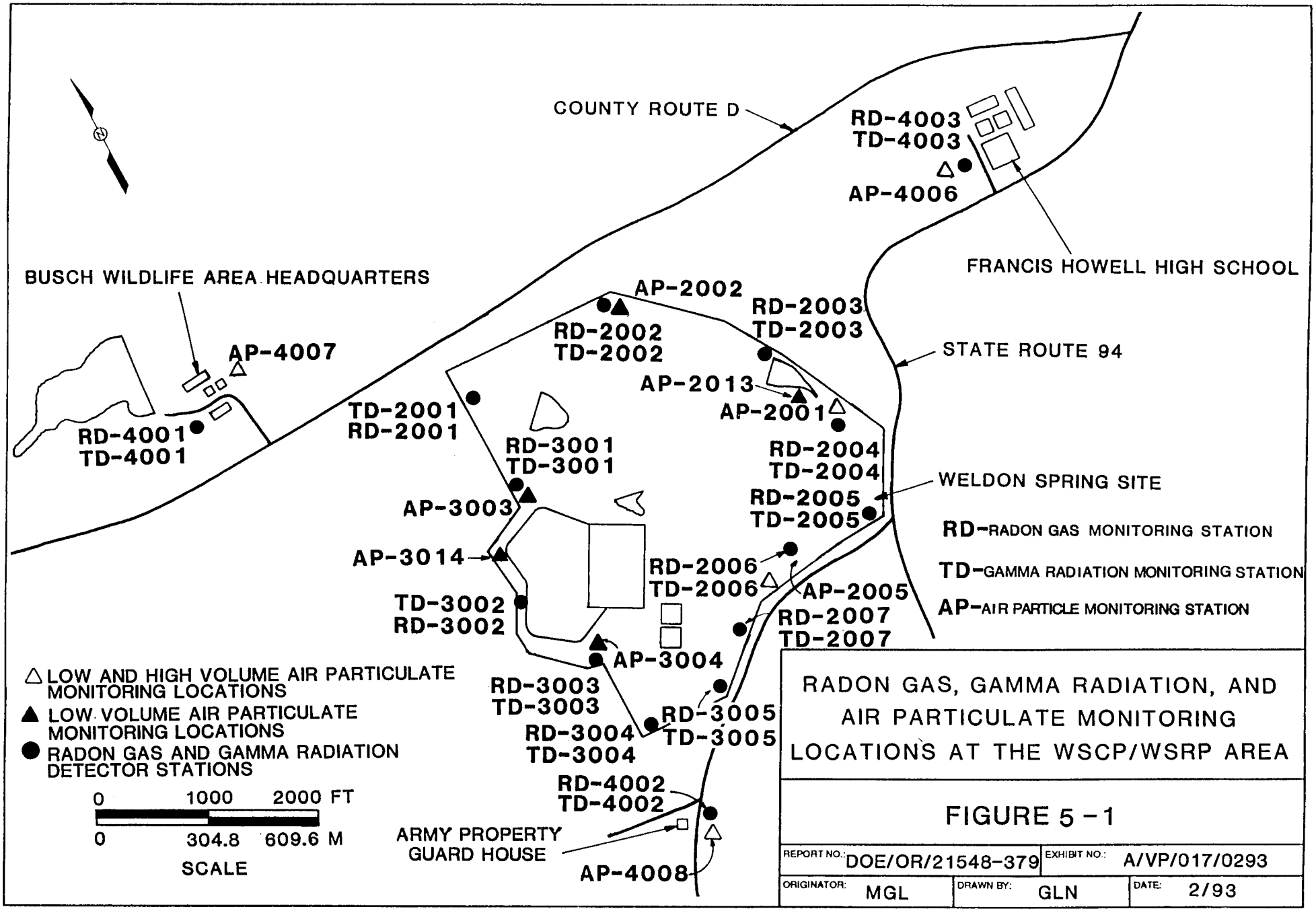
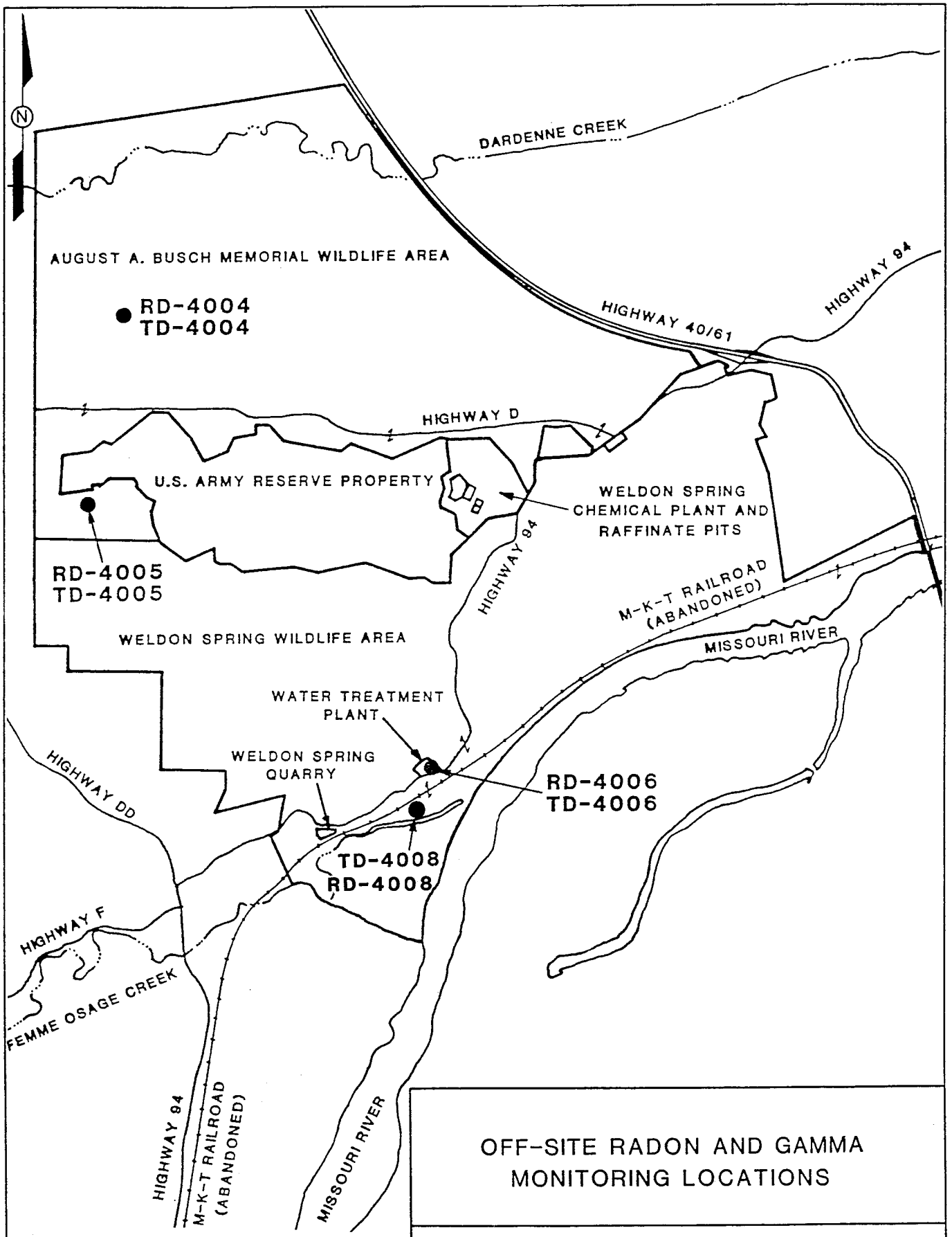
[1] To convert μCi/ml to Bq/m^3, multiply by 3.7E10.



RADON GAS, GAMMA RADIATION, AND AIR PARTICULATE MONITORING LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 5-1

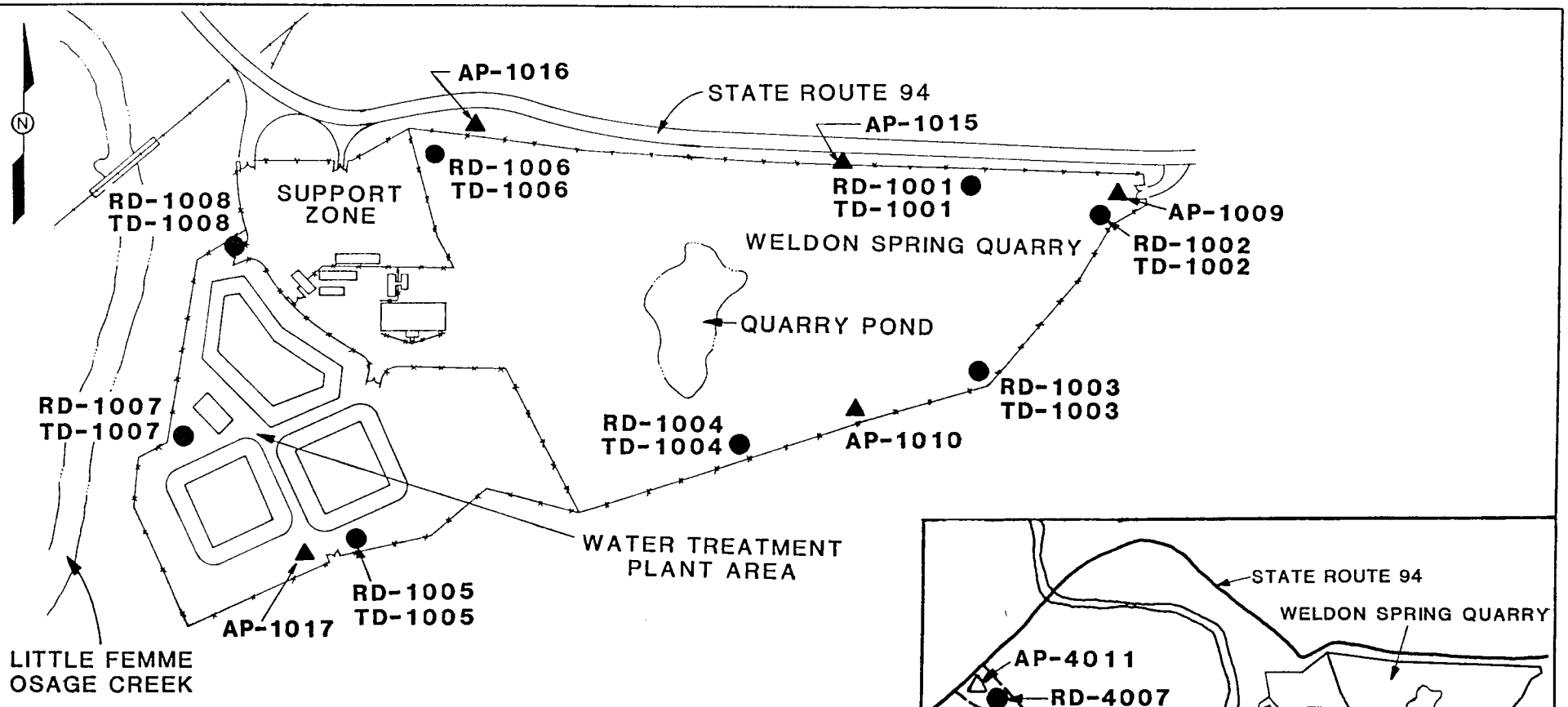
REPORT NO.: DOE/OR/21548-379		EXHIBIT NO.: A/VP/017/0293	
ORIGINATOR: MGL	DRAWN BY: GLN	DATE: 2/93	

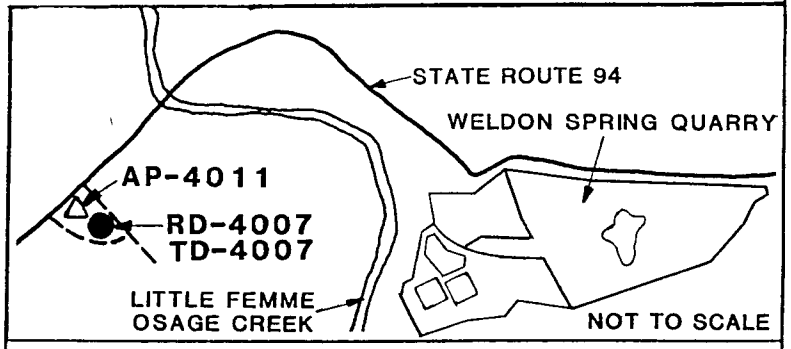


OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

FIGURE 5-2

REPORT NO.:	DOE/OR/21548-379	EXHIBIT NO.:	A/VP/042/0592		
ORIGINATOR:	DPC	DRAWN BY:	GLN	DATE:	5/92





● RADON GAS AND GAMMA RADIATION DETECTOR STATIONS

▲ LOW VOLUME AIR PARTICULATE MONITORING LOCATION

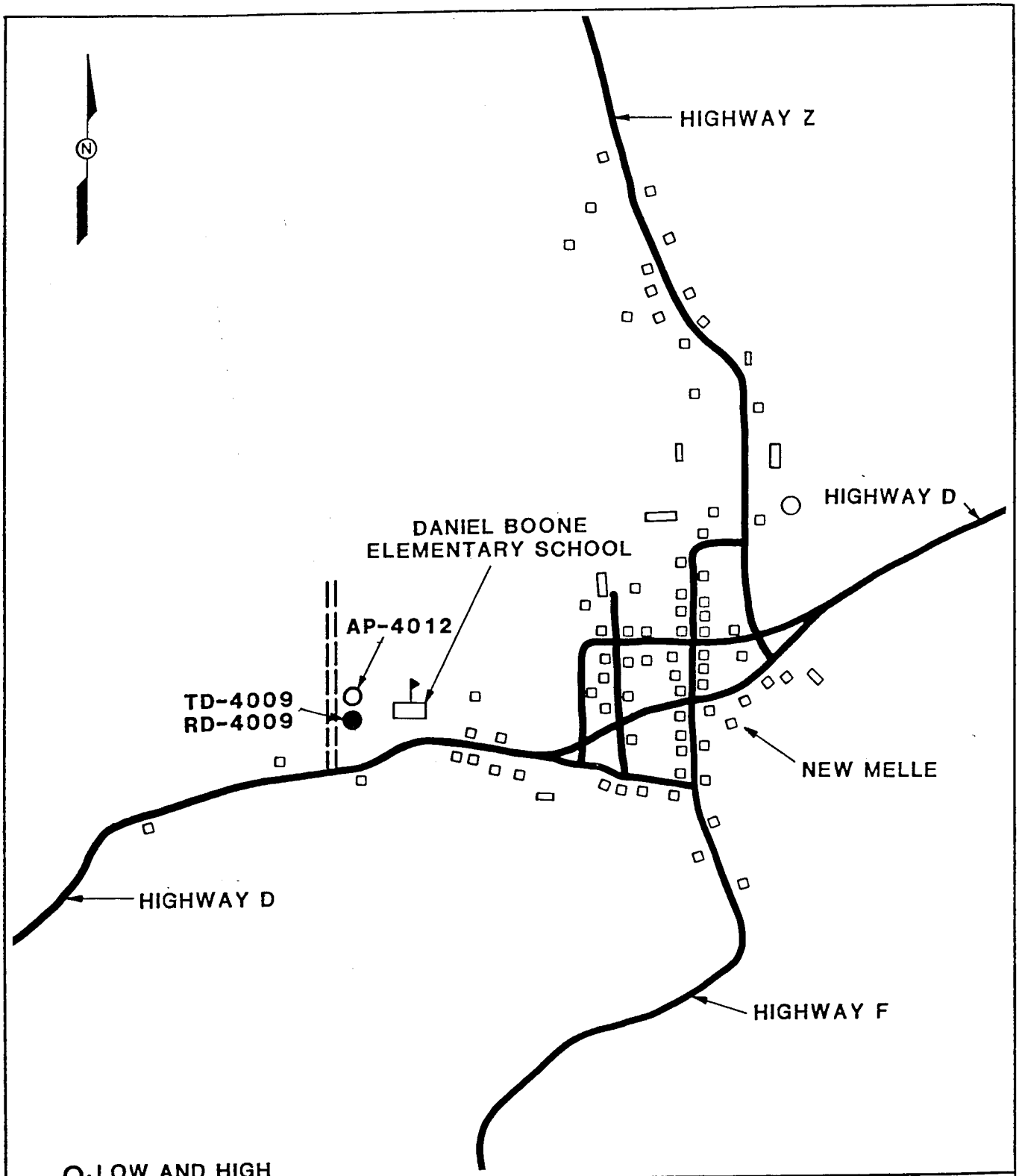
△ LOW AND HIGH VOLUME AIR PARTICULATE MONITORING LOCATION

0 150 300 FT
0 45.7 91.4 M
SCALE

RADON GAS, GAMMA RADIATION AND AIR PARTICULATE MONITORING LOCATIONS AT THE WSQ AREA

FIGURE 5-3

REPORT NO.: DOE/OR/21548-379		EXHIBIT NO.:	A/QY/012/0293
ORIGINATOR: MGL	DRAWN BY: GLN	DATE:	2/93



○ LOW AND HIGH VOLUME AIR PARTICULATE, RADON/THORON GAS, AND RADON/THORON DAUGHTER SAMPLERS

● RADON GAS DETECTOR AND GAMMA RADIATION DETECTOR STATION

0 .25 MI

0 SCALE .40 KM

BACKGROUND AIR MONITORING STATION

FIGURE 5-4

REPORT NO.: DOE/OR/21548-379	EXHIBIT NO.: A/VP/110/1192	
ORIGINATOR: RC	DRAWN BY: GLN	DATE: 11/92

TABLE 5-1 Fourth Quarter 1992 Track Etch Radon Monitoring Results[a]

Location ID	4th Quarter pCi/l	Percent of Guideline [b]
WSQ		
RD-1001	0.7	19
RD-1002	1.5	45
RD-1003	0.8	22
RD-1004	0.4	9
RD-1005	0.4	9
RD-1006	0.4	9
RD-1007	0.3	5
RD-1008	0.2	2
WSCP		
RD-2001	0.3	5
RD-2002	0.2	2
RD-2003	0.2	2
RD-2004	0.2	2
RD-2005	0.1	0
RD-2006	0.1	0
RD-2007	0.2	2
WSRP		
RD-3001	0.1	0
RD-3002	0.2	2
RD-3003	0.2	2
RD-3004	0.1	0
RD-3005	0.3	5

TABLE 5-1 Fourth Quarter 1992 Track Etch Radon Monitoring Results[a] (Continued)

Location ID	4th Quarter pCi/l	Percent of Guideline [b]
OFF-SITE		
RD-4001*	0.1	NA
RD-4002	0.2	2
RD-4003	0.2	2
RD-4004*	0.1	NA
RD-4005*	0.2	NA
RD-4006*	0.1	NA
RD-4007*	0.2	NA
RD-4008	0.4	9

(a) Results include natural background.

(b) Percent of guideline calculated by taking the quarterly average minus the average of the background stations divided by the DOE concentration guideline for Rn-222 which is 3 pCi/l (111 Bq/m^3)(Annual average above background) for uncontrolled areas.

* Denotes Background Station; therefore, percent of guideline not applicable (NA).

concentration was then subtracted from the concentration for each monitoring station, and compared to the U.S. Department of Energy (DOE) guideline of 3 pCi/l (111 Bq/m^3) above background.

Radon concentrations at the site and quarry perimeters and at off-site locations for the fourth quarter of 1992 were within the typical range expected during periods of normal precipitation. The quarterly radon concentrations at the Weldon Spring Chemical Plant/raffinate pit (WSCP/RP) area averaged 0.2 pCi/l (7.4 Bq/m^3), while the quarterly radon concentrations at the Weldon Spring Quarry (WSQ) averaged 0.6 pCi/l (22.2 Bq/m^3). The quarterly radon concentrations from each individual detector (background included) ranged from less than the detection limit of 0.06 pCi/l (2.22 Bq/m^3) to 1.5 pCi/l (55.5 Bq/m^3).

Radon concentrations found at the quarry are higher than concentrations measured at other locations, because the radium concentrations in quarry wastes are typically higher than in other areas. Also, the quarry is a large depression with side walls ranging from 3 m to 15 m (10 ft to 50 ft) high, which tends to trap emanating radon within the quarry and raise the concentrations along the quarry perimeter.

5.2 Gamma Radiation Exposure

This data is currently unavailable, however, it will be reported in the *1992 Annual Site Environmental Report*.

5.3 Radioactive Air Particulates

Seventeen low volume air particulate samplers continuously monitor the Weldon Spring site. Five of these (AP–2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the Weldon Spring Chemical Plant (WSCP) perimeter and five are located around the quarry perimeter. There are five critical receptor monitoring stations, AP-4006, AP-4008, AP-2001, AP-2005 and AP-4011, located off-site at the Francis Howell high School, the Army Reserve property, the highway maintenance facility, the Weldon Spring Site Remedial Action Project (WSSRAP) administration building, and near a residential site west of the quarry, respectively. Three new monitoring stations were recently added during the second quarter of 1992. Two of the new monitoring stations, AP-2013 and AP-3014, were installed at the WSCP perimeter. The other new station, AP-1017, was installed at the WSQ perimeter. At the end of the fourth quarter three additional samplers were added to the low volume sampling network and one sampler was relocated. Two of the stations were added to the WSQ perimeter, AP-1015 and AP-1016. The third sampler, AP-4012 (Figure 5-4), located approximately 12 km from the WSCP will be used as the background monitoring station and replaces AP-4007 in that capacity. As a result, AP-4007 was relocated from behind the large hill which shielded the station from potential emissions from the WSCP to a location near the Busch Wildlife headquarters building and will serve as an off-site monitoring station in the future. The monitoring station at the August A. Busch Wildlife Area (AP-4007) is used to monitor background levels in the vicinity of the WSCP. The air particulate monitoring station locations are shown in Figures 5-1 and 5-3.

Table 5-2 summarizes the quarterly average concentrations and the standard deviations for the 17 air monitoring locations. The quarterly average concentration for each monitoring location was calculated by averaging all weekly air particulate analysis results including results lower than the instruments lower limit of detection (LLD). The corresponding standard deviation for each monitoring location was also calculated using all weekly air particulate

TABLE 5-2 Fourth Quarter 1992 Low Volume Radiological Air Particulate Monitoring Results

Monitor Identification Number	Quarterly Average Gross Alpha Concentration (μCi/ml)	Standard Deviation (μCi/ml)	Number of Weeks Collected	Number of Values Above LLD
AP-2001	1.34E-15	1.02E-15	13	9
AP-2002	1.60E-15	8.19E-16	13	13
AP-3003	N/A	N/A	0	0
AP-3004	1.14E-15	7.28E-15	13	12
AP-2005	1.15E-15	5.54E-16	12	11
AP-4006	1.44E-15	1.41E-15	13	12
AP-4007	1.31E-15	6.41E-16	13	13
AP-4008	1.15E-15	6.51E-16	13	11
AP-1009	1.24E-15	6.91E-16	13	12
AP-1010	1.73E-15	4.28E-16	6	6
AP-4011	1.03E-15	5.62E-16	13	11
AP-4012	1.18E-15	7.49E-16	2	2
AP-2013	1.11E-15	6.29E-16	13	11
AP-3014	1.15E-15	7.14E-16	13	12
AP-1015	9.51E-16	5.83E-16	3	2
SP-1016	8.47E-16	4.38E-16	3	2
AP-1017	1.23E-15	5.01E-16	10	8

* Indicates background monitor station.
N/A Not available.

analysis results. Due to maintenance and installation of new samplers, all samplers were not operating the entire 13 weeks, as indicated in the fourth column of Table 5-2. The WSSRAP has deployed high volume air samplers, as well as low volume air samplers, at critical receptor locations. These high volume samplers are used in accordance with the *Plan for Monitoring Radionuclide Emissions Other Than Radon at the Weldon Spring Site Critical Receptors*

(MKF and JEG 1992b). The high volume monitoring results will be presented in the 1992 annual site environmental report.

The fourth quarter average long-lived gross alpha concentrations ranged from 7.96×10^{-16} μCi/ml to 1.60×10^{-15} μCi/ml for perimeter and off site locations. The average background concentration measured at AP-4007 and AP-4012 was 1.34×10^{-15} μCi/ml.

5.4 Asbestos

In accordance with the *Environmental Monitoring Plan* (MKF and JEG 1992a) the WSSRAP collected environmental airborne asbestos samples. These samples were collected at both the FHHS and the WSSRAP perimeter during bulk asbestos removal operations.

The samples collected at the perimeter locations all showed results of 0.001 fibers/cc or less. Fourteen samples were collected at the perimeter of which four had measured concentrations below the detection limit.

The samples collected at the FHHS all showed results of 0.002 fibers/cc or less. Thirty-five samples were collected at the FHHS of which 12 were less than the detection limit.

6 REFERENCES

MK-Ferguson Company and Jacobs Engineering Group, 1989. *Phase II Groundwater Quality Assessment for the Weldon Spring Site, Chemical Plant, Raffinate Pits and Surrounding Vicinity Properties*, Rev. 0. DOE/OR/21548-078. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. September.

MK-Ferguson Company and Jacobs Engineering Group, 1992a. *Environmental Monitoring Plan*, Rev. 1. DOE/OR/21548-237. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. January.

MK-Ferguson Company and Jacobs Engineering Group, 1992b. *Plan for Monitoring Radionuclide Emissions Other Than Radon at the Weldon Spring Site Critical Receptors*, Rev. 1. DOE/OR/21548-127. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO.

DOE Orders

5400.5 *Radiation Protection of the Public and the Environment*

Procedures

ES&H 4.4.1s *Groundwater Sampling*
ES&H 4.3.1s *Surface Water Sampling*

APPENDIX A
Letter from DOE to PMC regarding
Preparation of Environmental Monitoring Summaries

3589-90-F-DOE-418
MV-01-01

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

RECEIVED
JUL 02 1990
WSSRAP CONTRACT

July 2, 1990

Mr. R.E. Hlavacek
Project Director
MK-Ferguson Company
7295 Highway 94 South
St. Charles, Missouri 63303

Dear Mr. Hlavacek:

PREPARATION OF ENVIRONMENTAL MONITORING SUMMARIES

With the upcoming increase in remedial action work at the site, it will be necessary to disseminate environmental monitoring data in a timely manner to the Francis Howell High School (FHHS), St. Charles Countians Against Hazardous Waste (SCCAHW), Missouri Department of Natural Resources (MDNR), U.S. Environmental Protection Agency (EPA) and others. Therefore, you are requested to prepare a plan for DOE review which would result in preparation of a document that summarizes our environmental monitoring data on a quarterly basis.

I would like the document to be brief but contain appropriate explanation and discussion of the data. Issuance of the quarterly report should begin as soon as possible and include the first two quarters of FY 90 data, in order to get caught up with this fiscal year.

Sincerely,

Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

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CHEMICAL PLANT
200-203-1.01

CHEMICAL PLANT ADMINISTRATIVE RECORD FILE

ARFS FILE # C-203-1

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200	REMEDIAL INVESTIGATION (RI)
203	Work Plans

DOCUMENT NUMBERS

C-200-203-1.01(r)* HYDROGEOLOGICAL INVESTIGATION WORKPLAN

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

DOE/OR/21548-008
REV. : DRAFT

United States Department Of Energy

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HYDROGEOLOGIC INVESTIGATIONS WORK PLAN

ABBREVIATED SUBMITTAL :

PUMPING, OBSERVATION, AND DEEP MONITORING WELLS

JANUARY, 1988

Weldon Spring Site Remedial Action Project

WELDON SPRING SITE REMEDIAL ACTION PROJECT
HYDROGEOLOGIC INVESTIGATIONS WORK PLAN

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OF PUMPING TEST WELLS AND DEEP MONITORING WELLS

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WELDON SPRING SITE REMEDIAL ACTION PROJECT
HYDROGEOLOGIC INVESTIGATIONS WORK PLAN
IMMEDIATE FIELD EFFORT: INSTALLATION OF PUMPING WELLS, OBSERVATION WELLS, AND DEEP MONITORING WELLS

The attached submittal represents plans and specifications for installation of pumping and observation wells for aquifer testing at the Weldon Spring Site. Also included in this submittal are plans and specifications for installation of two deep monitoring well clusters to support related studies by the U.S. Geological Survey (USGS). Each cluster will consist of three wells penetrating the Burlington-Keokuk, Kimmswick, and St. Peter formations. These clusters will allow discrete hydraulic head measurements from deeper aquifers to calibrate a regional groundwater flow model. Sampling of these wells will confirm that these deeper aquifers have not been contaminated from the site.

This submittal is intended to support the process of drilling subcontract procurement to allow field efforts to proceed in a timely manner. Specific details of aquifer testing, sampling, and model development are subject to review following submission of the complete Hydrogeologic Investigations Work Plan. Well installation will be a relatively long field effort, approximately 3 months duration. Completion of the subsequent aquifer testing and other studies is essential to completion of site characterization. Completion of site characterization is critical to the scheduling of the Environmental Impact Statement (EIS) process leading to the Record of Decision for the Weldon Spring Site (WSS).

The attached submittal consists of subsections of the Hydrogeologic Investigations Work Plan describing the aquifer testing program and a portion of the USGS studies. An outline of the entire Hydrogeologic Investigation Work Plan is attached;

the subsections comprising this abbreviated submittal are underlined.

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HYDROGEOLOGIC INVESTIGATIONS WORK PLAN

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2.2 Aquifer Testing

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Aquifer testing will consist of single-well hydraulic conductivity (permeability) tests, and pumping tests to define the hydraulic characteristics of the aquifer in order to predict contaminant migration and assess groundwater remediation alternatives.

2.2.1 Single-Well Hydraulic Conductivity Tests

2.2.1.1 Test Design

Single-well hydraulic conductivity tests ("slug tests") will be performed to provide information on areal variations in permeability within the Burlington-Keokuk formation. A slug test will be performed in each new monitoring well installed as described in Section 2.1. Slug tests will also be performed in selected existing monitoring wells to verify the results of packer tests performed during well installation. Existing monitoring wells selected for slug tests are:

MW - 2002
MW - 2005
MW - 2006
MW - 2008
MW - 2013
MW - 2015
MW - 2018
MW - 4001

These wells provide an evenly spaced areal distribution for confirming the packer test results. In addition, deep monitoring wells to be installed adjacent to each of these wells will also be tested, allowing for comparison of permeability values at varying depths. The existing monitoring wells are shown on Figure 2-1; the new monitoring wells to be installed to

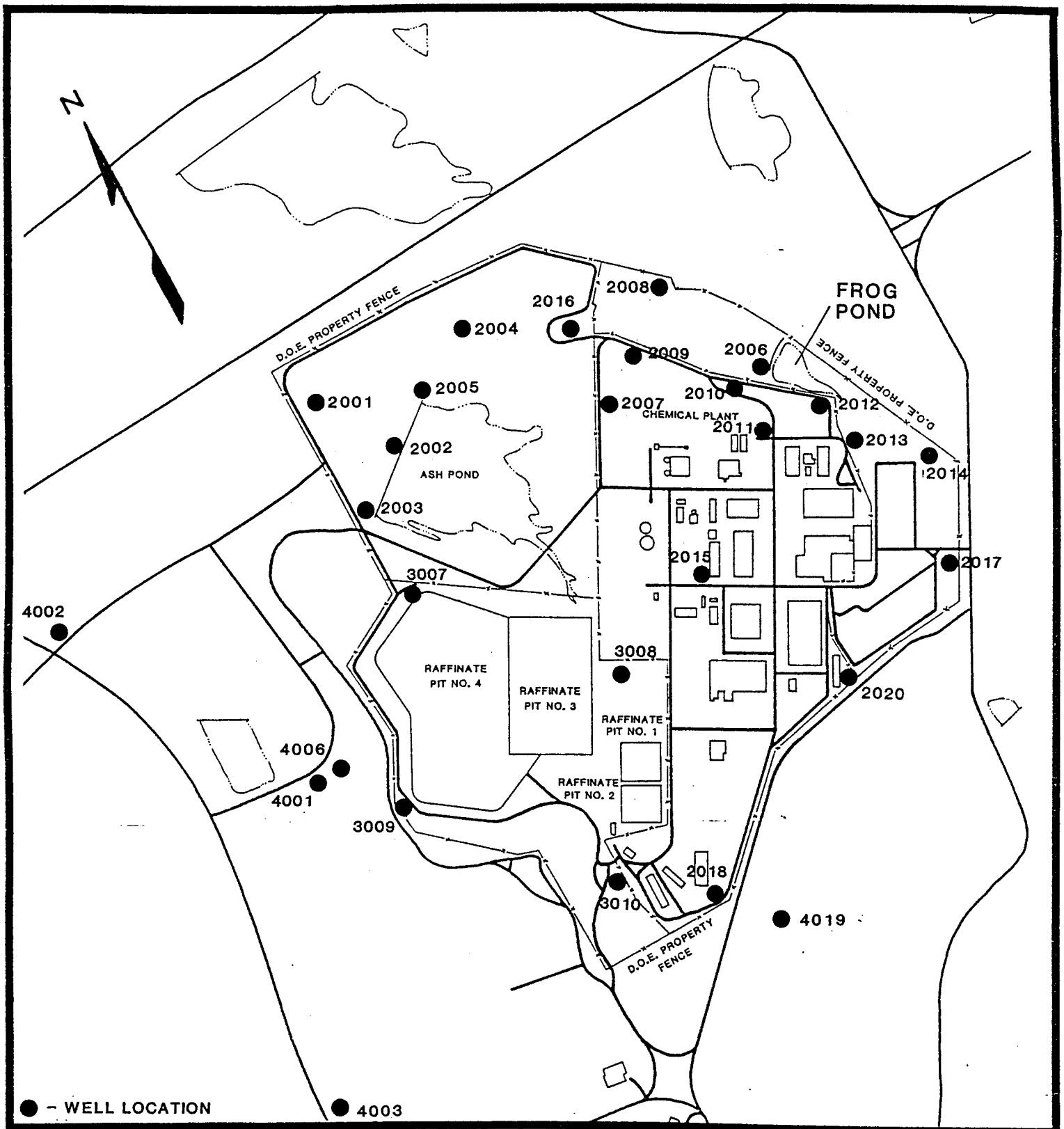

FIGURE 2-1

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EXISTING MONITORING WELLS

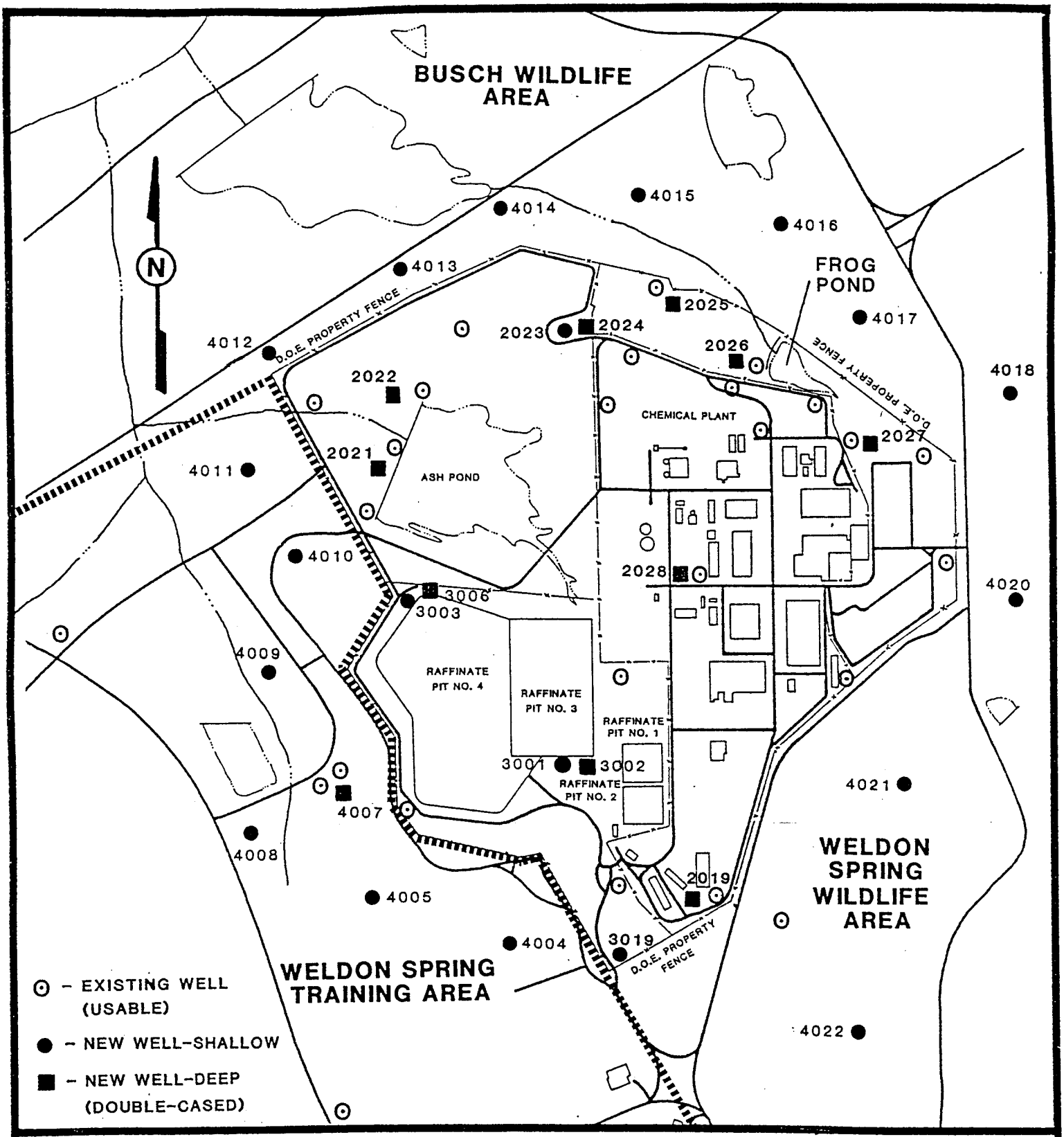

FIGURE 2-2

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EXTENDED MONITORING WELL NETWORK

complete the extended monitoring well network are shown on Figure 2-2.

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Slug tests are performed by displacing, adding or removing a known volume of water within the well. The test is designed to approach, to the extent possible, ideal conditions. The volume change is produced as close to instantaneously as feasible, and the volume is controlled to a premeasured amount. Readings of water levels within the well during the test will be made using a pressure transducer and electronic data logger, which will enable collection of measurements at short time intervals (1 second) during the early part of the test.

2.2.1.2 Test Performance

To begin the test, a pressure transducer is installed within the well and static water level measurements are collected. The water levels are observed to ensure that the aquifer is under steady-state conditions. The volume change is produced within the well and water levels are measured as the well recovers to the static water level.

For tests to be performed in the shallow, 2-inch diameter wells, a solid rod or similar object slightly smaller than the well diameter will be injected below water level in the well in order to displace the water to a higher level. Water levels will be measured at frequent time intervals as the water level falls to the original level. At this point the rod will be removed and water levels measured as the water level rises to the original level. The use of this test method allows for both falling head and rising head measurements. A falling head technique will be used to perform tests in the deep, 4-inch diameter monitoring wells. After monitoring static water levels, a known volume of potable water will be pumped into the well to produce an instantaneous rise in the water level. Water level measurements are collected until the water level has returned to a near

steady-state condition. Field measurements collected by the electronic data logger will be transferred to a computer data base.

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2.2.1.3 Data Analysis

The data will be analyzed to determine a hydraulic conductivity value using a standard formula such as the Hvorslev method. The hydrologic formula will be chosen to fit the conditions in the aquifer and well being tested. A qualified groundwater professional will determine the aquifer and well conditions, the formula to be used, and the data points for the hydraulic conductivity calculation.

2.2.2 Pumping Tests

Long-term pumping tests will be performed at three (3) locations on-site in order to determine aquifer properties such as transmissivity, storativity, and anisotropy. These results will allow prediction of contaminant migration and assessment of the effects of pumping on groundwater flow patterns and contaminant levels. Pumping tests affect a much larger portion of the aquifer than the single-well tests and consequently yield more accurate hydraulic conductivity values. Transmissivity, storativity, and anisotropy can be determined accurately only from pumping tests.

2.2.2.1 Pumping Test Design

Pumping tests are designed based on the known characteristics of the Burlington-Keokuk formation. The upper, weathered zone of the formation comprises an unconfined aquifer. Yields are expected to be relatively low, based on reported yields of 5-50 gallons per minute (gpm) for wells in this formation (USGS, 1986).

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Locations for the pumping tests are shown on Figure 2-4. Locations were selected to determine aquifer conditions in areas where contaminants have been detected in the groundwater and could potentially migrate off-site, and also at a location adjacent to the proposed disposal cell. Pumping Well 1 (PW-1) is located to the north of the apparent groundwater flow divide in the area where relatively high concentrations of nitroaromatic compounds were detected in groundwater samples. Pumping Well 2 (PW-2) is located adjacent to the proposed disposal cell area near the southern end of the site. Results from the pumping test at this location will allow for an assessment of aquifer conditions under the proposed disposal cell. The pumping and observation wells will be located adjacent to, rather than within, the proposed disposal cell area in order to minimize the number of wells and other boreholes within the disposal cell area which would need to be drilled out and grouted prior to disposal cell construction. Pumping Well 3 (PW-3) is located in the area where the highest nitrate concentrations were detected in groundwater samples from the Phase I Assessment.

The pumping wells are designed to be fully penetrating (continuously screened) over the upper forty feet (40') of saturated thickness of the Burlington-Keokuk formation. This interval has been selected to encompass the weathered, more permeable zone in which groundwater contamination has been detected. The test interval is limited to forty feet (40') to avoid producing a vertical pathway through which contaminants could migrate into deeper zones in the aquifer. The fully screened interval will allow for the most straightforward techniques for pumping test interpretation and calculations.

Each pumping test will have eleven (11) observation wells oriented to determine the distribution of drawdown due to pumping the aquifer. A set of nine (9) observation wells, labeled "a" to "i" on Figure 2-4, will be completed at the same

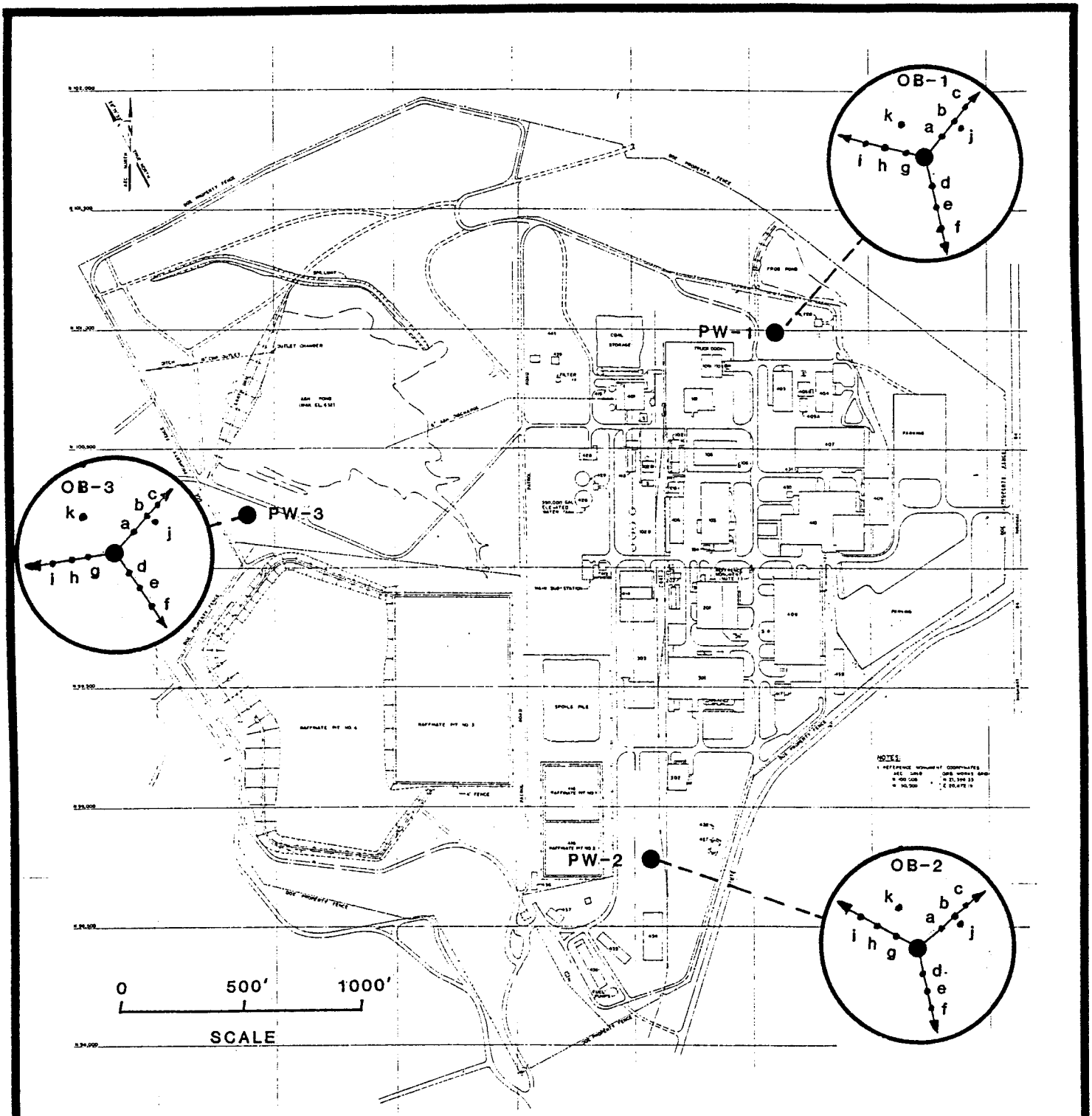

FIGURE 2-4

PUMPING AND OBSERVATION WELL LOCATIONS

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PW-1 -PUMP TEST WELL

OB-1 - OBSERVATION WELL (a-k)

depth within the Burlington-Keokuk formation with the same screened interval as the pumping well. These wells will be placed on three (3) lines radiating from the pumping well with 120 degrees of arc between lines. One line will be placed on a bearing of N60^{o}E, aligned with the predominant northeastward orientation of fractures in the Burlington-Keokuk formation. The other two lines will be located relative to this primary line. Following installation and development of the pumping well, a step-drawdown pumping test will be performed to determine the optimum distance from the pumping well for placement of the observation wells and optimum pumping rate for long-term pumping tests. It is anticipated that pumping rates will be relatively low (5-10 gpm) and that all observation wells will be within 100 feet from the pumping well.

Two (2) additional observation wells will be installed in a lower zone in the Burlington-Keokuk formation, screened from 40 to 50 feet below the bottom of the pumping well. These wells will be double-cased to a depth 10 feet below the bottom of the pumping well to prevent transport of contaminants to lower zones during drilling operations. Drawdown measurments in these wells will allow for a determination of the degree of hydraulic connection between shallow and deeper zones in the Burlington-Keokuk formation. These two wells, designated "i" and "j" on Figure 2-4, will be placed approximately 40 feet from the pumping well. One well will be along the primary N60^{o}E orientation of fracturing (offset slightly if necessary to avoid interfering with other observation wells on this line), the other well will be placed an equal distance from the pumping well on a line perpendicular to the orientation of fracturing.

During the pumping tests, water levels will also be measured in monitoring wells within a radius of approximately 500 feet from the pumping well in order to observe any effects of pumping at greater distances.

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The pumping tests will be 7 days (168 hours) in duration to allow for observation of delayed-yield effects, determination of specific yield, and observation of other effects of long-term pumping. Recovery measurements will continue until full recovery, a minimum of 24 hours under any circumstances. The duration of any individual pumping test may be modified by the project hydrogeologist as the test proceeds, based on drawdowns observed and determination of whether sufficient data has been collected.

2.2.2.2 Pumping and Observation Well Installation

The pumping wells will be installed by hollow-stem auger boring and bedrock coring to provide an accurate lithologic log of the formation at each pumping test location, followed by reaming to the final diameter by air-rotary techniques. Split-spoon samples will be collected at intervals of five feet (5') during auger drilling in the unconsolidated soils. The bedrock will be cored from the bedrock surface to the total depth of the well. The log will be recorded by a supervising hydrogeologist.

The borehole will be reamed to a final diameter of ten inches (10"). The well will be constructed using 6-inch inside diameter (ID) Schedule 40 PVC screen and casing. Screen length will be forty feet (40'), encompassing the entire saturated thickness penetrated by the pumping well. Screen slot size will be .020 inch. A filter pack consisting of 6 to 20 mesh silica sand will be emplaced through a tremie pipe to a point 2 to 4 feet above the top of the screen. A bentonite seal, a minimum of three feet (3') thick, will be emplaced above the filter pack, after which the annular space will be grouted to the surface using a tremie pipe.

Observation wells will be installed using air-rotary techniques to drill from the land surface to the total depth. Borehole diameter will be 5.5 inches. Wells will be constructed using

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2-inch ID Schedule 40 PVC screen and casing. Screen length for the nine (9) observation wells at equal depth with the pumping well will be forty feet (40'); slot size will be .020 inch. A filter pack will be emplaced around the screen and the annular space sealed with bentonite and grounted to the surface as described above for the pumping well.

In drilling the boreholes for the deep, double-cased, observation wells, an 8.5 inch diameter borehole will be drilled to a depth of approximately ninety feet (90'), or ten feet (10') below the bottom of the corresponding pumping well. A 6-inch ID PVC casing will be placed in the borehole to the total depth. The annular space will be grouted and a grout plug at least four feet (4') thick will be emplaced to seal the bottom of the borehole. After the grout has set for a minimum of 48 hours, drilling will continue by bedrock coring to the total depth in the well located along the primary orientation of fracturing. After completion of coring, the borehole will be reamed to the final diameter of 5.5 inches using air-rotary techniques. The borehole for the well located perpendicular to the orientation of fracturing will be drilled to the final depth and diameter of 5.5 inches without coring. The observation well will then be installed as described above.

After each pumping or observation well installation is complete and the grout has set for a minimum of 48 hours, each well will be developed to produce clear, sediment-free water and to insure hydraulic communication between the well and formation for accurate drawdown and recovery measurements.

Well development will be accomplished by surging and bailing or surging and pumping, using the same procedures as used for developing monitoring wells. The 5 NTU standard for completion of development will be applied and the same decontamination procedures will be followed.

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2.2.2.3 Pumping Test Performance

Electric submersible pumps will be used for the pumping tests. Discharge will be held at a constant rate through the use of a gate valve. Pumping rates less than 10 gpm will be measured with a calibrated container and stop watch. Flow measurements will be recorded hourly throughout the duration of the test. During pumping the well water will be discharged to a holding tank, after which it will be pumped or transported by tank truck to Raffinate Pit 4. All raffinate pit waters will be treated prior to discharge during remedial action.

Each pumping test will begin by recording static water level measurements in the pumping well, observation wells, and nearby monitoring wells. During pumping, water levels in the pumping well will be measured and recorded using a pressure transducer and electronic data logger. Water levels in observation and monitoring wells will be measured using an electrical water level indicator or wetted tapes. Multi-channel data loggers with pressure transducers in observation wells will be utilized as appropriate. Water level measurements will be recorded to the nearest 0.01 foot. Static water levels will be monitored for at least 48 hours prior to beginning each pumping test to ensure that steady-state conditions are present.

Water level measurements in the observation wells will be measured at logarithmic time intervals as pumping progresses, beginning with measurements at 1-minute intervals and increasing to 2-hour intervals after eight hours of pumping. Water levels in the pumping well will be recorded by the data logger at 1-second intervals initially, followed by logarithmically lengthening time intervals which will coincide with the observation well measurements after one hour of pumping.

After 168 hours of pumping, the pump will be shut off and recovery measurements will be collected as the aquifer recovers

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to the initial static water levels. Measurements will be collected during recovery at the same logarithmic time intervals used during the pumping period. Measurements will continue until all wells have recovered to the original static water levels. It is expected that the recovery period will be a minimum of 24 hours.

2.2.2.4 Data Analysis

The data will be extensively analyzed to determine aquifer characteristics including hydraulic conductivity, storage parameters, anisotropy, and boundaries. Data analysis will begin by correcting the drawdown data recorded during the test for antecedent water level trends (as determined during monitoring of static water levels), dewatering, partial penetration, residual drawdown (recovery data) and barometric pressure variations. Barometric pressure data is available from a National Oceanic and Atmospheric Administration (NOAA) meterological station approximately 12 miles northeast of the WSS and from a meterological station at a utility plant approximately 10 miles to the southwest. The corrected data will be plotted on the appropriate graph paper for type curve analysis using methods such as those developed by Boulton and Neuman for unconfined aquifers. The conditions that dictate the appropriate hydrologic analyses to be done will be determined by a qualified hydrogeologist.

In addition to calculating aquifer parameters from pumping test results, a qualitative analysis will estimate the degree to which the fractured bedrock responds to pumping as an equivalent porous medium, which will indicate the reliability of the calculated parameters. Recent publications on pumping tests in fractured bedrock will be consulted and applied as appropriate to both the quantitative and qualitative analyses.

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The combination of quantitative and qualitative analyses will allow pumping test results to be used in conjunction with groundwater monitoring data to predict contaminant migration, and also to predict the effects of pumping on groundwater flow patterns and contaminant concentrations.

2.6 Regional Hydrogeology and Water Balance

Studies of regional hydrogeology and water balance culminating in the development of a three-dimensional regional groundwater flow model will be performed by the U.S. Geological Survey. Additional USGS efforts will focus on site-related water quality issues and will serve to provide third-party verification of WSSRAP efforts.

2.6.1 Regional Groundwater Flow and Water Balance

USGS studies will include further refinement of regional hydrogeology as presented in previous USGS publications and comprehensive water balance measurements. These results will be combined with WSSRAP data to produce a regional groundwater flow model encompassing the shallow aquifer in the Burlington-Keokuk formation and the intermediate and deep aquifers in the Kimmswick and St. Peter formations.

Piezometric surface maps will be derived from water-level measurements in groundwater monitoring wells installed on-site by WSSRAP, from USGS monitoring wells located on Busch Wildlife Area to the north of the site, and from various private wells around the site which are suitable for monitoring and sampling.

Continuous water level recorders will be installed on four wells on the site near the groundwater flow divide. Daily fluctuations in the groundwater levels will be correlated with precipitation, evapotranspiration, infiltration and barometric fluctuations in order to evaluate and determine the role of each of these factors on the water balance of the plant site.

Twelve (12) steel infiltration tubes will be installed in various soils located on the Weldon Spring Site. A neutron probe will be used to measure the migration in the unconsolidated near-surface measurements. These measurements

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will be taken by inserting the neutron probe into the steel infiltration tubes and recording the neutron response to moisture content of the soils. This data will be compared with evapotranspiration and precipitation in the determination of the water balance.

Two clusters of deep monitoring wells will be installed in order to determine vertical gradients between the shallow and deep aquifers underlying the site. Water samples will be analyzed for the determination of water quality differences at various depths and aquifers. One well cluster will be located immediately south of the site near the groundwater flow divide. The second well cluster will be located near Dardenne Creek which is at a lower topographic elevation and is considered to be a hydrogeologic boundary for shallow groundwater flow (Figure 2-7).

Each observation well cluster will consist of one well with the screened sector open opposite the Burlington-Keokuk Limestone Formation at a depth of approximately 100 feet, one well with the screened sector open opposite the Kimmswick Limestone Formation at a depth of approximately 300 feet and one well with the screened sector open opposite the St. Peter Sandstone Formation at a depth of approximately 700 feet. The cluster immediately south of the site will consist of two deep wells clustered with an existing monitoring well screened in the Burlington-Keokuk formation (MW-4019). A geologist will monitor drilling programs, collect rock samples from cores and drill cuttings and ensure compliance with Standard Operating Procedures.

Surface features which relate to groundwater accumulation, movement or quality will be investigated in depth for the purpose of developing the groundwater flow model. Springs, seeps, losing stream segments, gaining stream segments, karst features in limestone bedrock, fractures, joints, geological

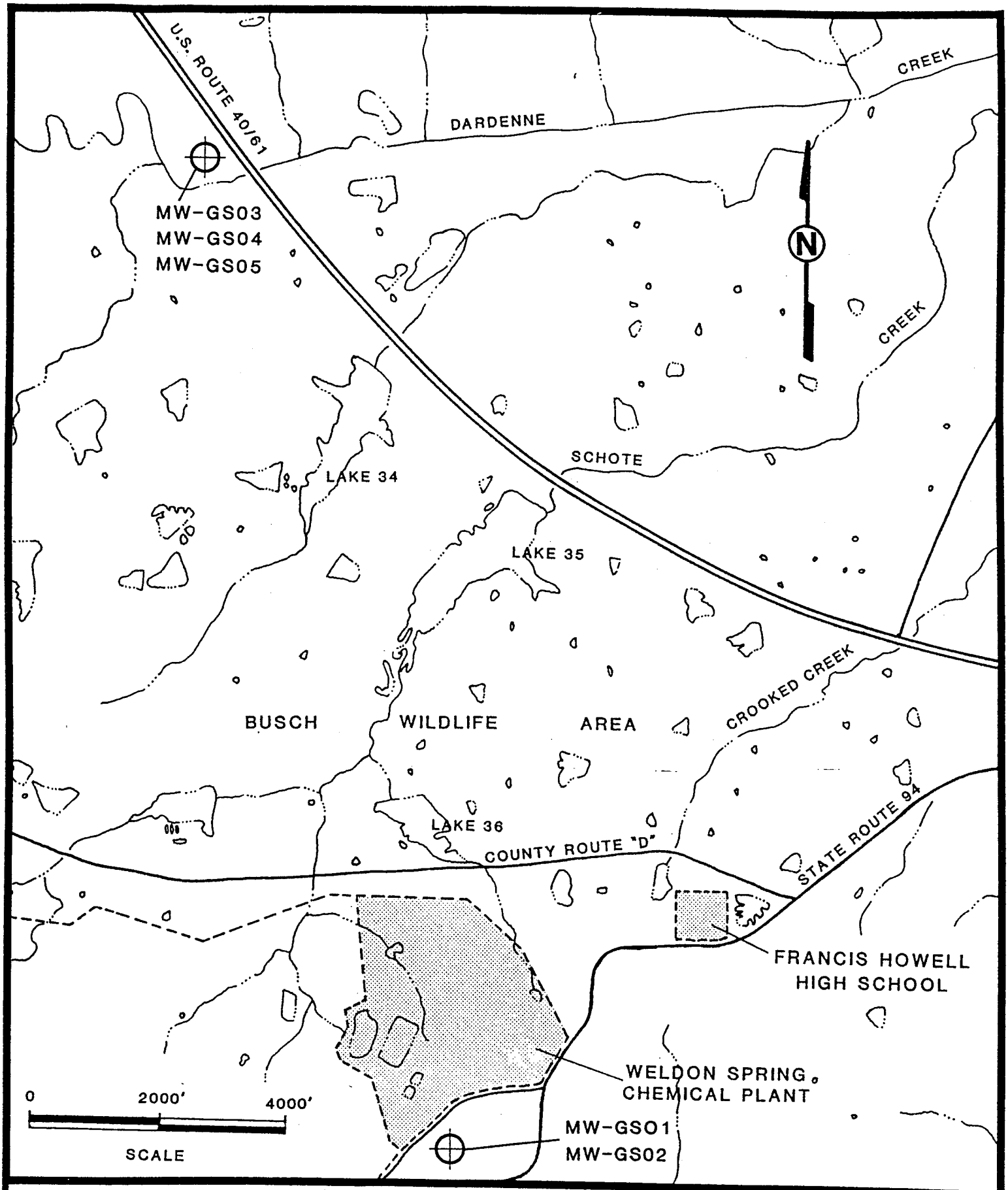

FIGURE 2-7

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MONITORING WELL CLUSTER LOCATIONS

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structure and any additional phenomena which may become evident during the course of field efforts will be investigated for the purpose of determining effects on water balance and flow characteristics. Remote sensing methods including air photos, side-looking radar, infrared photography and others may be employed. A field reconnaissance program will be conducted in order to locate and measure these features and to quantify their effects.

Continuously recording stream gauging stations are in place on Schote Creek and the unnamed tributary to Dardenne Creek which contains Burgermeister Spring. These gauging stations will continue in operation in order to gather flow and discharge data for use in water balance studies.

Continuous discharge monitoring of Burgermeister Spring and the adjacent wet-weather spring will be continued in order compare the effects of various weather conditions on spring discharge and chemical quality. Surface water discharge will be compared with other monitored parameters including water table fluctuations, barometric changes, precipitation, temperature, humidity, evapotranspiration and infiltration.

Nineteen (19) total catch rain gauges will be placed on-site in order to accurately determine the amount of precipitation within the study area for utilization in water balance calculations and groundwater flow modeling calibration.

The regional groundwater flow model will be constructed using the USGS 3-Dimensional Groundwater Flow Model (MOD). Vertical extent of the model will be from the surface (Burlington-Keokuk formation) to the base of the St. Peter Sandstone. Tentative horizontal boundaries are constant-head or constant-flow boundaries at the Missouri River and Dardenne Creek to the north and south and no-flow boundaries along major drainage divides to the east and west. Data used to construct the model

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will include the piezometric surface and water balance data discussed above and aquifer testing data from WSSRAP efforts discussed above in Section 2.2.

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APPENDIX

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SPECIFICATION WP059

SUBCONTRACT NO. 3589-SC-WP059C

DRILLING, INSTALLATION AND DEVELOPMENT

OF

PUMPING TEST WELLS AND

DEEP MONITORING WELLS

MK-FERGUSON COMPANY

WELDON SPRING SITE REMEDIAL ACTION PROJECT

ST. CHARLES, MISSOURI

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SPECIFICATION WP059

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WELDON SPRING SITE

DRILLING, INSTALLATION AND DEVELOPMENT

OF PUMPING TEST WELLS AND DEEP MONITORING WELLS

1.0 INTRODUCTION

Three pumping tests are planned for the Weldon Spring Site located in St. Charles County, Missouri (Figure 1). The purpose of the pumping tests is to determine aquifer characteristics of the Burlington-Keokuk Formation in order to assess contaminant migration and feasibility of groundwater restoration.

A total of three (3) 6-inch inside diamenter (ID) pumping test wells and thirty-three (33) 2-inch ID observation wells will be installed in the Burlington-Keokuk Formation at the three (3) pumping test locations (PW-1, PW-2 and PW-3) shown on Figure 2. At each pumping test area, one (1) pumping well and eleven (11) observation wells will be completed. Two (2) of the eleven observation wells at each pumping test location will be completed approximately 50 feet deeper than the rest of the wells and will be double cased through zones of known groundwater contamination. Depths of the shallow observation

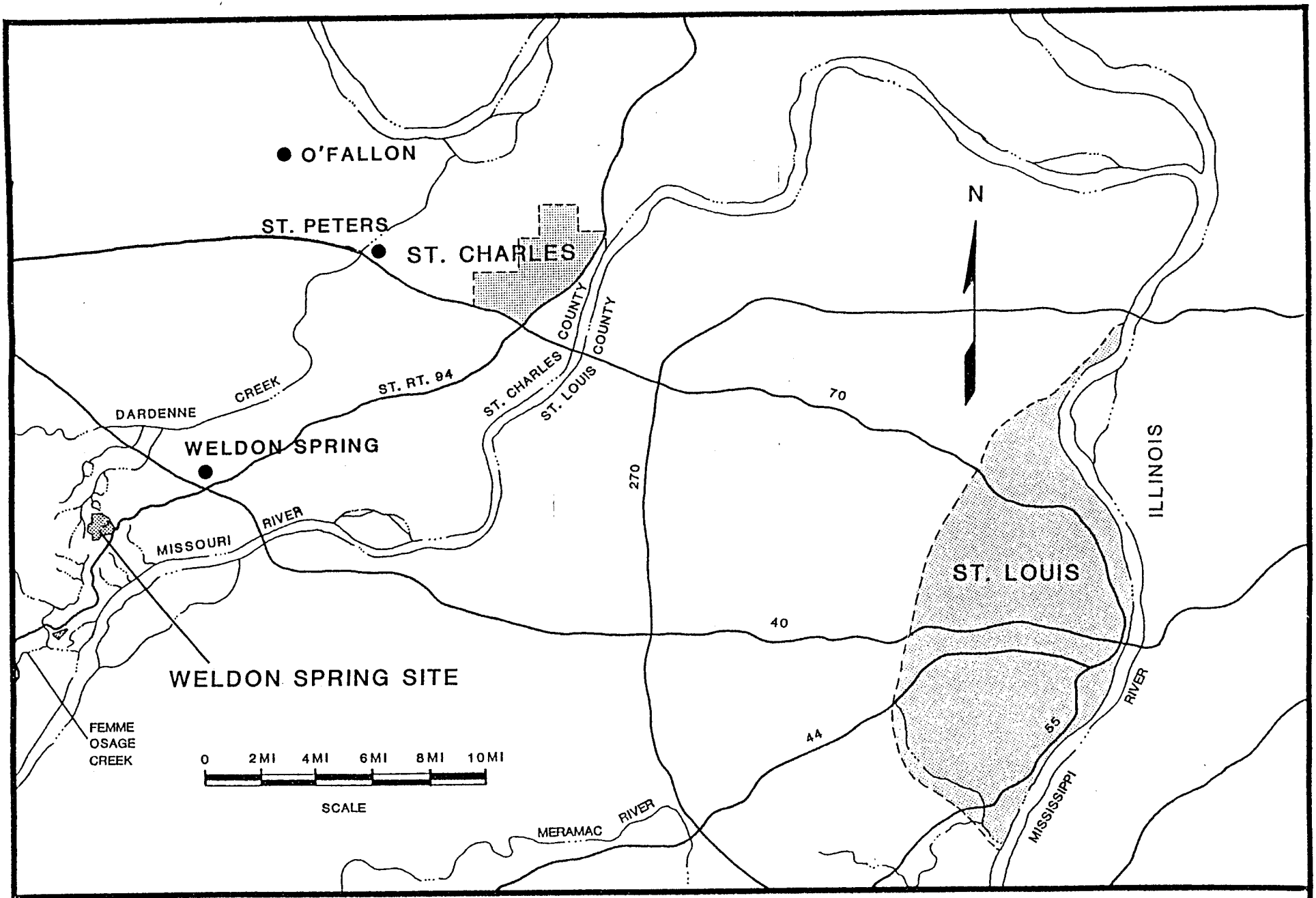

FIGURE 1

LOCATION OF WSS

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wells and pumping wells will range from approximately 80 to 100 feet in depth. Double-cased observation wells will range from approximately 130 feet to 150 feet in depth. Observation wells will be placed within a radius of approximately 100 feet from the pumping well. Actual distances will be determined from step-drawdown pumping tests to be conducted by the Subcontractor prior to installation of the observation wells. Estimated quantities of materials, drilling footage, and other work are given on the Pricing Schedule.

To distinguish pumping and observation wells from other on-site wells, each pumping test area will be assigned a unique designation. The pumping test wells will be coded PW-1 in the Chemical Plant, PW-2 in the Disposal Facility, and PW-3 in the Raffinate Pits. The observation wells associated with PW-1 will be assigned OB-1a to OB-1k (Figure 2). The observation wells associated with PW-2 will be assigned OB-2a to OB-2k and the observation wells associated with PW-3 will be assigned OB-3a to OB-3k.

In addition to wells installed on the site for the pumping tests, two monitoring well clusters will be installed to support continuing groundwater studies. One of these clusters will be on the northeast side of the site, the other will be approximately 2.5 miles to the north of the site near Dardenne Creek within the Busch Wildlife Area under the administration of the Missouri Department of Conservation. The Contractor will be

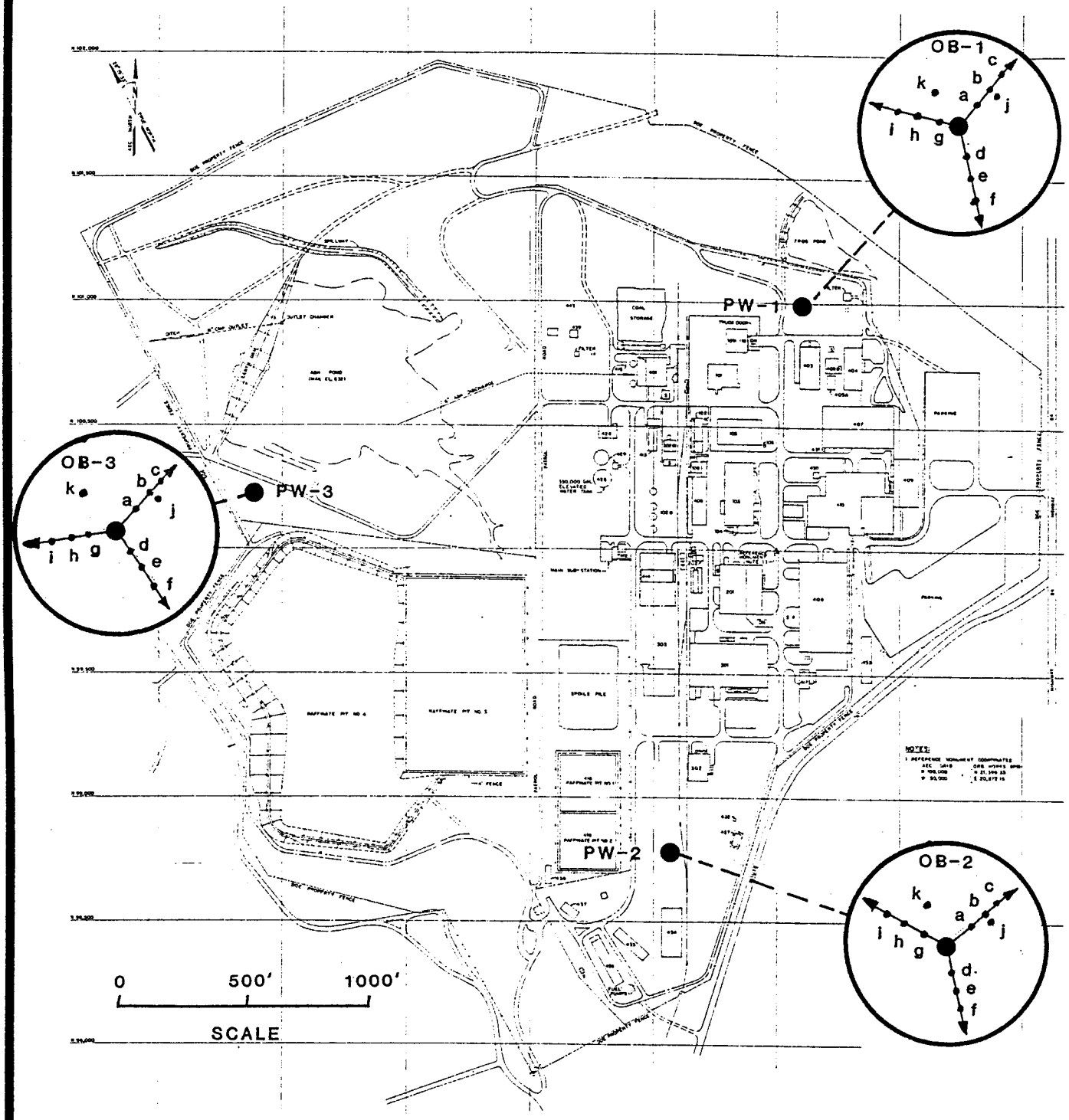

FIGURE 2

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PUMPING AND OBSERVATION WELL LOCATIONS

LEGEND

PW-1 -PUMP TEST WELL

OB-1 - OBSERVATION WELL (a-k)

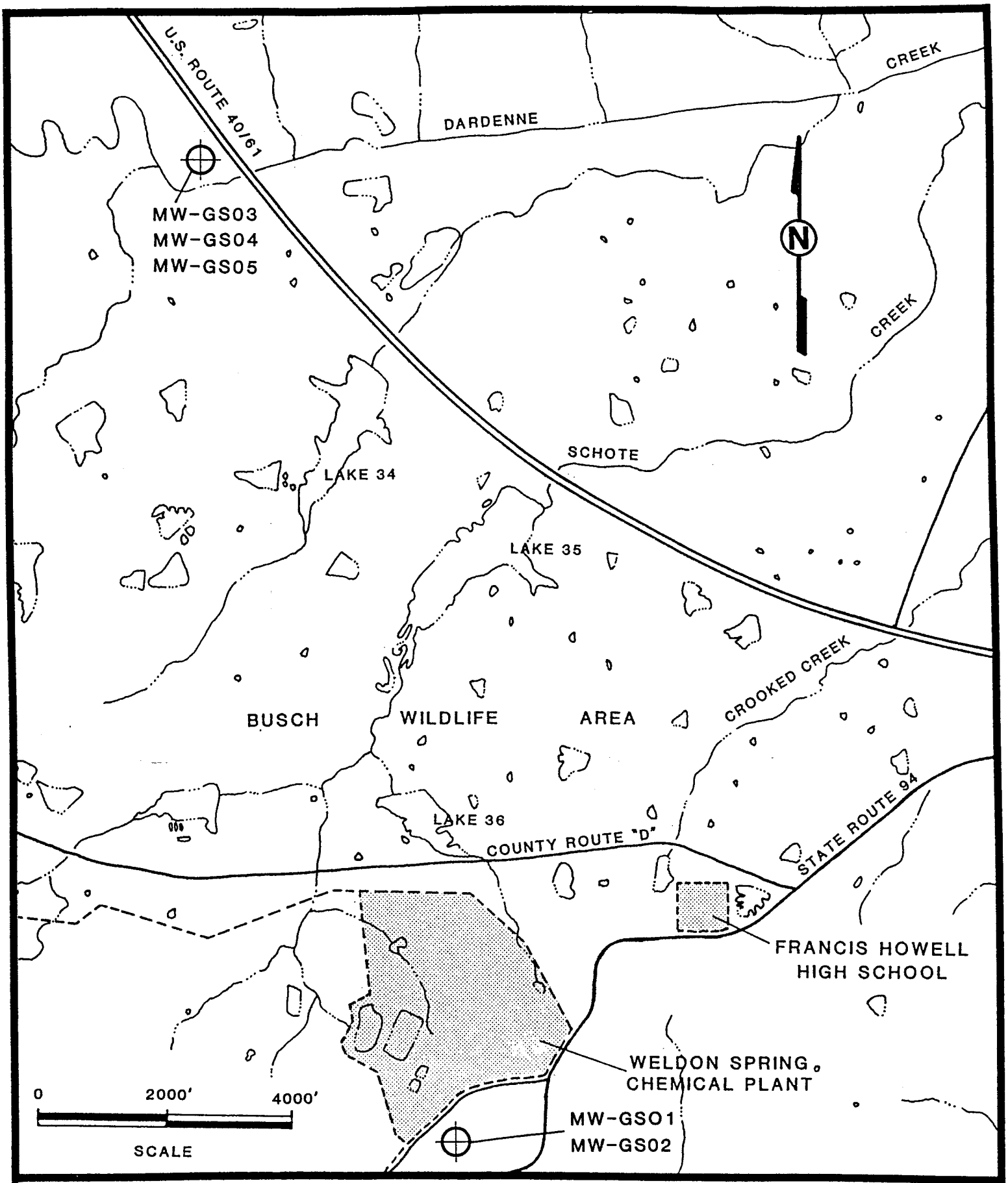

FIGURE 3

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MONITORING WELL CLUSTER LOCATIONS

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responsible for securing access to this area (Figure 3).

The cluster on the northeast side of the site will consist of two wells, one completed in the St. Peter formation at an approximate depth of 700 feet and the other completed in the Kimmswick formation at an approximate depth of 300 feet. The cluster near Dardenne Creek will consist of three wells: a well completed in the St. Peter formation at an approximate depth of 700 feet, a well completed in the Kimmswick formation at an approximate depth of 300 feet, and a well completed in the Burlington-Keokuk formation at an approximate depth of 100 feet. The monitoring wells will be designate MW-GS01 through MW-GS05.

A Contractor representative will be present to observe drilling and well installation operations.

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2.0 SITE CONDITIONS

2.1 Access

The pumping test wells and observation wells will be installed at locations within the site boundary, as shown on Figure 2. The on-site locations are accessible by paved or unimproved roads. The surface soil is a silty clay which should support truck-mounted drilling equipment, but may be slippery during wet weather.

2.2 Utilities

No underground utilities are expected at any of the drilling locations. The Contractor will supply a map of known utilities and will be responsible for contacting utility companies and insuring that utilities will not be encountered during drilling operations. The Contractor will be responsible if any utilities are inadvertently encountered.

2.3 Subsurface Conditions

The best information available indicates a variable thickness of soil, consisting of approximately 20 to 50 feet of loess, glacial till and weathered bedrock, overlying the limestone bedrock.

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The bedrock is the Mississippian Burlington-Keokuk Formation, a thickly-bedded limestone with abundant chert. Groundwater has been found to be within the limestone bedrock.

Past experience has indicated that drilling in this formation is very difficult due to the amount of chert.

A simplified stratigraphic column of the soil and bedrock formations on the site is shown on Figure 4. A geologic cross-section of the area surrounding the site is shown on Figure 5.

TOPSOIL – SILTY CLAY

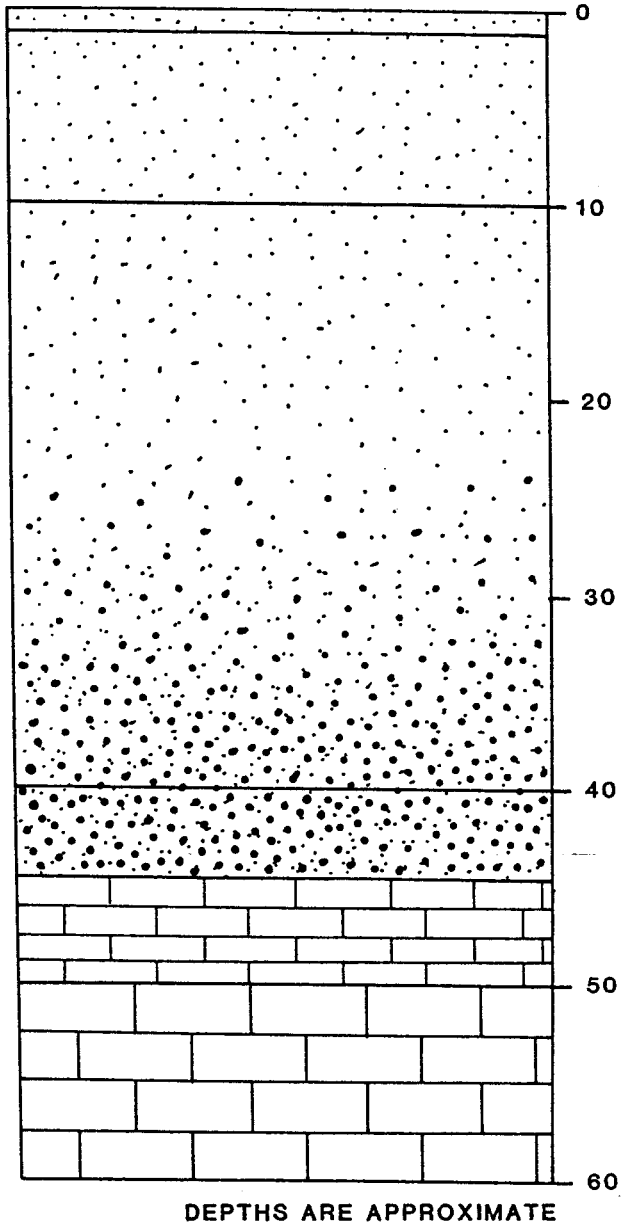
LOESS – SILTY CLAY

GLACIAL TILL – SILTY CLAY WITH VARYING AMOUNTS OF GRAVEL

RESIDUUM – GRAVELLY CLAY

WEATHERED BEDROCK

BEDROCK – BURLINGTON – KEOKUK FORMATION LIMESTONE WITH ABUNDANT CHERT



DEPTHS ARE APPROXIMATE

FIGURE 4

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SIMPLIFIED STRATIGRAPHIC COLUMN
WELDON SPRING SITE

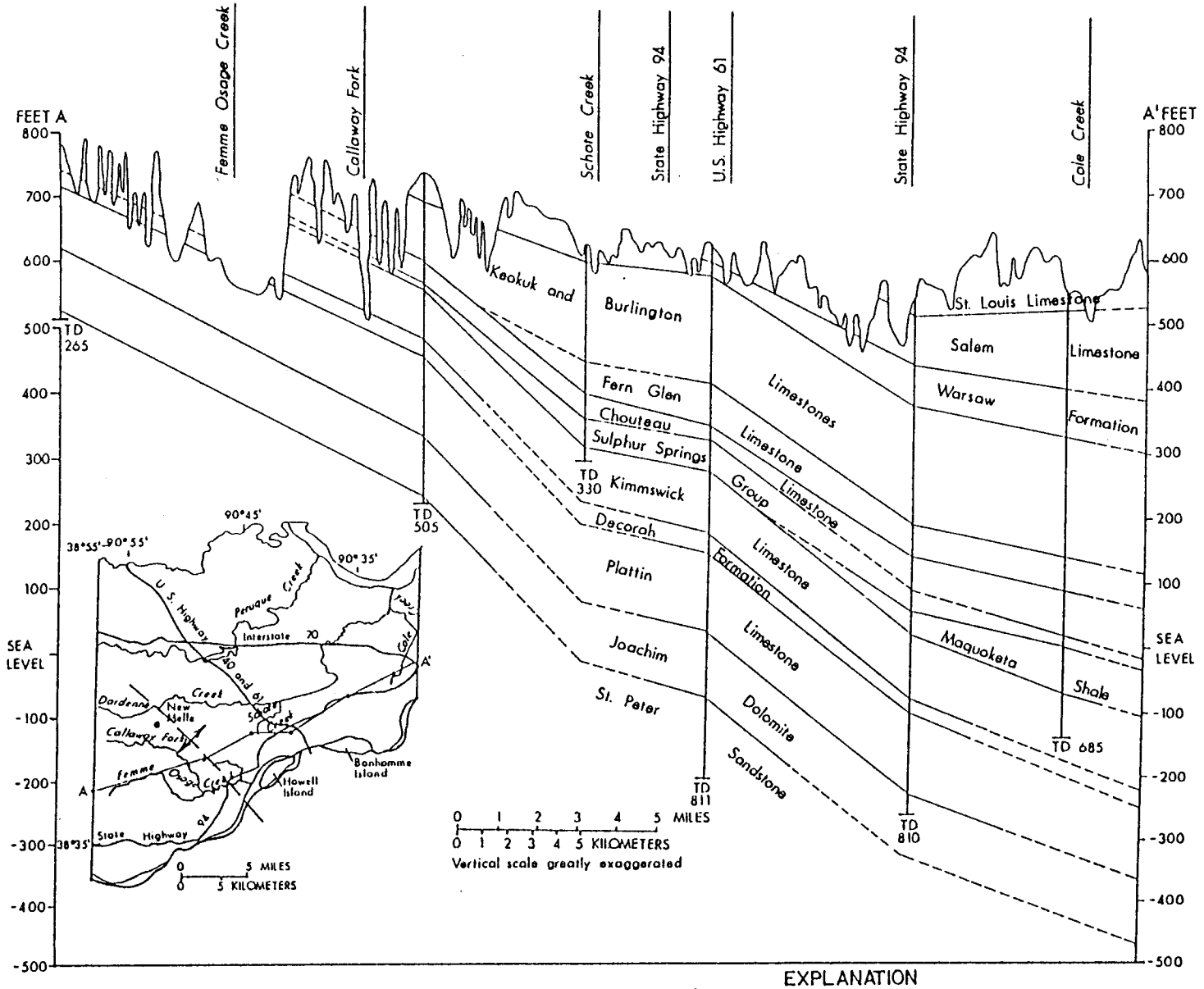

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FIGURE 5

GEOLOGIC SECTION OF SOUTHERN PART OF STUDY AREA

SOURCE : KLEESCHULTE & EMMETT, 1986

3.0 DRILLING

3.1 Drilling Equipment and Capabilities

The drilling rig(s) should be capable of drilling in clayey or granular soil and consolidated bedrock, above or below the water table.

Air-rotary drilling equipment shall be used for rock drilling prior to installation of the wells. The rotary rig(s) must be capable of collecting rock cores and also be capable of drilling through rock efficiently without coring. In order to avoid injecting oil into the borehole, the Subcontractor shall use in-line air filters on all air-rotary rigs.

Wireline coring apparatus with a diamond-impregnated coring bit is required for coring operations. The use of downhole hammer apparatus is an acceptable method for rock drilling in sections which are not cored and for reaming previously cored boreholes. Rig capabilities may be combined on a piece of equipment, or separate rigs with specialized functions may be used. Any change in drilling rig capabilities or other equipment must be approved in writing by the Contractor.

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3.2 Cross-Contamination Prevention Measures

The Subcontractor shall at all times prevent the contamination or cross-contamination of all wells and borings. Prevention measures include appropriate drilling and wellsite procedures and decontamination of drilling equipment and well screens and casing. A designated representative of the Contractor will observe wellsite and decontamination activities to assure that no contamination or cross-contamination occurs. Potential contaminants include, but are not limited to oil, grease, hydraulic fluids, fuels, and contaminated soils.

To reduce the potential of contamination occurring, the drilling rigs, tools, drilling stem, and all other pertinent equipment shall be cleaned using a hot water, high-pressure washer under the direct supervision of the Contractor upon entering the site. All decontamination shall be performed at the decontamination facility located near the south end of the site. The Contractor shall supply a portable hot water, high-pressure washer and water for use by the Subcontractor. Cleaning of the entire rig and tools shall be accomplished on a one-time basis before work begins. Decontamination of the entire rig will not be required again, unless the equipment is contaminated. If the rig or any other equipment becomes contaminated due to equipment breakdown or the Subcontractor's negligence,

decontamination shall be at the Subcontractor's expense. Drill bits, drilling rod, other downhole tools, and hand tools shall be decontaminated between boreholes. Only potable water from the Contractor's source shall be used to supply the hot water high-pressure washer.

Interior portions of equipment, such as pumps and hoses, which are not accessible for cleaning with a pressure washer shall be thoroughly cleaned and flushed with potable water from the Contractor's source. Oils, greases, or pipe dope shall not be used on pipe threads or drilling rods. Non-hydrocarbon based lubricants, such as silicon or teflon, are acceptable.

In addition, all well casing and screen shall be cleaned inside and out prior to use. The well casing and screen shall be stored in a non-contaminated area, elevated off the ground, and covered with clean, new, plastic sheeting. Any well casing or screen which is subsequently contaminated by contact with the ground shall be cleaned again prior to use. Any well casing or screen which is contaminated with soil shall be thoroughly rinsed with fresh, potable water and cleaned by hot water high-pressure wash prior to installation.

Drilling equipment used in known or suspected contaminated areas shall be handled with special precautions to prevent

the introduction of any contaminants into the well or boring. No hand tools, drill bits, drill stem, casing, screen, or any other equipment other than that in use in the borehole shall be allowed to contact the ground surface at any time. An elevated platform covered with plastic sheeting shall be required for the temporary storage of such items. At no time shall this platform be walked on or allowed to have soil deposited on it in any way. If any equipment or supplies come into contact with the ground, or are otherwise contaminated, they shall be thoroughly cleaned by pressure washing at the decontamination station.

Cross-contamination shall be minimized by thoroughly cleaning all external and internal surfaces of all drilling equipment, tools, drill bits, drilling stem, mud tubs, pumps, hoses, and all other appurtenant equipment after each hole is completed and before moving to the next drilling location. Cleaning shall be accomplished by completely removing all soil from the equipment and thorough hot water high-pressure washing.

During drilling operations, the Subcontractor shall prevent soils and liquids from entering the borehole. Steel surface casing of the appropriate diameter and at least five feet (5') in length shall be used when liquids are present on the surface at a drilling location. The surface casing shall be thoroughly decontaminated by hot water

high-pressure washing prior to use at another drilling location.

3.3 Drilling Fluids

All drilling operations, with the exception of coring and drilling through unconsolidated soils, shall be performed using air-rotary techniques with no drilling fluids other than air. Uncontaminated, potable water may be used as a drilling fluid for rock coring. The water source shall be provided by the Contractor. The Subcontractor shall be responsible for providing hoses, tanks, and other equipment as well as the transport of water to drilling locations. All tanks, hoses, and other water-handling equipment shall be decontaminated by hot water high-pressure washing prior to commencing work. Hoses, valves, and other fittings shall be cleaned between drilling locations.

No other drilling fluid or additives other than those outlined above shall be used. Toxic and/or contaminating substances shall not be added to the drilling fluids, nor be permitted to enter any well or boring as a result of the Subcontractor's operations.

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3.4 Drilling Procedures

3.4.1 Pumping Test Wells

In drilling the boreholes for pumping test wells, a borehole shall be drilled to the bedrock surface using air-rotary or hollow-stem auger techniques. Split-spoon samples, collected in accordance with ASTM D-1586, shall be taken at five foot intervals. The bedrock shall then be cored with an air-rotary drilling rig to an approximate depth of 80 feet (80') using an NX coring bit and wireline apparatus. Following completion of coring, the borehole shall be reamed to the final diameter of 10-inches using air-rotary techniques. The pumping test well shall be installed according to the specifications in Section 5.

3.4.2 Shallow Observation Wells

In drilling the boreholes for shallow observation wells, a minimum 5.5-inches diameter borehole shall be drilled to an approximate depth of 80 feet using air-rotary techniques. There will not be any sampling done for these boreholes. The observation well shall then be installed according to the specifications in Section 5.

3.4.3 Double Cased Deep Observation Wells

In drilling the boreholes for installation of the deep monitoring wells shown on Figure 2, an 8.5-inch diameter borehole shall be drilled to an approximate depth of 80 feet (80'). A 6-inch (ID) PVC casing shall be placed in the borehole to the total depth of the borehole. The casing shall be decontaminated by hot water high-pressure washing prior to emplacement. The outside of the casing shall be grouted to the surface using a grout mixture as specified in Section 4.7. A minimum of four feet (4') of grout shall be emplaced to seal the bottom of the borehole.

After the grout has set for a minimum of 48 hours, drilling shall continue on observation wells labeled "j" by coring using an NX coring bit and wireline apparatus to an approximate depth of 130 feet (130'). From 80 to 130 feet the borehole will be reamed to an approximate final diameter of 5.5-inches using air-rotary techniques. Observation wells labeled "k" will not be cored but will instead be drilled to a depth of 130 feet (130') with an approximate final diameter of 5.5-inches using air-rotary techniques. The well shall then be installed according to the specifications in Section 5.

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3.4.4 Monitoring Well Clusters

At each cluster location the deepest borehole penetrating the St. Peter Sandstone shall be drilled first. A borehole approximately 8.5 inches in diameter shall be drilled using air-rotary methods to a depth 10 feet (10′) below the top of the St. Peter formation, estimated to be 700 feet (700′) below the surface. Lithologic samples shall be collected during drilling as described below in Section 3.5. Well materials and completion methods are specified in Section 6.

The final depths of the adjacent monitoring wells to be completed in the Burlington-Keokuk and Kimmswick formations will be determined by the Contractor from the lithologic log of the borehole penetrating the St. Peter formation. Estimated depths are 300 feet (300′) for the wells in the Kimmswick formation and 100 feet (100′) for the wells in the Burlington-Keokuk formation. Borehole diameter for these wells shall be approximately 8.5 inches, drilled by air-rotary methods as specified above for the deep borehole penetrating the St. Peter formation. Well materials and completion methods are specified in Section 6.0.

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3.5 Lithologic Sampling

A representative of the Contractor will be responsible for maintaining a continuous written lithologic log of the boreholes.

Lithologic sampling will be performed during drilling for the pumping wells, the deep, double-cased observation wells, and the deepest well in each of the two monitoring well clusters.

3.5.1 Sampling During Drilling in Unconsolidated Soils

Split-spoon soil samples shall be collected at depth intervals of five feet (5'), with the initial sample collected at a depth of five feet. After the split-spoon sampler is removed from the drill string and opened, the Contractor representative will handle logging, labeling, and storage. Additional split-spoon samples shall be collected at the discretion of the Contractor. Six (6) of these additional samples are estimated.

3.5.2 Sampling During Rock Drilling

Lithologic sampling during rock drilling will consist

of a program of continuous coring in the boreholes for pumping and selected observation wells. During drilling of the deepest monitoring wells, lithologic sampling will consist
of sampling drilling cuttings.

The coring shall be accomplished using wireline methods. The core obtained shall be 1.875 inches in diameter (NX). A diamond-impregnated core bit and solid inner barrel shall be used.

Approximately 270 feet (270') of core will be collected from boreholes drilled for pumping test wells in order to obtain bedrock lithology, mineralogy, permeability, porosity, and evidence of bedrock contamination. Cores will be collected by continuous coring from the top of bedrock to the bottom of the hole in the pumping test wells and from the bottom of the cased interval to the total depth in the deep observation wells labeled "j".

Each core run shall be attempted to be a minimum of five feet (5') and a maximum of ten feet (10') in length. The Subcontractor shall supply pre-manufactured and treated cardboard core boxes capable of holding at least 10 feet of rock core. The cores will be delivered to the Contractor for logging

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and storage of the boxes. The Subcontractor will be required to use a 10-foot barrel and use his workman-like "best" techniques to obtain full runs. Rock coring shall be performed in accordance with the ASTM D-2113 standard.

Competent core will be stored in the cardboard core boxes. Unconsolidated, very friable, or clayey sections of core will be placed in clear, plastic-sheeting core tubing or bags, sealed, and stored along with the competent core in the core boxes. Some sections of core chosen by the Contractor may also be sealed in the core tubing for subsequent chemical analysis.

During drilling of the deepest monitoring wells, "grab" samples of drilling cuttings shall be collected at depth intervals of five feet (5') or distinct changes in lithology as noted by the Contractor representative.

The Subcontractor will assist the Contractor in collecting, sealing, and storing samples.

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3.6 Lost Equipment, Lost Boreholes, and Borehole Abandonment

A hole shall be termed "lost" if the Contractor determines that the condition of the hole will prevent its successful completion, or if for any reason it is impractical to continue operations. The term "abandonment" shall mean abandonment to suit the convenience of the Contractor.

A hole which is determined to be lost shall be grouted from its total depth to land surface using a cement-bentonite grout as specified in Sections 4.7 and 5.5 of these specifications.

If the Contractor determines that a hole has been lost for reasons within the control of the Subcontractor, or because of negligence, incompetence, or malpractice on the part of the Subcontractor or Subcontractor's personnel, or because of the use of defective or unsuitable equipment, the Subcontractor shall not be paid for any drilling, demobilization, or other services performed in the lost hole. This includes boreholes lost in the event drill bits, drill rod, or other downhole tools are lost in the borehole and cannot be recovered by the Subcontractor's efforts. In addition, the Subcontractor shall be required to grout the hole from its bottom to land surface, and then move over and drill a new hole in the proper manner to

replace the abandoned one. The Subcontractor shall be notified in writing of this decision.

3.7 Standby Time

Standby time shall be defined as time during which the Subcontractor has been instructed by the Contractor to cease working pending further instructions.

Decontamination time shall be defined as time spent decontaminating drilling equipment, well screens, and casing as specified in Section 3.2 and is not considered standby time.

Time spent for clean-up and restoration of drilling locations or for other routine housekeeping or equipment maintenance is not considered standby time.

All standby time shall be recorded on the Daily Field Activity Report discussed below.

3.8 Field Documentation

The Contractor will maintain a "Daily Field Activity Report" (a sample copy is attached as Figure 6) detailing Subcontractor activities. The Subcontractor is required to sign this report on a daily basis and note any differences

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that cannot be resolved. Any differences shall be documented for future reviews and resolution between the Contractor and Subcontractor. This is the only form that will serve to document quantities of work.

A designated Contractor representative will be assigned to each drilling rig to document the activities. The Contractor representative will assure that work is performed in accordance with these specifications.

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Figure 6

WELL DRILLING AND INSTALLATION
DAILY FIELD ACTIVITY REPORT

Driller:_____ Date:_____

Assistants:_____ _____

Boring or Well Number(s):_____

DRILLING

_____Number of Split-Spoon Samples at 5' Intervals

_____Additional Split-Spoon Samples

_____Feet Air Rotary Drilling _____ Diameter

_____Feet Water/Mud Rotary Drilling _____ Diameter

_____Feet NX Rock Coring

WELL INSTALLATION

_____Feet Screen Installed Type:_____

_____Feet Casing Installed Type:_____

_____Lbs. of Bentonite Pellets

_____Feet Grouted _____ Hours Standby

_____Sacks Cement _____ Hours Well Development

_____Lbs. Powdered Bentonite

_____Lbs. Sand _____ Hours Decontamination

Comments:

The above is a true and accurate record of the work performed on the above mentioned date.

Contractor's Representative: _____

Subcontractor's Representative: _____

3.9 Site Restoration

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The Subcontractor shall reclaim areas disturbed by drilling activities performed under this Subcontract. As a minimum the Subcontractor shall:

- Recontour all disturbed areas to approximate original contours.

- Purchase grass seed mix and reseed disturbed areas. The seed mix shall be one of the following, as appropriate for the time of year when seeding occurs:

Seeding between August 1 - April 15

Annual Ryegrass	38%
Orchard Grass	18%
Korean or Kobe Lespedeza	18%
Ladino Clover	2%
Switch Grass	15%
Timothy	9%

Seeding between April 16 - July 31

Big Blue Stem	33%
Indian Grass	25%
Little Blue Stem	25%
Sideouts Grama	17%

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- Any variations in the seed mixture must be approved by the Contractor.

- Seeding shall be accomplished by broadcast and raking into the soil.

- Following seeding, the Subcontractor shall apply a mulch consisting of clean straw to the area.

- Remove drilling cuttings from the well location and transport them to a location designated by the Contractor.

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4.0 WELL CONSTRUCTION MATERIAL

Pumping and observation wells shall be constructed using materials as specified below.

4.1 Well Casing

Well casing shall consist of new, decontaminated, threaded, flush-joint, Schedule 40 PVC casing with a nominal six inches (6") inside diameter (ID) for the pumping test wells and the outer casing of the double cased observation wells, and two inches (2") ID for the observation wells. All well riser pipe shall, as a minimum, conform to the requirements of ASTM Schedule 40 pipe. All riser pipe shall bear markings that will identify the material. There shall be no obstructions on the inside of the casing. The Subcontractor shall furnish data from the casing supplier prior to purchase.

4.2 Well Screen

The Subcontractor shall be responsible for supplying a decontaminated, factory constructed, flush-joint threaded, well screen. The well screen shall be constructed of ASTM Schedule 40 PVC with a nominal six inches (6") inside diameter for the pumping test wells and two inches (2") (ID) for the observation wells. Slot size shall be

0.020-inch. Well screen shall be supplied in lengths of 10 feet (10') each. It is estimated that forty feet (40') of 6" ID screen will be necessary for each pumping well. Forty feet (40') of 2" ID screen is estimated for each shallow observation well. Ten feet (10') of 2" ID screen is estimated for each deep observation well.

The Subcontractor shall supply data from the screen supplier prior to purchase.

4.3 Bottom Plug and Top Cap

The casing shall have a threaded PVC plug or end cap securely attached to its lower end. This will complete the well string, providing a sealed bottom.

The Subcontractor shall supply a threaded PVC top cap. A one-sixteenth inch (1/16") hole shall be drilled in the side of the cap.

4.4 Method of Joining Well Screen and Well Casing Sections

Well screen and well casing sections shall be joined by threaded, flush-jointed couplings, to form straight, water-tight unions. No threaded couplings shall be above land surface. Absolutely no solvents or glue shall be used

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in construction of the wells.

4.5 Filter Pack

The Subcontractor shall supply clean, inert materials (silica sand) from which to construct a filter pack which shall ensure continuous flow capability.

The sand shall have a gradation which will allow no more than five percent of the sand to pass through the well screen slots (6 to 20 mesh sand). The Subcontractor shall furnish the Contractor with written documentation including a test report that the sand meets these specifications.

Any unused bulk portions or opened bags of sand remaining after completion of a pumping test well location shall be properly disposed of as stated in Special Condition 9 rather than being transported to the next pumping test well location.

4.6 Bentonite Seal

The bentonite seal shall consist of a minimum thickness of three feet (3') of 1/2- to 3/8-inch bentonite pellets. The pellets shall have a minimum purity of 90 percent montmorillonite clay and a minimum dry bulk density of 75 pounds per cubic foot. The bentonite pellets shall not

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contain toxic or potentially hazardous compounds (such as kerosene, diesel fuel, etc.) The Subcontractor shall supply manufacturer's data certifying purity and composition of the pellets prior to purchase.

4.7 Grout Seal

A grout seal shall be installed from the top of the bentonite seal to land surface.

The grout shall consist of Portland cement (ASTM C150) mixed with six pounds of commercial bentonite powder and approximately 7-1/2 gallons of water added to each 94-pound bag of cement. An optional material is the use of Volclay grout by American Colloid. The grout mix can be adjusted or changed as dictated by the field conditions upon approval by the Contractor. A Contractor representative will be present during grouting operations and will verify that the grout has the proper consistency prior to installation.

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5.0 OBSERVATION AND PUMPING TEST WELL INSTALLATION

Observation and pumping test well installation shall begin as soon as practicable after completion of drilling. Typical well construction is illustrated on Figure 7. After beginning well installation, operations shall not be stopped for breaks, end of regular work shift, or darkness until the bentonite seal has been emplaced above the filter pack. The Subcontractor shall be prepared to arrange the work as needed to comply with this restriction. Well installation work may be stopped prior to placement of the bentonite seal if conditions exist which would prevent the successful completion of the well or if, in the opinion of the Contractor's Safety Supervisor, a safety hazard is present. The footage for this line item for each well shall be measured from the total depth of the well to the top of the Schedule 40 PVC casing.

5.1 Well String Installation

The final well depth and screened interval shall be determined by the Contractor before the borehole is reamed to the final diameter. Estimated depths are 130 feet (130') for deep observation wells and 80 feet (80') for the shallow observation and pumping test wells.

The well string (casing and screen) is to be lowered slowly into the borehole using clamps, elevators, or other

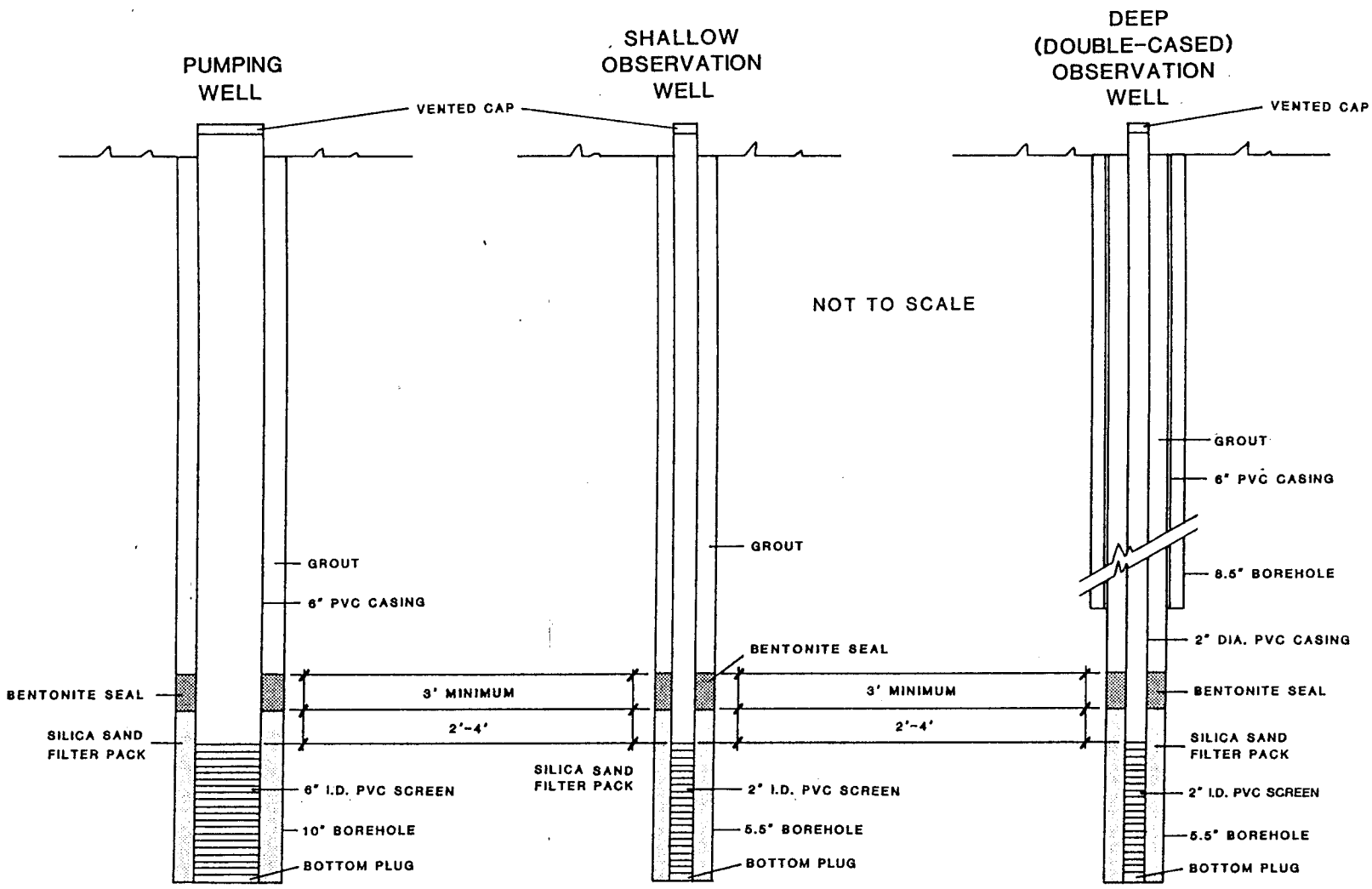

FIGURE 7

PUMPING AND OBSERVATION WELL CONSTRUCTION

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mechanical devices to ensure the well shall maintain alignment, plumbness, and roundness during installation. The well string shall not be dropped into place, or lowered by hand in an uncontrolled manner. The casing shall be fully supported from the top and held in tension during the placement of filter pack, seal, and grout.

The well shall be set with approximately two feet (2') of casing above the ground surface. The threaded cap shall be placed on the top of the well as soon as the well string is set to the final depth.

5.2 Casing Alignment

All wells shall be constructed, and all well casing and screen set round and true-to-line.

PVC centralizers shall be used to assure alignment of the well string in the lower portion of the boreholes. The centralizers shall be placed at the bottom of the well screen and at the top of the screen. One centralizer shall be placed halfway between these two if the screen length is greater than 20 feet (20'). This will allow the uniform and complete filling of the annular space by filter pack, seal, and grout materials.

Centralizers shall be fastened to the well casing and

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screen by using clamps and be radially spaced about the casing at 120°. No bonding agents shall be used to attach centralizers. Fasteners which penetrate the casing and extend into the well shall not be allowed since downhole sampling equipment may be hampered in its operation. Centralizers shall be placed such that the screen and casing are centered in the hole and in a manner which will not hinder the use of the tremie pipe while emplacing backfill materials.

5.3 Filter Pack Installation

The filter pack shall be installed using a 1.25 inch ID tremie pipe. The tremie pipe shall be initially placed near the bottom of the well and gradually raised. The filter pack shall be emplaced to a point at least two feet (2′) and not more than four feet (4′) above the top of the screen. The top of the filter pack shall be verified by measuring with a measured tremie or weighted tape measure.

5.4 Bentonite Seal Installation

The bentonite seal shall be installed via tremie pipe by slowly pouring the bentonite pellets from the surface. A minimum thickness of three feet (3′), measured before the pellets have expanded, shall be emplaced and measured with a tremie pipe or weighted tape measure.

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5.5 Grouting

The grout shall be pumped into the annular space using a minimum one-half inch (0.5") ID tremie pipe. The tremie pipe shall be set at the top of the bentonite seal. The grouting shall be performed in a continuous manner until the annular space is completely filled. After the grout has settled for 24 hours, it shall be "topped-off" as necessary until the annular space is completely filled.

5.6 Well Development

After the well installation is completed and the cement grout (or Volclay grout) has set for a minimum of 48 hours, each well shall be fully developed.

Development shall be accomplished by surging and bailing or surging and pumping. All surge blocks, bailers, and other development equipment shall be decontaminated by hot water, high-pressure washing before development begins and between each well. Pumps and hoses shall be thoroughly flushed with potable water from the approved source.

Each well shall be developed for a minimum of four (4) hours. Development shall be considered complete when the water yielded from the well has a measured turbidity of no greater than five (5) Nephelometric Turbidity Units (NTU).

The Subcontractor may supply a turbidity meter to make field measurements, or may collect visually clear water samples at the end of the four (4) hour minimum and submit these samples to a laboratory for confirmation that the five (5) NTU standard has been met.

A minimum of five (5) volumes of standing water in the well casing and annular space shall be removed from each well during development. In the event that a well is pumped or bailed dry and recharges slowly, the Subcontractor may move to another well and return to complete development at the original well after it has recharged. If the five (5) NTU standard or the five (5) well volume standard cannot be achieved after a total of four (4) hours, the Contractor may set an alternative standard. If additional efforts by the Subcontractor are necessary, the Subcontractor shall be compensated according to the provisions of the Changes clause.

During and after development all sediment collected in the bottom of the well shall be removed using a bailer. Absolutely no acids, dispersive agents, or explosives shall be permitted for well development.

5.7 Aquifer Step-Drawdown Test

Following installation and development of the pumping

wells, and prior to the installation of observation wells, the Subcontractor shall furnish and install an appropriate test pump and conduct a step-drawdown pumping test. The purpose of this pumping test will be to determine observation well spacing and the pump size and sustained pumping rate for the pumping wells. The pumping unit shall be complete with an ample power source, controls and appurtenances and shall be capable of being operated for a minimum period of 8 hours without interruption. The pump shall be removed at the completion of the step-drawdown test.

Prior to starting the pump, water level measurements shall be taken in the pumping test well. The well shall be "step" tested at rates of 0.5 gpm, 1 gpm, 2.5 gpm, 7.5 gpm, 10 gpm, 15 gpm, 20 gpm, and 25 gpm. It is estimated that each step will take one hour. The Subcontractor shall operate the pump. When the drawdown in the well reaches a stable level the Subcontractor shall increase the discharge. A Contractor's representative shall be present during the step-drawdown test. Discharge of the pump shall be controlled by a gate valve, if driven by an electric motor, and both gate valve and engine throttle if driven by a gasoline or diesel engine. The discharge shall be controlled and maintained at approximately the desired discharge for each step with an accuracy of plus or minus 5 percent. Pump discharge to the nearest one-tenth gallon

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per minute (0.1 gpm) shall be measured with a totalizing meter and stop watch, circular orifice meter, or Venturi meter. A 2-wire electric sonde (m-scope) shall be supplied by the Subcontractor to measure the static water level and drawdown in the well. The pump and hoses shall be thoroughly decontaminated between wells.

The Subcontractor shall convey and discharge all pumped water from the pumping wells to Raffinate Pit 4 on the west side of the site. Pumping through hoses or temporary piping or transport by tanker truck are acceptable methods of conveying the water from the pumping well to the raffinate pits. The Subcontractor shall supply all hoses, pipes, pumps, tanks, and vehicles necessary for these operations.

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6.0 MONITORING WELL MATERIALS, INSTALLATION AND DEVELOPMENT

6.1 Well Installation in St. Peter and Kimmswick Formations

The monitoring wells completed in the St. Peter and Kimmswick formations shall be constructed using steel casing having an outside diameter (OD) of 6.625 inches and wall thickness not less than 0.188 inch, conforming to specifications for ASTM A-53 Grade B pipe. The ends of each section shall be cut square with beveled edges. Casing sections shall be joined by welding as the casing is installed. Each length of casing shall be decontaminated by hot water high-pressure washing prior to installation as described above in Section 3.2. Typical monitoring well construction for wells in the individual formations is shown on Figure 8.

To install each well in the St. Peter formation, a borehole approximately 8.5 inches in diameter shall be drilled to a depth 10 feet (10′) below the top of the St. Peter formation as specified above in Section 3.4.4. Casing shall then be installed to the total depth of the borehole with approximately two feet (2′) extending above the ground surface. The annular space shall be sealed to the total depth using a cement bentonite grout mixture as specified in Section 4.7. After the grout has set for a minimum of

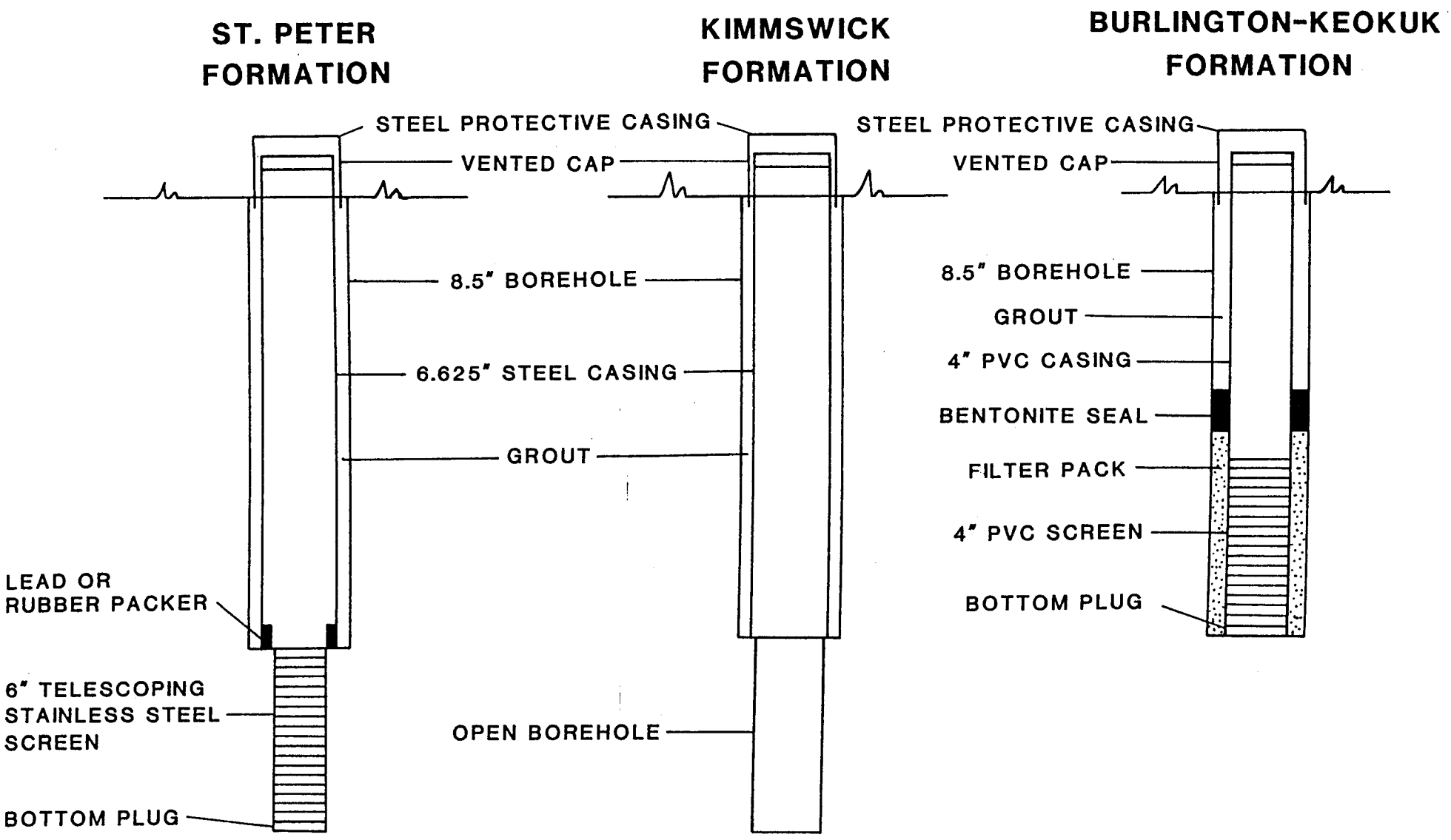

FIGURE 8

MONITORING WELL CONSTRUCTION

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72 hours, a borehole approximately 6 inches in diameter shall be drilled through the casing to a depth 20 feet (20') below the end of the casing. A six inch (6") nominal diameter telescoping screen 20 feet (20') in length shall then be installed below the casing. The screen shall be constructed from Type 304 stainless steel using wire-wound construction techniques. Screen slot size shall be 0.010 inch. The screen shall be fitted with a bottom seal and a lead or rubber packer to seal the top of the screen to the casing.

The wells in the Kimmswick formation shall be constructed by drilling a borehole approximately 8.5 inches in diameter to a depth 10 feet (10') below the top of the Kimmswick formation, then setting and grouting casing as described above for the wells completed in the St. Peter formation. After the grout has set for a minimum of 72 hours, a borehole approximately six inches (6") in diameter shall be drilled through the casing to a depth 20 feet (20') below the bottom of the casing. These wells shall be constructed as open-hole completions.

The Subcontractor shall assure that the open borehole interval is free of obstructions to the full depth and diameter.

The Subcontractor shall supply a threaded or loose-fitting

slip cap for each monitoring well. A one-sixteenth inch (0.0625") hole shall be drilled in the side of the cap or in the casing not more than two inches (2") below the cap.

6.2 Monitoring Well Installation in the Burlington-Keokuk Formation

The monitoring well completed in the Burlington-Keokuk formation shall be constructed using four inches (4") inside diameter, threaded, flush-jointed Schedule 40 PVC casing, screen, cap and bottom plug. Screen length shall be 20 feet (20'), slot size shall be 0.020 inch. All casing and screen shall be decontaminated by hot water high-pressure washing prior to installation as described above in Section 3.2. A borehole approximately 8.5 inches in diameter shall be drilled to the total depth 25 feet (25') below the bedrock surface, or 25 feet (25') below the water table if the water table is below the bedrock surface. Estimated total depth is 100 feet (100'). The well shall then be installed in the same manner as the pumping and shallow observation wells as specified above in Sections 5.1 through 5.5, utilizing filter pack materials, bentonite, and grout as specified in Sections 4.5 through 4.7.

6.3 Monitoring Well Protection

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The Subcontractor shall provide and install a steel protective casing around each monitoring well. Protective casings shall be a minimum of five feet (5′) in length and have a hinged, locking cap. Protective casings for the wells constructed with 6.625 inches (OD) casing shall be a minimum of ten inches (10") in diameter or ten inches (10") square. The protective casing for the four inches (4") diameter PVC well shall be a minimum of eight inches (8") in diameter or eight inches (8") square.

Each protective casing shall be set in a concrete pad at the surface. The concrete pad shall be two and one-half feet (2.5′) square, with a minimum thickness of six inches (6") and slope away from the protective casing. At least three inches (3") of this pad shall be below the ground surface. The minimum amount of slope from the protective casing is one inch (1") per two feet (2′). A one-fourth inch (0.25") diameter hole shall be drilled in the protective casing approximately one-half inch (0.5") above the surface of the concrete pad in order to allow drainage of the protective casing. The protective casing shall be painted yellow or orange using a weather-resistant enamel prior to installation.

The Subcontractor shall install three (3) protective posts

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around each well, one hundred twenty degrees (120°) apart. These posts shall be iron posts at lest four inches (4") in diameter, extending at least two feet (2') below the ground surface and at least four feet (4') above grade. The protective posts shall be between three and one-half feet (3.5') and four feet (4') from the protective casing. The posts shall be filled with concrete and all sharp edges removed. The posts shall be painted yellow or orange using a weather-resistant enamel.

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7.0 WELL DEVELOPMENT

After the well installation is completed and the final grout and surface concrete pad has set for a minimum of 48 hours, each well shall be fully developed.

Development shall be accomplished by surging and bailing or surging and pumping. All surge blocks, bailers, and other development equipment shall be decontaminated by hot water, high-pressure washing before development begins and between each well. Pumps and hoses shall be thoroughly flushed with potable water from the approved source.

Each well shall be developed for a minimum of four (4) hours. Development shall be considered complete when the water yielded from the well has a measured turbidity of no greater than five (5) Nephelometric Turbidity Units (NTU). The Subcontractor may supply a turbidity meter to make field measurements, or may collect visually clear water samples at the end of the four (4) hour minimum and submit these samples to a laboratory for confirmation that the five (5) NTU standard has been met.

A minimum of five (5) volumes of standing water in the well casing and annular space shall be removed from each well during development. In the event that a well is pumped or bailed dry and recharges slowly, the Subcontractor may move to another well and return to complete development at the original well after it

has recharged. If the five (5) NTU standard or the five (5) well volume standard cannot be achieved after a total of four (4) hours, the Contractor may set an alternate standard.

During and after development all sediment collected in the bottom of the well shall be removed using a bailer. Absolutely no acids, dispersive agents, or explosives shall be permitted for well development.

8.0 SURVEYING

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After completion of monitoring well installation, the Subcontractor shall conduct land surveys to determine the horizontal coordinates of each well on the site grid system and to determine the top-of-casing elevation of each well.

Horizontal coordinates shall be measured to the nearest one foot (1').

Top-of-casing elevations shall be measured to the nearest one-hundredth of a foot (0.01'). The top-of-casing elevation shall be measured at the top of the well casing with the cap removed. Before placing the rod on the top of the casing, the surveyor shall place a clean, new plastic bag over the base of the rod. A new plastic bag shall be used at each well.

The Contractor will supply information on vertical and horizontal control points on which to base the surveys.

The survey data, including copies of the surveyor's field notes, shall be submitted to the Contractor within thirty (30) days following completion of monitoring well installation.

All surveying shall be performed under the supervision of a Registered Land Surveyor in the State of Missouri.

CHEMICAL PLANT ADMINISTRATIVE RECORD FILE

ARFS FILE # C-204-1

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DOCUMENT NUMBERS	DOCUMENT TITLE
C-200-204-1.01(r)	REMEDIAL INVESTIGATION QUALITY ASSURANCE PROGRAM PLAN
C-200-204-1.02*	U.S. EPA RESPONSIVENESS SUMMARY COMMENTS ON RI/QA PROGRAM PLAN
C-200-204-1.03*(r)	ENVIRONMENTAL QUALITY ASSURANCE PROJECT PLAN

The administrative record documents will be numbered when the Record of Decision document is finalized and included in the administrative record.

CHEMICAL PLANT
204-1.01

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

March 14, 1989

ADDRESSEES

REMEDIAL INVESTIGATION QUALITY ASSURANCE PROGRAM PLAN

Enclosed is Revision 0 of the "Remedial Investigation Quality Assurance Program Plan" for the Weldon Spring Site. This plan has been revised to address comments received from the U. S. Environmental Protection Agency and the Missouri Department of Natural Resources as indicated in the "Responsiveness Summary", also enclosed.

Sincerely,

for R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

cc w/enclosure:
Administrative Record

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MAR 14 1988

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MAR 14 1989

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CE-541	KDLawver	3/13/89
CE-541	RRNelson	3/14/89

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(7-73)

OFFICIAL FILE COPY

QF

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

February 25, 1988

Mr. Dan Wall
U. S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Dear Mr. Wall:

REMEDIAL INVESTIGATION DOCUMENTS

Enclosed are six copies of the following documents for your review:

- Quality Assurance Program Plan Weldon Spring Site DOE/OR/21548-011 (Draft Copy) February 1988.
- Community Relations Plan
- Construction Safety and Health Management Program prepared under Contract No. DE-AC05-86OR21548 April 17, 1987
- WSSRAP Procedures Manual Volume No. V - Environmental Safety and Health Contract No. DE-AC05-86OR21548 (Revision 20, January 11, 1988)
- Waste Assessment Raffinate Pit Sampling Plan Weldon Spring Site DOE/OR/21548-010 (Draft Copy) February 1988

The QAPP and its enclosures were prepared following the format and content of the Galena, Kansas QAPP provided to DOE by EPA as an example. The Waste Assessment - Raffinate Pit Sampling Plan requires your formal concurrence prior to commencement of field activities.

ADMINISTRATIVE RECORD (_____ ARFS)
FILE NUMBER: _____ SECTION: _____
DOCUMENT NUMBER: _____ DATE: _____
DOCUMENT TITLE:
AUTHOR: _____ RECIPIENT: _____
TYPE: _____ # OF PAGE: _____

Your expeditious review and concurrence is requested in order to begin field activities. In order to avoid delays, should a question arise during the review process that an immediate answer by the PMC staff would help clarify, please contact me so arrangements with the proper site personnel can be made.

Sincerely,

Kenneth D. Lawver
Environmental Engineer
Weldon Spring Site
Remedial Action Project

Enclosures

cc w/enclosures:
Dave Bedan, MDNR

QF

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

February 25, 1988

Mr. David E. Bedan
Division of Environmental Quality
Missouri Department of Natural Resources
Post Office Box 176
Jefferson City, Missouri 65102

Dear Mr. Bedan:

REMEDIAL INVESTIGATION DOCUMENTS

Enclosed are five copies of the following documents for your review:

- Quality Assurance Program Plan Weldon Spring Site DOE/OR/21548-011 (Draft Copy) February 1988.
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Sincerely,

Kenneth D. Lawver
Environmental Engineer
Weldon Spring Site
Remedial Action Project

Enclosures

cc w/enclosures:
Dave Bedan, MDNR

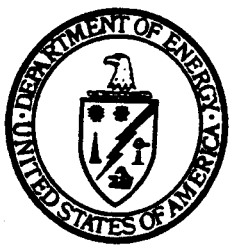
DOE/OR/21548-011
(CONTRACT NO. DE-AC05-86OR21548)

REMEDIAL INVESTIGATION QUALITY ASSURANCE PROGRAM PLAN

For The :
Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

Prepared By MK-Ferguson Company
DECEMBER, 1988

REV. 0



U.S. Department Of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

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DOE/OR/21548-011/REV. 0

Weldon Spring Site Remedial Action Project

REMEDIAL INVESTIGATION QUALITY ASSURANCE PROGRAM PLAN

December 1988

Prepared By

MK-FERGUSON COMPANY

Route 2, Highway 94 South

St. Charles, Missouri 63303

Project Management Contractor

For The

U.S. DEPARTMENT OF ENERGY

Oak Ridge Operations Office

Under Contract DE-AC05-86OR21548

	Approvals	Date
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WSSRAP Project Manager	J. Hammond	1-13-89
WSSRAP Project Quality Assurance Manager	J. J. Hairston	1-13-89
DOE Project Manager		1-23-89
DOE Quality Assurance Director	No Signature Required	

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DOCUMENTS INCORPORATED BY REFERENCE

OPERATIONAL PLANS AND PROCEDURES

Standard Operating Procedures (WSSRAP Procedures Manual, Volumes 1 through 5)

metaTRACE, Inc. Quality Assurance Manual, July 1987

WSSRAP Environmental, Safety and Health Plan, Rev. 0, January 1987

WSSRAP Spill Prevention, Control and Countermeasure Plan, January 1988

WSSRAP Community Relations Plan, Rev. 3, October 1988

Emergency Plans and Procedures for the Weldon Spring Site Remedial Action Project, Rev. 3, June 1988

SAMPLING PLANS

WSSRAP Chemical Soil Investigation Sampling Plan for Chemical Plant/Raffinate Pits, Rev. 1, May 1988

Hydrogeologic Investigation Sampling Plan, Rev. 0, November 1988

Waste Assessment - Raffinate Pit Sampling Plan, Rev. 1, May 1988

Buildings Sampling Plan, Rev. 0, August 1988

Geophysical/Geotechnical Investigation Sampling Plan, Rev. 1, July 1988

Other Investigations:

Radiological and Chemical Uptake by Edible Portions of Selected Biota at the Weldon Spring Site, November 1988

Plan for the Sampling and Analysis of Lake and Stream Sediments Influenced by the Weldon Spring Chemical Plant Drainage, November 1987

ABSTRACT

The Remedial Investigation Quality Assurance Program Plan (RIQAPP) for Weldon Spring Site Remedial Action Project (WSSRAP) is distinguished by purpose from the WSSRAP overall Quality Assurance/Quality Control Program Plan (QAPP). The RIQAPP is focused only on meeting EPA requirements under CERCLA whereas the QAPP is designed to meet quality assurance program requirements for nuclear facilities: NQA-1 (ANSI, 1986).

The RIQAPP specifically addresses factors, methods and criteria presented in Section 300.68 of the National Oil and Hazardous Substances Pollution Contingency Plan. Specific QC procedures are contained in existing documents incorporated into the plan by reference. These include Standard Operating Procedures, laboratory QA procedures, and activity level sampling plans. Most of the sampling and analysis activities rely heavily upon guidance in SW-846E (EPA, 1984).

The existing procedures provide many of the required QA elements: measurement, sampling, sample and document custody and control, calibration, analysis and data reduction, validation and reporting. Additional QA elements addressed in the RIQAPP include performance and system audits, surveillance, and reporting and correction of deficiencies.

System audits, on a regularly scheduled basis, will evaluate all components of measurement systems to determine capability, proper selection and use. Performance audits, on a scheduled basis, will determine adequacy and accuracy of a given measurement system and/or procedural compliance. Surveillance, both scheduled and unscheduled, of field and laboratory activities will be performed to verify conformance to specified requirements.

Audit reports will require responses from audited organizations which must include commitment dates for completion of actions

recommended to correct deficiencies. Completion of all corrective actions will be verified. Deficiencies noted during surveillance will be documented and will require responses and follow-up action.

All correspondence, plans, reports, certification and other relevant documentation will be processed through the WSSRAP Document Control Department.

Key QA positions in the PMC organization are the Project Quality Manager (PQM), reporting administratively to the Project Manager and authoritatively to the PMC's corporate QA/QC Manager, and a QA Engineer/Lead Auditor reporting to the PQM.

1.0 INTRODUCTION

The overall WSSRAP QA/QC program (including subsequent remedial action activities) is designed to meet the quality assurance program requirements for nuclear facilities: NQA-1 (ANSI, 1986). This RIQAPP is focused only on the EPA requirements under CERCLA. It is intended to meet the requirements of applicable EPA guidance documents, including Part 1 of Region VII's Quality Assurance Program Plan (EPA, 1986a) and U.S. EPA's Interim Guidelines and Specifications for the Preparation of Quality Assurance Project Plans (EPA, 1980). The primary purpose of this document is to provide a complete and accurate framework of information for assessing the amount and extent of hazardous materials present on site.

This plan incorporates the following operational plans and procedures by reference: a set of Standard Operating Procedures (WSSRAP Procedures Manual, Volumes 1 through 5); an Analytical Methods/Detection Limits Document (metaTRÀCE, Inc. Quality Assurance Manual, July 1987); WSSRAP Environmental, Safety and Health Plan, Rev. 0, January 1987; WSSRAP Spill Prevention, Control and Countermeasure Plan, January 1988; WSSRAP Community Relations Plan, Rev. 3, October 1988; and Emergency Plans and Procedures for the Weldon Spring Site Remedial Action Project, Rev. 3, June 1988. Additionally, this plan incorporates by reference the following Remedial Investigation sampling plans: WSSRAP Chemical Soil Investigation Sampling Plan for Chemical Plant/Raffinate Pits, Rev. 1, May 1988; Hydrogeologic Investigation Sampling Plan, Rev. 0, November 1988; Waste Assessment - Raffinate Pit Sampling Plan, Rev. 1, May 1988; Buildings Sampling Plan, Rev. 0, August 1988; Geophysical/ Geotechnical Investigation Sampling Plan, Rev. 1, July 1988; Radiological and Chemical Uptake by Edible Portions of Selected Biota at the Weldon Spring Site, November 1988; and Plan for the Samplng and Analysis of Lake and Stream Sediments Influenced by

the Weldon Spring Chemical PLant Drainage, November 1987.

The QA/QC program detailed in this document and within the associated sampling plans is intended to be utilized by personnel involved with the Remedial Investigation/Feasibility Study (RI/FS) at the Weldon Spring Site. Specific quality control procedures are detailed in the attached Standard Operating Procedures and in the individual remedial investigation sampling plans. This RIQAPP presents a methodology for gathering and analyzing information that will be included in the WSSRAP RI/FS-Environmental Impact Statement Report. This program is intended to fulfill DOE's commitment to meeting the requirements of the Federal Facilities Agreement signed by DOE and EPA for the Weldon Spring Site.

The RIQAPP addresses all 16 QA elements (see Table 1.1), as specified for environmentally related measurements by EPA's Office of Monitoring Systems and Quality Assurance (EPA, 1980).

TABLE 1.1

REMEDIAL INVESTIGATION QUALITY ASSURANCE PROGRAM PLAN ELEMENTS

QA Elements	Information Provided In
1. Title Page	RIQAPP[1]
2. Table of Contents	RIQAPP
3. Project Description	RIQAPP RI/FS-EIS Work Plan[2]
4. Project Organization and Responsibility	RIQAPP RI/FS-EIS Work Plan
5. Quality Assurance Objectives for Data Measurement	RIQAPP Sampling Plans[3]
6. Sampling Procedures	SOPs [4] Sampling Plans
7. Sample and Document Custody	RIQAPP Sampling Plans SOPs Laboratory QA Procedures[5]
8. Calibration Procedures	SOPs Laboratory QA Procedures
9. Analytical Procedures	Laboratory QA Procedures
10. Data Reduction, Validation, and Reporting	Sampling Plans SOPs

TABLE 1.1 (cont.)

REMEDIAL INVESTIGATION QUALITY ASSURANCE PROGRAM PLAN ELEMENTS

11.	Internal Quality Control	RIQAPP Sampling Plans SOPs Laboratory QA Procedures
12.	Performance and System Audits	RIQAPP
13.	Preventive Maintenance	RIQAPP SOPs Laboratory QA Procedures
14.	Specific Routine Measures Used to Assess Data (Precision, Accuracy, and Completeness)	RIQAPP Sampling Plans SOPs
15.	Corrective Action	RIQAPP
16.	Quality Assurance Reports to Management	RIQAPP

1 Remedial Investigation Quality Assurance Program Plan

2 Work Plan for the Remedial Investigation and Feasibility Study-Environmental Impact Statement for the Weldon Spring Site, Weldon Spring, Missouri (August 1988).

3 Sampling Plans: WSSRAP Documents as Listed on Page iv

4 SOPs: Standard Operating Procedures

5 metaTRACE, Inc. Quality Assurance Manual, July 1987

2.0 PROJECT DESCRIPTION

2.1 PHYSICAL SETTING

The Weldon Spring Site is located in St. Charles County, Missouri, about 30 miles west of St. Louis. The site consists of a 3.4-hectare (9-acre) former limestone quarry, a 21-hectare (51-acre) raffinate disposal area (settling basins), a 67.8-hectare (166-acre) abandoned uranium feed materials plant, and various vicinity properties that are contaminated as a result of past Department of Army (DA) and Atomic Energy Commission (AEC) activities at the site.

Approximately 238,600 cubic meters (312,000 cubic yards) of contaminated soil, equipment, and buildings remaining on the Weldon Spring Chemical Plant (WSCP) site require cleanup to meet current DOE guidelines for unrestricted use. In addition, surveys show that radioactive contamination of the surrounding vicinity properties, which occurred during and subsequent to plant operation, would require removal of about 20,800 cubic meters (27,200 cubic yards) of soil to meet guidelines for unrestricted use.

The Weldon Spring Raffinate Pits (WSRP) contain approximately 168,200 cubic meters (220,000 cubic yards) of uranium and thorium residues. In addition, soil underlying the raffinate pits is probably contaminated and will require remedial action.

During the period 1943-1957, the DA utilized an abandoned limestone quarry, about four miles from the site (used as an ordnance works during World War II), for disposal of rubble and soils contaminated with TNT and DNT. Also the AEC later disposed of building rubble and soils contaminated with thorium, uranium, and their decay products. The quarry contains about 95,000 cubic meters (124,000 cubic yards) of waste, including quarry materials contaminated by the presence of this radioactive waste.

A detailed project description including site history, environmental setting and a summary of the known and suspected nature and extent of existing contamination is presented in the Remedial Investigation/Feasibility Study - Environmental Impact Statement (RI/FS-EIS) Work Plan.

2.2 PROJECT OBJECTIVES

Specifically, the RI activities are undertaken to define the extent of contamination at the site and surrounding area and allow the determination of the potential impacts of these hazardous substances on public health, welfare, and the environment. In addition, the RI data will allow for the formulation of strategies to develop and implement appropriate Interim Remedial Actions (IRAs), prior to the final selection of remedial actions.

The FS activities are undertaken to assess and develop, through the FS process, types of remedial and/or removal actions that should be considered. These actions must be the most economically feasible measures to mitigate threats to and provide protection for the public health, welfare, and environment. In addition, an RI/FS-EIS report will be prepared which will address the technical and demographic issues and impacts associated with selecting viable and feasible remedial measures.

2.3 DATA QUALITY OBJECTIVES

The purpose of the RI program is to ensure that all data used to support decisions made by DOE meet quality requirements imposed by Federal and state regulatory agencies. Specifically, the data collected at the Weldon Spring Site shall be of adequate quantity and quality to accurately characterize the site and to evaluate and delineate remedial measures.

The data collection, evaluation and subsequent remedial measures,

and other actions on site, are governed by a Federal Facilities Agreement (FFA) between EPA and DOE. This agreement defines the procedures and actions necessary for DOE and EPA to discharge their respective responsibilities for effective completion of WSSRAP. It specifies that all actions pursuant to the agreement shall be done in accordance with all applicable or relevant and appropriate Federal laws, regulations and executive orders, and applicable state and local laws and regulations. A preliminary identification of applicable or relevant and appropriate project requirements (ARARs) is presented in the RI/FS Work Plan.

This RIQAPP specifically addresses those factors, methods and criteria presented in Section 300.68 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This RIQAPP also provides a mechanism for further evaluation of the existing data for its adequacy and usability and a method for extensive monitoring of the QA/QC procedures utilized at the time of data collection and their accompanying documentation.

A three-staged Data Quality Objective (DQO) program has been delineated by EPA and will be followed on the WSSRAP. A phased investigative approach allows for a "refinement or redefinition of data collection needs at the completion of each phase" (EPA, 1987). Data collected and analyzed under the DQO process can be used to support decisions related to remedial responses at the WSS.

The three stages identified in the DQO development process are as follows:

Stage 1- Identify Decision Types
Stage 2- Identify Data Uses/Needs
Stage 3- Design Data Collection Program

The Stage 1 program identifies types of decisions needed for site remediation, designates individuals responsible for decisions and

data users, and establishes data adequacy. Data users will include the technical staff of the Project Management Contractor, DOE, EPA, Missouri Department of Conservation, Missouri Department of Health, Agency for Toxic Substances and Disease Registry, and other governmental agencies and citizen groups.

Specific data needs and uses are identified in the Stage 2 DQO process. Individual sampling plans identify uses, types, quantity, and quality of data, and establish Precision, Accuracy, Representativeness, Completeness, and Comparability (PARCC) parameter goals. Since measurement data will be used for site characterization and remedial design, goals are for the highest practical attainable level of precision and accuracy. Definitions and examples of PARCC parameters are presented in this section.

Investigative activities at the Weldon Spring Site (WSS) have progressed, for the most part, beyond Stage 1, particularly the site characterization for radiological contamination. Extensive data are available from previous investigations to allow for the development of a conceptual model of the site.

The conceptual model can be expanded, data needs and uses can be redefined, and revisions or additions to the data collection program can be implemented under the DQO program. For example, groundwater samples will be collected and analyzed under the Stage 3 program. Results of this laboratory analysis will be evaluated under the Stage 1 data evaluation process.

The RI/FS-EIS Work Plan delineates those site characterization and environmental monitoring activities that have been conducted prior to submittal of this RIQAPP. These activities have included the acquisition of extensive data relating to the chemical and physical characteristics of soil, groundwater, surface water, sludges and sediments, building waste and debris, and existing facilities at the WSS. The characterization

programs have included hydrogeological, soils, geological, meteorological, radiological and geophysical studies conducted by DOE and predecessor governmental agencies and private organizations. Aquifer parameters, extent of both soil and groundwater contamination, site geology, and the hydrologic regime have been partially defined. A summary is presented in the RI/FS-EIS Work Plan.

Sufficient preliminary data are available to delineate sources of contaminants, e.g. raffinate pits, existing contaminated buildings, transformer storage areas, overhead piping with asbestos, etc., and to define the approach to future sampling activities.

Existing data, however, are not sufficiently complete for Weldon Spring Site characterization. Additional data collection activities are required. These data will be used to further define the extent of soil, groundwater, surface water and air contamination. Those media and existing structures and facilities will be sampled in accordance with the five sampling plans listed in Section 1.0.

Data collected under these sampling and analysis plans will also be utilized to modify current health & safety plans (if required) to assure worker protection, to evaluate risk to public health and environment, to delineate remediation measures, and to modify current and proposed monitoring programs. The collection and analysis of environmental and biological samples will partially fulfill the data requirements for the preparation of an RI/FS-EIS.

2.4 SITE ASSESSMENT

The National Contingency Plan (40 CFR Part 300, Subpart F, CFR, 1988) stipulates that assessment of a hazardous waste site (conducted under CERCLA) must be a phased response action,

including preliminary assessment and removal actions, site evaluation to determine whether the site should be included on the National Priorities List (NPL), and remedial action. Included under the latter are requirements and criteria for conducting investigations and feasibility studies.

The RI process at the WSS has advanced through initial or preliminary assessment and site evaluation phases. Extensive data have been collected at the site and vicinity properties. Individual sampling plans discuss the validity, sufficiency, and sensitivity of these data, and additional data needs and uses. These sampling plans also address site history and summarize the existing data base.

Hazardous substances considered to be potentially on site have been defined after a thorough review of the site history records. This review includes a documentation of manufacturing processes, wastes deposited on site, building construction materials, and support items (e.g. transformers, storage tanks containing chemicals, etc.). These source studies have provided a basis for defining data needs as well as potential impacts to the public and environment and for determining the need for removal action.

3.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The Department of Energy (DOE) is responsible for conducting remedial actions at the Weldon Spring Site that will place the site in a radiologically and chemically safe state in accordance with guidelines by DOE and EPA. The responsibility for management and technical direction of remedial actions has been delegated to the DOE Oak Ridge Operation Office. MK-Ferguson (MK-F) is the project management contractor (PMC) assisting DOE in the planning and management of remedial action activities. Headquartered in Cleveland, Ohio, MK-F is a wholly owned affiliate of Morrison Knudsen Company, a multi-disciplinary firm located in Boise, Idaho. Joining MK-F as an integrated member of the PMC team is Jacobs Engineering Group, Inc., headquartered in Pasadena, California.

The RI/FS-EIS Work Plan describes the environmental compliance process and the role of the various organizations (including the PMC) under contract to DOE for the implementation of remedial activities at the Weldon Spring Project.

Prior to the issuance of the RI/FS-EIS, it is the responsibility of the PMC to complete a site characterization program, in accordance with EPA's RI requirements. The RI/FS-EIS will be prepared in a format consistent with the requirements of a Feasibility Study (FS) and will contain the level of detail required by EPA under CERCLA/SARA.

The Project Organization Chart, Figure 3-1, shows lines of authority, responsibility and communication assigned to key project entities.

Listed below are the reporting responsibilities and duties of key PMC personnel.

The Project Director reports to DOE and the MK-F Senior

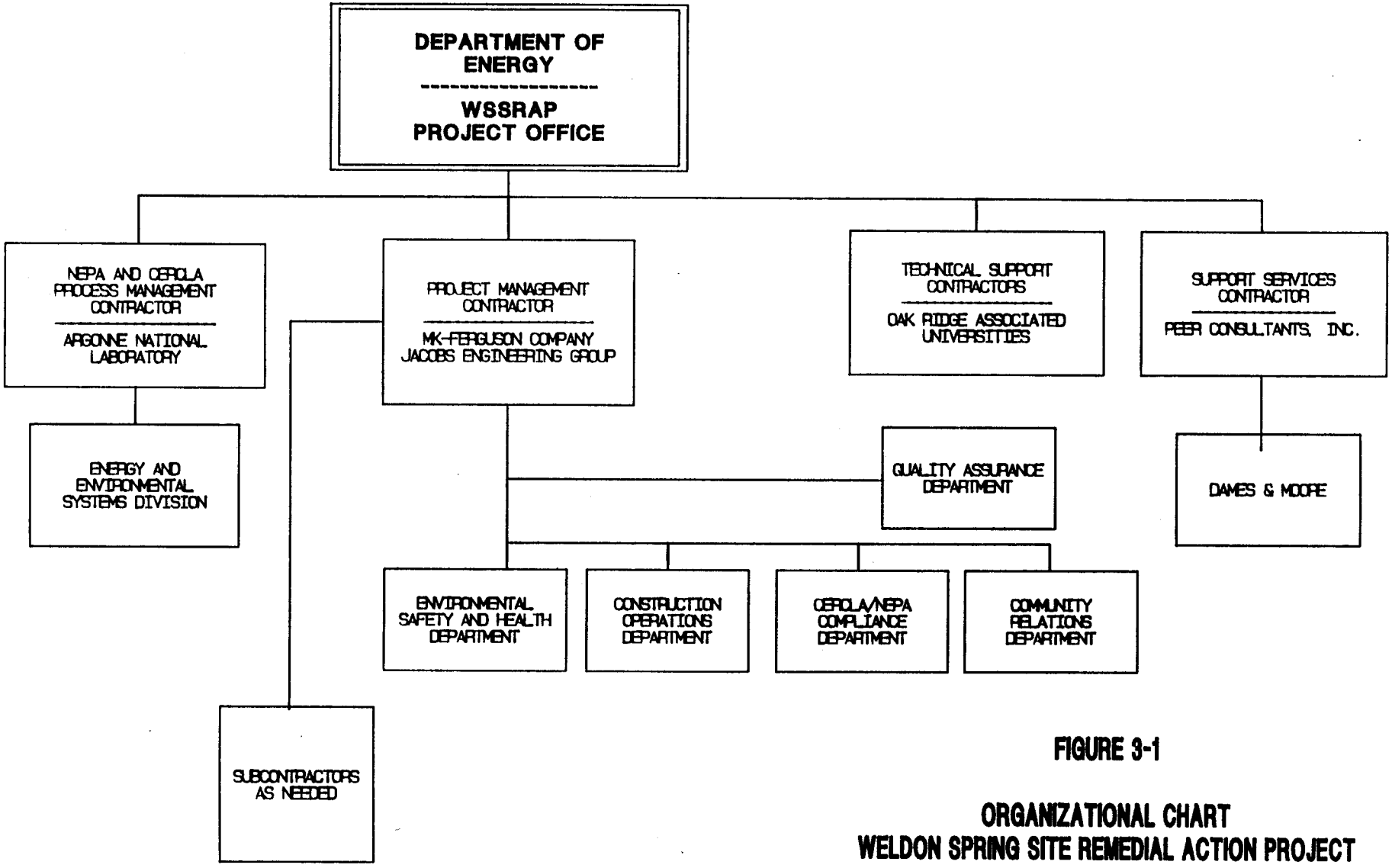

FIGURE 3-1

ORGANIZATIONAL CHART
WELDON SPRING SITE REMEDIAL ACTION PROJECT

Vice-President - Operations, and is responsible for the overall WSSRAP management. This includes completion of all contract requirements within the approved schedule and budget, and in accordance with applicable codes, standards, specifications, and the Quality Assurance Program.

The Project Manager (PM) reports to the Project Director and is responsible for regular project management and administrative duties. He directs and integrates the engineering, construction and environmental, safety and health efforts. The PM is authorized to act for the Project Director in his absence from the project office.

The Administrative Manager (AM) reports to the Project Director and is responsible for all project administrative matters, i.e. general records control, time-keeping, payroll, industrial relations, site security, property control, and all financial matters.

The Project Procurement Manager (PPM) reports to the Project Manager and is responsible for all project procurement and issuance of subcontracts, including evaluation and analysis of bids. Additional responsibilities include warehouse functions for disposal of excess property and materials.

The Community Relations Manager (CRM) reports to the Project Director and is responsible for the WSSRAP Public Information and Participation Plan. The CRM is responsible for interfaces with public groups and government agencies, arranging public presentations and all news media relations.

The Planning & Analysis Control Manager (PAM) reports to the Project Director and is responsible for the overall project management control system which includes the development of budgets and schedules, preparation of management reports and submittals, and review and analysis of progress.

The CERCLA Compliance Manager (CM) reports to the Project Manager. The CM is responsible for the preparation, review, control and distribution of all environmental compliance documentation used to perform and monitor the work. Additionally, the CM is responsible for assuring that all design documents contain all engineering information and instructions required by the contract and all applicable codes, standards and regulations.

The Environmental, Safety and Health (ES&H) Manager reports to the Project Manager. The ES&H Manager is responsible for construction safety, radiological and environmental monitoring and analysis, applied health physics, and all training required by these activities.

The Construction/Operations (C/O) Manager reports to the PM and is responsible for construction management and coordination of all subcontractors, constructability reviews, and resolution of field problems. The C/O Manager is additionally responsible for all construction type operations and maintenance functions for existing facilities, new facilities, utilities, and equipment.

The Project Quality Manager (PQM) reports to the Project Manager on an administrative and communication basis. Authoritatively, the PQM reports off-site to the corporate QA/QC Manager. The PQM is responsible for the development and implementation of the Quality Assurance Program and has the authority to stop the work or control further processing; identify the need for corrective action; initiate, recommend, coordinate and/or provide solutions and verify implementation of solutions and corrective actions related to the quality of the work. The PQM is assisted by a QA Engineer/Lead Auditor for performance and systems audits (described in Section 9.0 of this RIQAPP).

The Quality Control Supervisor (QCS) reports to the PQM and is responsible for performing and/or assigning certified inspection

personnel to perform inspections. The QCS is responsible for assuring that required inspections are performed and documented, that inspection reports identify the items inspected, and types of inspections performed, that applicable accept/reject criteria are specified, and that inspection results are indicated. The QCS is responsible for the timely performance of inspections and transmittal of inspection reports and documents to Quality Assurance Records.

Any unresolved difference between Project Quality Assurance and other project groups is first brought to the attention of the Project Manager and Project Director, and if still unresolved, it is then brought to the attention of the MK-F Senior Vice-President - Operations for resolution through the Corporate QA/QC Manager.

Names of key personnel responsible for specific components of the site characterization program and are listed below.

- **Sampling Operations**

Soils	Kenneth Meyer (JEG)
Groundwater and Surface Water	Don Penniman (JEG)
Waste Characterization	
Raffinate Pit Sludge	Rick Ferguson (JEG)
Buildings and Equipment	Steven Green (JEG)
Geophysical/Geotechnical Investigation	William Knight (JEG)
Environmental	Paul Blacker (JEG)
Other Investigations	
Lake & Stream Sediment	Kenneth Meyer (JEG)
Bio-uptake	Mark Lusk (JEG)

- **Laboratory Analysis** — Richard Manz (metaTRACE)

- **Data Processing Activities** — Yusuf Noorani (JEG)

- **Sampling and Analysis QA/QC**

Soils	Robert Hoffman (JEG)
Hydrogeology	Jim Meier (JEG)
Waste Assessment	Rick Ferguson (JEG)
Geophysical/Geotechnical Investigations	Edward Tom (MK-E)
Environmental	Karen Borkowski (JEG)
Laboratory	Kenneth Baughman (metaTRACE)
Data Processing QC	Yusuf Noorani (JEG)
Data Quality Review	Roger Nelson (JEG)
Performance Auditing	Joe Guyette (MK-F)
Systems Auditing	Joe Guyette (MK-F)
Overall QA	J.J. Hairston (MK-F)

4.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT

The overall purpose of establishing quality assurance objectives for measurement data is to ensure that data of known and acceptable quality are provided for the intended data use. These objectives apply to both existing and future sampling and field measurement data. Data reviewed or generated by this project are to be of such quality that they can be used as a direct indicator of the nature and extent of radiologic and chemical contamination at the Weldon Spring Site. Most sampling and analysis activities to be performed during the conduct of the WSSRAP rely heavily upon the guidance in SW-846 (EPA, 1984).

4.1 PARAMETERS

This section describes the five major data quality objective parameters: Precision, Accuracy, Representativeness, Completeness and Comparability (PARCC). These parameters comprise the major quality assurance objectives for all measurements made as part of the WSSRAP.

4.1.1 Precision

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average value.

Sampling and analytical precision will be demonstrated respectively by:

- Collecting field replicate samples and examining replicate results for degree of variance.
- Determining if sampling error has occurred by the variance of replicates.

- Creating and analyzing laboratory replicates of field samples for degree of variance.

- Computing an overall relative standard deviation that is applicable to all the field investigation data from a particular sampling episode.

- Validating data on groups of samples that should all have the same composition by examining the variance in each group in comparison to the overall variance (invalid data are discarded).

For example, at a recent WSSRAP sampling event (3/87) duplicate groundwater samples were collected from WSS monitoring well 2003. Results from analyses in ug/l of both samples are cited below:

Well #	2,4,6 TNT	2,4 DNT	2,6 DNT	NO_3	SO_4	Cr^-	F^-
2003	<0.5	0.3	0.7	886	223	33.2	14.7
2003D	<0.5	0.4	0.7	945	232	33.0	14.6

If there is mutual agreement among the individual measurements for samples that were collected under prescribed similar conditions, then sampling precision has been demonstrated (as with the above example).

The precision values calculated from the field replicates will be used in the data interpretations to determine how sensitive the site characterizations are to the variances in the data. Any data that are being compared to a standard, criteria, or action level will be compared as the reported value, the lower bound value, and the upper bound value. If this comparison identifies data that may be either above or below the standard or criteria, it will be mentioned in the report. Subsequent

sampling of these borderline areas will incorporate appropriate frequency of QC samples to reduce the variance to the point where more definitive statements can be made.

4.1.2 Accuracy

Accuracy measures the degree of bias in a measurement system. Sample collection and preparation accuracy will be monitored by using sample container blanks, shipping and storage blanks, and field handling blanks. These samples will provide information that could detect inconsistent field procedures.

Accuracy involved in laboratory analysis will be evaluated using matrix spike/matrix spike duplicates. Analytical accuracy will be monitored using recovery of analytes from surrogate spikes, matrix spikes, reference QC samples and performance evaluation samples.

Accuracy is the degree of agreement of a measurement with an accepted reference or true value and is usually expressed as percent recovery of spiked samples, where percent recovery is:

$$\frac{\text{(spiked result) - (unspiked result)}}{\text{(amount spiked)}} \times 100$$

Errors may occur during the sampling or the analysis operation. Samples may be contaminated in the field or laboratory. Errors may result from improper use of equipment during collection and analysis, improper preservation, handling and storage. For example, improper decontamination of equipment from a previous monitor-well drilling or sampling operation may result in groundwater contamination in a newly installed well. Also, an error or inaccuracy in analytical results can be introduced by an instrument being out of calibration during a portion of the analysis. Inaccuracy can result from random error or systematic error.

The WSS sampling plans (listed in Section 1.0) have incorporated requirements for accuracy (both sampling bias and laboratory analysis) and the protocol for monitoring to determine that these requirements are met. The sampling plans also provide a method for the project staff to detect the occurrence of cross contamination or external influences.

As described in the individual sampling plans, accuracy will be determined by:

- Computing percent recoveries for performance audit samples and spiked samples.
- Calculating the standard deviation in the overall average recovery value.
- Determining the range of uncertainty at a given level of confidence.

The accuracy data will be used to determine any bias in the analytical methods. All analysis will be performed according to the methods and standards set forth in the Contract Laboratory Program (CLP), (EPA, 1986b) where appropriate. The CLP provides control limits for the laboratory spikes and the appropriate qualifications for the use of the data if the control limits are not met. For the performance audit samples, the average recovery for each compound or element will be calculated and compared to the certified values. If the performance audit sample has an acceptable range stated by the CLP, an average recovery within this range will be considered acceptable. If the average recovery falls outside the acceptable range, the field sample results will be qualified as having either a high or low bias and the amount of bias will be calculated. The field sample results will not be adjusted for bias, but the bias will be considered in the interpretation of the data.

4.1.3 Representativeness

Representativeness is a measure of how closely the measured results reflect the actual concentration or distribution of the compounds in the sampled media.

Some typical examples of representativeness consideration include:

- Sampling of media at defined and representative depths.
- Pumping tests with observation wells at select locations and screened in consistent discrete zones to define aquifer parameters, confining layers, perched zones, etc.
- Sampling procedures for water quality, asbestos, waste, and soil contamination will be in accordance with those procedures appropriate for the media being sampled.
- Adherence to approved sampling plans, e.g. radiation sampling for building characterization, will include sampling of ceilings, walls, attic, air, piping, floors and exterior to define hazards and extent of contamination.

Data collected should represent actual conditions existing at the area to be sampled. For example, a groundwater sample collected at the top of the water table would not be a representative sample if potential contaminants had a higher specific gravity than water. A soil sample to be analyzed for PCBs or nitroaromatics should be collected in known storage areas for those contaminants in order to define representative contamination of that specific area; however, it would not necessarily be representative of PCB or nitroaromatic soil

contamination throughout the entire WSS area.

During the work planning process, existing data have been reviewed and site investigations have been designed so that they will yield information representative of site conditions. The sampling plans contain proper sample collection and handling techniques, equipment decontamination procedures, sampling locations, and rationale used to determine sampling locations.

4.1.4 Completeness

Completeness is a comparison of the amount of valid data that was obtained from a measurement system to the amount that was expected and needed to meet the project data goals. Completeness is typically expressed as a percentage.

For example, assume an environmental monitoring plan requires groundwater sampling activities to be performed quarterly for a one-year period. If one sampling event is missed, or if an analytical error occurred, or samples were unusable or invalid, data may still be complete if there is little quarterly variation.

Quality assurance completeness at the Weldon Spring Site will be calculated as the total number of samples collected for which acceptable analytical data are generated divided by the total number of samples collected, then multiplied by 100.

4.1.5 Comparability

Comparability is an expression of the confidence with which one data set can be compared to another as long as precision and accuracy are known. The comparability objective is to provide assurance that the data developed during separate field investigations are comparable to each other and that data

developed during the investigation are comparable with applicable hazard identification criteria.

Comparability is addressed by assuring consistency of measuring units, standardized sampling, sample preparation, methods of analysis and data format. Comparability allows for the comparison of one set of data against another. For example, it is preferable to report all boring log depths at WSS in feet instead of meters.

Standard sampling techniques (see WSSRAP SOPs) will be used to provide consistency in subsequent sampling episodes. The WSSRAP SOPs and the Analytical Methods/Detection Limits Document used at metaTRACE Laboratory or other selected laboratories address sampling procedures and analytical methodology.

5.0 SAMPLING, ANALYTICAL AND CALIBRATION PROCEDURES

The objectives for sampling procedures and field measurements are to obtain samples and measurements that are representative and comparable. The location of the sampling and field measurements will be selected to meet the data gaps identified in the scoping process. Trace levels of contaminants from external sources and cross-contamination will be eliminated through the use of experienced field personnel, good sampling techniques, proper sampling equipment and adequate decontamination.

Operational procedures are explained in detail in the activity-specific sampling plans. The WSSRAP SOPs include descriptions of sampling techniques, sample preparation requirements, sample packaging and labeling, equipment calibration, and decontamination procedures. Substantive changes or deviations from these standard operating procedures will be approved by EPA and DOE prior to implementation.

The standard Operating Procedures contain the means for demonstrating and documenting instrument accuracy, e.g.:

- All measurement devices will be assigned individual identification numbers. Documentation will be provided for each device which identifies its use, maintenance performed, and standards used for calibration.

- Each measuring device will be calibrated against a standard of known and, if possible, higher accuracy.

- Sampling and analytical methodology is documented and referenced to federal standards.

The Standard Operating Procedures and analytical methods, then, describe operations, analyses, or actions which are thoroughly

- o Engineering Design Documents
- o Design Procedures
- o Standard Operating Procedures
- o Safety Plans

6.3.2 Field and Laboratory Data

Records generated by the site RI/FS program are, where practicable, numbered and assigned to individuals designated to perform specific tasks. They include:

- o Field logbooks
- o Field data record forms, e.g. well inventory forms, pumping test data sheets
- o Analytical logbooks
- o Lab data, calculations, graphs, etc
- o Location maps, photos, selected drawings
- o Checklists of equipment performance
- o Equipment maintenance logs including repair and calibration information
- o Photographic logs

6.3.3 Project Files

A WSSRAP filing system has been established and is under the jurisdiction of the Document Control Specialist. Project files have been assigned identifying numbers. Files will contain those controlled documents, logbooks, field data sheets, and tracking forms described above, as well as contractual documents, reports, correspondence, health and safety records, telephone conversation records, design information, notes, calculations, standard operating procedures, letters of transmittal, and other records necessary to document site activities.

6.3.4 Computerized Data

A large amount of data will be generated during site characterization. Those data collected and analyzed during the sampling and analysis program will be reduced for input into the computerized data base. These data will include logs, tracking forms, and results of laboratory analyses. Computer software is protected and documentable.

6.3.5 Document Ownership and Distribution

All project documents generated on the WSS are the property of DOE. The distribution of such documents to state agencies, federal agencies, other regulatory agencies, and citizens' groups is in accordance with DOE policies and guidelines. Distribution to third parties is upon receipt of a formal request and subsequent approval by DOE. Controlled documents, i.e. manuals, procedures, instructions and guidelines, are distributed on the basis of a written, approved Standard Distribution List. All documents distributed to parties other than DOE and PMC are inventoried and are accompanied by a document transmittal form. A return receipt is required and documented on the controlled document transmittal log.

6.3.6 Document Storage

Documents are stored in locked, secure filing cabinets. Dual document storage facilities will be provided at locations sufficiently remote from each other to eliminate the chance of simultaneous exposure to a hazard. Access to both facilities will be controlled by document control specialists. This applies to both computer generated data and hard copy documents. Copy-protected software is replaceable from the supplier.

measurement, temperature, conductivity, flow measurements, and air monitoring data are recorded in field logbooks or on field data record forms. All other samples are identified by a sample tag which delineates preservation methods and required laboratory analyses. All samples are accompanied by a chain-of-custody record.

6.2 LABORATORY SAMPLE CUSTODY

All samples are packaged and shipped to the laboratory in accordance with U.S. Department of Transportation procedures with a separate custody record accompanying each shipment. An authorized sample custodian at the laboratory facility signs for incoming field samples, obtains documents of shipment, and verifies data entered onto the sample custody records. The Analytical Methods/Detection Limits Document delineates the chain-of-custody, tracking and document control procedures employed by metaTRACE Laboratory or other selected laboratories.

6.3 EVIDENTIARY FILE AND DOCUMENT CONTROL

Documentation required for sample custody will be retained and incorporated into the WSSRAP Document Control Program. Evidentiary files will include all laboratory and field reports and will be maintained by the WSSRAP.

The goal of the WSS Document Control Program is to assure that all documents used by WSS personnel will be accounted for at the termination of project activities.

To achieve the stated goal, procedures for the identification and control of documents that specify methods of assuring data quality for WSSRAP project activities have been developed. These procedures include the establishment of a numbered document system and a document inventory procedure for accountable documents. This document control system allows for

the identification and retrieval of data for any characterization work component.

Document control for this program includes the following requirements:

- o Originals and copies of documents are kept secure and under custody where necessary.

- o Individuals holding documents.

- o Individuals holding documents receive revisions and updates when appropriate.

At the Weldon Spring Site, prescribed project activities are documented in order to meet QA/QC requirements. Documents generated from these activities can be categorized as follows:

- Controlled Documents
- Field and Laboratory Data
- Tracking Forms
- Project Files
- Computerized Data

6.3.1 Controlled Documents

Controlled documents are those documents issued by authorized personnel that, in accordance with requirements of NQA-1, are assigned a unique identifying number and logged out to selected individuals. These documents specify quality requirements on prescribed activities affecting quality. A distribution list of these documents is maintained in Document Control for each document. These documents include:

- o QA/QC Plans
- o Procurement Plans

prescribed, documented, and performed in accordance with accepted standards.

Preventive maintenance and inspection procedures for laboratory and field equipment are also prescribed. Inspection and testing of equipment will be done on a regular basis. The SOPs describe calibration procedures to be employed on all field equipment, including referenced standards, QC samples employed, and operation methods. Also included are provisions for equipment maintenance.

On-site audits of both field and laboratory procedures as described in Section 9.0 will be conducted by the QA Engineer/Lead Auditor and designated technical specialist as required. Systems audits will consist of evaluation of all components of the applicable measurement systems to determine their proper selection and use.

In order for equipment to be used effectively, the operator must demonstrate an understanding of operating principles and procedures, and be competent in calibrating, reading and interpreting the instrument. Manufacturers' operating manuals provide comprehensive guides for the use of field and laboratory equipment. The operator must also be familiar with sample preservation, equipment decontamination, health and safety procedures (as applicable), and equipment limitations to assure the acquisition and analysis of valid samples in a safe manner.

6.0 SAMPLE CUSTODY AND DOCUMENT CONTROL

A major required component of all field investigation sampling plans is the maintenance of the integrity of the sample from collection to data reporting. To maintain and document sample possession, chain-of-custody procedures are followed on the WSSRAP. Elements of the chain may include sample seals, sample labels with a sample identification number to allow for sample tracking, field logbooks, field data record forms, chain-of-custody records, sample analysis request sheets, receipts, bills of lading, and field and laboratory tracking forms. Field and laboratory sample custodians or their designated representatives are responsible for maintaining custody of samples. A sample is considered to be under a person's custody if 1) it is in the person's physical possession, 2) in view of the person, 3) secured by that person so that no one can tamper with the sample, or 4) secured by that person in an area that is restricted to authorized personnel.

Sample custody is divided into three parts as follows:

- Field sample custody
- Laboratory sample custody
- Evidentiary files

6.1 FIELD SAMPLE CUSTODY

Sampling procedures for groundwater, soil, waste, etc. are addressed in the SOPs and the five individual sampling plans. The sample custody program for the Weldon Spring Site includes the documentation of procedures for the preparation of reagents, sample identification, the recording of sampling locations, and specific considerations associated with sample acquisition. Applicable forms for recording these data, and tracking of samples, as required by the chain-of-custody procedures are presented in the SOPs. In-situ measurements, e.g. pH

- o Identity of sampling teams or team leader
- o Sampling location
- o Description of sampling location
- o Collection technique
- o Field preparation technique
- o Laboratory analytical methods
- o Laboratory detection limits

Data validation also entails a review of the QC data and the raw sample data to verify that the laboratory is operated within the required control limits, the analytical results are correctly transcribed from the instrument readouts, and which, if any, natural samples are related to any outside-of-control laboratory QC samples. The objective of the data validation is to identify any qualitative, unreliable, or invalid measurements and to also verify compliance with the CLP protocol for laboratory determination.

7.3 REPORTING

Documentation of the data collection and analysis process is an integral part of the QA/QC program. Data validation techniques require that standard operating procedures, sample tracking methods, validation formulas, QC checks on PARCC criteria, and all sampling and laboratory activities be documented. Data obtained from the sample collection and analysis operation will be recorded on standardized report forms or logbooks.

These documents include DOE, EPA and corporate management forms. Some of these documents are listed below:

- o CLP Report Forms
- o Receipt of Sample Forms
- o Chain-of-Custody Forms
- o Sample Labels
- o Field Tracking Report Forms

7.0 DATA REDUCTION, VALIDATION, AND REPORTING

Statistical parameters are used to assess the quality of data obtained. Section 4.0 addresses the procedures used to routinely assess precision and accuracy of Weldon Spring environmental monitoring and measurement data. This section presents data reduction schemes and validation criteria to be used for collected data.

7.1 DATA REDUCTION

A data reduction process has been developed for all data collected on site for WSSRAP. Generally these procedures are prescribed in the documents referenced in Section 1.0 of this document. Principal devices for field sample collection or measurement, as described in the Standard Operating Procedures (SOPs) include air, surface and groundwater, soil, and waste sample collection instruments. Associated in-situ measurements, e.g. water temperature, pH, specific conductance, meteorological, and radiation are also delineated in the SOPs. Where relevant, data reduction formulas are presented, e.g. SOP Section 2.06.05 lists formulae for computing background count rates, daily efficiency, and estimating radioactivity per unit surface area with the use of the Ludlum Model 2220/43-5 Alpha Detector.

7.2 DATA VALIDATION

Many measurement activities are underway at the WSS and large quantities of data will be obtained. A major component of the Data Quality Objective process involves the assessment of data adequacy, i.e. data validity and data sufficiency. For data validation at the WSS the following will be documented:

- Sampling date

data sets in terms of the QA/QC requirements for the current WSSRAP characterization program.

3. Utilize the existing data sets' QA/QC documentation and a retroactive data validation/evaluation program to categorize the existing data as discussed above.

- o Laboratory Tracking Report Form
- o Sample Analysis Request Forms
- o PARCC Objectives Summary Forms
- o QA/QC Report Forms for Laboratory
- o Equipment Calibration Report Forms
- o Standard Field and Laboratory Log Forms

7.4 QUALITY ASSURANCE FOR THE EXISTING DATA BASE

An important element of the WSSRAP is the validation of the large amount of data that has been collected on site at WSSRAP. The specifics of data evaluation and validation are discussed in the individual associated sampling plans listed in Section 1.0. A conceptual framework for evaluation of existing data is presented in this subsection.

Data from previous sampling and analysis programs which were used in the development of the five sampling plans were considered to fall into one of the following categories:

- o Data that are not useful
- o Data that are adequate for a qualitative assessment of contamination (i.e. contaminated or not contaminated)
- o Data that are adequate for semi-quantitative comparisons (i.e. order of magnitude)
- o Good quantitative data not meeting all QA objective requirements (but generally valid)
- o Data meeting all QA requirements

For qualitative development of the sampling plans, the following steps have been taken:

1. Determine what QA/QC documentation was available for a sampling/analysis program and obtain the documentation.

2. Evaluate QA objectives and QA/QC results of existing

Internal quality control at the laboratory also includes the utilization of matrix spikes, including EPA quality control ampules, Standard Reference Materials (SRMs) and laboratory-prepared solutions made from pure compounds.

The selected laboratory at WSS participates in EPA's Quality Control Program and utilizes those standards and guidelines prescribed by EPA for analyzing relevant chemical and radiological constituents.

The Users Guide to the Contract Laboratory Program (EPA, 1986b) presents analytical internal quality control operations which are applied at the WSS. They include:

- Inductively Coupled Argon Plasma (ICP) Interference Check Sample Analyses: Performed at least twice per eight-hour shift, to verify inter-element and background correction factors.

- Preparation Blank Analyses: Performed for each batch of samples or for each set of 20 samples, to ascertain whether sample concentrations reflect contamination.

- Spiked Sample Analyses and Duplicate Sample Analyses: Performed for each concentration and matrix within each set of 20 samples of a similar matrix, to provide information concerning sample homogeneity, analytical precision and accuracy, the effect of the sample matrix on the analytical methodology, and to allow for evaluation of the long-term precision of the method.

- Serial Dilution Analyses: Performed for each group of samples of a similar matrix type and concentration for each 20 samples received to ascertain whether significant chemical or physical interferences exist due to sample matrix.

8.0 INTERNAL QUALITY CONTROL

To achieve the highest practical attainable level of precision and accuracy, the sampling program at WSS includes the use of QC samples to measure field and laboratory performance. (Section 4.0 of this document discusses QA objectives for measurement.) QC samples are submitted to the laboratory as blind samples. To provide quality control information for interpretation of data, the following types of QC samples may be utilized:

- Background Samples: These samples are obtained from media characteristic of the site but outside of the zone of contamination; e.g. groundwater samples collected from the upper Burlington-Keokuk aquifer upgradient of the WSCP areas.

- Duplicate or Replicate Samples: These samples are collected at the same time from common collection manifolds, locations, or sampling devices, or as split samples from one sampling event, and sent to the same laboratory to verify sampling and laboratory precision. Generally, one out of every 20 investigative samples is replicated.

- Split Samples: Split or replicate samples, divided into two portions, are sent to different laboratories to assess laboratory precision.

- Field Blanks: Analyte-free deionized water is used to rinse sampling equipment that has been decontaminated, e.g. bailers, pumps, augers, split tube samplers, etc. One rinsate sample is collected per day or for every 20 investigative samples, whichever is greater. Upon analysis, these samples are used to assess the adequacy of the field decontamination process.

- Furnace Atomic Absorption QC Analysis: Required for quantification; incorporates duplicate injections and analytical spikes in order to evaluate the precision and accuracy of the individual analytical determinations on each sample.

- Laboratory Control Samples (LCS): Standards carried through sample preparation and analysis procedures to document the performance of the entire analytical process. The results for analysis of LCS are submitted with the data package. Laboratories on a quarterly basis verify their instrument detection limits, ICP linear ranges, ICP inter-element correction factors and ICP integration times.

It is the responsibility of the laboratory to document, in each data package submitted, that both initial and ongoing instrument and analytical QC requirements have been met. Any samples that have not been analyzed according to contract QC requirements are re-analyzed by the laboratory.

9.0 AUDITS AND CORRECTIVE ACTIONS

Quality assurance objectives for the Weldon Spring Site Remedial Action Project (WSSRAP) will be met in part by audits of field sampling and laboratory analysis activities. All existing and future data developed for the site will be evaluated to determine its validity and completeness. To accomplish this evaluation, audits will be conducted to insure that data of known and acceptable quality are provided. The goals or objectives of the Weldon Spring Site Characterization QA/QC audit program are to ensure that:

- Program-specific QA/QC training is provided to personnel and that QA/QC requirements are clearly established.

- Data quality meets specified goals in terms of precision, accuracy, representativeness, completeness, and comparability (PARCC) for all environmentally related measurement criteria.

- All sampling and analytical efforts are described by an approved sampling plan (listed in Section 1.0).

- Standard operating procedures are developed for each measurement activity, that qualified personnel are assigned to perform these activities in accordance with the procedures, and that proper documentation is performed in order to establish data validity.

- Audits are performed to determine compliance with the established QA/QC requirements.

- Corrective actions are proposed and implemented to address deficiencies identified during audits.

This section describes the performance, reporting and

documentation phases of the audit portion of the WSSRAP QAPP.

9.1 AUDITS-GENERAL

An audit system shall be implemented to assure compliance with the QA/QC program requirements established for the WSSRAP in the approved Project Quality Assurance Program Plan dated 02/03/87. This mechanism is intended to assess systems and procedure effectiveness. Audits will:

- Identify weaknesses and strengths.
- Dictate corrective actions as required.
- Allow for modifications and enhancement of the QA/QC program.
- Serve as a vehicle for providing necessary technical assistance.
- Measure the effectiveness of the QA/QC programs to assure quality of data.

The types of audits to be conducted during the course of actions for the WSSRAP will include performance and systems audits. These audits will be performed both internal and external to the Project Management Contractor (PMC).

System(s) audits consist of an evaluation of all components of the measurement system to determine their capability, proper selection and use. A systems audit includes a careful evaluation of field and/or laboratory quality assurance/quality control programs. Systems audits are normally performed prior to or shortly after systems are operational; however, such audits will be performed on a regularly scheduled basis for the duration of the WSSRAP.

Performance audits are conducted to determine the adequacy and accuracy of a total measurement system or on selected elements

of field or laboratory Quality Assurance/Quality Control programs to determine procedural compliance, thereby ensuring Data Quality Objectives. Performance audits are conducted periodically on a scheduled basis, generally after a system is operational and generating data.

Audits will be scheduled in intervals consistent with the schedule for accomplishing the activity and commensurate with the status and importance of the activity.

Audits shall be performed in accordance with written procedures or checklists based upon the QA/QC programs and the project's procedures manuals and conducted by appropriately trained personnel not having direct responsibilities in the areas being audited.

Audit results shall be documented by auditing personnel and reviewed by management having responsibility in the area audited.

Audits shall be performed under the direction of a certified Lead Auditor who is assisted by certified auditors and/or appropriately trained technical specialists as required to audit all components of the WSSRAP QA/QC programs.

9.2 AUDIT PREPARATION

The Lead Auditor is responsible for preparing and maintaining an audit schedule, reviewing and documenting the qualifications on all audit personnel including technical specialists, providing notification to the audited organizations, preparing and/or approving audit plans and checklists.

The Lead Auditor, after a review of applicable requirements, such as procedures, contracts, plans, standards and project schedules, prepares an audit schedule indicating the organization to be audited, subjects to be audited, schedule of

the audits and proposed Lead Auditor. The audit schedule shall be reviewed periodically and revised as necessary to assure that coverage is kept current. In advance of the scheduled audit the Lead Auditor will notify the organization to be audited of the proposed schedule and scope of the audit.

The Lead Auditor selects the audit team members including auditors, technical specialists and observers as required to best perform a comprehensive audit of the selected systems or components to be audited. The Lead Auditor will document the qualifications of audit team members selected.

The Lead Auditor is responsible for preparation of a written audit plan, when requested by the Project Quality Manager (PQM). The audit plan includes:

- Audit number
- Organization to be audited
- Subject(s) to be audited
- Scope of the audit
- Projects or activities to be audited
- Audit team members
- Audit schedule
- Applicable documents

The audit plan can be used to provide the audited organization(s) management with the proposed audit scope, audit requirements, audit personnel and the schedule for the audit.

The audit team will prepare audit checklists based on their review of applicable or relevant and appropriate requirements; documents including procedures, standards, contracts, and plans; and previous audits, if any, of the systems or tasks to be audited. The Lead Auditor is responsible for review and approval of the audit checklists. These checklists will be used to evaluate the performance of the audited activity.

The Lead Auditor provides the audit team with the audit plan and checklists, orients the team to the schedule for the audit and the internal and external organization and contractual interfaces and responsibilities of the organization to be audited.

9.3 AUDIT PERFORMANCE

The Lead Auditor conducts a pre-audit meeting at the audit site with the audit team and responsible management of the organization to be audited. The pre-audit meeting provides a means to introduce the audit team, establish contacts and interfaces, present and confirm the audit plan, scope and sequence, and schedule the post-audit meeting.

The audit will be conducted following the approved audit checklist as a guideline. The Lead Auditor may assign portions of the audit or checklist to members of the audit team commensurate with their expertise. The audit checklists are a guideline; responsible questioning or investigation may lead the audit into areas not described in the audit plan or by the audit checklist.

Audits shall include the objective examination of work areas, activities, processes and items; review of documents and records; and quality-related practices, procedures and instructions to determine compliance with the QA/QC program requirements and the project procedures manual. The audit checklists will be used by the auditors to record the results of their investigations.

Discrepancies or concerns discovered during the course of the audit by the audit team members will be presented to the Lead Auditor for review and discussion prior to formalizing. Audit discrepancies may be characterized as follows:

1) An observation is the recognition of an activity or action that might be improved but is not a significant violation of a specific requirement. Discrepancies that are corrected during the course of the audit may be addressed as observations. Isolated violations may be determined to be observations rather than findings.

2) A finding is the recognition of a specific requirement that has been significantly violated.

A post-audit meeting chaired by the Lead Auditor will be conducted at the conclusion of the audit. The objective of the post-audit meeting is to present the findings and observations to the responsible management of the audited organization. Resolution of findings and observations and commitments for corrective actions including a tentative schedule for completion of corrective actions should be discussed at this time.

9.4 AUDIT REPORTING

Audit reports will be submitted to responsible management by the PQM, or Lead Auditor. These reports will address the performance of measurement systems and data quality. Audit reports will include the dates of audit, audit procedures, names of auditors and audited organization participants, specific procedures audited, a summary of audit results including findings and observations (if any), recommendations for correcting deficiencies or improving the QA/QC programs, if necessary.

Audit findings are recorded on an Internal Quality Audit Finding Report Form and are included as part of the audit report.

Audit reports shall be issued promptly upon completion of the audit (within 30 days), and will contain the date required for response to audit findings. Audit findings require response

from the audited organization within 30 days of receipt. Audit finding responses should include a commitment date for completion of corrective actions to be taken, results of a review for potential impact on previous items or activities (if any) and the root cause of the deficiency.

Observations may or may not require a formal response depending upon the severity, type and number or specific deficiencies. The Lead Auditor will specify which of the observations require written response. Observations are recorded in the body of the audit report.

Completion of corrective actions noted in audit responses shall be verified upon receipt of the response or by the date specified on the response.

9.5 SURVEILLANCE

In addition to regularly scheduled audits, the QA Department shall perform surveillance of field or laboratory activities. Surveillance is the act of monitoring or observing to verify whether an item or activity conforms to specified requirements.

Surveillances may be planned or unplanned, scheduled or unscheduled. No checklist is required, rather the approved procedure for the operation or task will be followed to ensure adherence to the requirements. Surveillances will be documented by the individual performing the surveillance, and reviewed by the Lead Auditor.

When deficiencies are noted, the responsible department shall be notified by use of the Quality Deficiency Report (QDR).

Response to the QDR must be returned to the QA Department by the responsible department manager and appropriate follow-up actions must be prescribed at that time.

9.6 FINDING/DEFICIENCY CORRECTIVE ACTION AND CLOSURE

The Lead Auditor is responsible for the evaluation of corrective action responses to determine that the corrective action for each finding/deficiency is adequate, has been scheduled or has been completed. The Lead Auditor will ensure that responses to findings written by other audit team members such as technical specialists fully address the discrepancy identified during the course of the audit.

Follow-up may be accomplished through written communication, re-audit, surveillance or other appropriate means. Unsatisfactory responses will be addressed in writing, indicating why the response is unsatisfactory, and will specify a reply due date. Findings/deficiencies are considered open until the approved corrective action has been completed. The Lead Auditor is responsible for closing all findings/deficiencies.

9.7 QA RECORDS

All audit plans, correspondence relating to audits/surveillance, audit findings, audit reports, individual certifications, Quality Deficiency Reports and surveillance reports will be routed to Document Control for processing in accordance with Section 6 of this document.

10.0 PREVENTIVE MAINTENANCE

The preventive maintenance program at WSSRAP includes numerous tasks to prevent or minimize downtime of field sampling and laboratory analytical equipment. These measures are documented in Appendices A & B.

Operational checks and calibration procedures are prescribed in these appendices -- for example, Alpha Detector (SOP No. 2.06.01)-- and instruction manuals are referenced to show maintenance procedures. Duplicate instruments and spare parts are stocked for critical instruments in order that sampling and measurement operations can continue without delays and in an orderly manner.

Preventive and regular maintenance will be provided by trained, qualified specialists only. If feasible, maintenance responsibilities will be delegated to one or two individuals who will also bear the responsibilities of assuring proper documentation of equipment users, dates of use, maintenance and calibration, and inventory identification numbers. Preventive maintenance will be performed on a regular scheduled basis and in accordance with manufacturers' manuals and applicable SOPs.

In order to fulfill PARCC requirements, stand-by or duplicate laboratory or sampling equipment may be required.

11.0 REFERENCES

(CFR, 1988) Code of Federal Regulations 40 CFR Ch. 1, Part 300 - National Oil and Hazardous Substances Contingency Plan.

Effectuates the response powers and responsibilities created by CERCLA and Section 311 of the Clean Water Act, as amended.

(EPA, 1986a) U.S. Environmental Protection Agency, 1986, Quality Assurance Program Plan for Region VII. Doc. Control No. R7QAO-86-001. Kansas City, Missouri.

Describes data quality objectives; guidelines for preparation of Standard Operating Procedures.

(EPA, 1987) U.S. Environmental Protection Agency, Office of Emergency & Remedial Response & Office of Waste Programs Enforcement, March 1987, Data Quality Objectives for Remedial Response Activities. EPA 540/G-87/003.

Guidance on development of DQOs for site-specific activities.

(EPA, 1980) U.S. Environmental Protection Agency, Office of Monitoring Systems and Quality Assurance, Office of Research and Development, Dec. 29, 1980, Interim Guidelines & Specifications for Preparing Quality Assurance Project Plans. QAMS - 005/80.

Describes 16 elements that must be included in all QA project plans.

(EPA, 1984) Environmental Protection Agency, Office of Solid Waste, 1984 Proposed Sampling and Analytical Methodologies for Addition to Test Methods for Evaluating Solid Waste. SW-846.

Data acceptance and evaluation criteria.

(ANSI, 1986) Quality Assurance Program Requirements for Nuclear Facilities, ANSI/ASME NQA-1-1986. Published by American Society of Mechanical Engineers, New York.

Requirements for the WSSRAP QA Program Design Control.

(EPA, 1986b) U.S. Environmental Protection Agency, December 1986, Office of Emergency and Remedial Response, Users' Guide to the Contract Laboratory Program, Washington, D.C.

Outlines the requirements and analytical procedures of the new CLP protocols.

(DOE-MKF, 1987) Quality Assurance Program Plan for U.S. Department of Energy, Oak Ridge Operations, Weldon Spring Site Remedial Action Project (Contract DE-AC05-86OR21548).

Defines the overall Quality Assurance Program to be followed for the Weldon Spring Site Remedial Action Project in accordance with applicable DOE Orders and NQA-1-1986.

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CHEMICAL PLANT
204-1.02

QUALITY ASSURANCE PROGRAM PLAN
RESPONSIVENESS SUMMARY

EPA April 6, 1988

RESPONSE TO GENERAL COMMENTS: General comments are addressed in the cover letter and in the specific responses as follows:

Comment:

1. Section 3.0 - It is not made clear what role, if any, the DOE has regarding oversight of the contractor.

Response:

The responsibility for management and technical direction of remedial actions has been delegated to the DOE Oak Ridge Operation Office. MK-Ferguson (MK-F) is the project management contractor (PMC) assisting DOE in the planning and management of remedial action activities.

An organization chart is included in Section 3.0 of the RIQAPP (Rev. 0) which delineates lines of authority, responsibility and communication assigned to key project entities.

Comment:

2. Section 6.0 - It might be appropriate to establish frequency of collection of different types of QC samples used for assessing precision and accuracy in particular.

Response:

Sections 4.0 and 8.0 of the RIQAPP (Rev. 0) summarize methods for ensuring accuracy and precision. Details are presented in the Standard Operating Procedures (SOPs) and sampling plans previously published and incorporated by reference as associated documents to the RIQAPP.

Comment:

3. Section 6.3 - We feel that, on page 105, Item 6.3, or some other appropriate location, reference should be made to a needed requirement that all laboratory data should come from laboratories that participate in EPA or other quality control programs. For example, EPA operates, out of the Las Vegas Laboratory, a Radiation Quality Control Program which about 195 laboratories utilize. We feel that any lab producing quality radiation data should participate in this program, or,

an equivalent, alternate program. The EPA, from Cincinnati, offers similar programs for many other analyses.

Response:

metaTRACE Laboratory, JTC Environmental Consultants, ACCULABS Research Inc., and other WSS selected laboratories participate in EPA's Quality Control Program and utilize those standards including CLP procedures and guidelines prescribed by EPA for analyzing relevant chemical and radiological constituents. Internal quality control, as described in Section 8.0 of the RIQAPP (Rev. 0), prescribes the utilization of EPA quality control ampules, Standard Reference Materials, and pure laboratory-prepared solutions.

Comment:

4. Section 6.4 - It is not made clear in the text what level of completeness needs to be attained for the data to be valid.

Response:

The amount of valid data required to meet data goals is determined by specialists and task leaders, e.g., engineers, hydrogeologists, and geologists. The ultimate responsibility for determination of data completeness, i.e. amount of valid data obtained compared to amount of valid data needed, rests with the project director. Sampling plans delineate specific data needs, uses, and goals.

Comment:

5. Section 6.5.1 - The discussion of standard operating procedures for sampling is not consistent with the Raffinate Pit Sampling Plan.

Response:

The Raffinate Pit Sampling Plan and this section of the RIQAPP have been revised.

Comment:

6. Section 6.5.3 - The text is unclear on what points need to be considered in evaluating the representativeness of the data.

Response:

This section has been expanded and is included in Section 4.1.3 of the RIQAPP (Rev. 0).

Comment:

7. Section 7.0 - SOPs for each field operational procedure are not explained in detail in the Raffinate Pit Sampling Plan as this section prescribes.

Response:

This section has been deleted.

Refer to Table 1.1 of the RIQAPP (Rev. 0) for associated documents which provide information on sampling, calibration and analytical procedures.

Comment:

8. Section 8.0 - The text does not state who will perform all the calculations specified. Clarify who will perform the calculations (contractor, laboratory, etc.) and how the calculations will be checked and audited. If the laboratory is to perform the calculations, is this part of their standard QA/QC package?

Response:

Section 8.0 has been revised to present a synopsis of the data reduction validation and reporting process (see Section 7.0 of the revised document). Section 1.0 (Table 1.1) of the RIQAPP (Rev. 0) references documents that prescribe procedures for this QA element. The role of the laboratory is presented in Analytical Methods/Detection Limits, an associated document to the RIQAPP. The Laboratory QA/QC Manual is presented in this document.

Comment:

9. Section 8.0 - It was not clear how new data will be evaluated and reported in terms of quality.

Response:

EPA Document EPA 540/G-87/003, entitled "Data Quality Objectives for Remedial Response Activities" provides guidance for collection and evaluating the quality of data which are needed to support decisions to be made by DOE during remedial response activities. The three-stage program presented in this guidance document

is described in Section 2.3 of the RIQAPP (Rev. 0). The RI/FS-EIS Work Plan and sampling plans provide rationale and describe the data evaluation process.

Comment:

10. Section 8.5 - Why is a discussion of data quality audits provided in this section and not in Section 9.1.

Response:

This discussion has been deleted. Section 4.0 of the RIQAPP (Rev. 0) describes Quality Assurance Objectives for Measurement. Section 9.0 addresses the audits and corrective actions.

Comment:

11. Section 8.2 - The last sentence in Section 8.2 appears to be in error. In environmental monitoring, sampling error is considered to have a greater impact on variability of data than laboratory analyses.

Response:

This sentence has been deleted.

Comment:

12. Section 9.0 - It was not clear who would perform or how often audits would be performed. Mention is made of QA/QC plans on page 137, but it is unclear what these are.

15. Section 9.1 - The text is unclear on the number and type of audits that are included.

16. Section 9.1 - Field audits do not seem to include the checking of field procedures. Will this be done? Is it a separate audit?

Response to Comments 12, 15, 16:

Section 9.0 has undergone extensive revision to address concerns expressed in the above comments.

Comment:

13. Section 9.0 and Table 9-1 - QA/QC training does not include: 1) SOPs for sampling, 2) SOPs for field activities and 3) documentation of field activities.

14. Section 9.0 and Table 9-1 - It is unclear what specific items are included under 6.0 Inspection and Testing.

Response to Comments 13 and 14:

SOP training is a routine part of the WSSRAP. All employees are required to read SOPs they will implement. The employee then discusses any questions regarding specific SOPs with his supervisor. The employee then performs the SOP with oversight of a staff person familiar with the SOP. This training is documented by a sign-off form specific to the pertinent SOP being performed.

Inspection and testing is addressed in the SOPs and is in accordance with NQA-1 (ANSI, 1986). The relationship between the overall WSSRAP QA/QC program and the revised QAPP is addressed in Section 1.0.

Specific Comments:

1. In order to make Figure 2-6 (p. 30) consistent with the text (p. 32) I suggest using "pCi/l" in the title of the figure.

2. The 2nd paragraph on p. 35 refers to DOE guidelines for uncontrolled areas, but does not state what these guidelines are (see general comment 3 above).

   Special Studies in Support of Feasibility Studies (Section 4.2) should consider the following items to determine compliance with requirements of the Missouri Air Pollution Control Program within MDNR:

   - Asbestos removal from buildings and pipes,

   - Permits may be required if the remedial action is to take longer than two years or if the potential annual emissions of any criteria pollutant exceeds 100 tons,

   - Special non-attainment area regulations for volatile organic compounds apply to facilities in St. Charles County,

   - Controls for noncriteria pollutants are expected to be promulgated by the end of 1988. This may be important for the Weldon Spring project when considering the potential for radiologically contaminated airborne particles and radon-222, especially during remedial activities.

Response:

See Response to General Comments 1, 2 and 3.

Comment:

4. The list of data users (p. 99) should include the Missouri Department of Health and the Agency for Toxic Substances and Disease Registry.

Response:

Names of these data users have been added to the RIQAPP (Rev. 0).

MISSOURI DEPARTMENT OF NATURAL RESOURCES (MoDNR)

March 21, 1988

MoDNR General Comments on the QAPP.

As discussed in our meeting of March 17, 1988, the MDNR concurs that information presented in pages 1-91 more properly belongs in the Remedial Investigation/Feasibility Study (RI/FS) Work Plan.

However, in order to facilitate preparation of the RI/FS Work Plan I offer the following comments:

1. The title should indicate whether this document applies to the entire project or only the Chemical Plan/Raffinate Pit area. Section 2.4 is ambivalent since 2.4.1 includes a discussion of the Quarry while 2.4.2 does not.

2. The QAPP contains a useful presentation of characterization data. However, the data would be more useful if presented in a clearer graphic form. For example, when presenting data showing the area of contamination, I suggest using maps with isopleth showing contaminant levels.

3. The meaning of the data could better be illustrated by including an isopleth for background levels. If clean-up levels have been established then another isopleth could be included showing the clean-up levels, thereby clearly indicating the area where remedial action is needed. If this information is not available at the time the RI/FS Work Plan is prepared it can be added in the RI/FS report.

4. Will the basis for and levels of clean-up standards be included in the RI/FS Work Plan?

Response to General Comments 1, 2, and 3:

Sections 1.0, 2.0 and 4.0 (pages 1-54 and 63-91) have been revised and included in the RI/FS-EIS Work Plan. Isopleth maps will be prepared and submitted with the RI report. Background levels will be addressed in the ARAR section of this report.

Response to General Comment 4:

Applicable Relevant and Appropriate Requirements (ARARs) have been identified on a preliminary basis in the RI/FS-EIS Work Plan. As additional information becomes available, ARARs used to identify clean-up goals will be presented at the completion of the RI Phase.

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

March 8, 1988

Ms. B. Katherine Biggs, Chief
U. S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Dear Ms. Biggs:

QUALITY ASSURANCE PROGRAM PLAN (QAPP) AND RAFFINATE PIT SAMPLING PLANS

Our February 25, 1988 letter transmitted copies of the Quality Assurance Program Plan (QAPP) and the Raffinate Pit Sampling Plan for your review.

In accordance with prior agreements that these types of plans be reviewed within three (3) weeks, we are requesting your comments by March 21, 1988.

Sincerely,

for Stephen H. McCracken
Deputy Project Manager
Weldon Spring Site
Remedial Action Project

cc: Dave Bedan, MDNR

JOHN ASHCROFT
Governor

DERICK A. BRUNNER
Director

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation,
and Historic Preservation

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL QUALITY
P.O. Box 176
Jefferson City, MO 65102

March 21, 1988

Ms. B. Katherine Biggs, Chief
Environmental Review Branch
U.S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, KS 66101

Dear Ms. Biggs:

This letter contains the comments of the Missouri Department of Natural Resources (MDNR) on the draft "Quality Assurance Program Plan" (QAPP), February 1988, prepared by the U.S. Department of Energy (DOE) for the Weldon Spring Site Remedial Action Project (WSSRAP). It also contains comments on DOE's draft "Waste Assessment Raffinate Pit Sampling Plan", February 1988.

General Comments on the QAPP

As discussed in our meeting of March 17, 1988, the MDNR concurs that information presented in pages 1-91 more properly belongs in the Remedial Investigation/Feasibility Study (RI/FS) Work Plan.

However, in order to facilitate preparation of the RI/FS Work Plan I offer the following comments:

1. The title should indicate whether this document applies to the entire project or only the Chemical Plan/Raffinate Pit area. Section 2.4 is ambivalent since 2.4.1 includes a discussion of the Quarry while 2.4.2 does not.

2. The QAPP contains a useful presentation of characterization data. However, the data would be more useful if presented in a clearer graphic form. For example, when presenting data showing the area of contamination, I suggest using maps with isopleth showing contaminant levels.

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3. The meaning of the data could better be illustrated by including an isopleth for background levels. If clean-up levels have been established then another isopleth could be included showing the clean-up levels, thereby clearly indicating the area where remedial action is needed. If this information is not available at the time the RI/FS Work Plan is prepared it can be added in the RI/FS report.

4. Will the basis for and levels of clean-up standards be included in the RI/FS Work Plan?

Specific Comments on the QAPP

1. In order to make figure 2-6 (p.30) consistent with the text (p. 32) I suggest using "pCi/l" in the title of the figure.

2. The 2nd paragraph on p. 35 refers to DOE guidelines for uncontrolled areas, but does not state what these guidelines are. (see general comment 3 above)

3. Special Studies in Support of Feasibility Studies (Section 4.2) should consider the following items to determine compliance with requirements of the Missouri Air Pollution Control Program within MDNR:

- Asbestos removal from buildings and pipes,

- Permits may be required if the remedial action is to take longer than two years or if the potential annual emissions if any criteria pollutant exceeds 100 tons,

- Special non-attainment area regulations for volatile organic compounds apply to facilities in St. Charles County,

- Controls for noncriteria pollutants are expected to be promulgated by the end of 1988. This may be important for the Weldon Spring project when considering the potential for radiologically contaminated airborne particles and radon-222, especially during remedial activities.

4. The list of data users (p. 99) should include the Missouri Department of Health and the Agency for Toxic Substances and Disease Registry.

General Comments on the Waste Assessment Raffinate Pit Sampling Plan

1. General comments 2 and 3 on the QAPP (above) are also relevant to this plan. Graphic presentation of contaminant levels, background levels and clean-up levels would be helpful.

2. More specific labelling of figures would be helpful, for example, figure 1.4 should indicate that this was a sampling effort by BNI in 1986.

Specific Comments on the Waste Assessment Raffinate Pit Sampling Plan

Because of potential air pollution control considerations, the plan should consider sampling for appropriate volatile and Semi-volatile chemicals. The median vapor pressure of the organic fraction would also be helpful in emission rate calculations.

Since several concerns related to air pollution control have been mentioned, I suggest contacting Mr. Doug Baker of the Air Pollution Control Program at (314) 751-4817, for further information.

Thank you for this opportunity to comment on these draft documents. Please call me at (314) 751-4533 or 4758, if you have any questions regarding this letter.

Sincerely,

DIVISION OF ENVIRONMENTAL QUALITY

David E. Bedan
Weldon Spring Work Group Coordinator

DEB/jtw

cc: Rod Nelson, Project Manager, WSSRAP
Ron Kucera, Deputy Director, DNR
William Ford, Director, DEQ
Bob Hentges, WPCP
Nick Di Pasquale, Director, WMP
Doug Baker, APCP
Nick Nikkila, Director, APCP
Jim Long, Director, LSP
Jerry Lane, Director, PDWP
John Crellin, DOH
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII
726 MINNESOTA AVENUE
KANSAS CITY, KANSAS 66101

Cys: Rod
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Ken
Glen
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Peer

APR 06 1988

Mr. Rodney R. Nelson
U.S. Department of Energy
Weldon Spring Site Remedial
Action Project
Route 2, Highway 94, South
St. Charles, Missouri 63303

Dear Mr. Nelson:

We have reviewed the draft Quality Assurance Program Plan (QAPP) and draft Raffinate Pit Sampling Plan. Many of our comments which follow were discussed at our meeting of March 17, 1988.

Although it is called a program plan, the QAPP basically has the elements of a project plan. However, we have no problem with using that title as long as the contents of the document are appropriate. As was discussed in our March 17 meeting, most of the information in the first 90 pages of the QAPP more appropriately belongs in the Remedial Investigation/Feasibility Study (RI/FS) work plan. The purpose of a QAPP is to provide guidelines for ensuring the quality of work conducted in a RI/FS. The QAPP should present and describe the organization, responsible personnel (including duties and responsibilities related to quality), requirements for planning document contents (i.e., sampling plan rationale, sampling procedures, sample locations, decontamination procedures, blanks, duplicates, etc.), auditing program (field and lab), reports to management and corrective action scheme.

In this case, most of these elements have been included in the QAPP; however, it is not made clear as to how each element relates to one another. The audit system is well described, but the specific responsibilities of each individual involved are not spelled out. This specific observation is representative of the entire plan. Many individual components are described, but understanding how each of the components impact one another is difficult.

In general, we suggest that the Raffinate Pit Sampling Plan provide a greater level of detail in Section 2.0, Sampling. This section should be expanded to include specific sampling locations identified by number, a table showing depth intervals and

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sampling locations, and a table showing analytical parameters with the depth intervals. This is necessary since one of the primary purposes of a sampling plan is to act as a field guide for the sampling program.

Specific comments on the QAPP and Raffinate Pit Sampling Plan are enclosed. Also enclosed is a copy of the comment letter prepared by the Missouri Department of Natural Resources. Thank you for the opportunity to comment on these documents. Please call me if you have any questions.

Sincerely yours,

Katie

B. Katherine Biggs
Chief, Environmental Review Branch

Enclosure

cc: Dave Bedan, MDNR (w/enclosure)

Comments on the Quality Assurance Program Plan
Weldon Spring Site

1. Section 3.0 - It is not made clear what role, if any, the DOE has regarding oversight of the contractor.

2. Section 6.0 - It might be appropriate to establish frequency of collection of different types of QC samples used for assessing precision and accuracy in particular.

3. Section 6.3 - We feel that, on page 105, Item 6.3, or some other appropriate location, reference should be made to a needed requirement that all laboratory data should come from laboratories that participate in EPA or other quality control programs. For example, EPA operates, out of the Las Vegas Laboratory, a Radiation Quality Control Program which about 195 laboratories utilize. We feel that any lab producing quality radiation data should participate in this program or, an equivalent, alternate program. The EPA, from Cincinnati, offers similar programs for many other analyses.

4. Section 6.4 - It is not made clear in the text what level of completeness needs to be attained for the data to be valid.

5. Section 6.5.1 - The discussion of standard operating procedures for sampling is not consistent with the Raffinate Pit Sampling Plan.

6. Section 6.5.3 - The text is unclear on what points need to be considered in evaluating the representativeness of the data.

7. Section 7.0 - SOPs for each field operational procedure are not explained in detail in the Raffinate Pit Sampling Plan as this section prescribes.

8. Section 8.0 - The text does not state who will perform all the calculations specified. Clarify who will perform the calculations (contractor, laboratory, etc.) and how the calculations will be checked and audited. If the laboratory is to perform the calculations, is this part of their standard QA/QC package?

9. Section 8.0 - It was not clear how new data will be evaluated and reported in terms of quality.

10. Section 8.5 - Why is a discussion of data quality audits provided in this section and not in Section 9.1.

11. Section 8.2 - The last sentence in Section 8.2 appears to be in error. In environmental monitoring, sampling error is considered to have a greater impact on variability of data than laboratory analyses.

12. Section 9.0 - It was not clear who would perform or how often audits would be performed. Mention is made of QA/QC plans on page 137, but it is unclear what these are.

13. Section 9.0 and Table 9-1 - QA/QC training does not include: 1) SOPs for sampling, 2) SOPs for field activities and 3) documentation of field activities.

14. Section 9.0 and Table 9-1 - It is unclear what specific items are included under 6.0 Inspection and Testing.

15. Section 9.1 - The text is unclear on the number and type of audits that are included.

16. Section 9.1 - Field audits do not seem to include the checking of field procedures. Will this be done? Is it a separate audit?

CHEMICAL PLANT
204-1.03

SET I.D.

DOE/OR/21548-352
CONTRACT NO. DE-AC05-86OR21548

ENVIRONMENTAL QUALITY ASSURANCE PROJECT PLAN

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

JULY 1993

SUPERSEDED

REV. 1

U.S. Department of Energy
Oak Ridge Field Office
Weldon Spring Site Remedial Action Project

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MK-FERGUSON
A MORRISON KNUDSEN COMPANY

Weldon Spring Site Remedial Action Project
Contract No. DE-AC05-86OR21548

Rev. No. 1

PLAN TITLE: Environmental Quality Assurance Project Plan

APPROVALS

Originator — Date: 07/16/93

Project Quality Manager — Date: 07/16/93

Environmental Safety & Health Manager — Date: 7/20/93

Continuous Improvement Manager — Date: 7-20-93

Project Director FOR JRT — Date: 7-20-93

m:\users\joanne\qa\eqapp.apr

DOE/OR/21548-352

Weldon Spring Site Remedial Action Project

Environmental Quality Assurance Project Plan

Revision 1

July 1993

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

ABSTRACT

The Environmental Quality Assurance Project Plan (EQAPjP) in addition to the WSSRAP Quality Assurance Program has been written to fulfill DOE Order 5700.6C requirements under the Federal Facilities Agreement between the DOE and the EPA for the Weldon Spring site. The EQAPjP addresses the 16 quality assurance elements for environmentally related measurements by the EPA QAMS 005/80 (1980) and is intended to be utilized by personnel conducting routine environmental monitoring and remedial investigation/feasibility studies (RI/FS) at the Weldon Spring site.

The primary purpose of this document is to specify Quality Assurance requirements for assessing environmental activities at the Weldon Spring site and to support the WSSRAP Quality Assurance Program as required by the DOE.

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A Environmental Quality Assurance Project Plan Document Hierarchy

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MK-FERGUSON COMPANY
STATEMENT OF POLICY

MK-Ferguson Company, a division of Morrison Knudsen Corporation, is the Project Management Contractor (PMC) for the U.S. Department of Energy (DOE) at the Weldon Spring Site Remedial Action Project (WSSRAP). The goal of the PMC is to perform all work activities in such manner that the required quality is attained or exceeded. The PMC's policy is for senior management to provide planning, organization, direction, control, and support to achieve the organization's objectives; for the line organizational units to achieve quality; and for overall performance to be reviewed and evaluated using a rigorous assessment process (DOE 5700.6C, Sec.8).

To obtain these quality assurance (QA) objectives, the PMC has developed the formal *Environmental Quality Assurance Project Plan* (EQAPjP) described in this manual. The plan is tailored for the remediation of the Weldon Spring site Chemical Plant and quarry and to meet the requirements of DOE Order 5700.6C and the guidance set forth in the QA Requirements and Description (QARD) produced by the DOE Office of Environmental Restoration and Waste Management. The EQAPjP is subordinate to the Quality Assurance Program (QAP) and expands on specific EPA/QAMS-005/80 requirements.

As Project Director, I am committed to the implementation of the WSSRAP PMC QAP. I have assigned to senior managers the responsibility and authority to implement, assess, and improve the program in their respective areas of control.

The corporate Quality Assurance/Quality Control manager has delegated to the Project Quality Manager the authority for developing and maintaining the WSSRAP PMC QAP and for ensuring its effective implementation.

Compliance with the requirements of the WSSRAP PMC QAP is mandatory for all PMC personnel, and Subcontractors are required to comply with all sections that apply to their activities.

Project Director

Deputy Project Director

Deputy Project Director

Deputy Project Director

1 INTRODUCTION

The Weldon Spring Site Remedial Action Project (WSSRAP) Quality Assurance Plan (QAP) (including subsequent remedial action activities) is written to meet the quality assurance program requirements of DOE Order 5700.6C. This *Environmental Quality Assurance Project Plan* (EQAPjP) is focused only on the U.S. Environmental Protection Agency (EPA) requirements under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). This document replaces the existing *Environmental Quality Project Plan* that addresses the remedial investigation activities for the Weldon Spring Quarry. It meets the applicable requirements of EPA QAMS 005/80, *Interim Guidelines and Specifications for the Preparation of Quality Assurance Project Plans* (EPA 1980). The primary purpose of this document is to specify QA requirements for assessing the amount and extent of hazardous materials present on site and to support the WSSRAP Quality Assurance Program as required by the DOE.

The QAP and the EQAPjP support quality affecting activities and implement environmental activities at the WSSRAP. The EQAPjP is supported by WSSRAP Standard Operating Procedures (SOPs), Administrative Procedures, the WSSRAP Health and Safety Program, and work plans written for specific environmental tasks.

Quality assurance for the environmental program detailed in this document and within the associated work plans is intended to be utilized by personnel conducting routine environmental monitoring and remedial investigation/feasibility studies (RI/FS) at the Weldon Spring site. Specific quality control procedures are detailed in WSSRAP SOPs and in specific remedial investigation and monitoring sampling plans. This program fulfills DOE requirements under the Federal Facilities Agreement between the DOE and the EPA for the Weldon Spring site.

The Quality Assurance Program and the EQAPjP address the 16 quality assurance elements (see Table 1.1) specified for environmentally related measurements by EPA QAMS 005/80 (1980).

TABLE 1-1 Environmental Quality Assurance Project Plan Elements

QA Elements	Information Provided In
1. Title Page	EQAPjP
2. Table of Contents	EQAPjP
3. Project Description	EQAPjP RI/FS
4. Project Organization and Responsibility	EQAPjP QAP
5. Quality Assurance Objectives for Data Measurement	EQAPjP WSSRAP Sampling Plans WSSRAP Monitoring Plans QAP
6. Sampling Procedures	EQAPjP SOPs[a]
7. Sampling and Document Custody	EQAPjP WSSRAP Sampling Plans SOPs/Administrative Procedures Laboratory QA Procedures[b] WSSRAP Monitoring Plans
8. Calibration Procedures	EQAPjP SOPs Laboratory QA Procedures
9. Analytical Procedures	EQAPjP SOPs Laboratory SOPs
10. Data Validation, Verification, Reduction, and Reporting	EQAPjP WSSRAP Sampling Plans SOPs/Administrative Procedures WSSRAP Monitoring Plans
11. Internal Quality Control	EQAPjP WSSRAP Sampling Plans SOPs Laboratory QA Procedures WSSRAP Monitoring Plans
12. Performance and System Audits	Administrative Procedures QAP EQAPjP
13. Preventive Maintenance	EQAPjP SOPs Laboratory QA Procedures
14. Specific Routine Measures Used to Assess Data (Precision, Accuracy, and Completeness)	EQAPjP WSSRAP Sampling Plans SOPs WSSRAP Monitoring Plans Laboratory QA Procedures

TABLE 1-1 Environmental Quality Assurance Project Plan Elements (Continued)

QA Elements	Information Provided In
15. Corrective Action	Administrative Procedures QAP EQAPjP
16. Quality Assurance Reports to Management	QAP EQAPjP

[a] Standard Operating Procedures for WSSRAP.
[b] Individual Laboratory Quality Assurance Manuals.

2 PROJECT DESCRIPTION

2.1 Physical Setting

The Weldon Spring site is located in St. Charles County, Missouri, approximately 30 mi west of St. Louis. The site consists of an abandoned limestone quarry, a raffinate disposal area (raffinate pits), a former chemical plant, and various vicinity properties that are contaminated as a result of past U.S. Department of the Army (DA) and U.S. Atomic Energy Commission (AEC) activities at the site. During World War II, explosives were manufactured at the Chemical Plant. After the war, the plant was used to process uranium.

The contaminated soil, equipment, and buildings remaining on the Chemical Plant site require cleanup to meet current U.S. Department of Energy (DOE) guidelines for unrestricted use. The raffinate pits contain uranium and thorium residues. In addition, soil underlying the pits is probably contaminated and will require remedial action.

During the period from 1943 to 1957, the DA utilized the quarry, which is about 4 mi from the site, for disposal of rubble and soils contaminated with trinitrotoluene (TNT) and dinitrotoluene (DNT). The AEC also later disposed of building rubble and soils contaminated with thorium, uranium, and their decay products in the quarry.

A detailed project description including site history, environmental setting, and a summary of the known and suspected nature and extent of existing contamination is presented in the *The Feasibility Study for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (DOE 1992) and the *Feasibility Study/Environmental Assessment for the Weldon Spring Quarry Bulk Waste Remedial Action* (ANL 1990).

2.2 Project Objectives

Environmental monitoring and characterization sampling activities are being undertaken to define the nature, extent, and magnitude of contamination at the site and surrounding area, and to determine the potential impact of these hazardous substances on public health and the environment. In addition, the data will assist in the formulation of strategies to develop and implement appropriate Interim Remedial Actions (IRAs) prior to the selection of final remedial actions.

Feasibility studies are being undertaken to assess and develop types of remedial and/or removal actions that should be considered. These actions must mitigate threats to, and provide protection for, public health and welfare and the environment. Additionally, a Remedial Investigation/Feasibility Study-Environmental Impact Statement (RI/FS-EIS) report will be prepared that will address the technical and demographic issues and impacts associated with selecting viable and feasible remedial measures.

RI/FS activities are conducted by using the U.S. Environmental Protection Agency (EPA) Total Quality Management (TQM) phased approach, which implements the Data Quality Objective (DQO) process as detailed in Section 4.0.

2.3 Site Assessment

The National Contingency Plan (NCP) (40 CFR Part 300, Subpart F) sets forth the guidelines and requirements for assessment of a hazardous waste site (conducted under the Comprehensive Environmental Response, Compensation and Liability Act [CERCLA]) including response actions, preliminary site assessments and removal actions, site evaluation to determine whether the site should be included on the National Priorities List (NPL), and remedial actions. Included in the NCP are requirements and criteria for conducting investigations and feasibility studies.

Environmental sampling activities for site characterization require sampling plans that summarize the existing database and address the validity, sufficiency, and sensitivity of the data generated.

2.4 Hazardous Materials Handling

Hazardous waste, hazardous substances, and hazardous materials will be handled, stored, and shipped in accordance with the appropriate requirements of the EPA, the State of Missouri, U.S. Department of Transportation (DOT) requirements, DOE Orders, and Weldon Spring Site Remedial Action Project (WSSRAP) Compliance Procedures. Specific procedures and requirements for handling, shipping, and storage of hazardous waste and substances will be addressed in procedures and work plans approved by the WSSRAP Project Quality Manager.

3 PROJECT ORGANIZATION AND RESPONSIBILITIES

The U.S. Department of Energy (DOE) is responsible for conducting environmental monitoring and remedial actions at the Weldon Spring site that will place the site in a radiologically and chemically safe state in accordance with guidelines established by the DOE and the U.S. Environmental Protection Agency (EPA). The responsibility for management and technical direction of these environmental activities has been delegated to the DOE Oak Ridge Operations Office. MK-Ferguson is the Project Management Contractor (PMC) assisting the DOE in planning and managing remedial action activities. Headquartered in Cleveland, Ohio, MK-Ferguson is a wholly owned affiliate of Morrison Knudsen Corporation of Boise, Idaho. Joining MK-Ferguson as an integrated subcontractor is Jacobs Engineering Group, Inc. (JEG), headquartered in Pasadena, California. Project support is also provided by Argonne National Laboratories (ANL) in the development of environmental documents. ANL serves as an independent contractor reporting directly to the DOE.

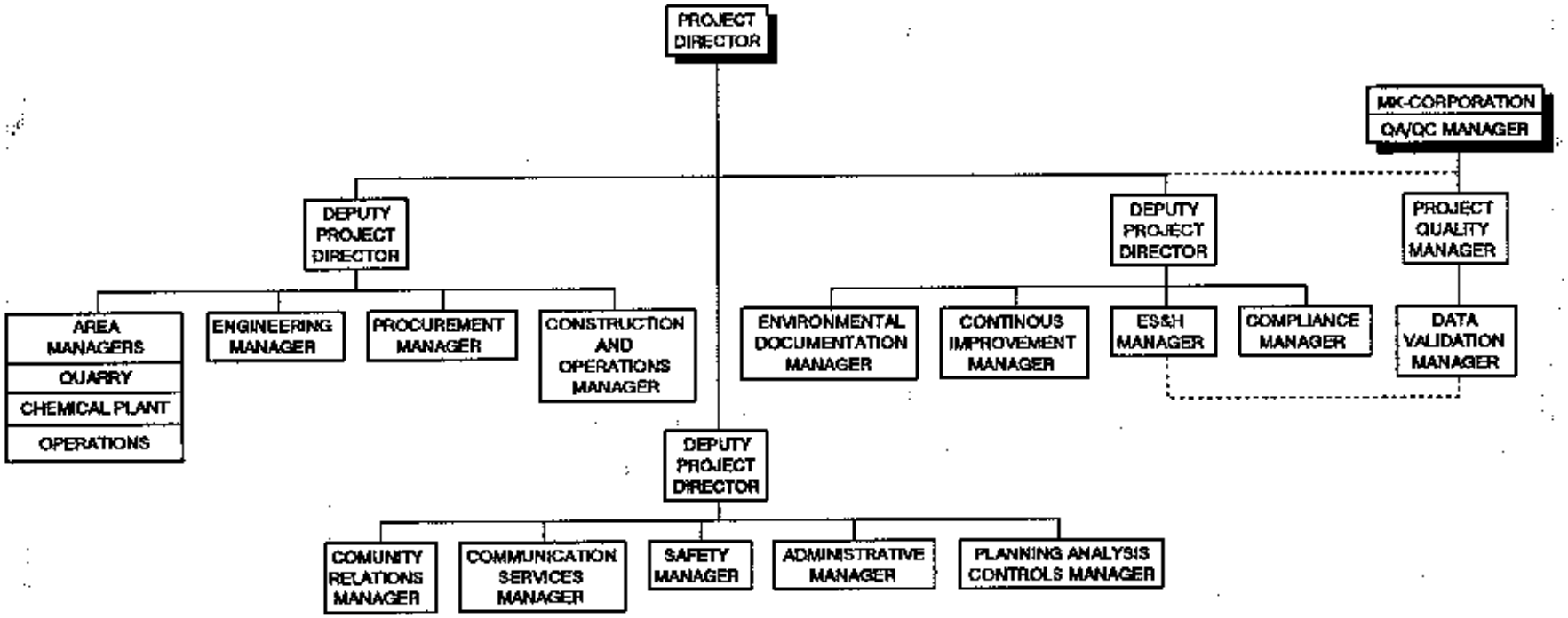
The *Remedial Investigation/Feasibility Study-Environmental Impact Statement (RI/FS-EIS) Work Plan for the Weldon Spring Site Remedial Action Project* (ANL 1988) describes the environmental compliance process and the role of the various organizations (including the PMC) under contract to the DOE for implementation of remedial activities at the Weldon Spring site.

The PMC is responsible for all on-site activities including routine monitoring and site characterization programs in accordance with EPA requirements and DOE guidelines and orders.

The Project Organization Chart, Figure 3-1, shows the lines of authority, responsibilities, and communications assigned to key project entities.

Listed below are the reporting responsibilities and duties of key PMC personnel.

The Project Director reports to the DOE and to MK-Ferguson corporate management. He is responsible for the overall management of the Weldon Spring Site Remedial Action Project (WSSRAP). The Project Director's responsibilities include completion of all contract requirements within the approved schedule and budget and in accordance with applicable codes, standards, specifications, and the WSSRAP Quality Assurance Program (QAP).



WSSRAP PROJECT
ORGANIZATIONAL CHART

FIGURE 3-1

REPORT NO.: DOE/OR/21548-352	EXHIBIT NO.: A/PI/085/0593	
ORIGINATOR: GJ	DRAWN BY: GLN	DATE: 8/9/93

The Deputy Project Directors report to the Project Director and are responsible for aiding him in accomplishing project management and administrative duties. The Deputy Directors are authorized to act for the Project Director when the latter is absent from the project office.

The Administrative Manager reports to a Deputy Project Director and is responsible for all administrative matters; i.e., time-keeping, payroll, industrial relations, property control, and all matters concerning finance.

The Project Procurement Manager reports to a Deputy Project Director and is responsible for all procurement activity including the issuing and administration of subcontracts. Additional responsibilities include evaluation and analysis of bids and warehouse functions.

The Community Relations Manager reports to a Deputy Project Director and is responsible for interfacing with public groups and government agencies, arranging public presentations, and all news media relations.

The Planning Analysis and Control Manager reports to a Deputy Project Director and is responsible for the overall project management control system which includes the development of budgets and schedules, preparation of management reports and submittals, and review and analysis of progress.

The Compliance Manager reports to a Deputy Project Director and is responsible for waste management activities and for ensuring regulatory compliance. He is also the Federal Facilities Agreement coordinator for the WSSRAP.

The Engineering Manager reports to a Deputy Project Director and is responsible for directing and coordinating on- and off-site design activities. He provides engineering support to remedial investigation/feasibility study (RI/FS), interim response action (IRA), conceptual design, and engineering evaluation/cost analysis (EE/CA) documents as well as site construction and remediation activities. He is also responsible for preparation, review, and approval of all WSSRAP engineering documents, including Title 1, 2, and 3 design drawings and construction specifications.

The Environmental Safety and Health (ES&H) Manager reports to a Deputy Project Director. The ES&H Manager is responsible for industrial hygiene, radiological protection and

environmental monitoring, radiological and chemical analysis interpretation and data verification, applied health physics, and all training required by these activities.

The Continuous Improvement Department Manager reports to a Deputy Project Director and is responsible for evaluating new DOE programs for implementation; coordinating and managing self-assessments, lessons learned, root cause analyses, and the Site Wide Audit Tracking System (SWATS); developing and maintaining document hierarchy; providing operational assessment for conduct of operations and conduct of maintenance programs; coordinating and managing independent assessments; coordinating and managing the Project Performance Indicator System; and trending and tracking SWATS reports.

The Construction Management and Operations (CM&O) Manager reports to a Deputy Project Director. The CM&O Manager is responsible for construction management and coordination of all subcontractors, constructability reviews, and resolution of field problems. The CM&O Manager is additionally responsible for all construction operations and maintenance functions including those regarding existing facilities, new facilities, utilities, and equipment.

The Project Quality Manager reports to the Project Director on an administrative basis. Authoritatively, the Quality Manager reports off site to the MK-Corporate QA Manager. The Quality Manager is responsible for development and implementation of the Quality Assurance Program. He has the authority to stop work or control further processing; identify the need for corrective actions; initiate, recommend, coordinate and/or provide solutions; and verify implementation of solutions and corrective actions related to the quality of the work.

The Environmental Documentation Manager reports to a Deputy Project Director and is responsible for preparation, review, control, and distribution of environmental documentation including the RI/FS.

The Data Validation/Verification Supervisor reports functionally to the ES&H Manager and administratively to the Project Quality Manager in order to ensure the independence necessary for this quality assurance function. The Data Validation Supervisor is responsible for evaluation and application of qualifiers to radiological and chemical data and provides technical assistance pertaining to laboratory analyses and procedures.

The Communication Services Manager reports to a Deputy Project Director. He manages the technical editing, word processing, document control, computer hardware and software support, project support, and visitor reception functions, as well as the Project Training and Improvement Program.

The Safety Manager reports to a Deputy Project Director, and is responsible for the Construction Safety Program. He promotes safety awareness and ensures that accidents are properly investigated and reported on, and that action is taken to prevent recurrence.

The Chemical Plant Manager reports to a Deputy Project Director and is responsible for all activities within the chemical plant area.

The Quarry Plant Manager reports to a Deputy Project Director and is responsible for all Quarry Bulk Waste Removal operations.

The Operations Manager reports to a Deputy Project Director and is responsible for activities associated with the water treatment plants and other administrative activities associated with labor and building construction.

4 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT

The overall purpose of establishing quality assurance objectives for measurement data is to ensure that data of known and acceptable quality are provided for the intended uses. These objectives apply to both existing and future sampling and field measurement data. Data reviewed or generated by the Weldon Spring Site Remedial Action Project (WSSRAP) are to be of such quality that they can be used as direct indicators of the nature and extent of radiological and chemical contamination at the Weldon Spring site.

These objectives are achieved through the implementation of standard operating procedures for the following:

- Document control
- Field activities, including sample collection for routine monitoring and characterization
- Chain of custody
- Equipment calibration
- Laboratory analyses
- Data validation, verification, reduction, and reporting
- Internal quality control checks
- Audits and surveillances
- Preventive maintenance
- Corrective actions
- Document hierarchy

4.1 Data Quality Objectives

Environmental activities that support decisions (i.e., remedial investigations [RIs], risk assessments, and feasibility studies [FSs]) should be conducted by implementing the U.S. Environmental Protection Agency (EPA) Data Quality Objective (DQO) process (EPA 1990 Draft). The DQO process is a Total Quality Management approach to planning for data collection in support of environmental decision making. This planning tool utilizes seven key steps to ensure that decision makers and data collectors communicate effectively to address cleanup problems. The Project Management Contractor (PMC) recognizes that effective planning to implement the DQO process requires coordination with the Argonne National Laboratory (ANL) (an independent contractor to the DOE with responsibility for RI/FS work

plans, risk assessments, etc.) as well as U.S. Department of Energy (DOE). The PMC will make every effort to facilitate the coordination through training, reporting, and task coordination. Key players involved in each step are also identified. These steps are defined in the following subsections. They are:

(1) Define the problem.
(2) Identify alternative actions that will resolve the problem.
(3) Identify inputs affecting the decision.
(4) Specify the domain of the decision.
(5) Develop a logic statement.
(6) Establish constraints on uncertainty.
(7) Optimize the design for collecting data.

The DQO process is implemented in an iterative manner. Each iteration helps to:

- Better define the scope of the problem.
- Focus the decision.
- Clarify courses of action and inputs needed.
- Establish go/no-go alternatives.
- Identify resources constraints.
- Describe consequences of incorrect decisions.

The initial iteration of the DQO process is qualitative in nature. Each subsequent iteration clarifies and quantifies each step of the process to develop defensible design criteria for data collection. The overall benefit of implementing the DQO process can be summarized as follows:

- It helps promote effective communication with data collectors by organizing key planning issues in a thoughtful sequence.

- It helps establish objective and quantitative criteria for knowing when to stop sampling.

- It helps ensure that investigations will produce the types and amounts of data needed to decide which course of action to take, with acceptable and pre-specified measures of risks of incorrect decisions.

- It reduces overall time for investigations by decreasing the likelihood of false starts and minimizing rework.

The DQO process is implemented within all activities that support environmental decision making (e.g., RI/FS, risk assessment, site closure). Implementation is described in the *Environmental Data Administration Plan* (EDAP) (MKF and JEG 1992a). The individual sampling plans present Stage I and Stage II reports for decision making and the optimum design criteria for data collection.

Step 1: Define the Problem

The problem is defined in terms of what is known about or expected to be discovered in the affected area. This may include exposure pathways, types of contaminants, and changes to the site since original activities.

Step 2: Identify Alternative Actions to Resolve the Problem

The product of this step is a list of alternative courses of action that address the problem. Courses of action may include:

- Study the site of contamination further and develop remedial alternatives.
- Recommend "no action" based on information available.
- Recommend corrective action, such as an emergency response action, based on information indicating an immediate threat to public health.

Step 3: Identify Inputs Affecting the Decision

This step generates a list of questions that must be answered to decide which action to take, how criteria for decision making will be established, and the relevance of social and political factors.

Step 4: Specify Domain of Decision

Spatial and temporal boundaries are defined in this step to address the area and time frame required to collect data to determine the smallest area to which a separate decision will apply.

Step 5: Develop a Logic Statement

An "if/then" statement is developed from knowledge summarized in the previous DQO steps. This statement explains what actions will be taken under what circumstances.

Step 6: Establish Constraints on Uncertainty

Quantitative and qualitative statements concerning the level of uncertainty that will be allowed in the data to implement the logic statement are addressed in this step. The consequences of incorrect decisions are determined to evaluate the risk involved.

Step 7: Optimize Design for Obtaining Data

In this step a statistical approach is used to design a sampling program that will achieve the desired constraints on uncertainty.

4.2 Document Control

The goal of the Weldon Spring site document control system is to ensure that pertinent documents, including drawings, procedures, and specifications used by WSSRAP personnel, are current. To achieve this goal, procedures for identifying and controlling quality-affecting documents have been developed. These procedures include establishment of a numbered document control system and a document inventory procedure. WSSRAP Procedures ENG-5a, SQP-7a, SQP-8a, SQP-9a, SQP-10a, CID-10a, PS-6a, and PS-9a implements this system.

The document control system ensures that originals and copies of documents are kept secure and under custody, when necessary, and that individuals holding documents receive revisions and updates when appropriate.

4.2.1 Controlled Documents

Controlled documents are documents issued by authorized personnel which, in accordance with requirements of WSSRAP Standard Operating Procedures (SOPs) and Administrative Procedures, are assigned unique identifying numbers and logged out to specific individuals. These documents specify quality requirements for activities affecting quality. A distribution list for each document is maintained in the Document Control Center. These documents include:

- Quality assurance/quality control (QA/QC) plans.
- Procurement plans.
- Engineering design documents.
- Design procedures.
- SOPs/Administrative Procedures.
- Safety plans.
- Plans and procedures required by regulation.

4.2.2 Document Ownership and Distribution

All quantitative project documents generated by the WSSRAP are the property of the DOE. Such documents are distributed to State agencies, Federal agencies, other regulatory agencies, and citizen's groups in accordance with DOE approvals, policies, and guidelines. Distribution of information and documents to third parties is with concurrence of, or at the direction of, the DOE. Controlled documents (i.e., manuals, procedures, instructions, and guidelines) are distributed on the basis of a written, approved, standard distribution list. Controlled documents distributed to parties are inventoried and are accompanied by a document transmittal form. A return receipt is required and documented on the controlled document transmittal log. All quality-affecting documents submitted to the DOE are reviewed and approved by the PMC in accordance with WSSRAP Administrative Procedures.

5 SAMPLING AND ANALYTICAL PROCEDURES

The objective of field sampling and laboratory analytical procedures is to obtain defensible data that meet data quality requirements for precision, accuracy, representativeness, comparability, and completeness (PARCC) as required by characterization and monitoring sampling plans which utilize the data quality objective (DQO) process for data collection.

5.1 Field Sampling

Precision, comparability, representativeness, and completeness for field sampling activities at the Weldon Spring Site Remedial Action Project (WSSRAP) are controlled and directed by approved standard operating procedures (SOPs) and sampling plans. All SOPs and sampling plans are reviewed, approved, and controlled by appropriate WSSRAP procedures. Field sampling SOPs are developed to standardize, where possible, sampling procedures to ensure that samples are comparable to, and compatible with, other data collection activities at the WSSRAP. Sampling is conducted by trained individuals. Training of individuals is documented according to WSSRAP training requirements, including Procedure PS-14a, before any individual conducts or assists with sampling activities.

The WSSRAP SOPs include descriptions of:

- Reference of sample methods.
- Sample collection techniques.
- Sample identification.
- Sample preservation.
- Sample packaging and handling.
- Sampling quality control (QC) procedures.
- Quality assurance (QA) records.
- Equipment calibration and maintenance.

The WSSRAP has developed an *Environmental Data Administration Plan* (EDAP) (MKF and JEG 1992a) to manage the use of environmental data. The EDAP directs the implementation of the DQO process for the sampling plans where appropriate.

Field sampling plans establish the QC criteria necessary to meet the sampling precision, representativeness, comparability, and completeness required to support the data quality objective process as defined in the EDAP.

Field sampling activities that produce data (e.g., log books, field data sheets, equipment calibration records) become QA records and are maintained in accordance with the Quality Assurance Program (QAP).

Also, many geotechnical field activities and laboratory analyses are performed for the WSSRAP. The geotechnical activities also comply with the WSSRAP QAP and SOPs, when applicable, and with ASTM standards which regulate most geotechnical work such as drilling, compaction, permeability testing, etc.

5.2 Analytical Procedures

All quantitative laboratories conducting geotechnical, radiological, and/or chemical analysis for the WSSRAP are required to submit controlled copies of site-specific Quality Assurance Project Plans (QAPjPs) and SOPs to be reviewed and accepted by the Project Management Contractor (PMC). The WSSRAP and contract laboratory SOPs direct operations, analyses, and activities which are thoroughly prescribed, documented, and performed in accordance with accepted standards and methodologies. Any changes to controlled SOPs and QAPjPs must be approved by the PMC. Laboratory QAPjPs and SOPs specify QC requirements to demonstrate the precision and accuracy of methods and procedures.

All data generated by analytical activities (e.g., calculations, chromatographs, calibration curves, QC analyses) that are received by the WSSRAP are QA records and are maintained in accordance with the QAP and/or SQP-7, SQP-8, SQP-9, and SQP-10.

Maintenance and storage of completed records, charts, and logs of all pertinent calibrations, analyses, QC activities, and data generated by contract laboratories are kept in a WSSRAP-specific project file. Both electronic and hard copy data reports must be available at contract laboratory facilities for 3 yr after termination or expiration of any contract. Storage areas must keep records safe from damage by moisture or fire.

Routine audits and surveillances are conducted by the Project Quality Department on all contract laboratories to verify their conformance to their QA programs, WSSRAP contract specifications, and appropriate regulatory requirements.

6 CALIBRATION AND PREVENTIVE MAINTENANCE

To help achieve the necessary data quality, calibration and preventive maintenance procedures control the use of field sampling equipment and laboratory instruments.

6.1 Field Sampling Equipment

To ensure the precision, accuracy, and minimal down time of field sampling equipment, the Weldon Spring Site Remedial Action Project (WSSRAP) develops Standard Operating Procedures (SOPs) for operation, calibration, and maintenance of all site field sampling equipment.

These SOPs include means for demonstrating and documenting instrument precision and accuracy. Such means are:

- All measurement devices must be assigned individual identification numbers. Documentation must identify the function, calibration requirements, operating technicians, and standards used for calibration of each device.

- Each measuring device must be calibrated against a traceable standard of known accuracy.

- Sampling and analytical calibration methodologies must be documented and referenced to Federal and regulatory standards.

The SOPs also identify the type and frequency of routine preventive maintenance required for each model of field equipment used. Equipment must be maintained at least in accordance with manufacturers' recommendations. Logbooks must be maintained for each field sampling instrument. These logs must document the maintenance performed, the technician performing the maintenance, and whether maintenance was routine or for repair.

Personnel must be appropriately trained before operating field sampling equipment. Documentation of training is in accordance with WSSRAP SOP training procedures. Only trained, qualified technicians perform preventive maintenance.

All records of calibration and maintenance are quality assurance (QA) records and are maintained in accordance with QA Procedure SQP-7, *Quality Assurance Records*.

6.2 Laboratory Instruments

All laboratories conducting radiological and chemical analyses for the WSSRAP must include in their site-specific quality assurance project plans (QAPjPs), calibration and preventative maintenance requirements for all instruments used to conduct WSSRAP analyses. For each model of instrument the QAPjPs must identify:

- Calibration requirements
- Calibration acceptance criteria
- Corrective action, if required
- Routine maintenance requirements

Laboratories must, upon request, provide to the WSSRAP documentation for all calibration, maintenance, and corrective actions required. Calibration and maintenance documents are QA records and are maintained in accordance with QA procedure SQP-7, *Quality Assurance Records*.

7 SAMPLE CUSTODY

A major required component of all field investigation sampling plans is maintaining sample integrity from collection to data reporting. To maintain and document sample possession, chain-of-custody procedures must be implemented. Elements of the chain may include at a minimum:

- Sample seals
- Labels with identification numbers to allow for sample tracking
- Field log books
- Field data record forms
- Chain-of-custody records
- Sample analysis request sheets
- Bills of lading and air bills
- Field and laboratory tracking forms

Field and laboratory sample custodians or their designated representatives are responsible for maintaining custody of samples. A sample is considered to be under a person's custody if one or more of the following conditions are met:

- It is in the person's physical possession.
- It is in view of the person.
- It is secured by the person so that no one can tamper with the sample without being detected.
- It is secured by the person in an area that is restricted to authorized personnel.

Sample custody is divided into the following three parts:

(1) Field sample custody
(2) Laboratory sample custody
(3) Quality Assurance (QA) record

7.1 Field Sample Custody

Sampling procedures for groundwater, soil, waste, etc., are addressed in the Weldon Spring Site Remedial Action Project (WSSRAP) Standard Operating Procedures (SOPs) and sampling plans. The sample custody program for the Weldon Spring site includes documentation of procedures for the preservation of samples, sample identification, recording sample collection locations, and specific considerations associated with sample acquisition. Applicable forms for recording these data, and the tracking of samples as required by chain-of-custody procedures, are specified in SOPs. The chain of custody requires at a minimum, the following:

- Sample identification
- Sample location
- Sample date
- Sample matrix
- Sample preservation
- Analysis required
- Release and acceptance information; i.e., date, location, and technician's signature

In situ or field measurements (e.g., pH measurements, temperature, conductivity, flow measurements, and air monitoring data) are recorded in field log books or on field data record forms. Sample containers are labeled or tagged appropriately according to applicable SOPs. Labels or tags contain the following information:

- Organization name
- Location
- Date
- Matrix type
- Preservation
- Sample identification number
- Name(s) of sampler(s)

Samples are accompanied by chain-of-custody records. Completed chain-of-custody documents are retained as quality assurance records and maintained in accordance with the Quality Assurance Program.

7.2 Laboratory Sample Custody

Samples are packaged and shipped to the laboratory in accordance with U.S. Department of Transportation requirements and WSSRAP procedures RC-17 and RC-19 with a separate custody record accompanying each shipment. Authorized sample custodians at the laboratories sign for incoming field samples, obtain documents of shipment, and verify data entered onto the sample custody records. The laboratories are required to inform the PMC of receipt of samples within one working day. If any damage or shipping discrepancy is noted upon receipt of samples, the laboratories are required to inform the PMC immediately. Contract laboratories are required to maintain custody of samples as defined in Section 7.0.

8 DATA EVALUATION, REDUCTION, AND REPORTING

Statistical parameters are used to assess the quality of data obtained. Section 4.1 discusses the process used to establish and assess the precision, accuracy, representativeness, completeness, and comparability (PARCC) of Weldon Spring Site Remedial Action Project (WSSRAP) environmental monitoring and measurement data. This section discusses criteria to be used in handling collected data.

8.1 Data Packages

Data packages received from contract laboratories undergo several processes to evaluate the quality of the data. When the data are first received, copies are distributed to the Quality Assurance (QA) Department for storage as QA records and to the Verification Group and data users for review. If validation of sample analysis has been requested, a copy is forwarded to the Validation Group for data qualification. The following subsections further describe the evaluation process.

8.1.1 Data Verification

The WSSRAP processes all data received from contract laboratories in accordance with ES&H 4.9.1s *Environmental Monitoring Data Verification*. The following factors are reviewed to verify if a sample has been properly handled according to WSSRAP protocol:

- Chain of custody
- Holding times
- Sample preservation requirements
- Laboratory chain of custody
- Sample analysis request form
- Quality control (QC) samples
- Laboratory receipt forms

8.1.2 Data Review

Copies of the data packages are distributed to the data users for their review. The data are reviewed to identify discrepancies in the field QC samples, inconsistencies of the data in

comparison to historical data, or apparent abnormalities. Deficiencies reported by data users are reported to the verification group. Data users may request validation of any data that appear to be of questionable quality.

8.1.3 Data Validation

Randomly selected laboratory data and data selected by verification or data users undergo thorough reviews of the analytical process in accordance with WSSRAP data validation Standard Operating Procedures (SOPs). These reviews are conducted by the validation group.

The purpose of the validation procedure is to specify a consistent means for reviewing and evaluating the data resulting from laboratory analyses and for providing a consistent means for documenting the evaluation, and reporting the usefulness, of the data to the data users. This is accomplished through a thorough review of the analytical data utilizing laboratory analytical records to assess laboratory conformance to QC criteria, data quality requirements for data quality objectives, and procedural requirements.

8.2 Data Reduction

A data reduction process has been developed for all data collected on site for the WSSRAP. Generally, these procedures are described in WSSRAP SOPs.

8.2.1 Computerized Data Reduction

A large amount of data will be generated during site characterization. Those data collected and analyzed during the sampling and analysis program will be reduced for input into the computerized database. These data may include logs, tracking forms, and results of laboratory analyses. Computer software used for data reduction will be managed in accordance with Section 6 of the Quality Assurance Program (QAP).

8.3 Reporting

Documentation of the data collection and analysis process is an integral part of the QA/QC program. Data validation techniques require that SOPs, sample tracking methods, validation procedures, QC checks on PARCC criteria, and all sampling and laboratory activities

be documented. Data obtained from sample collection and analysis operations are recorded on standardized report forms or log books.

These documents include approved WSSRAP forms. Some of these documents are listed below:

- Contract Laboratory Program (CLP) report forms
- Chain-of-custody forms
- Sample labels
- Sample analysis request forms
- PARCC objectives summary forms
- QA/QC report forms for laboratory
- Equipment calibration report forms
- Standard field and laboratory log forms

8.3.1 Field and Laboratory Quality Assurance Records

Documents used to record environmental activities are, where practicable, numbered and assigned to individuals designated to perform specific tasks. They include:

- Field log books
- Field data record forms (e.g., well inventory forms, pumping test data sheets)
- Analytical log books
- Laboratory data, calculations, graphs, etc.
- Location maps, photos, selected drawings, as-builts
- Checklists of equipment performance
- Equipment maintenance logs including repair and calibration information
- Photographic logs
- Engineering calculations

8.3.2 Quality Assurance Record Storage

QA records are monitored as specified in SQP-7, SQP-8, SQP-9, and SQP-10 and are stored in locked and secure facilities. Dual document storage facilities are maintained at locations sufficiently remote from each other to eliminate the chance of simultaneous exposure

to a hazard. Access to both facilities is controlled. This applies to both computer-generated data and hard copy documents. Copy-protected software can be replaced by the supplier.

Documents are reviewed for technical adequacy by the responsible management before submittal to the Project Quality Department for retention as QA records. QA records are one-of-a-kind documents not being retained by the Document Control Center in the project correspondence or controlled document system. Appropriate documents become QA records upon completion.

9 INTERNAL QUALITY CONTROL

To achieve the highest practical attainable level of precision and accuracy, sampling programs at the Weldon Spring Site Remedial Action Project (WSSRAP) include the use of quality control (QC) samples to measure field and laboratory performance. QC samples are submitted to laboratories as blind samples. These samples are defined for aqueous media in procedure ES&H 4.1.4. To provide quality control information, the following types of QC samples may be utilized:

- Background Samples: The samples are obtained from media characteristic of the site but outside of the zone of contamination; e.g., groundwater samples collected from the upper Burlington-Keokuk aquifer upgradient of the Weldon Spring Chemical Plant area.

- Duplicate Samples: These samples are collected at the same time from common collection manifolds, locations, or sampling divides, or as split samples from one sampling event, and sent to the same laboratory to verify sampling and inter-laboratory precision. Generally, one out of every 20 investigative samples is replicated.

- Secondary Duplicate Samples: Replicate samples, divided into two portions, are sent to different laboratories to assess inter-laboratory precision.

- Equipment Blanks: Analyte-free deionized water is used to rinse sampling equipment that has been decontaminated; e.g., bailers, pumps, augers, split tube samplers, etc. When using non-dedicated sampling equipment, one rinsate sample is collected per day or for every 20 investigative samples, whichever is greater. Upon analysis, these samples are used to assess the adequacy of the field decontamination process.

- Trip Blank: This is analyte-free water taken from a laboratory to the sampling site and returned to the laboratory unopened. Trip blanks are used only when sampling for volatile organics.

- Performance Audit Sample: This is a sample containing known concentrations of analytes which is submitted to a laboratory without warning to assess its performance. See Section 10.3.

Internal QC samples at the laboratories include the utilization of matrix spikes and laboratory control samples, including U.S. Environmental Protection Agency (EPA) quality control ampules, Standard Reference Materials (SRMs), and laboratory-prepared solutions made from pure compounds and method or analytical blanks.

The laboratories selected by the WSSRAP utilize the standards and guidelines prescribed by the EPA, where appropriate, for analyzing relevant chemical and radiological constituents.

The analytical internal QC operations presented in *Users Guide to the Contract Laboratory Program* (EPA 1986b) are applied to contract laboratories performing analyses on samples generated by the WSSRAP. These operations include:

- Inductively Coupled Argon Plasma (ICP) Interference Check Sample Analysis: Performed at least twice per 8-hr shift to verify inter-element and background correction factors.

- Preparation Blank Analysis: Performed on each batch of samples or on each set of 20 samples to ascertain whether sample concentrations reflect contamination.

- Spiked Sample Analysis and Duplicate Sample Analysis: Performed on each concentration and matrix within each set of 20 samples of a similar matrix to provide information concerning sample homogeneity, analytical precision and accuracy, and the effect of the sample matrix on the analytical methodology and to allow for evaluation of the long-term precision of the method.

- ICP Serial Dilution Analysis: Performed on one of each 20 samples received in each group of samples of a similar matrix type and concentration to ascertain whether significant chemical or physical interferences exist due to sample matrix.

- Furnace Atomic Absorption Quality Assurance (QA) Analysis: Required for quantification; incorporates duplicate injections and analytical spikes in order to

evaluate the precision and accuracy of the individual analytical determinations on each sample.

- Laboratory Control Spikes (LCS): Standards carried through sample preparation and analysis procedures to document the performance of the entire analytical process. The results of LCS analysis are submitted with the data package. Laboratories verify, on a quarterly basis, their instrument detection limits, ICP linear ranges, ICP inter-element correction factors, and ICP integration times.

It is the responsibility of each laboratory to document in each data package submitted that both initial and ongoing instrument and analytical QC requirements have been met. Any samples that have not been analyzed according to contract QC requirements are re-analyzed by the laboratory or properly qualified by the Validation Group.

10 AUDITS AND CORRECTIVE ACTIONS

Quality assurance (QA) objectives for the Weldon Spring Site Remedial Action Project (WSSRAP) will be met in part by audits of field sampling and laboratory analysis activities. The goals or objectives of the Weldon Spring site characterization quality assurance/quality control (QA/QC) audit program are to ensure that:

- QA/QC requirements are clearly established.
- All sampling and analytical efforts are described by an approved sampling plan.
- Standard operating procedures are developed for each measurement activity.
- Qualified personnel are assigned to perform these activities in accordance with the procedures.
- Proper documentation is prepared to establish data validity.
- Audits are performed to determine compliance with the established QA/QC requirements.
- Corrective actions are proposed and implemented to address deficiencies identified during audits. The corrective actions are also verified and validated.

This section describes the performance, reporting, and documentation phases of the audit portion of the WSSRAP Quality Assurance Program.

10.1 Audits—General

An audit program is implemented to ensure compliance with the QA/QC program requirements established for the WSSRAP in the approved *Project Management Contractor Quality Assurance Program* (MKF and JEG 1992c). This mechanism is intended to assess systems and procedure effectiveness.

Audits:

- Identify weaknesses and strengths of overall programs.
- Dictate corrective actions as required.
- Allow for modification and enhancement of QA/QC programs.
- Serve as a vehicle for providing necessary technical assistance.
- Measure the effectiveness of QA/QC programs to ensure data quality.

Audits at the WSSRAP include performance and systems audits. These audits are performed both internally and externally to the Project Management Contractor (PMC). All audits are performed by PMC personnel that have been certified in accordance with SQP-17s, *Auditor Training and Lead Auditor Certification*.

Systems audits consist of an evaluation of all components of a measurement system to determine their capability, proper selection, and use. A systems audit includes a careful evaluation of field and/or laboratory QA/QC programs. Systems audits are normally performed prior to, or shortly after, systems are operational; however, such audits are performed on a regularly scheduled basis for the duration of the WSSRAP. Systems audits are performed in accordance with SQP-18s, *Independent Assessment*.

10.2 Audit Preparation

Audits are performed under the direction of certified lead auditors who are assisted by certified auditors and/or appropriately trained technical specialists as required to audit all components of the WSSRAP QA/QC programs. For each audit, the lead auditor is responsible for preparing and maintaining an audit schedule, reviewing and documenting the qualifications of all audit personnel (including technical specialists), providing notifications to audited organizations, and preparing and/or approving audit plans and checklists.

The lead auditor, after a review of applicable requirements such as procedures, contracts, plans, standards, and project schedules, prepares an audit schedule indicating the organization to be audited, subjects to be audited, and schedule of the audits. The audit schedule is reviewed periodically and revised as necessary to ensure that coverage is kept current. In advance of the scheduled audit, the lead auditor notifies the organization to be audited of the proposed schedule and scope of the audit.

The lead auditor selects the audit team members including auditors, technical specialists, and observers as required to best perform a comprehensive audit of the systems or components to be audited. Team personnel are appropriately trained as auditors and do not have direct responsibilities in the areas being audited. The lead auditor documents the qualifications of the audit team members.

The lead auditor is responsible for preparing a written audit plan as requested by the Project Quality Manager. The audit plan includes:

- Audit number
- Organization to be audited
- Subjects to be audited
- Scope of the audit
- Projects or activities to be audited
- Audit team members
- Audit schedule
- Applicable documents

The audit plan is used to provide the audited organization's management with the proposed scope, requirements, personnel, and schedule for the audit.

The audit team prepares audit checklists based on their review of applicable or relevant and appropriate requirements, documents, including procedures; standards, contracts, and plans; and previous audits, if any, of the systems or tasks to be audited. The lead auditor is responsible for review and approval of the audit checklists. These checklists are used to evaluate the performance of the audited activity.

The lead auditor provides the audit team with the audit plan and checklists. The lead auditor also orients the team to the audit schedule as well as the internal and external organization and contractual interfaces and responsibilities of the organization to be audited.

Audits are scheduled at intervals consistent with the schedule for accomplishing the activity and commensurate with the status and importance of the activity.

Audits are performed in accordance with written procedures.

Audit results are documented by auditing personnel and reviewed by management having responsibility in the area audited.

10.3 Performance Audits

Performance audits are used to quantitatively determine the accuracy of a laboratory's performance, using a blind quality control sample. The WSSRAP requires that laboratories generating data that are to be used for making decisions that may impact the health and safety of the public or the environment participate in the appropriate performance sample programs. The following are examples of programs that are presently used for this purpose:

- U.S. Department of Energy (DOE) Environmental Measurement Laboratory QA Program
- U.S. Environmental Protection Agency (EPA) Environmental Monitoring System Laboratory Program
- EPA Water Pollution and Water Supply Intra-laboratory Performance Program

The laboratories' performance in these programs is evaluated during annual system audits conducted by the PMC.

10.4 System Audit Performance

For each audit, the lead auditor conducts a pre-audit meeting at the audit site with the audit team and responsible management of the organization to be audited. The pre-audit meeting provides a means to introduce the audit team; establish contacts and interfaces; present and confirm the audit plan, scope, and sequence; and schedule the post-audit meeting.

The audit is conducted following the approved audit checklist as a guideline. The lead auditor may assign portions of the checklist to members of the audit team commensurate with their expertise. The checklist is a guideline; responsible questioning or investigation may lead the audit into areas not described in the audit plan or by the audit checklist.

Audits include objective examination of work areas, activities, processes, and items and review of documents, records, quality-related practices, procedures, and instructions to determine compliance with the QA/QC program requirements and the project procedures manual. The results of the investigations are recorded on the audit checklists.

Discrepancies or concerns discovered during the course of the audit are presented to the lead auditor for review and discussion prior to formalizing. Discrepancies are categorized as follows:

1. Finding: A deficiency or non-compliance to established procedures, requirements, or regulations.

2. Item of Concern: A condition or item identified during an assessment which, although currently meeting established requirements, may, if left without management attention, lead to a departure from established requirements.

3. Observation: A conclusion which is the result of a generally subjective evaluation of implementation practices or management systems related to the area under review.

At the conclusion of the audit, a post-audit meeting chaired by the lead auditor is conducted. The purpose of the post-audit meeting is to present the findings, items of concern, and observations to the responsible management of the audited organization. Resolution of discrepancies and commitments for corrective actions, including a tentative schedule for completion of corrective actions, are discussed at this time.

10.5 Audit Reporting

Audit reports are submitted to cognizant managers by either the Project Quality Manager or the lead auditor. These reports address the performance of measurement systems and data quality. Audit reports include the dates of audits, audit procedures, names of auditors, audited organization participants, specific procedures audited, a summary of audit results including findings and observations (if any), and recommendations for correcting deficiencies or improving the QA/QC programs, if necessary.

Audit findings are recorded on the Quality Finding Report Form and are included as part of the audit report as detailed in SQP-18s. Items of concern are also included in the audit report.

Audit reports are issued promptly upon completion of an audit (with 30 days), and include the date required for response to audit findings. Findings require responses within 30 days. Responses must include commitment dates for completion of corrective actions to be taken, results of a review for potential impact on other items or activities (if any), and the causes of deficiencies.

Items of concern also require responses within 30 days as appropriate and do not necessarily include corrective actions or causes of deficiencies.

Observations may or may not require formal responses, depending upon the severity, type, and number of specific deficiencies. The lead auditor specifies which of the observations require written responses. Observations are recorded in the body of the audit report.

Completion of corrective actions noted in audit responses are verified and validated upon receipt of the responses or by the dates specified on the responses.

10.6 Surveillance

In addition to regularly scheduled audits, the QA Department performs surveillances of field and laboratory activities in accordance with SQP-2s, *Quality Assurance Surveillance*. Surveillance is the act of monitoring or observing to verify whether an item or activity conforms to specified requirements.

Surveillances may be planned or unplanned, scheduled or unscheduled. No checklist is required; however, the approved procedure for the operation or task is followed to ensure adherence to the requirements. Surveillances are documented by the individuals performing them and reviewed by the lead auditor.

When deficiencies are noted, the responsible departments are notified by either Quality Finding Reports (QFRs) or items of concern as presented in the audit report.

Responses to QFRs and items of concern must be returned to the Project Quality Department by the responsible department manager and appropriate follow-up actions must be prescribed at that time.

10.7 Finding/Deficiency Corrective Action and Closure

The lead auditor is responsible for the evaluation of corrective action responses to determine if the corrective action for each finding/deficiency is adequate, has been scheduled, or has been completed. The lead auditor ensures that responses to findings written by audit team members fully address discrepancies.

Follow-up may be accomplished through written communication, re-audit, surveillance, or other appropriate means. Unsatisfactory responses are addressed in writing, indicating why they are unsatisfactory, and specifying a reply due date. Findings and deficiencies are considered open until approved corrective actions have been completed. The lead auditor is responsible for closing all findings and deficiencies.

10.8 Quality Assurance Records

All audit plans, correspondence relating to audits/surveillances, audit findings, audit reports, individual certifications, QFRs, and surveillance reports become QA records and are maintained in accordance with the WSSRAP *Quality Assurance Program* (MKF and JEG 1992c).

11 QUALITY ASSURANCE REPORTS TO MANAGEMENT

11.1 Assessment of PARCC

The Validation Group generates periodic and quarterly reports to management. The appropriate validation standard operating procedures (SOPs) clearly define the mechanism for transmitting these reports.

11.1.1 Periodic Reports

Reports generated by the Validation Group from random selection or data user requests are submitted to management upon completion. These periodic reports are submitted to the managers of the appropriate departments for their information.

11.1.2 Quarterly Reports

The Validation Group reports to management all data assessments to date on a quarterly basis. These reports are submitted, as a minimum, to the following:

- The Deputy Project Director
- The Quality Assurance (QA) Department
- Environmental Safety and Health Manager

11.2 Quality Assurance Reports

The QA Department's standard quality procedures define the disposition of all reports generated by QA activities to the appropriate management levels.

The QA Department developed the Site Wide Audit Tracking System (SWATS) to identify, track, and document closure of quality-affecting deficiencies. The SWATS has been divided into three categories:

- Extrinsic SWATS: Deficiencies that have been identified and issued to the WSSRAP from an outside source (e.g., the DOE or a PMC corporate office).

- Internal/Subcontractor SWATS: Deficiencies that were identified by QA surveillances, inspections, and audits.

- Self-assessment SWATS: Deficiencies identified by the specific department conducting a self assessment.

11.2.1 Monthly Reports

- QA monthly reports will be submitted to the MK corporate QA Manager.

- Monthly SWATS reports will be submitted to PMC management to identify open deficiencies.

11.2.2 Quarterly Reports

- Quarterly quality reports summarizing quality activities will be submitted to the DOE Project Office and MK corporate QA manager.

- The Extrinsic SWATS Reports will be submitted quarterly to the DOE project office for closure of externally identified deficiencies.

12 REFERENCES

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MK-Ferguson Company and Jacobs Engineering Group, 1992b. *Site Consolidated Transportation Activity Manual*, Rev. 0. DOE/OR/21548-309. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. October.

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U.S. Department of Energy, 1992. *Feasibility Study for Remedial Action at the Chemical Plant Area of the Weldon Spring Site*. Volume I: Main Text; Volume II: Appendixes. RI/FS-EIS Document: DOE/EIS-0185D; Feasibility Study: DOE/OR/21548-148. Oak Ridge Field Office, Weldon Spring Remedial Action Project. November.

U.S. Environmental Protection Agency, 1983. *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans*. QAMS - 005/80; EPA-600/4-83-004. Office of Monitoring Systems and Quality Assurance, Office of Research and Development, February.

U. S. Environmental Protection Agency, 1986b. Office of Emergency and Remedial Response, *Users Guide to the Contract Laboratory Program*, Washington, D.C. December.

U. S. Environmental Protection Agency, 1987. *Data Quality Objectives for Remedial Response Activities*. EPA 540/G-87/003. Office of Emergency and Remedial Response and Office of Waste Programs Enforcement, March.

Regulations

Code of Federal Regulations 40 CFR 300 - *National Oil and Hazardous Substances Contingency Plan*.

DOE Order

DOE Order 5700.6C, *Quality Assurance*

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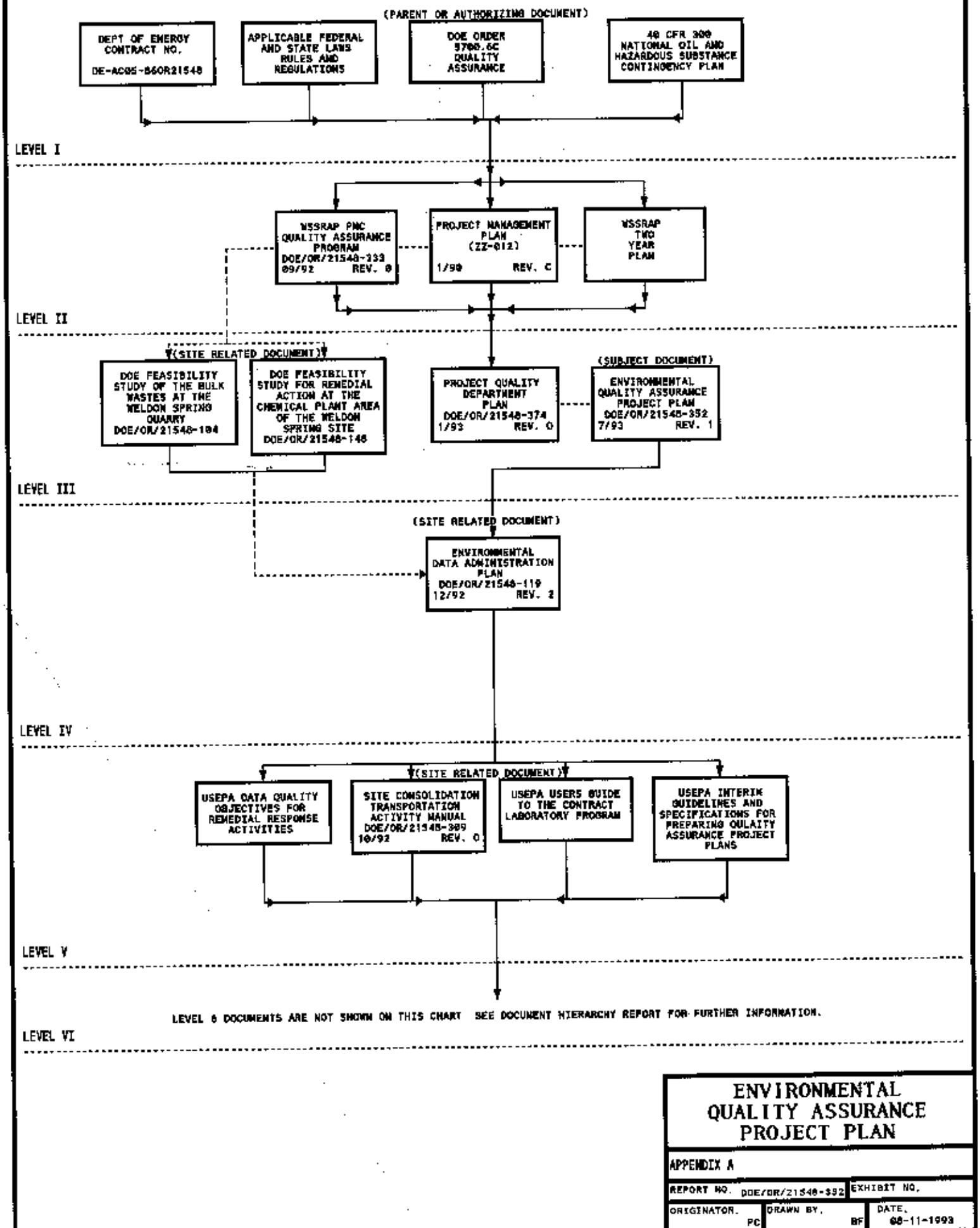
APPENDIX A
Environmental Quality Assurance Project Plan Document Hierarchy


(PARENT OR AUTHORIZING DOCUMENT)
DEPT OF ENERGY CONTRACT NO. DE-AC05-86OR21548
APPLICABLE FEDERAL AND STATE LAWS RULES AND REGULATIONS
DOE ORDER 5700.6C QUALITY ASSURANCE
40 CFR 300 NATIONAL OIL AND HAZARDOUS SUBSTANCE CONTINGENCY PLAN
LEVEL I
WSSRAP PMC QUALITY ASSURANCE PROGRAM DOE/OR/21548-333 09/92 REV. 0
PROJECT MANAGEMENT PLAN (ZZ-012) 1/90 REV. C
WSSRAP TWO YEAR PLAN
LEVEL II
(SITE RELATED DOCUMENT)
DOE FEASIBILITY STUDY OF THE BULK WASTES AT THE WELDON SPRING QUARRY DOE/OR/21548-184
DOE FEASIBILITY STUDY FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE DOE/OR/21548-148
PROJECT QUALITY DEPARTMENT PLAN DOE/OR/21548-374 1/93 REV. 0
(SUBJECT DOCUMENT)
ENVIRONMENTAL QUALITY ASSURANCE PROJECT PLAN DOE/OR/21548-352 7/93 REV. 1
LEVEL III
(SITE RELATED DOCUMENT)
ENVIRONMENTAL DATA ADMINISTRATION PLAN DOE/OR/21548-119 12/92 REV. 2
LEVEL IV
(SITE RELATED DOCUMENT)
USEPA DATA QUALITY OBJECTIVES FOR REMEDIAL RESPONSE ACTIVITIES
SITE CONSOLIDATION TRANSPORTATION ACTIVITY MANUAL DOE/OR/21548-389 10/92 REV. 0
USEPA USERS GUIDE TO THE CONTRACT LABORATORY PROGRAM
USEPA INTERIM GUIDELINES AND SPECIFICATIONS FOR PREPARING QULAITY ASSURANCE PROJECT PLANS
LEVEL V
LEVEL 6 DOCUMENTS ARE NOT SHOWN ON THIS CHART SEE DOCUMENT HIERARCHY REPORT FOR FURTHER INFORMATION.
LEVEL VI
ENVIRONMENTAL QUALITY ASSURANCE PROJECT PLAN
APPENDIX A
REPORT NO. DOE/OR/21548-352
EXHIBIT NO.
ORIGINATOR. PC
DRAWN BY. BF
DATE. 08-11-1993