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CONTRACT NO. DE-AC05-86OR21548

WELDON SPRING SITE REMEDIAL ACTION PROJECT SECOND FIVE-YEAR REVIEW

WELDON SPRING SITE REMEDIAL ACTION PROJECT
WELDON SPRING, MISSOURI

AUGUST 2001 **REV. 0**

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

Prepared by MK-Ferguson Company and Jacobs Engineering Group

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Deputy Project Director — Date: 8/30/01

DOE/OR/21548-891

Weldon Spring Site Remedial Action Project

Weldon Spring Site Remedial Action Project Second Five-Year Review

Revision 0

August 2001

Prepared by

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and
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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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EXECUTIVE SUMMARY

The second five-year review of the Weldon Spring Site Remedial Action Project in St. Charles, Missouri was completed in June 2001. The results of the five-year review indicate that the remedies are expected to be protective of human health and the environment. Overall, the remedies at the four operable units at the Weldon Spring Site Remedial Action Project are functioning as intended. The four operable units include (1) the Quarry Bulk Waste Operable Unit, (2) the Chemical Plant Operable Unit, (3) the Quarry Residuals Operable Unit, and (4) the Groundwater Operable Unit.

Quarry Bulk Waste Operable Unit: The remedy for the Quarry Bulk Waste Operable Unit is protective of human health and the environment. This remedial action was completed in June 1996. The action consisted of excavating the bulk waste from the quarry and placing them in controlled temporary storage pending a final decision on waste disposal as documented by the *Chemical Plant ROD* (Ref. 8). Excavating the wastes from the quarry and placing it in controlled storage mitigated the potential for exposure through direct contact with the waste material and removed the source of ongoing contaminant migration to groundwater. The final remedy for the quarry including groundwater is being addressed through the Quarry Residual Operable Unit.

Chemical Plant Operable Unit: The ROD for the Chemical Plant Operable Unit was issued in September 1993. The remedy for the Chemical Plant Operable Unit consisted of the following main components:

- Dredge sludge from the raffinate pits; excavate sediment from Frog Pond and Ash Pond; and excavate soil from specific locations on site and vicinity properties off site;
- Dispose of material stored at the temporary facilities on site (including bulk waste excavated from the quarry and chemical plant area, and building material from the chemical plant area);
- Treat raffinate pit materials by chemical stabilization/solidification (CSS);
- Dispose of treated and untreated contaminated materials in facility designed and constructed specifically for the Weldon Spring Site wastes.

The Chemical Plant Operable Unit remedial action is substantially complete. The source areas have all been remediated and confirmed to cleanup criteria which support anticipated land use. The disposal cell was closed on June 5, 2001, and the only field activities remaining are completion of the cell cap and final grading and seeding. Long term monitoring of the cell and the site will be conducted as described in the *Long Term Monitoring and Maintenance Plan for the Weldon Spring Site* (Ref. 67). The remedy for the Chemical Plant Operable Unit is expected to be protective of human health and the environment.

Quarry Residuals Operable Unit: The ROD for the Quarry Residuals Operable Unit was issued in September 1998. This response action follows up the Quarry Bulk Waste remedial action and constitutes the final remedy for the Quarry area. Residual contaminated soil has been removed from the quarry proper and backfilling of the quarry is underway, eliminating any remaining potential for exposure through direct contact with soil or waste material. Final reclamation of the quarry will be completed in 2002. In conjunction with this action, assessments were performed to evaluate the risks associated with potential exposure to contaminated surface water, sediments, and groundwater in the vicinity of the quarry. The results indicate that residual conditions in the quarry area are protective of public health and the environment under current and reasonably anticipated future uses. Although not a threat under existing conditions, the contaminated groundwater is in proximity to a drinking water source, and long-term monitoring will be performed to assure conditions remain protective. The remedy is expected to be protective of human health and the environment.

Groundwater Operable Unit: The final remedy for the Groundwater Operable Unit has not been selected at this time. The interim ROD for the Groundwater Operable Unit was issued in September 2000 and only addressed the active remediation of the trichloroethylene impacted groundwater at the chemical plant. This remedial action is in the design stages, with actual field work planned to begin in the fall of 2001. To support the final GWOU ROD, studies of pump tests, including some with artificial recharge, were conducted in the Spring/Summer of 2001. The results of these studies will lead to the final ROD for the groundwater operable unit.

The potential threats to public health are based on hypothetical exposure through usage of groundwater as drinking water. The groundwater is expected to be protective of human health and the environment under current and expected use. If contaminants remain in the groundwater above health-based levels, use will be restricted and long-term monitoring and surveillance will be conducted.

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ABSTRACT

The second five-year review of the Weldon Spring Site Remedial Action Project in St. Charles, Missouri was completed in June 2001. The results of the five-year review indicate that the remedies are expected to be protective of human health and the environment. Overall, the remedies at the four operable units at the Weldon Spring Site Remedial Action Project are functioning as intended. The four operable units include (1) the Quarry Bulk Waste Operable Unit, (2) the Chemical Plant Operable Unit, (3) the Quarry Residuals Operable Unit, and (4) the Groundwater Operable Unit.

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1. INTRODUCTION

1.1 Authority Statement and Purpose

The U.S. Department of Energy (DOE) has conducted a second five-year review of the remedial actions implemented at the Weldon Spring Site Remedial Action Project (WSSRAP) in St. Charles County, Missouri. This review was conducted from January 2001 through June 2001. This report documents the results of the review and has been prepared in accordance with the Environmental Protection Agency (EPA) draft guidance document, *Comprehensive Five-Year Review Guidance,* (Ref. 1).

The first five-year review, *The U.S. Department of Energy Five-Year Review (Type 1a)* (Ref. 5) was completed in June 1996. This was the initial review to ensure that the remedial actions established in the *Record of Decision for Management of Bulk Wastes at the Weldon Spring Quarry* (Quarry Bulk Waste ROD) (Ref. 6) and *Record of Decision for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Chemical Plant ROD) (Ref. 8) remained protective of human health and the environment. As directed by the EPA guidance existing at that time, it was designated as a Type 1a review, applicable to a site at which a response was ongoing. The above-referenced draft guidance eliminated the system of review levels presented in previous five-year directives.

This five-year review encompasses all four operable units that have been designated part of the remedial action at the WSSRAP. This includes (1) the Quarry Bulk Waste Operable Unit which had its ROD issued in September 1990, (2) the Chemical Plant Operable Unit, which had its ROD issued in September 1993, (3) the Quarry Residuals Operable Unit (QROU), which had its ROD issued in September 1998, and (4) the Groundwater Operable Unit (GWOU), which had an interim ROD issued in September 2000. Although the remedial actions for the QROU and the GWOU have not been operational for five years, they are included in this five-year review. The draft EPA guidance states that "Five-year reviews should address all operable units (OUs) and remedial actions for which there is a ROD or Action Memorandum" and "An entire site is subject to a statutory review if any of its remedial actions is subject to a statutory review." Also, for organizational and practical reasons, it is logical to conduct the five-year review on the four operable units at the same time.

The purpose of five-year reviews is to determine whether the remedy at a site is expected to be protective of human health and the environment. Where a site has remedial actions that are still under construction or ongoing, a five-year review should confirm that immediate threats have been addressed and that the remedy will be protective when complete. The main purpose of the five-year review is not to reconsider decisions made during the selection of a remedy, but to evaluate the implementation and performance of the selected remedy. The methods, findings, and conclusions of reviews are documented in five-year review reports. In addition, five-year review reports identify deficiencies found during the review, if any, and recommendations to address them.

Five-year reviews are required by statute. They must be implemented consistent with the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) and the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP). CERCLA Section 121(c), as amended, states:

> If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to ensure that human health and the environment are being protected by the remedial action being implemented.

The NCP Part 300.430(f)(4)(ii) of the Code of Federal Regulations (CFR) states:

> If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.

2. CHRONOLOGY

Following is a chronology of the Weldon Spring Site Remedial Action Project.

EVENT	DATE
Army ordnance works begins operations	1941
Army begins burning waste and dumping rubble	1942
Army ordnance works ends operations	1945
Majority of ordnance works property transferred to State of Missouri	1949
Army stops quarry activity	1949
Chemical plant site transferred to AEC	1955
Uranium feed materials plant operations begin	1958
AEC acquires quarry title	1958
AEC begins waste disposal in quarry	1963
Uranium feed materials plant operations end	1966
Chemical plant site transferred to Army	1967
AEC stops waste disposal at quarry	1967
Army starts waste disposal at quarry	1968
Army begins decontaminating buildings and removing equipment at chemical plant	1968
AEC stops waste disposal in quarry	1969
Army transfers raffinate pits to AEC	1971
DOE designates Weldon Spring Site Remedial Action Project as a Major Project	1985
The Prime Management Contractor (PMC) is selected	2/1986
DOE and PMC establish site office	7/1986
PMC assumes site control	10/1986
Quarry is placed on the NPL	7/1987
WSSRAP designated as a Major Systems Acquisition	5/1988
Chemical plant and raffinate pits added to the NPL	3/1989
Remedial investigation for the quarry bulk waste complete	12/1989
Feasibility study for the quarry bulk waste complete	2/1990
Record of Decision for management of the bulk waste at the Weldon Spring Quarry complete	9/1990
Quarry bulk waste excavation support begins	6/1991
Building dismantlement begins	3/1992
Remedial investigation/feasibility study for chemical plant complete	11/1992
First batch of water discharged from quarry water treatment plant	1/1993
Quarry bulk waste excavation begins	5/1993
First batch of water discharged from site water treatment plant	5/1993
Record of Decision for remedial action at the chemical plant area of the Weldon Spring site complete	9/1993
Remedial design work plan for the chemical plant complete	1/1994
CSS pilot plant testing	1995
Building dismantlement is completed	1/1995
Remedial action work plan for the chemical plant complete	11/1995
Quarry bulk waste excavation complete	12/1995
Remedial action report for the quarry bulk waste complete	3/1997
Remedial investigation for groundwater operable unit complete	7/1997
Remedial investigation for quarry residuals complete	2/1998
Feasibility study for quarry residuals complete	3/1998
First load of waste placed in disposal cell	3/5/1998
Chemical stabilization/solidification (CSS) plant begins operation	7/1998
Record of Decision for quarry residuals complete	9/1998
CSS plant completed operations	11/13/98
Feasibility study for groundwater operable unit complete	12/1998
Supplemental feasibility study for groundwater operable unit complete	6/1999

EVENT	DATE
Remedial design/remedial action work plan for the quarry residuals complete	1/2000
Demolition of site water treatment plant completed	7/6/2000
Interim Record of Decision for groundwater operable unit complete	9/2000
Confirmation of chemical plant soil completed	3/2001
Demolition of quarry water treatment plant completed	5/2001
Disposal cell closed	6/2001

3. BACKGROUND

3.1 Site Description

The Weldon Spring site is in southern St. Charles County, Missouri, approximately 30 mi west of St. Louis, as shown in Figure 3-1. The chemical plant site consists of two main areas, the Weldon Spring Chemical Plant and raffinate pits and the Weldon Spring Quarry, both located along Missouri State Route 94. Access to both the chemical plant site and quarry is restricted by locked chain-link fences with on-site security.

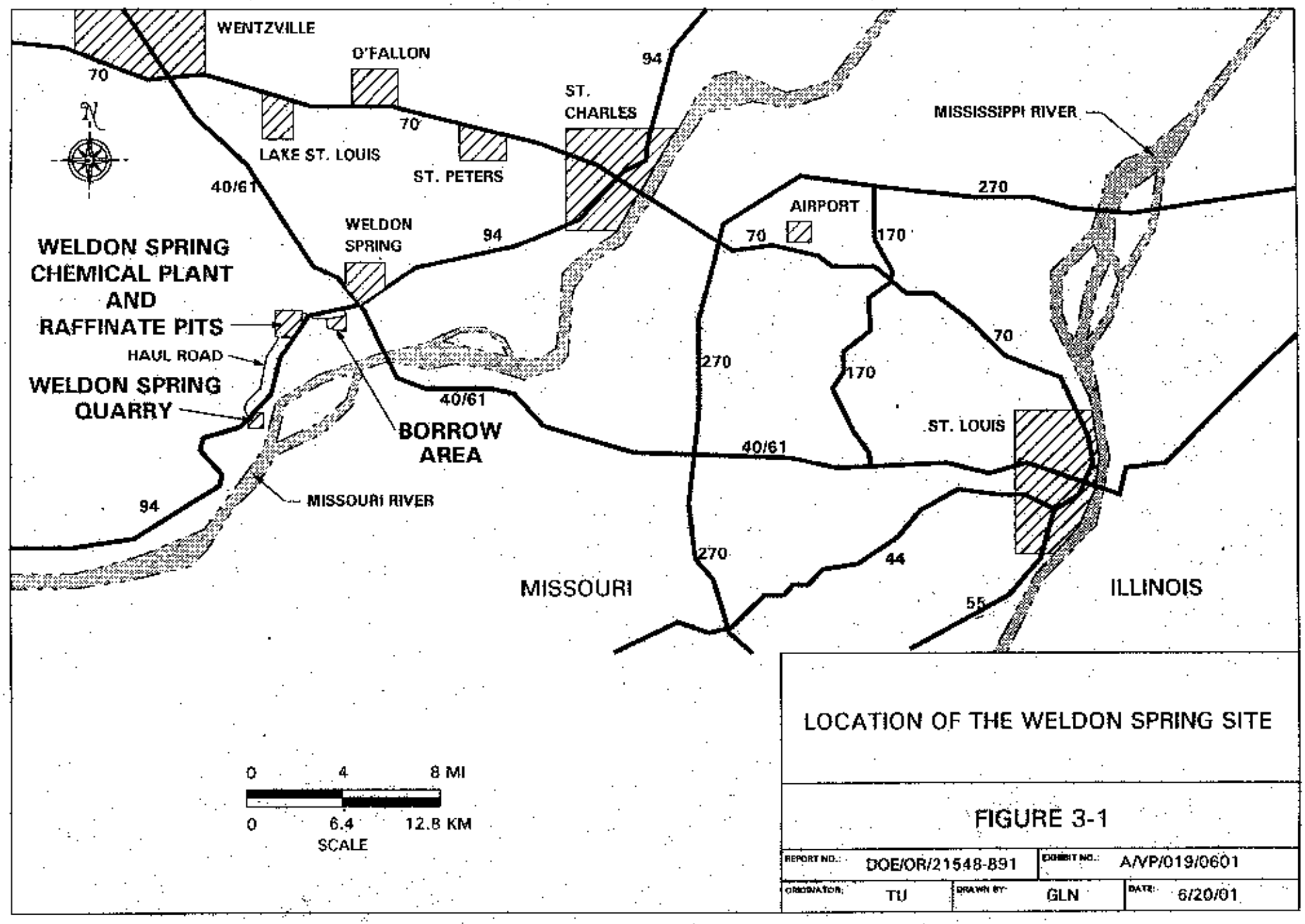
The Weldon Spring Chemical Plant is a 226-acre area that operated as the Weldon Spring Uranium Feed Materials Plant (WSUFMP) until 1966. Buildings were contaminated with asbestos, hazardous chemical substances, uranium, and thorium. (Building dismantlement was completed in 1994.) Radiological and chemical (polychlorinated biphenyls [PCBs], nitroaromatic compounds, metals and inorganic ions) contaminants were found in the soil in many areas around the site. The raffinate pits consisted of four settling basins that covered approximately 26 acres as shown in Figure 3-2. These pits were characterized as being contaminated with uranium and thorium residues and chemical contaminants including nitrate, fluoride, PCBs, and various heavy metals (Ref. 2). The two largest pits were remediated and backfilled in 1999, and the remaining two were remediated in 2000.

The Weldon Spring Quarry is a former 9-acre limestone quarry south-southwest of the chemical plant area (Figure 3-3). The quarry is essentially a closed basin; surface water within the rim flows to the quarry floor and into a sump. Backfilling of the sump has begun to eliminate ponding and mitigate physical hazards. Removal of the bulk waste from the quarry was completed in 1995. This waste contained radiological and chemical contaminants including uranium, radium, thorium, metals, nitrates, PCBs, semivolatile organic compounds, nitroaromatics, and asbestos (Ref. 3).

3.2 Site History

From 1941 to 1945, the U.S. Department of the Army produced trinitrotoluene (TNT) and dinitrotoluene (DNT) at the Weldon Spring Ordnance Works, which covered 17,233 acres of land that now includes the Weldon Spring site. Two hundred five acres of the former ordnance works property were transferred in May 1955 to the Atomic Energy Commission (AEC) for construction of the Weldon Spring Uranium Feed Materials Plant (WSUFMP), now referred to as the Weldon Spring Chemical Plant. Considerable explosives decontamination was performed by Atlas Powder Company and the Army prior to construction of the WSUFMP.

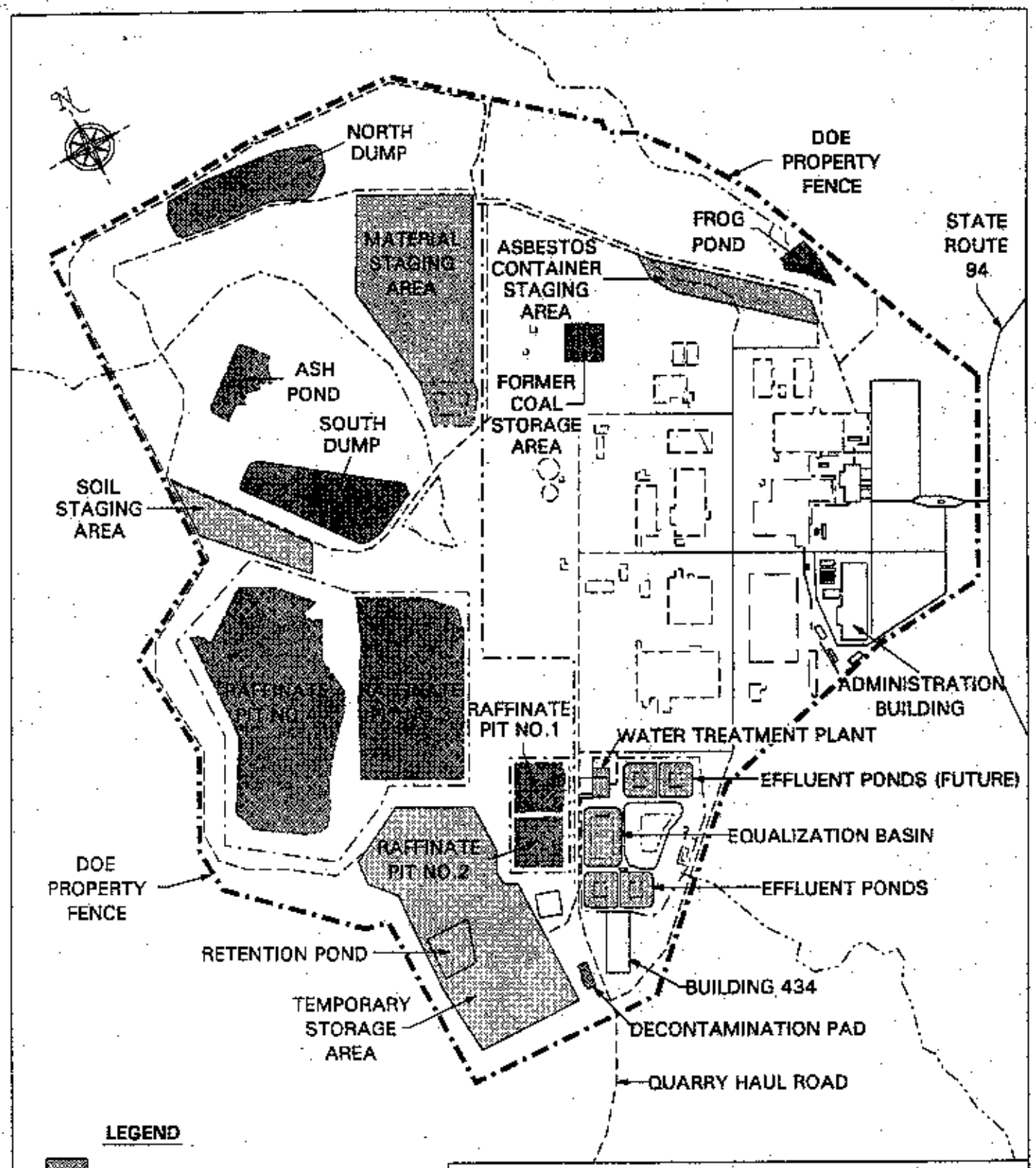
From 1958 until 1966, the WSUFMP converted processed uranium ore concentrates to pure uranium trioxide, intermediate compounds, and uranium metal. A small amount of thorium



LOCATION OF THE WELDON SPRING SITE

FIGURE 3-1

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/VP/019/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/20/01	



LEGEND

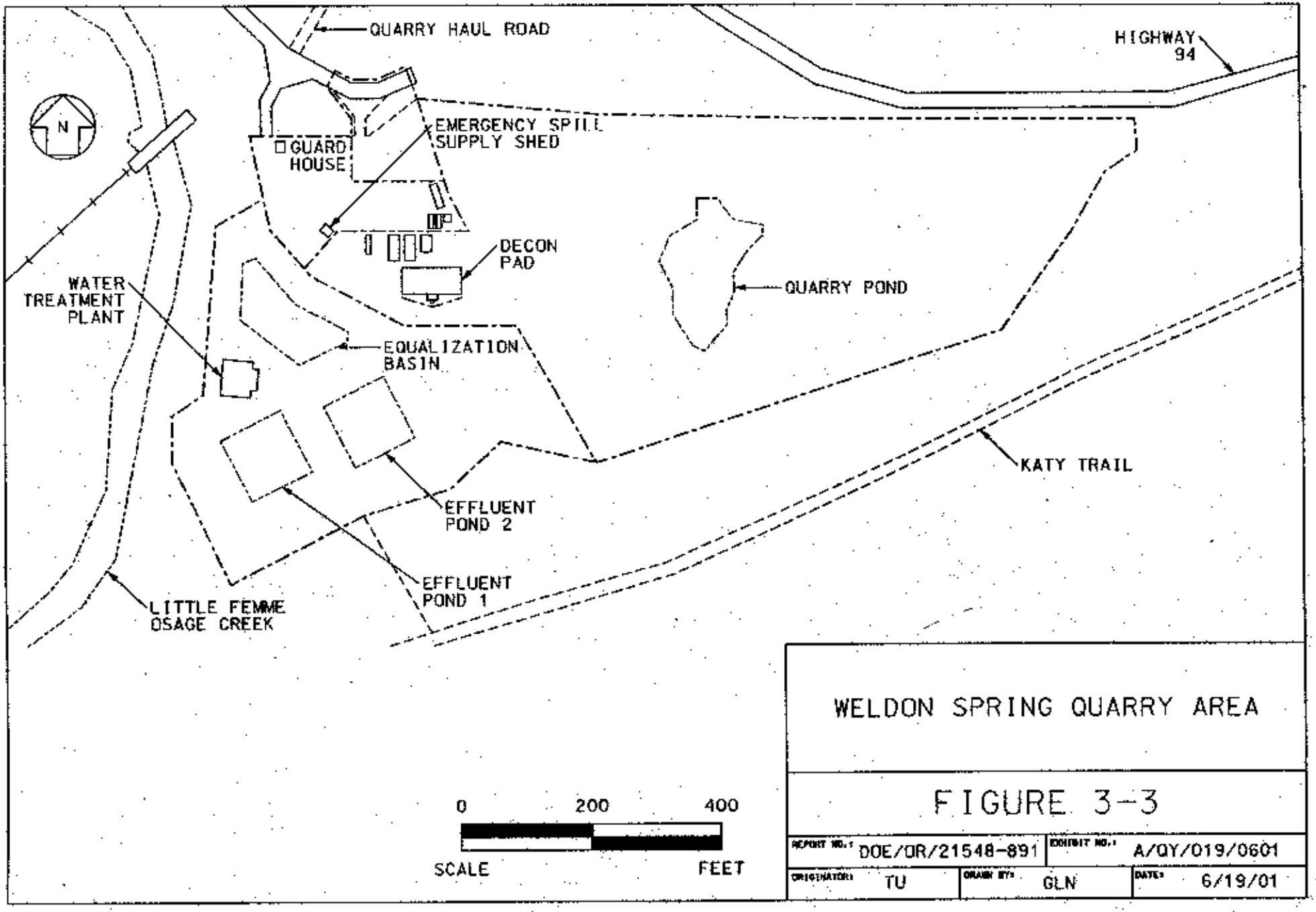
- CONTAMINATED SOURCE AREAS
- FACILITIES BEING CONSTRUCTED
- STRUCTURES BEING DISMANTLED

0 500 1000 FT
0 152.4 304.8 M
SCALE

GENERAL LAYOUT OF THE CHEMICAL PLANT AREA

FIGURE 3-2

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/CP/017/0293	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/20/01	



WELDON SPRING QUARRY AREA

FIGURE 3-3

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/QY/019/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/19/01	

was also processed. Wastes generated during these operations were stored in the raffinate pits. These pits were radiologically contaminated with uranium and thorium residues and chemically contaminated with nitrate, fluoride, PCBs, and various heavy metals. The buildings were contaminated with asbestos, hazardous chemical substances, and small quantities of uranium and thorium. Radiological and chemical contaminants (PCBs, nitroaromatic compounds, metals, and inorganic ions) were also found in the soil at many locations.

Prior to 1942, limestone aggregate was extracted from the quarry for use in construction of the ordnance works. After 1942, the Army used the quarry for burning wastes produced during manufacture of TNT and DNT and for disposal of TNT-contaminated rubble. In 1958, the AEC acquired title to the quarry and used it from 1963 to 1969 as a disposal area for building rubble and soils from the demolition of a uranium ore processing facility in St. Louis and from the chemical plant. Other wastes disposed of in the quarry included drummed radioactive materials, uncontained wastes, and contaminated process equipment. The bulk waste contained radiological and chemical contaminants including uranium, radium, thorium, metals, nitrates, PCBs, semivolatile organic compounds, nitroaromatics, and asbestos.

The chemical plant site was in caretaker status from 1967 through 1985. In 1985, the U.S. Department of Energy (DOE) designated control and decontamination of the chemical plant, raffinate pits, and quarry as a major project. The Project Management Contractor 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, and the PMC, MK-Ferguson Company and Jacobs Engineering Group, Inc., assumed control of the site on October 1, 1986. The quarry was placed on the Environmental Protection Agency's National Priorities List (NPL) in July 1987. The DOE redesignated the site as a Major System Acquisition in May 1988. The chemical plant and raffinate pits were added to the NPL in March 1989.

In 1986, the Environmental Protection Agency (EPA) and DOE entered into a Federal Facilities Agreement (FFA). This agreement has since been amended and is consistent with the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA), Section 120. The amended FFA includes agreements to ensure that the environmental impacts associated with past and present activities at the Weldon Spring site are thoroughly investigated and that appropriate remedial action is taken, as necessary, to protect public health and the environment. This FFA also facilitates the exchange of information among the EPA, DOE, and the State of Missouri and contains procedures for resolving disputes, assigning penalties for nonconformance, and ensuring public participation in the remedial action decision-making process.

For purposes of CERCLA compliance, the WSSRAP has been broken into four operable units (OUs). The quarry is addressed by the Quarry Bulk Waste OU, which included excavation, transportation, and temporary storage of bulk waste materials; and the Quarry Residuals OU, which will address any contamination remaining in the quarry area following bulk waste removal. The Chemical Plant OU addresses the final disposal of the quarry bulk waste, chemical

plant, and vicinity property materials in an engineered land disposal facility. The Groundwater OU addresses contamination in the groundwater of the area surrounding the chemical plant site.

3.3 Current and Future Land and Resource Use

3.3.1 Current Land Use

The Weldon Spring site is in St. Charles County which in 2000 had a population of approximately 283,833. The largest city in the county is St. Charles, which is approximately 15 mi northeast of the site and has a population of about 58,156. The two communities closest to the site are Weldon Spring and Weldon Spring Heights, about 2 miles to the northeast. The combined population of these two communities in 2000 was 5,349.

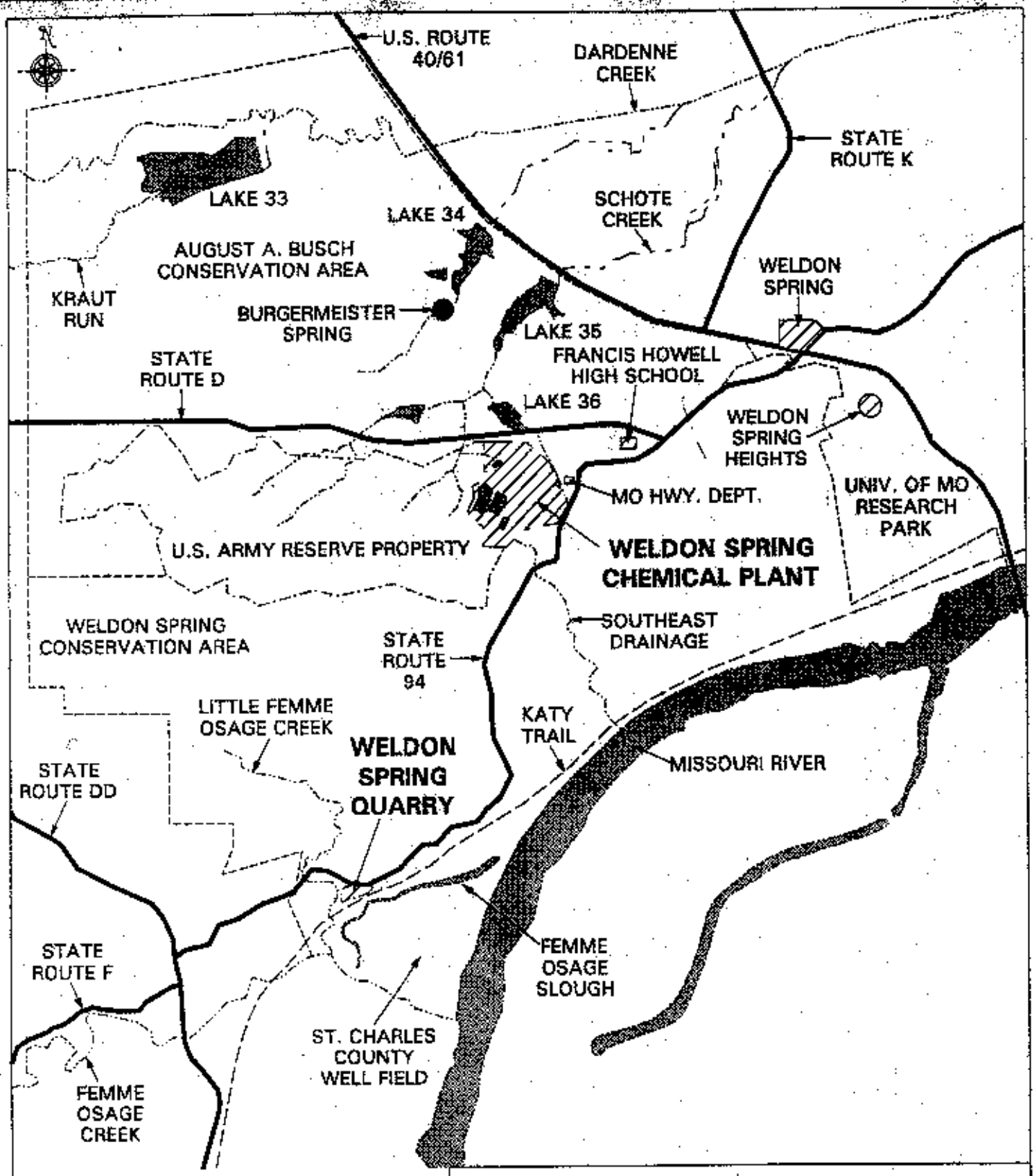
Adjacent to the chemical plant area, portions of the Weldon Spring Training Area that are within the ordnance works area are currently used for field training and outdoor maneuvers by the U.S. Army reserve, the Missouri Army National Guard, and other military and police units. An estimated 3,300 local Army reservists and 3,400 other reserve troops use the training area each year. The Department of the Army intends to continue using the area for training activities.

A large portion of the ordnance works area has been converted into conservation areas. The August A. Busch Memorial Conservation Area and the Weldon Spring Conservation Area (see Figure 3-4) are managed by the Missouri Department of Conservation and are open throughout the year for recreational use. These areas receive an estimated 1.2 million visitors each year.

A state highway maintenance facility just east of the chemical plant area employs eleven full-time employees. The former staff housing complex for the ordnance works, which lies southeast of the intersection of State Route 94 and U.S. Route 40/61, is currently a private housing development know as Weldon Spring Heights; it has about 80 residents.

Francis Howell High School, about 0.6 mi east of the chemical plant area, employs approximately 150 faculty and staff (including employees at the Francis Howell Administration Annex) and is attended by about 1,500 students (Ref. 4).

The Weldon Spring quarry is located within the Weldon Spring Conservation Area, which occupies 7,356 acres and is managed for recreational use by the Missouri Department of Conservation. The August A. Busch Memorial Conservation Area and the Howell Island Conservation Area are north and east of the quarry, respectively. Katy Trail State Park traverses the Weldon Spring Conservation Area along the route of an abandoned railroad bed that runs adjacent to the southern margin of the quarry. This trail, which was established by the Missouri



SURFACE FEATURES NEAR THE WELDON SPRING SITE

FIGURE 3-4

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/VP/020/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/20/01	

Department of Natural Resources, is used annually by several thousand people from the local area. The town of Defiance is about 3 mi from the quarry with a population of 100.

3.3.2 Future Land Use

The 217-acre chemical plant area is expected to remain under control and ownership of the DOE. As currently planned, only three buildings will remain within the chemical plant proper after project completion and site closure.

The access control building may contain the DOE maintenance equipment storage area and the Weldon Spring site interpretative center. The center is expected to be a place where the public can obtain information about the site after the project office closes.

The disposal facility, which covers approximately 60 acres of the chemical plant area, will be maintained and monitored by the DOE. A small water treatment enclosure will be located near the leachate sump. The land outside the disposal cell perimeter road will remain under DOE control.

The training area will continue to be used for field training. The Missouri Department of Conservation will continue to maintain the remaining surrounding areas for recreational use (Ref. 4).

3.3.3 Current Groundwater and Spring Water Use

Groundwater under the chemical plant and raffinate pits area is not currently used for drinking or other domestic purposes. Most of the residents in the nearby communities are supplied with municipal water.

Several springs and seeps that receive groundwater discharge are present near the chemical plant area. Burgermeister Spring, 1 mi northwest of the chemical plant area, is a major discharge point for groundwater migrating from the chemical plant area. Recreational visitors to the August Busch Memorial Conservation Area have access to this spring. Groundwater south of the groundwater divide at the chemical plant area primarily flows toward the Southeast Drainage. This drainageway is also accessible to recreational visitors in the area (Ref. 4).

3.3.4 Potential Future Groundwater and Spring Water Use

A municipal water supply is currently available to serve the household needs of the area communities. Thus, for the foreseeable future, it is unlikely that the impacted groundwater beneath the chemical plant area would be used for household purposes. In addition, the impacted shallow portion of the aquifer is characterized by low yields. The deeper, unaffected higher yielding aquifers would more likely serve as a groundwater source in the unlikely event groundwater use were ever to occur. Despite the unlikelihood of the impacted groundwater

actually ever being used for household purposes, in accordance with EPA guidelines and for purposes of making the remedial action determination, this shallow groundwater is a potentially usable resource.

Access to spring water will remain similar to current conditions, consistent with recreational land use (Ref. 4).

3.4 Interim Response Actions

Initial remedial activities at the chemical plant site consisted of a series of Interim Response Actions (IRAs) authorized through the use of Engineering Evaluation/Cost Analysis (EE/CA) reports. Table 3-1 is a list of these IRAs. Electrical transformers, electrical poles and lines, and overhead piping and asbestos were removed by IRAs because they presented an immediate threat to workers and the environment. An isolation dike was built to divert runoff around the Ash Pond area to reduce the concentration of contaminants going off site in surface water. The Debris Consolidation IRA consisted of detailed characterization of on-site debris, separation of radiological and nonradiological debris, and transport of the materials to designated staging areas for interim storage. A separate IRA addressed handling, stabilizing, transporting, and disposing of the hazardous and nonhazardous chemicals.

Two major activities addressed by IRAs were treatment of water and dismantlement of the chemical plant buildings. Separate EE/CAs were prepared for the site and quarry water treatment plants. The first batch of water from the quarry water treatment plant was discharged in January 1993. The first batch from the site water treatment plant was discharged in May of the same year. Water was treated at both sites to remove chemical and radiological contaminants. The water was tested prior to batch discharge, and released. Two hundred seventy-six million gallons of water meeting National Pollutant Discharge Elimination System (NPDES) discharge criteria were treated and released. Dewatering of the four raffinate pits was completed in September 1999. Demolition of the site water treatment plant was completed on July 6, 2000, and the quarry water treatment plant demolition was completed in May 2001 (Ref. 4).

Another on-site activity consisted of dismantling the 44 chemical plant buildings through four IRAs. Each of these actions consisted of:

- Manual removal of radioactive contamination from surfaces (e.g., by aggressively vacuuming and/or wiping equipment exteriors and building interiors and exteriors).

- Removal of all PCB-contaminated material, with transport of all nonradiologically PCB-contaminated material to an approved commercial treatment/disposal facility (radiologically contaminated PCB wastes were shipped to the Oak Ridge *Toxic Substance Control Act* (TSCA) incinerator in 1996).

- Isolation of asbestos containing material with storage on site pending final disposal in the disposal cell.
- Follow-on decontamination of structural surfaces, as appropriate, to remove loose radioactive contamination.
- Dismantlement of structures, with further decontamination of previously inaccessible surfaces.
- Placement of material in a controlled area for temporary storage.

Table 3-1 WSSRAP Interim Response Actions

NUMBER	DESCRIPTION	STATUS
1	Electrical Transformer Removal	Closed
2	Ash Pond Diversion Dike	Closed
3	MSA (Moved to IRA 15)	Cancelled
4	Army Property 7	Closed
5	Busch Wildlife Areas 3, 4, 5, 8	Cancelled
6	Overhead Piping/Asbestos Removal	Closed
7	Containerized Chemicals	Complete
8	Electrical Pole/Overhead Line Removal	Closed
9	Consolidate Loose Yard Debris	Closed
10	Building 409 Dismantlement	Closed
11	Building 401 Dismantlement	Closed
12	Construct a dike on SE Drainage	Cancelled
13	Army Reserve Properties 1, 2, 3, 7	Cancelled
14	Non-Process Building Dismantlement (Moved to IRA 15-19)	Cancelled
15	Non-Process Building Dismantlement	Closed
16	Non-Process Building Dismantlement (Moved to IRA-18)	Cancelled

Table 3-1 WSSRAP Interim Response Actions (Continued)

NUMBER	DESCRIPTION	STATUS
17	Non-Process Building Dismantlement (Moved to IRA 18)	Cancelled
18	Process Building Dismantlement	Closed
19	Decontamination Facility	Cancelled
20	Site Water Treatment Plant	Complete
21	Quarry Water Treatment Plant	Complete
22	Quarry Construction Staging Area (Incorp. into Bulk Waste ROD)	Cancelled
23	Southeast Drainage Soil Removal	Closed

Closed = Final Closure Report has been completed.
Complete = The action has been completed but the Closure Report has not been finalized.

Two IRAs addressed off-site activities: IRA-4 for Vicinity Property 7, included cleanup of approximately 1.5 cu yd of radiologically contaminated soils in 1988. The Southeast Drainage EE/CA, which addressed hot-spot cleanup in a drainage leaving the chemical plant site, is discussed in Section 4.2.4.7.

4. REMEDIAL ACTIONS

This five-year review encompasses all four operable units that have been designated part of the remedial action. This includes (1) the Quarry Bulk Waste Operable Unit, which had its Record of Decision (ROD) issued in September 1990, (2) the Chemical Plant Operable Unit, which had its ROD issued in September 1993, (3) the Quarry Residuals Operable Unit, which had its ROD issued in September 1998, and (4) the Groundwater Operable Unit, which had an interim ROD issued in September 2000

4.1 Quarry Bulk Wastes Operable Unit

The three major components listed in the *Record of Decision for the Management of Bulk Wastes at the Weldon Spring Quarry* (Ref. 6) were:

- Removing bulk wastes from the quarry using standard equipment and procedures.
- Transporting the bulk wastes along a dedicated haul road to the chemical plant area.
- Placing the bulk wastes in controlled storage in an engineered temporary storage area.

The actions related to this operable unit were substantially complete and documented at the time of the previous five-year review. Prior to completion of the five-year review, characterization performed as part of the remedial investigation for the Quarry Residuals Operable Unit detected a pocket of radiologically contaminated soils along the northeast rim of the quarry. To remediate this area, which threatened to recontaminate the quarry proper, the U.S. Department of Energy (DOE) requested an extension of the Quarry Bulk Waste Operable Unit completion date from March 31, 1996, to July 15, 1996. Removal of contaminated soils began on May 13 and was completed May 21, 1996. In this campaign 561 cu yd of soil were excavated. Reclamation activities were completed on June 7, 1996. The excavated materials were transported via the haul road to the temporary storage area. The *Quarry Bulk Waste Excavation Remedial Action Report* (Ref. 7) documents completion of this operable unit. Final disposition of the excavated bulk waste was determined by *the Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (*Chemical Plant ROD*) (Ref. 8). The waste was disposed of in the on-site disposal cell. Final disposition of the quarry and vicinity groundwater is being addressed through the Quarry Residuals Operable Unit.

4.2 Chemical Plant Operable Unit

According to the *Chemical Plant ROD* (Ref. 8), the major components of the Chemical Plant Operable Unit remedial action were:

- Dredge sludge from the raffinate pits; excavate sediment from Frog Pond, Ash Pond, and three off-site lakes; and excavate soil from specific locations (including two former

dump areas adjacent to the chemical plant buildings on site, and 10 vicinity properties off site) using standard construction equipment and procedures.

- Remove material stored at the temporary facilities on site (including bulk waste excavated from the quarry and the chemical plant area, and building material from the chemical plant area) using standard construction equipment and procedures.

- Treat certain contaminated materials such as the raffinate pit sludges and portions of quarry soil on site by chemical stabilization/solidification (CSS). Dispose of treated and untreated materials in a facility designed and constructed specifically for the Weldon Spring site wastes.

- Continue to evaluate vitrification as a contingency treatment option (Ref. 8).

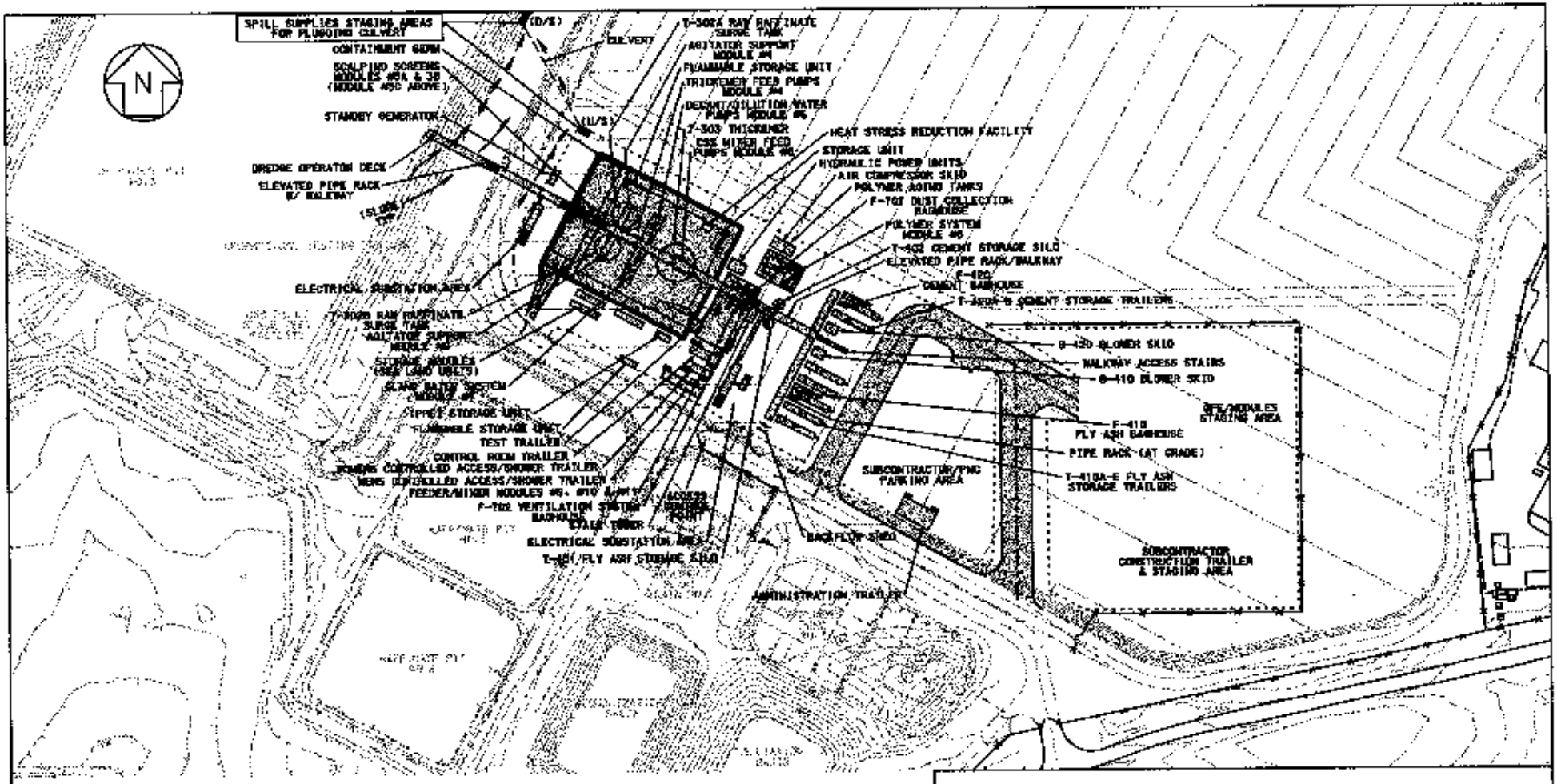
4.2.1 Chemical Stabilization Solidification

Raffinate sludges, which were a waste product from the uranium refining process, were determined to require treatment to form a structurally stable product before the sludges could be placed in the disposal cell. During development of the *Chemical Plant ROD*, on-site chemical stabilization/solidification (CSS) was identified as the most effective technology for treatment of the contaminated sludges. In this process, fly ash and portland cement were mixed with the sludge to produce a grout product that was suitable for permanent placement in the disposal cell.

To provide design data for the full-scale CSS plant, a pilot-scale facility was constructed in 1994 and a testing program, including dredging, was implemented in 1995. The pilot testing data and related conclusions and recommendations were used to design the full-scale CSS plant.

Construction of the plant began in May 1997 and was completed in February 1998. Commissioning and functional testing took place from March to June 1998, and full-scale operations began in July 1998. The plant resembled a concrete plant engineered to efficiently handle sludge and binder to produce grout while controlling particulate and radon emissions. (Figure 4-1) The sludge contained U-238, Th-232 and associated decay products. On November 13, 1998, the CSS plant completed dredging and processing sludge from Raffinate Pit 3. Approximately 122,000 cu yd of sludge was treated and piped directly to the cell as grout. More than 75 million gallons of water with average 8% to 10% solids was pumped through the dredge. The sludge was screened for oversized materials, then thickened with polymer before it was blended with binder materials and transferred to the disposal cell.

The total volume of CSS grout produced (from June 24, 1998 the contractual operations start date), was 188,443 cu yd. The total volume of Pit 3 raffinate treated from June 24, 1998, was 159,990 cu yd. A total of 63,259 short tons of binder was used to stabilize the thickened raffinate. This consisted of 37,915 tons of fly ash and 25,341 tons of cement.



CSS PRODUCTION FACILITY
SITE ARRANGEMENT PLAN

FIGURE 4-1

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/RP/001/0701	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 7/2/01	

The CSS grout product exceeded the *Chemical Plant ROD* minimum design criteria of 50 psi unconfined compressive strength (UCS) at 28 days. The average UCS for the 514 cylinders, representing the 256 grout samples taken for UCS testing, was 216.7 psi. A total of 843 grout samples taken for unit weight testing had an average density of 86.2 lb/cu ft. A total of 815 grout samples taken for percent solids testing had an average percent solids value of 43.3%.

UCS testing was performed on 3 in. by 6 in. grout cylinders that were formed in plastic molds. Eight cylinders were molded from each sample and stored in curing tanks inside the cylinder storage shed. This shed was heated and air conditioned with thermostatic controls that allowed the cylinders to be cured under controlled conditions. Of the eight cylinders that were molded for each sample, one was broken at 3 days, the next at 7 days, the next at 14 days, and another at 21 days. Two were broken at 28 days, and two were saved as archive specimens. The cylinders were stripped from the plastic mold using a commercial cylinder stripping tool. The ends were trued using a jig developed for this purpose and a large knife.

The cylinders were broken in the Geo-Test multi-loader in the CSS QC Laboratory. They were loaded, and readings on the digital display were taken at 0.005-in. increments of travel. The data were recorded on a worksheet and then transferred into a computer spreadsheet which assembled the data into a two page report which included a stress/strain graph.

Ten cylinders failed to achieve the 28-day 50 psi UCS strength required by design. CSS process engineering provided justification for these failures with concurrence from Project Management Contractor (PMC) engineering. Two of the cylinders broke as they were removed from the mold. This operation could be challenging because the plastic of the molds did not always separate easily from the cured grout. The previous breaks, i.e., 7-day, 14-day, etc., had occurred above 50 psi, and this provided the basis for acceptance. Two cylinders were deemed acceptable by averaging the results with the other 28-day cylinders. The remaining six cylinders were made from three samples that were taken when the plant was undergoing routine cleaning or plant system upsets that lasted less than 15 minutes.

The *Operations Plan for the Chemical Stabilization and Solidification Production Facility* (*CSS Ops Plan*) (Ref. 9) required slump test results to be between 5 in. and 10 in. It was apparent during commissioning of the plant that exceeding this slump requirement did not indicate that the grout would fail the 28-day UCS criteria. The slump of the CSS grout product was affected by the lower than expected percent solids from the thickener underflow. The design of the full scale CSS facility was based on 25.1% solids by weight from the thickener underflow stream. This condition was not reproducible in full scale operations. On average, the thickener produced approximately 20.5% solids. Due to binder having less plastic fines than raffinate solids, the resulting CSS grout product had a higher slump than the pilot plant produced. This did not affect the ultimate UCS strength of the product.

The CSS plant was designed and constructed to *Resource Conservation Recovery Act* (RCRA) standards, but in accordance with a nonsignificant change to the ROD dated October 30,

1997, the CSS was not required to meet the operational requirements of RCRA. The basis of this change was the determination that the raffinate pit sludge was not a hazardous waste based on further characterization and additional examination of the data presented in the report, *WSSRAP Raffinate Pit Sludge Characterization Report* (Ref. 10).

During review of the draft *CSS Ops Plan* the Missouri Department of Natural Resources (MDNR) requested that the CSS grout, oversize material, and sand filter material be sampled for toxicity characteristic leaching procedure (TCLP) parameters. The CSS grout was sampled based on the following schedule, which was coordinated with the MDNR through comments/ responses to the *CSS Ops Plan*.

- 1st Week: Once per shift - All TCLP parameters
- 2nd Week: Once per day - TCLP metal parameters
- 3rd Week to End of Operations: Once per week - TCLP metal parameters

The results of the analysis indicated that TCLP constituents were well below the regulatory level for hazardous waste. Table 4-1 summarizes the TCLP metal results for each sample.

The CSS oversize material sampling plan included in the *CSS Ops Plan* required that the first 10 boxes be sampled for the complete TCLP list. The results were well below the RCRA TCLP levels; therefore, it was determined that further sampling was not necessary. The TCLP metal results are in Table 4-2. The sand filter results, also well below TCLP, are summarized in Table 4-3.

Field work for demolition of the CSS plant was initiated on April 23, 1999, and demolition and demobilization activities were completed in late June 1999. Most of the plant components were contaminated radiologically, but some of the items located outside the controlled area of the plant, such as the fly ash and cement storage tanks, were not contaminated and were removed for salvage.

4.2.2 Mixed Waste Treatment

The Federal Facility Compliance Act, signed on October 6, 1992, waived sovereign immunity for fines and penalties for RCRA violations at Federal facilities; however, the Act postponed the waiver for three years for Land Disposal Restriction (LDR) storage prohibition violations for the DOE mixed wastes and required the DOE to prepare plans for developing the required treatment capacity for its mixed waste at each site at which it stored or generated mixed waste. Each plan was required to be approved by the State or EPA by October 1995. The *Site Treatment Plan for the Weldon Spring Site* (Ref. 68) was completed and approved by the required deadline.

Table 4-1 CSS Grout TCLP Metal Results (mg/l)

	Shift No.	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
TCLP LEVELS		**5.0**	**100.0**	**1.0**	**5.0**	**5.0**	**0.2**	**1.0**	**5.0**
WM-C868-062498	pre-prod	ND	4.34	ND	ND	ND	ND	ND	ND
WM-C871-070798	1	ND	1.75	ND	.088	ND	ND	ND	ND
WM-C873-070898	1	ND	2.44	ND	.0664	ND	ND	ND	ND
WM-C874-070898	2	ND	3.07	ND	.0784	ND	ND	ND	ND
WM-C875-070998	1	ND	1.71	ND	.0693	ND	ND	ND	ND
WM-C876-070998	2	ND	2.55	ND	.0819	ND	ND	ND	ND
WM-C877-071098	1	.057	7.1	ND	.026	ND	.00014	ND	ND
WM-C879-071398	1	ND	6.47	.0041	.0080	ND	ND	ND	ND
WM-C880-071398	2	ND	4.33	ND	.0165	ND	ND	ND	ND
WM-C881-071498	1	.0668	4.59	ND	.019	ND	ND	ND	ND
WM-C882-071498	2	.0531	5.92	ND	.0153	ND	ND	ND	ND
WM-C883-071598	1	.0113	6.75	ND	.0208	.163	.0051	.0083	ND
WM-C884-071598	2	.0106	7.17	ND	.0214	.103	.00053	.009	.0011
WM-C885-071698	1	.0149	5.23	ND	.0244	.138	.00081	.013	ND
WM-C886-071798	1	ND	10.9	ND	ND	ND	.001	ND	ND
WM-C887-072098	1	ND	10.3	ND	ND	ND	.0001	ND	ND
WM-C888-072998	1	.0187	4.04	ND	.0492	ND	ND	.0169	ND
WM-C889-080498	1	.010	4.70	.002	.0268	.0018	.00021	.0122	ND
WM-C895-081298	1	.0119	4.99	ND	.0376	.0132	ND	.0189	ND
WM-C897-082098	1	.0116	4.32	ND	.113	ND	ND	.0194	ND
WM-C898-082598	1	.0068	6.16	.00052	.146	.049	ND	.0135	ND
WM-C899-090298	1	.0021	6.02	ND	.0113	.0026	ND	.0062	ND
WM-D001-091098	1	.0025	8.29	ND	.720	ND	ND	.0055	ND
WM-D002-091698	1	.0062	4.83	ND	.022	ND	.00034	.007	ND
WM-D004-092398	1	.004	10.6	ND	.0172	.042	ND	.0077	ND
WM-D007-100298	1	.0902	.709	.00069	.255	.0077	ND	.105	ND
WM-D008-100898	1	.0124	1.77	ND	.0843	ND	ND	.0395	ND
WM-D009-101598	1	.0079	4.69	ND	.0255	.0061	ND	.0118	.002
WM-D030-102198	1	.0048	5.56	ND	.0223	.0072	ND	.0066	ND
WM-D033-102898	1	.0044	7.410	.00042	.045	.0026	ND	.0093	ND
WM-D034-110498	1	.0069	3.650	.00072	.0766	.0032	ND	.0089	ND
WM-D043-111198	1	.014	10.8	ND	.064	.0094	.0015	.024	ND

Table 4-2 CSS Oversize Box TCLP Data

Constituent	Box 1 (mg/l) #5843	Box 2 (mg/l) #5844	Box 3 (mg/l) #5845	Box 4 (mg/l) #5847	Box 5 (mg/l) #5850	Box 6 (mg/l) #5870	Box 7 (mg/l) #5876	Box 8 (mg/l) #5879	Box 9 (mg/l) #5885	Box 10 (mg/l) #5888	TCLP Levels (mg/l)
Arsenic	.193	.17	.154.	.891	.0994	.0645	.168	.188	.007	.0129	5.0
Barium	.078	.44	.072	.232	.163	1.020	.159	.113	.284	.749	100.0
Cadmium	.00379	.0035	ND	.0088	.0020	.0049	.010	.010	ND	ND	1.0
Chromium	.000239	.0038	ND	.135	.0008	.0042	.0168	.0168	.0032	.0173	5.0
Lead	.00129	.048	ND	.020	.0016	.0302	.121	.121	ND	ND	5.0
Mercury	ND	.00010	ND	.00010	.00010	.00010	.00013	.00036	ND	ND	0.2
Selenium	.0582	.033	ND	.0562	.0203	.0483	.193	.193	.114	.0304	1.0
Silver	.0062	.0066	ND	.00070	.0009	.0060	.024	.024	ND	ND	5.0

Table 4-3 CSS Sand Filter TCLP Data

Constituent	Box 1 (mg/l)	TCLP Levels (mg/l)
Silver	.0016	5.0
Arsenic	.0144	5.0
Barium	.296	100.0
Cadmium	.0015	1.0
Chromium	.0021	5.0
Lead	.0020	5.0
Mercury	ND	0.2
Selenium	.0126	1.0

The mixed waste inventory that was the subject of the *Site Treatment Plan*, included reactives, oxidizers, organic liquids and sludges, PCB contaminated wastes, soils, wastewaters, liquid mercury, toxic metal contaminated wastes, aqueous liquids, and debris. The quantity included 902 drums; three 96-cu yd containers; ninety-two 20-cu yd containers; ten 3-cu yd, 4-cu yd, and 10-cu yd containers; 4,600 gal of bulk wastewater, and 4,700 cu yd of soil.

Several different technologies were utilized to treat the wastes, including amalgamation, chemical precipitation, carbon absorption, neutralization, stabilization, chemical oxidation, macroencapsulation and Solvated Electron Technology which were all conducted on site. Prior to treatment, extensive bench testing took place, and a detailed treatment procedure was developed for each technology. After extensive discussions with the State of Tennessee and the K-25 Oak Ridge Incinerator, most of the organic liquids and sludges were shipped to the Oak Ridge K-25 Incinerator for treatment. Small quantities of organic liquids were also shipped for treatment to Diversified Scientific Services, Inc. (DSSI), a commercial facility licensed for radioactive wastes which is located in Kingston, Tennessee.

Table 4-4 summarizes the types and quantities of wastes, treatment technologies, milestones, and treatment dates.

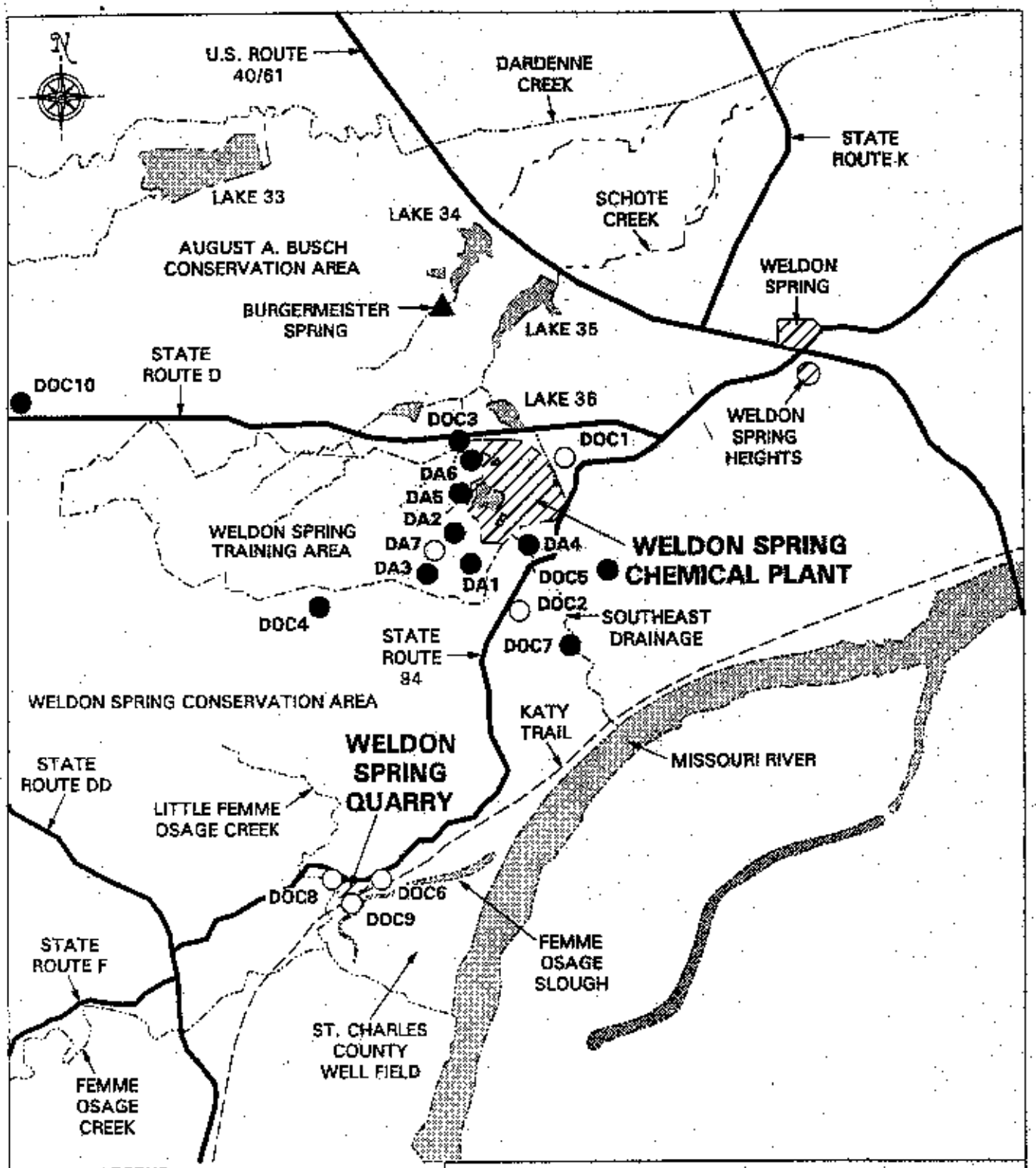
Treatment of the mixed waste inventory identified in the *Site Treatment Plan* was completed in October 1998.

4.2.3 Vicinity Properties

In 1985, Oak Ridge Associated Universities (ORAU) conducted a comprehensive radiological survey of all areas outside the chemical plant boundary and within the ordnance works area. The purpose of the study was to assess the extent and levels of off-site radiological contamination resulting from operation of the uranium feed materials plant. Radiologically contaminated areas outside the boundaries of the chemical plant and quarry areas were defined by ORAU as vicinity properties. Vicinity properties that required remedial action are shown in Figure 4-2. The study examined surface and subsurface soils, water, and sediment on the

Table 4-4 WSSRAP Mixed Waste Treatment Summary

TREATABILITY GROUP	QUANTITY (m^3)	QUANTITY (Containers)	TREATMENT TECHNOLOGY	START- MILESTONE START- ACTUAL	END- MILESTONE END-ACTUAL
Aqueous Liquids	7.5	36 (55-gal)	Chemical precipitation, Carbon Absorption, Neutralization	3QFY95 2/8/95	4QFY96 2/8/96
Inorganic Sludges	62.9	287 (55-gal)	Stabilization	3QFY96 3/22/96	3QFY00 8/20/98
Inorganic Debris	1,700.1	180 (55-gal) 3 (96-cu yd) 92 (20-cu yd) 3 (4-cu yd) 5 (3-cu yd) 1 (10-cu yd)	Macroencapsulation	3QFY99 5/12/98	3QFY00 10/26/98
Contaminated Debris	0.2	1 (55-gal)	Stabilization	4QFY96 7/11/96	3QFY00 7/11/96
Liquid Mercury	0.4	2 (55-gal)	Amalgamation	1QFY96 3/13/95	Complete 3/14/95
Reactives/Oxidizers	6.9	33 (55-gal)	Deactivation	3QFY96 4/2/96	3QFY97 6/18/97
Organic Liquids	66.4	319 (55-gal)	Incineration	4QFY96 1/10/96	2QFY97 5/14/96
Organic Sludges	5.0	21 (55-gal)	Incineration, SET	4QFY96 5/7/96	10/1/98 8/20/98
Nitroaromatic Soils	3593	NA	Stabilization	3QFY99 9/28/97	1QFY01 2/14/98
Organic Liquids 2	4.0	19 (55-gal)	Incineration, Chemical Oxidation, DSSI	4QFY97 9/9/97	10/1/98 5/28/98
Selenium Water	17.45	NA	Chemical Precipitation	2QFY98 12/1/97	2QFY98 1/8/98



LEGEND

- ○ REMEDIATED PROPERTY
- ● CONTAMINATED PROPERTY
- DA ARMY PROPERTY
- DOC MISSOURI DEPARTMENT OF CONSERVATION PROPERTY

0 1 MI
0 1.6 KM
SCALE

LOCATION OF THE WELDON SPRING SITE AND VICINITY PROPERTIES

FIGURE 4-2

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/VP/021/D601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/20/01	

properties adjacent to the chemical plant site. Background levels and baseline concentrations were taken of each matrix in the vicinity of the area. These levels and concentrations were used to determine the extent of radiological contamination within a surveyed area. ORAU used the following concentrations to determine radioactively contaminated soil: Ra-226 and Th-232 were 5 pCi/g averaged over the first 6 in. of soil depth or 15 pCi/g if more than 6 in. deep. U-238 was 60 pCi/g averaged over the suspect area. The results of the study revealed soils in small areas in the chemical plant area, and the Missouri Department of Conservation (MDOC) conservation areas containing generally low levels of radioactivity as a result of previous site activities. In total ORAU identified 17 vicinity properties, seven of which were in the Weldon Spring Training Area (DA-1, DA-2, DA-3, DA-4, DA-5, DA-6, and DA-7) and 10 in the MDOC wildlife areas (MDC-1, MDC-2, MDC-3, MDC-4, MDC-5, MDC-6, MDC-7, MDC-8, MDC-9, MDC-10). The properties and descriptions are listed in Table 4-5. The MDOC properties have also been referred to as DOC-1 through DOC-10. The *Chemical Plant ROD* is the remedial action decision document for most of the vicinity properties. Specific cleanup decisions for DA-7, MDC-8, and the Southeast Drainage (DA-4, and MDC-7) were addressed either before or after the ROD was signed under the following documentation (Ref. 11):

- DA-7 — Interim Response Action 4 (IRA-4) Army Property No. 7
- MDC-8 — *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 12)
- DA-4/MDC-7 — *Engineering Evaluation /Cost Analysis for the Proposed Removal Action at the Southeast Drainage near the Weldon Spring Site, Weldon Spring, Missouri* (Ref. 13)

Table 4-5 Vicinity Properties

Vicinity Property	ROD Designation	Description
DA-1	A1	Located on approximately 7 acres of wooded field, the contaminated area consists of a soil-covered mound and surrounding area, an approximately 1.2 m wide ditch adjacent to a railroad track east of the wooded field and a drainage ditch flowing northwest.
DA-2	A2	Located adjacent to a railroad track in a grass field approximately 122 m north of the Weldon Spring Training Area entrance road and about 1,159 m from the entrance off Hwy. 94. The area is rectangular measuring 21.4 m by 79.3 m.
DA-3	A3	Wooden loading dock, approximately 75 m to the south of the Weldon Spring Training Area entrance road and 1,380 m from the entrance off Hwy 94. The dock rises approximately 4.6 m above an abandoned railroad track.
DA-4	A4	Short segment of Southeast Drainage running from the Imhoff Tanks within the Weldon Spring Chemical Plant to the Missouri River.
DA-5	A5	Surface drainage ditch leading west from raffinate pits across a part of the Weldon Spring Training Area to drainage ditch No. 4.
DA-6	A6	About 201 m of a drainage ditch beginning at Ash Pond which crosses a portion of the Weldon Spring Training Area.
DA-7	A7	Isolated area about 1 m north of the Weldon Spring Training Area entrance road about 1,156 m from the entrance off Hwy. 94. The area is rectangular measuring roughly 2.1 m by 1.5 m.
DOC-1	B1	An area of soil approximately 167 m^2 on the west side of Hwy. 94 just north of the entrance to the Missouri Highway Department property.
DOC-2	B2	Small piece of pipe on the surface approximately 1 m off Hwy 94 to the east and about 3,498.4 m from Hwy 40/61
DOC-3	B3	Two small isolated areas of contamination south of Highway D at the 7,462.1 m reference marker.
DOC-4	B4	Situated near an access road to the radio tower (Road C) and the DA- property perimeter fence. Consists of mounds of soil and miscellaneous wood, metal and other debris.
DOC-5	B5	Located 471 m from the intersection of Highway D and Hwy 94 and is in a drainageway along an eroded gravel road. Consists of abandoned drums and adjacent soil.
DOC-6	B6	An isolated spot of contamination adjacent to the quarry perimeter fence. Consists of an area of soil approximately 1 m^2.
DOC-7	B7	The main Southeast Drainage area running from the Department of Conservation perimeter fence through the Weldon Spring Wildlife Area to the Missouri River.
DOC-8	B8	Three isolated spots near a railroad bridge spanning the Little Femme Osage Creek. One measuring 0.5 m^2, two measuring 1 m^2.
DOC-9	B9	Located between the abandoned Missouri-Kansas-Texas Railroad and the Femme Osage Slough, south of the Weldon Spring Quarry.
DOC-10	B10	Old DA disposal area along Highway D adjacent to an access road leading to Busch Wildlife Area Lake 21. Isolated area of soil estimated to be 0.15 m^2

MDC-1 was remediated in accordance with Formerly Utilized Sites Remedial Action Program (FUSRAP) protocol prior to ROD signature. MDC-2 was remediated prior to ROD signature by ORAU during the initial identification campaign.

4.2.3.1 DA-1, DA-2, DA-3, and DA-5

Remediation of DA-1, DA-2, DA-3, and DA-5 began on December 16, 1997, and was completed on July 9, 1998. The remediation was performed under WP-458 (Army Properties 1, 2, 3, 5 and MDC-4 remediation). Contaminated soil, root balls, and miscellaneous materials were excavated and transported to the Ash Pond storage area, the chipped wood storage area, or the material staging area, respectively. Temporary access roads leading to and from the vicinity properties were constructed and maintained during these activities. Surface water and erosion control systems were built to prevent uncontaminated water from entering the excavation zones and becoming contaminated. Any area exceeding 1.5 times background radioactivity was excavated until the background activity fell below this criteria. After contaminated soil within the vicinity property had been excavated, the PMC performed confirmation sampling to verify that the contaminants exceeding *Chemical Plant ROD* cleanup criteria levels had been removed. A discussion on the confirmation sampling process and cleanup criteria levels is included in Section 4.2.4.3. Compete details of the remediation are in *Closeout Report for Vicinity Properties DA-1, DA-2, DA-3, DA-5, and DA-7* (Ref. 14).

4.2.3.2 DA-6

Vicinity Property DA-6 consists of a losing stream reach of the Ash Pond drainage extending approximately 1,132 ft west of the U.S. Department of Energy (DOE) fence line.

The extent of this drainage was initially characterized to provide data regarding potential contamination of surface and shallow subsurface sediments and soils. Results of the soil sampling indicated the presence of U-238 above as low as reasonably achievable (ALARA) at the westernmost sampling location.

Based upon this data, a walkover/hotspot sampling effort was conducted along the length of the drainage extending northward to the Busch Lake 35 inlet, as well as south to the previously remediated portion of Vicinity Property DA-5. Walkover surveys and hotspot sampling were also performed in DA-6 proper to verify U-238 levels. Both the Department of Energy and the Oak Ridge Institute for Science and Education (ORISE) conducted these surveys.

Data results indicated al U-238 concentrations within the extended drainage were below or at the surface ALARA goal of 30 pCi/g. U-238 concentrations within the DA-6 drainage proper were below or at the surface criteria level of 120 pCi/g.

Th-230 was analyzed in the sediment samples obtained after a contaminated surface water discharge into the drainage. Results showed that levels of Th-230 were below the surface ALARA goal of 5.0 pCi/g.

No remediation was required for DA-6 based on the additional characterization performed on the vicinity property. This was a decision determined by the As Low As

Reasonably Achievable (ALARA) committee. The analytical results are documented in *Analytical Data Results for Engineering Characterization of Vicinity Property DA-6; Ash Pond Drainage* (Ref. 15).

4.2.3.3 MDC-3, MDC-4, MDC-5, and MDC-10

Remediation of MDC-3, MDC-4, MDC-5, and MDC-10 began on October 26, 1997, and was completed on June 22, 1998, as a part of WP-458. Contaminated soils were transported to the Ash Pond storage area, root balls to the chipped wood storage area, and miscellaneous materials to the material staging area. Temporary access roads leading to and from the vicinity properties were constructed and maintained during the activities. Surface water and erosion control systems were built to prevent uncontaminated water from entering the excavation zone and becoming contaminated. Any area exceeding 1.5 times background radioactivity was excavated until the background activity fell below these criteria. After contaminated soil within the vicinity property had been excavated, the PMC performed confirmation sampling to verify that the contaminants exceeding *Chemical Plant ROD* cleanup criteria levels had been removed. Compete details of the remediation are in *Closeout Report for Vicinity Properties MDC-3, MDC-4, MDC-5, and MDC-10* (Ref. 16).

4.2.3.4 MDC-6

Remediation of MDC-6 was conducted in November 1993 as part of bulk waste removal from the quarry. The work was performed under WP-186 and began on November 11, 1993. Once remedial activities commenced, the area of contaminated soil removal increased from approximately 1 m^2 to 200 m^2 based upon NaI 2x2 readings obtained during walkover of the excavation. The depth of the excavation ranged from 6 in. to 12 in. with an approximate total soil volume between 109 cu yd and 219 cu yd. The quarry perimeter fence was taken down and excavated soils were placed inside the fence line on the inner rim of the quarry. The soil was then grouped with additional contaminated soil within the quarry and dispositioned per the *Record of Decision for the Management of the Bulk Wastes at the Weldon Spring Quarry* (Ref. 69). The soil was removed at a later date and transported to the temporary storage area to await final disposal in the cell.

4.2.3.5 MDC-9

Remediation of MDC-9 began on January 4, 1996, and was completed on February 29, 1996. The remediation was performed under WP-461. Roadways were developed prior to soil removal by adding gravel to, and grading of, the Katy Trail and the access road to the quarry area. Haul trucks used a route from MDC-9 over the Katy Trail to Gate F at the quarry near the water treatment plant. The trucks then followed the quarry haul road to the chemical plant site and off-loaded at either the Ash Pond storage area or chipped wood storage area.

Because local surface water bodies and shallow groundwater could interfere with excavation, excavation activities were scheduled to maximize safe access to soils. Trees were cleared and grubbed and the vegetative debris was hauled to the chipped wood storage area. Surface water and runoff control structures were constructed to prevent uncontaminated water from entering the excavation zone and becoming contaminated. A soil berm was constructed from the Katy Trail to the Femme Osage Slough to divert surface water runoff.

Vicinity Property MDC-9 consisted of three work zones. Soil excavated to the depth defined in the work package, plus additional soil excavated on the basis of radiological walkover surveys, was transported to the Ash Pond storage area. Any area where radioactivity exceeded 1.5 times background activity was excavated until the background activity was well below this criterion. The soil was removed in 1-ft lifts to a point approximately 6 in. above the groundwater level. Approximately 4,450 bank cu yd was removed and transported to the storage area to await placement in the cell. Depending on the results of the walkover surveys, final excavation depths ranged from 1 ft to the capillary fringe (approximately 5 ft to 6 ft). No building foundations, utilities, or other potentially contaminated materials were located. Hauling was completed on February 15, 1996. Clean soil from the Lost Valley area (Drainage 5100, northwest of the quarry) was used as backfill material after confirmation sampling had been completed and the sampling results permitted unrestricted release of the property. Reseeding was completed on February 22, 1996, and the subcontractor completed demobilization of equipment on February 28, 1996.

Compete details of the remediation of MDC-6 and MDC-9 are in *Closeout Report for Vicinity Properties MDC-6 and MDC-9* (Ref. 17).

4.2.3.6 MDC-8

The remediation of the quarry construction staging area, including vicinity property MDC-8, was performed under WP-157. The start date was August 8, 1990, with a completion date of February 24, 1992. In 1990, each zone of contaminated soil was excavated using a backhoe and dump truck. The excavated soil was placed in a soils pile within the fenced inner quarry area. Soil removed from the quarry construction staging area and vicinity property MDC-8 was not specifically separated or identified once placed in the inner quarry area. After soil removal, each zone was confirmed clean. Complete details of the remediation of MDC-8 are included in the *Vicinity Property DOC-8 Close-Out Report* (Ref. 18).

4.2.3.7 Southeast Drainage

The Southeast Drainage is a natural drainage area with intermittent flow that traverses both the Army property and the Weldon Spring Conservation Area from the chemical plant site to the Missouri River (Figure 4-3). Both the Army and the Atomic Energy Commission (AEC) used the drainage to discharge water from sanitary and process sewers to the Missouri River. As a result, sediments and soils in the Southeast Drainage were contaminated. Radioactive contaminants of concern were U-238, Ra-226, Th-232, and Th-230.

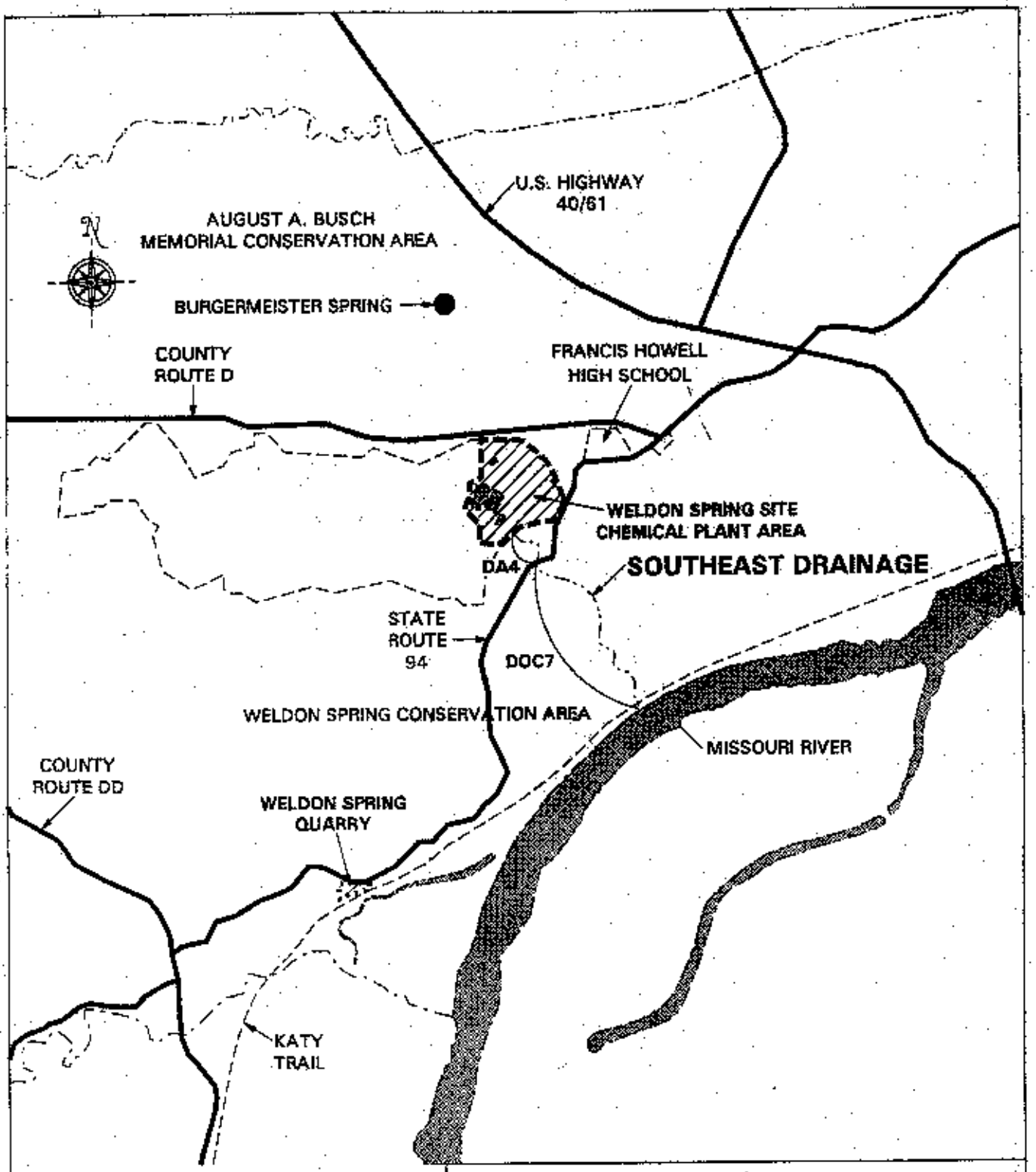
The DOE decided to address remedial actions for the Southeast Drainage as a separate action under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA). The *Engineering Evaluation/Cost Analysis for the Proposed Removal Action at the Southeast Drainage near the Weldon Spring Site, Weldon Spring, Missouri* (Ref. 13) was prepared in August 1996 to evaluate the human and ecological health risks within the drainage. The EE/CA recommended that selected sediment in accessible areas of the drainage would be removed with track-mounted equipment and transported by off-road haul trucks to the chemical plant area. The excavated materials would be stored temporarily at an on-site storage area with final disposal in the disposal cell. On the basis of stability testing previously performed for related wastes, the waste material from the excavations would not be treated before disposal.

Soil removal was performed under WP-470 and WP-470A. Work completed under WP-470 included:

- Constructing temporary unsurfaced and gravel surfaced access roads.
- Constructing protection for an underground petroleum crossing (Explorer Pipeline Co.).

Further contract negotiations for soil removal were unresolved and a second contract was issued and identified as WP-470A. Work conducted under this contract included:

- Clearing trees from the extended pioneered path and grading.
- Placing aggregate on designated haul road.
- Constructing haul road turnouts.
- Reinforcing haul road overpass above the Explorer pipeline.
- Improving Hamburg Quarry Road/Highway 94 intersection.
- Removing contaminated soil.
- Grading soil removal areas with surrounding soil.
- Restoring the Katy Trail.



LOCATION OF THE SOUTHEAST DRAINAGE AND THE WELDON SPRING CHEMICAL PLANT AREA

FIGURE 4-3

REPORT NO.:	DOE/OR/21548-891	EXHIBIT NO.:	A/VP/022/0601		
DESIGNATOR	TU	DRAWN BY:	GLN	DATE:	6/20/01

Construction began in November 1997 and was completed on February 19, 1998. A total of 1,931 bank cu yd of soil was excavated in accordance with engineering design. Restoration of the Katy Trail was completed in August 1998.

Post-remediation soil sampling was conducted at Southeast Drainage locations after the soil was excavated. The purpose of this sampling was to determine the remaining radiological concentrations within the soil and sediment and to calculate the risk reduction achieved from soil removal. Sampling was conducted in accordance with *Post-Remediation Sampling Plan for the Southeast Drainage* (Ref. 19).

Sixty-six samples were collected from the 55 remediated locations and analyzed for U-238, Ra-226, Ra-228, and Th-230. All post-remediation data results were used by Argonne National Laboratory to calculate risk reduction achieved by the removal action. Risk calculations were performed using the same methodology used in the EE/CA and were estimated for both the current hunter and hypothetical future child scenarios. The exposure routes evaluated included incidental ingestion of sediment and external irradiation. Post-cleanup data for each segment were aggregated with data from locations in each segment that were not targeted for cleanup. At locations where more than one sample was collected, the data were averaged to obtain a representative concentration for that location prior to aggregating the data for each segment.

Although significant risk reduction was achieved, upon evaluation, a decision was made to remove additional volumes of soil from two sample areas due to elevated Th-230 levels. The PMC conducted a follow-up investigation and evaluation to determine the potential hazard of the two areas. It was determined that even though the drainage satisfactorily met the risk reduction criteria, the two areas would be remediated under a limited removal effort conducted under WP-505, Task J.

Approximately 22.5 cu yd total of contaminated soil was removed from the two locations and transported to the disposal cell. The soil was sampled immediately after excavation was completed at each location. Sampling began on April 19, 1999, and was completed on April 29, 1999. The results showed a significant reduction in radiological contamination. The data were used to evaluate post-cleanup risks and determine the amount of risk reduction achieved by both WP-470A and WP-505J.

Complete details of the remediation as well as the post-cleanup risk assessment of the Southeast Drainage are in *Southeast Drainage Closeout Report Vicinity Properties DA-4 and MDC-7* (Ref. 20).

4.2.3.8 Frog Pond Drainage Area

The following information was incorporated from the *Closeout Report for the Frog Pond Drainage* (Ref. 76). The Frog Pond drainage begins in the Frog Pond area within the chemical plant site and ends at Busch Lake 36. Frog Pond was a man-made pond excavated out of an

existing drainage at some time during operation of the feed materials plant. The pond received precipitation runoff from the northeast corner of the chemical plant and from the plant storm sewer system. Even though characterization of Frog Pond showed radiological contamination, there is no known record of contaminated material being stored or buried in this area.

The Frog Pond drainage area can be broken into three separate sections. The first section consists of the area from Frog Pond on the chemical plant site to the perimeter fence. The second section runs from the chemical plant perimeter fence to the south side of Missouri County Highway D. This section is on MDOC property and henceforth is referred to as the Frog Pond drainage. The last section consists of the drainage north of Highway D running into Lake 36. This section is also part of the MDOC property and is referred to as the Frog Pond outlet.

During the vicinity property study conducted by ORAU in 1985, the Frog Pond areas were sampled. Elevated levels of U-238 were identified within the Frog Pond drainage; however, the levels did not exceed DOE residual contamination criteria for classification as a contaminated MDOC vicinity property. Therefore, they were not included in the *Chemical Plant ROD* as a vicinity property.

In 1997 and 1998 an engineering characterization was performed on all three sections of the Frog Pond drainage area (the Frog Pond area, the Frog Pond drainage, and the Frog Pond outlet). The Frog Pond area was characterized from October 1997 to January 1998 under the *Frog Pond Characterization Sampling Plan* (Ref. 21). The pond was drained prior to sampling. Samples were collected from 15 locations within the Frog Pond area and 18 locations surrounding the pond. Samples were collected at 1-ft intervals to a depth of 12 ft for inner Frog Pond samples and to a depth of 16 ft at locations outside the pond. Analysis revealed that five locations exhibited elevated concentrations for a single ROD chemical constituent. Eighteen other locations exhibited elevated concentrations for multiple ROD chemical constituents, radioactive constituents, or both. Additional information may be found in the *Analytical Data Results for the Frog Pond Characterization Sampling Plan* (Ref. 22).

The Frog Pond drainage was sampled from October 30, 1998, to November 4, 1998, in accordance with the *Engineering Soils Sampling Plan for Army and MDOC Vicinity Properties Addendum 4 Soil Sampling at Frog Pond Drainage Outlet and MDC-6* (Ref. 23). Sixty-three samples from 32 locations were generated during this characterization. Biased sample locations were determined in the field on the basis of both walkover survey results greater than two times background levels and relevant geomorphic principles of sediment deposition such as point bar deposits. Walkover survey results revealed, however, that no location was greater than two times background. Hence, biased samples consisted solely of sediment deposition areas along the drainage. Sixteen biased sample locations, 12 unbiased sample locations, and four areas within the twin culverts on both the north and south sides of Highway D were taken.

Analysis revealed that no sample location along the Frog Pond drainage exceeded ROD cleanup criteria levels for any radiological parameter. Elevated concentrations of U-238

exceeded ALARA levels (30 pCi/g) at 10 out of the 32 locations. Ra-226, Ra-228, Th-230, Th-232, arsenic, chromium, lead, thallium, 2,4,6-TNT, and PCB concentrations were all below ALARA levels. Additional details of the results of this sampling activity may be found in the *Closure Report for Soil Sampling at Frog Pond Drainage Outlet and MDC-6 Addendum 4 of the Engineering Soil Sampling Plan for Army and MDOC Vicinity Properties* (Ref. 24).

In April of 1998, the Frog Pond outlet was originally sampled for radiological characterization in accordance with the *Engineering Soils Sampling Plan for Army and MDC Vicinity Properties: Addendum 4: Soil Sampling at Frog Pond Drainage Outlet And MDC-6* (Ref. 23). Discrete soil samples were collected at 1-ft intervals from the drainage surface to the original stream base (approximately 2.5 ft to 4 ft below ground surface). Analysis of samples from the 15 locations revealed that numerous locations exceeded the ROD U-238 cleanup criteria level of 120 pCi/g.

The Frog Pond outlet sample locations were re-sampled from September 29, 1998, through October 2, 1998, to obtain additional information on contaminant depth and potential chemical contaminants. Samples were collected using a power auger and split spoon sampler at 1-ft intervals. Depths that had been previously characterized were excluded. Analysis revealed that samples from nine of the 15 sample locations exceeded cleanup criteria levels for U-238 at either one of multiple depth intervals. Every sample location exceeded the U-238 ALARA level (30 pCi/g) at either one or multiple depth intervals. Chemical characterization for ROD contaminants of concern performed at four locations revealed that all four sample locations were below both ROD cleanup criteria and ALARA levels. Specific details of this sampling activity can be found in the *Closure Report for Soil Sampling at Frog Pond Drainage Outlet and MDC-6 Addendum 4 of the Engineering Soil Sampling Plan for Army and MDOC Vicinity Properties* (Ref. 24).

Based on the data from the three separate engineering characterization activities, remediation was required in the Frog Pond area and the Frog Pond outlet. Remediation was not required in the Frog Pond drainage because no samples taken exceeded ROD cleanup criteria.

Remediation of the Frog Pond area began on July 29, 1998, and was completed on September 12, 1998. Remediation was performed under WP-437. Contaminated sediment and soil were excavated and transported directly to the disposal cell. Any area exceeding 1.5 times background activity was excavated until the background activity fell below this criterion. The volume of contaminated material removed increased from the original engineering estimate of 10,500 cu yd to 16,292 cu yd. The increase was a result of both NaI 2x2 walkovers and high levels of polycyclic aromatic hydrocarbons (PAHs) which required additional excavation of the area. Upon successful completion of confirmation sampling and unrestricted release of the area, the excavation was backfilled. Approximately 16,140 cu yd of clean common fill was returned to the excavated area and sloped so that the pond was eliminated.

Remediation of the Frog Pond outlet began on July 7, 1999, and was completed on October 7, 1999 under WP-505F. Contaminated soil and root balls were excavated and transported directly to the disposal cell. A temporary access road running along County Hwy D to an area across from Gate D of the chemical plant site was constructed and maintained during the remediation. The road was removed and the area seeded after completion of backfill activities.

Once remediation commenced, the volume of contaminated material removed increased from an estimate of 1,634 cu yd to 2,864 cu yd. Radiological surveys obtained during walkover of the excavation revealed that contaminated material extended beyond the designed excavation limits in two locations. The first location was under the two 60-in. culverts running from the Frog Pond drainage, under Highway D, and into the eastern end of the outlet. The second location was under the 42-in. culvert leading from the western end of the outlet into Lake 36. In both situations, it was decided to excavate or "chase" the contamination.

Approximately 20 ft of both 60-in. culverts and 293 cu yd of soil were removed from the eastern end of the outlet. Radiological measurements revealed that remaining soils under the culverts continued to exhibit elevated levels (500 to 800 counts per minute). The additional excavated area was within close proximity to the MDOT right-of-way. As a result of discussions with the DOE on August 26, 1999, excavation ceased at the eastern end of the Frog Pond outlet. Samples were taken of the soil under both culverts, and the edge of the excavation was surveyed for future reference. Soil sampling was conducted under the *Engineering Soils Sampling Plan for Army and MDC Vicinity Properties: Addendum 6: Engineering Characterization Sampling at Frog Pond Outlet (Soil Beneath Twin 60-Inch Culverts)* (Ref. 70). After the samples had been taken, 70-in. diameter extensions were fit over the 60 in. culverts and entombed with concrete at the culvert joints. The area was then backfilled to the original topography.

Analysis of the samples revealed the that soil under the easternmost culvert was above the ROD cleanup criterion for U-238 with a concentration of 310 pCi/g. The soil was below the Th-230 cleanup criterion of 16.2 pCi/g; however, it did exceed the Th-230 ALARA level of 5.0 pCi/g. Soil under the westernmost culvert was below U-238 cleanup criteria but did exceed the ALARA level (30 pCi/g). Further details on this sampling may be found in the *Closure Report for Soil Sampling at the Frog Pond Outlet, Addendum 6 of the Engineering Soil Sampling Plan for Army and MDC Vicinity Properties.* (Ref. 71). The ALARA committee met on March 23, 2000, to discuss the results of sampling under the two culverts.

The depth of contaminated soil under the 42-in. culvert ranged from 2 ft to 5 ft. The culvert was removed and a small berm of soil between the lake and the outlet was maintained so that water from the lake would not run into the excavation area. The excavation extended approximately 8 ft into the lakebed. It was 12 ft wide and 2 ft below the bottom of the lake. This was beyond the contract established excavation boundary and it was decided to stop excavating along the lake. It was decided that a detailed characterization of the area would be performed at a later date. The excavated area was backfilled with clay material to act as a dam.

Rain was forecast, and it was imperative that rainwater be prevented from flowing through the contaminated area into Lake 36, and that lake water was prevented from seeping into the outlet.

On September 1, 1999, the PMC received a letter from the MDOC requesting that the area from the 42 in. culvert at the Lake 36 inlet to the first rock jetty be "thoroughly tested" to ensure that all contaminants had been removed. In response, the PMC generated the *Sampling Plan for Radiological Characterization of Sediments and Soil Within the Southeast Corner of Busch Lake 36* (Ref. 25) and sampled the area in accordance with this plan.

Additional sampling along the edge and within Lake 36 was conducted in accordance with the *Sampling Plan for Radiological Characterization of Sediments and Soil Within the Southeast Corner of Busch Lake 36* (Ref. 25). Sample locations were established by creating a 20-ft by 20-ft grid encompassing 40,000 sq ft. Grid intersections were identified as potential sample locations. Numerous sample locations were then eliminated because they were at a higher elevation, and surface water and sediment runoff from the chemical plant site would not flow to them. It was determined that 38 locations would be sufficient to characterize the southeast end of the lake. Extensive sampling was conducted in the southeast corner of the lake where the excavation was discontinued.

Analytical results generated from the sampling revealed that none of the 106 samples exceeded the 30 pCi/g ALARA level for U-238, let alone the 120 pCi/g ROD cleanup criterion. Additional details of the sampling activity are in the *Closure Report for Radiological Characterization of Sediments and Soil within the Southeast Corner of Busch Lake 36 Sampling Plan* (Ref. 72).

4.2.3.9 Busch Lakes

Busch Lakes 34 and 35 are man-made bodies in the eastern portion of the August A. Busch Memorial Conservation Area. Lake 34 covers 35-acres, and Lake 35 covers 60-acres. Both were constructed in the 1960s when the feed materials plant was in operation.

Lake 35 is part of the Schote Creek surface water drainage, which collects storm water runoff from the chemical plant site. Contaminants in this lake are likely the direct result of runoff from the chemical plant. Lake 34 is in a surface water drainage that receives no direct runoff from the chemical plant, but does receive groundwater that originates from the chemical plant and discharges from Burgermeister Spring. Contaminants are likely transported to Lake 34 from the Burgermeister Spring drainage.

When the sediments in these lakes was characterized in 1989, it was determined that the nature of radiological contamination in them was limited to U-238.

Sampling was performed in accordance with the *Sampling Plan for Sampling Sediments at Busch Lakes 34 and 35* (Ref. 26). Because the lakes were not drained prior to sampling, a

radiological survey of the sediment surface could not be performed. Sampling locations were laid out on a 50-m by 50-m sampling grid with sample points at the corners and center of each grid square. This was done to obtain an adequate density of sampling points to support characterization and potential design. The grid spacing resulted in 124 sampling locations in Lake 34, and 195 in Lake 35.

Sediment in Lake 34 was sampled beginning July 29, 1998, and ending on August 13, 1998. Sampling was attempted at 117 of the 124 locations. Sediment was retrieved from 49 locations, resulting in 59 samples being collected. Samples could not be collected from 68 locations due to inability to retrieve sediment.

Sediment in Lake 35 was sampled beginning on June 25, 1998, and ending on July 24, 1998. Sampling was attempted at each of the 195 locations. Sediment was retrieved from 145 locations, resulting in 240 samples being collected. Samples could not be collected from 50 locations due to inability to retrieve sediment, which accounted for 21% of the attempted locations.

None of the samples obtained from either lake indicated U-238 results greater than 120 pCi/g, which is the cleanup criterion for U-238. Based on the data, it was determined that remediation of the sediments in these lakes was not warranted; therefore, no further action was required. Additional details may be found in the *Completion Report for Sediment Sampling at Busch Lakes 34 and 35* (Ref. 27).

Busch Lake 36 is a 15.5 acre man-made lake in the southeast portion of the August A. Busch Memorial Conservation Area immediately north of State Highway D and approximately 1 mi west of Francis Howell High School. Water flows to the lake via a natural drainage from the chemical plant site. From the lake, the water flows through an overflow structure into another drainage that flows into Lake 35. Lake 36 was constructed while the chemical plant was in operation. From January through February 1997, the DOE sampled the sediments in this lake after it had been drained by the MDOC for scheduled restoration. Sampling was performed in accordance with the *Engineering Design and Characterization Sampling Plan for Soils and Sediments from Busch Lake 36* (Ref. 28). Per the sampling plan, gamma walkover surveys (2 in. x 2 in. NaI) were performed on every accessible area within the lake bed. Areas covered with water could not be surveyed. Sediment samples were then collected using a hollow-stem, split-spoon auger driven either mechanically or by hand.

The characterization results indicated approximately 10,000 bank cu yd of sediment within the lake bed was above the ALARA goal (30 pCi/g) but below the cleanup criterion (120 pCi/g). Of 136 samples taken at 58 separate locations, only 12 were above the U-238 post-remediation ALARA goal of 30 pCi/g. Details of characterization results are provided in the *Busch Lake 36 Summary Closeout Report* (Ref. 29).

See Section 4.2.3.8 for the discussion of Frog Pond outlet (inlet to Lake 36) sampling and remediation.

4.2.4 Site Remediation

After six years and 100,000 analyses, confirmation at the chemical plant was completed on March 5, 2001. Following is a detailed description of the confirmation process and how it was developed and implemented, a summary of the confirmation units and final data, and a discussion of the ALARA Committee.

4.2.4.1 Development of the Con firmation Attainment Plan

The confirmation process was developed to provide statistically defensible evidence that remediation efforts were complete to the extent required by the *Chemical Plant ROD* (Ref. 8). This ROD established two different sets of cleanup standards: protective risk-based cleanup criteria and more restrictive ALARA goals. A detailed discussion of cleanup criteria and ALARA goal development is in the *Feasibility Study for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 30).

Development of the confirmation plan began in 1994. Input was obtained from outside agencies, including Argonne National Laboratories (ANL), the EPA and the MDNR. The final product was the *Chemical Plant Area Cleanup Attainment Confirmation Plan* (*Attainment Plan*) (Ref. 31) that detailed the requirements for confirmation, including clean up standards (ALARA goals and cleanup criteria), sampling methods, sampling frequency, analytical parameters, and the statistical evaluation to be performed to accomplish this determination. This plan created discrete areas known as confirmation units (CUs). A CU was a 2,000 m^2 area for which a decision was made as to whether or not remediation was complete. Decisions in regard to each CU were based upon the data collected.

4.2.4.2 Design

The ALARA goal discussed above represented the level that could reasonably be achieved during field implementation. With only a few exceptions, most contaminated soil excavations were designed to remove all soils where contaminant concentrations were in excess of the ALARA goals.

Exceptions to this design principle occurred in Raffinate Pits 3 and 4. The decision to design to subsurface criteria in these areas was based on locations that contained deeper contamination with significant clean material above. This decision was not contradictory to the ROD since all areas would remain more than 6 in. below final grade. The decision was based on the cost vs. benefit of excavating this material. The areas not targeted for remediation that exceeded ALARA are best described by the associated characterization data and will be discussed in the post remedial action reports specific to those areas.

4.2.4.3 Confirmation Process

Using the guidelines in the *Attainment Plan* (Ref. 31), work package confirmation sampling plans were developed which detailed confirmation units, sampling locations, and parameters specific to the areas being excavated. The confirmation process began immediately after excavation of contaminated soil to design depth. The radiological and chemical contaminants of concern, cleanup criteria, and ALARA goals for the chemical plant area are identified in Table 4-6. The confirmation process is illustrated in Figure 4-4.

For radiological contaminants, surface scans for gamma activity were performed over each 100 m^2 grid within all confirmation units after soil excavation was completed. Any locations of elevated direct gamma radiation exceeding 1.5 times ambient site background levels were further excavated. Once readings were less than 1.5 times background, soil samples were collected. Confirmation samples were analyzed only for the contaminants that were known to exist in the area, not for all contaminants of concern over the entire site.

Sample results were reviewed and compared to the ALARA goals. Additional excavation and/or sampling was conducted upon identification of hot spots. Results exceeding criteria were considered hot spots and were handled in one of two ways: automatic excavation or size determination. (1) Automatic excavation: If a hot spot result exceeded three times criteria, it was automatically excavated, another walkover was performed, and an additional confirmation sample was collected. (2) Size Determination: If a result ranged between criteria and 3 times criteria, localized gamma scans were performed to determine the lateral extent of the elevated activity (radiological contaminants) or additional sampling was conducted (chemical contaminants). If the area was determined to exceed 25 m^2, additional remediation was performed (as discussed above). If the area was less than 25 m^2, the size of the anomaly, together with analytical data, were used to determine whether hot spot cleanup goals were met based on the calculation:

Maximum Concentration = (cleanup criteria) x $(100/A)^{1/2}$.
A=Area of the hotspot.

If the hot spot met the above condition, it was not excavated.

Once a CU met the following criteria: (1) all averages less than ALARA, (2) any remaining results exceeding criteria meet the hot spot rule, and (3) all 100-m^2 averages less than criteria, a disposition release form was completed and the CU was determined to meet final cleanup criteria. If averages exceeded ALARA, an ALARA Committee meeting was called to determine whether the CU could be determined to meet final cleanup criteria or if additional excavation was warranted. ALARA Committee meetings are discussed later in this section.

A summary of remedial activities, walkover information, confirmation data and identification of hot spots encountered during the process were provided in a post remedial action report for each work package. Details were also provided if any additions or deviations from the sampling plan occurred.

Table 4-6 Radionuclide and Chemical Contaminant Cleanup Standards

	SURFACE[c]		SUBSURFACE[d]	
Radionuclide (pCi/g)	**ALARA**	**Criteria**	**ALARA**	**Criteria**
Radium-226[a,b]	5.0	6.2	5.0	16.2
Radium-228[a,b]	5.0	6.2	5.0	16.2
Thorium-230[a]	5.0	6.2	5.0	16.2
Thorium-232[a]	5.0	6.2	5.0	16.2
Uranium-238	30.0	120	30	120
Chemical (mg/kg)				
Arsenic	45	75	75	750
Chromium (total)	90	110	110	1,110
Chromium (VI)	90	100	100	1,000
Lead	240	450	450	4,500
Thallium	16	20	20	200
PAHs[e]	0.44	5.6	5.6	56

Table 4-6 Radionuclide and Chemical Contaminant Cleanup Standards (Continued)

	SURFACE[c]		SUBSURFACE[d]	
Chemical (mg/kg)	ALARA	Criteria	ALARA	Criteria
PCBs[f]	0.65	8	8	80
TNT	14	140	140	1,400

(a) If both Th-230 and Ra-226, or both Th-232 and Ra-228, are present and not in secular equilibrium, the cleanup criterion applies for the radionuclide with the higher concentration.
(b) At locations where both Ra-226 and Ra-228 are present, the cleanup criterion of 6.2 pCi/g (including background) in the top 6 in. of soil, and 16.2 pCi/g (including background) in each 6-in. layer of soil more than 6-in. below the surface, applies to the sum of the concentrations of these two radionuclides.
(c) Values listed for surface soils apply to contamination within the upper 6 in. of the soil column.
(d) Values for subsurface apply to contamination in soils below 6 in. unless otherwise noted.
(e) Benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, and ideno (1,2,3-cd)pyrene.
(f) Aroclor 1248, Aroclor 1254, Aroclor 1260.

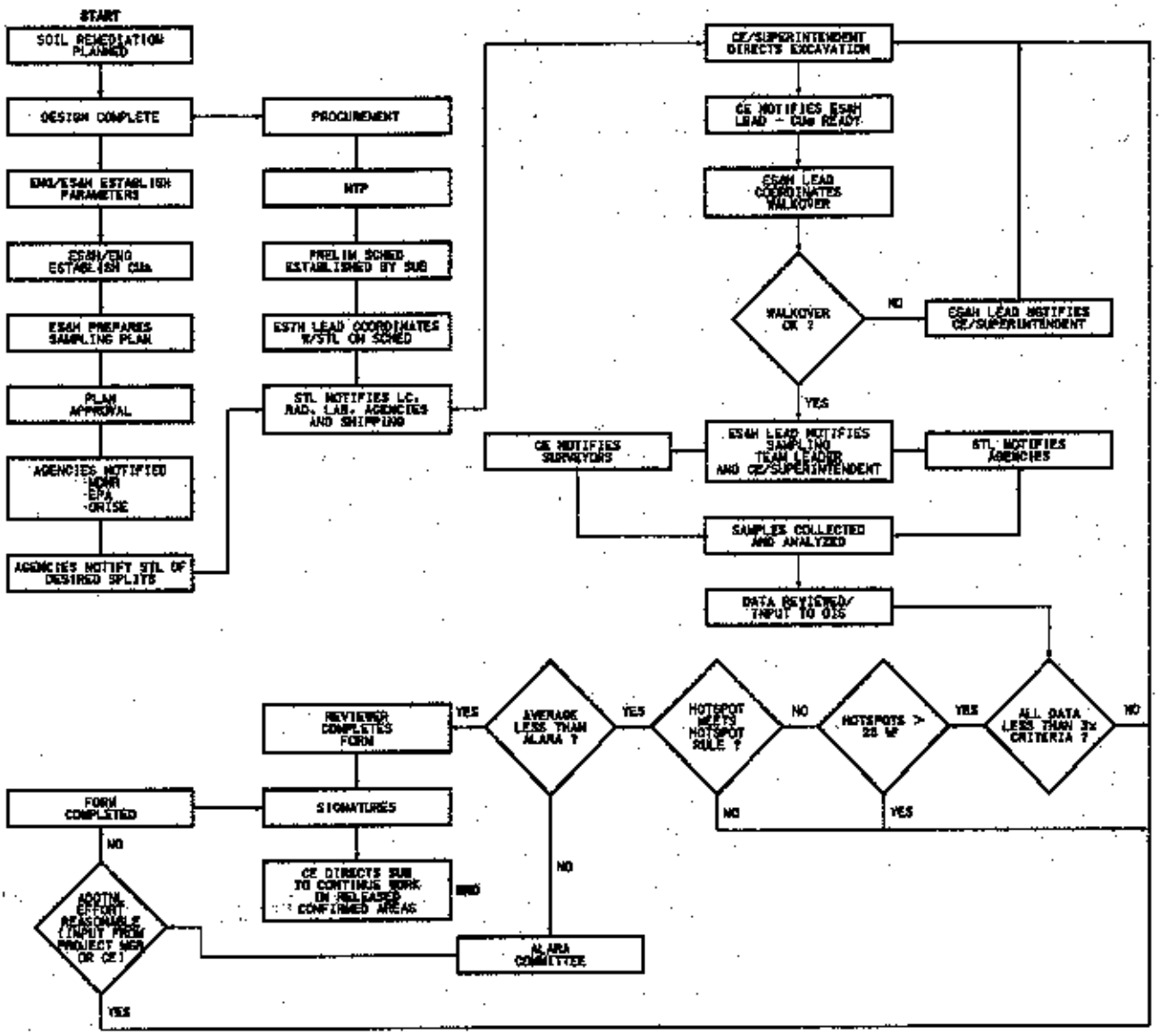
Source: *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 8)

4.2.4.4 Confirmation Statistics

Since 1995, more than 400 confirmation units have been confirmed to meet final cleanup criteria. Table 4-7 identifies the work packages and the confirmation units associated with each package. Figure 4-5 identifies the confirmation units, except those at the quarry and vicinity properties.

Table 4-7 Summary of Confirmation Remedial Units/Confirmation Units

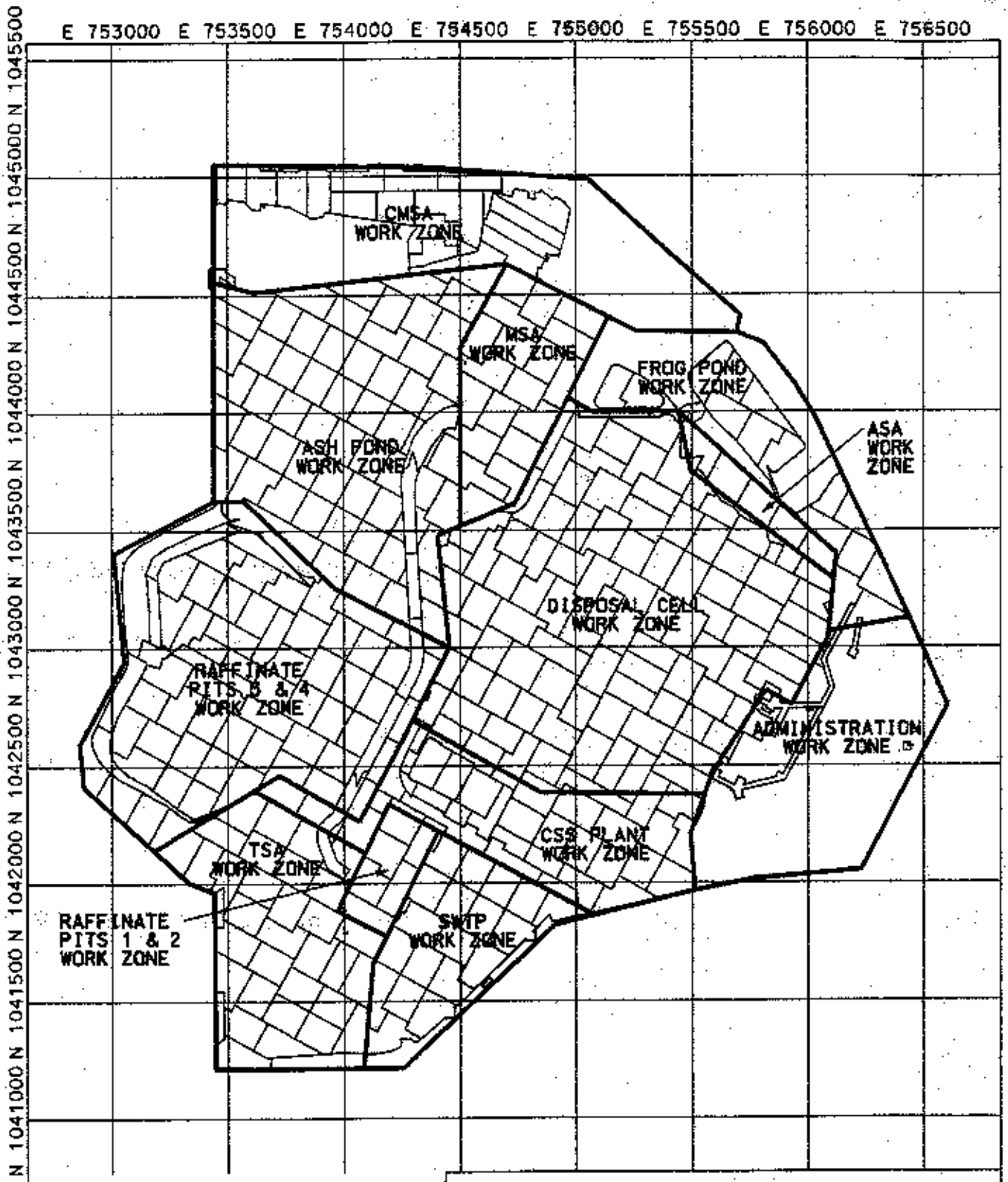
Remedial Unit (RU)	Confirmation Unit (CU)	Area Description
001	001 – 002	WP-399 – Northwest of ASA
002	003	WP-399 – Southeast of Frog Pond
003	004	WP-399 – West of Ash Pond
004	005 – 018	WP-253 – CMSA
005	019	WP-253 – CMSA
006	020 – 050, 157 – 158	WP-420 – Work Zone 1
007	051 – 077	WP-420 – Work Zone 2
008	078 – 083	WP-420 – Work Zone 3
009	084 – 122, 142	WP-420 – Work Zone 4
010	123 – 138	WP-420 – Work Zone 5
011	139 – 140	WP-461 – VP9
012	141	Vicinity Property MDC-6
013	143 – 156, 159 – 161	WP-471 – N. Raffinate Pit 4
014	162 – 169	WP-458 – VP DA-1, 2, 3, & 5/MDC-3, 4, 5 & 10
015	382, 385 – 386, 395, 398 – 399, 414	WP-437 – Administration Work Zone
016	357 – 368, 387 – 389	WP-437 – Frog Pond Work Zone
017	272 – 276	WP-437 – ASA Work Zone
018	170 – 188, 396	WP-437 – MSA Work Zone

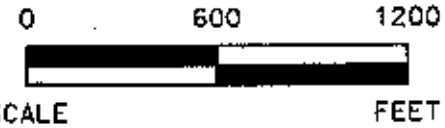


CLEANUP CONFIRMATION PROCESS

FIGURE 4-4

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/PI/031/0601	
ORIGINATOR: ML	DRAWN BY: GLN	DATE: 6/28/01	





WSSRAP CONFIRMATION UNITS

FIGURE 4-5

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/CP/058/0601	
ORIGINATOR: ML	DRAWN BY: GLN	DATE: 6/28/01	

Table 4-7 Summary of Confirmation Remedial Units/Confirmation Units (Continued)

Remedial Unit (RU)	Confirmation Unit (CU)	Area Description
019	369, 406 – 409	WP-437 – CMSA Work Zone
020	277 – 337	WP-437 – Ash Pond Work Zone
021	221 – 271, 391 – 394	WP-437 – Raffinate Pits Work Zone
022	189 – 220	WP-437 – TSA Work Zone
023	370 – 377, 384	WP-437 – CSS Work Zone
024	338 – 356	WP-437 – SWTP Work Zone
025	378 – 381, 400 – 405, 410	WP-437 – Disposal Cell Work Zone
026	397	QWTP Equalization Basin
027	390	Frog Pond Outlet
028*	411 – 413, 416 – 420	Quarry Proper

CU383 and CU415 – These CU numbers were not used.
CU383 had been DA-6, which was not remediated.
CU415 became part of CU399.

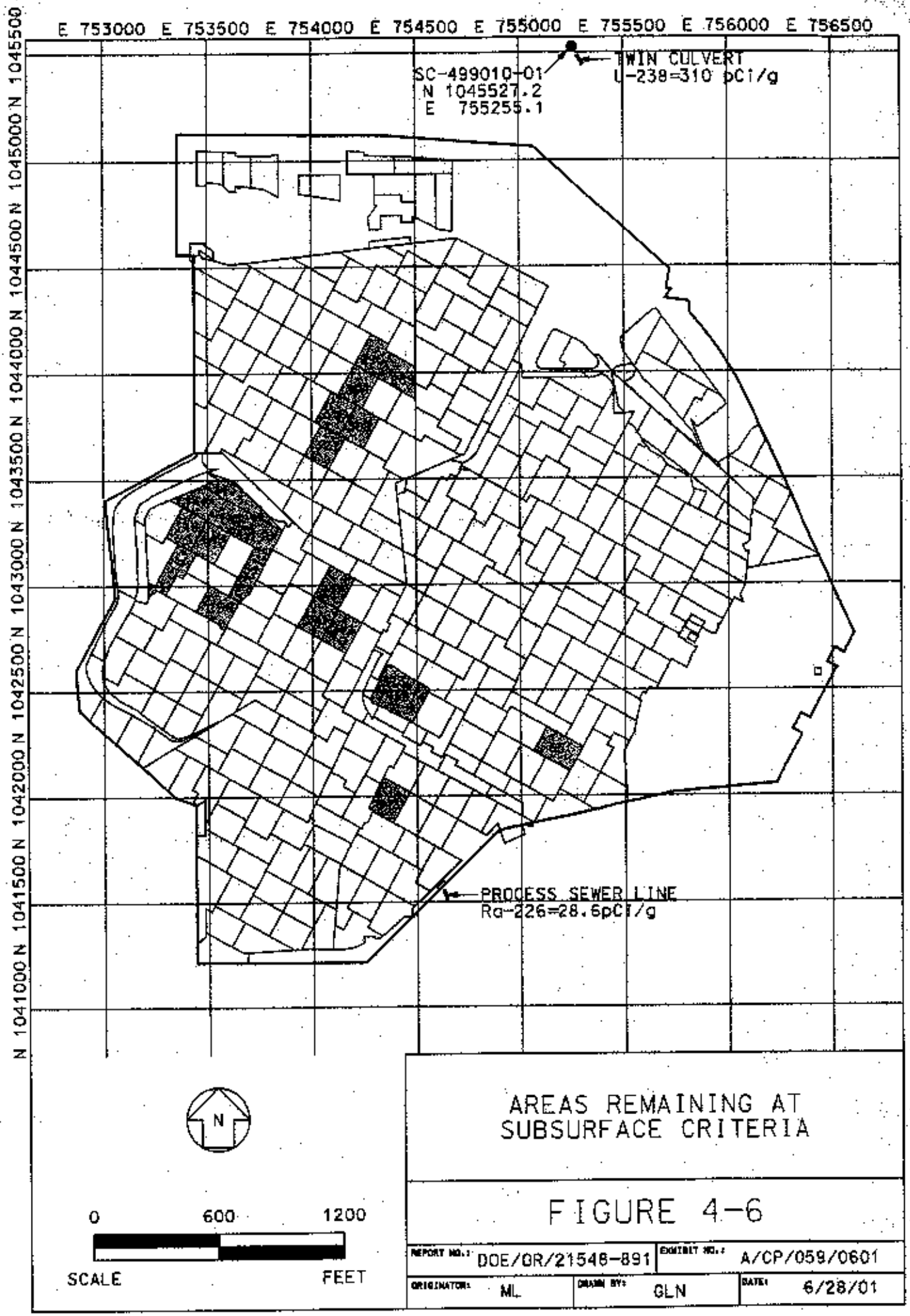
* This RU covers quarry proper confirmation being conducted under the *Record of Decision for Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site (Quarry Residuals OU)* (Ref. 32).

Table 4-8 summarizes the final confirmation results. As can be seen in this table, 99% were less than ALARA.

Table 4-8 Final Confirmation Statistics

Parameter	No. of Samples	No. < ALARA	Range	Average	ALARA Goal
Arsenic (mg/kg)	2782	2781	0.48 – 123	8.19	45
Chromium (mg/kg)	3090	3090	1.4 - 76.2	17.37	90
Lead (mg/kg)	2689	2681	1.8 – 817	18.22	240
Thallium (mg/kg)	1084	1082	0.12 - 20.3	1.78	16
U-238 (pCi/g)	9195	9115	0.07 – 228	2.91	30
Ra-226 (pCi/g)	6911	6905	0.125 - 16.8	1.04	5
Ra-228 (pCi/g)	6733	6730	0.16 - 6.6	1.04	5
Th-230 (pCi/g)	6184	6059	0.09 - 23.1	1.56	5
PAH (µg/kg)	2718	2568	0 – 14100	98.07	440
PCB (µg/kg)	3113	3065	0 – 6400	46.67	650
TNT (mg/kg)	1516	1513	0.003 – 34	0.17	14

Figure 4-6 identifies which CUs were confirmed using subsurface criteria. The CUs confirmed using these criteria accounted for approximately 5% of the total number released. Most of these CUs were in the northern portion of Raffinate Pit 4, which was designed to subsurface criteria.



AREAS REMAINING AT SUBSURFACE CRITERIA

FIGURE 4-6

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/CP/059/0601	
ORIGINATOR: ML	DRAWN BY: GLN	DATE: 6/28/01	

4.2.4.5 ALARA Committee

An ALARA Committee was formed to ensure that contaminant concentrations remaining in soil in the chemical plant area after remediation met the intent of the ROD. This committee's five positions were held by the Deputy Project Director Operations, the Deputy Project Director Environmental, the Environmental Safety and Health Department Manager (committee chairman), the Environmental Protection Group Supervisor, and a DOE Project Manager/Engineer. This committee held 37 meetings to discuss confirmation and remediation topics. Approximately half of these meetings were called to determine whether CUs having averages greater than ALARA could be confirmed to meet final cleanup criteria or additional excavation was required. These decisions were based on the number of confirmation results for the contaminant in question that were collected to date and the number that were less than ALARA. If the number was greater than 50%, the CU was confirmed. This was true of all cases where the ALARA committee met to make this determination. If the number was less than 50%, the CU was re-excavated and re-sampled. Table 4-9 lists the meetings, but does not include those held only for CUs with averages exceeding ALARA.

Table 4-9 ALARA Committee Meetings

Date	Topic(s)
06/06/1995	Process Sewer Pipe Beneath Army Road
07/25/1996	Hauling Material from WP-420 to CMSA, WP-420 utilities, ORISE hot spot in CU034, and QC samples
08/ /1996	Busch Lake 36 sediments
10/15/1996	Re-visit of QC sample issue, surface vs. subsurface releases
10/30/1996	WP-420 stockpiles, hotspot identified in CU025 area, CU084 drainage, and overview of polygons
07/17/1997	Confirmation walkovers at raffinate pits, XRF/Vicinity Property MDC-5, and Vicinity Property DA-8
08/11/1997	Vicinity Property MDC-10, Busch Lake 36 sediment placement, Sedimentation Basins 1 and 4 sediment placement, and designing to ALARA
09/02/1997	WP-471 – Design excavation using subsurface criteria
12/15/1997	CU150 – Partial release with a hot spot
01/29/1998	Raffinate Pit 4 - Zone G and cut areas in subsurface CUs
05/01/1998	Vicinity Property DA-5
04/15/1999	TSA hot spots
05/11/1999	Characterization results at HR1 (within Frog Pond drainage off site)
05/26/1999	Use of subsurface criteria
06/07/1999	Use of subsurface criteria in Ash Pond work zone (<2 ft)
07/08/1999	CSS Mod 11 foundation
09/20/1999	WP-471/WP-437 final grade
11/10/1999	Administration storm sewers
02/07/2000	Vicinity Property DA-6
03/23/2000	Frog Pond outlet contamination remaining under the culverts
08/23/2000	CU411 – NE slope at the quarry

4.2.4.6 Independent Verification By ORISE

The Oak Ridge Institute for Science and Education (ORISE) was contracted by the DOE to verify confirmation soil sampling in the chemical plant area. Verification activities included independent walkover radiological surveys and collection and analysis of soil samples to verify proper disposition of CUs. Field verification activities were conducted in accordance with the ORISE final survey plan. To date, ORISE verification reports have agreed with the PMC post remedial action reports that the remedial action objectives have been met, i.e., that soil contaminant levels range between cleanup criteria and the ALARA goals, reaching the goals in most cases

4.2.5 Disposal Cell

A major component of the Chemical Plant Operable Unit remedial action was the construction of the disposal facility, or "cell," where material resulting from the chemical plant remediation would be placed. Construction of the disposal facility began on April 24, 1997, with a ceremonial groundbreaking. The facility is in the area formerly occupied by the chemical plant production buildings and will provide long-term containment and management of the waste materials. It covers about 45 acres in an area that has been tested to confirm its geological suitability for this use. At its apex the cell will be approximately 75 feet high and will contain approximately 1.48 million cu yd of contaminated material.

The cell consists of four primary systems: the base liner with leachate-collection and removal systems, the disposed wastes, the clean-fill dike and the cover systems.

The base liner is designed to prevent leachate from migrating vertically from the bottom of the cell. The liner is composed of a 3-ft low-permeability clay liner, a secondary composite liner, a secondary leachate collection and removal system, a primary liner, and a primary leachate collection and removal system. The primary liner is composed of a flexible membrane and a geosynthetic clay liner with leak-sealing capability. The flexible membrane in the secondary liner is paired with a compacted clay liner than can absorb or reduce many of the radionuclides and heavy metals that may be present in the leachate. The composite liners cover the bottom, excavation sidewalls, and interior slopes of the perimeter clean-fill dike.

The basal liner system contains both primary and secondary leachate collection systems (LCRS). The primary system collects leachate and directs it to the leachate collection sump. The secondary system provides redundant leachate collection and also directs the collected leachate to the sump. The primary LCRS consists of an 8-in. layer of filter sand overlying an 8-in. gravel drain layer in which a 4-in. diameter high density polyethylene (HDPE) perforated piping system is embedded. The final layer of the primary LCRS consists of a 160-mil protective geotextile liner. The secondary LCRS system consists of a gravel drainage layer containing 4-in. diameter HDPE perforated piping between two 250 mil geonet liners.

A geochemical barrier was installed above the basal liner material and below the bottom of the waste. This barrier is 1 ft deep and is composed of low-level radioactivity soils and peat mixed in a 3:1 volumetric ratio. The barrier attenuates contaminants in the leachate as the liquid migrates through the barrier into the primary LCRS.

The clean-fill dike is constructed of compacted clay soil and surrounds the disposal facility. Its function is to resist erosion, limit infiltration of moisture into the waste, minimize radon emissions, reduce long-term maintenance, discourage animal and human intrusions into the waste, and reduce risk to human health and the environment.

Wastes have been placed and stabilized within the disposal facility in a controlled and engineered manner so as minimize settling, minimize volume, and retard radon emissions. Metal and concrete wastes are spread in layers and covered with soil in a manner to eliminate voids.

The cover system serves the same purpose as the clean-fill dike in regard to storm water runoff, infiltration, and intrusion. It consists of multiple layers including (from bottom to top) an infiltration/radon barrier of low permeability clay, a geomembrane and geosynthetic clay liner, drainage (gravel) and filter (sand) layers, a bedding layer, and a biointrusion layer of rock.

Quality Assurance (QA) assessments and surveillance and Quality Control (QC) inspections and testing were performed during design and construction of the disposal facility. Quality Assurance oversight was maintained over project management groups, design agencies, suppliers, and subcontractors. Quality Control activities were conducted in accordance with the *Remedial Action Inspection and Test Plan for Disposal Cell Construction, Work Package 437* (Ref. 33). All aspects of cell construction were included in the *Test Plan*, from field density and moisture control testing, quality requirements for riprap and aggregate materials, to inspections of the geosynthetic clay liners.

Quality Control personnel developed material checklists for each type of material placed in or on the cell. Test plans and daily checklists delineated the contract specification requirements for each type of material. While subcontractors were used for QC inspections of non-critical work packages, PMC QC personnel performed these inspections and tests for critical work packages utilizing an on-site laboratory. Vendors and subcontractors were required to develop their own quality programs, which were then approved by the PMC.

Because the PMC implemented both the construction management and direct hire contracts for construction of the disposal cell, the DOE subcontracted an independent oversight group to oversee all QA/QC activities performed by the PMC and Direct Hire Organization. This independent oversight was initiated in the spring of 1997.

The disposal facility is 100% filled with 1.48 cu yd of waste deposited. Cell cap construction is underway, and the cell will be completed and capped by December 2001.

4.2.6 Borrow Area

On June 9, 1995, the Missouri Department of Conservation approved a plan allowing the Department of Energy at the WSSRAP to excavate nearly 2 million cu yd of clay material from land in the Weldon Spring Conservation Area. This borrow area is approximately one-half mile southeast of the site and one-quarter mile east of Francis Howell High School across Highway 94. The clay soil is being used to construct the disposal cell. Clay soil was chosen because it has very low permeability when compacted. Extensive testing showed that the proper quality and quantity of material was located in the borrow area. The excavated clay is being used for foundation backfill, clay liners, and clean fill perimeter dikes, and for regrading excavated areas.

The borrow area easement was surveyed to determine whether soil removal would disturb any archeological or historical sites. The land was also assessed from an ecological standpoint to check for threatened or endangered species and wetland areas. The DOE signed a separate agreement with the MDOC to mitigate any loss of wetlands in the area. The agreement authorized the creation of a wetlands area in the August A. Busch Memorial Conservation to provide aquatic habitat to replace areas disturbed during work at the chemical plant site.

The borrow area comprises more than 213 acres of land including 150 acres for borrow development and operations. The remaining acreage was used to construct a haul road leading from the borrow source to an entrance at the north side of the chemical plant area. The haul road is dedicated to borrow operations in order to separate project vehicles and equipment from public roadway users. The DOE reached an agreement with the Missouri Highway and Transportation Department, Francis Howell School District, and the MDOC which permitted a portion of Highway 94 to be realigned to allow for a grade separation crossing. The separation routes borrow traffic through an underpass at Highway 94. Construction of the grade separation in 1996 included reduction of two dangerous curves in Highway 94 that had been the scene of numerous accidents.

After borrow operations are complete, the area will be restored per consultation with the MDOC. Mulch and seed will be added to restore groundcover.

4.2.7 Changes to the Chemical Plant ROD

The Changes to the *Chemical Plant ROD* (Ref. 8) which have been identified since the previous five-year review are listed in Table 4-10. These changes were all considered "non-significant."

Table 4-10 Changes to the *Chemical Plant ROD*

CHANGE NO.	DATE	DESCRIPTION
7	6/11/96	TSA rubble will be washed and transported to Ash Pond for stockpiling and rock crushing.
8	7/17/96	PCB soils will be stored at the TSA under a tarp or in tight boxes.
9	7/31/96	Water from the chemical plant will be transported to the QWTP for treatment.
10	8/30/96	Placement of tanks and secondary containment at the TSA for temporary storage of RCRA brine wastes.
11	12/12/96	An area of toluene contamination was discovered during foundations removal. Toluene was not a contaminant of concern in the ROD. Cleanup levels were developed using the same methods as used for the chemical plant OU, and the contaminated area was remediated consistent with techniques used for the chemical plant remediation.
12	6/20/97	An area of hexane contamination was discovered during soil removal in preparation for disposal cell construction. Hexane was not a contaminant of concern in the ROD. As a precaution and part of routine waste management, the contaminated area was remediated consistent with techniques used for the chemical plant remedial action. Contaminated soil was removed to hexane levels well below the Preliminary Remediation Goal (PRG) recommended by EPA Region VII.
13	10/30/97	The ROD states, "Chemical stabilization/solidification will be the treatment method used for contaminated sludge, certain quarry soil and sediment, and certain other contaminated soil from the chemical plant site (such as soil taken from beneath the raffinate pits.)". The change was to clarify that the only material that would be treated by the CSS facility would be the raffinate sludge. The nitroaromatic soils from the quarry were to be treated by an in situ process.
14	10/30/97	The ROD states, "Two new facilities would be constructed on site to support this alternative: one for CSS…and another for physical treatment (the volume reduction facility)." During planning for the disposal cell, it was determined that using conventional means (e.g., mechanical shears) would be sufficient for sizing material. Therefore, the volume reduction facility was eliminated.
15	10/30/97	The ROD states, "The CSS grout material resulting from the mixing of raffinate sludge and binder agents would be…transported by truck to the disposal facility for grouting of voids in dismantlement debris or be further mixed with contaminated soils to produce a CSS soil-like product." It was determined that the grout would be pumped by pipe instead of trucked. Pumping was chosen to reduce traffic safety issues and minimize the amount of decontamination and waste. Also it was determined to pour the grout as a monolith and to fill the voids with soil.
16	10/30/97	The ROD states, "The RCRA requirements are applicable to the following facilities as they are used to treat, store, or dispose of RCRA wastes or were designed in accordance with RCRA requirements and were constructed after 1980, the chemical stabilization/solidification facility…" Although designed to RCRA standards, the CSS plant will not be required to meet the operational requirements of 40 CFR 264. The raffinate pit sludge is not a RCRA material; therefore, RCRA is not applicable to the CSS operation.
17	10/30/97	The ROD states, "The borrow area action will comply with the reclamation standards and will register with the commission". On 11/3/94 the WSSRAP contacted the Mining Reclamation Office of the MDNR to clarify the applicability of the Mining Rec. Regulations. They stated that a permit was not required, the regulations were not applicable to the borrow area, the MDOC requirements for this operation would be more stringent than the mining reclamation requirements, and there was no need to further coordinate with the Mining Reclamation Office. Therefore, the borrow area action will not be registered with the Land Reclamation Commission.

Table 4-10 Changes to the *Chemical Plant ROD* (Continued)

CHANGE NO.	DATE	DESCRIPTION
18	10/30/97	The ROD states, "Included as part of the permit process is a Water Pollution Prevention Plan, which will be prepared for the borrow area and which will include preventative measures for erosion control." The State of Missouri does not require a Pollution Prevention Plan. Although, a specific plan has not been written, erosion control and pollution prevention are addressed in specifications for all work packages. In addition erosion control is addressed in accordance with the WSRRAP Chemical Plant Surface Water and Erosion Control Report. Storm water permitting for the borrow area is addressed through the St. Charles County Permit.
19	8/4/98	Previously unidentified contamination detected in the Frog Pond outlet area will be remediated using the guidelines in the ROD for vicinity properties. This area was not previously identified as contaminated or in need of remediation. This area was addressed as though it were a vicinity property. Radiological surface scans and soil sampling detected elevated uranium and thorium levels in the drainage outlet leading from the Frog Pond. Soil characterization results indicated contamination above the uranium criteria (120 pCi/g) and Th-230 (6.2 pCi/g).
20	10/22/98	The ROD states, "Sludge would be removed from the raffinate pits with a floating dredge and then pumped as a slurry to an adjacent treatment facility." It was determined that instead of processing all the sludge in the CSS plant, a batch or in situ process would be used to chemically stabilize/solidify approximately 15,000 cu yd of sludge in the southern portion of Raffinate Pit 4. An additional 5,000 cu yd of a dry and dense sludge/soil mixture from Raffinate Pit 4 will be placed directly in the cell.
21	7/23/99	A listed hazardous waste, waste code F002, was inadvertently generated as a result of on site decontamination activities. Delisting a hazardous waste for CERCLA remedial response actions is accomplished by documenting compliance with the substantive requirements of RCRA as outlined in 40 CFR 260.20 and 260.22. Hazardous wastes containing low concentrations of hazardous constituents and that pose no threat to the environment should be considered as candidates for delisting. Delisting requires a demonstration that a listed RCRA hazardous waste no longer meets any of the criteria under which the waste was listed. The supporting documentation was attached to the change.

4.3 Quarry Residuals Operable Unit

4.3.1 Introduction

The Quarry Residuals Operable Unit (Quarry Residuals OU) is the second of two operable units established for the quarry area. The Quarry Residuals OU addresses residual conditions at the quarry, including (1) residual soil contamination at the quarry proper remaining after completion of bulk waste removal, (2) surface water and sediment contamination in the Femme Osage Slough and nearby creeks, and (3) contaminated groundwater north of the Femme Osage Slough.

The *Record of Decision for Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site* (Ref. 32) was signed by the U.S. Environmental Protection Agency and the U.S. Department of Energy on September 30, 1998. The *Quarry Residuals OU ROD* presents the selected remedial action for the OU following the requirements of CERCLA. The selected action stipulates long-term monitoring of groundwater to ensure continued protection of human health and the environment. Institutional controls will also be implemented to prevent groundwater usage inconsistent with recreation uses, or uses that would adversely affect contaminant migration. Field studies will collect data to verify the existing conceptual fate and transport model for the quarry.

4.3.2 Components of the Quarry

The quarry residuals project can be divided into two tasks: (1) implementation of the *Quarry Residuals OU ROD* and (2) final reclamation of the quarry area. Implementation of both projects is necessary to attain final closure of the quarry area, and both impact the final configuration of the quarry area.

4.3.2.1 Quarry Residuals Operable Unit

Components of this operable unit include soil in the quarry proper, surface water and sediments in the slough and nearby creeks, and contaminated groundwater north of the slough. Each of these components was investigated during the remedial investigation phase to determine the nature and extent of contamination resulting from quarry disposal activities or the migration of contaminants in groundwater and surface water.

4.3.2.1.1 Soil in the Quarry Proper

At the quarry proper, soil at the rims and slopes was sampled, and sediment was sampled from the wall and floor fractures and from the ramp and floor of the quarry sump. Due to poor access, two areas, the northeast slope and the ditch area near the transfer station, were not completely characterized prior to the *Quarry Residuals OU ROD*. The ROD specified performance of a risk assessment after completion of the additional characterization to determine if excavation of residually contaminated soils from the two areas was warranted due to unacceptable risk. Review of the additional characterization data indicated no increase in the risk levels within the quarry proper. Radiological and chemical results from the remedial investigation samples, as well as subsequent characterization samples form the northeast slope and the ditch area, indicated that under a recreational scenario, potential exposures are below to within the acceptable risk range of 10^{-6} to 10^{-4} (Ref 35).

Because contaminated materials were being removed during the early stages of quarry restoration, removal of some soil from several areas in the quarry proper was included in the restoration projection. Excavation limits were based on the cleanup criteria for radionuclides presented in the *Chemical Plant ROD* (Ref. 8).

A summary of the radiologically contaminated soil removal performed under this operable unit is in Table 4-11. Initially, soil in three areas of the quarry proper (northeast slope area, ditch area, and snake pit area) were to be excavated as contaminated. A confirmation plan was developed to address verification of removal of soils to the pre-selected release criteria. Confirmation of the utility lines associated with contaminated facilities used during bulk waste removal was added to the plan since a 1-ft envelope of soils was being removed as contaminated. The soils beneath the clarifier pad were added based on initial walkovers after removal of the concrete pad, which was removed as contaminated. Each confirmation unit was released in accordance with the *Quarry Proper Confirmation Plan* (Ref. 35).

Table 4-11 Contaminated Soil Removal Summary for the Quarry Residuals OU

Location	Release Criteria	Volume Removed	Notes
Northeast Slope	Surface	764 CU YD	The area had a Th-230 average exceeding surface criteria. Also, the area contained more than five hot spots for Th-230 and two exceeded three times criteria. Deferred to ALARA committee – decision was that no additional RA was required, and the area was backfilled. It was decided that while the cleanup concentrations were not obtained, the ALARA principle was met during this action.
Ditch Area	Subsurface	241 cu yd	Additional excavation based on initial confirmation sampling
Snake Pit	Subsurface	322 cu yd	None
Utility Line (Sump to EQB)	Subsurface	293 cu yd	Partial release – segment near EQB beneath water line to be removed during QWTP demolition.
Clarifier Pad	Subsurface		None

An addendum to the *Quarry Proper Confirmation Plan* (Ref. 35) was prepared to address three radiologically contaminated soil areas associated with demolition of the quarry water treatment plant.

4.3.2.1.2 Surface Water and Sediment in the Slough and Nearby Creeks

Surface water and sediment from the upper and lower reaches of the Femme Osage Slough, the Little Femme Osage Creek, and downstream portions of the Femme Osage Creek were characterized for radiological and chemical contamination. Fish from the slough were collected and analyzed to investigate potential impacts from site contaminants.

Radiological and chemical results from the surface water and sediment samples indicated that under a recreational scenario the potential risks estimated for the slough and creeks are within the acceptable range of 10^{-6} to 10^{-4} (Ref. 32). The current levels of contamination in surface water and sediments from the slough and the Little Femme Osage Creek do not appear to

have affected ecological resources at these habitats and do not pose a future risk to biota. The results from the risk assessment indicated that no action was warranted for the surface water and sediments in the slough and nearby creeks.

4.3.2.1.3 Groundwater North of the Slough

Groundwater from the well field south of the slough is used for residential purposes, and monitoring data indicate that uranium levels in this area are similar to background levels. The contaminated quarry groundwater is not accessible to either current or future recreational users. For informational purposes, risk estimates for groundwater were calculated for a hypothetical residential user. At some locations north of the slough, the potential estimated risk is greater than the acceptable risk range of 10^{-6} to 10^{-4} (Ref. 32).

Because source removal was accomplished under a previous action, no additional contaminants to the groundwater system should be introduced. However, because of the presence of significant levels of uranium in groundwater north of the slough, it was considered prudent to continue an evaluation through field studies of the effectiveness and benefit of reducing the levels of uranium in the groundwater in the quarry area. The available hydrological and geochemical information, as well as water quality data, support the conclusion that site contaminants will not measurably affect the aquifer of the Missouri River alluvium south of the slough. However, given the reliance on natural systems to preclude potentially significant impacts to this aquifer, alternatives addressing groundwater remediation were evaluated in the *Feasibility Study for Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site, Weldon Spring, Missouri* (Ref. 36).

Long-term groundwater monitoring with institutional controls on groundwater usage in the area of impact was presented as the selected action in the *Quarry Residuals OU ROD* (Ref. 32). The selected action addresses groundwater contamination by monitoring to provide data for verifying that conditions in the quarry area and the well field will remain protective of human health and the environment. This determination will be made based on the collection of groundwater data from strategically selected monitoring wells, both inside and outside the area of groundwater impact. This data will also document any continued effects of source removal from the quarry and natural processes on contaminant concentrations within the area.

This action will be designed to provide for long-term monitoring of groundwater, including the groundwater in the Missouri River alluvium. Existing wells, with the possible addition of several new monitoring wells, will be utilized in this network. If long-term monitoring identifies a trend or change in monitoring wells south of the slough resulting in increased levels of uranium approaching a trigger level of 30 pCi/l, the potential for significant impacts to the well field and the alluvial aquifer will be re-evaluated.

Chemical- and action-specific applicable or relevant and appropriate requirements (ARARs) for the selected action are discussed in the *Quarry Residuals OU ROD* (Ref. 32). Chemical specific ARARs set concentration limits or ranges in various environmental media for

specific hazardous substances, pollutants, and contaminants of concern. Missouri water quality standards in groundwater for nitrobenzene (17 μg), 2,4-DNT (0.11 μg), and 1,3-DNB (1.0 μg) are chemical-specific ARARs for quarry groundwater. Currently only a few locations exceed the Missouri water quality standards for groundwater. It is projected that these ARARs are likely to be met within a reasonable period of time and that long-term monitoring of the groundwater will confirm compliance with these limits.

The standard for uranium in groundwater outlined in 40 CFR 192.02 was considered as a potential ARAR for this action during development of the *Quarry Residuals OU Feasibility Study* (Ref. 36) and *Proposed Plan for Remedial Action at the Quarry Residuals Operable Unit at the Weldon Spring Site* (Ref. 37). The groundwater north of the slough is impacted; however, it is not considered to be a usable groundwater source. Conversely, the Missouri River alluvium south of the slough is currently not impacted and is presently being used as a potable water source. Because groundwater north of the slough is not a useable source, 40 CFR 192.02 is not considered an ARAR for that groundwater. However, 40 CFR 192.02 would likely be an ARAR for any remedial action considered for the useable groundwater source south of the slough in the unlikely event of contaminant migration from north of the slough. While 40 CFR 192.02 currently appears to be the only groundwater standard that would be considered as a potential ARAR for any future remedial action, other standards in place at the time of any future action would also be considered in the ARAR analysis.

Institutional controls will be necessary to prevent uses inconsistent with recreational use or uses that would adversely affect contaminant migration. In coordination with the Missouri Department of Natural Resources and the Missouri Department of Conservation (affected landowners), a written agreement, such as a license agreement, memorandum of understanding, or deed attachment, outlining and agreeing to the terms of the institutional controls will be established. Terms may include limiting access to groundwater north of the slough for purposes of irrigation, consumption, etc. The terms of the agreement will be evaluated periodically based on the results of the long-term monitoring program and changed as appropriate.

During bulk waste removal, the DOE developed the *Well Field Contingency Plan* (Ref. 38) to ensure the continued availability of a safe and reliable public water supply for St. Charles County. Specific activities undertaken as part of this plan were:

- Continued water quality monitoring to detect trends or abrupt changes in contaminant levels near the well field.
- Contaminant transport calculations and numerical modeling of the Weldon Spring Quarry and St. Charles County well field hydrogeologic system to enhance the understanding of processes controlling groundwater flow and contaminant migration.
- Definitions of action levels and response actions.

- Preparation of a plan for hydrogeological characterization to support development of a replacement well field.

- Development of design criteria for design and construction of a replacement well field.

The monitoring portion of the *Well Field Contingency Plan* has been integrated into the long-term monitoring program for this operable unit. The monitoring program outlined in the *Plan* may be modified based on specifics discussed in the *Quarry Residuals OU ROD* (Ref. 32). The contingencies outlined will be re-evaluated based on current data and understandings and they may be updated and summarized in a revision of the *Plan*.

Field studies are planned in response to significant levels of contamination in quarry groundwater north of the slough, which is in close proximity to the St. Charles County well field, and the reliance on natural systems to limit potential exposure. The following studies will be conducted to support the selected action described in the *Quarry Residuals OU ROD* (Ref. 32):

- Studies to support the evaluation presented in the *Quarry Residuals OU Feasibility Study* (Ref. 36) regarding the need for, and effectiveness of, groundwater remediation, which includes an interceptor trench.

- Field sampling to further characterize conditions controlling the fate and transport of uranium in the shallow aquifer.

4.3.2.1.3.1 Quarry Interceptor Trench Field Study

Several configurations of an interceptor trench were evaluated in the *Quarry Residuals OU Feasibility Study* (Ref. 36). The most effective configuration was determined to be a trench near the center of the uranium plume. This configuration could result in expedited removal of the highest uranium concentrations. Groundwater modeling using analytical methods have indicated that this extraction system had the potential to reduce the mass of uranium in groundwater north of the slough by 8% to 10% over a 2-year operating period. This removal would constitute a small reduction of the total uranium contamination present and would not provide a measurable increase in protectiveness over the foreseeable future.

The objective of the field study is to confirm the predictive model on uranium removal from the shallow aquifer using actual field data. If the performance of the trench is less effective or within the specified performance goals (≤ 10% of the mass of uranium removed within the 2-year testing period), further evaluation of the groundwater will not be necessary. If the performance of the trench exceeds the specified goals (> 10% of the mass of uranium removed

within the 2-year testing period), the effectiveness of groundwater extraction will be re-evaluated.

The trench will be monitored to determine (1) the efficiency of the uranium removal from the aquifer and (2) the area of influence of the trench. Levels of nitroaromatic compounds will also be monitored. Effluent from the trench, groundwater samples, and measurement of the static water levels in the vicinity of the trench will be used to assess the performance of the trench system.

The system will be evaluated and monitored for up to 2 years. Data will be collected from the trench (i.e., volume of water extracted and uranium and nitroaromatic compound levels) and from observation wells installed in the area of influence of the trench. This data will be combined with other data collected as part of the hydrogeologic field data to evaluate the effectiveness of the trench versus predicted performance goals.

Operation of the interceptor trench started on April 27, 2000. Sampling of the trench and nearby monitoring wells has been performed as outlined in the *Sampling Plan for the QROU Interceptor Trench Field Study* (Ref. 39). The following is a summary from April 27, 2000 through March 31, 2001.

As of April 27, 2001, a total 407,644 gal of water had been pumped from the trench. A summary of the production from each sump is in Table 4-12.

Table 4-12 Quarry Interceptor Trench Production (gal) Summary

Sump	Production to Date
3004	220
3104	36,882
3204	25,532
3304	345,010
Total	**407,644**

Samples have been collected from the operating pumps on a daily basis for on-site analysis of uranium and weekly for off-site analysis of uranium and nitroaromatic compounds. Analytical data for the trench are summarized in Tables 4-13 and 4-14.

Table 4-13 Summary of Uranium Data[a] from the Interceptor Trench

Sump	Uranium (pCi/l)		
	Average	Maximum	Minimum
3004	1,309	—	—
3104	2,768	3,100	1,690
3204	2,268	2,920	1,889
3304	1,227	5,173	45.5

(a) Unfiltered data.

Table 4-14 Summary of Nitroaromatic Compound Data from the Interceptor Trench

Nitroaromatic Compounds		Sump			
		3004	3104	3204	3304
1,3,5-TNB	# Detects/# Samples	0	2 / 4	1 / 3	11 / 23
	Average (µg/l)	NS [a]	7.6	1.30	0.36
	Maximum (µg/l)	NS	12.0	—	2.7
	Minimum (µg/l)	NS	3.2	—	< 0.03
1,3-DNB	# Detects/# Samples	0	2 / 4	1 / 3	2 / 23
	Average (µg/l)	NS	0.85	0.47	0.06
	Maximum (µg/l)	NS	1.60	—	0.42
	Minimum (µg/l)	NS	0.095	—	< 0.09
2,4,6-TNT	# Detects/# Samples	0	2 / 4	1 / 3	13 / 23
	Average (µg/l)	NS	1.66	0.28	0.13
	Maximum (µg/l)	NS	2.70	---	0.48
	Minimum (µg/l)	NS	0.62	---	< 0.03
2,4-DNT	# Detects/# Samples	0	2 / 4	1 / 3	15 / 23
	Average (µg/l)	NS	0.30	ND (< 0.2)	0.10
	Maximum (µg/l)	NS	0.55	—	0.25
	Minimum (µg/l)	NS	0.053	—	< 0.03
2,6-DNT	# Detects/# Samples	0	2 / 4	1 / 3	15 / 23
	Average (µg/l)	NS	0.40	ND (< 0.2)	0.17
	Maximum (µg/l)	NS	0.64	—	0.55
	Minimum (µg/l)	NS	0.15	—	< 0.01

NS not sampled

The total mass of uranium removed from the shallow aquifer is 3.6 kg. A summary of the mass removed in each sump is in Table 4-15. A graph of the mass removed each day and the cumulative mass removed is in Figure 4-7.

Table 4-15 Quarry Interceptor Trench Uranium Mass Removal Summary

Sump	Mass Removed to Date (g)
3004	1.4
3104	558
3204	245
3304	2,824
Total	3,628

Nearby monitoring wells were sampled weekly in the first 3 months of the field study for uranium, nitroaromatic compounds, and geochemical parameters. After the first 3 months, the six OW-series monitoring wells have been sampled bi-weekly for on-site analysis of uranium and monthly for off-site analysis of uranium, nitroaromatic compounds, and geochemical parameters. The remainder of the nearby monitoring wells has been on the monthly sampling frequency. A summary of the data for uranium and nitroaromatic compounds this reporting period is provided in Tables 4-16 and 4-17.

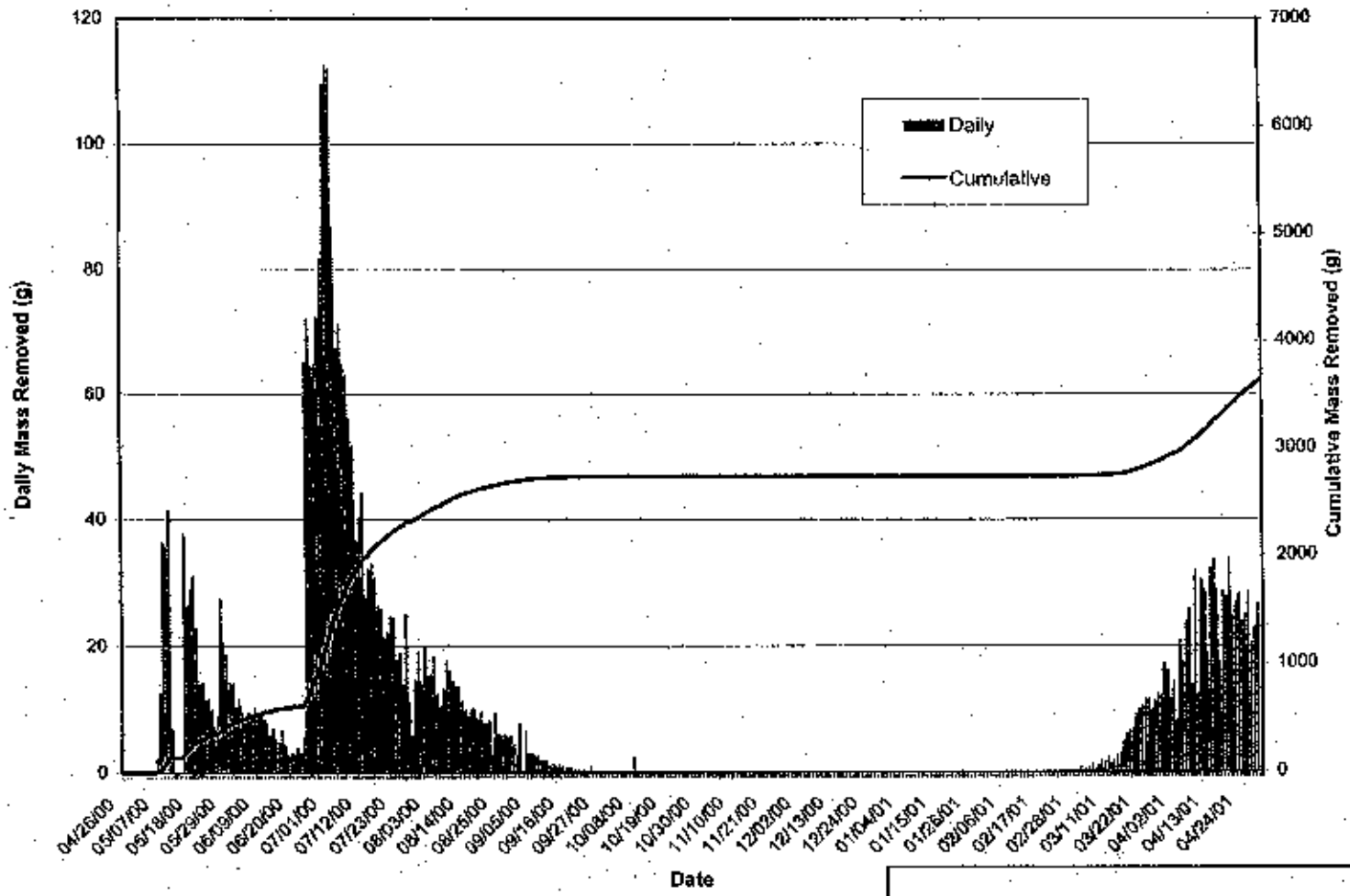
Table 4-16 Summary of Uranium Data[a] for Monitoring Wells

Location	Uranium (pCi/l)		
	Average	Maximum	Minimum
OW01	196	255	91
OW02	207	511	45
OW03	531	1,300	17
OW04	2,220	2,740	1,490
OW05	57	1,040	0.77
OW06	135	630	0.75
1008	2,470	4,490	960
1009	5.7	75	0.21
1013	556	718	449
1014	628	812	371
1031	43	61	27
1032	1,190	1,520	982
1047	4.6	35	(0.27)
1048	466	672	385
1049	1.6	12	(0.03)

a Unfiltered data
b Detectable concentrations reported
c ND = Not detected
d NS = Not sampled

Table 4-17 Summary of Nitroaromatic Compound (µg/l) Data for Monitoring Wells

Location		1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT
OW01	# Detects/# Samples	0 / 6	0 / 6	1 / 6	1 / 6	0 / 6
	Average	—	—	—	—	—
	Maximum	—	—	0.052	0.053	—
	Minimum	—	—	—	—	—
OW02	# Detects/# Samples	0 / 6	0 / 6	0 / 6	0 / 6	0 / 6
OW03	# Detects/# Samples	0 / 6	0 / 6	0 / 6	0 / 6	0 / 6
OW04	# Detects/# Samples	0 / 6	0 / 6	0 / 6	0 / 6	0 / 6
OW05	# Detects/# Samples	0 / 6	0 / 6	0 / 6	0 / 6	0 / 6
OW06	# Detects/# Samples	0 / 6	0 / 6	0 / 6	0 / 6	0 / 6
1008	# Detects/# Samples	0 / 6	0 / 6	0 / 6	0 / 6	1 / 6
	Average	—	—	—	—	—
	Maximum	—	—	—	—	(0.0024)
	Minimum	—	—	—	—	—
1009	# Detects/# Samples	0 / 7	0 / 7	0 / 7	0 / 7	0 / 7
1013	# Detects/# Samples	0 / 7	0 / 7	0 / 7	1 / 7	0 / 7
	Average	—	—	—	—	—
	Maximum	—	—	—	0.052	—
	Minimum	—	—	—	—	—
1014	# Detects/# Samples	0 / 7	0 / 7	0 / 7	0 / 7	0 / 7
1031	# Detects/# Samples	0 / 1	0 / 1	0 / 1	0 / 1	0 / 1
1032	# Detects/# Samples	0 / 7	0 / 7	0 / 7	2 / 7	0 / 7
	Average	—	—	—	0.03	—
	Maximum	—	—	—	0.09	—
	Minimum	—	—	—	< 0.03	—
1047	# Detects/# Samples	0 / 4	0 / 4	0 / 4	0 / 4	0 / 4
1048	# Detects/# Samples	0 / 7	0 / 7	0 / 7	0 / 7	0 / 7
1049	# Detects/# Samples	0 / 7	0 / 7	0 / 7	0 / 7	0 / 7



QUARRY INTERCEPTOR TRENCH
MASS OF URANIUM REMOVED
THROUGH 4/30/01

FIGURE 4-7

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/PI/029/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 8/23/01	

4.3.2.1.3.2 Hydrogeological Field Studies

Geologic, hydrologic, and geochemical field studies will be performed to provide data from within the area north of the slough where uranium has been detected in the groundwater. This site-specific data will be used to supplement and verify the current model of the hydrogeologic and geochemical site characteristics that dictate fate and transport and potential remediation of uranium in this area.

The objectives of the hydrogeologic characterization is to:

- Further define the lateral and vertical distribution of the differing fine-grained materials north of the slough.
- Provide a detailed description of the underlying Decorah Group.
- Provide information for stratigraphic correlation of hydrologic and geochemical characteristics from characterized portions of the shallow aquifer to the remaining portions north of the slough.
- Determine the variation in aquifer parameters due to the heterogeneity of the fine-grained alluvium.
- Identify zones within the bedrock that facilitate migration of uranium-contaminated groundwater.
- Assess the natural conditions of the aquifer system, which attenuates uranium in groundwater north of the slough.
- Estimate distribution coefficients for differing locations and material types north of the slough.
- Characterize the oxidation potential within the aquifer.
- Provide additional supporting evidence for the presence of a reduction zone north of the slough.

4.3.2.2 Quarry Reclamation

Components of reclamation of the quarry area include restoration of the quarry proper, demolition of the quarry water treatment plant, removal of the interceptor trench system (field study), and dismantlement of facilities utilized during bulk waste removal. Reclamation of the quarry area is planned as a project.

The quarry proper restoration design plan includes backfilling the quarry with soil to:

- Reduce fall hazards.
- Eliminate ponding of surface water.
- Force groundwater flow around the inner quarry.
- Reduce infiltration of precipitation through the backfill.
- Prevent mobilization to the surface of residual contamination in fractures through erosion and/or freeze/thaw action,

The facilities used during bulk waste removal have already been dismantled. This included removal of:

- Decontamination facility.
- Transfer station.
- Fuel station.
- Associated piping.
- Ancillary structures.
- Quarry water treatment plant.

Final reclamation of the quarry area will be performed at the completion of the interceptor trench field study. Reclamation will include:

- Dismantlement of the interceptor trench.
- Grading of the treatment plant and interceptor trench areas to conditions that are as close as possible to natural contours.

4.4 Chemical Plant Groundwater Operable Unit

The Groundwater Operable Unit (Groundwater OU) is the second of two operable units established for the chemical plant area of the Weldon Spring site. The Chemical Plant Operable Unit, which was the first operable unit, addressed the treatment of sludges, excavation of soil, and placement of these materials and the quarry bulk wastes, treated sludge, contaminated soils, buildings, drums, process equipment, and debris in the disposal cell. The Groundwater OU addresses contaminated groundwater and springs in the chemical plant area.

4.4.1 Environmental Documentation

It was decided in 1993 to prepare separate environmental documentation regarding remediation of groundwater beneath the chemical plant site. It was also decided at that time that the U.S. Department of Energy and the U.S. Department of the Army would work jointly to address the groundwater issues for both sites. The remedial investigation was conducted in 1995 and included a joint sampling effort by the DOE and the Corps of Engineers of all wells in the chemical plant area. The *Remedial Investigation for the Groundwater Operable Units at the Chemical Plant Area and the Ordnance Works Area, Weldon Spring, Missouri* (Ref. 40) and the *Baseline Risk Assessment for the Groundwater Operable Units at the Chemical Plant and the Ordnance Works Area, Weldon Spring, Missouri* (Ref. 41) were finalized in July 1997. The contaminants of potential concern were identified as nitrate, sulfate, chloride, lithium, molybdenum, nitroaromatic compounds, uranium, trichloroethylene (TCE), and 1,2-DCE (Ref. 40). Contamination in groundwater is generally confined to the shallow, weathered portion of the uppermost bedrock unit, the Burlington-Keokuk Limestone.

The feasibility study for remedial action for the groundwater operable unit at the chemical plant area and ordnance works area was initiated in 1997 (Ref. 42). This study evaluated potential options for addressing groundwater contamination at both the chemical plant site and the former ordnance works area. The preferred alternative was long-term monitoring of groundwater in conjunction with in situ treatment of portions of the shallow aquifer impacted by TCE. In 1998, a long-term pumping test was performed at the chemical plant to evaluate potential groundwater remediation methods for TCE contaminated groundwater. Results indicated that the transmissivity of the aquifer in the area of TCE impact was higher than expected, but due to the geology in the area, dewatering of the aquifer occurred. Evaluation of conventional pump-and-treat technologies indicated that this might not be the most effective method for possible remediation of this area. These data were evaluated in the *Supplemental Feasibility Study for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site* (Ref. 43) and utilized in preparation of the *Proposed Plan for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site* (*Groundwater OU Proposed Plan*) (Ref. 44).

The *Groundwater OU Proposed Plan* was submitted to the public and the regulatory agencies on August 3, 1999. A first public comment period was from August 3 through

September 1999. After a public meeting on August 25, 1999, at the Weldon Spring site, the comment period was extended from November 2, 1999, through January 6, 2000, in response to public requests.

When the plan was issued, the MDNR provided comments taking issue with certain aspects of it. To resolve these issues, the EPA, the DOE, and the MDNR mutually agreed to engage in a defined issue-resolution process similar to the dispute process provided for under the Federal Facilities Agreement. In addition, the public comment period was further extended to run concurrent with the dispute process.

At the request of the EPA Region VII Regional Administrator, Dr. James Williams, Director, MDNR-DGLS, was tasked to review the *Completion Report for the Pilot Pumping Test for the GWOU* (Ref. 45) with respect to his views on necessary testing and to make recommendations for additional tests, if necessary. The MDNR-DGLS, DOE, and EPA met on February 9, 2000, to discuss the feasibility of groundwater pump-and-treat with injection at the chemical plant site and to provide additional information to Dr. Williams to assist in his review of additional testing. The DOE received a letter outlining Dr. William's position on March 10, 2000. This letter stated that it was the MDNR-DGLS opinion that the DOE had not shown that extraction of a meaningful amount of contaminated groundwater is infeasible. It was recommended that pilot studies should be performed to determine what quantities of contaminants could be extracted under different pumping and artificial recharge scenarios.

In May, 2000, the EPA recommended that the DOE agree to perform a pilot-scale study designed to further define the level of application and effectiveness of groundwater pump-and-treat, consistent with the recommendation of the MDNR. The EPA concluded that a sufficient body of information existed to form the basis for a final decision on an appropriate groundwater remedy. The EPA further concluded that this existing information strongly indicated that there is a low probability that an appropriate measure of effectiveness could be achieved through groundwater extraction techniques. The EPA recommended that the DOE move forward with a final Record of Decision based on the existing *Groundwater OU Proposed Plan.*

Following the conclusion of the dispute process, the plan was reissued for public comment. On June 12, 2000, the DOE announced that there would be an additional public comment period so that the public could have another opportunity to review the plan along with the documents generated during the issue resolution. This additional public comment period was originally scheduled to end on July 14, 2000, but was later extended through August 15, 2000, in response to requests for additional time. Numerous public comment letters were received that expressed concern over the proposal not to actively treat all the groundwater contaminants of concern. In response to these comments, the DOE reconsidered the initial decision to move forward to a final ROD and decided to postpone the final groundwater decision and final groundwater ROD.

The DOE proposed active remediation of the TCE impacted groundwater at the chemical plant site as presented in the proposed plan and to conduct further field studies to re-examine the effectiveness and practicability of further active remediation for the remaining contaminants of concern. An interim ROD relating to the remediation of TCE contaminated groundwater at the chemical plant site was signed by the DOE and EPA on September 29, 2000. This *Interim Record of Decision for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site* (Ref. 5) authorizes treatment of TCE in groundwater utilizing in situ chemical oxidation methods.

A final ROD for the remainder of the groundwater at the chemical plant will be delayed until the DOE addresses concerns received during the recent public comment period. To do this, the DOE is planning to conduct additional studies of the feasibility of extracting groundwater as a means of treating the remaining contaminants of concern.

4.4.2 Additional Groundwater Field Studies

Additional groundwater field studies are being performed to obtain data to be used in deciding whether enhancement of a conventional pump-and-treat system through artificial recharge or modification of the configuration of the system by using angled extraction wells can significantly improve contaminant removal rates as compared to a conventional system. The study consists of six stages designed to compare the methods used to improve a pump-and-treat option for remediation of groundwater in Zone 1. The study was started in March of 2001 and is scheduled to be completed in late 2001.

Stage 1 was initially started on March 9, 2001. After 72 hours of operation, the pump in MW-3028 failed mechanically. This stage was restarted on March 14, 2001. A total of 295,283 gal of water had been pumped from MW-3028 as of March 31, 2001. Extraction rates ranged from 8.7 gpm to 15 gpm. The sustainable yield has not been established.

Samples have been collected daily and submitted for off-site analysis of TCE, nitrate, nitroaromatic compounds, and uranium. Analytical data are summarized in Table 4-18.

Table 4-18 Summary of Analytical Data for MW-3028[a]

PARAMETER	AVERAGE	MAXIMUM	MINIMUM
Nitrate (mg/l)	222	274	146
TCE (µg/l)	352	470	274
2,4-DNT (µg/l)	0.14	0.19	0.08
Uranium (pCi/l)	1.06	1.10	1.03

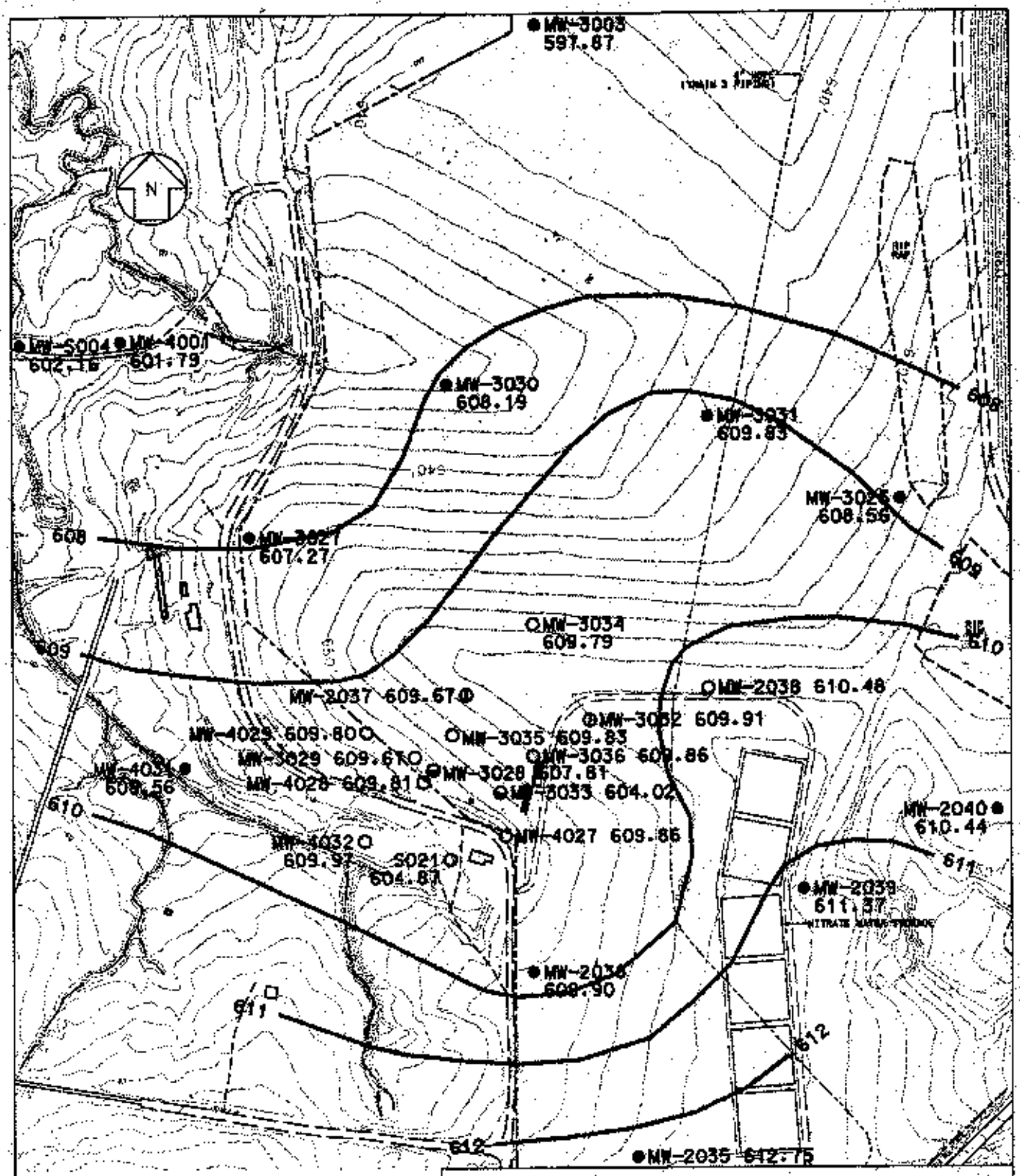
(a) Data from March 9 through March 31, 2001

Observation wells and nearby monitoring wells were sampled prior to the start of the study to establish baseline levels. A summary of the baseline data is in Table 4-19.

Table 4-19 Baseline Data for the Pumping, Observation, and Monitoring Wells

LOCATION	PARAMETERS			
	Nitrate (mg/l)	TCE (µg/l)	2,4-DNT (µg/l)	Uranium (pCi/l)
2036	2.8	ND	ND	0.75
2037	229	660	ND	1.05
2038	655	36	0.27	1.72
3003	313	ND	0.08	24.3
3025	72	83	ND	1.30
3027	33	(0.45)	ND	0.96
3028	195	470	0.08	0.99
3029	238	450	0.09	1.16
3030	117	220	0.79	51.9
3031	31.3	ND	ND	3.50
3032	20.2	1.6	0.06	1.37
3033	52.2	39	0.08	0.74
3034	378	780	0.18	2.45
3035	72	83	ND	1.3
3036	619	(0.71)	ND	2.02
4001	44.6	5.9	ND	ND
4027	22.8	2.5	ND	1.1
4028	34.2	380	0.07	0.92
4029	554	520	0.11	0.83
4031	172	170	0.11	1.05
4032	231	170	0.07	1.05
S021	127	110	0.11	1.42

Water level measurements are obtained on a frequent basis to evaluate the effects of groundwater extraction on the shallow aquifer in Zone 1. The water level was measured prior to the start of the study to establish the natural potentiometric surface (Figure 4-8). Extraction of groundwater from MW-3028 has resulted in a groundwater depression and changes in flow direction around this location (Figure 4-9).



LEGEND

- ⊖ – PUMPING WELL
- ⊕ – INJECTION WELL
- ○ – OBSERVATION WELL
- ● – MONITORING WELL

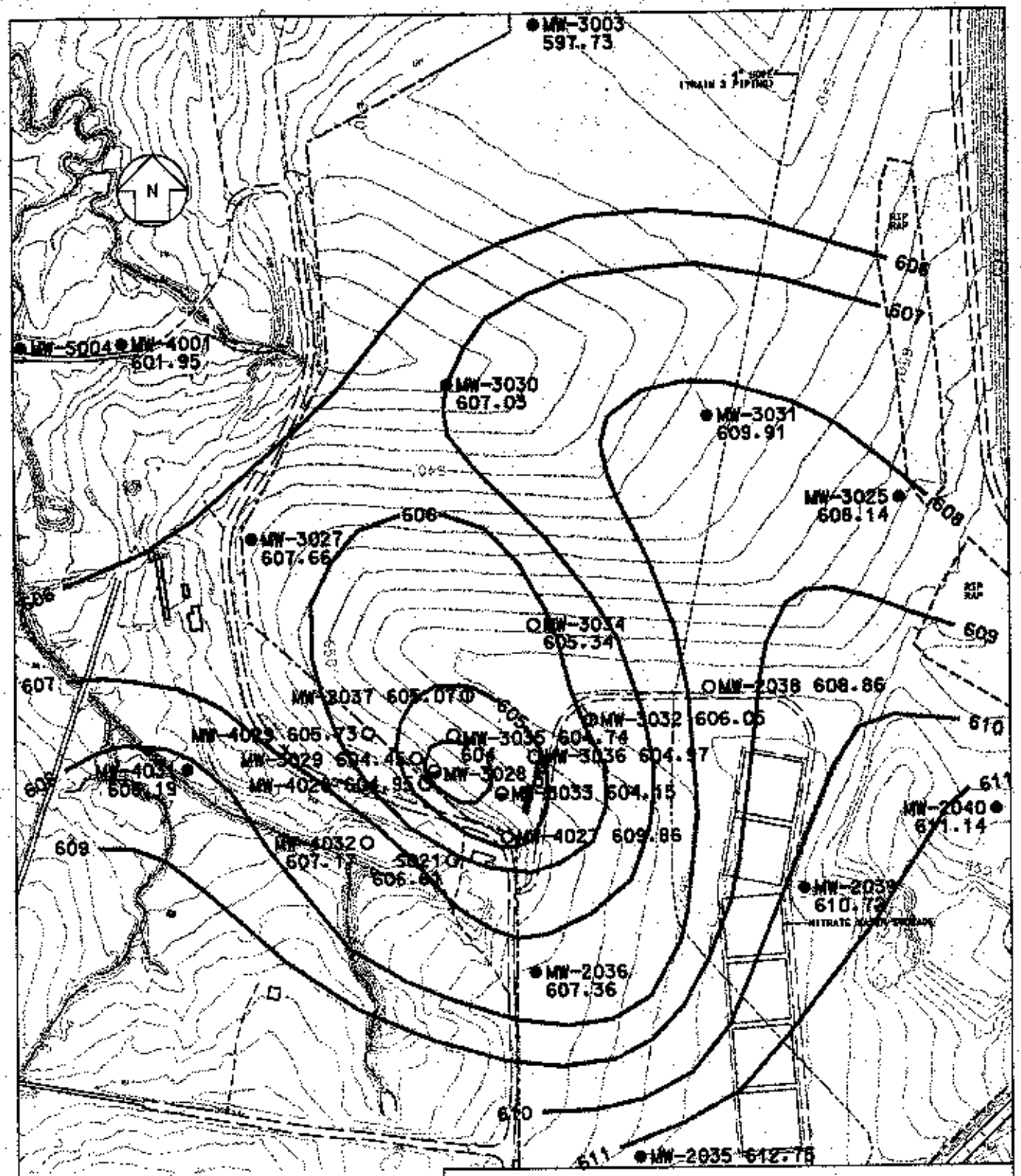
0 300 600

SCALE FEET

ADDITIONAL GROUNDWATER
FIELD STUDIES
BASELINE GROUNDWATER ELEVATIONS

FIGURE 4-8

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/CP/056/0601	
ORIGINATOR: RC	DRAWN BY: GLN	DATE: 6/28/01	



LEGEND

- PUMPING WELL
- INJECTION WELL
- OBSERVATION WELL
- MONITORING WELL

0 300 600

SCALE FEET

ADDITIONAL GROUNDWATER
FIELD STUDIES
STAGE 3 GROUNDWATER ELEVATIONS

FIGURE 4-9

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/CP/057/0601	
ORIGINATOR: RC	DRAWN BY: GLN	DATE: 6/28/01	

4.4.3 In Situ Chemical Oxidation of TCE in Groundwater

The GWOU *Interim Record of Decision* (Ref. 5) relating to remediation of TCE contaminated groundwater at the chemical plant site was signed by the DOE and EPA on September 29, 2000. This ROD authorized the treatment of TCE in groundwater utilizing in situ chemical oxidation methods. This process will be performed to reduce the levels of TCE in groundwater to the maximum contaminant level (MCL) of 5 μg/l.

The DOE has prepared a work plan to provide the transition from the environmental documentation phase to final design and implementation of the interim remedial action. The *Remedial Design/Remedial Action Work Plan for the Interim Remedial Action for the Groundwater Operable Unit* (Ref. 46) will be used as the primary document in defining the design and implementation of the selected interim remedial action for this operable unit. The work plan also provides a summary of the major deliverables that will define the design and construction activities of the selected remedy and the overall schedule and general costs. The draft version of this work plan was submitted to the regulatory agencies on February 14, 2001 and the draft final version was submitted on May 11, 2001.

Activities associated with in situ chemical oxidation of TCE in groundwater are bench-scale testing, pilot-scale testing, and full-scale implementation. The bench-scale portion of this work was performed by several specialty subcontractors in order to evaluate the different oxidation methods available. Results of this testing indicate that use of either permanganate or Fenton's reagents would result in the reduction of TCE in the shallow aquifer at the chemical plant site.

The pilot-scale and full-scale portions of this project will be performed under WP-550, In Situ Chemical Oxidation of TCE in Groundwater. This work package has been prepared as performance based specifications that define the requirements the specialty subcontractor must incorporate into the design and operation of pilot-scale testing and full scale implementation. It is expected that field activities will be initiated in late 2001 after completion of the additional groundwater field studies.

5. ENVIRONMENTAL MONITORING INFORMATION

The information provided in this section is incorporated from the *Weldon Spring Site Environmental Report for Calendar Year 2000* (Ref. 47).

5.1 Radon Gas Monitoring Program

5.1.1 Program Overview

Both U-238 and Th-232 are naturally occurring radionuclides in soil and rock. Radon gases (i.e., Rn-222, radon and Rn-220, thoron) are naturally occurring radioactive gases in the U-238 and Th-232 decay series. A fraction of the radon produced from radioactive decay of U-238 and Th-232 diffuses from soil and rock into the atmosphere, accounting for natural background airborne radon concentrations. Radon and thoron gases are produced at the Weldon Spring site from these natural sources as well as from the contaminated waste materials present.

Airborne radon and thoron concentrations are governed by source strength and dilution factors, both of which are strongly affected by meteorological conditions. The soil surface constitutes the largest source of radon and thoron, although secondary contributors include oceans, natural gas, geothermal fluids, volcanic gases, ventilation from caves and mines, and coal combustion. Radon and thoron levels in the atmosphere have been observed to vary with height above the ground, season, time of day, and location. The chief meteorological parameter governing airborne radon and thoron concentrations is atmospheric stability; however, the largest variations in atmospheric radon and thoron occur spatially (Ref. 48).

Two types of alpha track detectors are used at the Weldon Spring Site Remedial Action Project (WSSRAP) to measure ambient levels of radon gas: standard "F-type" detectors, which measure a combination of radon and thoron gas (results are termed "integrated"), and modified "M-type" detectors, which indirectly indicate ambient levels of thoron only. F-type and M-type alpha track detectors are used in conjunction to distinguish radon and thoron concentrations by analyzing the relative response of paired sets of these detectors at each monitoring location where they are deployed.

The following information pertains to the year 2000 data monitoring and information and is included to demonstrate the current status of radon gas monitoring. Specific detailed data for 1996-1999 may be found in the respective annual site environmental reports. A 5-year comparative discussion and graph is included in Section 5.1.4.4.

In 2000, a pair of standard F-type alpha track detectors was deployed quarterly at each of 19 permanent monitoring locations: seven at the chemical plant site perimeter, two at the Weldon Spring Quarry perimeter, three inside the chemical plant site boundary, and seven at off-site locations. Alpha track monitoring locations are identified with an "RD" prefix in Figures 5-1

through 5-4. Two of the three locations inside the chemical plant site boundary were discontinued after the first quarter.

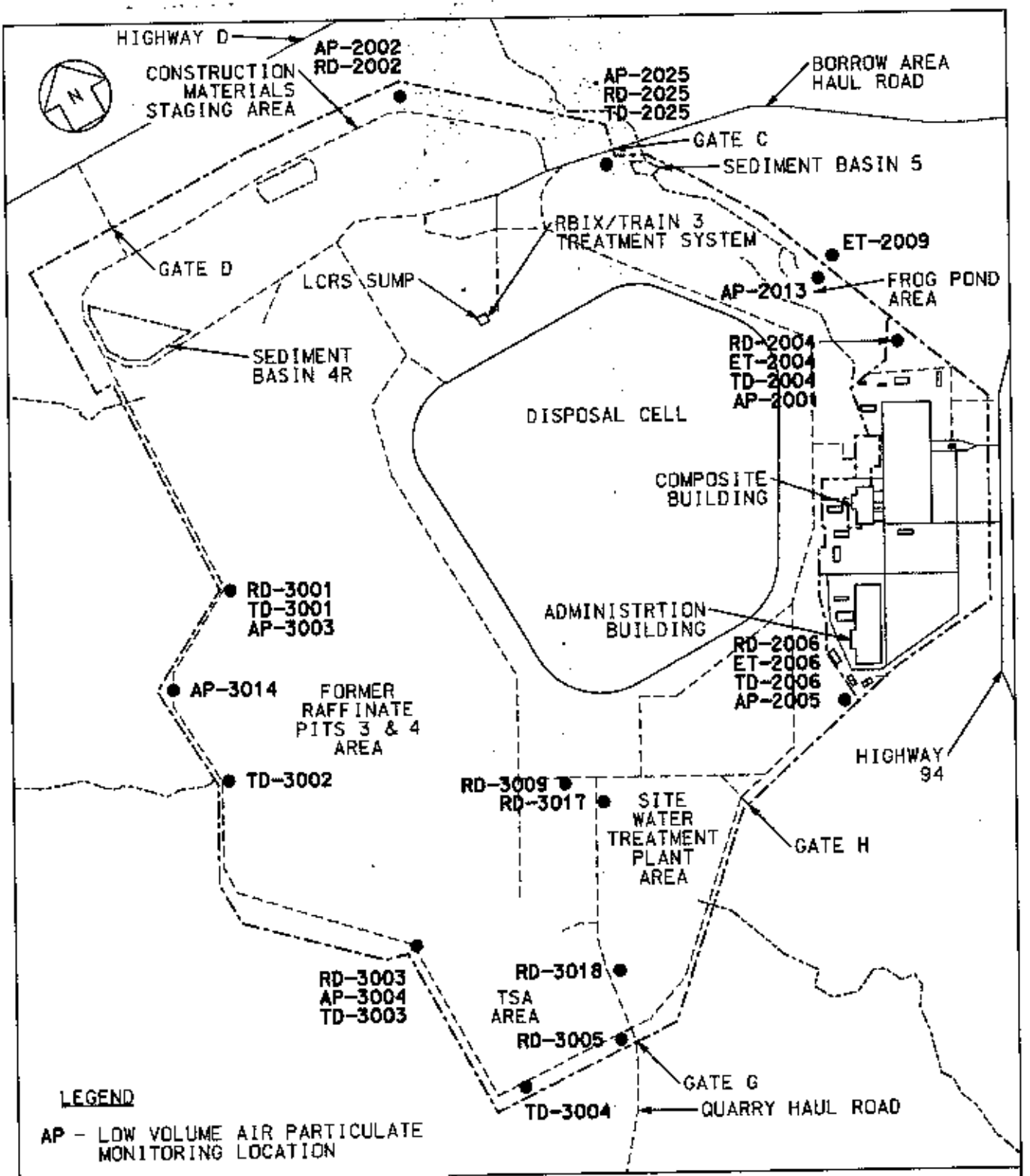
Monitoring locations are distributed around the chemical plant, and quarry perimeters to ensure adequate detection of radon and thoron under varying meteorological conditions. Locations RD-4005 and RD-4009 monitor background radon and thoron concentrations.

Paired M-type alpha track detectors were deployed quarterly at 17 monitoring locations: six at the chemical plant site perimeter, one at the quarry perimeter, three inside the chemical plant site boundary, and seven at off-site locations (including two background locations, RD-4005 and RD-4009). Two of the three locations inside the chemical plant site boundary were discontinued after the first quarter. Specific locations are identified on Figures 5-1 through 5-4. These detectors were placed in conjunction with F-type alpha track detectors to distinguish radon from thoron concentrations. Using Pearson's method (Ref. 48), separate concentrations of radon and thoron were calculated for these stations.

The WSSRAP radon monitoring program also used electret detectors, which provided more timely data (bi-weekly) than the alpha track detectors (quarterly). Like alpha track detectors, electret detectors provide a passive means of measuring radon and thoron gas concentrations in air. The main purpose for the electret program was to assess short-term trends in radon and thoron gas concentrations in work areas. By May 2000, when most areas had been remediated, and radon and thoron concentration in those areas had returned to near background levels, the electret program was discontinued. There was no longer a need for a large network of radon monitors to demonstrate compliance with DOE Order 5400.5. During the first quarter and half of the second quarter, 13 pairs of electret detectors that measure radon only were placed at the following monitoring locations: 10 in the chemical plant area (including six along perimeter), and three off site. Eight pairs of electrets that indicate thoron concentrations were deployed at the following locations: five in the chemical plant area, and three off site. The electrets were exchanged and read bi-weekly. These locations, designated by an "ET" prefix, are shown in Figures 5-1 through 5-5.

5.1.2 Applicable Standards

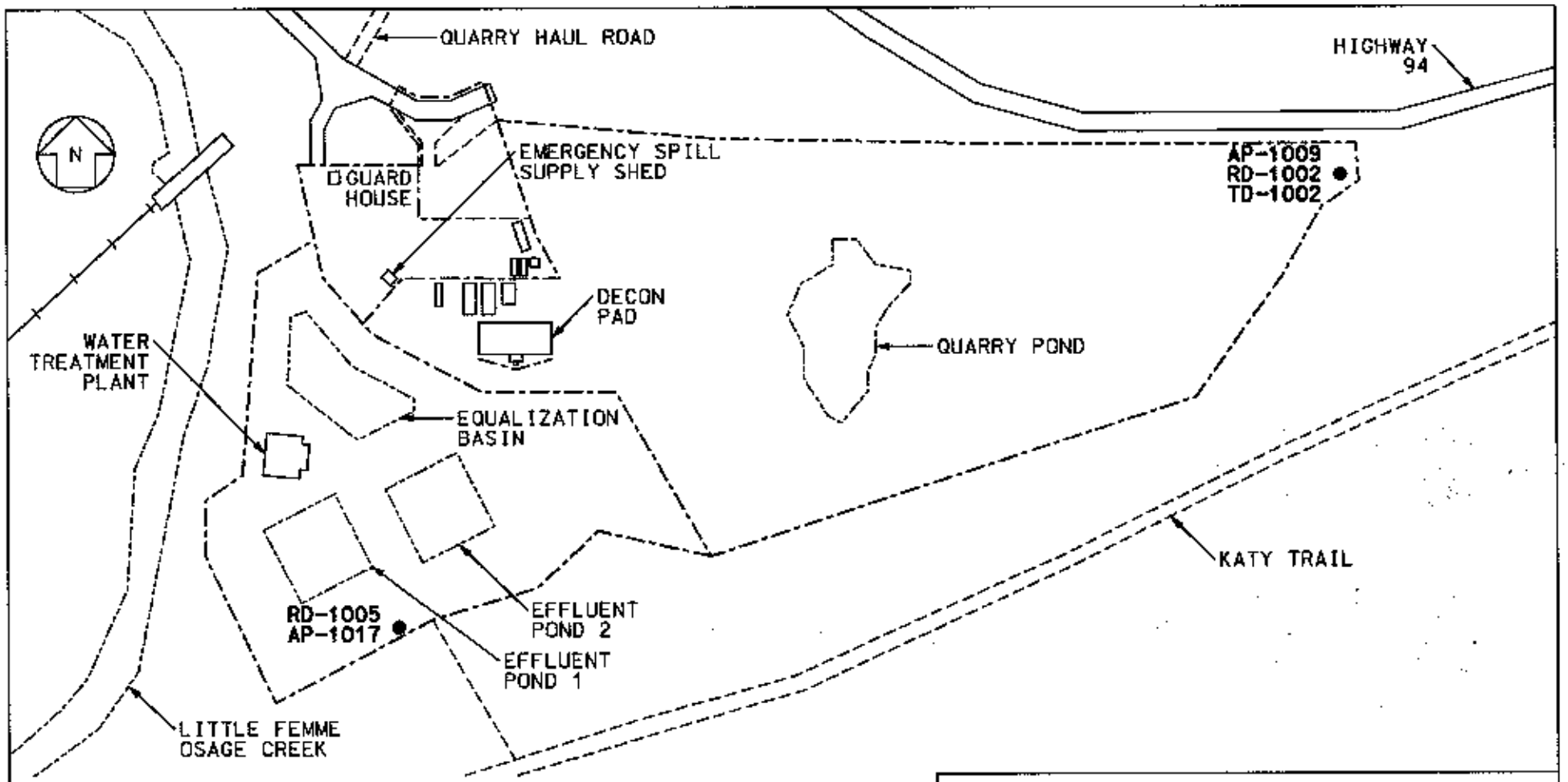
As established by DOE Order 5400.5, the U.S. Department of Energy (DOE) annual public dose equivalent limit is 100 mrem (1 mSv) total effective dose equivalent (TEDE).



AIR MONITORING LOCATIONS AT THE CHEMICAL PLANT AREA

FIGURE 5-1

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/CP/049/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/13/01	



LEGEND

AP - LOW VOLUME AIR PARTICULATE MONITORING LOCATION

RD - ALPHA TRACK RADON GAS MONITORING LOCATION

ET - ELECTRET RADON GAS MONITORING LOCATION

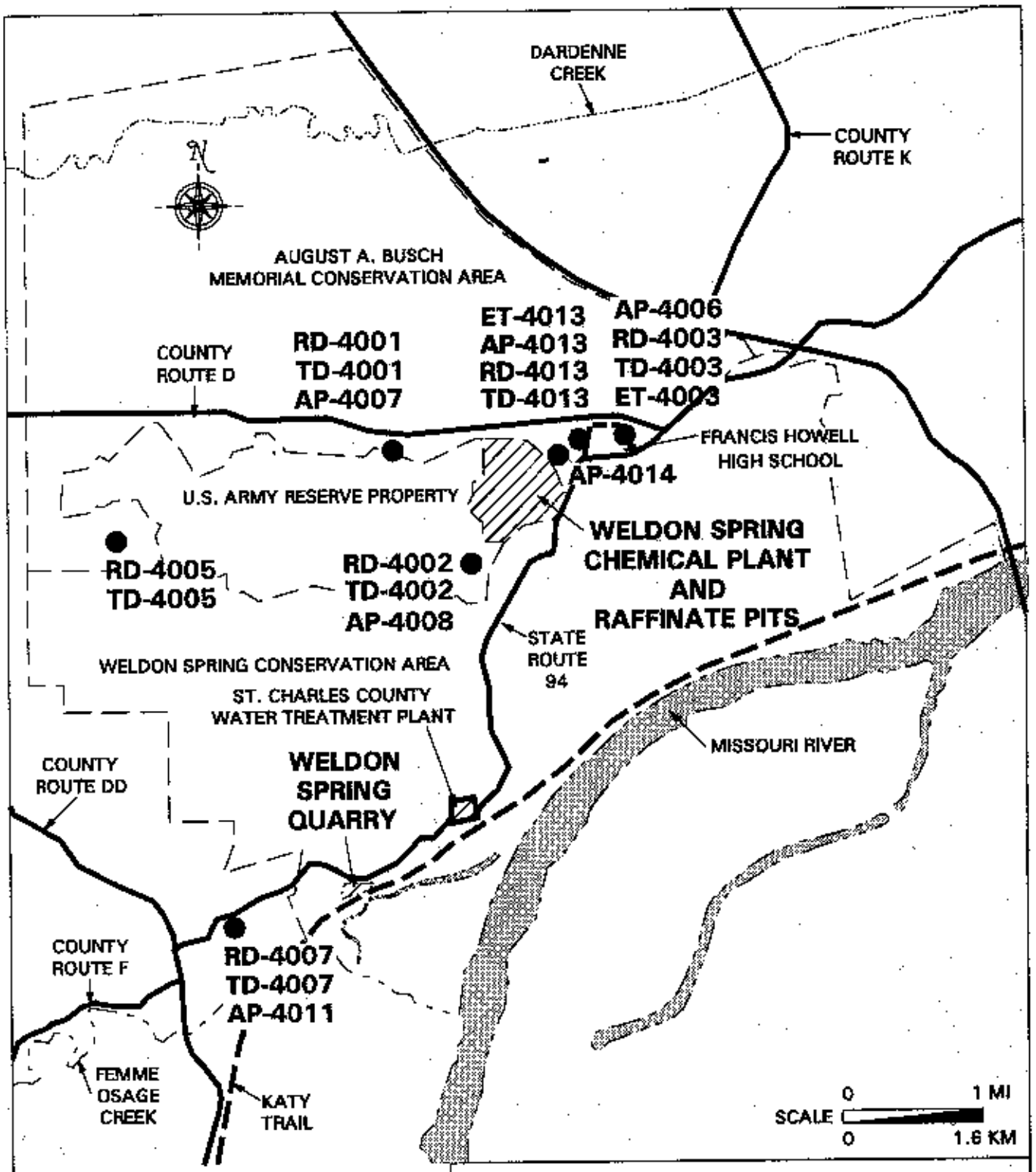
TD - GAMMA RADIATION MONITORING LOCATION

0 200 400
SCALE FEET

AIR MONITORING LOCATIONS AT THE QUARRY AREA

FIGURE 5-2

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/QY/015/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/13/01	



LEGEND

AP - LOW VOLUME AIR PARTICULATE MONITORING LOCATION

RD - ALPHA TRACK RADON GAS MONITORING LOCATION

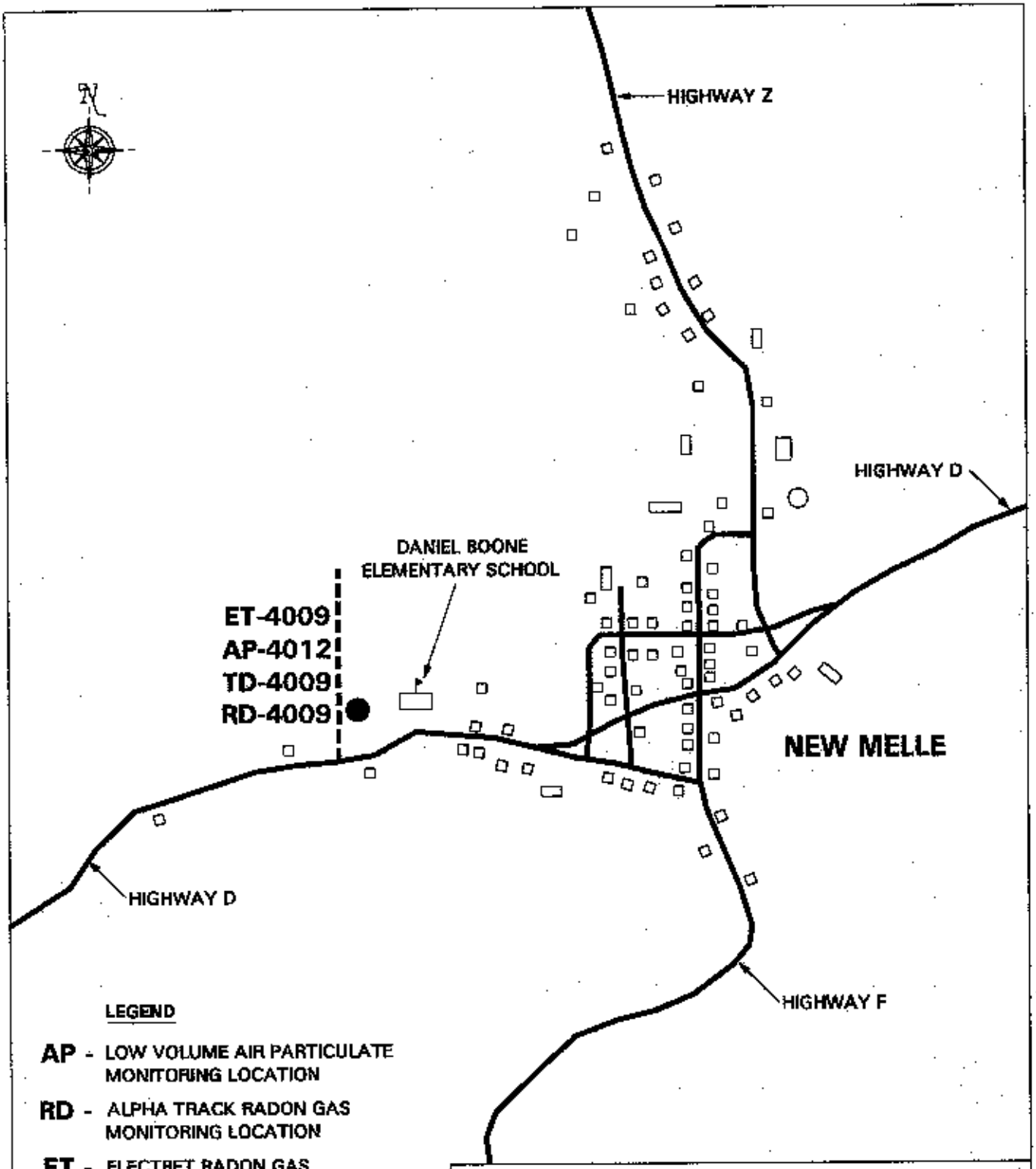
ET - ELECTRET RADON GAS MONITORING LOCATION

TD - GAMMA RADIATION MONITORING LOCATION

OFF-SITE AIR MONITORING LOCATIONS

FIGURE 5-3

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/VP/014/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/13/01	



LEGEND

AP - LOW VOLUME AIR PARTICULATE MONITORING LOCATION

RD - ALPHA TRACK RADON GAS MONITORING LOCATION

ET - ELECTRET RADON GAS MONITORING LOCATION

TD - GAMMA RADIATION MONITORING LOCATION

0 .125 .25 MI

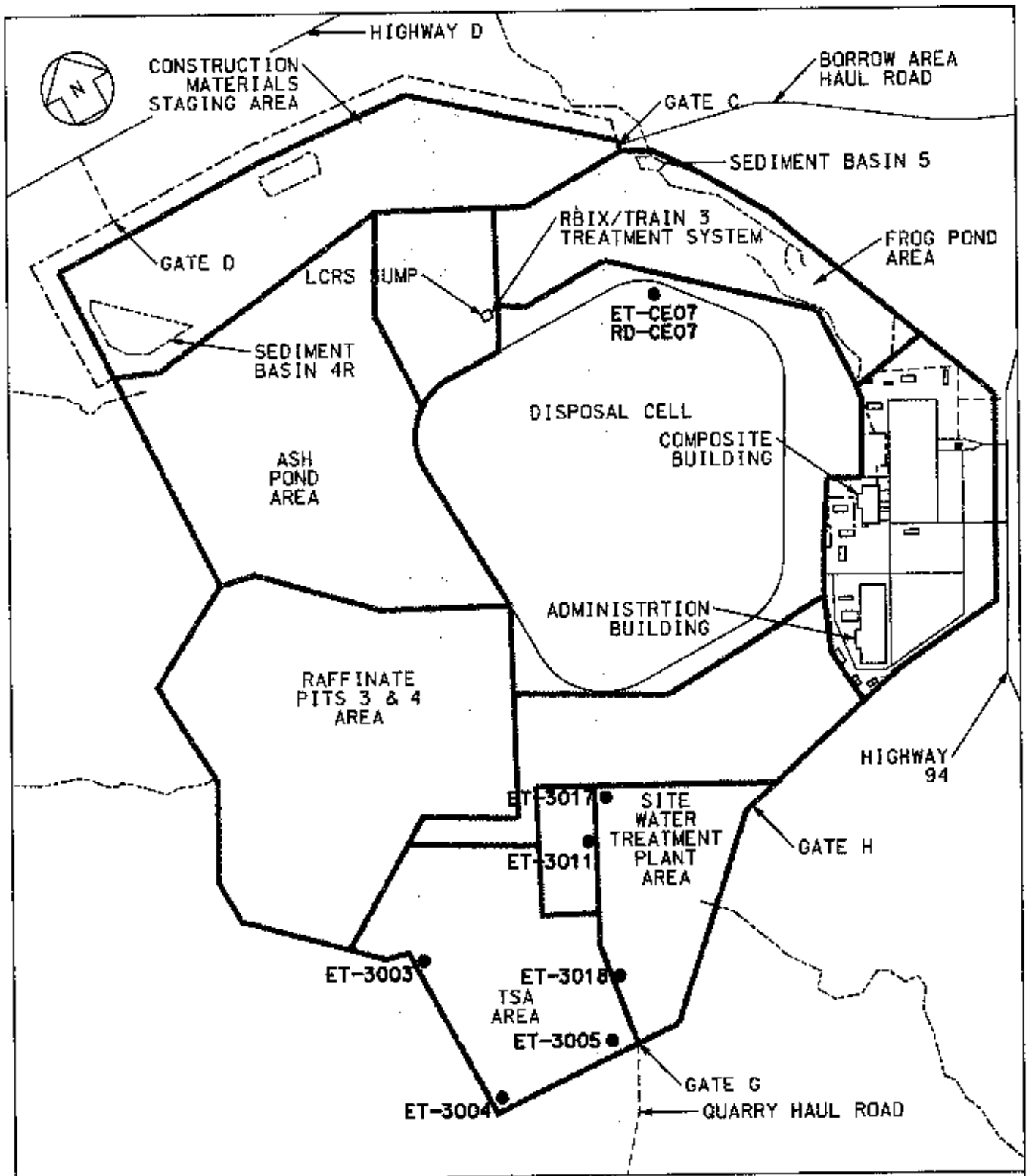
0 .0381 .0762 KM

SCALE

BACKGROUND AIR MONITORING STATION

FIGURE 5-4

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/VP/015/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/13/01	



ELECTRET AND RADON MONITORING LOCATIONS IN THE DISPOSAL CELL AND RAFFINATE PIT AREAS

FIGURE 5-5

0 600 1200

SCALE FEET

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/CP/050/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/13/01	

Dose limits for inhalation of radon and thoron progeny and gas are based on working levels and concentrations in air, and are addressed independently in the Order. The Derived Concentration Guide (DCG), specified by DOE 5400.5 is a reference value for airborne concentrations of specific radionuclides. The DCG reference value for radon and thoron is 3pCi/l in unrestricted (off-site) areas.

5.1.3 Monitoring Results

Table 5-1 summarizes quarterly and annual average integrated radon concentrations as measured by F-type alpha track detectors. Since radon is naturally occurring, concentrations measured at each monitoring location were compared to measured background concentrations to determine whether any significant differences existed at the 95% confidence level. Only perimeter locations with integrated radon concentrations statistically greater than background were compared to the DCG for radon by subtracting the average annual background concentration from the gross annual average concentration measured at a given location.

The results obtained from the pair of F-type alpha track detectors at each location were averaged to determine the quarterly average integrated radon concentration. These averages were then used to calculate the annual average integrated radon concentration. The annual standard deviation reported reflects the error propagated by taking the sample standard deviation of the mean of each of the quarterly results.

The annual F-type alpha track background concentration was calculated using the arithmetic average of the two background locations. The data yielded an annual background average integrated radon concentration in 2000 of 0.3 pCi/l. This result is consistent with results in previous years.

Based on measurements from F-type and M-type alpha track detectors at locations where the potential for a combined release of radon and thoron was suspected, thoron concentrations were estimated using Pearson's method (Ref. 49). Results are presented in Table 5-2.

The annual thoron background concentration was determined to be 0.1 pCi/l and was calculated using the arithmetic average of the two background locations. This result is consistent with results in previous years.

Concentrations measured by the electret monitors ranged from 0 pCi/l to 0.89 pCi/l for radon and from 0 pCi/l to 2.44 pCi/l for thoron. The highest results measured for both radon and thoron occurred at station CE07, which is on top of the disposal cell. Because electret results were obtained bi-weekly rather than quarterly (as with the alpha track detectors), they were used primarily as advance indicators of trends in radon/thoron levels at a given monitoring location. Therefore, alpha track results, rather than electret results, are used in performing off-site dose calculations.

Table 5-1 2000 Alpha Track Integrated Radon Results[a]

Location ID	1st Quarter (pCi/l) (b)	2nd Quarter (pCi/l) (b)	3rd Quarter (pCi/l) (b)	4th Quarter (pCi/l) (b)	Annual Average (pCi/l) (b)	Annual Standard Deviation	Statistically Significant (X) [c]	Percent of Guidelines[d]
Quarry Stations								
RD-1002	0.2	0.5	0.4	0.5	0.4	0.14		n/a
RD-1005	0.3	0.4	0.2	0.4	0.3	0.10		n/a
Chemical Plant Perimeter Stations								
RD-2002	0.2	0.5	0.3	0.4	0.4	0.13		n/a
RD-2004	0.2	0.4	0.2	0.4	0.3	0.12		n/a
RD-2006	0.2	0.4	0.2	0.4	0.3	0.12		n/a
RD-2025	0.2	0.7	0.4	0.4	0.4	0.21		n/a
RD-3001	0.2	0.5	0.5	0.4	0.4	0.14		n/a
RD-3003	0.2				0.2	n/a		n/a
RD-3005	0.2	0.4	0.3	0.3	0.3	0.08		n/a
Stations Inside Chemical Plant Boundary								
RD-3017	0.2	--	--	--	0.2	n/a		n/a
RD-3018	0.3	--	--	--	0.3	n/a		n/a
RD-CE07	0.7	0.5	0.3	0.3	0.5	0.19	X	n/a (e)
Off-Site Stations								
RD-4001	0.2	0.3	0.2	0.3	0.3	0.08		n/a
RD-4002	0.1	0.3	0.3	0.3	0.2	0.12		n/a
RD-4003	0.2	0.2	0.2	0.3	0.2	0.05		n/a
RD-4005 (f)	0.1	0.3	0.2	0.3	0.2	0.10		n/a
RD-4007	0.2	0.3	0.4	0.4	0.3	0.10		n/a
RD-4009 (f)	0.2	0.3	0.3	0.3	0.3	0.05		n/a
RD-4013	0.2	0.3	0.3	0.3	0.3	0.05		n/a

(a) Results include natural background except where otherwise noted.
(b) To convert from pCi/l to Bq/m^3, multiply by 37.
(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the 1-year background average concentration for a Student's t-test at the 95% confidence level.
(d) Percent guideline is calculated by taking the annual station average minus the average of the background stations, divided by the DOE Concentration guideline for Rn-222 of 3 pCi/l annual average above background for uncontrolled areas.
(e) No percentage calculation performed for above background monitoring locations within the chemical plant site boundary.

Table 5-1 2000 Alpha Track Integrated Radon Results [a] (Continued)

(f) Background station.
n/a No percentage calculation performed for background locations or locations not statistically greater than background.
-- No data for this quarter.

Table 5-2 2000 Alpha Track Rn-220 Concentrations[a]

Location ID	1st Quarter (pCi/l) (b)	2nd Quarter (pCi/l) (b)	3rd Quarter (pCi/l) (b)	4th Quarter (pCi/l) (b)	Annual Average (pCi/l) (b)	Annual Standard Deviation	Statistically Significant (X) [c]	Percent of a Guideline[d]
Quarry Stations								
RD-1002	0.0	0.3	0.0	0.3	0.2	0.17		n/a
Chemical Plant Perimeter Stations								
RD-2002	0.0	0.1	0.0	0.2	0.1	0.10		n/a
RD-2004	0.0	0.1	0.0	0.2	0.1	0.10		n/a
RD-2006	0.0	0.2	0.0	0.4	0.2	0.19		n/a
RD-2025	0.0	0.4	0.0	0.1	0.1	0.18		n/a
RD-3001	0.0	0.0	0.0	0.4	0.1	0.20		n/a
RD-3005	0.0	0.2	0.0	0.4	0.2	0.19		n/a
Stations Inside Chemical Plant Boundary								
RD-3017	0	--	--	--	0.0	n/a		n/a
RD-3018	0.1	--	--	--	0.1	n/a		n/a
RD-CE07	0.4	0.4	0	0.3	0.3	0.19	X	n/a
Off-Site Stations								
RD-4001	0	0	0	0.2	0.1	0.10		n/a
RD-4002	0	0	0	0	0.0	0.00		n/a
RD-4003	0	0	0	0.3	0.1	0.15		n/a
RD-4005 (f)	0	0	0	0	0.0	0.00		n/a
RD-4007	0	0	0	0.1	0.0	0.05		n/a
RD-4008 (f)	0	0.1	0	0.3	0.1	0.14		n/a
RD-4013	0	0	0	0	0.0	0.00		n/a

(a) Results include natural background except where otherwise noted.
(b) To convert from pCi/l to Bq/m^3, multiply by 37.
(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the 1-year background average concentration for a Student's t-test at the 95% confidence level.
(d) Percent guideline is calculated by taking the annual station average minus the average of the background stations, divided by the DOE Concentration guideline for Rn-220 of 3 pCi/l annual average above background for uncontrolled areas.
(e) No percentage calculation performed for above background monitoring locations within the chemical plant site boundary.
(f) Background station. Average concentration = 0.05 pCi/l.
n/a No percentage calculation performed for background locations or locations not statistically greater than background.
-- No data for this quarter.

5.1.4 Data Analysis

Statistical analysis of the alpha track radon results indicated that at the 95% confidence level the measured concentration at one of the 19 monitoring locations was greater than the combined background result. This station, RD-CE07, was on top of the disposal cell. The results for other stations were not statistically distinguishable from background levels.

Statistical analysis of alpha track thoron results indicated that at the 95% confidence level the annual average concentration at 1 of the 17 monitoring locations exceeded background levels. This station, RD-CE07, is at the disposal cell. Results for all other stations were statistically indistinguishable from background levels.

5.1.4.1 Chemical Plant and Raffinate Pits

Statistical analysis of one radon alpha track monitoring location, RD-CE07, indicated a result greater than background. The annual average concentration for this station exceeded background by 0.25 pCi/l. With the exception of the immediate vicinity of the disposal cell, radon results in most areas were lower than in previous years, and are likely to remain low because most of the contaminated materials have been removed to the disposal cell. The quarterly measured radon concentrations for all stations ranged from 0.1 pCi/l to 0.7 pCi/l.

Statistical analysis of one thoron track etch monitoring location, RD-CE07, indicated an annual average result greater than the background level. The annual average concentration for this station exceeded the annual average background by 0.25 pCi/l. The quarterly thoron measurements for all stations ranged from 0 pCi/l to 0.4 pCi/l. Just as with the integrated radon results, these results are lower than in previous years due to the removal of most contaminated material to the disposal cell.

5.1.4.2 Quarry

Statistical analysis of track etch radon and thoron monitoring results from the two quarry stations indicated that at the 95% confidence level these results did not exceed background levels. The quarterly measured results for integrated radon from both quarry stations ranged from 0.2 pCi/l to 0.5 pCi/l. Quarterly Rn-220 results at the quarry station ranged from 0 pCi/l to 0.3 pCi/l.

5.1.4.3 Off-Site Locations

Statistical analysis of both track etch integrated radon and thoron monitoring results from off-site locations (shown in Figure 5-3) indicated that there was no reason at the 95% confidence level to suspect that measured concentrations at any of the stations were greater than background levels. The quarterly integrated radon concentration measurements at off-site locations ranged

from 0.1 pCi/l to 0.4 pCi/l. Quarterly results for thoron at the off-site stations ranged from 0 pCi/l to 0.2 pCi/l. These results are similar to results obtained in previous years.

5.1.4.4 Five-Year Trend Analysis of Integrated Radon Gas

Figure 5-6 shows 5 years of annual average alpha track integrated radon concentrations for the monitoring stations at the quarry, chemical plant, raffinate pits, and off-site locations. These monitoring results include natural background radon concentrations. Radon levels in the raffinate pits area reached a maximum in 1997 due to excavation of residual sludge pockets in Raffinate Pit 4. However, all results were well below the DCG of 3 pCi/l for radon and thoron gas.

5.2 Gamma Radiation Monitoring

5.2.1 Program Overview

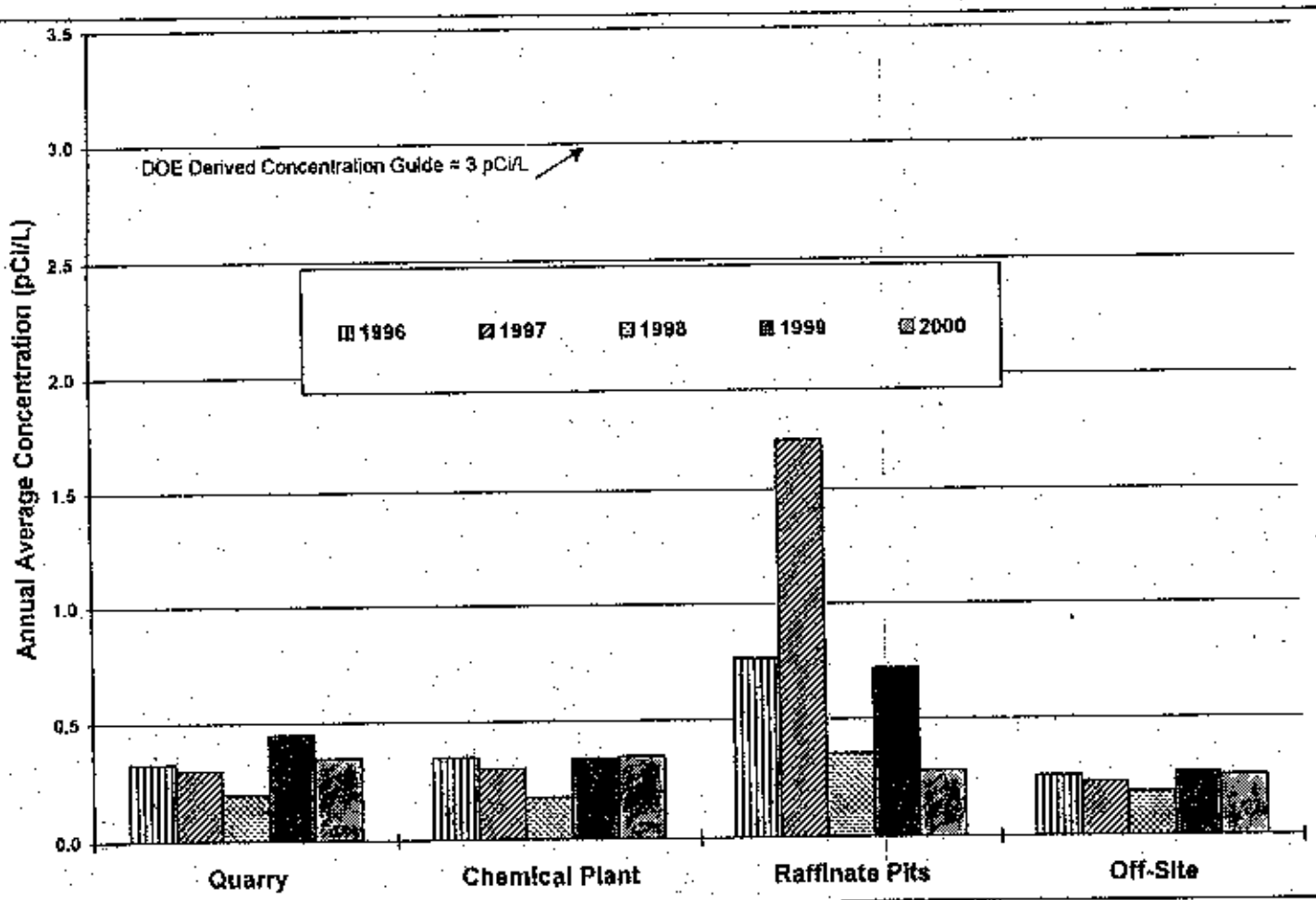
Gamma radiation is emitted from natural, cosmic, and man-made sources. The earth naturally contains gamma radiation-emitting substances, such as uranium, thorium, and potassium (K-40). Cosmic radiation originates in outer space and filters through the atmosphere to the earth. Together, these two sources comprise most natural gamma background radiation. The National Council on Radiation Protection and Measurements (NCRP) estimates the typical gamma radiation dose is 28 mrem/year from terrestrial sources and 27 mrem/year from cosmic sources (Ref. 50). The total estimated background radiation dose equivalent due to gamma exposure is thus 55 mrem/year.

The following information pertains to the year 2000 data monitoring and information and is included to demonstrate the current status of gamma radiation monitoring. Specific detailed data for 1996-1999 may be found in the respective annual site environmental reports. A 5-year comparative discussion and graph is included in Section 5.2.4.4.

Gamma radiation was monitored in 2000 using thermoluminescent dosimeters (TLDs) at 13 monitoring stations: five at the chemical plant site perimeter, one at the quarry perimeter, and seven off site. The locations are denoted by a "TD" prefix on Figures 5-1 through 5-5. Stations TD-4005 and TD-4009 measure natural background at locations unaffected by the site. The TLDs are exchanged and read every calendar quarter.

5.2.2 Applicable Standards

No specific standard for gamma radiation is stated in the DOE orders. However, DOE Order 5400.5 specifies that members of the public shall receive less than 100 mrem/year total effective dose equivalent (TEDE) from DOE operations for all exposure pathways, excluding exposure to natural background radiation.



RADON TRACK ETCH DETECTOR
5-YEAR TRENDS

FIGURE 5-6

REPORT NO.:	[redacted]	EXHIBIT NO.:	[redacted]
ORIGINATOR:	[redacted]	DRAWN BY: GLN	DATE: [redacted]

5.2.3 Monitoring Results

Table 5-3 summarizes quarterly and annual total gamma radiation monitoring results. The table includes quarterly results, annual totals, and the annual sample standard deviation for each station, and indicates whether a station's annual monitoring results are statistically distinguishable from background levels as determined by a one-tailed Student's t-test at the 95% confidence level.

Gamma background levels for 2000 were determined by averaging the annual total measurement from the two background stations. The annual average result from these stations was 54.2 mrem/year with a standard deviation of 3 mrem/year. This average background is within 10% of the NCRP 94 estimate of 55 mrem/year (Ref. 50).

Table 5-3 2000 Environmental TLD Results[a]

Location ID	1st Quarter (mrem) (b)	2nd Quarter (mrem) (b)	3rd Quarter (mrem) (b)	4th Quarter (mrem) (b)	Annual Total (mrem/yr) [b]	Annual Average (pCi/l) [b]	Annual Standard Deviation	Statistically Significant (X) [c]
Quarry Stations								
TD-1002	13.2	12.2	15.2	7.6	48.2	12.1	3.22	
Chemical Plant Perimeter Stations								
TD-2004	17.1	14.9	18.2	12.9	63.1	15.8	2.36	
TD-2006	14.8	12.8	15.4	7.4	50.4	12.6	3.84	
TD-2025	16.4	14.3	16.7	8.5	55.9	14.0	3.80	
TD-3001	15.8	12.5	17.4	7.5	53.2	13.3	4.37	
TD-3003	16.9	–	--	–	–	16.9	n/a	
Off-Site Stations								
TD-4001	14.8	12.8	16.4	7.2	51.2	12.8	4.01	
TD-4002	13.4	12	15.6	7.1	48.1	12.0	3.60	
TD-4003	12.8	11.1	14.4	7.1	45.4	11.4	3.14	
TD-4005 (d)	14.8	12.3	16.2	10	53.3	13.3	2.74	
TD-4007	15.1	13.3	16.1	9.6	54.1	13.5	2.86	
TD-4009 (d)	15	12.9	16.3	10.8	55.0	13.8	2.41	
TD-4013	15.9	14.1	17.7	7.6	55.3	13.8	4.40	

(a) Results include natural background gamma radiation.
(b) To convert from mrem to mSv, divide by 100.
(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the 1-year background average concentration using a Student's t-test at the 95% confidence level.
(d) Background location. (Average = 13.54 mrem (0.14 mSv)

5.2.4 Data Analysis

Statistical analysis of TLD results revealed that at the 95% confidence level no stations had annual results greater than background levels. As a comparison, two stations had annual results greater than background in 1999 and four were greater than background in 1998.

5.2.4.1 Chemical Plant/Raffinate Pits

The annual effective dose equivalent from external gamma radiation measured by TLDs at the chemical plant and raffinate pits area ranged from 50.4 mrem to 63.1 mrem. These results are lower than previous years due to completion of remediation of most of the chemical plant area.

5.2.4.2 Quarry

The annual effective dose equivalent from external gamma radiation measured by TLDs at the quarry was 48.2 mrem. This result is lower than previous years and essentially represents background.

5.2.4.3 Off-Site Locations

The annual effective dose equivalent from external gamma radiation measured by TLDs at off-site locations ranged from 45.4 mrem to 55.3 mrem. Background concentrations ranged from 53.3 mrem to 55.0 mrem. These results are lower than previous years and essentially represent background.

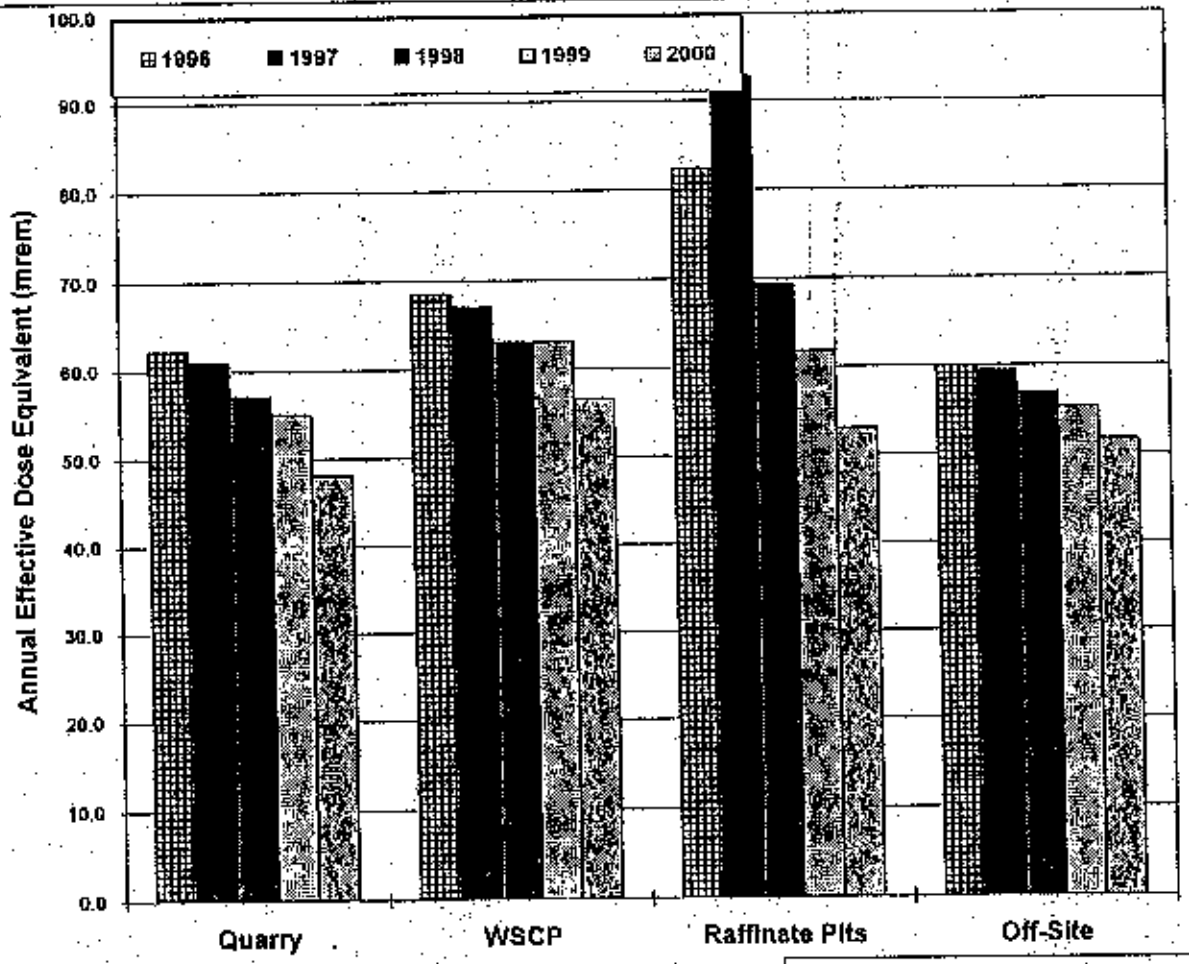
5.2.4.4 Five-Year Trend Analysis of TLDs

Gamma radiation exposure monitoring results for the last 5 years are depicted in Figure 5-7. The graph shows yearly totals for the chemical plant area, raffinate pits area, quarry area, and off-site locations. The results include the natural background dose rate. The indicate a downward trend around the raffinate pits due to completion of most of the remediation work in this area. Year 2000 gamma radiation exposure is essentially at background levels.

5.3 Radioactive Air Particulate Monitoring

5.3.1 Program Overview

Radioactive air particulates are airborne dust particles that contain radioactive contaminants. Background concentrations of radioactive air particulates are affected by the soil concentrations of naturally occurring radionuclides, soil moisture content, meteorological conditions, and geological conditions. Increased airborne radioactive particulate emissions from



ENVIRONMENTAL TLD
5-YEAR TRENDS

FIGURE 5-7

REPORT NO.: [redacted]		EXHIBIT NO.: [redacted]	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: [redacted]	

the chemical plant site can result from wind erosion of contaminated soils piles or remedial work activities, such as moving equipment and vehicles in contaminated areas.

The following information pertains to the year 2000 data monitoring and information and is included to demonstrate the current status of air particulate monitoring. Specific detailed data for 1996-1999 may be found in the respective annual site environmental reports.

In 2000, the WSSRAP monitored radioactive air particulates weekly at 18 continuous permanent low volume air sampling stations: nine at the chemical plant perimeter, two at the quarry, and seven at off-site locations. These locations are denoted by an "AP" prefix on Figures 4-1, 5-2, 5-3, and 5-4. Additional low volume air monitoring samplers may be deployed on a temporary basis when current activities warrant their use. The low volume samplers collect airborne particulates by drawing ambient air at a flow rate of approximately 40 l/min (1.4 cfm) through mixed cellulose ester filters with a 0.80-micron pore size. The filters are then counted using a gas flow proportional counter to determine the amount of long-lived gross alpha activity in the particulates on the filter surface.

The WSSRAP also monitored specific airborne radionuclides (i.e., total uranium, Ra-226, Ra-228, Th-228, Th-230, and Th-232) as part of the *National Emission Standards for Hazardous Air Pollutants (*NESHAP*)* program to demonstrate compliance with 40 CFR 61, Subpart H, *National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities.* Details of NESHAP monitoring are in Section 6.

5.3.2 Applicable Standards

The Weldon Spring site is contaminated with a combination of alpha-emitting radionuclides, including isotopes of uranium, thorium, and their decay products. The gross alpha concentrations measured by the low-volume samplers thus include contributions from a wide array of alpha emitters. The DCGs for inhalation of the radionuclides found at the WSSRAP are listed in Chapter III of DOE Order 5400.5.

5.3.3 Monitoring Results

The annual average long-lived gross alpha concentrations and standard deviations for the 18 permanent low volume stations are summarized in Table 5-4. Annual averages were calculated using uncensored weekly air particulate analytical results. Uncensored data refers to all results, including those near or below the minimum detectable concentration (MDC). The DOE *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (Ref. 51) requires the use of uncensored data to minimize any bias in arithmetic averages and calculation of standard deviations. Annual results represent the average of up to 52 weeks of data for each monitoring station.

Table 5-4 2000 Radioactive Air Particulate Gross Alpha Results

MONITORING STATION ID	ANNUAL AVERAGE LONG-LIVED GROSS ALPHA CONCENTRATION (xE-15 µCi/ml)[b][d]	STANDARD DEVIATION (xE-15 µCi/ml)	NUMBER OF SAMPLES/TOTAL NUMBER OF WEEKS	STATISTICALLY SIGNIFICANT (X)[c]
WELDON SPRING QUARRY				
AP-1009	1.33	0.44	52/52	
AP-1017	1.39	0.44	52/52	
WELDON SPRING CHEMICAL PLANT/RAFFINATE PIT PERIMETER				
AP-2001	1.3	0.44	52/52	
AP-2002	1.42	0.43	52/52	
AP-2005	1.25	0.4	52/52	
AP-2008	1.3	0.39	52/52	
AP-2013	1.27	0.32	15/52	
AP-2025	1.44	0.43	52/52	X
AP-3003	1.19	0.38	44/52	
AP-3004	1.13	1.33	22/52	
AP-3014	1.27	0.32	31/52	
OFF SITE				
AP-4006[a]	1.29	0.39	50/52	
AP-4007	1.25	0.4	52/52	
AP-4008	1.35	0.42	52/52	
AP-4011	1.32	0.44	52/52	
AP-4012[e]	1.27	0.41	51/52	
AP-4013	1.15	0.39	52/52	
AP-4014	1.25	0.36	45/52	

(a) Indicates background monitoring station. Background concentration is based on 1 year of data.
(b) The annual average gross alpha concentrations include background and were calculated using uncensored data, which includes results less than reported minimum detectable concentrations.
(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the 1-year (52-week) background average concentration, using a one-tailed Student's t-test at the 95% confidence level.
(b) To convert from µCi/ml to Bq/ml, multiply by 37,000.
(e) Includes results from two colocated monitors.

The typical MDC for low volume air particulate sampling at the WSSRAP is 2.0E-16 µCi/ml. This MDC is low enough to allow detection of Th-232, which has the lowest DCG at the site of 7.0E-15 µCi/ml. If an individual inhales airborne contaminants at the DCG for 1 year, the resulting committed effective dose equivalent is 100 mrem. Thus, this MDC allows the WSSRAP to demonstrate compliance with the DOE Order 5400.5 limit of 100 mrem.

5.3.4 Data Analysis

Statistical analysis of the annual results from the low volume airborne particulate samplers indicated that one monitoring station was greater than the 52-week background

concentrations. Station AP-4012 indicated an annual average background concentration of 1.27E-15 µCi/ml .

5.3.4.1 Chemical Plant/Raffinate Pits

The average annual concentrations at the chemical plant/raffinate pits perimeter ranged from 1.13E-15 µCi/ml to 1.44E-15 µCi/ml. Statistical analysis of the gross alpha air monitoring results revealed at the 95% confidence level that one station had an annual average result greater than the annual background average. The station was AP-2025, on the northern chemical plant site perimeter. Results for all other stations were indistinguishable from background levels and were similar to those measured in 1999.

5.3.4.2 Quarry

The average concentrations at the quarry perimeter ranged from 1.33E-15 µCi/ml to 1.39E-15 µCi/ml. These results were comparable to those measured in 1999.

5.3.4.3 Off-Site Locations

The average concentrations at off-site locations ranged from 1.15E-15 µCi/ml to 1.35E-15 µCi/ml. All results were similar to those measured in previous years.

5.4 Airborne Asbestos Monitoring

Environmental monitoring for asbestos fibers was conducted during May-June 2000 at Francis Howell High School (AP-4006) and at the chemical plant site perimeter (AP-2001, AP-2002, and AP-3004). These locations are identified in Figures 5-1 and 5-3. Filters were collected weekly and shipped off site for bi-weekly for analysis.

Two methods are used to analyze asbestos samples. Phased contrast microscopy (PCM) indicates fibers that have the same general size and shape as asbestos; however, this method does not distinguish between asbestos and nonasbestos fibers. Transmission electron microscopy (TEM) measures actual asbestos fiber concentrations. If a PCM measurement indicates a concentration above environmental action level (0.01 fibers per milliliter of air), the sample is then reanalyzed by the off-site laboratory by the TEM method.

The following information pertains to the year 2000 data monitoring and information and is included to demonstrate the current status of airborne asbestos monitoring. Specific detailed data for 1996-1999 may be found in the respective annual site environmental reports.

The results of environmental samples collected at Francis Howell High School and the chemical plant site perimeter are in Table 5-5. A total of 22 PCM samples were collected with

all samples indicating results above the detection limit. The range of samples above the detection limit (generally 7 fibers/mm^2) was 0.0002 to 0.0007 fibers per milliliter of air (f/ml). Because all PCM results were less than environmental action level, no samples were resubmitted for TEM analysis. All results of the environmental air samples collected from the chemical plant site perimeter and Francis Howell High School were below the site environmental action level of 0.01 f/ml. These results indicate that asbestos fibers were effectively contained during the year.

Table 5-5 Summary of Asbestos Air Monitoring Results

MONITORING LOCATION ID	NUMBER OF SAMPLES/SAMPLES ABOVE DETECTION LIMIT	RANGE (fiber/ml)	AVERAGE (fiber/ml)
AP-2001	6	0.0002 – 0.0003	0.0002
AP-2002	6	0.0002 – 0.0005	0.0004
AP-3004	6	0.0002 – 0.0007	0.0004
AP-4006	4	0.0002 – 0.0006	0.0003

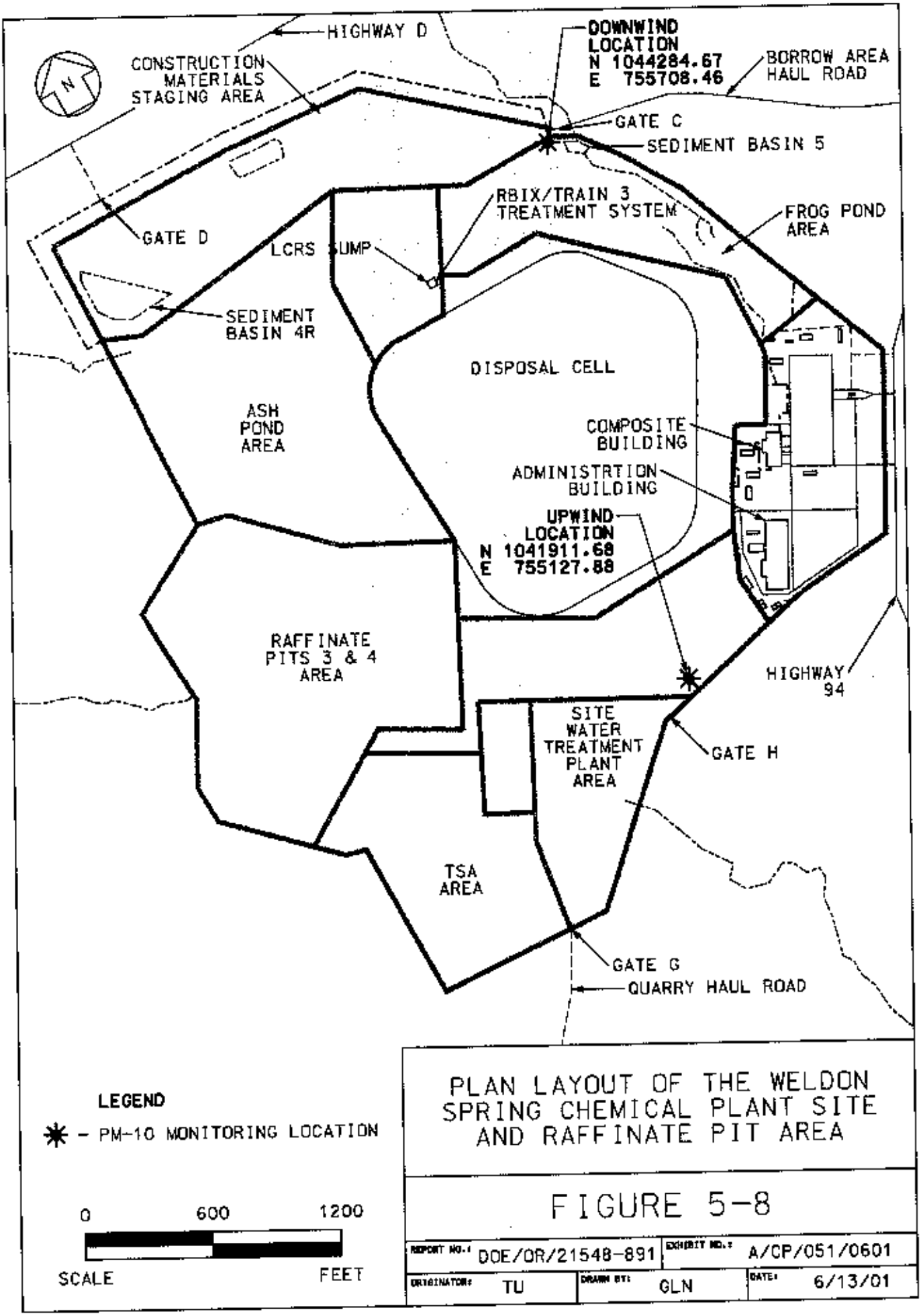
5.5 PM-10 Monitoring

5.5.1 Program Overview

PM-10 consists of airborne particulate matter (PM) with an aerodynamic equivalent diameter of less than 10 μm. It is often referred to as respirable dust because it is the fraction of total suspended particulate matter that can be entrained by the lungs upon inhalation, thus causing a potential health concern.

PM-10 is emitted during many different types of construction activities, such as:

- Pulverization or abrasion of surface materials by mechanical means (e.g., soil excavation or treatment).
- Loading or unloading of bulk dry material (e.g., transfer of fly ash from trucks to storage silos).
- Movement of turbulent air currents over exposed surfaces (e.g., wind erosion of stockpiles).
- Re-entrainment of road dust due to vehicle or heavy equipment traffic (e.g., soil hauling activities).



PLAN LAYOUT OF THE WELDON SPRING CHEMICAL PLANT SITE AND RAFFINATE PIT AREA

FIGURE 5-8

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/CP/051/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/13/01	

- Combustion of fossil fuels (e.g., diesel-powered engines).

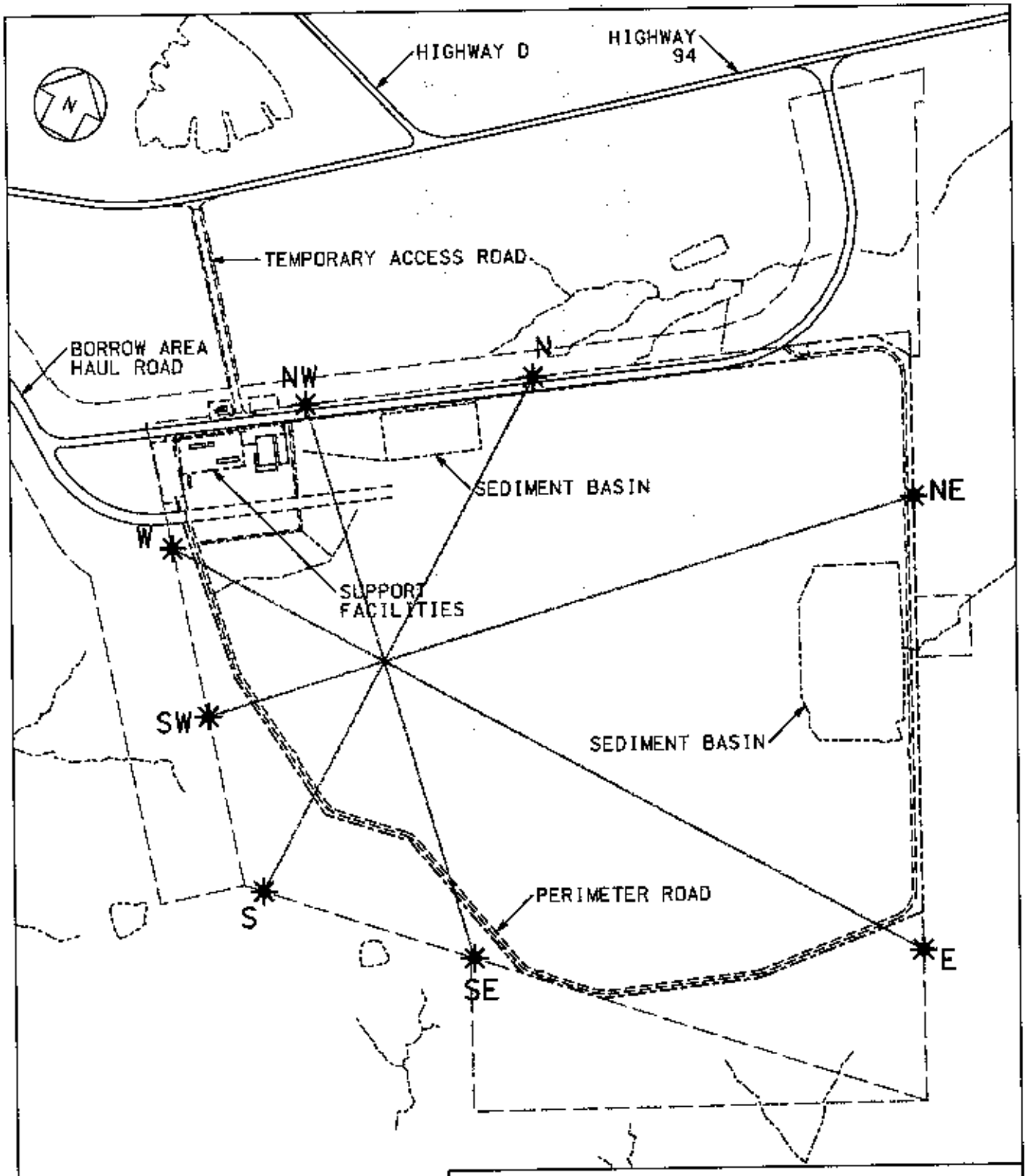
The following information pertains to the year 2000 data monitoring and information and is included to demonstrate the current status of PM-10 monitoring. Specific detailed data for 1996-1999 may be found in the respective annual site environmental reports.

During 2000, the WSSRAP monitored ambient PM-10 levels at the perimeter of both the chemical plant area and the Borrow Area, along the Borrow Area haul road, and at the Weldon Spring Quarry. Portable monitoring stations, consisting of real-time aerosol monitors (RAMs) fitted with PM-10 impactor heads were used to monitor concurrently upwind and downwind of work activities. The chemical plant area map in Figure 5-8 shows the permanent locations established to monitor PM-10 emissions from disposal cell operations. These locations are based on historical prevailing wind patterns. Borrow Area locations were determined each monitoring period, based on the National Weather Service local 24-hour forecast. Figure 5-9 shows the eight designated locations along the Borrow Area perimeter where monitors could be placed, depending on predicted wind directions for the monitoring period. Figure 5-10 shows the location at the Weldon Spring Quarry where monitors were placed.

PM-10 monitoring was conducted weekly during the construction season (i.e., March to October) at both the chemical plant and Borrow Area perimeters. The chemical plant site was also monitored once during November since construction activities were taking place in and around the disposal cell. In addition, monthly measurements were made along the haul road between the Borrow Area and the disposal cell and at the Weldon Spring Quarry. Occasionally, severe weather conditions such as high winds, below-freezing temperatures, or significant precipitation precluded the use of the monitoring equipment, and the affected monitoring period was skipped. Since this usually coincided with the curtailment of excavation and hauling activities, it is unlikely that any exceedances of action level would have occurred during these times.

5.5.2 Applicable Standards

PM-10 monitoring is conducted at the WSSRAP to assess the ambient effects of construction and remedial activities, as committed to in the *Record of Decision for Remedial Action at the Chemical Plant of the Weldon Spring Site (ROD)* (Ref. 8). The ROD states that although the National Ambient Air Quality Standards (NAAQS) "are not applicable and/or relevant and appropriate requirements (ARARs), the standards provide a sound technical basis for ensuring protection of public health and welfare during implementation and will be considered for components of the remedial action involving potential air releases" (pp. 55-56).



LEGEND

✱ - PM-10 MONITORING LOCATION

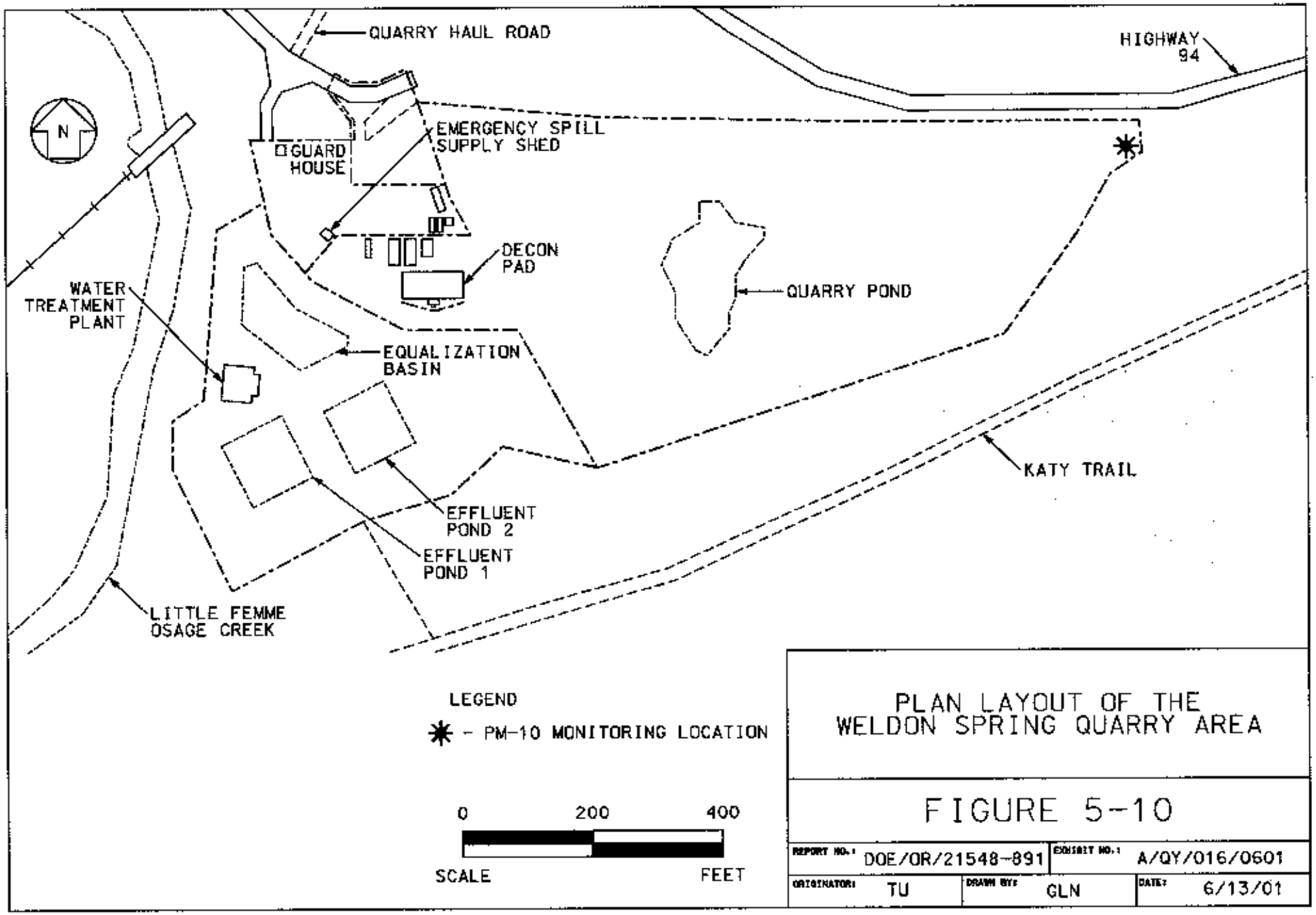
0 500 1000

SCALE FEET

PLAN LAYOUT OF THE WELDON SPRING BORROW AREA

FIGURE 5-9

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/DC/006/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/13/01	



PLAN LAYOUT OF THE WELDON SPRING QUARRY AREA

FIGURE 5-10

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/QY/016/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/13/01	

Table 5-6 2000 PM-10 Data for the Weldon Spring Site Remedial Action Project

LOCATION	NUMBER OF SAMPLING EVENTS (UPWIND/DOWNWIND)	24-HR AVERAGE MEASURED CONCENTRATION ($\mu g/m^3$)	
		UPWIND	DOWNWIND
WSCP			
February	1/2	18	23
March	4/8	25	31
April	2/4	36	22
May	2/4	24	20
June	4/3	21	31
July	2/2	37	8
August	2/2	15	21
September	4/5	17	14
October	2/2	18	23
November	1/0	12	ND
BORROW AREA			
February	1/2	45	93
March	2/2	15	19
April	2/4	19	22
May	2/6	27	28
June	3/5	16	23
July	3/3	25	22
August	2/2	30	31
September	3/3	9	17
October	3/2	16	24
HAUL ROAD			
April	2	27	N/A
May	1	25	N/A
June	1	5	N/A
July	2	11	N/A
August	2	25	N/A
September	2	12	N/A
October	1	33	N/A
QUARRY			
June	1	14	N/A
July	2	14	N/A
August	2	29	N/A

N/A Not applicable
ND No data recorded

While not specifically subject to the PM-10 NAAQS, the WSSRAP instituted a voluntary PM-10 monitoring program in April 1998, based on the results of screening models and discussions with the Missouri Department of Natural Resources (MDNR). The program is designed to assess the effectiveness of dust control measures and provide a basis for modifying them as necessary during remedial activities. A site action level of 150 $\mu g/m^3$ has been established for 24-hour average concentrations of PM-10 at the WSSRAP perimeter. Any exceedances of this limit would trigger the actions outlined in Procedure ES&H 1.1.7, *Environmental Data Review and Above Normal Reporting.*

5.5.3 Monitoring Results

Data loggers attached to the RAMs recorded ambient PM-10 concentrations once per second. Hourly minimum, maximum, and average, as well as 15-minute STEL values were calculated and reported for each monitoring period. The resulting 24-hour average concentrations were all below action level of 150 $\mu g/m^3$. Table 5-6 shows the monthly average concentrations measured at the chemical plant, borrow, haul road, and quarry areas.

The highest 24-hour average concentrations of PM-10 recorded at the chemical plant area in 2000 were 57 $\mu g/m^3$ at the upwind site and 90 $\mu g/m^3$ at the downwind site. The highest 24-hour average concentrations at the Borrow Area were 49 $\mu g/m^3$ at the upwind site and 114 $\mu g/m^3$ at the downwind site. The highest haul road concentration was 36 $\mu g/m^3$. The highest concentration at the quarry was 31 g/m^3.

5.5.4 Data Analysis

Results of the 2000 PM-10 monitoring program demonstrate that remediation activities conducted at the WSSRAP have had no significant impact on ambient dust levels. Monitoring stations near the chemical plant site perimeter have recorded minor fluctuations in PM-10, but all results have been substantially below the 150-$\mu g/m^3$ standard for 24-hour average concentrations.

5.6 NESHAP Program

This section provides information on 2000 annual atmospheric emissions of radionuclides in accordance with the requirements of 40 CFR 61, Subpart H, *National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities*. Evaluations presented here include airborne emissions data as well as dose assessment and compliance information related to potential sources of radioactive particulate emissions.

The following information pertains to the year 2000 data monitoring and information and is included to demonstrate the current status of NESHAP monitoring. Specific detailed data for 1996-1999 may be found in the respective annual site environmental reports.

5.6.1 NESHAP Monitoring and Dose Assessment Highlights

- Results of NESHAP monitoring at the seven critical receptor monitoring locations indicated that no member of the public received greater than the effective dose equivalent limit of 10 mrem/yr.

- The highest dose assessment was for a maximally exposed individual residing continuously near the quarry. Results indicated an annual committed effective dose equivalent (CEDE) of 0.014 mrem in 2000.

- The NESHAP monitoring program was discontinued as of December 31, 2000, since there were no longer any sources of radiological emissions with the potential to cause an effective dose equivalent greater than 1% of the 10 mrem/yr standard.

5.6.2 Source Description

The Weldon Spring site is being remediated in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) and the *National Environmental Policy Act* (NEPA). The Weldon Spring Feed Materials Plant no longer exists nor do any of the original uranium processing plant sources of radionuclide emissions (i.e., stacks, vents, or pipes described in 40 CFR 61, Subpart H).

Specific remedial activities that may have contributed to airborne emissions of radionuclides in 2000 included the following:

- Excavation and hauling of contaminated soils from various locations around the chemical plant site, including the quarry and vicinity properties.
- Placement of contaminated waste materials in the permanent on-site disposal cell.
- Operation of the chemical plant site and quarry water treatment plants.
- Demolition of the chemical plant site water treatment plant.

Radiological and chemical contaminants (i.e., polychlorinated biphenyl [PCBs], nitroaromatic compounds, and metals) were historically found in soil and sludge from several areas around the chemical plant site. Most of the 226 acres of the chemical plant surface area had above background concentrations of uranium (>1 pCi/g) prior to remediation. Radionuclide concentrations measured in site soil and sludge ranged as shown in Table 5-7 (Ref. 52 and Ref. 53). Excavation, hauling, and disposal of these contaminated materials was completed in 2000.

5.6.3 Air Emission Data

Most airborne emissions of radionuclides at the Weldon Spring site in 2000 were diffuse in nature, resulting from wind dispersion of surface soils, re-entrainment of dust and dirt from

Table 5-7 Contamination Levels in Site Soils and Raffinate Pit Sludge

	SITE SOIL CONCENTRATIONS (pCi/g)		RAFFINATE PIT SLUDGE CONCENTRATIONS (pCi/g)	
CONTAMINANT	MIN	MAX	MIN	MAX
U-238	0.3	2,259	N/A	N/A
Total Uranium	N/A	N/A	<10	3,400
Ra-226	0.2	452	<1	1,700
Ra-228	0.1	155	<4	1,400
Th-228	N/A	N/A	<3	1,100
Th-230	0.3	123	<8	34,000
Th-232	N/A	N/A	<4	1,400

N/A Not applicable

temporary waste storage areas, and generation of fugitive dust during remedial actions. The filter press rooms at the chemical plant site and quarry water treatment plants constituted potential point sources of radionuclide emissions other than radon while the plants were in operation. These sources were controlled using high efficiency particulate air (HEPA) filter exhaust systems.

The site water treatment plant was decommissioned and dismantled in July 2000. The quarry water treatment plant ceased operation in December 2000 and was decommissioned and dismantled in Spring 2001. Thus, these plants no longer constitute a potential point source of radionuclide emissions.

Traditional methods of estimating airborne emissions of radionuclides have been used at the WSSRAP to support engineering design studies. These methods involve identification of the various industrial activities, characterization of the activities by assuming numerous process parameters (e.g., soil characteristics, vehicle characteristics, meteorological conditions, etc.), and application of empirically-derived emission factors. While this process has been useful for evaluating the need for emissions control during planned construction and remedial activities, the high degree of uncertainty associated with the resulting emissions estimates precludes its use in obtaining an accurate assessment of effective dose equivalents to maximally exposed members of the public.

The WSSRAP uses an alternate method of tracking emissions as allowed by 40 CFR 61, Subpart H, and approved by U.S. Environmental Protection Agency (EPA) Region VII. A network of critical receptor monitors has been established to measure airborne radionuclide concentrations at locations where members of the public have the potential to be impacted by emissions from remedial activities at the chemical plant site. Background concentrations are also measured so that the net contribution of emissions from remedial activities and the resulting effective dose equivalents can be determined. Details of this monitoring program are presented in the *Plan for Monitoring Radionuclide Emissions other than Radon at Weldon Spring Site Critical Receptors* (Ref. 73).

The design of the critical receptor network is summarized in Table 5-8. Locations of the monitors are shown on Figure 5-11.

Table 5-8 Design of Critical Receptor Monitoring Network

STATION ID	LOCATION
AP-2001	Highway Maintenance Facility
AP-2005	WSSRAP Administration Building
AP-4006	Francis Howell High School
AP-4007	Busch Memorial Conservation Area
AP-4008	Army Reserve Training Area
AP-4011	Nearest Quarry Residence
AP-4012 (background)	Daniel Boone Elementary School
AP-4013	Francis Howell High School Annex

5.6.3.1 Point Sources

Table 5-9 summarizes airborne effluent control at the chemical plant site water treatment plant and the quarry water treatment plant, along with the nearest critical receptor locations. Because critical receptor monitoring was performed at the WSSRAP, no source-specific effluent monitoring was required by either 40 CFR 61, Subpart H, or DOE Order 5400.5. Engineering calculations were performed to estimate releases from the quarry and chemical plant water treatment plants and resulting dose equivalents to members of the public. These results predicted an effective dose equivalent of less than 0.1 mrem/yr at the nearest critical receptor location.

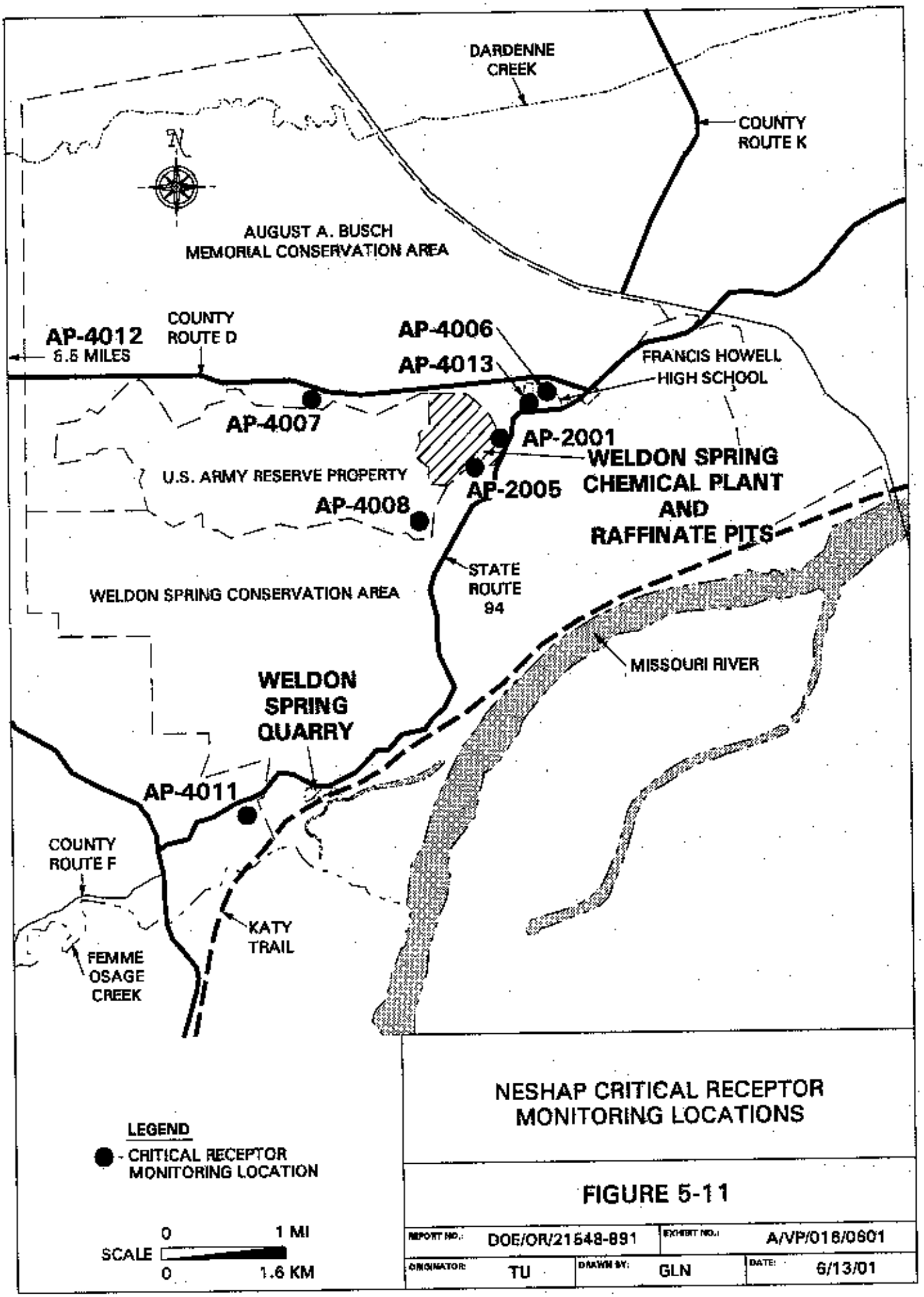
5.6.3.2 Grouped Sources

The WSSRAP has not defined any grouped sources.

5.6.3.3 Non-Point Sources

The primary sources of airborne emissions at the WSSRAP in 2000 were diffuse sources in two general geographic areas: the chemical plant area and the quarry area. The characteristics of these sources and the potential for airborne emissions are discussed below.

The quarry diffuse source is a 9-acre limestone quarry approximately 4 mi south-southwest of the chemical plant area. The quarry is essentially in a closed basin; surface water within the rim flows to the quarry floor and into a pond that covers approximately 0.2 acres. Historically, the quarry was used as a disposal area for dinitrotoluene (DNT) and trinitrotoluene (TNT) manufacturing process wastes; uranium, radium, and thorium residues; decay products from on-site and off-site processing of uranium and thorium; and building rubble and soils from



NESHAP CRITICAL RECEPTOR MONITORING LOCATIONS

FIGURE 5-11

REPORT NO.:	DOE/OR/21548-891	EXHIBIT NO.:	A/VP/016/0601		
ORIGINATOR:	TU	DRAWN BY:	GLN	DATE:	6/13/01

Table 5-9 WSSRAP Point Sources of Airborne Radionuclides

	EFFLUENT CONTROL		NEAREST RECEPTOR	
POINT SOURCE ID	DESCRIPTION	EFFICIENCY	DESCRIPTION	DISTANCE
Site Water Treatment Plant	High Efficiency Air Particulate (HEPA) Filtered	99.97% for 0.3 micron DOP*	Administration Building	400 m
Quarry Water Treatment Plant	High Efficiency Air Particulate (HEPA) Filtered	99.97% for 0.3 micron DOP*	Residence	700 m

* DOP – Dioctylphthalate

the demolition of a uranium processing facility in St. Louis, Missouri. A major remediation project involving removal and controlled temporary storage of approximately 144,000 cu yd of contaminated bulk waste was started in 1993 and completed at the end of 1995. Residual radioactive contamination was remediated in 2000 and was a potential source of radiological airborne particulate emissions.

The chemical plant diffuse source encompasses 226 acres on which the Ash Pond storage area, four raffinate pits, the temporary storage area, the material staging area, and the disposal cell are, or were, located. Airborne emissions from the chemical plant area had the potential to occur during mechanical operations such as soil excavation and hauling, transfer of waste material to the disposal cell, and treatment and mixing of contaminated materials at the temporary storage area and raffinate pits. Emissions may also have resulted from windblown resuspension of radioactive particulates from site soils. The entire chemical plant area was confirmed clean by the end of 2000, thus eliminating any further potential to generate diffuse emissions of radioactive particulates.

The emissions control strategy used during remediation of the quarry and chemical plant diffuse sources was to minimize the quantity of fine grain soil that was to be relocated, select equipment that would minimize dust generated during operations, limit surface exposure of contaminated soils, minimize hauling distances, and use water sprays to suppress dust.

5.6.4 Dose Assessment

The net measured concentrations of radionuclides at each critical receptor location have been used to assess the annual committed effective dose equivalent (CEDE) to members of the public. The exposure scenarios listed in Table 5-10 represent the maximum expected exposure of any single individual working, residing, or visiting near each critical receptor location. Annual CEDEs have been calculated for each exposure scenario and are summarized in Table 5-10.

The rest of this section provides further details of the critical receptor monitoring network and how it has been used to estimate CEDEs and demonstrate compliance with the NESHAP requirements.

5.6.4.1 Sampling Procedure

The seven designated critical receptor locations surrounding the Weldon Spring site were selected based on their proximity to the chemical plant site (less than 0.6 mi) and the probability that members of the public would spend at least 8 hours per day near them. The seven critical receptor locations and the background monitoring location are shown in Figure 5-11. They include the common boundary of the Weldon Spring Chemical Plant and the Missouri Highway and Transportation Department maintenance facility (AP-2001), the WSSRAP administration building (AP-2005), Francis Howell High School (AP-4006), the August A. Busch Memorial Conservation Area (AP-4007), the Weldon Spring Army Reserve Training Area on the Department of the Army property (AP-4008), 0.1 mi from the residence nearest to the quarry (AP-4011), and the Francis Howell High School Annex (AP-4013). Daniel Boone Elementary School in New Melle, Missouri, is the designated background monitoring location (AP-4012). Technically, the WSSRAP administration building is considered an on-site receptor rather than a critical receptor because its occupants are not members of the general public, and the area is under DOE control. However, for reporting purposes, it is referred to as a critical receptor.

Each critical receptor location included a low volume air particulate sampler (~40 lpm) and a high volume air sampler (~950 lpm). Low volume samples were collected on mixed cellulose ester membrane filters approximately 5 ft above the ground. They were exchanged and analyzed for gross alpha activity on a weekly basis. High volume samples were collected on large 8 in. x 10 in. glass fiber filters approximately 4 ft above the ground. They were also exchanged weekly, but composited and analyzed quarterly for isotopic radionuclides. It is the high volume sampling results that are used to demonstrate NESHAP compliance at the WSSRAP.

At the beginning of each calendar quarter, the high volume filters collected over the previous quarter were composited to form eight distinct samples, one for each critical receptor location and background station. The samples were analyzed for isotopic thorium, total uranium, Ra-226, and Ra-228. Background concentrations (i.e., those measured at AP-4012) were subtracted from the results for each critical receptor location to obtain net measured concentrations.

Table 5-10 Exposure Scenarios and NESHAP Dose Estimates for 2000

SCENARIO	LOCATION OF MONITOR	EXPOSURE SCENARIO			COMMITTED EFFECTIVE DOSE EQUIVALENT (mrem/person)
		DESCRIPTION	NUMBER OF PERSONS	DURATION (hr/yr)	
AP-2001	Highway Maintenance Facility	Employee	11	2,000	0.0055 ± 0.0005
AP-2005	WSSRAP Administration Building	Employee	160	2,500	0.0129 ± 0.0126
AP-4006-a	Francis Howell High School	Faculty or Student	1,600	1,620	0.0022 ± 0.0043
AP-4006-b	Francis Howell High School	Staff Member	7	2,250	0.0030 ± 0.0059
AP-4007-a	Busch Memorial Conservation Area	Employee	46	2,000	0.0021 ± 0.0042
AP-4007-b	Busch Memorial Conservation Area	Resident	2	8,760	0.0092 ± 0.0186
AP-4007-c	Busch Memorial Conservation Area	Visitor	450,000	2	0.0000 ± 0.0000
AP-4008-a	Army Reserve Training Area	Employee	1	832	0.0019 ± 0.0051
AP-4008-b	Army Reserve Training Area	Subcontractor	10	1,387	0.0031 ± 0.0084
AP-4008-c	Army Reserve Training Area	Maintenance Worker	1	1,040	0.0023 ± 0.0063
AP-4011	Nearest Quarry Residence	Resident	3	8,760	0.0142 ± 0.0267
AP-4013-a	Francis Howell High School Annex	Employee	53	2,000	0.0023 ± 0.0061
AP-4013-b	Francis Howell High School Annex	Bus Driver	50	540	0.0006 ± 0.0016

NOTE: 1 mrem/person = 0.01 Sv/person.

5.6.4.2 Net Measured Radionuclide Concentrations

Net measured radionuclide concentrations for 2000 are listed in Table 5-11. These values are based on the quarterly sample analysis results obtained at each critical receptor location. Annual average net concentrations of radionuclides are also listed in Table 5-11 for each critical receptor, along with the limiting levels prescribed in 40 CFR 61, Subpart H, Appendix E, Table 2. The NESHAP requires that there be no exceedances of the limiting levels for net concentration of each radionuclide, and that the sum of the fractions obtained by dividing the annual net concentration of each radionuclide by its limiting level be less than one. Both of these requirements were met during 2000.

5.6.4.3 Dose Estimates

The net measured concentrations of radionuclides have been combined with the maximum exposure scenario at each critical receptor location to estimate committed effective dose equivalents (CEDEs) according to the following formula:

$$CEDE\ (mrem) = Concentration\ (\mu Ci/m^3) \times DCF\ (mrem/\mu Ci) \times Exposure\ Duration\ (hr/yr) \times Breathing\ rate\ (m^3/hr)$$

where:

- Concentration is the net airborne concentration measured for a specific radionuclide at a specific monitoring station.
- DCF is the 50-year radioisotopic dose conversion factor listed for the inhalation exposure pathway in the EPA *Federal Guidance Report No. 11* (Ref. 54).
- Exposure duration represents the maximum time an individual is expected to be in the vicinity of a particular critical receptor location.
- Breathing rate of 42.4 cu ft/hr is assumed, as provided in International Commission on Radiation Protection (ICRP) Report No. 23, *Report of the Task Group on Reference Man* (Ref. 55).

Table 5-12 shows the CEDEs and associated errors calculated for each quarter at each critical receptor location. No dose equivalent is calculated for concentrations measured at the background location since the purpose of this analysis is to estimate CEDEs in excess of naturally occurring background levels. At locations where several different exposure scenarios have been identified (e.g., at the high school and the wildlife area), dose equivalents are calculated only for the individual exposed for the maximum duration. In cases where net

Table 5-11 2000 Isotopic Air Monitoring Results (Net Concentration at Each Critical Receptor)

AP-2001	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	-1.16E-11 +/- 4.05E-11	6.24E-12 +/- 2.62E-11	8.70E-12 +/- 4.11E-11	3.07E-12 +/- 2.38E-11	2.12E-12 +/- 6.77E-11	3.30E-09	0.06%
Ra-228	4.33E-13 +/- 1.66E-11	1.73E-13 +/- 7.64E-12	6.25E-12 +/- 2.08E-11	4.78E-13 +/- 1.30E-19	1.83E-12 +/- 2.77E-11	5.90E-09	0.03%
Th-228	9.42E-12 +/- 3.12E-11	1.20E-11 +/- 3.19E-11	6.55E-12 +/- 5.63E-11	8.93E-12 +/- 2.29E-11	8.73E-12 +/- 7.54E-11	3.10E-09	0.28%
Th-230	-3.17E-12 +/- 1.19E-10	3.48E-11 +/- 3.37E-11	2.80E-12 +/- 8.98E-11	4.75E-11 +/- 8.00E-11	2.05E-11 +/- 1.73E-10	3.40E-09	0.60%
Th-232	-1.32E-11 +/- 2.94E-11	1.39E-11 +/- 1.59E-11	-1.56E-11 +/- 3.97E-11	8.62E-12 +/- 2.75E-11	-1.56E-12 +/- 5.87E-11	6.20E-10	-0.25%
U, total	-4.27E-12 +/- 4.38E-12	8.52E-11 +/- 8.57E-12	4.22E-11 +/- 5.59E-12	7.15E-13 +/- 2.75E-12	3.10E-11 +/- 1.15E-11	7.98E-09	0.39%
						Total :	1.12%

AP-2005	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	-3.13E-12 +/- 2.69E-11	4.16E-12 +/- 1.57E-11	1.55E-11 +/- 5.48E-11	3.61E-13 +/- 1.17E-11	4.22E-12 +/- 6.48E-11	3.30E-09	0.13%
Ra-228	-4.77E-13 +/- 1.50E-11	1.03E-12 +/- 7.51E-12	-3.10E-12 +/- 3.13E-12	-1.14E-13 +/- 2.46E-12	-8.65E-13 +/- 1.73E-11	5.90E-09	-0.01%
Th-228	1.33E-13 +/- 2.52E-11	2.02E-11 +/- 5.62E-11	4.36E-11 +/- 1.41E-10	1.90E-11 +/- 6.64E-11	2.07E-11 +/- 1.69E-10	3.10E-09	0.67%
Th-230	-3.03E-11 +/- 5.71E-11	7.76E-11 +/- 1.35E-10	6.82E-11 +/- 2.04E-10	3.58E-11 +/- 8.50E-11	4.28E-11 +/- 2.65E-10	3.40E-09	1.26%
Th-232	-1.82E-11 +/- 2.25E-11	1.46E-11 +/- 2.60E-11	1.88E-11 +/- 7.38E-11	6.23E-12 +/- 2.13E-11	5.36E-12 +/- 8.41E-11	6.20E-10	0.86%
U, total	2.16E-11 +/- 1.10E-11	6.33E-11 +/- 1.11E-11	6.14E-11 +/- 4.54E-12	1.66E-12 +/- 3.92E-12	3.70E-11 +/- 1.68E-11	7.98E-09	0.46%
						Total :	3.37%

AP-4006	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	-6.72E-12 +/- 3.11E-11	-1.90E-12 +/- 1.21E-11	2.71E-11 +/- 7.15E-11	4.47E-13 +/- 2.84E-11	4.74E-12 +/- 8.38E-11	3.30E-09	0.14%
Ra-228	4.86E-12 +/- 6.31E-12	-7.08E-13 +/- 7.95E-12	-3.80E-12 +/- 3.46E-12	8.97E-13 +/- 3.40E-12	3.12E-13 +/- 1.13E-11	5.90E-09	0.01%
Th-228	1.42E-11 +/- 3.90E-11	2.65E-11 +/- 4.13E-11	3.76E-13 +/- 4.59E-11	7.67E-12 +/- 2.39E-11	1.22E-11 +/- 7.68E-11	3.10E-09	0.39%
Th-230	2.36E-11 +/- 8.43E-11	1.01E-11 +/- 2.62E-11	-2.38E-11 +/- 5.42E-11	-5.90E-13 +/- 2.67E-11	2.33E-12 +/- 1.07E-10	3.40E-09	0.07%
Th-232	-2.01E-11 +/- 3.59E-11	2.46E-12 +/- 1.27E-11	-2.11E-11 +/- 2.48E-11	4.17E-12 +/- 1.43E-11	-8.65E-12 +/- 4.77E-11	6.20E-10	-1.39%
U, total	2.93E-11 +/- 8.00E-12	-5.06E-12 +/- 6.71E-12	2.72E-11 +/- 1.72E-12	7.67E-12 +/- 1.01E-11	1.48E-11 +/- 1.58E-11	7.98E-09	0.19%
						Total :	-0.60%

AP-4007	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	-8.44E-12 +/- 3.00E-11	1.68E-11 +/- 5.24E-11	2.30E-11 +/- 7.60E-11	1.35E-11 +/- 4.12E-11	1.12E-11 +/- 1.05E-10	3.30E-09	0.34%
Ra-228	1.65E-11 +/- 3.02E-11	-1.54E-12 +/- 7.58E-12	3.63E-13 +/- 1.04E-11	-4.83E-14 +/- 1.20E-19	3.81E-12 +/- 3.29E-11	5.90E-09	0.06%
Th-228	-1.60E-12 +/- 2.12E-11	7.90E-12 +/- 1.93E-11	-6.97E-12 +/- 2.77E-11	-1.05E-12 +/- 2.14E-11	-4.82E-13 +/- 4.52E-11	3.10E-09	-0.02%
Th-230	-3.76E-11 +/- 4.87E-11	8.11E-12 +/- 1.74E-11	-7.85E-12 +/- 4.54E-11	9.62E-12 +/- 4.26E-11	-8.88E-12 +/- 8.09E-11	3.40E-09	-0.20%
Th-232	-2.18E-11 +/- 2.50E-11	5.97E-12 +/- 1.06E-11	-2.65E-11 +/- 2.18E-11	6.90E-13 +/- 1.75E-11	-1.04E-11 +/- 3.90E-11	6.20E-10	-1.67%
U, total	6.06E-12 +/- 1.17E-11	7.42E-11 +/- 2.17E-11	8.40E-12 +/- 3.54E-12	2.05E-13 +/- 5.13E-12	2.22E-11 +/- 2.55E-11	7.98E-09	0.28%
						Total :	-1.20%

Table 5-11 2000 Isotopic Air Monitoring Results (Net Concentration at Each Critical Receptor) (continued)

AP-4008	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	7.05E-12 +/- 4.44E-11	8.25E-12 +/- 3.50E-11	6.37E-12 +/- 4.51E-11	1.87E-11 +/- 3.52E-11	9.10E-12 +/- 8.04E-11	3.30E-09	0.28%
Ra-228	1.29E-12 +/- 1.50E-11	-1.82E-12 +/- 7.74E-12	5.94E-12 +/- 1.95E-11	-8.81E-14 +/- 1.20E-19	1.39E-12 +/- 2.57E-11	5.90E-09	0.02%
Th-228	2.06E-11 +/- 8.50E-11	1.37E-11 +/- 2.57E-11	4.45E-11 +/- 9.27E-11	-2.44E-12 +/- 1.66E-11	1.91E-11 +/- 1.29E-10	3.10E-09	0.62%
Th-230	1.20E-11 +/- 1.71E-10	8.90E-12 +/- 2.82E-11	-1.95E-11 +/- 8.88E-11	1.48E-11 +/- 3.97E-11	4.04E-12 +/- 1.99E-10	3.40E-09	0.12%
Th-232	1.80E-11 +/- 1.10E-10	3.17E-12 +/- 1.29E-11	-2.89E-11 +/- 3.05E-11	1.72E-12 +/- 1.51E-11	-1.49E-12 +/- 1.16E-10	6.20E-10	-0.24%
U, total	7.16E-12 +/- 5.15E-12	2.53E-11 +/- 3.55E-12	3.78E-12 +/- 2.63E-12	6.68E-12 +/- 4.22E-12	1.15E-11 +/- 6.67E-12	7.98E-09	0.14%
						Total :	0.94%

AP-4011	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	2.17E-11 +/- 5.07E-11	-5.19E-13 +/- 1.65E-11	3.53E-11 +/- 6.08E-11	5.11E-12 +/- 2.94E-11	1.54E-11 +/- 8.60E-11	3.30E-09	0.47%
Ra-228	4.82E-12 +/- 8.45E-12	-5.59E-13 +/- 8.14E-12	2.28E-12 +/- 1.30E-11	-8.60E-14 +/- 1.19E-19	1.61E-12 +/- 1.68E-11	5.90E-09	0.03%
Th-228	3.53E-11 +/- 7.43E-11	1.20E-11 +/- 2.31E-11	-1.32E-11 +/- 1.61E-11	-3.68E-12 +/- 1.49E-11	7.63E-12 +/- 8.08E-11	3.10E-09	0.25%
Th-230	2.95E-11 +/- 1.22E-10	1.29E-11 +/- 2.07E-11	-4.52E-11 +/- 4.06E-11	5.31E-12 +/- 2.60E-11	8.28E-13 +/- 1.33E-10	3.40E-09	0.02%
Th-232	-1.88E-12 +/- 4.78E-11	4.23E-12 +/- 1.37E-11	-3.15E-11 +/- 1.85E-11	8.05E-12 +/- 1.29E-11	-5.78E-12 +/- 5.46E-11	6.20E-10	-0.93%
U, total	1.23E-11 +/- 6.50E-12	1.47E-11 +/- 1.60E-11	-2.54E-11 +/- 9.58E-13	4.71E-12 +/- 2.20E-12	1.60E-12 +/- 1.74E-11	7.98E-09	0.02%
						Total :	-0.15%

AP-4013	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(uCi/m3)	of Limit)
Ra-226	-4.24E-12 +/- 3.82E-11	4.12E-12 +/- 1.86E-11	1.50E-11 +/- 5.65E-11	4.22E-12 +/- 5.90E-11	4.78E-12 +/- 9.13E-11	3.30E-09	0.14%
Ra-228	1.18E-10 +/- 1.66E-10	-1.68E-12 +/- 7.61E-12	-2.36E-12 +/- 5.06E-12	-5.19E-14 +/- 1.20E-19	2.85E-11 +/- 1.66E-10	5.90E-09	0.48%
Th-228	-1.11E-12 +/- 2.58E-11	6.36E-12 +/- 2.26E-11	-3.89E-12 +/- 3.60E-11	-5.02E-12 +/- 1.33E-11	-9.15E-13 +/- 5.15E-11	3.10E-09	-0.03%
Th-230	-3.08E-11 +/- 8.40E-11	1.55E-11 +/- 3.48E-11	-2.25E-12 +/- 9.61E-11	5.54E-12 +/- 2.54E-11	-3.00E-12 +/- 1.35E-10	3.40E-09	-0.09%
Th-232	-1.44E-11 +/- 3.64E-11	5.38E-12 +/- 1.62E-11	-8.01E-12 +/- 3.34E-11	4.44E-12 +/- 1.60E-11	-2.64E-12 +/- 5.44E-11	6.20E-10	-0.43%
U, total	-2.06E-11 +/- 1.28E-12	1.21E-11 +/- 1.46E-11	2.88E-11 +/- 1.89E-12	4.87E-12 +/- 9.51E-12	6.27E-12 +/- 1.70E-11	7.98E-09	0.08%
						Total :	0.16%

AP-4012 (bkg.)	Net Concentration (uCi/m3)					NESHAPs Limit	Concentration (%
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average	(Ci/m3)	of Limit)
Ra-226	1.72E-11 +/- 3.96E-11	3.84E-12 +/- 1.83E-11	1.41E-11 +/- 2.84E-11	1.22E-11 +/- 1.59E-11	1.19E-11 +/- 5.44E-11	NA	NA
Ra-228	1.42E-11 +/- 1.46E-11	2.05E-11 +/- 8.01E-12	1.16E-11 +/- 9.31E-12	6.33E-12 +/- 1.21E-19	1.31E-11 +/- 1.91E-11	NA	NA
Th-228	7.54E-12 +/- 3.97E-11	4.38E-12 +/- 2.26E-11	1.75E-11 +/- 4.25E-11	7.70E-12 +/- 1.41E-11	9.27E-12 +/- 6.40E-11	NA	NA
Th-230	1.12E-10 +/- 8.89E-11	2.21E-11 +/- 3.74E-11	7.73E-11 +/- 9.53E-11	2.12E-11 +/- 2.40E-11	5.82E-11 +/- 1.26E-10	NA	NA
Th-232	4.14E-11 +/- 8.78E-11	4.77E-12 +/- 2.00E-11	3.84E-11 +/- 6.27E-11	5.32E-12 +/- 1.39E-11	2.25E-11 +/- 9.55E-11	NA	NA
U, total	8.91E-11 +/- 4.55E-12	5.05E-11 +/- 4.07E-12	1.66E-10 +/- 7.99E-12	4.70E-11 +/- 2.36E-12	8.38E-11 +/- 1.03E-11	NA	NA

Notes:

1) Net concentrations are calculated by subtracting background levels (i.e., levels measured at Station AP-4012) from gross concentrations measured at each critical receptor.

2) NESHAPs limits are extracted from 40 CFR 61, Subpart H, Appendix E, Table 2.

3) To convert uCi/m3 to Bq/m3, multiply concentration by 37,000.

measured concentrations are negative (i.e., below background), the resulting dose equivalent is assumed to be zero.

Total annual CEDEs are calculated by summing the quarterly contributions of each radionuclide at each monitoring location. Total errors are derived by calculating the square root of the sum of the squares. The highest annual CEDE to a member of the public in 2000 is estimated to be 0.014 mrem, based on the exposure scenario of an individual residing near the quarry.

5.6.4.4 Compliance Assessment

Subpart H of 40 CFR 61 states the following: "*emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.*" According to DOE Order 5400.5, the total effective dose equivalent (TEDE) includes the 50-year CEDE from internal deposition of radionuclides and the effective dose equivalent (EDE) due to penetrating radiation from sources external to the body. Because the WSSRAP emits no radionuclides that could result in an appreciable submersion dose potential to members of the public, the external dose equivalent portion of the TEDE is not applicable to NESHAP dose calculations. In addition, ingestion of radionuclides other than radon is not an applicable pathway for a potentially maximally exposed individual at any critical receptor. Thus, for the purpose of demonstrating NESHAP compliance, the EDE specified in 40 CFR 61 is assumed to equal the CEDE from internal deposition by the inhalation pathway.

Results of isotopic radionuclide monitoring at critical receptor locations demonstrate that airborne emissions from the WSSRAP contributed a maximum CEDE of 0.014 mrem/yr. This value, which represents the maximum CEDE calculated for any critical receptor location in 2000, is several orders of magnitude less than the NESHAP limit of 10 mrem/yr.

All 2000 critical receptor monitoring data used to calculate CEDEs and demonstrate compliance with the 10-mrem/yr standard meet the criteria specified in 40 CFR 61, Subpart H, for monitoring and test procedures (including a quality assurance program), compliance and reporting procedures, and record keeping requirements. In addition, as mentioned in Section 5.6.4.2, net measured concentrations of individual radioisotopes are all below the limiting levels and proportional limits specified in 40 CFR 61, Subpart H, Appendix E, Table 2.

Data quality objectives for precision and accuracy, as outlined in the *Plan for Monitoring Radionuclide Emissions other than Radon at Weldon Spring Site Critical Receptors* (Ref. 73), were achieved in all four quarters of the year, except the third quarter accuracy results for uranium spikes. These samples exhibited high recovery rates for uranium, possibly due to matrix interference. Thus, it is likely that uranium values reported for the environmental samples from this quarter may overstate the actual concentrations.

Table 5-12 2000 Isotopic Air Monitoring Results (Committed Effective Dose Equivalent Contributions for Each Exposure Scenario)

AP-2001	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0000 +/- 0.0002	0.0000 +/- 0.0001	0.0000 +/- 0.0002	0.0000 +/- 0.0001	0.0001 +/- 0.0003
Ra-228	0.0000 +/- 0.0002	0.0000 +/- 0.0001	0.0000 +/- 0.0004	0.0000 +/- 0.0001	0.0000 +/- 0.0004
Th-228	0.0001 +/- 0.0002	0.0002 +/- 0.0001	0.0001 +/- 0.0004	0.0001 +/- 0.0002	0.0005 +/- 0.0005
Th-230	0.0000 +/- 0.0007	0.0007 +/- 0.0012	0.0001 +/- 0.0017	0.0009 +/- 0.0009	0.0017 +/- 0.0024
Th-232	0.0000 +/- 0.0002	0.0014 +/- 0.0001	0.0000 +/- 0.0002	0.0008 +/- 0.0001	0.0022 +/- 0.0003
U, total	0.0000 +/- 0.0011	0.0006 +/- 0.0004	0.0003 +/- 0.0014	0.0000 +/- 0.0007	0.0010 +/- 0.0019
Total EDE	0.0001 +/- 0.0002	0.0029 +/- 0.0001	0.0005 +/- 0.0003	0.0019 +/- 0.0003	0.0055 +/- 0.0005

AP-2005	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0000 +/- 0.0002	0.0000 +/- 0.0001	0.0001 +/- 0.0004	0.0000 +/- 0.0001	0.0001 +/- 0.0004
Ra-228	0.0000 +/- 0.0001	0.0000 +/- 0.0000	0.0000 +/- 0.0000	0.0000 +/- 0.0000	0.0000 +/- 0.0001
Th-228	0.0000 +/- 0.0005	0.0004 +/- 0.0011	0.0008 +/- 0.0026	0.0004 +/- 0.0012	0.0016 +/- 0.0032
Th-230	0.0000 +/- 0.0014	0.0019 +/- 0.0033	0.0022 +/- 0.0050	0.0009 +/- 0.0021	0.0049 +/- 0.0065
Th-232	0.0000 +/- 0.0028	0.0018 +/- 0.0032	0.0023 +/- 0.0091	0.0008 +/- 0.0028	0.0049 +/- 0.0103
U, total	0.0002 +/- 0.0001	0.0006 +/- 0.0001	0.0006 +/- 0.0000	0.0000 +/- 0.0000	0.0014 +/- 0.0002
Total EDE	0.0002 +/- 0.0031	0.0047 +/- 0.0047	0.0060 +/- 0.0107	0.0020 +/- 0.0036	0.0129 +/- 0.0126

AP-4006-b	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0000 +/- 0.0002	0.0000 +/- 0.0001	0.0002 +/- 0.0004	0.0000 +/- 0.0002	0.0002 +/- 0.0005
Ra-228	0.0000 +/- 0.0000	0.0000 +/- 0.0000	0.0000 +/- 0.0000	0.0000 +/- 0.0000	0.0000 +/- 0.0000
Th-228	0.0002 +/- 0.0007	0.0004 +/- 0.0007	0.0000 +/- 0.0008	0.0001 +/- 0.0004	0.0008 +/- 0.0013
Th-230	0.0005 +/- 0.0019	0.0002 +/- 0.0006	0.0000 +/- 0.0012	0.0000 +/- 0.0006	0.0007 +/- 0.0024
Th-232	0.0000 +/- 0.0040	0.0003 +/- 0.0014	0.0000 +/- 0.0027	0.0005 +/- 0.0016	0.0007 +/- 0.0053
U, total	0.0002 +/- 0.0001	0.0000 +/- 0.0001	0.0002 +/- 0.0000	0.0001 +/- 0.0001	0.0005 +/- 0.0001
Total EDE	0.0010 +/- 0.0044	0.0009 +/- 0.0017	0.0004 +/- 0.0031	0.0007 +/- 0.0017	0.0030 +/- 0.0059

AP-4007-b	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0000 +/- 0.0007	0.0004 +/- 0.0012	0.0005 +/- 0.0017	0.0003 +/- 0.0009	0.0012 +/- 0.0024
Ra-228	0.0002 +/- 0.0004	0.0000 +/- 0.0001	0.0000 +/- 0.0001	0.0000 +/- 0.0000	0.0002 +/- 0.0004
Th-228	0.0000 +/- 0.0014	0.0005 +/- 0.0013	0.0000 +/- 0.0018	0.0000 +/- 0.0014	0.0005 +/- 0.0030
Th-230	0.0000 +/- 0.0042	0.0007 +/- 0.0015	0.0000 +/- 0.0039	0.0008 +/- 0.0036	0.0015 +/- 0.0069
Th-232	0.0000 +/- 0.0108	0.0026 +/- 0.0046	0.0000 +/- 0.0094	0.0003 +/- 0.0076	0.0029 +/- 0.0168
U, total	0.0002 +/- 0.0004	0.0024 +/- 0.0007	0.0003 +/- 0.0001	0.0000 +/- 0.0002	0.0029 +/- 0.0008
Total EDE	0.0004 +/- 0.0117	0.0066 +/- 0.0052	0.0008 +/- 0.0105	0.0014 +/- 0.0066	0.0092 +/- 0.0186

Table 5-12 2000 Isotopic Air Monitoring Results (Committed Effective Dose Equivalent Contributions for Each Exposure Scenario) (continued)

AP-4008-b	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0000 +/- 0.0002	0.0000 +/- 0.0001	0.0000 +/- 0.0002	0.0001 +/- 0.0001	0.0001 +/- 0.0003
Ra-228	0.0000 +/- 0.0000	0.0000 +/- 0.0000	0.0000 +/- 0.0000	0.0000 +/- 0.0000	0.0000 +/- 0.0001
Th-228	0.0002 +/- 0.0009	0.0001 +/- 0.0003	0.0005 +/- 0.0010	0.0000 +/- 0.0002	0.0008 +/- 0.0013
Th-230	0.0002 +/- 0.0023	0.0001 +/- 0.0004	0.0000 +/- 0.0012	0.0002 +/- 0.0005	0.0005 +/- 0.0027
Th-232	0.0011 +/- 0.0075	0.0002 +/- 0.0009	0.0000 +/- 0.0021	0.0001 +/- 0.0010	0.0014 +/- 0.0079
U, total	0.0000 +/- 0.0000	0.0001 +/- 0.0000	0.0000 +/- 0.0000	0.0000 +/- 0.0000	0.0002 +/- 0.0000
Total EDE	0.0015 +/- 0.0079	0.0006 +/- 0.0010	0.0005 +/- 0.0026	0.0004 +/- 0.0012	0.0031 +/- 0.0084

AP-4011	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0005 +/- 0.0011	0.0000 +/- 0.0004	0.0006 +/- 0.0014	0.0001 +/- 0.0007	0.0014 +/- 0.0019
Ra-228	0.0001 +/- 0.0001	0.0000 +/- 0.0001	0.0000 +/- 0.0002	0.0000 +/- 0.0000	0.0001 +/- 0.0002
Th-228	0.0023 +/- 0.0049	0.0008 +/- 0.0015	0.0000 +/- 0.0011	0.0000 +/- 0.0010	0.0031 +/- 0.0053
Th-230	0.0025 +/- 0.0105	0.0011 +/- 0.0018	0.0000 +/- 0.0035	0.0005 +/- 0.0022	0.0041 +/- 0.0114
Th-232	0.0000 +/- 0.0206	0.0018 +/- 0.0059	0.0000 +/- 0.0080	0.0026 +/- 0.0056	0.0044 +/- 0.0235
U, total	0.0004 +/- 0.0002	0.0005 +/- 0.0005	0.0000 +/- 0.0000	0.0002 +/- 0.0001	0.0010 +/- 0.0006
Total EDE	0.0058 +/- 0.0236	0.0042 +/- 0.0064	0.0008 +/- 0.0089	0.0033 +/- 0.0061	0.0142 +/- 0.0267

AP-4013-a	Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
Ra-226	0.0000 +/- 0.0002	0.0000 +/- 0.0001	0.0001 +/- 0.0003	0.0000 +/- 0.0003	0.0001 +/- 0.0005
Ra-228	0.0003 +/- 0.0005	0.0000 +/- 0.0000	0.0000 +/- 0.0000	0.0000 +/- 0.0000	0.0003 +/- 0.0005
Th-228	0.0000 +/- 0.0004	0.0001 +/- 0.0003	0.0000 +/- 0.0005	0.0000 +/- 0.0002	0.0001 +/- 0.0006
Th-230	0.0000 +/- 0.0016	0.0003 +/- 0.0007	0.0000 +/- 0.0019	0.0001 +/- 0.0005	0.0004 +/- 0.0026
Th-232	0.0000 +/- 0.0036	0.0005 +/- 0.0016	0.0000 +/- 0.0033	0.0004 +/- 0.0016	0.0010 +/- 0.0054
U, total	0.0000 +/- 0.0000	0.0001 +/- 0.0001	0.0002 +/- 0.0000	0.0000 +/- 0.0001	0.0003 +/- 0.0001
Total EDE	0.0003 +/- 0.0040	0.0010 +/- 0.0018	0.0003 +/- 0.0038	0.0006 +/- 0.0017	0.0023 +/- 0.0061

Notes:

1) Monitor locations and exposure scenarios are listed in Table 3-1. For critical receptors with more than one exposure scenario, the exposure of greatest duration is used to calculate dose.
2) Dose calculations are based on inhalation pathway. Dose conversion factors are from Federal Guidance Report No. 11.
3) No dose is calculated for AP-4012, since it represents background conditions.
4) Assume breathing rate of 1.2 m^3/hr, as provided in ICRP Report No. 23.
5) In cases where net measured concentrations are below background, dose is listed as zero.
6) To convert mrem to mSv, multiply dose by 0.01.

Based on verification and validation of each reported value, overall completeness of the NESHAP data is greater than 95%. One-tailed Student's t-tests performed at the 95% confidence level indicate that only two of 42 quarterly data sample sets were statistically above background at any of the critical receptors. Data sets that failed the t-test analysis included Th-228 at both AP-2001 and AP-4006. The statistical test failure is most likely an artifact of the extremely low concentrations reported (i.e., the reported values are generally less than five times the detection limit, and the net quarterly concentrations are in all but one case, less than associated errors).

The NESHAP monitoring program was discontinued as of December 31, 2000, since there are no longer any sources of radiological emissions with the potential to cause an effective dose equivalent greater than 1% of the 10 mrem/yr standard.

5.7 Surface Water Protection

5.7.1 Highlights of the Surface Water Program

In 2000, completion of soil remediation strongly affected the surface water program. These items, and others, are discussed in detail in this chapter.

- The mass of uranium migrating off site in storm water and treated effluent, 11.84 lb/yr, was a 44% reduction from the 1999 mass of 21.08 lb/yr (see Tables 5-17 and 5-51) and a 98.8% reduction from the 1987 mass of 974 lb.

- Twenty-three samples of treatment plant effluent were collected at the chemical plant site and quarry in 2000. All parameters monitored in treatment plant effluent were in compliance with National Pollutant Discharge Elimination System (NPDES) permit conditions.

- The annual average for uranium in storm water was reduced to less than 16 pCi/l at all outfalls (Table 5-15).

- The overall results of the whole effluent toxicity (WET) tests indicated that the chemical plant site and quarry water treatment plant effluents were not toxic to test organisms in 2000 (Table 5-19).

- All major water sources (i.e., Ash Pond, raffinate pits) have been remediated.

- Surface water bodies downstream of the chemical plant site continue to show a decline in uranium levels (Figure 5-13 and Table 5-21).

5.7.2 Program Overview

The environmental monitoring and protection program for surface waters is prescribed in the *Environmental Monitoring Plan* (Ref. 56) and includes monitoring discharge points permitted under the NPDES program and streams, ponds, and lakes under the surface water monitoring program.

The NPDES effluent monitoring program establishes sampling requirements for discharge points (outfalls) at the chemical plant and quarry sites and the borrow areas. The goals of this program are to maintain compliance with the NPDES permit requirements and to protect the health of downstream water users and the environment by characterizing water released from the site. In accordance with the policy that all surface water be closely monitored and treated (as necessary) to meet Federal and State requirements, the PMC uses the water sample data to develop strategies to minimize the discharge of waterborne contaminants from the site and to measure the effectiveness of remediation.

In addition, the surface water monitoring program monitors off-site water bodies for uranium contamination and temporal changes in uranium levels. The data generated from this monitoring are used in conjunction with NPDES monitoring to measure the success of the project goal of cleaning up the site with no long-term increase in contaminant discharge or degradation of off-site water bodies.

5.7.3 Applicable Standards

The WSSRAP is subject to, and complies with, Executive Order 12088, which requires all Federal facilities to comply with applicable pollution control standards. Effluent discharges from the site for 2000 were authorized by five NPDES permits issued by the Missouri Department of Natural Resources (MDNR). The MDNR requires specific parameters to be monitored at outfalls listed in each permit. Each parameter is assigned either effluent limits or a "monitoring only" status, which means the concentrations are reported but not limited by the permit. In addition, the WSSRAP monitors and reports some parameters on an informational basis. Sampling frequencies and reporting requirements for the two major permits, MO-0107701 and MO-0108987, are summarized in Tables 5-13 and 5-14. These permits were reissued on July 14, 2000, and June 17, 1998, respectively. Permit MO-0108987 was revised on April 21, 2000.

The chemical plant site Borrow Area land disturbance storm water permit, MO-R100B69, issued on September 1, 1994, and reissued on May 29, 1998, has no specified monitoring or reporting requirements. A program was developed in the *Environmental Monitoring Plan* (Ref. 56) for monitoring settleable solids and, under certain circumstances, oil and grease. The results of this monitoring were used to measure the effectiveness of erosion controls and to improve them, if need be.

The Quarry Borrow Area land disturbance storm water permit, MO-R104031, issued to the WSSRAP on July 28, 2000, has no specified monitoring or reporting requirements. Settleable solids will be monitored if adverse effects are noted at the Borrow Area.

Effluent discharges are also regulated by DOE Order 5400.5, which calls for a best available technology evaluation if the annual average uranium concentration at an outfall exceeds the derived concentration guideline (DCG) for natural uranium (600 pCi/l). Measures are taken to keep uranium concentrations as low as reasonably achievable (ALARA), not just below the DCG.

The primary criteria used to develop the surface water monitoring program were the Missouri Water Quality Standards for drinking water supplies established under the Missouri Clean Water Commission Regulation 10 CSR 20-7.031 and the U.S. Environmental Protection Agency primary and secondary maximum contaminant level concentrations for drinking water. A table of applicable drinking water standards that includes contaminants routinely monitored in the surface water program can be found in Section 5.8.

Surface water other than NPDES outfalls is also monitored under the requirements of DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, which designates DCGs for ingestion of water.

Table 5-13 Weldon Spring Chemical Plant Storm and Sanitary Water (NPDES Permit MO-0107701) and Quarry Storm Water (MO-0108987) Monitoring Requirements

PARAMETER	LOCATION	
	NP-0002, NP-0003, NP-0004, NP-0005, NP-0010, NP-0050[a] NP-1005	NP-0006
Sampling Frequency	once/month	Once/quarter
Flow	GPD (monitor only)	GPD (monitor only)[b]
Settleable Solids	1.0 ml/l/hr	—
TSS	mg/l (monitor only)[c]	30/45 mg/l[d]
Nitrate and Nitrite as N**	mg/l (monitor only)	—
Uranium, total	mg/l (monitor only)*	—
Gross alpha, beta	pCi/l (monitor only)	—
PH	6 - 9 standard units	6 - 9 standard units
Fecal coliform	---	400/1000 colonies/ 100 ml[e]
BOD	—	30/45 mg/l[d]
Total Residual Chlorine	—	1.0 mg/l

NOTE: Refer to Figure 5-12 for NPDES monitoring locations.

* Permit requires reporting in both mg/l and pCi/l and notification of MDNR if uranium concentration in any sample exceeds 2 mg/l.

** Does not apply to quarry storm water Outfall NP-1005.

(a) Outfall NP-0050 represents two outfalls from the TSA. The outfall was not permitted during the first half of 2000. Permission was given by MDNR to discharge at the outfall as long as it was monitored as at other storm water outfalls. The outfall was permitted when the permit was reissued on July 13, 2000
(b) Frequency is once/month.
(c) Limit is 50 mg/l if erosion control is not designed for a one in 10 year, 24-hour storm.
(d) Monthly average/weekly average
(e) Monthly average/daily maximum.
-- Not Applicable.

Table 5-14 Effluent Parameter Limits and Monitoring Requirements for Site Water Treatment Plant (NPDES Permit MO-0107701) and Quarry Water Treatment Plant (NPDES Permit MO-0108987) Outfalls*

PARAMETER	LOCATION NP-0007/NP-1001	PARAMETER	LOCATION NP-0007/NP-1001
Gross α	pCi/l[a]	Pb, total	0.20/0.10 mg/l
Gross β	pCi/l[a]	Mn, total	0.50/0.10 mg/l
Uranium, total	pCi/l[a][b]	Hg, total	0.005/0.004 mg/l
Ra-226[c]	pCi/l[a]	Se, total	0.05 mg/l/NA
Ra-228[c]	pCi/l[a]	Cyanide, amenable	0.05 mg/l/NA
Th-230[c]	pCi/l[a]	2,4-DNT	1.1/0.22 µg/l
Th-232[c]	pCi/l[a]	Fluoride, total	12 mg/l/NA
Flow	GPD[a]	Nitrate and Nitrite as N	100 mg/l[g]
COD	90 (60) mg/l [e]	Sulfate as SO_4	1000/500 mg/l
TSS	50 (30) mg/l[e]	Chloride	mg/l[a]/NA
pH	6-9 standard units	Priority Pollutants[f]	mg/l[a][h][i]
Al, total	7.5 mg/l/NA (k)	Whole Effluent Toxicity	[j][k]
As, total	0.20 mg/l/NA		
Cr, total	0.40 mg/l/NA		

NOTE: Refer to Figures 5-12 and 5-13 for NPDES monitoring locations.
NA Not applicable.
* Frequency = once per batch unless otherwise noted.
(a) Monitoring only.
(b) Water treatment plants designed for an average concentration of 30 pCi/l and never to exceed concentrations of 100 pCi/l.
(c) Once/month.
(d) Polychlorinated biphenyls (PCBs) have a limit of 1.0 µg/l until July 14, 2000. After that the limit is 0.5 µg/l.
(e) Daily maximum (monthly average).
(f) Priority pollutants are listed in 40 CFR 122.21 Appendix D, Tables II and III.
(g) Limit applies to chemical plant; monitoring only at quarry.
(h) Annual monitoring.
(i) Quarterly monitoring.
(j) No statistical difference between effluent and upstream results at 95% confidence level.
(k) Added when permit reissued on July 14, 2000.

5.7.4 Hydrology Description of the Chemical Plant Site and Quarry

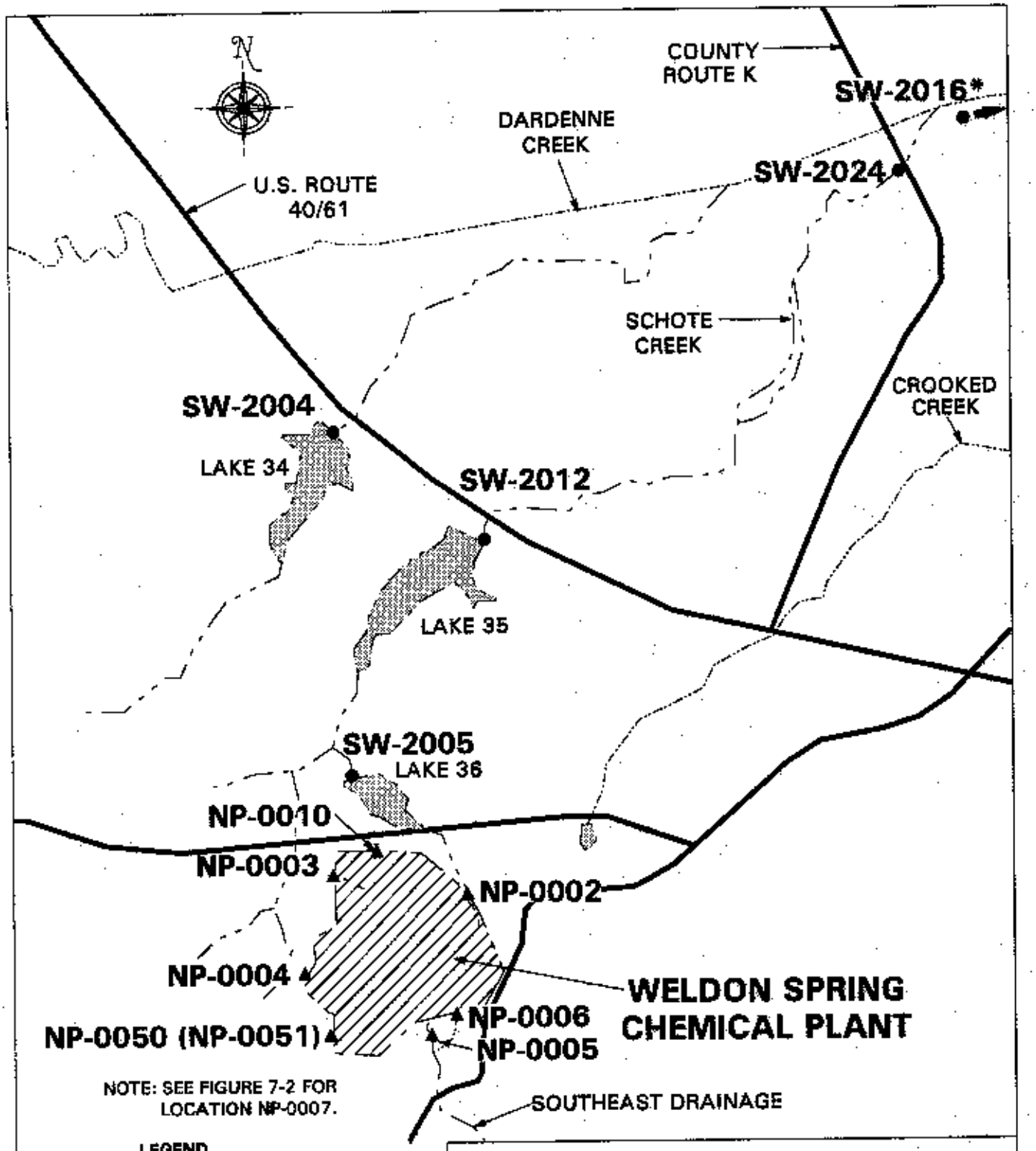
Separate surface water monitoring programs have been developed at the chemical plant and quarry due to differences in the topography and hydrologic conditions. Both programs take into account the mechanisms controlling surface water source areas.

5.7.4.1 Weldon Spring Chemical Plant and Raffinate Pits Area

The chemical plant area is on the Missouri-Mississippi River surface drainage divide (Figures 5-12 and 5-13). The topography is gently undulating and generally slopes northward to the Mississippi River and, more steeply, southward to the Missouri River. Streams do not run through the property, but because the site is elevated above surrounding areas, drainageways originate on the property and convey storm water off site. Surface drainage from the western portion of the site, which included (before remediation) Ash Pond, the south and north dump areas, the temporary storage area, and the raffinate pits, drains to tributaries of Busch Lake 35 and then to Schote Creek, which in turn enters Dardenne Creek, ultimately draining to the Mississippi River (Figure 5-12).

Ash Pond, Raffinate Pits 3 and 4, the chipped wood storage area, and the south end of the temporary storage area were completely remediated and confirmed clean in 1999. The remainder of the site was remediated and confirmed clean in 2000. A portion of the water that discharges at NP-0003 flows through Sedimentation Basin 4R before reaching Outfall NP-0003. Outfalls NP-0004, NP-0005, and NP-0050 (NP-0051) do not have sedimentation basins but have appropriate vegetation and/or erosion control upstream of the outfalls.

Surface water drainage from the north and east sections of the chemical plant site, which includes the administration parking lots and part of the disposal cell outer berm and the construction material staging area, discharges to Dardenne Creek from Schote Creek after first flowing through Busch Lakes 36 and 35 (Figures 5-12 and 5-13). Leachate from the interior of the cell and storm water runoff from open portions of the cell were collected in Removal Basins 1 and 2 and Sedimentation Basin 1 (converted to a retention basin) for sampling and/or treatment. These basins were remediated in 2000. Retention Basin 2 was made smaller and may be used to store treated storm water from open portions of the cell when it is reopened for a brief period in 2001. Leachate is now collected in the Leachate Collection and Removal System (LCRS) sump. Runoff from the construction material staging area equipment area near the north decontamination pad was collected in the construction material staging area retention basin and sampled to ensure compliance before being discharged to Outfall NP-0010 during 2000. The equipment area, decontamination pad, and retention basin were removed, and the area was remediated in 2000.



NOTE: SEE FIGURE 7-2 FOR LOCATION NP-0007.

LEGEND

- ● - SURFACE WATER LOCATION
- ▲ - NPDES LOCATION
- * - AT COUNTY ROUTE N, APPROXIMATELY 2 MILES

0 1/2 1 Mi

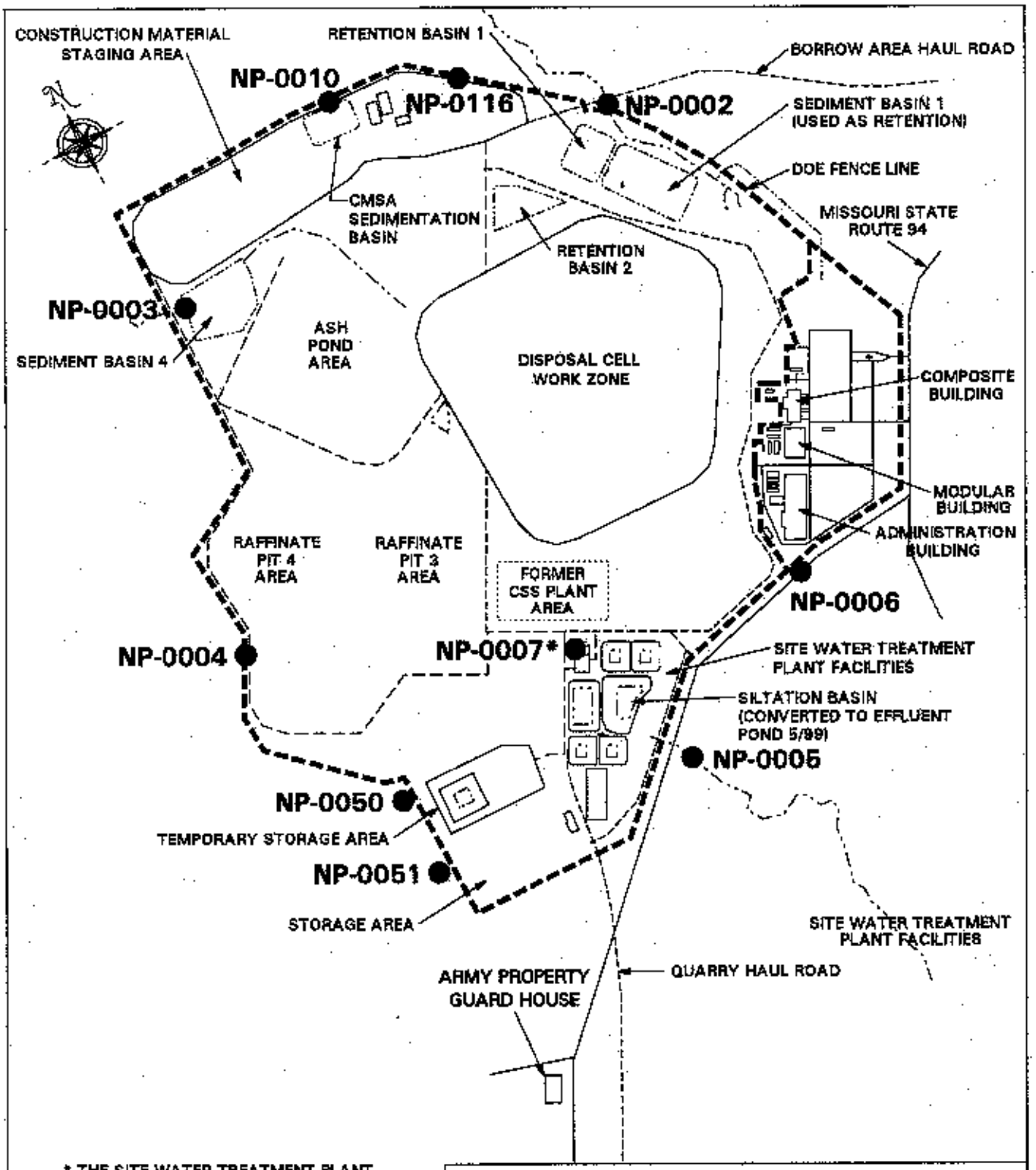
0 .8 1.6 KM

SCALE

SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT AND RAFFINATE PITS

FIGURE 5-12

REPORT NO.:	DOE/OR/21548-891	EXHIBIT NO.:	A/VP/017/0601		
ORIGINATOR:	TU	DRAWN BY:	GLN	DATE:	6/13/01



* THE SITE WATER TREATMENT PLANT DISCHARGES TO THE MISSOURI RIVER, VIA THE EFFLUENT PIPELINE AT NP-0007. (SEE FIGURE 4-2)

● - SAMPLE LOCATION

0 500 1000 FT
0 152.4 304.8 M
SCALE

SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT AND RAFFINATE PITS - 1/1/2000

FIGURE 5-13

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/CP/052/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/13/01	

Runoff from the southern portion of the chemical plant site (Figures 5-12 and 5-13), which included the site water treatment plant, Building 434, and parking and equipment areas for the former chemical stabilization and solidification facility, flows southeast to the Missouri River via the Southeast Drainage (Valley 5300). The site water treatment plant, effluent basins, equalization basin, Raffinate Pits 1 and 2, and Building 434 were removed and the area remediated in 2000. By the end of 2000, all surface water runoff was from confirmed clean areas.

5.7.4.2 Weldon Spring Quarry

Surface water bodies in the quarry area are the Femme Osage Slough, Little Femme Osage Creek, and Femme Osage Creek (Figure 5-14). These water bodies do not receive direct runoff from the quarry, but are sampled to monitor potential changes due to movement of contaminated groundwater from the fractured bedrock of the quarry through fine-grained alluvial materials.

The Femme Osage Slough is directly south of the quarry and is known to receive contaminated groundwater from the quarry through subsurface recharge. There is no natural surface flow from the slough; it is essentially land locked. Little Femme Osage Creek is located west of the quarry and discharges into Femme Osage Creek approximately 0.3 mi southwest of the quarry. Femme Osage Creek flows into the Missouri River. Although there has been no evidence of impact from contaminated groundwater on the creeks via stream emergence, they are monitored to detect changes in the system.

5.7.5 Monitoring

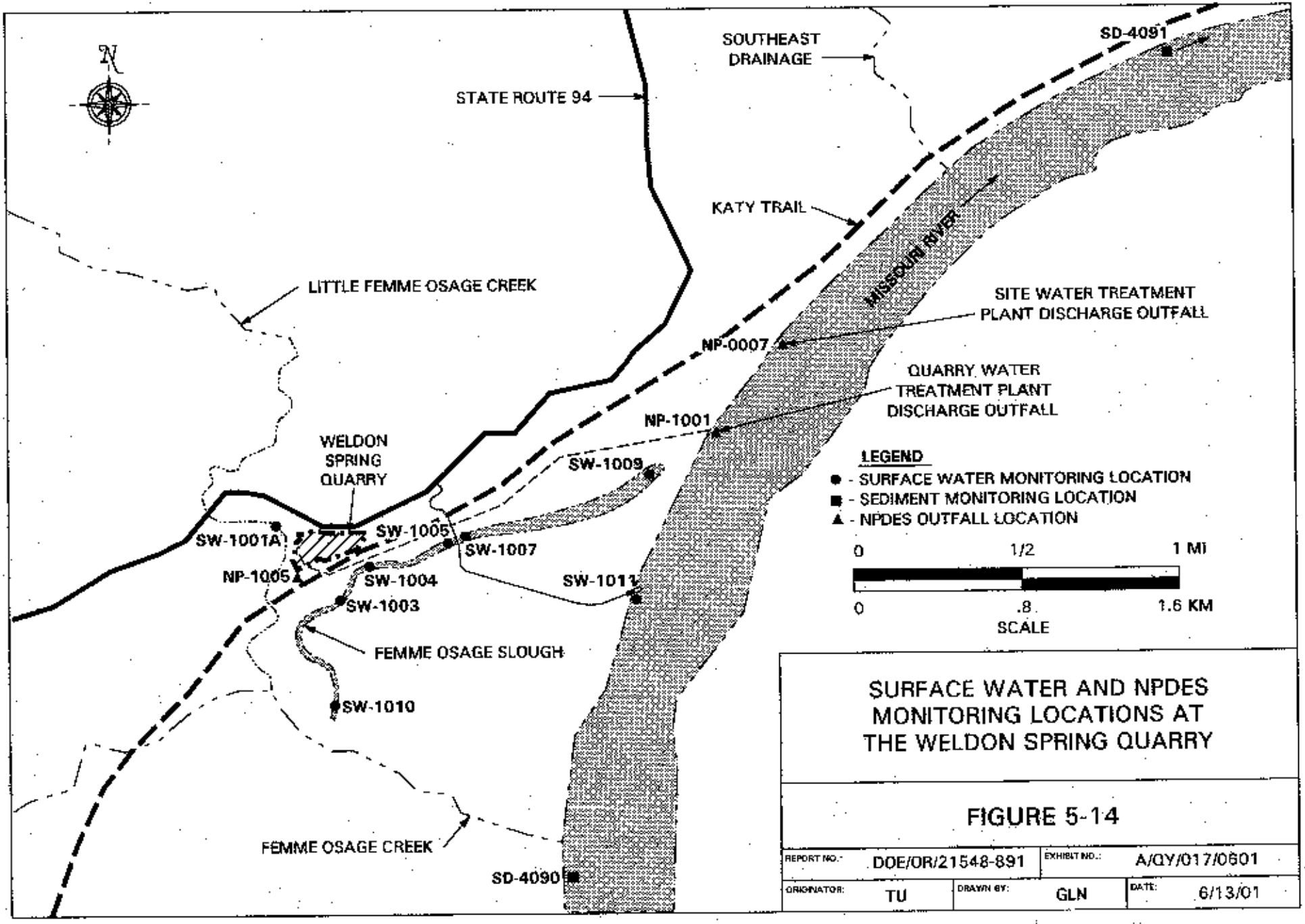
Sections 5.7.5.1 and 5.7.5.2 discuss monitoring requirements at NPDES outfalls and surface water locations at the chemical plant site and the quarry.

5.7.5.1 National Pollutant Discharge Elimination System Monitoring

The NPDES permits identify the parameters to be monitored. The requirements for the two major permits are shown in Tables 5-13 and 5-14, and the requirements for the three minor permits are discussed in the text. Physical, chemical, and radiological parameters were monitored at all storm water outfalls, as well as the quarry and site water treatment plant outfalls. The *Environmental Monitoring Plan* (Ref. 56) reflects the requirements of the NPDES permits.

5.7.5.2 Surface Water Monitoring

The following two subsections discuss surface water monitoring requirements at the chemical plant site and the quarry.



SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 5-14

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/QY/017/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/13/01	

5.7.5.2.1 Weldon Spring Chemical Plant and Raffinate Pits

In accordance with the surface water monitoring program, Dardenne Creek and Busch Lakes 34, 35, and 36 were sampled quarterly at five locations (Figure 5-12) for total uranium (Ref. 56). Samples were split and analyzed by the site Kinetic Phosphorescent Analyzer (KPA) and an off-site lab. This monitoring was conducted to measure the effects of surface water discharges from the site on the quality of downstream surface water.

5.7.5.2.2 Weldon Spring Quarry

Six locations within the Femme Osage Slough were monitored to determine the impact of groundwater migration from the quarry. Surface water locations SW-1003, SW-1004, and SW-1005 (Figure 5-14) were monitored quarterly by on-site KPA for total uranium. Due to elevated total uranium concentrations detected at slough locations in 1999, uranium samples were analyzed by off-site laboratories semi-annually in support of on-site results.

5.7.6 Monitoring Results

Analytical results of the monitoring of surface water and NPDES outfalls are presented in the following subsections.

5.7.6.1 National Pollutant Discharge Elimination System Program Monitoring Results

Radiochemical, chemical, and physical analytical results for NPDES outfalls are discussed in subsections 5.7.6.1.1 and 5.7.6.1.2.

5.7.6.1.1 Radiochemical Analysis

In 2000 the annual average uranium concentrations at the storm water discharge points ranged from 1.0 pCi/l at NP-1005 to 15.6 pCi/l at NP-0003, which are 0.1% and 2.3%, respectively, of the DCG for natural uranium. Average annual gross alpha concentrations ranged from 2.5 pCi/l at NP-1005 to 37.7 pCi/l at NP-0005. The year 2000 annual average radionuclide concentrations for all the permitted storm water outfalls are shown in Table 5-15.

Uranium concentration averages were calculated on a flow weighted basis for storm water Outfalls NP-0002, NP-0003, NP-0004, NP-0005, NP-0010, and NP-1005. Flow was measured at these outfalls by flowmeters, v-notch weirs, or visual estimates. Beginning January 1, 2000, total flows were calculated using watershed areas, precipitation measurements, and runoff coefficients. Flow weighted averages (rather than straight averages) were calculated for uranium levels at these outfalls to estimate the total uranium that migrated off site during 2000. The flow rated average for the year was calculated by summing the total activity (pCi) for the days the samples were collected and dividing by the sum of the total daily flows (liters) for the

same days. A straight average was used for outfall NP-0050 (and NP-0051) because the temporary storage area is relatively flat and the flow was diffuse, so it was difficult to get a flow measurement accurate enough for averaging.

Treatment plants at both the site and quarry were in operation during 2000. Eight batches were discharged from the quarry plant, and 15 batches were discharged from the site plant. Ten of the site and three of the quarry batches were continuous discharge (as opposed to batch discharge). A true batch discharge is treated water that is stored, then sampled, then discharged when compliance is demonstrated. A continuous discharge is discharged as it is treated and sampled at the discharge. Analytical results are received after the discharge. No daily maximum or monthly average limits are established for uranium in treated water; however, the design of the treatment plants is based on achieving an average of 30 pCi/l uranium with a maximum never to exceed 100 pCi/l. The average uranium concentrations for the site and quarry water treatment plants were well below this level at 2.7 pCi/l and 0.84 pCi/l, respectively (Table 5-17). In addition, the site water treatment plant averaged 5.0 pCi/l for gross alpha and 7.6 pCi/l for gross beta. The quarry water treatment plant averaged 2.3 pCi/l and 7.1 pCi/l, respectively for these same parameters (Table 5-16).

Table 5-15 2000 Annual Average NPDES Results for the Weldon Spring Chemical Plant and Quarry Storm Water Outfalls[c]

PARAMETER	LOCATIONS						
	NP-0002	NP-0003	NP-0004	NP-0005	NP-0010	NP-1005	NP-0050, 51
Number of sample events	12	11	11	13	9	8	10
pH range	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Nitrate as N (mg/l)	1.3	4.2	47.7**	4.5(13)	0.2	NS	2.4
Total suspended solids (mg/l)	1,029	282	175	282	142	42.4	602
Settleable solids (ml/l/hr)	15/6(b)	12/2(b)	11/0(b)	12/0(b)	9/0(b)	8/0(b)	10/0(b)
Arsenic (mg/l)	0.004(2)	0.022	NS	0.005(9)	NS	NS	0.017(2)
Chromium (mg/l)	0.012(2)	0.066	NS	0.014(9)	NS	NS	0.046(2)
Lead (mg/l)	0.020(2)	0.039	NS	0.009(9)	NS	NS	0.020(2)
Thallium (mg/l)	0.026(2)	0.003	NS	0.003(9)	NS	NS	0.003(2)
Total uranium (pCi/l)	5.6*	15.6*	6.0*	6.9*	6.1*	1.0*	8.4
Gross alpha (pCi/l)	35.2	27.8	15.9	37.7	12.3	2.5	14.9
Gross beta (pCi/l)	42.6	33.4	22.2	24.5	8.7	5.9	15.7
Radium-226 (pCi/l)	NS	1.88(10)	NS	0.42(7)	NS	NS	NS
Radium-228 (pCi/l)	NS	0.82(10)	NS	0.68(7)	NS	NS	NS
Thorium-228 pCi/l)	NS	1.72(10)	NS	0.28(7)	NS	NS	NS

Table 5-15 2000 Annual Average NPDES Results for the Weldon Spring Chemical Plant and Quarry Storm Water Outfalls (Continued)

PARAMETER	LOCATIONS						
	NP-0002	NP-0003	NP-0004	NP-0005	NP-0010	NP-1006	NP-0050, 51
Thorium-230 pCi/l)	NS	13.7(10)	NS	0.58(7)	NS	NS	NS
Thorium-232 pCi/l)	NS	1.84(10)	NS	0.30(7)	NS	NS	NS

(a) All pH readings were in the permitted range of 6.0 to 9.0.
(b) Top number is number of samples. Bottom number is number of results above daily maximum limit of 1.0 ml/l/hr.
(c) The number in parentheses indicates the number of samples analyzed for the specified parameter, if it differs from the number of sample events.
* Flow proportional averages.
** Suspected outlier of 374 mg/l elevates average to this level. Next highest level is 46.8 mg/l.
NS Not Sampled.
Note: 1 pCi/l = 0.037 Bq/l.

Table 5-16 Site and Quarry Water Treatment Plant Annual Averages for Radium and Thorium (pCi/l)

PARAMETER	SITE WTP (NP-0007)*	QUARRY WTP (NP-1001)*
Ra-226	0.53 (3/12)	0.26 (4/6)
Ra-228	0.92 (8/12)	0.27 (6/6)
Th-228	0.18 (8/12)	0.22 (4/6)
Th-230	0.79 (2/12)	0.83 (1/6)
Th-232	0.21 (6/12)	0.32 (4/6)
Gross alpha	5.0 (4/15)	2.3 (5/8)
Gross beta	7.6 (4/15)	7.1 (3/8)

* Number in parentheses represents the number of results below detection limit (including uncensored values)/total number of samples.
Note: 1 pCi/l = 0.037 Bq/l

In addition to effluent monitoring, the NPDES permit for the quarry, MO-0108987, required that river sediment sampling be conducted upstream and downstream of the quarry water treatment plant outfall (NP-1001) on an annual basis. The river sediment was sampled for uranium at locations SD-4090 (upstream) and SD-4091 (downstream) (see Figure 5-14). The one-time sampling results were 3.06 pCi/g at SD-4090 and 2.88 pCi/g at SD-4091. These concentrations are an indication that discharges from the site have not had a deleterious effect on river sediment.

Radium and thorium were monitored once per month (as required by the permit) in both site and quarry water treatment plant batches. Annual averages for radium and thorium at both plants are shown in Table 5-16. Radium and thorium levels were all well below the DCGs at annual averages less than 1.0 pCi/l.

Estimated quantities of total natural uranium released off site through surface water runoff and treatment plant discharges are in Table 5-17. The total volume of storm water at all the outfalls was calculated using watershed area, total precipitation, and runoff curve numbers. Runoff curve numbers are cited in the U.S. Department of Transportation *Design of Roadside Drainage Channels* (Ref. 57). Best professional judgement was used in determining the numbers. The estimated mass of uranium released off site in storm water and treated effluent in 2000 was 11.83 lb and was calculated by multiplying the total runoff volume by the average uranium concentration. This is a substantial decrease from the calculated amount released in 1999, which was 21.08 lb. Table 5-18 shows the annual average uranium concentrations at NPDES outfalls from 1987 to 2000. Average uranium concentrations for 2000, in comparison to levels for 1999, decreased at all outfalls except NP-0004 and NP-0050(51). The uranium levels at outfalls NP-0004 and NP-0050 (51) were very low in 1999, and although they increased during 2000, they were still below 10 pCi/l. This is suspected to be a natural variation due to soil disturbances and does not appear to be the start of an upward trend. Historical trends of uranium at Outfalls NP-0002, NP-0003, and NP-0005 are discussed in Section 5.10.1. Radium and thorium were both periodically monitored at Outfalls NP-0002, NP-0003, and NP-0005 throughout the year to monitor the effects and effectiveness of remediation. The parameters for each outfall are discussed in the following paragraphs.

Table 5-17 2000 Estimated Annual Release of Natural Uranium from NPDES Outfalls

OUTFALL	DRAINAGE AREA (ACRES)	ESTIMATED % OF PRECIPITATION AS RUNOFF(a)	AVERAGE URANIUM CONCENTRATION (pCi/l)	TOTAL RAINFALL VOLUME (Mgal/yr)	TOTAL RUNOFF VOLUME (Mgal/yr)	TOTAL U RELEASE (Ci/yr)	TOTAL U RELEASE (Kg/yr)
NP-0002	78.6	60	5.6*	87.19	52.32	1.11E-3	1.631
NP-0003	58.5	40	15.6*	64.90	25.96	1.53E-3	2.254
NP-0004	28	40	6.0*	31.06	12.42	0.28E-3	0.415
NP-0005	29.6	40	6.9*	32.84	13.13	0.34E-3	0.504
NP-0010	14	30	6.1*	15.53	4.66	0.11E-3	0.158
NP-0050, 51[b]	12.4	30	8.4	13.76	4.13	0.13E-3	0.193
NP-1005	1.3	60	1.0*	1.44	0.87	3.28E-6	0.005
NP-0007	N/A	N/A	2.7	NA	12.51	0.13E-3	0.188
NP-1001	N/A	N/A	0.8	NA	6.92	2.20E-5	0.032
TOTAL	N/A	N/A	NA	246.72	132.91	3.66E-3	5.380

* Flow-weighted average.
(a) Runoff curve number estimated from U.S. Department of Transportation *Design of Roadside Drainage Channels* (Ref. 57).
(b) One outfall is monitored to represent both.
N/A Not Applicable.
Note: To convert from Ci/yr to Bq/yr, multiply Ci/yr by 3.7×10^{10}

Table 5-18 Fourteen-Year Annual Average Uranium Concentrations at NPDES Outfalls

	NP-0001	NP-0002	NP-0003	NP-0004	NP-0005	NP-0010	NP-0007	NP-1001	NP-1005	NP-0050, NP-0051
1987	680	210	2,240	9.5	780	---	---	---	---	---
1988	539	141	1,178	6.2	497	---	---	---	---	---
1989	368	145	280	6.5	347	---	---	---	---	---
1990	413	139	89	7.6	364	---	---	---	---	---
1991	475	158	456	6.4	581	---	---	---	---	---
1992	516	228	478	6	296	---	---	<0.0003	---	---
1993	1,003*	230*	607*	9	133*	---	---	1.9	---	---
1994	1,226*	182*	332*	12	347*	82	0.74	1.6	---	---
1995	(a)	124*	67*	(b)	128*	107	0.46	1.8	---	---
1996	(a)	54*	88*	(b)	107*	50	1.37	1.1	---	---
1997	(a)	14*	143*	(b)	19*	2.7	1.50	0.5	---	---
1998	(a)	22*	83*	23	10*	10.7*	3.11	0.4	1.0(c)	---
1999	(a)	8.0*	38.3*	3.5*	20.3*	7.3	17.1	1.1	1.9	2.7(d)
2000	(a)	5.6*	15.6*	6.0*	6.9*	6.1*	2.7	0.8	1.0*	8.4

* Flow weighted average.
-- Not applicable.
(a) Outfall removed, flow diverted to NP-0005.
(b) Outfall removed from permit in 1995, added in 1998.
(c) Outfall added in 1998.
(d) Outfall added in 1999.

Outfall NP-0001 was the outlet of the abandoned process sewer line. This outfall was physically removed in May 1994 and was officially eliminated from the permit on August 4, 1995.

The average uranium concentration for Outfall NP-0002 in 2000 was 5.6 pCi/l, a decrease from the 1999 average of 8.0 pCi/l. No radiological contaminants were detected above baseline values. Baseline values for contaminants in storm water were set before soil and foundation removal started and the site was still stabilized with vegetation. Baseline monitoring and values are in table E-6, Appendix E, of the *Environmental Monitoring Plan* (Ref. 56). All levels were well below the DCGs. Annual average NPDES results for Outfall NP-0002 are in Table 5-15.

The average uranium concentration for Outfall NP-0003 was 15.6 pCi/l, which was much less than the 1999 average of 38.3 pCi/l. The decrease may be the result of completing remediation and establishing vegetation in the watershed. Although numerous thorium and radium levels were above baseline levels with the exception of one sample, they were well below the DCGs for the specific parameters. The exception was a sample collected on February 18, 2000. Radium and thorium levels were elevated, particularly Thorium-230, at 119 pCi/l. The sample was out of compliance for settleable solids and above the notification level of 100 µg/l for arsenic, chromium, and lead. The flow on February 18 was the result of more than 3 in. of rainfall in the previous 24 hours, of which 2 in. fell during a 2-hr period. Elevated metals are typically seen with elevated solids; however, radium and thorium, especially Thorium-230 were also elevated. All the radiological levels were below their respective DCGs, but the unexpectedly high levels of both metals and thorium triggered an investigation to find the source. Soil and sediment samples were collected during the investigation, and the results indicated that the source was soil that had accumulated on the contaminated haul road (between the cell and Raffinate Pits 1 and 2) and, to a lesser extent, the contaminated vehicle parking area in the former material staging area. Both of these areas shed storm water to the diversion channel that flows to Sedimentation Basin 4 (Figure 5-13). This normally allows settling of the solids in the basin before the storm water leaves the site. It was determined that the water management methods worked as designed, but could not accommodate the heavy rains in combination with the lack of vegetation. Corrective actions were taken as follows:

- The top level of soil was removed from the surface of the haul road and the parking area and placed in the cell.
- Sediment was removed from the diversion channel and placed in the cell. Rock check dams were inspected and built up as required.
- Sedimentation Basin 4 was operated as a retention basin to allow a longer settling time before the water was released. Water was sampled for uranium before release was authorized.

- The haul road and parking area were monitored more frequently to ensure that there was no build up of contaminated material.

- Monthly NPDES samples of effluent at Outfall NP-0003 were analyzed for arsenic, chromium, lead, thallium, radium, and thorium. Seven-day or faster turnaround times were requested.

Monitoring of sediment downstream of outfall NP-0003 indicated that all levels were below the cleanup criteria. Parameters for the storm water runoff samples collected in March were all in compliance with NPDES limits, below notification levels for metals, and below the DCGs for the radiological contaminants. Radium and thorium were reduced to levels that had been seen in the past. In the latter part of 2000, Sedimentation Basin 4 and the Outfall NP-0003 area were remediated and confirmed clean. A new sedimentation basin was installed to slow water flow and retain settleable solids from the confirmed clean watershed. Baseline values are in Table E-6, Appendix E, of the *Environmental Monitoring Plan* (Ref. 56). Annual average values for uranium, radium, thorium, gross alpha, and gross beta are shown in Table 5-15.

Outfall NP-0004 was eliminated from NPDES permit MO-0107701 on March 4, 1994, but was repermitted on May 22, 1998, because a portion of Raffinate Pit 4 was being remediated upstream of the outfall, and storm water from the area flows to Outfall NP-0004. The annual average for uranium at NP-0004 was 6.0 pCi/l, slightly higher than the 1999 annual average of 3.5 pCi/l. The slight increase was most likely due to soil disturbance in the area and precipitation patterns.

The annual average uranium concentration at Outfall NP-0005 for 2000, which was less than the 1999 average of 20.3 pCi/l was 6.9 pCi/l. There were instances of radium and thorium being above baseline values but still within levels seen during remediation and well below DCGs. Baseline monitoring and values are in Table E-6, Appendix E, of the *Environmental Monitoring Plan* (Ref. 56). Annual average NPDES results are in Table 5-15.

Outfall NP-0010 was added to NPDES Permit MO-0107701 when it was reissued on March 4, 1994. This outfall is near the west end of the north perimeter fence in the construction material staging area, and drains a portion of that area (Figure 5-13). Clean soil, gravel, and other construction material are stored there. Contaminated soil was removed, and the construction material staging area was completed early in 1996. The annual average uranium concentration for 2000 was 6.1 pCi/l, well below the DCG of 600 pCi/l and slightly less than the 1999 average of 7.3 pCi/l. The annual average NPDES results are in Table 5-15.

Outfall NP-0051 represents two outfalls on the west side of the temporary storage area (Figure 5-13). Outfall NP-0050 is the other outfall. Before the temporary storage area was remediated, these outfalls served its north and south ends. After the remediation, sheet flow was established, and only one outfall is now being sampled at the property line. The annual average uranium concentration for 2000 was 8.4 pCi/l, well below the DCG of 600 pCi/l and somewhat

higher than the 1999 average of 2.7 pCi/l. The increase is suspected to be the result of soil disturbances and precipitation patterns. The annual average NPDES results are in Table 5-15.

Outfall NP-1005 is the storm water outfall at the quarry. In 2000 the flow was from a hillside and a ditch along the effluent ponds from the quarry water treatment plant. This outfall will discharge water from the quarry after the quarry is backfilled and graded. The annual average uranium concentration in 2000 was 1.0 pCi/l, a decrease from the 1999 average of 1.9 pCi/l. The annual average NPDES results are reported in Table 5-15.

5.7.6.1.2 Physical and Chemical Results

Analytical results for physical and chemical parameters at NPDES outfalls and other sample locations are discussed in Subsections 5.7.6.1.2.1 through 5.7.6.1.2.4.

5.7.6.1.2.1 Chemical Plant and Quarry Storm Water

The annual averages for the physical and chemical parameters for storm water Outfalls NP-0002, NP-0003, NP-0004, NP-0005, NP-0010, NP-0050, NP-0051, and NP-1005 are in Table 5-15. In addition to the permitted parameters, arsenic, chromium, lead, and thallium were periodically monitored at some outfalls. In three instances at outfall NP-0003 of metals that do not have permit limits having levels above the 100 µg/l reporting levels for toxic pollutants. These elevated levels were noted in the sample collected on February 18, 2000. Radium and thorium were elevated in this same sample. This incident is discussed in Section 5.7.6.1.1.

There were also eight samples where settleable solids were above the 1.0 ml/1 hr limit. The results are shown in Table 5-15.

5.7.6.1.2.2 Site and Quarry Water Treatment Plant Physical and Chemical Parameters

Physical and chemical parameters were all within permitted limits (where limits were assigned) for water treatment plants at the site and quarry. Therefore, the parameter levels are not summarized here.

In 2000, whole effluent toxicity (WET) tests were required quarterly for effluent from both the site and quarry water treatment plants. Because neither the quarry nor the site plant was in operation in one quarter, there are only three sample results for each site. The WET test is a measure of toxicity without quantifying or identifying the toxic constituents. Tests were conducted on both Ceriodaphnia dubia (water flea) and Pimephales promelas (fathead minnow). The tests were conducted in effluents and in test controls of upstream river water and laboratory control water. No samples failed the WET tests in 2000, indicating that the site and quarry water treatment plant effluents did not cause the receiving stream to be toxic to test organisms (see Table 5-13). WET test results are summarized in Table 5-19.

Table 5-19 2000 Whole Effluent Toxicity Test Results for the Site and Quarry Water Treatment Plants*

BATCH	DATE	DAPHNIA (D) % MORTALITY	PIMEPHALES (P) % MORTALITY	RIVER CONTROL D,P % MORTALITY	LAB CONTROL D,P % MORTALITY
S179	1/10/00	0	2.5	0,2.5	0,2.5
S181	4/6/00	0	0	0,0	0,0
S187	8/7/00	0	5	0,2.5	0,2.5
Q064	3/16/00	0	0	0,0	0,2.5
Q065	6/28/00	0	0	0,0	0,0
Q071	11/28/00	0	0	0,0	0,0

S Site
Q Quarry
P Pimephales
D Daphnia (Ceriodaphnia)
* Each test is on four replicates of 10 organisms. Percent mortality is based on 40 organisms.

5.7.6.1.3 Borrow Area Land Disturbance Results

NPDES permit MO-R100B69 was reissued on May 29, 1998, and has no specified monitoring or reporting requirements. The 2000 *Environmental Monitoring Plan* (Ref. 56), however, requires that settleable solids be monitored once every calendar quarter, and that oil and grease be monitored as indicated by operations at the facility. Settleable solids and oil and grease results are shown in Table 5-20. Settleable solids were all less than 1.6 ml/l/hr. Oil and grease were monitored five times at the NP-0040 outfall, which is the outfall from the vehicle maintenance area sedimentation basin. Three results were above the 10 mg/l water quality standard for oil and grease. There was no noticeable sheen or odor when these samples were collected. When elevated values were detected, additional sorbent booms were placed downstream of the maintenance building. This resulted in decreased levels.

Table 5-20 Borrow Area Settleable Solids (ml/l/hr) and Oil and Grease

DATE	LOCATIONS			
	NP-0040*		NP-0046**	NP-0052***
	SETTLEABLE SOLIDS	OIL AND GREASE	SETTLEABLE SOLIDS	SETTLEABLE SOLIDS
2/18/00	0.4	2.1	<0.1	N.S.
5/8/00	<0.1	33.9	<0.1	N.S.
7/28/00	1.6	19	N.S.	N.S.
9/9/00	0.2	N.S.	N.S.	N.S.
9/10/00	<0.1	N.S.	N.S.	N.S.
9/11/00	<0.1	N.S.	N.S.	N.S.
9/25/00	0.1	N.S.	N.S.	N.S.
10/5/00	<0.1	13	N.S.	N.S.
11/6/00	0.2	<0.5	N.S.	0.5

N.S. Not Sampled
* North borrow area sedimentation basin.
** East borrow area sedimentation basin.
*** Discharge to Missouri River watershed. Water was pumped only one time from the east side of the borrow area to NP-0052.

5.7.6.2 Surface Water Monitoring Results

Analytical results for surface water monitoring locations at the chemical plant site and quarry are in Subsections 5.7.6.2.1 and 5.7.6.2.2.

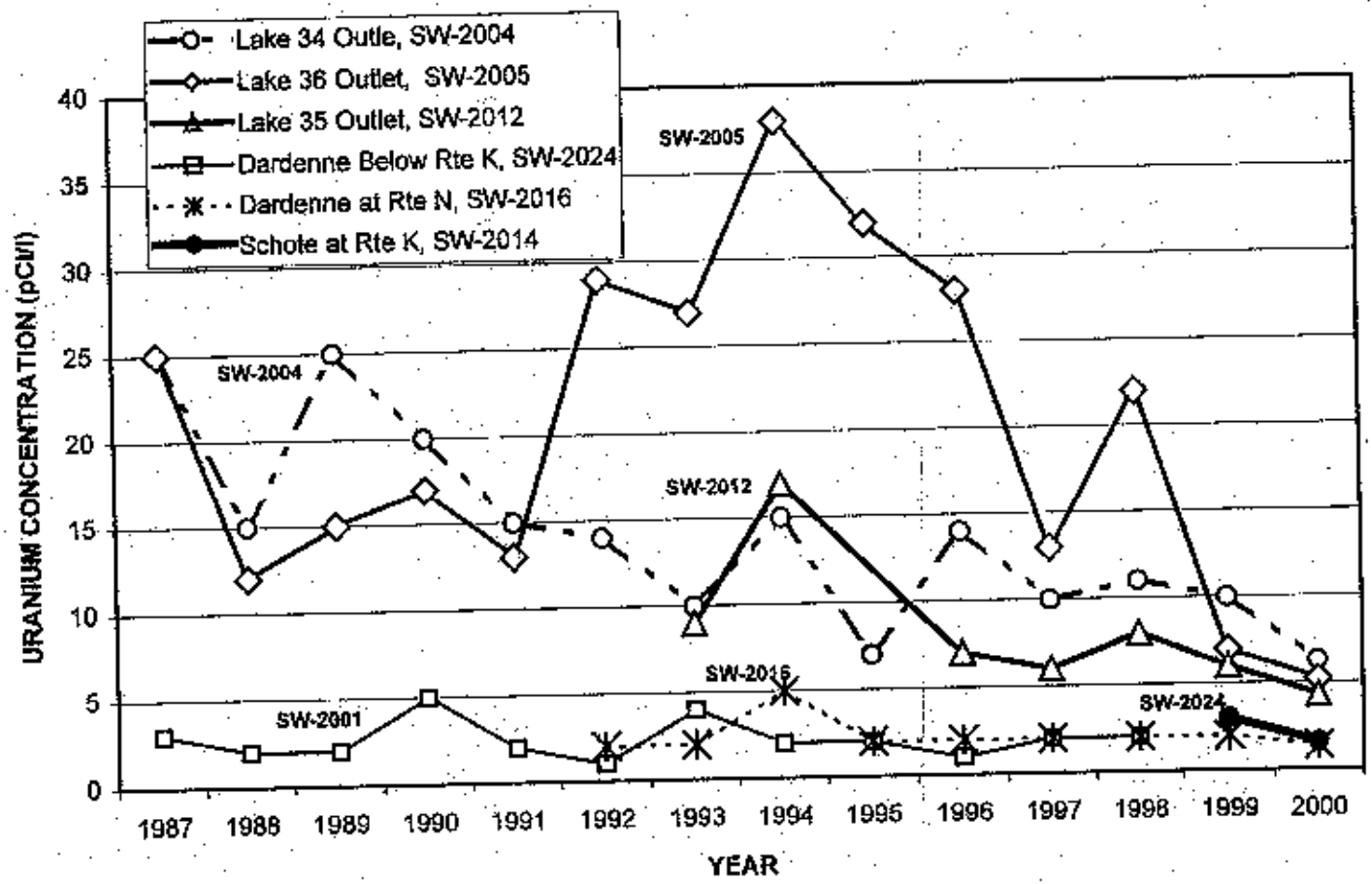
5.7.6.2.1 Weldon Spring Chemical Plant and Raffinate Pits

Average uranium levels at the off-site surface water locations were lower than the 1999 annual averages at four of five locations, and very slightly higher at one location. This reflects the lower levels seen at the NPDES outfalls. Average annual uranium concentrations for surface water are in Table 5-21, along with the 1999 figures and the historic high for each location for comparison. Surface water locations are shown in Figure 5-12. Historic annual averages for Lakes 34, 35, and 36 outlets, as well as locations in Schote Creek and Dardenne Creek, are plotted in Figure 5-15. Uranium levels at the Busch Lake outlets have shown an overall decline since remediation started. The Schote Creek and Dardenne Creek locations are downstream of the lakes and have always shown relatively low levels because the chemical plant portion of the watershed is much smaller than the total watershed area. Data points are shown from the date the samples were first collected. No samples were collected for SW-2012, the outlet of Lake 35, in 1995 because there was no flow from the lake. The historic high of 326 pCi/l at this location is considered an outlier. An outlier is a sample result that does not fit the rest of the results for the location. It does not necessarily mean that the result was not real, but that it is an anomaly and is suspect. This was an isolated sample with no samples collected before or after (until 1993). This location is downstream of Lake 36, which showed no similar elevated levels. The second highest uranium concentration at location SW-2012 was 17 pCi/l in 1994.

Table 5-21 Annual Averages for Total Uranium Concentrations at Weldon Spring Chemical Plant Area Surface Water Locations* (pCi/l)

LOCATION	AVERAGE	MAXIMUM	MINIMUM	HISTORIC HIGH
SW-2004	6.3(9.3)	11.5(10.7)	<0.7(6.3)	39 (1989)
SW-2005	5.2(7.0)	8.0(7.7)	3.3(6.0)	53.7 (1996)
SW-2012	4.3(5.7)	7.5(8.5)	<0.7(3.7)	326 (1991)
SW-2016	1.4(1.3)	3.1(2.2)	<0.7(0.6)	7.8 (1994)
SW-2024	1.6(2.8)	1.9(5.3)	0.9(1.1)	5.3(1999)

* 1999 results are given in parentheses.
** This historic high is considered an outlier.
Note 1: 1 pCi/l = 0.037 Bq/l.
Note 2: Four samples were collected from each location during the year.



HISTORICAL LAKE AND DOWNSTREAM URANIUM ANNUAL AVERAGES

FIGURE 5-15

REPORT NO.:	[illegible]	EXHIBIT NO.:	A/P/023/0601
ORIGINATOR:	TU	DRAWN BY: GLN	DATE: 8/13/01

5.7.6.2.2 Weldon Spring Quarry

The annual averages for the surface water locations at the quarry are summarized in Table 5-22. Uranium levels in the Femme Osage Slough remain within historical ranges. No new historic total uranium high concentrations were reported for quarry surface water in 2000.

Table 5-22 Annual Averages for Total Uranium at Weldon Spring Quarry Surface Water Monitoring Locations (pCi/l)

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM	HISTORIC HIGH
SW-1003	22.6 (32.67)	23.3 (57.28)	21.9 (10.60)	252 (1989)
SW-1004	19.9 (40.10)	21.8 (65.95)	17.9(14.04)	362 (1991)[a]
SW-1005	15.0 (18.40)	18.3 (28.17)	11.6 (12.42)	116 (1991)
SW-1007	15.2 (20.88)	19.8 (46.46)	10.5 (7.04)	69 (1992)
SW-1009	15.7 (12.81)	20.4 (21.97)	11.0 (6.13)	28.6 (1991)
SW-1010	19.6 (28.57)	23.4 (57.85)	15.8 (9.91)	156 (1991)

Note 1: 1999 results given in parentheses
Note 2: 1 pCi/l = 0.037 Bq/l
(a) A sample collected during 1993 flood conditions, which represented groundwater discharge to the surface had a result of 4,000 pCi/l. This sample is not reported as the historic high since it represents groundwater, not surface water.

5.8 Groundwater Monitoring

5.8.1 Program Overview

The groundwater monitoring and protection program includes sampling and analysis of water collected from wells at the chemical plant and raffinate pits site, the quarry site, adjacent properties, and selected springs in the vicinity of the chemical plant site. The groundwater protection program is formally defined in the *Weldon Spring Site Remedial Action Project Groundwater Protection Management Program Plan* (Ref. 58). The groundwater monitoring portion of the program is detailed in the *Environmental Monitoring Plan* (Ref. 56).

Due to lithologic differences, including geologic features that influence groundwater flow mechanics, and the geographical separation of the chemical plant and quarry areas, separate groundwater monitoring programs have been established for these two areas. A generalized stratigraphic column for reference is provided in Figure 5-16, and hydrogeologic descriptions of lithologies monitored for the program are in Section 5.8.3.

SYSTEM	SERIES	STRATIGRAPHIC UNIT	TYPICAL THICKNESS (FT.)(1)	LITHOLOGY	PHYSICAL CHARACTERISTICS	HYDROSTRATIGRAHIC UNIT
QUATERNARY	HOLOCENE	ALLUVIUM	0 - 120		GRAVELLY, SILTY LOAM.	ALLUVIAL AQUIFER
	PLEISTOCENE	LOESS AND GLACIAL DRIFT (2)	10- 60	VARIABLE	SILTY CLAY, GRAVELLY CLAY, SILTY LOAM, OR LOAM OVER RESIDUUM FROM WEATHERED BEDROCK.	(UNSATURATED)(2)
MISSISSIPPIAN	MERAMECIAN	SALEM FORMATION (3)	0 - 15		LIMESTONE, LIMEY DOLOMITE, FINELY TO COARSELY CRYSTALINE, MASSIVELY BEDDED, AND THIN BEDDED SHALE.	
		WARSAW FORMATION (3)	60 - 80		SHALE AND THIN TO MEDIUM BEDDED FINELY CRYSTALINE LIMESTONE WITH INTERBEDDED CHERT.	
	OSAGEAN	BURLINGTON AND KEOKUK LIMESTONES	100 - 200		CHERTY LIMESTONE, VERY FINE TO VERY COARSELY CRYSTALINE, FOSSILIFEROUS, THICKLY BEDDED TO MASSIVE.	SHALLOW AQUIFER SYSTEM
		FERN GLEN LIMESTONE	45 - 70		CHERTY LIMESTONE, DOLOMITIC IN PART, VERY FINE TO VERY COARSELY CRYSTALINE, MEDIUM TO THICKLY BEDDED.	
	KINDERHOOKIAN	CHOUTEAU LIMESTONE	20 - 50		DOLOMITIC, ARGILLACEOUS LIMESTONE; FINELY CRYSTALINE; THIN TO MEDIUM BEDDED.	UPPER LEAKY CONFINING UNIT
DEVONIAN	UPPER	SULPHUR SPRINGS GROUP (4) BUSHBERG SANDSTONE	40 - 55		QUARTZ ARERNITE, FINE TO MEDIUM GRAINED, FRIABLE.	
		LOWER PART OF SULPHUR SPRINGS GROUP (UNDIFFERENTIATED)			CALCAREOUS SILTSTONE, SANDSTONE, OOLITIC LIMESTONE, AND HARD CARBONACEOUS SHALE.	
ORDOVICIAN	CINCINNATIAN	MAQUOKETA SHALE (5)	10 - 30		CALCAREOUS TO DOLOMITIC SILTY SHALE AND MUDSTONE, THINLY LAMINATED TO MASSIVE.	
	CHAMPLAINIAN	KIMMSWICK LIMESTONE	70 - 100		LIMESTONE, COARSELY CRYSTALLINE, MEDIUM TO THICKLY BEDDED, FOSSILIFEROUS AND CHERTY NEAR BASE.	MIDDLE AQUIFER SYSTEM
		DECORAH GROUP	30 - 60		SHALE WITH THIN INTERBEDS OF VERY FINELY CRYSTALINE LIMESTONE.	LOWER CONFINING UNIT
		PLATTIN LIMESTONE	100 - 130		DOLOMITIC LIMESTONE, VERY FINELY CRYSTALLINE, FOSSILIFEROUS, THINLY BEDDED.	
		JOACHIM DOLOMITE	80 - 105		INTERBEDDED VERY FINELY CRYSTALLINE, THINLY BEDDED DOLOMITE; LIMESTONE; AND SHALE. SANDY AT BASE.	
		ST. PETER SANDSTONE	120 - 150		QUARTZ ARENITE, FINE TO MEDIUM GRAINED, MASSIVE.	DEEP AQUIFER SYSTEM
	CANADIAN	POWELL DOLOMITE	50 - 60		SANDY DOLOMITE, MEDIUM TO FINELY CRYSTALINE, MINOR CHERT AND SHALE.	
		COTTER DOLOMITE	200 - 250		ARGILLACEOUS, CHERTY DOLOMITE; FINE TO MEDIUM CRYSTALINE. INTERBEDDED WITH SHALE.	
		JEFFERSON CITY DOLOMITE	160 - 180		DOLOMITE, FINE TO MEDIUM CRYSTALINE.	
		ROUBIDOUX FORMATION	150 - 170		DOLOMITIC SANDSTONE.	
		GASCONADE DOLOMITE	250		CHERTY DOLOMITE AND ARENACEOUS DOLOMITE (GUNTER MEMBER).	
CAMBRIAN	UPPER	EMINENCE DOLOMITE	200		DOLOMITE, MEDIUM TO COARSELY CRYSTALLINE, MEDIUM BEDDED TO MASSIVE.	
		POTOSI DOLOMITE	100		DOLOMITE, FINE TO MEDIUM CRYSTALLINE, THICKLY BEDDED TO MASSIVE. DRUSY QUARTZ COMMON.	

(1) THICKNESS DATA SOURCES VARY. QUATERNARY UNIT THICKNESS BASED ON ON-SITE DRILLING AND TRENCHING. BURLINGTON AND KEOKUK THROUGH JOACHIM DOLOMITE BASED ON USGS WELLS MW-G502 AND G509. ST. PETER SANDSTONE AND BELOW FROM KLEESCHULTE AND EMMELL (REF 54). WARSAW AND SALEM FORMATIONS FROM MISSOURI DNR-DGLS GEOLOGIC MAP OFM-89-252-GI (REF 53).

(2) GLACIAL DRIFT UNIT SATURATED IN NORTHERN PORTION OF ORDNANCE WORKS WHERE THIS UNIT BEHAVES LOCALLY AS A LEAKY CONFINING UNIT. (GEOLOGIC LOG)

(3) THE WARSAW AND SALEM FORMATIONS ARE CONSIDERED TO BE ABSENT FROM THE WELDON SPRING AREA DUE TO EROSION.

(4) THE SULPHUR SPRINGS GROUP ALSO INCLUDES THE BACHELOR SANDSTONE AND THE GLEN PARK LIMESTONE-MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY. (REF 53)

(5) THE MAQUOKETA SHALE IS NOT PRESENT IN THE WELDON SPRING AREA BASED ON GEOLOGIC LOGS.

GENERALIZED STRATIGRAPHY AND HYDROSTRATIGRAPHY OF THE WELDON SPRING AREA

FIGURE 5-16

REPORT NO.	EXHIBIT NO.	
DOE/OR/21548-891	A/PI/024/0601	
ORIGINATOR: TU	DRAWN BY: SRS	DATE: 6/13/01

5.8.2 Referenced Standards

Two references used to develop the criteria for the groundwater monitoring program are: (1) the U.S. Environmental Protection Agency (EPA) *Quality Criteria for Water 1986* (Ref. 59), which protects public groundwater resources, and (2) the Missouri Drinking Water Standards (Ref. 60). Table 5-23 identifies EPA water quality standards and Missouri Drinking Water Standards for contaminants that are routinely monitored in the groundwater program. Maximum contaminant levels (MCLs) and other drinking water standards are used only as references by the WSSRAP since the affected groundwater aquifer underlying the site is not a public drinking water source as defined in 40 CFR, Part 141, Subpart A - *General*.

Table 5-23 Referenced Federal and State Water Standards

PARAMETER		LEVEL	REFERENCE STANDARD
Radiochemical	Uranium, total	30 pCi/l	Groundwater Standards for Remedial Action at Inactive Uranium Processing Sites – 40 CFR 192
	Gross Alpha	15 pCi/l	MDWS – Primary Maximum Contaminant Level
	Radium [a]	5 pCi/l	MDWS – Primary Maximum Contaminant Level
Misc.	2,4-DNT	0.11 µg/l	MDNR – Water Quality Standard for Groundwater
	TCE	5 µg/l	MDNR – Water Quality Standard for Groundwater
Metals	As	50 µg/l	MDWS – Primary Maximum Contaminant Level
	Ba	2 mg/l	MDWS – Primary Maximum Contaminant Level
Anions	NO_3	10 mg/l	MDWS – Primary Maximum Contaminant Level
	SO_4	250 mg/l	MDWS – Secondary Maximum Contaminant Level

(a) Standard for combined Ra-226 and Ra-228.
MDNR Missouri Department of Natural Resources
MDWS Missouri Drinking Water Standard.

Groundwater is also monitored under the requirements of Department of Energy Order 5400.5, *Radiation Protection of the Public and the Environment*, which designates derived concentration guidelines (DCGs) for ingestion of water equivalent to 100 mrem effective dose equivalent, based on consumption of 193 gal/year (Table 5-24). As specified in DOE Order 5400.5, liquid effluent from DOE activities may not cause private or public drinking waters to exceed the radiological limit of an effective dose equivalent greater than 4 mrem per year or 4% of the DCG.

Table 5-24 Derived Concentration Guidelines for Discharge Waters

PARAMETER	DERIVED CONCENTRATION GUIDELINE
Natural Uranium	600 pCi/l
Ra-226	100 pCi/l
Ra-228	100 pCi/l
Th-230	300 pCi/l
Th-232	50 pCi/l

Note: 1 pCi/l = 0.037 Bq/l.

5.8.3 Weldon Spring Chemical Plant

5.8.3.1 Hydrogeologic Description

The chemical plant site is in a physiographic transitional area between the Dissected Till Plains of the central lowlands province to the north and the Salem Plateau of the Ozark Plateaus province to the south.

The site is on a groundwater divide from which groundwater flows north toward Dardenne Creek and ultimately to the Mississippi River, or south to the Missouri River. Regional groundwater flow for St. Charles County is toward the east. Localized flow is controlled largely by topographic highs and streams, and drainages. Groundwater movement is generally by diffuse flow with localized zones of discrete fracture-controlled flow.

The chemical plant and raffinate pits area lithologies consist of two major geologic units: unconsolidated surficial material and carbonate bedrock. The unconsolidated surficial materials are clay-rich, mostly glacially derived units, which are generally unsaturated. Thicknesses range from 20 ft to 50 ft (Ref. 52).

Potential groundwater impacts are assessed by monitoring groundwater from the monitoring well network at the site. The aquifer of concern beneath the chemical plant, raffinate pits, and vicinity properties is the shallow bedrock aquifer comprised of Mississippian-age Burlington-Keokuk Limestone (the uppermost bedrock unit). The Burlington-Keokuk Limestone is composed of two different lithologic zones, a shallow weathered zone underlaid by an unweathered zone. The weathered portion of this formation is highly fractured and exhibits solution voids and enlarged fractures. These features may also be found on a limited scale in the unweathered zone. The unweathered portion of the Burlington-Keokuk Limestone is thinly to massively bedded. Fracture densities are significantly less in the unweathered zone than in the weathered zone. Localized aquifer properties are controlled by fracture spacing, solution voids,

and preglacial weathering, including structural troughs along the bedrock unconsolidated material interface.

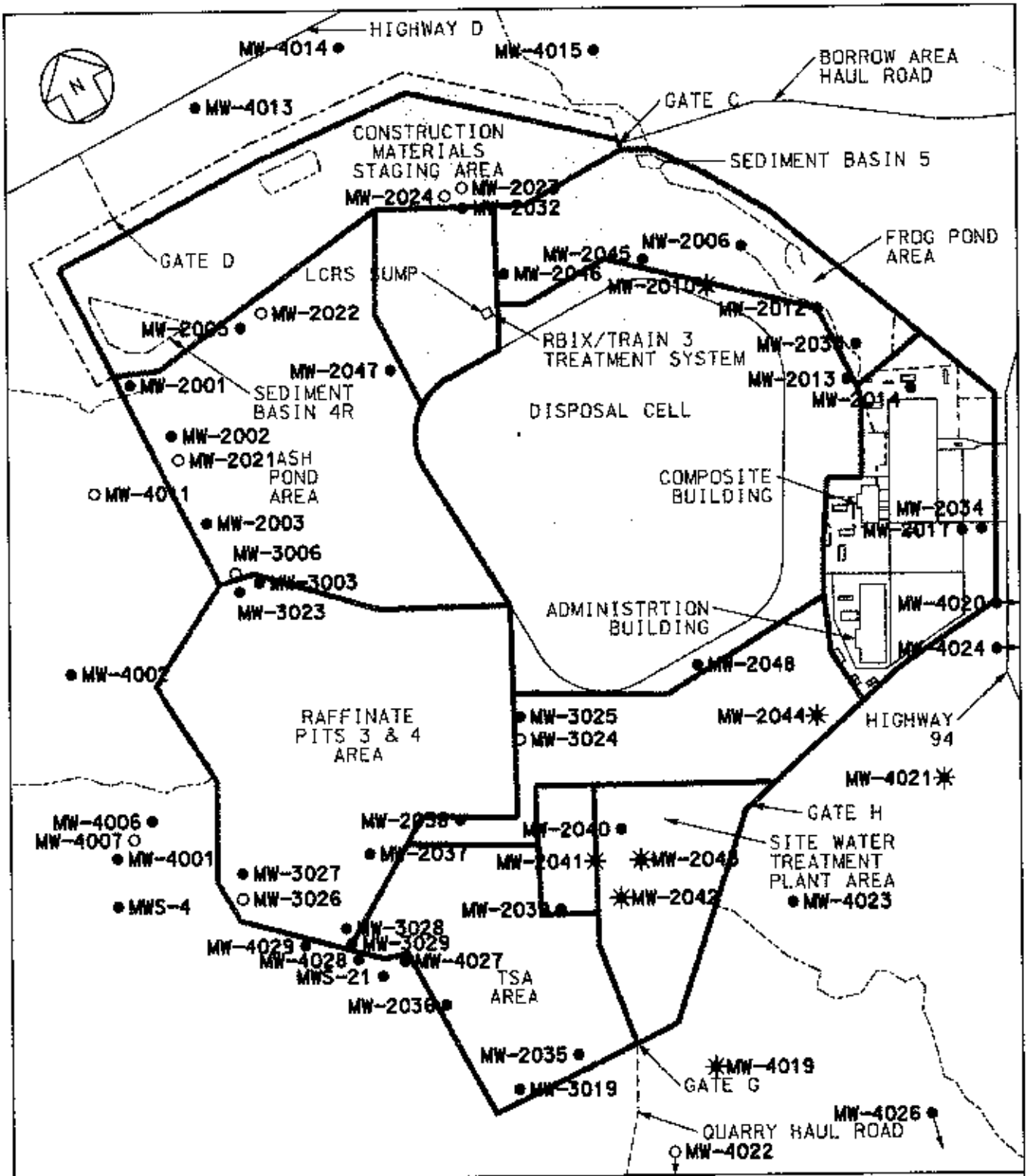
More than 100 monitoring wells have been used for groundwater observations and sampling since 1987. Many of these have been deactivated and abandoned. In 2000, seven wells were abandoned, and active monitoring was performed in 46.

All monitoring wells are completed in the Burlington-Keokuk Limestone. Some wells that are screened in the unweathered zone the Burlington-Keokuk limestone are used to assess vertical migration of contaminants. Most of the wells are completed in the weathered unit of the bedrock where groundwater has the greatest potential to be contaminated. Where possible, monitoring wells within the boundaries of the chemical plant area are located near potential contaminant sources to assess migration into the groundwater system. Additional wells are located outside the chemical plant boundary to detect and evaluate potential off-site migration of contaminants (Figure 5-17).

Upgradient-downgradient water quality comparisons are not practical for the chemical plant site because it straddles the regional groundwater divide. Background values developed by the U.S. Geological Survey (USGS) for uranium and sulfate in the shallow aquifer have previously been used as reference levels in lieu of these comparisons. In this year's report, the site-specific background levels established in the Groundwater Operable Unit (GWOU) Remedial Investigation (Ref. 40) are used.

Springs, a common feature in carbonate terrains, are present in the vicinity of the site. Four springs are monitored routinely as part of the *Environmental Monitoring Plan* (Ref. 56). These springs, which are shown on Figure 5-18, have been historically influenced by chemical plant discharge water that contained one or more contaminants of concern..

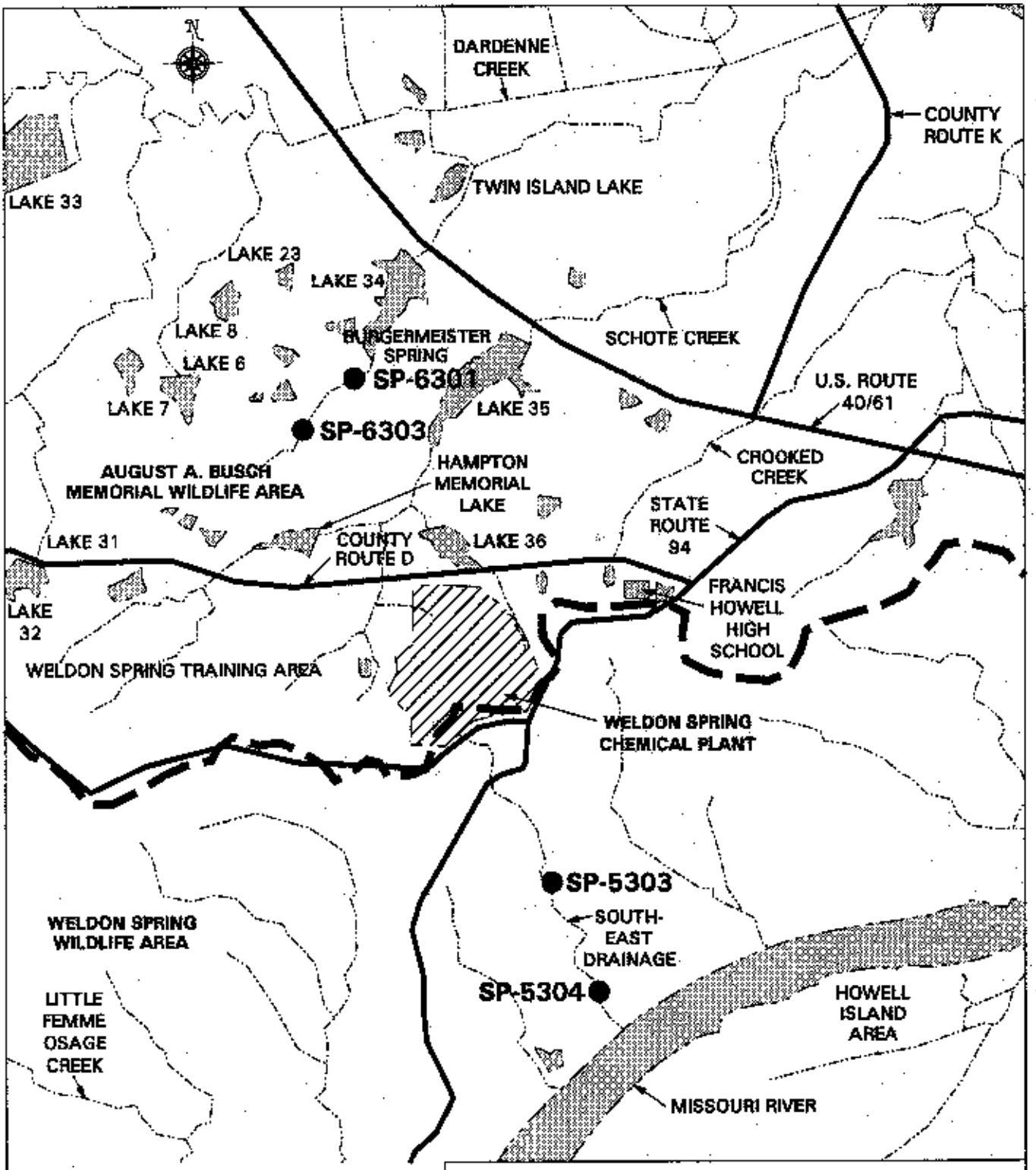
The presence of elevated total uranium and nitrate levels at Burgermeister Spring (SP-6301), which is 1.2 mi north of the site, indicates that discrete flow paths are present in the vicinity of the site. Groundwater tracer tests performed in 1995 (Ref. 40) indicated that a discrete and rapid hydraulic connection exists between the northern portion of the chemical plant and Burgermeister Spring.



GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT MONITORING WELL NETWORK

FIGURE 5-17

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/CP/053/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/13/01	



LEGEND

- SPRING
- GROUNDWATER DIVIDE
- SURFACE WATER CHANNEL

0 1 MI
0 1.6 KM
SCALE

SPRINGS IN THE VICINITY OF THE WELDON SPRING CHEMICAL PLANT AREA

FIGURE 5-18

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/VP/018/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/13/01	

5.8.3.2 Monitoring Program

The following information pertains to the year 2000 data. It is included here to demonstrate the current status of groundwater monitoring. Specific detailed data for 1996-1999 may be found in the respective annual site environmental reports.

The 2000 groundwater monitoring program at the chemical plant and raffinate pits area focused on monitoring known contaminants and determining any groundwater impacts which may have resulted from remedial action (e.g., soil excavation and sludge removal) at the site. A summary of monitoring locations and parameters are in the *Environmental Monitoring Plan* (EMP) (Ref. 56). The EMP includes provisions for initiation of special environmental studies if evidence or conditions arise that warrant investigation beyond the scope of the EMP sampling schedule.

Total uranium, nitroaromatic compounds, volatile organic compounds (VOCs), and nitrate were monitored at selected locations throughout the chemical plant area. The frequency and type of sampling performed at each location was based on recent concentrations of contaminants in the groundwater at each location and on the likelihood of nearby remedial activities causing mobilization of contaminants into the groundwater. Analytical results for all monitored parameters are summarized and discussed in Section 5.8.4.3.

Prior to construction of the chemical plant, the site was part of the Army ordnance works for production of the nitroaromatic compounds trinitrotoluene (TNT) and dinitrotoluene (DNT). One of the first nitroaromatic production lines was located within what is now the chemical plant area perimeter. Wastes generated from the initial operation of these early production lines were disposed of in open earthen pits which released contaminated seepage to groundwater. Wastewater containing nitroaromatic compounds was transported through wooden pipe networks. Discrete locations at the chemical plant known to be impacted by nitroaromatics were sampled and analyzed for these compounds in 2000.

Groundwater in the vicinity of the former raffinate pits has been impacted with elevated nitroaromatic compounds, nitrate and uranium concentrations. The pits contained ore-refining wastes from uranium ore concentrates that were digested with nitric acid during the original chemical plant operations. Some of the wastes generated and disposed of as raffinate also contained isotopes of thorium and radium. Groundwater samples from selected locations near the raffinate pits were analyzed for nitrate, thorium, radium isotopes, total uranium, and nitroaromatic compounds.

Monitoring wells in the vicinity of the former Frog Pond, which began demonstrating elevated concentrations of nitroaromatic compounds in 1999, were sampled quarterly in 2000. In addition, three new wells were installed at the end of 2000 to further define the extent of nitroaromatic contamination in this area.

Groundwater in the vicinity of the former Ash Pond has been impacted with elevated nitrate as well as some uranium and nitroaromatic compounds. Since recent remedial activities may have mobilized more of these contaminants into the groundwater, wells in this area were monitored quarterly for nitrate, uranium, and nitroaromatics.

Trichloroethene (TCE) was detected in groundwater southeast of Raffinate Pit 4 during 1996. VOC monitoring was conducted bi-monthly at selected wells during 2000 to evaluate potential trends in the area of TCE impact, assess the mobility of the contaminant, and evaluate the effect of remediation activities on VOC contamination levels. In addition, several new monitoring wells were installed in this area in early 2001 to further define the extent of contamination.

Groundwater moves under the chemical plant by both diffuse and discrete flow components. In order to monitor the discrete flow component, Burgermeister Spring was monitored in 2000 for total uranium, nitroaromatic compounds, volatile organic compounds, nitrate, sulfate, and geochemical parameters. The spring was sampled during high- and base-flow conditions to monitor the potential impacts to the spring recharge from surface water runoff in the vicinity of the chemical plant. Three other springs along drainages that flow away from the site were sampled quarterly for VOCs during base-flow conditions.

5.8.3.3 Chemical Plant Monitoring Results

5.8.3.3.1 Groundwater Monitoring Wells

Analytical data for contaminants monitored during 2000 (e.g., uranium, radiological parameters, nitrate, sulfate, volatile organic compounds, and nitroaromatics) are summarized and compared with background levels and water quality standards in the following paragraphs. Comparisons to drinking water standards are for reference purposes only, and are not intended to imply that groundwater from WSSRAP monitoring wells must be in compliance with drinking water standards. Average annual concentrations are compared to background levels established during the GWOU remedial investigation.

Uranium. Total uranium, which is measured at all monitoring wells, continues to be present in groundwater near the raffinate pits. In 2000, groundwater from seventeen monitoring wells exceeded the average background level of 0.93 pCi/l established during the Groundwater OU remedial investigation. Only one well exceeded the groundwater standard of 30 pCi/l. Average measured values exceeding background are shown in Table 5-25. A new historic high for uranium in MW-3024 was recorded during 2000 (64.7 pCi/l), although subsequent samples indicated lower concentrations.

Table 5-25 Annual Averages for Total Uranium Above Background at the Weldon Spring Chemical Plant (pCi/l)

LOCATION	AVERAGE (pCi/l)	SAMPLE POPULATION
MW-2003	1.80	4
MW-2017	7.18	1
MW-2034	2.42	1
MW-2037	1.0	2
MW-2038	1.74	2
MW-2039	3.25	1
MW-3003	14.77	3
MW-3023	9.90	2
MW-3024	52.43*	3
MW-3025	2.61	3
MW-3026	1.92	1
MW-3027	1.13	2
MW-4020	6.79	2
MW-4024	5.84	2
MW-4027	2.67	2
MW-4028	1.02	2
MW-S021	1.40	2

* Concentration exceeds the newly promulgated EPA maximum contaminant level of 30 µg/l (20.4 pCi/l).
Note 1: Background uranium concentration equals 0.93 pCi/l.
Note 2: 1 pCi/l = 0.037 Bq/l.

Radiological Parameters. The other radiological parameters (Ra-226, Ra-228, and isotopic thorium) that were measured in the raffinate pit wells were within historic values. The annual averages are presented in Table 5-26 for all wells where at least one parameter was present above the detection limit. No wells in the chemical plant area exceeded the EPA drinking water MCL of 5 pCi/l for Ra-226 and Ra-228 combined.

Nitrate and Sulfate. In 2000, nitrate was measured at 27 monitoring wells in the chemical plant area that previously exceeded the reference levels. Nitrate levels exceeded the Missouri drinking water primary MCL (10 mg/l) at 22 of those locations (see Table 5-27).

Sulfate was measured at 10 monitoring wells in the chemical plant area. Average sulfate levels exceeded background (12 mg/l) as determined during the GWOU remedial investigation at eight locations. No well indicated sulfate concentrations above the Missouri Drinking Water Secondary MCL (250 mg/l).

Table 5-26 Year 2000 Annual Radiological Isotope Activities at the Weldon Spring Chemical Plant (pCi/l)

	AVERAGE CONCENTRATION (pCi/l)				
LOCATION	Ra-226	Ra-228	Th-228	Th-230	Th-232
MW-2037	<0.15	<0.79	<0.07	0.05	<0.03
MW-2038	<0.14	1.11	<0.08	0.10	<0.05
MW-2040	1.09	<0.93	0.27	0.42	0.17
MW-3003	0.27	<0.81	<0.09	<0.05	0.04
MW-3023	<0.17	<0.79	<0.08	0.11	0.02
MW-3024	0.57	<0.88	<0.09	0.10	<0.03
MW-3025	0.40	<0.81	<0.05	0.09	0.05
MW-3026	0.88	<1.20	0.10	0.11	<0.03
MW-3027	0.50	<0.89	<0.07	0.06	<0.03

< All samples less than the highest detection limit.

Table 5-27 Annual Values of Nitrate Levels Exceeding Drinking Water Quality Standard at the Weldon Spring Chemical Plant Area (mg/l)

LOCATION	AVERAGE (mg/l)	SAMPLE POPULATION
MW-2001	108	4
MW-2002	220	4
MW-2003	356	4
MW-2005	230[a]	4
MW-2037	275	2
MW-2038	614	2
MW-2040	138	4
MW-3003	318[b]	4
MW-3023	183	4
MW-3024	411	3
MW-3025	245	3
MW-3026	153	4
MW-3027	28	4
MW-4001	50	4
MW-4006	12	4
MW-4011	104	4
MW-4027	30	4
MW-4028	291	4
MW-4029	513	4
MW-S021	172	4

Note : Missouri drinking water standard designates the primary maximum contaminant level as 10 mg/l.

(a) This value contains a historical high of 563 mg/l. When this value is disregarded, the average concentration is 119 mg/l.

(b) This value contains a historical high of 189 mg/l. When this value is disregarded, the average concentration is 361 mg/l.

Table 5-28 Year 2000 Annual Values of Sulfate (mg/l) Above Background at the Weldon Spring Chemical Plant

LOCATION	AVERAGE	SAMPLE POPULATION
MW-2001	16.7	2
MW-2002	140	2
MW-2003	209	2
MW-2005	75	2
MW-3003	129	1
MW-3024	70	1
MW-3025	45	1
MW-4011	43	1

Note : Background sulfate concentration equals 12 mg/l.

Nitroaromatic Compounds Nitroaromatic compounds, which are not naturally occurring, were detected in 25 monitoring wells (Table 5-29). New historic highs were reported during 2000 at several wells in the vicinity of the former Frog Pond, most notably at MW-2012. Levels of nitroaromatics have increased at this well since 1997, most likely as a result of remedial activities in this area. Three additional wells were installed in the vicinity of MW-2012 at the end of 2000 to further define the extent of contamination in this area.

Table 5-29 Year 2000 Annual Averages for Monitoring Locations with at Least One Detectable Concentration of a Nitroaromatic Compound at the Weldon Spring Chemical Plant Area (µg/l)

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-2001	0.07	<0.09	<0.03	0.05	0.05	<0.03
MW-2002	<0.03	<0.09	<0.03	0.05	0.32	<0.03
MW-2003	<0.03	<0.09	<0.03	0.15*	1.00	<0.03
MW-2005	0.13	0.08	<0.03	0.06	0.17	<0.03
MW-2006	4.75	<0.20	0.22	1.27*	2.17	<0.20
MW-2012	86.3	<2.0	180	598	635	<2.0
MW-2013	4.60	<0.20	0.34	0.19*	1.84	<0.20
MW-2014	3.15	<0.20	<0.20	0.17*	0.81	<0.20
MW-2033	2.36	<0.20	0.33	0.19*	1.49	<0.20
MW-2037	<0.03	<0.09	<0.03	0.10	3.03	<0.03
MW-2038	0.07	<0.09	<0.03	0.40*	0.07	0.03
MW-3003	<0.03	<0.09	<0.03	0.14	0.19	<0.03
MW-3023	<0.03	<0.09	<0.03	0.09	0.45	<0.03
MW-3025	<0.03	<0.09	<0.03	0.74	0.09	<0.03
MW-3026	0.12	<0.09	<0.03	0.07	0.05	<0.03

Table 5-29 Year 2000 Annual Averages for Monitoring Locations with at Least One Detectable Concentration of a Nitroaromatic Compound (µg/l) at the Weldon Spring Chemical Plant Area (µg/l) (Continued)

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-3027	0.09	<0.09	<0.03	0.04	0.05	<0.03
MW-4001	46	<0.09	2.05	0.11*	1.75	0.02
MW-4006	13.5	<0.09	<0.03	0.11*	2.35	<0.03
MW-4011	<0.03	<0.09	<0.03	<0.03	0.04	<0.03
MW-4015	3.70	<0.09	<0.03	0.07	0.69	<0.03
MW-4027	0.04	<0.09	<0.03	0.08	0.02	<0.03
MW-4028	0.56	0.093	<0.03	0.16*	0.18	<0.03
MW-4029	0.93	0.16	0.073	0.17*	0.52	0.03
MW-S004	9.10	0.08	0.68	0.09	0.85	<0.03
MW-S021	0.09	<0.09	0.05	0.27*	0.09	<0.03

< All samples less than the highest detection limit.
* Equals or exceeds the Missouri water quality standard of 0.11 µg/l.

The Missouri drinking water standard for 2,4-DNT of 0.11 µg/l was equaled or exceeded in 14 locations at the chemical plant area (see Table 5-29). Elevated nitroaromatics in groundwater underlying the site are attributable to wastewater impoundments and production lines used in the production of TNT and DNT in the 1940s.

Volatile Organic Compounds. TCE monitoring continued through 2000 to monitor the extent of contamination and changes in concentration that may have resulted from remedial activities. The analytical results for all wells with detectable levels of TCE are summarized in Table 5-30. Six wells exceeded the Missouri water quality standard of 5 µg/l. Many new wells have been installed in this area to further define the extent of contamination. Data from these wells will be used to support remediation of the VOC-contaminated groundwater, scheduled to begin in 2001.

Metals. One location was monitored for metals (TCLP metals) as part of the environmental monitoring program. This well did not exceed Missouri drinking water primary MCLs for any metals and will not be monitored for metals in 2001.

Groundwater Overview. Contaminant levels generally remained within recent historical ranges at the monitoring wells sampled under the environmental monitoring program in 2000.

Table 5-30 Year 2000 Annual Average TCE (µg/l) Analytical Results

	TCE (by EPA CLP)	
LOCATION	AVERAGE	(N)
MW-2037	625[a]	6
MW-2038	207[b]	6
MW-3024	2.0	5
MW-3025	4.7	5
MW-4001	5.5*	6
MW-4027	4.4	6
MW-4028	447*	6
MW-4029	647*	6
MW-S021	122*	6

(N) Sample population
* Concentration exceeds the Missouri water quality standard of 5 µg/l.
(a) This value includes a historic low of 66 µg/l, which is 10 times lower than other data collected in 2000. When this value is disregarded, the average concentrations is 736 µg/l.
(b) This value includes a historic low of 960 µg/l, which is 10 times lower than other data collected in 2000. When this value is disregarded, the average concentrations is 55.8 µg/l.

Select chemical plant locations were trended and are discussed in Section 5.8.3.4. Uranium, sulfate, and nitrate contamination continues to be concentrated in the area of the raffinate pits, with a small area of elevated uranium near the eastern boundary of the chemical plant area. Discrete areas of nitroaromatic-contaminated groundwater continue to be present in the vicinity of Frog Pond, along the northern perimeter of the site, near Raffinate Pit 4, and west of the raffinate pits on the former Weldon Spring Ordnance Works property. The VOC contamination southeast of Raffinate Pit 4 remains under investigation.

5.8.3.3.2 Springs

Springs in Valley 6300 and Valley 5300 were monitored in accordance with the 2000 environmental monitoring program. Burgermeister Spring (SP-6301) is a perennial spring and is a localized emergence of groundwater impacted by a recognizable contribution of contaminants from the chemical plant area throughout the year, with the highest concentrations occurring during base flow stages. During high flow conditions, surface water recharge along the stream segments mixes with contaminated groundwater from the chemical plant area, and the concentrations are effectively lowered. This spring (SP-6301) was monitored during both high and base stages during 2000.

Uranium, nitrate, sulfate, and nitroaromatic data for Burgermeister Spring were all lower than data collected in 1999. Sampling results for these parameters are in Table 5-31. Nitroaromatic compounds were analyzed in samples from base stage flow only, and the compounds 2,4,6-TNT and 2,6-DNT were reported above detection limits. These results are also in Table 5-31.

Monitoring of Burgermeister Spring will continue for the duration of the project to determine whether remediation activities across the northern half of the chemical plant area have impacted local groundwater quality.

Table 5-31 2000 Monitoring Data for Burgermeister Spring

	HIGH FLOW				LOW (BASE) FLOW			
PARAMETER	MIN	MAX	AVG	(n)	MIN	MAX	AVG	(n)
Nitrate	5.19	7.3	6.25	2	0.82	13.8	7.40	6
Sulfate	24.2	26.3	25.25	2	22.6	48.6	33.78	6
U-Total	1.02	20.2	13.17	3	14.1	81.1	47.74	7
2,4,6-TNT	NS	NS	NS	0	<0.09	0.05	0.01	4
2,6-DNT	NS	NS	NS	0	0.11	0.15	0.13	4

(n) Sample population
NS Not sampled.

VOCs were monitored quarterly at SP-5303, SP-5304, SP-6301, and SP-6303 in 2000 to assess the potential for off-site migration of TCE that was detected in groundwater in the vicinity of the raffinate pits. These locations were sampled during base flow conditions, which are predominated by groundwater flow. No TCE concentrations were reported above detection limits at any of these locations in 2000.

5.8.3.4 Trend Analysis

The computer program TREND, developed at Pacific Northwest Laboratories, was used to perform the formal groundwater trend testing. Results of the TREND analyses indicated the potential presence of statistically-significant trends as well as their direction and magnitude. The TREND testing output data are to be interpreted as screening indicators based on existing cumulative data. Results of the analyses are not intended to be used for prediction of future concentrations, but they may be used to indicate areas that should be more closely monitored in the future.

5.8.3.4.1 Statistical Methods

The TREND program was selected because it does not require the data to conform to a particular distribution (such as a normal or lognormal distribution). The nonparametric method used in this program is valid for scenarios where there are a high number of non-detect data points. Data reported as trace concentrations or less than the detection limit can be used by assigning them a common value that is smaller than the smallest measured value in the data set (i.e., one-half the specified quantitation limit). This approach is valid since only the relative magnitudes of the data, rather than their measured values, are used in the method. The TREND program was also used in past analyses of chemical plant area groundwater data. Thus, use of

the TREND program offered the advantage of maintaining continuity in the analysis methodology.

The two-tailed version of the Mann-Kendall test was employed to detect either an upward or downward trend for each data set. In this approach, a test statistic, Z, is calculated. A positive value of Z indicates an upward trend, and a negative value of Z indicates a downward trend. The alpha value (or error limit) selected for testing was 0.05. In this test, the null hypothesis of "no trend" was rejected if the absolute value of the Z statistic was greater than $Z_{1-\alpha/2}$, where $Z_{1-\alpha/2}$ was obtained from a cumulative normal distribution table. In other words, the absolute value of the TREND output statistic, Z, was compared to the table $Z_{.975}$ value of 1.96. If the absolute value of the Z output statistic was greater than 1.96, then a significant trend was reported.

The linear slope of the trend was estimated for all data sets in which an upward or downward trend was identified. The slope was estimated using a nonparametric procedure included in the computer code for the TREND program. A 95% two-sided confidence interval about the true slope was calculated to indicate the variability of the values upon which the trend line was based. The direction and slope of the trend, along with the upper and lower 95% confidence limit estimates, are in the summary tables at the end of this section.

One-half the specified quantitation limit (on the date of analysis) was used in the trend analysis for all data reported as below the detection limit. The purpose of using one-half the quantitation limit was to minimize the potential bias of the data. However, a consequence of this approach may be that, in some instances, the results may have been impacted by quantitation limits changing over time. The effect of varying quantitation limits is more likely to impact the trending analysis in instances where a large number of non-detect data are present within a given time series. The summary tables include the total number of data observations and the total number of non-detect data points for each data set so that this factor may be considered.

In cases where both filtered and unfiltered samples were collected for uranium analysis, the unfiltered sample data were used in the trend analysis. Filtered sample data are typically used only for evaluating whether a particular parameter (e.g., metals) exceeds baseline conditions established under the detection monitoring program at one of the on-site waste treatment facilities. (Baseline levels are based on 1993 to 1994 data collected from filtered samples.) For trending purposes, the unfiltered sample data are used because the 1997 to 2000 data are based predominantly on unfiltered samples.

Graphs presenting the contaminant concentration versus time for each contaminant per trending location were developed. These graphs were used to identify suspect data outliers only for each trending analysis and are not presented in this report. No statistical tests were conducted for suspect outliers. Data that were suspect were flagged and rechecked for potential data transcription errors. No obvious errors were identified. Outliers were included in the analysis since the TREND program corrects for these.

5.8.3.4.2 Chemical Plant Trend Results

The selected wells from the chemical plant were trended for nitrate, trichloroethene, and nitroaromatic compounds. The cumulative results for the time period 1997 through 2000 were evaluated using the TREND program and are summarized below.

Nitrate

Fifteen locations near the chemical plant area were selected for nitrate trend analyses. These locations consisted of both weathered and unweathered bedrock wells in the chemical plant and raffinate pit areas.

Nitrate trends for 1997 through 2000 data were stationary at seven locations as shown in Table 5-32. Two of these locations, MW-2003 and MW-4029, were not previously trended for nitrate. The stationary trend was a change from the analyses using the 1995 through 1999 data where two locations, MW-2037 and MW-2038, previously indicated an upward trend, and MW-3024 previously indicated a downward trend.

Nitrate trends were upward for MW-2001 and MW-2002, possibly due to remedial activities in the Ash Pond area. These wells were not previously trended for nitrate, thus no comparisons to past trend results can be made.

Nitrate trends were downward for the following six wells: MW-3025, MW-3026, MW-3027, MW-4006, MW-4011, and MW-4028. One location, MW-4028, was not previously trended for nitrate. The downward trend was a change from the analyses using the 1995 through 1999 data where two locations, MW-4006 and MW-4011, previously indicated a stationary trend.

Five of the 15 locations that were evaluated for the 1997 through 2000 period had concentrations in 2000 that exceeded all past 1997, 1998, and 1999 data for their respective sampling locations. The 2000 new high concentrations for these locations are in the far right column of Table 5-33.

Trichloroethene

Six locations near the chemical plant were selected for trichloroethene trend analyses. Five of these locations are weathered bedrock wells, and one is an unweathered bedrock well.

Table 5-32 Chemical Plant Groundwater Wells Nitrate Trend Analysis Summary for 1997 to 2000

Well ID	Location	No. of Observations	No. of Non-Detect Data	Trend Direction (Alpha = 0.05)	Trend Slope (mg/l/yr)	95% Upper & Lower Confidence Intervals on Slope (mg/l/yr)	2000 New High Concentration (mg/l)
MW2001	Weathered bedrock, west of Ash Pond	7	0	U	12.300	6.964, 18.363	115
MW2002	Weathered bedrock, west of Ash Pond	7	0	U	63.400	35.712, 81.884	252
MW2003	Weathered bedrock, west of Ash Pond	7	0	S	15.000	-24.706, 56.836	414
MW2037	Weathered bedrock, RAF	25	0	S	2.583	-6.509, 15.000	No
MW2038	Weathered bedrock, RAF	25	0	S	10.000	-40.115, 49.000	No
MW3003	Weathered bedrock, RAF	22	0	S	-1.167	-10.944, 5.000	No
MW3023	Weathered bedrock, RAF	22	0	S	5.667	-4.000, 15.000	No
MW3024	Weathered bedrock, RAF	16	0	S	-11.000	-28.015, 11.733	493
MW3025	Unweathered bedrock, RAF	19	0	D	-71.667	-86.465, -55.535	No
MW3026	Weathered bedrock, RAF	12	0	D	-8.000	-11.380, -4.000	No
MW3027	Unweathered bedrock, RAF	21	0	D	-6.825	-8.770, -4.600	No
MW4006[1]	Weathered bedrock, west of chemical plant	17	0	D	-3.500	-4.576, -2.000	No
MW4011	Unweathered bedrock, west of chemical plant	8	0	D	-32.000	-89.457, -18.484	No
MW4028[2]	Weathered bedrock, RAF	10	0	D	-63.000	-95.431, -18.853	No
MW4029[2]	Weathered bedrock, RAF	5	0	S	-17.500	n too small, n too small	573

D = Downward S = Stationary U = Upward

[1] Data from 1998 are not available for well MW4006.

[2] Data from 1997 and 1998 are not available for wells MW4028 and MW4029.

Table 5-33 Chemical Plant Groundwater Wells Trichloroethene Trend Analysis Summary for 1997 to 2000

Well ID	Location	No. of Observations	No. of Non-Detect Data	Trend Direction (Alpha = 0.05)	Slope (µg/l/yr)	95% Upper & Lower Confidence Intervals on Slope (µg/l/yr)	2000 New High Concentration (µg/l)
MW2037	Weathered bedrock, RAF	30	0	D	-209.250	-261.608, -170.000	No
MW2038	Weathered bedrock, RAF	29	0	D	-205.833	-265.000, -155.090	No
MW3025	Unweathered bedrock, RAF	28	0	D	-12.310	-15.000, -10.772	No
MW4028[1]	Weathered bedrock, RAF	12	0	D	-130.000	-205.092, -67.270	No
MW4029[2]	Weathered bedrock, RAF	13	0	S	100.000	20.208, 150.000	No
MWS021	Weathered bedrock, RAF	30	0	D	-180.000	-231.262, -139.475	No

D = Downward
S = Stationary
1 Data for 1997 and 1998 are not available for well MW4028.
2 Data for 1997 are not available for well MW4029.

Trichloroethene trends for 1997 through 2000 data were stationary at one location and downward at the remaining five as shown in Table 5-33. The wells with the downward trends were MW-2037, MW-2038, MW-3025, MW-4028, and MWS021. MW-4028 and MW-4029 were not previously trended for trichloroethene. The results of the recent analyses for the four other locations were the same as in previous tests using the 1995 through 1999 data.

None of the six locations evaluated for the 1997 through 2000 time frame had concentrations in 2000 that exceeded all past 1997, 1998, and 1999 data for the specific sampling locations. These results are consistent with the removal of TCE source material from the overburden in this area of the site.

Nitroaromatic Compounds

Seven locations near the chemical plant were selected for trend analyses of nitroaromatic compounds. All seven of these locations are weathered bedrock wells. The results of these analyses are in Table 5-34. Each of these locations was trended for the following nitroaromatic compounds: 2,4-DNT, 2,6-dinitrotoluene (2,6-DNT), 2,4,6-trinitrotoluene (2,4,6-TNT), and 1,3,5-trinitrobenzene (1,3,5-TNB). A total of 26 trend analyses were performed on the nitroaromatic compounds at the seven groundwater monitoring well locations. Trending was not performed on 2,4,6-TNT at MW-2006 and MW-2014 because either none or only one detectable concentration was reported for the time period between 1997 and 2000.

One location, MW-2012, had an upward trend for 1,3,5-TNB. The results of analyses from the three other nitroaromatic compounds trended for this location previously indicated upward trends, using the 1995 through 1999 data, but changed to stationary trends using the 1997 through 2000 data. No other upward trends were identified.

Downward trends were indicated for all four nitroaromatic compounds at MW-2032, which is consistent with previous analyses using the 1995 through 1999 data. Downward trends were also indicated for 2,4,6-TNT at two other locations: MW-2013 and MW-2033. The analyses for 2,4,6-TNT for these two locations had previously indicated a stationary trend.

All other results of the trend analysis indicated stationary trends, which is consistent with prior analyses with the following exceptions: 2,6-DNT at MW-2033 and MW-4001 previously indicated downward trends and 2,4-DNT, 2,6-DNT, and 2,4,6-TNT at MW-2012 previously indicated upward trends.

As shown in Table 5-34, all four nitroaromatic compounds at MW-2006 and MW-2012 reported concentrations in 2000 that exceeded all past 1997, 1998, and 1999 data for their respective sampling locations. New highs were also observed at MW-2013, NW-2014, and MW-2033 for at least one of the four nitroaromatic compounds. The 2000 new high values for these locations are at the far right column of Table 5-34.

5.8.4 Weldon Spring Quarry

5.8.4.1 Hydrogeologic Description

The geology of the quarry area is separated into three units: upland overburden, Missouri River alluvium, and bedrock. The unconsolidated upland material overlying bedrock consists of up to 30 ft of silty clay soil and loess deposits and is not saturated (Ref. 1). Three Ordovician-age formations comprise the bedrock: The Kimmswick Limestone, the limestone and shale of the Decorah Group, and the Plattin Limestone. The alluvium along the Missouri River consists of clays, silts, sands, and gravels above the bedrock. The alluvium thickness increases with distance from the bluff towards the river where the maximum thickness is approximately 100 ft. The alluvium is truncated at the erosional contact with the Ordovician bedrock bluff (Kimmswick, Decorah, and Plattin formations) which also composes the rim wall of the quarry. The bedrock unit underlying the alluvial materials north of the Femme Osage Slough is the Decorah Group. Primary sediments between the bluff and the Femme Osage Slough are intermixed and interlayered clays, silts, and sands. Organic materials are intermixed throughout the sediments.

The uppermost groundwater flow systems in the quarry area are composed of alluvial and bedrock aquifers. The alluvial aquifer is predominantly controlled by recharge from the Missouri River, and the bedrock aquifer is chiefly recharged by precipitation and overland runoff.

At the quarry, 17 monitoring wells are screened within either the Kimmswick-Decorah (upper unit) or Plattin Formations (lower unit) to monitor contaminants near the quarry within the bedrock (Figure 5-19). Eleven of the 17 monitoring wells were installed to monitor contaminants within the Kimmswick-Decorah Formations comprising and surrounding the quarry. The remaining six monitoring wells are located south of the quarry within the Plattin Limestone to assess vertical contaminant migration.

There are 25 monitoring wells completed into the alluvium at the quarry and the Missouri River. The wells west of the quarry monitor the uppermost water bearing unit below the quarry water treatment plant equalization basin and effluent ponds. Those north of the Femme Osage Slough monitor contaminant migration south of the quarry, while those south of the slough monitor for possible migration of contaminants toward the well field.

Table 5-34 Chemical Plant Groundwater Wells Nitroaromatics Trend Analysis Summary for 1997 to 2000

Well ID	Location	Compound	No. of Observations	No. of Non-Detect Data	Trend Direction (Alpha = 0.05)	Trend Slope (µg/l/yr)	95% Upper & Lower Confidence Intervals on Slope (µg/l/yr)	2000 New High Concentration (µg/l)
MW2006	Weathered bedrock –	2,4-DNT	8	1	S	0.003	-0.035, 0.875	4.8
	Frog Pond	2,6-DNT	8	0	S	-0.050	-0.147, 0.693	5.6
		1,3,5-TNB	8	1	S	-0.350	-1.846, 0.120	7.2
		2,4,6-TNT	8	7	(a)	(a)	(a)	0.84
MW2012	Weathered bedrock -	2,4-DNT	9	0	S	181.333	-88.869, 321.434	730
	Frog Pond	2,6-DNT	9	0	S	153.333	5.8, 296.784	690
		1,3,5-TNB	9	0	U	27.000	8.159, 38.821	99
		2,4,6-TNT	9	0	S	50.000	0.655, 78.172	200
MW2013	Weathered bedrock -	2,4-DNT	8	0	S	-0.010	-0.039, 0.049	0.41
	Frog Pond	2,6-DNT	8	0	S	0.050	-0.664, 0.382	2.7
		1,3,5-TNB	8	0	S	0.100	-1.284, 1.349	7.2
		2,4,6-TNT	8	0	D	-0.140	-0.203, -0.030	No
MW2014	Weathered bedrock -	2,4-DNT	8	0	S	-0.003	-0.018, 0.026	0.26
	Frog Pond	2,6-DNT	8	1	S	-0.040	-0.162, 0.103	No
		1,3,5-TNB	8	0	S	0.150	-0.296, 0.627	3.8
		2,4,6-TNT	8	8	(a)	(a)	(a)	No
MW2032	Weathered bedrock -	2,4-DNT	12	2	D	-0.023	-0.031, -0.010	No
	northern chem. plant	2,6-DNT	12	2	D	-0.125	-0.421, -0.058	No
		1,3,5-TNB	12	2	D	-0.059	-0.795, -0.029	No
		2,4,6-TNT	12	2	D	-0.170	-1.762, -0.089	No
MW2033	Weathered bedrock -	2,4-DNT	8	1	S	0.010	-0.029, 0.084	0.44
	Frog Pond	2,6-DNT	8	0	S	0.000	-0.420, 0.443	3.0
		1,3,5-TNB	8	0	S	-0.735	-1.633, 0.569	No
		2,4,6-TNT	8	1	D	-0.313	-0.439, -0.027	No
MW4001	Weathered bedrock -	2,4-DNT	5	0	S	-0.010	-0.022, 0.006	No
	west of chem. plant	2,6-DNT	5	0	S	-0.200	-0.498, -0.017	No
		1,3,5-TNB	5	0	S	-4.667	-9.633, 2.022	No
		2,4,6-TNT	5	0	S	-0.050	-0.383, 0.266	No

D = Downward2,4-DNT 2,4-Dinitrotoluene

S = Stationary
U = Upward
1,3,5-TNB

2,6-DNT 2,6-Dinitrotoluene
2,4,6-TNT 2,4,6-Trinitrotoluene
1,3,5-Trinitrobenzene

The St. Charles County monitoring wells, the RMW series wells, are designed to provide an early warning of contaminant migration toward the county production well field. The county production wells are monitored to verify the quality of the municipal well field water supply. Eight groundwater monitoring wells located in the Darst Bottom area approximately 1 mi southwest of the St. Charles County well field were utilized to study the upgradient characteristics of the Missouri River alluvium in the vicinity of the quarry. These wells provided a reference for background values in the well field area and were sampled by both the USGS (1992) and the DOE (1994). These wells have since been abandoned.

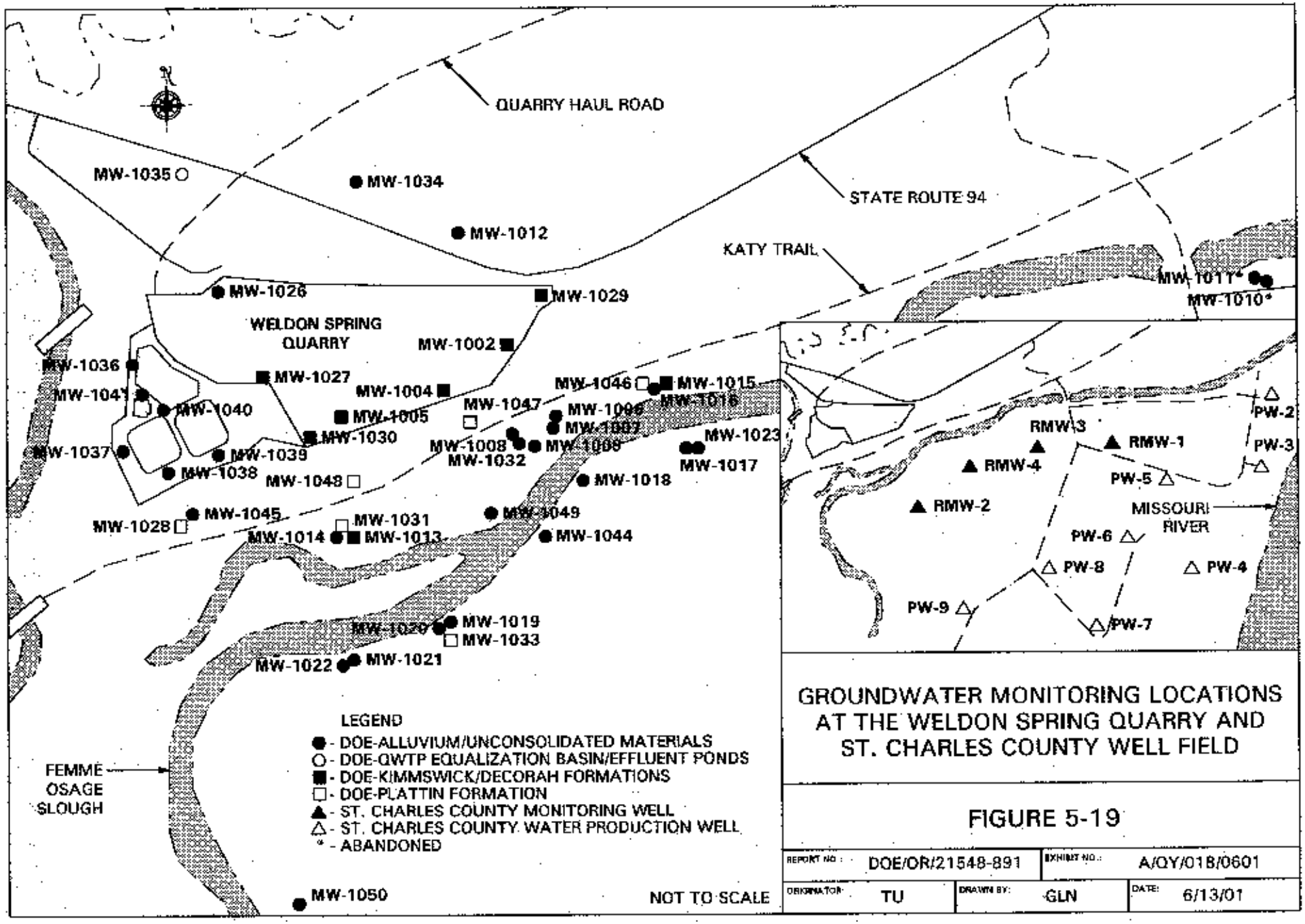
A summary of background values used at the quarry is provided in Table 5-35 (Ref. 61).

5.8.4.2 Monitoring Program

Three separate monitoring programs were employed in 2000. The first program addressed sampling the DOE wells and monitoring the quarry area to determine contaminant migration and the effects of quarry dewatering and bulk waste removal. These activities began in mid-1993 and were completed in late-1995.

The frequency of sampling for each location was based on the distance of the well from the source or migration pathway. Due to changes in concentrations over time, monitoring wells on the quarry rim were sampled quarterly for total uranium to better establish the trend in concentrations at these locations and to monitor the effects of quarry dewatering and bulk waste removal activities on the groundwater system. All locations were sampled at least annually for radiochemical parameters, nitroaromatic compounds, and sulfate.

The second program monitors the St. Charles County well field and the associated water treatment plant. Active production wells, the St. Charles County RMW-series monitoring wells, and untreated and treated water from the county public drinking water treatment plant are sampled quarterly or semiannually for selected parameters. This portion of the monitoring program was developed by representatives of the DOE, EPA, several State regulatory agencies, and St. Charles County.



GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING QUARRY AND ST. CHARLES COUNTY WELL FIELD

FIGURE 5-19

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/QY/018/0601	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 6/13/01	

Table 5-35 Average Background Values (pCi/l) for Quarry Monitoring Locations

PARAMETER	ALLUVIUM [a]	KIMMSWICK/DECORAH [b]	PLATTIN [c]
Total Uranium (pCi/l)	2.77	3.41	12.30
Ra-226 (pCi/l)	0.61	0.41	3.01
Ra-228 (pCi/l)	2.15	1.06	2.95
Th-228 (pCi/l)	0.33	0.33	4.25
Th-230 (pCi/l)	1.59	0.61	11.20
Th-232 (pCi/l)	0.28	0.38	3.02
Gross Alpha (pCi/l)	4.32	15.80	NA
Gross Beta (pCi/l)	6.82	19.30	NA
Nitroaromatics (µg/l)	NA	NA	NA
Arsenic (µg/l)	5.15	1.48	10.90
Barium (µg/l)	463.00	147.00	109.00
Sulfate (mg/l)	44.20	95.90	165.00

(a) Darst Bottom Wells (USGS and DOE)
(b) MW-1034 and MW-1043 (DOE)
(c) MW-1042 (DOE)
NA Not analyzed

The third program monitors the equalization basin at the quarry water treatment plant (Section 5.8.5). Monitoring wells MW-1035 through MW-1037, MW-1040, and MW-1041 were sampled quarterly and annually for selected parameters. The monitoring program was initially developed to meet the substantive requirements of 40 CFR Part 264, Subpart F, and 10 CSR Part 25.7, which require monitoring of contaminants of concern in groundwater beneath RCRA land-based facilities. The contaminants of concern were derived from *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 12) and *Baseline Risk Evaluation for Exposure to Bulk Waste at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 62).

5.8.4.3 Weldon Spring Quarry Monitoring Results

5.8.4.3.1 Quarry

Radiochemical Parameters. Groundwater monitoring wells at the quarry were sampled for the following radiochemical parameters: total uranium, Ra-226, Ra-228, and isotopic thorium. The uranium values continued to indicate that the highest levels occur in the bedrock downgradient from the quarry and in the alluvial material north of the Femme Osage Slough. The 2000 annual averages for the locations that exceed background are summarized in Table 5-36.

Table 5-36 Annual Averages for Total Uranium Above Background at the Weldon Spring Quarry (pCi/l)

LOCATION	AVERAGE	(n)	BACKGROUND VALUE
MW-1002	4.79	2	3.41
MW-1004	1,695	2	3.41
MW-1005	1,630	1	3.41
MW-1006	990	2	2.77
MW-1007	104	2	2.77
MW-1008	1,340	1	2.77
MW-1012	4.6	1	3.41
MW-1013	508	2	3.41
MW-1014	519	2	2.77
MW-1015	168	2	3.41
MW-1016	72	2	2.77
MW-1027	384	2	3.41
MW-1030	18	2	3.41
MW-1031	32	1	12.30
MW-1032	1,605	2	3.41
MW-1045	6.7	1	2.77
MW-1048	448	1	12.30

NOTE: 1 pCi/l = 0.037 Bq/l
(n) Sample population.

The groundwater standard of 30 pCi/l (40 CFR 192) was exceeded at 13 locations. All of these monitoring wells are located north of the Femme Osage Slough and have no direct connection to the drinking water sources in the Missouri River alluvium. The standard, while used as a reference level, is not applicable to groundwater north of the slough because this area is not considered a usable groundwater source. Locations exceeding background remained unchanged from 1999 with only a few exceptions. MW-1038 and MW-1046 no longer had averages greater than background. While MW-1012 and MW-1045 were added to the list with averages slightly above background.

Ra-226, Ra-228, and isotopic thorium (Th-228, Th-230, and Th-232) were analyzed at all groundwater monitoring locations at the quarry. The 2000 annual averages for the locations that exceeded background are summarized in Table 5-37. Only 10 locations during 2000 had values exceeding background compared with 20 identified in 1999.

Nitroaromatic Compounds. In 2000, samples from quarry monitoring wells were analyzed for nitroaromatic compounds. The monitoring wells, which have historically been impacted with nitroaromatics, are situated in the alluvial materials or bedrock downgradient of

Table 5-37 Year 2000 Annual Averages for Isotopic Radionuclides Above Average Background at the Weldon Spring Quarry (pCi/l)

LOCATION	Ra-226	(n)	Ra-228	(n)	Th-228	(n)	Th-230	(n)	Th-232	(n)
MW-1002	-	-	-	-	-	-	1.11	1	-	-
MW-1004	-	-	-	-	-	-	-	-	0.59	1
MW-1013	0.75	1	-	-	-	-	-	-	-	-
MW-1017	1.25	2	-	-	0.46	2	-	-	-	-
MW-1023	2.25	1	-	-	1.49	1	-	-	1.07	1
MW-1027	-	-	2.26	1	-	-	-	-	-	-
MW-1030	0.69	1	-	-	0.84	1	-	-	0.61	1
MW-1032	-	-	1.1	1	-	-	-	-	-	-
MW-1038	1.56	1	-	-	0.37	1	-	-	-	-
MW-1044	-	-	-	-	-	-	-	-	0.29	1

NOTE: 1 pCi/l = 0.037 Bq/l.
(n) Sample population.
\- Did not exceed average background.
Background values are in Table 5-36.

the quarry and north of the Femme Osage Slough. Results were similar to those reported in 1999. No detectable concentrations were observed south of the Femme Osage Slough. A summary of the annual averages for all locations where at least one nitroaromatic compound was measured above the detection limit is provided in Table 5-38. One location, MW-1027, had an average concentration which exceeded the Missouri drinking water standard of 0.11 µg/l for 2,4-DNT during 2000.

Table 5-38 Year 2000 Annual Averages for Monitoring Locations with at Least One Detectable Concentration of Nitroaromatic Compound at the Weldon Spring Quarry (µg/l)

LOCATION	1,3,5-TNB	(n)	1,3-DNB	(n)	2,4,6-TNT	(n)	2,4-DNT	(n)	2,6-DNT	(n)	NB	(n)
MW-1002	5.6	2	0.04	2	2.00	2	0.05	2	3.15	2	<0.03	2
MW-1004	0.22	2	<0.09	2	0.56	2	0.10	2	0.25	2	<0.03	2
MW-1005	<0.03	1	<0.09	1	<0.03	1	<0.03	1	<0.01	1	<0.03	1
MW-1006	2.00	2	<0.09	2	0.18	2	0.06	2	0.33	2	<0.03	2
MW-1013	<0.03	2	<0.09	2	<0.03	2	0.02	2	0.01	2	<0.3	2
MW-1015	0.95	2	0.17	2	0.46	2	0.02	2	0.12	2	<0.03	2
MW-1016	<0.03	2	<0.09	2	<0.03	2	<0.03	2	<0.01	2	<0.03	2
MW-1027	<0.03	2	<0.09	2	0.20	2	1.21	2	1.6	2	<0.03	2
MW-1030	<0.03	1	<0.09	1	<0.03	1	<0.03	1	0.02	1	<0.03	1
MW-1032	<0.03	1	<0.09	1	<0.03	1	0.03	1	0.02	1	<0.03	1

< All samples less than highest detection limit.
(n) Sample population.

Sulfate. Groundwater analyses in 2000 continued to indicate elevated sulfate levels were elevated in the monitoring wells in the bedrock of the quarry rim and in the alluvial materials

north of the Femme Osage Slough. Those wells with annual averages above background are summarized in Table 5-39. One location, MW-1005 had an annual average which exceeded the secondary MCL of 250 mg/l in 2000. Overall only 11 monitoring wells have averages above background, which is less than the 16 monitoring wells from 1999.

Table 5-39 Year 2000 Annual Averages for Sulfate Above Background at the Weldon Spring Quarry (mg/l)

LOCATION	ANNUAL AVERAGE	(n)	BACKGROUND VALUE
MW-1005	859*	1	95.90
MW-1006	52.8	2	44.20
MW-1008	129	1	44.20
MW-1013	106	2	95.90
MW-1014	110	2	44.20
MW-1016	95.9	2	44.20
MW-1029	107	2	95.90
MW-1032	246	2	95.90
MW-1038	225	1	44.20
MW-1039	69.6	1	44.20
MW-1045	60.8	1	44.20

* Exceeds secondary MCL of 250 mg/l.
(n) Sample population

5.8.4.3.2 St. Charles County Well Field

Radiochemical Parameters. The St. Charles County production wells, the RMW-series monitoring wells and DOE well MW-1024, were sampled semiannually during 2000 for the radiochemical parameters Ra-226, Ra-228, and isotopic thorium. Gross alpha, gross beta, and total uranium were analyzed quarterly. A summary of the radiochemical annual averages is provided in Table 5-40. The annual averages for total uranium in the well field remain at background. No production well exceeded the groundwater standard of 30 pCi/l as established in 40 CFR 192.

The St. Charles County production wells, the RMW-series wells, and pretreated (MW-RAWW) and treated water (MW-FINW) from the St. Charles County water treatment plant were sampled quarterly for gross alpha and gross beta. The annual averages for these locations are within the statistical variation of background ranges for groundwater in the Missouri River alluvium. The Missouri drinking water standard of 15 pCi/l for gross alpha was not exceeded at any of the production wells. The St. Charles County treatment plant finished waters were in compliance with the gross alpha level of 10 pCi/l as established in 40 CFR 141 and endorsed in DOE Order 5400.5. The Missouri drinking water standard of 5 pCi/l for combined Ra-226 and Ra-228 was not exceeded at any of the St. Charles County production well

locations. No water quality standards have been established for isotopic thorium in drinking water.

Nitroaromatic Compounds. The St. Charles County production wells and the RMW-series monitoring wells were sampled quarterly for six nitroaromatic compounds. No detectable concentrations were observed at any of these locations.

Sulfate. The St. Charles County production wells were sampled semiannually and the RMW-series monitoring wells were sampled quarterly for sulfate. The 2000 annual averages for the well field are summarized in Table 5-40. The secondary MCL for sulfate of 250 mg/l was not exceeded at any location in the well field.

Metals. Arsenic and barium were monitored during 2000 at the St. Charles County well field. The primary MCL for arsenic (50 µg/l) was exceeded at locations RMW-2 and RMW-4. The MCL for barium (2,000 µg/l) was not exceeded at any location. None of the values for either metal exceeded their respective MCLs in samples from the public water supply wells or from the St. Charles County water treatment plant (see Table 5-41). The 2000 results were similar to those reported for 1999.

5.8.4.4 Trend Analysis

Statistical tests for time-dependent trends at the quarry were performed on historical data from selected groundwater wells. Trending was performed on total uranium and nitroaromatic data collected from 1997 to 2000. The analyses were performed at specific monitoring locations based on historical data and knowledge of the quarry groundwater system. Total uranium trends were analyzed at locations down-gradient of bulk waste sources and in areas of possible impact south of the slough. Nitroaromatic compounds were analyzed for locations down-gradient of bulk waste sources.

The computer program, TREND, which is described in detail in Section 5.8.3.4, was used for this trend testing. The method employed was the nonparametric Mann-Kendall test.

5.8.4.4.1 Quarry Trend Results

The cumulative results for the period 1997 through 2000 for each analyte that was evaluated using the TREND program are summarized below. Remedial actions that addressed contamination source areas at the quarry were completed in 1995. The trending results for the period 1997 through 2000 for the quarry area were also compared to past trending results for the period 1995 through 1999. The results of these analyses are also summarized below by analyte.

Table 5-40 Year 2000 Summary of Annual Averages of Radiochemical Parameters for the St. Charles County Well Field (pCi/l)

LOCATION	TOTAL URANIUM		GROSS ALPHA		GROSS BETA		Ra-226		Ra-228		Th-228		Th-230		Th-232	
	AVG	(n)	AVG	(n)	AVG	(n)	AVG	(n)	AVG	(n)	AVG	(n)	AVG	(n)	AVG	(n)
MW-1024	0.52	4	<2.3	4	5.38	4	0.29	2	<0.81	2	<0.07	2	0.04	2	<0.04	2
MW-RMW1	<0.68	4	<2.7	4	5.47	4	0.34	2	<0.84	2	0.05	2	<0.07	2	<0.05	2
MW-RMW2	4.36	4	3.16	4	6.87	4	0.34	2	<0.78	2	<0.05	2	0.06	2	<0.03	2
MW-RMW3	<0.68	4	<2.9	4	5.53	4	<0.22	2	0.67	2	<0.05	2	<0.05	2	<0.07	2
MW-RMW4	0.75	4	2.62	4	6.28	4	0.18	2	<0.69	2	<0.09	2	0.05	2	<0.08	2
MW-PW02	<0.68	2	2.02	2	7.45	2	0.72	1	1.23	1	0.14	1	<0.07	1	<0.07	1
MW-PW03	<0.68	4	<1.66	4	6.47	4	<0.24	2	0.96	2	<0.05	2	<0.04	2	<0.03	2
MW-PW04	<0.68	4	<2.2	4	6.97	4	<0.22	2	1.13	2	<0.06	2	0.03	2	<0.05	2
MW-PW05	<1.4	4	<2.4	4	5.11	4	<0.22	2	1.1	2	<0.11	2	0.05	2	<0.035	2
MW-PW06	<1.35	4	<2	4	6.78	4	<0.18	2	1.07	2	<0.09	2	0.05	2	<0.06	2
MW-PW07	<0.68	4	1.28	4	5.61	4	0.23	2	0.96	2	0.04	2	<0.09	2	<0.04	2
MW-PW08	<0.68	4	1.59	4	3.87	4	<0.2	2	0.98	2	<0.09	2	<0.08	2	<0.07	2
MW-PW09	<0.68	3	1.45	3	5.89	3	<0.18	2	1.08	2	<0.06	1	<0.05	1	<0.03	2
MW-RAWW	<0.68	4	1.74	4	5.73	4	<0.2	2	1.18	2	<0.08	2	<0.05	2	0.02	2
MW-FINW	<0.68	4	<1	4	5.32	4	0.18	2	<0.75	2	<0.09	2	0.06	2	<0.04	2

Note 1: 1 pCi/l = 0.037 Bq/l.
(n) Sample population.
< All samples less than highest detection limit.

Table 5-41 Year 2000 Annual Averages for Sulfate (mg/l), Arsenic (µg/l), and Barium (µg/l) in the St. Charles County Well Field

LOCATION	SULFATE		ARSENIC		BARIUM	
	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)
MW-1024	23	4	19	4	425	4
MW-RMW1	24	4	14	4	408	4
MW-RMW2	16	4	100	4	265	4
MW-RMW3	40	4	34	4	415	4
MW-RMW4	42	4	35	4	289	4
MW-PW02	115	1	<1.40	1	437	1
MW-PW03	138	2	<1.50	2	337	2
MW-PW04	156	2	<1.50	2	325	2
MW-PW05	84	2	1.50	2	406	2
MW-PW06	75	2	1.70	2	396	2
MW-PW07	79	2	1.80	2	460	2
MW-PW08	36	2	3.30	2	505	2
MW-PW09	32	1	2.90	1	490	1
MW-RAWW	106	2	1.15	2	403	2
MW-FINW	109	2	<1.50	2	91	2

(n) Sample population.
< All samples less than highest detection limit.

Table 5-42 Quarry Groundwater Wells Uranium Trend Analysis Summary for 1997 to 2000

Well ID	Location	No. of Observations	No. of Non-Detect Data	Trend Direction (Alpha = 0.05)	Slope (pCi/l/yr)	95% Upper & Lower Confidence Intervals on Slope (pCi/l/yr)	2000 New High Concentration (pCi/l)
MW1002	Bedrock – east rim	7	0	S	-0.020	-5.686, 0.611	No
MW1004	Bedrock – rim	7	0	D	-246.667	-330.000, -99.186	No
MW1006	Alluvium – north of slough	7	0	S	-497.000	-1038.458, 222.953	No
MW1007	Alluvium - north of slough	7	0	S	34.500	-12.215, 91.507	No
MW1008	Alluvium – north of slough	6	0	S	-130.000	-609.282, 291.489	No
MW1009	Alluvium - north of slough	6	0	S	-0.330	-4.260, 5.297	No
MW1013	Bedrock – north of slough	5	0	S	-58.000	-251.744, 7.200	No
MW1014	Alluvium - north of slough	6	0	S	-96.000	-222.703, 20.064	No
MW1015	Bedrock – north of slough	6	0	S	-18.500	-56.441, 33.694	No
MW1016	Alluvium - north of slough	6	0	D	-34.000	-43.187, -24.145	No
MW1027	Bedrock – west of quarry	6	0	S	68.000	-18.577, 192.150	No
MW1030	Bedrock – south rim	6	0	S	-2.700	-5.258, 0.018	No
MW1031	Bedrock - north of slough	6	0	S	-28.100	-63.885, 27.590	No
MW1032	Bedrock – north of slough	6	0	S	-30.000	-600.648, 634.793	No
MW1036	Bedrock – north of slough	16	0	S	0.823	-0.329, 2.242	No
MW1048[1]	Bedrock – north of slough	4	0	S	-82.500	n to small, -6.901	No

D = Downward
S = Stationary
U = Upward

Table 5-43 Quarry Groundwater Wells Nitroaromatic Trend Analysis Summary for 1997 to 2000

Well ID	Location	Compound	No. of Observations	No. of Non-Detect Data	Trend Direction (Alpha = 0.05)	Slope (µg/l/yr)	95% Upper & Lower Confidence Intervals Slope (µg/l/yr)	2000 New High Concentration (µg/l)
MW1002	Bedrock – east rim	2,4-DNT	12	0	D	-0.010	-0.012, -0.008	No
MW1004	Bedrock – south rim	2,4-DNT	12	0	S	-0.014	-0.024, 0.000	0.14
MW1006	Alluvium - north of slough	2,4-DNT	12	1	D	-0.085	-0.151, -0.025	No
MW1027	Bedrock – rim	2,4-DNT	12	0	S	-0.105	-0.587, 0.372	No

D = Downward
S = Stationary

2,4-DNT 2,4-Dinitrotoluene

Total Uranium

Sixteen locations near the quarry were selected for total uranium trend analyses. Of these, 10 were bedrock wells and six were alluvial wells. Total uranium trends for 1997-2000 data were stationary except for two locations as shown in Table 5-42.

Overall, all trend directions are downward or stationary. The data from the bedrock well MW-1004 again indicated a downward trend. The recent data from the alluvial well MW-1016, previously reported a stationary trend, now appear to indicate a change to a downward trend. The recent data for MW-1002, previously reported as indicating an upward trend based on the 1995 through 1999 data, appeared to indicate a change to a stationary trend. The alluvial well MW-1014 and the bedrock wells MW-1013 and MW-1027, previously reported as indicating downward trends, also indicated a change to a stationary trend.

The stationary and downward trends of the quarry rim wells (which were similar to the nitroaromatic compound trends) may be due to bulk waste removal at the quarry. None of the 16 locations that was evaluated for the 1997 through 2000 period had uranium concentrations in 2000 that exceeded all past 1997 through 1999 data for the specific sampling locations.

Nitroaromatic Compounds

Four locations near the quarry were selected for trend analyses of 2,4-DNT. Of these locations, three were bedrock wells and one was an alluvial well. The results of the 2,4-DNT analyses are presented in Table 5-43. Based on the results of the analyses, upward trends were identified in groundwater from the alluvial well or the bedrock wells that were analyzed from the 1997 to 2000 period. The most recent analysis of MW-1004 indicated a change from a downward to a stationary trend. The most recent analysis of MW-1006 indicated a change from a stationary to a downward trend. MW-1027 was not included in last year's scope of work; therefore, no comparison can be made.

As shown in Table 5-43, one of the four locations that were evaluated for the 1997 to 2000 period reported concentrations in 2000 that exceeded all past 1997, 1998, and 1999 data for the specific sampling locations. The concentration was 0.14 μg/l at MW-1004. Consistent with last year's trending, all trends were downward or stationary.

5.8.5 Waste Treatment Facilities

5.8.5.1 Monitoring Program

Groundwater monitoring wells were used to monitor three waste management units during 2000: the temporary storage area, the quarry water treatment plant, and the disposal cell (see Figures 5-17 and 5-19). These wells were installed to detect contaminants in the uppermost

aquifer units under these facilities in order to meet the substantive requirements of 40 CFR 264, Subpart F, and 10 CSR 264, Subpart F. The monitoring parameters were derived from previous evaluations documented in *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 12), *Baseline Risk Evaluation for Exposure to Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 62), and *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (Ref. 63).

The detection monitoring programs at the temporary storage area and quarry water treatment plant and consisted of quarterly sampling for the following parameters:

- Total uranium.
- Anions (nitrate, sulfate, chloride, and fluoride).
- Metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver).
- Nitroaromatic compounds.

and annual sampling for the following parameters:

- Radiochemical parameters (Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, and U-238).
- Polychlorinated biphenyls (PCBs).
- Polynuclear aromatic hydrocarbons (PAH).
- Pesticides.

The detection monitoring program for the disposal cell consisted of semi-annual sampling for the following parameters:

- Total uranium.
- Anions (nitrate, sulfate, chloride, and fluoride).
- Metals (aluminum, antimony, arsenic, barium, chromium, cobalt, copper, lead, lithium, magnesium, molybdenum, nickel, selenium, silver, vanadium, and zinc).
- Nitroaromatic compounds.
- Radiochemical parameters (Ra-226, Ra-228, Th-228, Th-230, and Th-232).
- Miscellaneous indicator parameters (chemical oxygen demand, total cyanide, total dissolved solids, total organic carbon, and total organic halogen).

After each sampling event, the concentrations of constituents in the facility monitoring wells were compared with previously established baseline concentrations for each well. By definition, any exceedance of baseline was determined to be statistically significant, and triggered certain reporting requirements. These requirements involved evaluation of historical and analytical data and leachate volumes collected within the liners of the basins or in the storage unit to determine whether basin liners were intact.

5.8.5.2 Temporary Storage Area Monitoring Results

Collection of baseline data for the wells surrounding the temporary storage area (TSA) was completed in December 1994. The baseline dataset for each well was established with a minimum of eight samples collected on a quarterly basis. A summary of baseline data for wells MW-2035 through MW-2039 is in Table 5-44. Monitoring data collected during 2000 were compared to the baseline values to identify significant changes in groundwater quality potentially attributable to operation of these facilities.

Once the TSA was removed and subsequent confirmation of the underlying soil met cleanup criteria detection monitoring of these wells was discontinued in June 2000 in accordance with the *RCRA Closure Document* (Ref. 82). Annual average concentrations based on data collected during the first two quarters of 2000 are listed in Table 5-45. The only exceedance of baseline at the TSA was barium in MW-2039 during the first quarter of 2000. The reported concentration, however, was well below the EPA MCL of 2,000 µg/l.

5.8.5.3 Quarry Water Treatment Plant Monitoring Results

Monitoring wells MW-1035 through MW-1039 were installed in 1991 to monitor the shallow groundwater in the vicinity of the quarry water treatment plant. In 1993, two additional monitoring wells, MW-1040 and MW-1041, were installed closer to the equalization basin to better monitor the facility. A baseline was established for these newer wells utilizing 1994 and 1995 quarterly data. Monitoring wells MW-1038 and MW-1039 were deleted from this program because they were located cross gradient from the equalization basin at a distance too far to adequately monitor the basin and were possibly downgradient of contaminant sources in the quarry.

A summary of baseline data for these wells is in Table 5-46. Annual average concentrations are in Table 5-47. Monitoring data collected during 2000 were compared to the baseline values to identify significant changes in groundwater quality potentially attributable to operation of these facilities. All metals, PAHs, PCBs, and pesticides were below baseline. Exceedances of baseline were as follows:

- Anions exceeded baseline at all wells, including the upgradient well, during all four quarters.

- Total uranium exceeded baseline during two quarters at MW-1036.
- Radium-226 exceeded baseline during one quarter at MW-1036.
- Thorium-230 and 232 exceeded baseline during one quarter at MW-1037.

While ions were elevated above baseline concentrations, these values are not believed to be attributable to operation of the waste facility and they are similar to past results. Ion values are similarly increasing at the upgradient monitoring location. The Radium-226 and Thorium 230/232 exceedances were each slightly above baseline (less than 0.05 pCi/l over baseline in all three cases) and within two times background for the quarry area (Ref. 3).

Table 5-44 Baseline for the Detection Monitoring System at the Temporary Storage Area

PARAMETER	MW-2035	MW-2036	MW-2037	MW-2038	MW-2039
Arsenic (µg/l)	2.25	2.09	1.82	5.77	2.43
Barium (µg/l)	107	333	250	563	240
Cadmium (µg/l)	3.91	3.89	3.67	3.67	6.98
Chromium (µg/l)	4.21	4.33	3.83	3.83	14.1
Lead (µg/l)	4.08	2.17	1.65	1.65	1.50
Mercury (µg/l)	0.14	0.14	3.40	4.37	0.15
Selenium (µg/l)	4.71	1.86	20.0	24.9	24.5
Silver (µg/l)	5.78	6.07	6.08	6.08	13.8
Total Uranium (pCi/l)	1.93	1.64	2.17	2.32	4.12
Nitrate (mg/l)	2.05	5.03	668	2,271	117
Sulfate (mg/l)	6.89	5.64	177	132	54.6
1,3,5-TNB (µg/l)	0.02[a]	0.02[a]	0.29	0.37	0.02[a]
2,4,6-TNT (µg/l)	0.02[a]	0.02[a]	0.02[a]	0.02[a]	0.02[a]
2,4-DNT (µg/l)	0.02[a]	0.02[a]	0.79	2.14	0.02[a]
2,6-DNT (µg/l)	0.01[a]	0.01[a]	0.19	0.41	0.01[a]

Note: 1 pCi/l = 0.037 Bq/l.
(a) Value represents the detection limit.

Table 5-45 Summary of the 2000 Detection Monitoring Data for the Weldon Spring Site Temporary Storage Area Groundwater Wells

	MW-2035		MW-2036		MW-2037		MW-2038		MW-2039	
PARAMETER	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)
Arsenic (µg/l)	<2.20	2	<2.20	2	<2.20	2	<2.20	2	2.30	1
Barium (µg/l)	101.20	2	269.5	2	96.55	2	380	2	538	1
Cadmium (µg/l)	<0.80	2	<0.80	2	<0.80	2	<0.80	2	<0.23	1
Chromium (µg/l)	2.65	2	1.90	2	<1.10	2	<1.10	2	8.90	1
Lead (µg/l)	<2.80	2	<2.80	2	<2.80	2	<2.80	2	<1.10	1
Mercury (µg/l)	<0.10	2	<0.10	2	<0.10	2	<0.10	2	<0.04	1
Selenium (µg/l)	1.30	2	1.50	2	1.65	2	12.25	2	5.80	1
Silver (µg/l)	<1.00	2	<1.00	2	0.95	2	0.80	2	<1.10	1
Total Uranium (pCi/L)	<0.68	2	<0.68	2	0.98	2	1.74	2	3.31	1
Nitrate (mg/l)	0.61	2	1.33	2	279	2	877	2	74.6	1
Sulfate (mg/l)	1.95	2	3.85	2	87.6	2	34.4	2	25.0	1
1,3,5-TNB (µg/l)	<0.03	2	<0.03	2	<0.03	2	0.07	2	<0.03	1
2,4,6-TNT (µg/l)	<0.03	2	<0.03	2	<0.03	2	<0.03	2	<0.03	1
2,4-DNT (µg/l)	<0.03	2	<0.03	2	0.2	2	0.52	2	<0.03	1
2,6-DNT (µg/l)	<0.01	2	<0.01	2	0.05	2	0.09	2	<0.01	1

NOTE: 1 pCi/l = 0.037 Bq/l
(n) Sample population.
< All samples less than highest detection limit.

Table 5-46 Baseline for the Detection Monitoring System at the Weldon Spring Quarry Water Treatment Plant

PARAMETER	MW-1035	MW-1036	MW-1037	MW-1040	MW-1041
Uranium, total (pCi/l)	2.66	9.70	3.08	12.0	7.56
U-234 (pCi/l)	12.1	(a)	4.95	10.8	5.79
U-238 (pCi/l)	13.2	(a)	3.26	6.72	3.45
Ra-226 (PCi/l)	1.32	0.25	0.72	2.17	1.47
Ra-228 (pCi/l)	0.81	1.00	1.58	1.79	1.25
Th-230 (pCi/l)	1.23	2.94	0.48	0.88	1.41
Th-232 (pCi/l)	0.35	0.34	0.40	0.39	0.35
Chloride (mg/l)	6.82	102	11.8	16.0	8.34
Fluoride (mg/l)	0.28	0.18	0.71	0.12	0.26
Nitrate (mg/l)	0.37	0.32	0.82	0.28	0.32
Sulfate (mg/l)	70.0	82.0	55.5	186	52.8
Arsenic (µg/l)	6.09	4.71	5.50	9.83	6.64
Barium (µg/l)	315	351	752	330	553
Cadmium (µg/l)	3.18	3.61	3.44	3.96	3.67
Chromium (µg/l)	4.81	7.57	7.57	19.6	15.5
Lead (µg/l)	1.59	2.06	2.06	2.72	5.84
Mercury (µg/l)	0.18	0.20	0.17	0.42	0.58
Selenium (µg/l)	7.81	3.63	5.09	5.63	5.28
Silver (µg/l)	4.99	4.78	4.78	5.69	8.45

(a) No data available for determination of baseline.
Note: 1 pCi/l = 0.037 Bq/l.

Table 5-47 Summary of the 2000 Detection Monitoring Data for the Weldon Spring Quarry Water Treatment Plant

PARAMETER	MW-1035		MW-1036		MW-1037		MW-1040		MW-1041	
	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)	AVERAGE	(n)
Uranium, Total (pCi/l)	0.41	4	9.09	4	1.00	4	3.98	4	5.47	4
U-234 (pCi/l)	0.24	1	3.27	1	0.70	1	3.34	2	3.58	1
U-235 (pCi/l)	0.05	1	0.15	1	0.02	1	0.24	2	0.13	1
U-238 (pCi/l)	0.18	1	2.80	1	0.38	1	2.89	2	2.85	1
Ra-226 (pCi/l)	0.26	1	0.29	1	<0.14	1	0.37	1	0.38	1
Ra-228 (pCi/l)	0.31	1	0.19	1	0.87	1	<0.83	1	0.43	1
Th-230 (pCi/l)	0.11	1	0.06	1	0.50	1	0.03	1	0.04	1
Th-232 (pCi/l)	0.075	1	0.018	1	0.44	1	<0.02	1	0.01	1
Chloride (mg/l)	30	4	102	4	4.06	4	17.03	1	10.15	4
Fluoride (mg/l)	0.23	4	0.25	4	0.46	4	0.19	4	0.14	4
Nitrate (mg/l)	0.20	4	0.18	4	0.49	4	0.08	4	0.07	4
Sulfate (mg/l)	59	4	81	4	342	4	139	4	61	4
Arsenic (µg/l)	<2.20	4	1.24	4	1.56	4	1.64	4	<2.20	4
Barium (µg/l)	254	4	223	4	44	4	197	4	405	4
Cadmium (µg/l)	<0.80	4	<0.80	4	<0.80	4	<0.80	4	<0.80	4
Chromium (µg/l)	<4.80	4	<2.00	4	<3.50	4	<1.10	4	<1.10	4
Lead (µg/l)	<2.80	4	<2.80	4	<2.80	4	<2.80	4	<2.80	4
Mercury (µg/l)	<0.10	4	<0.10	4	<0.10	4	<0.10	4	<0.10	4
Selenium (µg/l)	<2.40	4	1.51	4	<2.40	4	<2.40	4	<2.40	4
Silver (µg/l)	0.98	4	<1.40	4	1.03	4	1.41	4	<1.40	4

Note: 1 pCi/l = 0.037 Bq/l.
(n) Sample population.
< All samples less than highest detection limit.

The detection monitoring program for the quarry water treatment plant facility was discontinued in December 2000 following remediation. The equalization basin was confirmed in November 2000 and all results were less than the cleanup criteria. Once confirmation was complete, the requirements for a detection monitoring program were no longer applicable as outlined in the *RCRA Closure Document* (Ref. 82). Evaluation of historical analytical data from these wells shows no discernible impact on groundwater quality due to the quarry water treatment plant equalization basin. The evaluation involved comparison of the data to respective monitoring well baselines, to background values for the quarry alluvium north of the Femme Osage Slough (presented in the report on Quarry Residuals operable unit remedial investigation [Ref. 61]), and to the process water data.

5.8.5.4 Disposal Cell Groundwater Monitoring

In the *Record of Decision for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 8), substantive requirements of Federal and State hazardous and/or solid waste regulations are identified as applicable or relevant and appropriate requirements (ARARs) for the selected remedy. 40 CFR 264, Subpart F, 10 CSR 25-7.264(2)(F), and 10 CSR 80-3.010(8) are identified as relevant and appropriate requirements for the disposal cell.

Groundwater monitoring requirements under the *Resource Conservation and Recovery Act* (RCRA) (40 CFR 264) specify that a monitoring system must consist of a sufficient number of wells installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that represent the quality of background water and provide detection of contamination.

The disposal cell groundwater detection monitoring network consists of one upgradient well (MW-2048), four downgradient wells (MW-2032, MW-2045 through MW-2047), and one downgradient spring (SP-6301). All six monitoring locations were sampled quarterly during all of 1997 and early 1998 to provide baseline data. Semi-annual detection monitoring began in mid-1998 after waste placement in the disposal cell was initiated. In accordance with Missouri Hazardous Waste Management Regulation 10 CSR 25-7.264(2)(F), a surface water component is also included in the detection monitoring program. Spring 6301 (Burgermeister Spring) has been identified as the appropriate downgradient location for surface water monitoring. Sampling of this spring will yield samples representative of the quality of surface water hydraulically downgradient of the disposal cell.

5.8.5.4.1 Baseline Conditions

Prior to waste placement, the disposal cell monitoring wells and SP-6301 were sampled on a quarterly basis for 1 year in order to establish baseline water quality conditions. A comprehensive list of parameters was analyzed at this time. Baseline conditions for each location were determined by generating an upper bound value for each parameter based on a 95% tolerance interval calculated for each data set.

The *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (Ref. 63) indicates that the analysis of variance (ANOVA) procedure was the preferred method for data comparisons between the upgradient well and the compliance wells. However, subsequent monitoring data results have shown that, due to the presence of preexisting groundwater contamination, such inter-well comparisons cannot provide conclusive results. Instead, an intra-well comparison of baseline conditions with detection monitoring results is performed using the tolerance interval approach. This method is an accepted alternative procedure, as discussed in the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (Ref. 64) and recommended in the *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance* (Ref. 64).

Table 5-48 presents the baseline values for each monitoring well in the cell well network and SP-6301. No baseline values are presented for volatiles, PCBs, PAHs, and nitrobenzene, as these parameters were not detected during baseline sampling. The baseline values in Table 5-48 represent a revision to baseline values used in previous years, based on a re-interpretation of the applicable guidance (Ref. 64).

5.8.5.4.2 Monitoring Results

The detection monitoring program for the cell well network provides for semi-annual sampling at each location. The 2000 monitoring results are presented in Tables 5-49 and 5-50. Results are reported for all parameters that exceeded the detection limit in at least one location.

Results of the first semi-annual sampling event, as shown in Table 5-49, indicated that the following parameters exceeded baseline:

- MW-2045 chromium, molybdenum
- MW-2046 molybdenum
- MW-2047 chromium
- MW-2048 magnesium, molybdenum

Results of the second semi-annual sampling event, as shown in Table 5-50, indicated the following parameters exceeded baseline:

- MW-2045 chromium, molybdenum
- MW-2048 sulfate, chromium, magnesium

Table 5-48 Baseline Values for the Disposal Cell Compliance Wells

PARAMETER	MW-2032	MW-2045	MW-2046	MW-2047	MW-2048	SP-6301
Chloride (mg/l)	30.55	87.26	19.66	13.10	16.09	29.21
Fluoride (mg/l)	1.64	0.25	0.26	1.28	0.49	0.57
Nitrate (mg/l)	163.32	3.04	3.64	150.42	2.11	35.28
Sulfate (mg/l)	91.53	69.43	71.56	52.98	270.88	121.35
Aluminum (µg/l)	3546.22	342.84	472.97	858.76	129.15	1,711.64
Antimony (µg/l)	9.93	15.59	28.07	27.20	13.47	13.57
Arsenic (µg/l)	4.74	3.80	4.45	4.59	3.80	3.90
Barium (µg/l)	547.66	304.62	319.96	501.17	59.20	280.61
Beryllium (µg/l)	1.06	1.14	1.19	1.16	1.16	3.86
Cadmium (µg/l)	1.62	2.43	2.75	2.75	2.49	8.83
Calcium (µg/l)	249,464	129,390	189,591	178,502	135,972	207,661
Chromium (µg/l)	11.91	61.34	9.56	12.54	2.38	10.96
Cobalt (µg/l)	2.79	14.14	2.71	2.46	2.73	13.12
Copper (µg/l)	28.89	42.22	18.01	48.56	10.34	8.64
Iron (µg/l)	7462.46	846.21	1877.25	3056.67	495.44	1205.90
Lead (µg/l)	15.70	1.78	4.27	4.43	2.02	4.27
Lithium (µg/l)	25.13	35.31	17.43	87.30	14.56	44.41
Magnesium (µg/l)	68,895	60,867	86,642	94,431	47,493	54,057
Mercury (µg/l)	0.46	0.29	3.04	0.35	0.69	0.11
Manganese (µg/l)	316.13	236.76	244.53	356.83	28.91	45.68
Molybdenum (µg/l)	7.05	10.75	7.65	23.06	8.13	8.49
Nickel (µg/l)	22.62	1161.79	22.10	56.41	3.33	19.40
Potassium (µg/l)	9453.35	3,473.78	5150.06	4143.03	4152.69	7652.97
Selenium (µg/l)	9.57	5.12	5.08	8.64	17.74	5.91
Silver (µg/l)	17.73	3.77	6.12	5.41	4.87	2.75
Sodium (µg/l)	112,226	32,857	37,315	61,051	84,474	70,500
Thallium (µg/l)	8.42	7.32	6.89	6.77	7.98	8.67
Vanadium (µg/l)	8.29	7.97	13.69	13.09	2.73	20.78
Zinc (µg/l)	61.07	30.24	45.86	40.25	53.49	53.03
C.O.D. (mg/l)	3.94	8.44	8.45	5.74	10.54	29.84
Cyanide (µg/l)	138.71	4.73	3.94	5.70	5.53	4.88
T.D.S (µg/l)	1,262	568	637	1,051	913	552
T.O.X (µg/l)	0.07	0.07	0.05	0.06	0.82	0.04
T.O.C.(mg/l)	49.55	56.35	109.75	102.94	57.51	46.32
1,3,5-TNB (µg/l)	7.80	0.03	4.74	<DL	<DL	0.156
1,3-DNB (µg/l)	1.18	0.16	0.75	0.075	<DL	0.10
2,4,6-TNT (µg/l)	12.94	<DL	3.93	<DL	<DL	0.357
2,4-DNT (µg/l)	1.04	0.18	1.12	0.56	<DL	0.151
2,6-DNT (µg/l)	7.08	1.12	129.23	1.25	<DL	0.508
Radium-226 (pCi/l)	1.02	1.03	0.45	0.70	1.11	0.50
Radium-228 (pCi/l)	3.62	2.79	4.11	2.12	7.20	6.17
Thorium-228 (pCi/l)	0.36	0.87	0.21	0.27	0.22	1.13
Thorium-230 (pCi/l)	0.35	0.91	0.29	0.68	0.60	1.74
Thorium-232 (pCi/l)	0.15	0.38	0.19	0.19	0.22	0.74
Uranium, Total (pCi/l)	6.56	1.76	2.13	1.69	2.39	203.73
pH (Std. Units)	7.81	7.46	7.33	7.80	7.36	7.12
Specific Conductance (umhos)	2,021	1,114	1,081	1,545	1,122	543

Table 5-49 Summary of Detection Monitoring Data for Cell Well Network (June 2000)

	CONCENTRATION					
PARAMETER	GW-2032	GW-2045	GW-2046	GW-2047	GW-2048	SP-6301
Chloride (mg/l)	2.7	63.3	14.5	6.1	6.9	33.1
Fluoride (mg/l)	0.21	0.14	0.13	<DL	0.2	0.36
Nitrate-N (mg/l)	7.5	1.5	2.0	91	1.2	13.8
Sulfate (mg/l)	17.6	38.1	45.3	22	269	36.9
Aluminum (µg/l)	164	<DL	415	200	89.5	336
Barium (µg/l)	167	189	221	386	39.8	144
Chromium (µg/l)	7.9	586	5.3	13.5	8.6	<DL
Cobalt (µg/l)	<DL	5.3	<DL	<DL	<DL	<DL
Copper (µg/l)	<DL	11.6	<DL	<DL	<DL	<DL
Cyanide, total (µg/l)	<DL	<DL	<DL	<DL	<DL	7.5
Lithium (µg/l)	<DL	<DL	<DL	<DL	<DL	28.4
Magnesium (µg/l)	26,200	44,500	45,500	79,000	49,400	23,500
Molybdenum (µg/l)	<DL	111	15.6	18.5	11.4	3.5
Nickel (µg/l)	<DL	1,090	<DL	<DL	<DL	<DL
Selenium (µg/l)	<DL	<DL	2.7	3.4	15	<DL
Zinc (µg/l)	<DL	<DL	5.8	<DL	<DL	<DL
Vanadium (µg/l)	<DL	4.4	<DL	<DL	<DL	<DL
Chemical Oxygen Demand (mg/l)	<DL	7	12	13	12	<DL
Total Dissolved Solids (mg/l)	405	483	547	786	747	418
Total Organic Carbon (mg/l)	1.3	<DL	1.2	<DL	1.3	1.4
TOX (mg/l)	0.01	0.013	0.02	<DL	0.03	<DL
1,3,5-Trinitrobenzene (µg/l)	<DL	<DL	1.8	<DL	<DL	<DL
2,4,6-Trinitrotoluene (µg/l)	<DL	<DL	2.8	<DL	<DL	<DL
2,4-Dinitrotoluene (µg/l)	<DL	<DL	<DL	0.17	<DL	<DL
2,6-Dinitrotoluene (µg/l)	<DL	0.71	0.79	0.44	<DL	0.13
Thorium-228 (pCi/l)	0.02	<DL	<DL	<DL	<DL	<DL
Thorium-230 (pCi/l)	0.03	<DL	0.17	0.04	0.04	0.15
Thorium-232 (pCi/l)	0.02	<DL	0.03	0.03	0.01	<DL
Uranium, Total (pCi/l)	1.94	<DL	<DL	0.96	1.31	78.1

Note: Parameters for which average concentration was below the highest detection limit for each sampling location are not included in table.

<DL Average concentration was less than highest detection limit.

Table 5-50 Summary of Detection Monitoring Data for Cell Well Network (December 2000)

	CONCENTRATION					
PARAMETER	GW-2032	GW-2045	GW-2046	GW-2047	GW-2048	SP-6301
Chloride (mg/l)	2.8	97.4	14.2	7.3	8.7	11.7
Fluoride (mg/l)	0.21	0.13	0.14	0.15	0.26	0.21
Nitrate-N (mg/l)	5.02	1.72	4.05	82.4	14.2	6.6
Sulfate (mg/l)	19.2	40	42.9	25.8	286	26.2
Aluminum (µg/l)	<DL	134	62.5	<DL	<DL	529
Barium (µg/l)	191	194	213	452	42.1	122
Chromium (µg/l)	4.9	108	2	3.9	2.8	<DL
Cobalt (µg/l)	<DL	3.1	<DL	<DL	<DL	<DL
Cyanide, total (µg/l)	<DL	<DL	5.1	30.6	280	<DL
Lead (µg/l)	<DL	<DL	6.0	<DL	<DL	<DL
Lithium (µg/l)	<DL	<DL	<DL	40.3	<DL	NS
Magnesium (µg/l)	34,400	48,200	35,600	92,600	55,100	13,500
Molybdenum (µg/l)	1.5	29.3	<DL	1.9	1.6	NS
Nickel (µg/l)	9.4	743	13.8	7.1	<DL	NS
Selenium (µg/l)	<DL	<DL	<DL	5.5	16.5	<DL
Silver (µg/l)	1.2	<DL	<DL	<DL	1.1	<DL
Zinc (µg/l)	<DL	<DL	22.2	<DL	<DL	<DL
Chemical Oxygen Demand (mg/l)	<DL	<DL	<DL	<DL	<DL	24
Total Dissolved Solids (mg/l)	270	428	500	672	726	335
Total Organic Carbon (mg/l)	<DL	<DL	1.0	<DL	1.2	1.6
TOX (mg/l)	<DL	0.012	0.01	<DL	0.006	<DL
1,3,5-Trinitrobenzene (µg/l)	<DL	<DL	2.3	<DL	<DL	<DL
1,3-Dinitrobenzene (µg/l)	<DL	0.16	<DL	<DL	<DL	<DL
2,4,6-Trinitrotoluene (µg/l)	<DL	<DL	1.7	<DL	<DL	0.5
2,4-Dinitrotoluene (µg/l)	<DL	0.081	0.17	0.21	<DL	<DL
2,6-Dinitrotoluene (µg/l)	<DL	0.62	1.00	0.38	<DL	0.15
Thorium-228 (pCi/l)	<DL	0.03	<DL	<DL	<DL	0.42
Thorium-230 (pCi/l)	0.125	0.10	0.11	0.17	0.27	0.09
Thorium-232 (pCi/l)	<DL	<DL	<DL	0.05	<DL	<DL
Uranium, Total (pCi/l)	1.94	<DL	<DL	1.32	1.7	31.4

Note: Parameters for which average concentration was below the highest detection limit for each sampling location are not included in table.
NS Parameter was not sampled.
<DL Average concentration was less than highest detection limit.

It is believed that these above-baseline data are a result of natural variations in the existing groundwater contamination underlying the site. Evaluation of the disposal cell leachate water quality and volume confirm that the elevated groundwater data are not the result of adverse impacts from the disposal cell. A demonstration report was prepared in November 2000 to identify the contributing factors to recurring above-baseline conditions. The report (*Weldon Spring Site Cell Groundwater Monitoring Demonstration Report* [Ref. 65]) discusses results of

resampling the wells, evaluation of historical site-wide water quality, analysis of disposal cell leachate data and flow rates, and review of cell well hydraulic performance.

5.9 Biological Monitoring Program

5.9.1 Biological Program Highlights

DOE Order 5400.1, 5400.5, and the *Regulatory Guide* (Ref. 51) have requirements for monitoring contaminant levels in terrestrial foodstuffs as well as in aquatic biota in the water column and sediments of affected surface waters. Past monitoring focused primarily on properties that received effluent from the site such as Busch Lakes 34, 35, and 36; Femme Osage Slough; and associated drainages.

Historical calculations have consistently shown that the radiation dose to native aquatic organisms in water influenced by the chemical plant site is well within the protective guidelines of <1 rad/day (they have never exceeded 0.1 rad/day) as established in DOE Order 5400.5. Over the past few years, biological monitoring was reduced to surveillance levels, with air and surface water results being used to determine the need for additional sampling. Statistical analyses of results from annual effluent sampling of both air and surface water indicated there was no need for further biological sampling. In addition, the total uranium migrating off site in surface water has steadily decreased since 1987 and is approaching background levels. The air monitoring program has been discontinued because the WSSRAP has no remaining sources of airborne radiological emissions. Based upon this information, no further biological monitoring will be conducted.

5.9.2 Program Description

Many of the biological sampling activities directed by DOE Orders 5400.1 and 5400.5 such as preoperational monitoring, effluent monitoring, and environmental surveillance are used to support the *National Environmental Policy Act* (NEPA) and *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) biological monitoring program and may include the collection and analysis of water, soil, foodstuffs, and biota samples.

Activities for the biological monitoring program are selected from the results of pathway analyses. Exposure pathways identified for human and ecological receptors are identified in Section 2.1 of the *Environmental Monitoring Plan* (Ref. 56). Complete pathways are those that show a link between one or more contaminant sources, through one or more environmental transport processes, to a human or ecological exposure point. These exposure pathways are used to direct biological sampling activities and determine the type of data that need to be gathered, documented, and reported.

Results of biological monitoring also provide data for human ingestion pathways and calculations of dose to native aquatic organisms. The remaining pathways are monitored to

support biological risk assessment studies and compliance with environmental surveillance requirements.

5.9.3 Applicable Standards

DOE Order 5400.5 addresses protection of native aquatic organisms from potential bioaccumulation of radionuclides. The Order states that the dose absorbed by such organisms shall not exceed 1 rad per day from exposure to the radioactive material in liquid wastes discharged to natural waterways.

5.9.4 Aquatic Monitoring

Biota are primarily exposed to radionuclides and other contaminants of concern at the chemical plant site by aquatic pathways. Contaminated surface water runoff from the site to off-site lakes and streams provides the main route of exposure to biota. Studies have been conducted to determine the uptake of contaminants by biota at on-site and off-site properties. Uranium is the main contaminant monitored in off-site surface water.

5.9.4.1 Fish Monitoring

The *Environmental Monitoring Plan* (Ref. 56) required that sunfish samples from Busch Lake 35 be collected if the average annual uranium concentration in the lake was found to be statistically higher than the average concentration found in previous years. Surface water samples collected in 1999 demonstrated that annual average uranium concentrations in the lake waters were no higher than in previous years; therefore, no fish samples were collected during 2000.

5.9.5 Terrestrial Monitoring

The *Environmental Monitoring Plan* (Ref. 56) stipulated that monitoring of terrestrial foodstuffs should be conducted only if annual average air monitoring results indicate above background concentrations of radionuclides at critical receptor sites. Since annual air monitoring results did not show above background air monitoring results at these sites during 1999, foodstuff sampling did not take place in 2000.

5.10 Special Studies

This section highlights significant activities and efforts at the Weldon Spring Site Remedial Action Project (WSSRAP) that support implementation of environmental protection policies. In addition, short term environmental studies are described that support implementation of regulatory requirements not specifically covered DOE Order 5400.1 or that were not planned in the *Environmental Monitoring Plan* (Ref. 56).

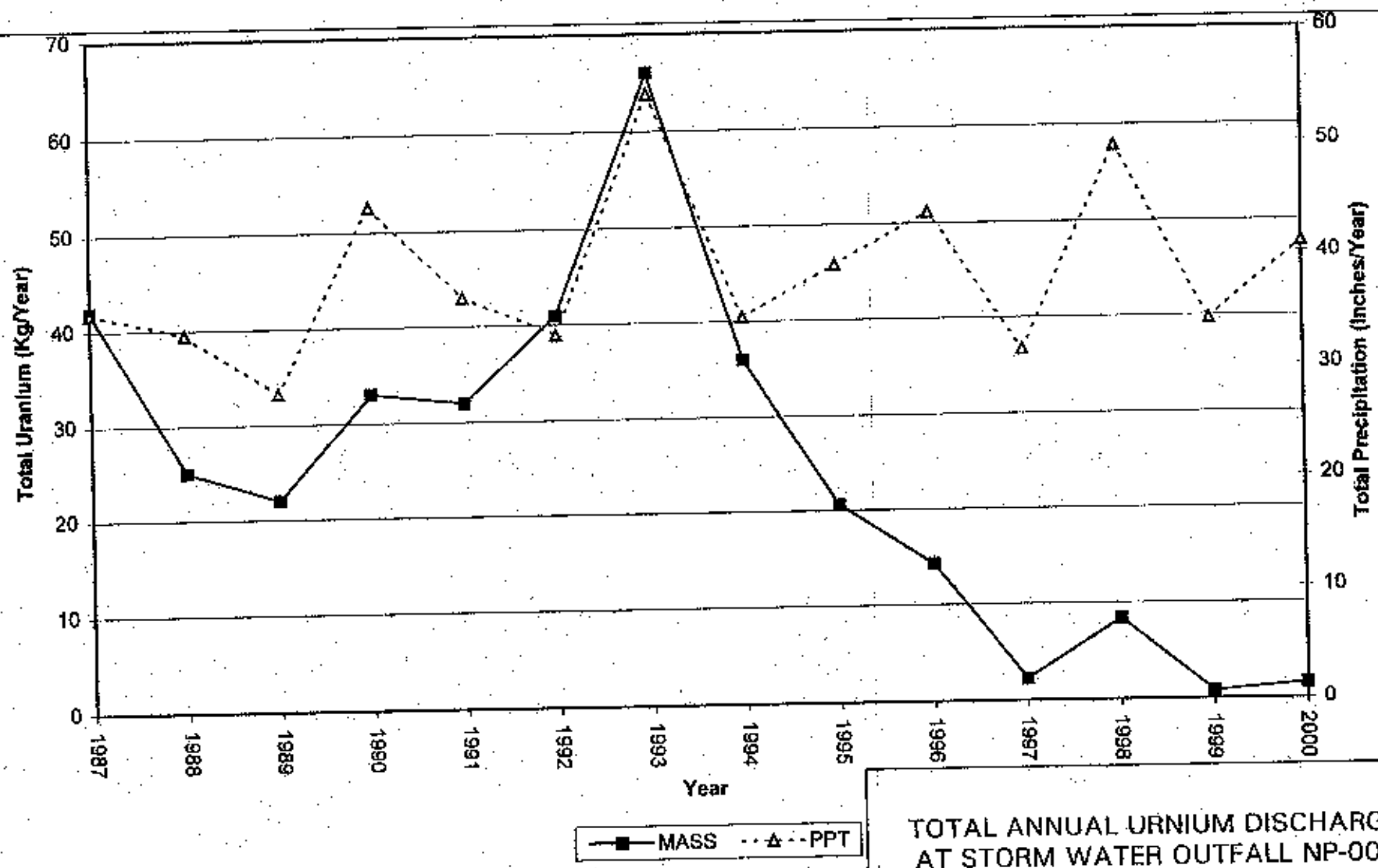
5.10.1 Off-Site Migration of Uranium in Storm Water

In an effort to determine the effect of site activities and annual rainfall on off-site migration of uranium in storm water at the three major National Pollutant Discharge Elimination System (NPDES) outfalls (NP-0002, NP-0003, NP-0005), annual mass migrating from each outfall is plotted with annual precipitation. The mass per inch of precipitation for each outfall is also plotted with precipitation. The uranium data for the years 1987 through 1994 were reviewed previously and corrected for several factors, as required, to normalize the data. The corrections were for precipitation, watershed areas, and runoff coefficients and are outlined in the *Weldon Spring Site Environmental Report for Calendar Year 1994* (Ref. 74).

These data have been updated with data for 1995 through 2000. The recent data did not require correction. The annual mass, annual precipitation, and mass per inch of precipitation are in Table 5-51. The annual precipitation and total annual mass discharged off site through 2000 are plotted in Figure 5-20, Figure 5-21, and Figure 5-22. The mass per inch of precipitation and annual precipitation are plotted for 1987 through 2000 for all three outfalls in Figure 5-23.

Table 5-51 Mass of Uranium Discharged from NPDES Storm Water Outfalls[a]

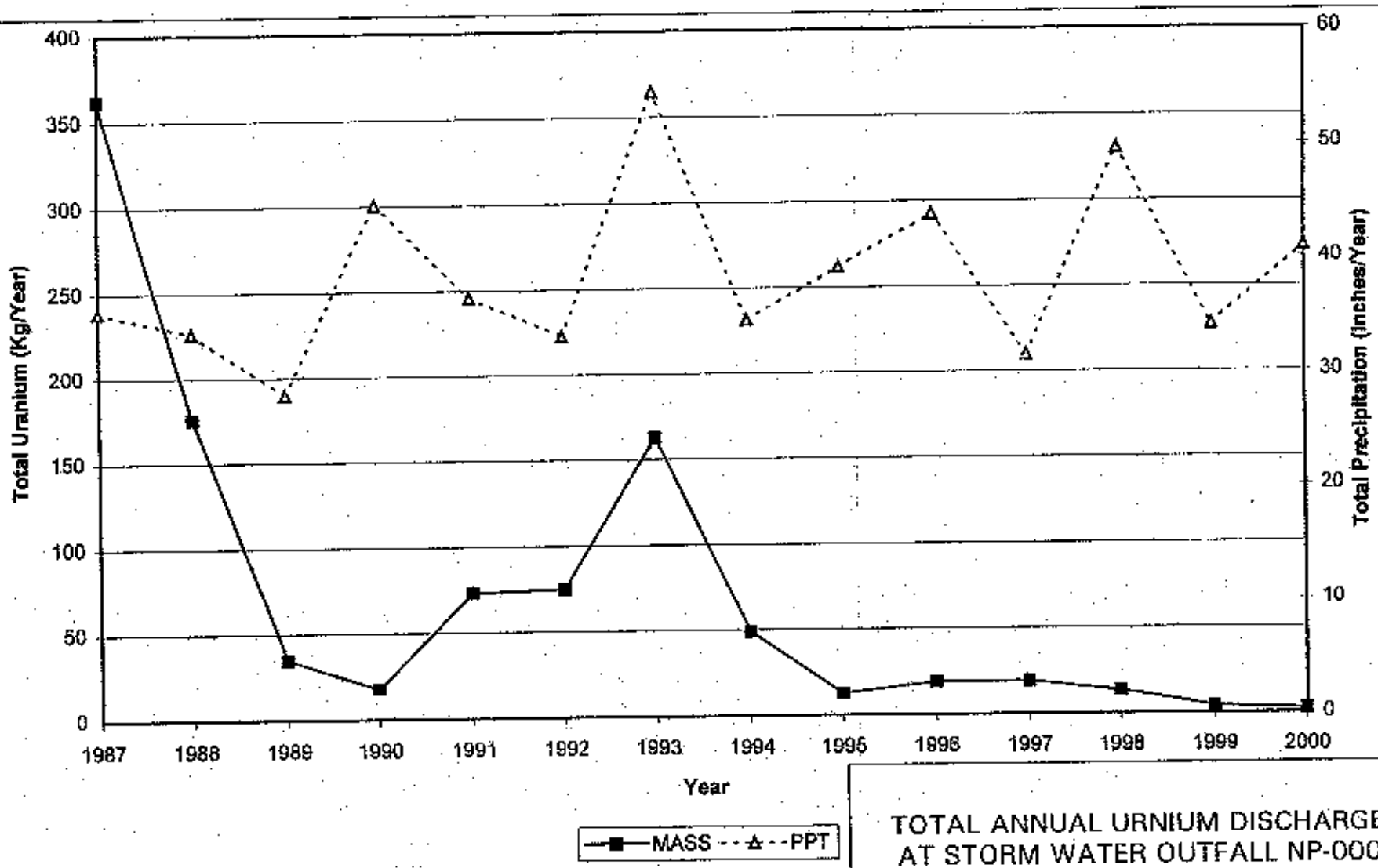
		OUTFALL						
		NP-0002		NP-0003		NP-0005		
YEAR	PPT (Inches)	MASS (kg)	MASS/INCH OF PPT (kg/inch)	MASS (kg)	MASS/INCH OF PPT (kg/inch)	MASS (kg)	MASS/INCH OF PPT (kg/inch)	TOTAL MASS/YEAR (kg) (a)
1987	35.8	42	1.17	362	10.11	38	1.06	442
1988	33.9	25	0.74	176	5.19	26	0.77	227
1989	28.5	22	0.77	35	1.23	15	0.53	72
1990	45.1	33	0.73	17.7	0.39	25	0.55	75.7
1991	36.9	32	0.87	73	1.98	27	0.73	132
1992	33.4	41	1.23	75	2.25	16	0.48	132
1993	54.7	66	1.21	163	2.98	31	0.57	260
1994	34.7	36	1.03	49	1.41	12	0.34	97
1995	39.3	20.6	0.52	12.6	0.32	5	0.13	38.2
1996	43.9	14.3	0.33	19.1	0.44	4	0.09	37.4
1997	31.5	2.3	0.07	19.2	0.61	0.5	0.02	22.0



TOTAL ANNUAL URNIUM DISCHARGED AT STORM WATER OUTFALL NP-0002

FIGURE 5-20

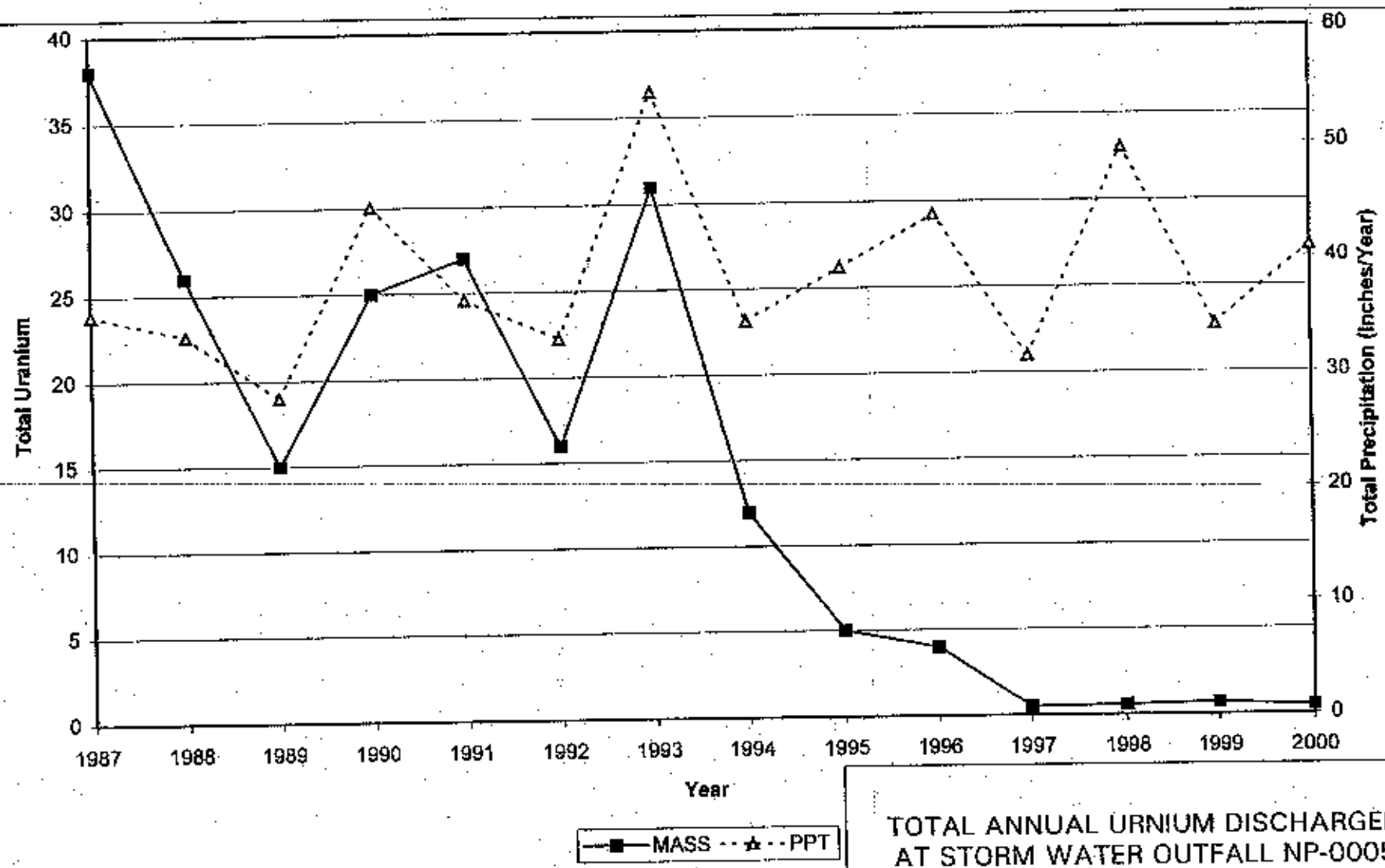
REPORT NO.:	DOE/OR/21548-891	EXHIBIT NO.:	A/PV025/0601		
ORIGINATOR:	TU	DRAWN BY:	GLN	DATE:	8/13/01



TOTAL ANNUAL URNIUM DISCHARGED AT STORM WATER OUTFALL NP-0003

FIGURE 5-21

REPORT NO.: DOE/OR/21548-881		EXHIBIT NO.: AJPV025/0001	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 8/13/01	



TOTAL ANNUAL URNIUM DISCHARGED AT STORM WATER OUTFALL NP-0005

FIGURE 5-22

REPORT NO.:	[illegible]	DOCUMENT NO.:	[illegible]
ORIGINATOR: TU	DRAWN BY: GLN	DATE:	[illegible]

Table 5-51 Mass of Uranium Discharged from NPDES Storm Water Outfalls [a] (Continued)

		OUTFALL						
		NP-0002		NP-0003		NP-0005		
YEAR	PPT (Inches)	MASS (kg)	MASS/INCH OF PPT (kg/inch)	MASS (kg)	MASS/INCH OF PPT (kg/inch)	MASS (kg)	MASS/INCH OF PPT (kg/inch)	TOTAL MASS/YEAR (kg) (a)
1998	49.6	8.4	0.17	13.3	0.27	0.57	0.01	22.3
1999	34.1	0.83	0.02	3.9	0.11	0.67	0.02	5.4
2000	41	1.8	0.04	2.3	0.06	0.5	0.01	4.4

PPT Precipitation
(a) Includes Outfalls NP-0002, NP-0003, and NP-0005. Other outfalls have historically contributed negligible amounts.

5.10.1.1 Storm Water Outfall NP-0002

Outfall NP-0002 is downstream of Frog Pond and receives runoff from the eastern section of the chemical plant area. Figure 5-20 indicates that before remediation started, uranium migrating off site initially decreased or increased in relative proportion to annual precipitation. Building dismantlement in 1992 appeared to increase the mass of uranium migrating off site, although precipitation was less than the previous year. With the completion of building dismantlement, the positive correlation of uranium versus precipitation resumed until 1995 when precipitation increased and uranium decreased. This trend continued into 1996.

Mass reduction in 1995 was presumed to be due to precipitation patterns, since the reductions were similar at all three outfalls, although activities in the three watersheds differed. The reduction in 1996 is believed to be due to action of the sedimentation basin in addition to the removal of contaminated soil and building foundations. The downward trend continued in 1997. In 1997, storm water was diverted around Frog Pond, and the pond was removed in mid 1998. Total mass at Outfall NP-0002 increased slightly in 1998. An increase in precipitation in 1998 is suspected to be the cause.

The mass for 1999 was much reduced, as was the mass per inch of precipitation. This reduction is attributed to the NP-0002 watershed being almost completely remediated, and a significant reduction from 1998 precipitation. Precipitation in 1999 was not only less than in 1998, but there were few major storm events, which reduced runoff from the site.

There was a slight increase in total mass at outfall NP-0002 in 2000. Although the area was completely remediated, there was a large area of unvegetated soil which increased the runoff coefficient. In addition, precipitation was greater in 2000 than in 1999. The cell and parking areas have high runoff coefficients which also added to the increase in runoff and subsequently, mass.

5.10.1.2 Storm Water Outfall NP-0003

Figure 5-21 indicates that uranium migrating off site sharply decreased from 1987 to 1989 at Outfall NP-0003. The reduction for 1988 is assumed to be due to precipitation patterns since there was no other activity in the watershed. The reduction in 1989 was due to construction of the Ash Pond diversion channel, which began in November of 1988 and was completed in April of 1989, along with lower precipitation in 1989. Prior to construction of the diversion channel, most of the water in the watershed flowed through Ash Pond, which was a highly contaminated area. Following construction of the diversion channel, the only water that flowed from Ash Pond was precipitation that fell directly on the pond area.

Construction of the diversion channel made the fluctuations in annual uranium mass at Outfall NP-0003 highly dependent on the flow from Ash Pond. During the summer and other dry periods, there was little or no flow from the pond. As a result, the diversion channel flow (from a much less contaminated area of the site) made up the bulk of the flow. This caused overall lower uranium levels at the outfall during periods of normal precipitation. During winter, when the Ash Pond soils may have become saturated and precipitation amounts generally have been higher and evaporation lower, flow from Ash Pond increased and concentrations at the outfall trended higher.

The mass in 1990 was again reduced over the previous year although precipitation was much higher. This may have been a result of precipitation patterns and/or the times the samples were taken (i.e., no flow from Ash Pond). In 1991 and 1992, precipitation was less than in 1990, but uranium mass was higher. Again, this presumably was due to precipitation patterns and the time of sample collection.

Uranium mass increased greatly in 1993 because precipitation increased dramatically, and Ash Pond discharged throughout the year. Mass decreased in 1994 with the decrease in precipitation, and a soil cover was placed over the South Dump area of Ash Pond in the middle of the year. Mass was again reduced in 1995 with an increase in precipitation. This was likely the result of precipitation patterns (because reductions were similar at all three outfalls) and construction during 1995 of a sedimentation basin immediately upstream of Outfall NP-0003. Mass increased slightly in 1996 due to increased precipitation and the storage of contaminated soil and debris in Ash Pond. With this storage, the water was managed and was not discharged to the sedimentation basin unless it was less than the 600 pCi/l Derived Concentration Guideline (DCG). With the storage of contaminated materials in Ash Pond, the mass of uranium at Outfall NP-0003 was expected to be highly dependent on precipitation and water discharged from the pond. The mass of uranium discharged during 1997 was slightly higher than that discharged during 1996, even though precipitation was much less. This was likely the result of the storage of contaminated materials in the pond area. During 1998, total mass at Outfall NP-0003 was less than in 1997, even though precipitation was much higher. The decrease is assumed to be the result of management of the pond water and the removal of contaminated materials from the pond in 1998.

In 1999 the mass of uranium migrating off site at Outfall NP-0003 was less than the 1998 mass. This reduction is attributed to both a reduction in precipitation and remediation of the Ash Pond area. The entire Ash Pond area and the chipped wood storage area were remediated and confirmed clean in 1999.

In 2000, the NP-0003 watershed was largely vegetated, and uranium mass migration was slightly decreased over 1999 levels even though there was an increase in precipitation. With remediation and soil stabilization, uranium discharges are expected to stabilize at a low level.

5.10.1.3 Storm Water Outfall NP-0005

Figure 5-22 indicates that the mass of uranium migrating off site at Outfall NP-0005 has been generally proportional with annual precipitation through 1994. Construction of the site water treatment plant, which began in 1992, appeared to have had little effect on the outfall, even though it involved substantial earth disturbance for construction of the effluent and equalization basins. A siltation basin was constructed to settle sediments from the water flowing off the treatment plant area, and storm water from the siltation basin has historically contained less than 10 pCi/l uranium. The other major source for the outfall (until it was remediated in 1996) was a watershed that drained the highly contaminated Building 301 area. This area was partially capped in 1994 to decrease the concentration of uranium in storm water leaving the area.

The concentration of uranium in storm water from individual sampling events was highly dependent on precipitation rates, periods between precipitation, and the ratio of flow from the sedimentation basin and the Building 301 area. The mass of uranium migrating off site was reduced in 1995 and again in 1996. The reduction in 1995 was likely the result of precipitation patterns because all three outfalls had similar reductions. The watershed for NP-0005 was remediated in 1996. This resulted in another reduction in uranium mass leaving the site. The mass of uranium migrating off site at Outfall NP-0005 in 1997 was much reduced over 1996 most likely due to the near complete remediation of the watershed. Because of the remediation, uranium mass was expected to remain near background levels at Outfall NP-0005. The total mass at the outfall remained low in 1998, despite the increased precipitation. There was very little soil disturbance in the watershed during 1998.

There was a slight increase in mass at Outfall NP-0005 in 1999 although the total mass remained low. This increase was attributed to a collection sump near the chemical stabilization and solidification (CSS) area that prevented water from flowing to the NP-0003 watershed. The water was collected to allow construction of the cell berm. The water was then pumped to Outfall NP-0005. The water that collected in the sump was from an area that was only partially remediated and slightly higher in uranium than other NP-0005 waters, thus causing the slight increase.

Mass at Outfall NP-0005 for 2000 decreased from 1999 levels despite an increase in precipitation and earth disturbance caused by the removal of the site water treatment plant and ponds. Complete remediation of the watershed contributed to the reduction.

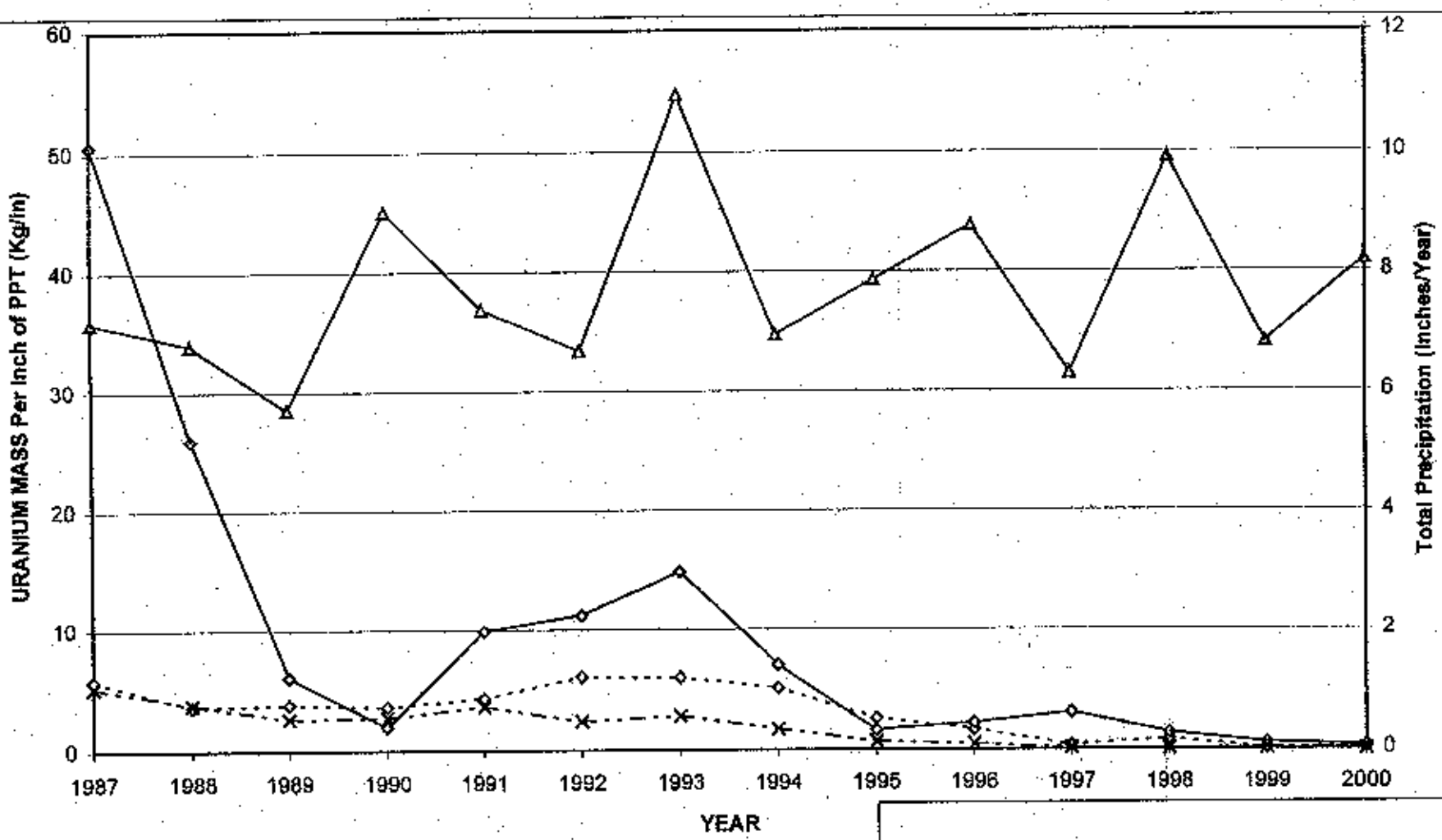
5.10.1.4 Mass of Uranium Per Inch of Precipitation

Figure 5-23 and Table 5-20 indicate that the mass of uranium migrating from the chemical plant site per inch of precipitation has relatively flat trend lines for the three major outfalls since 1995. This indicates that, all other factors remaining constant, the mass of uranium migrating off site is dependent upon annual precipitation and the contamination level in the watershed. Outfalls NP-0002 and NP-0005 show similar levels, with NP-0003 showing relatively higher levels. This is to be expected because the Outfall NP-0003 watershed contained Ash Pond, which was a highly contaminated area.

Variations may be due to precipitation patterns, soil disturbance, or remediation, and in the case of Outfall NP-0003, the storage of contaminated materials in Ash Pond. Outfalls NP-0002 and NP-0005 have trended downward as a result of remediation in the watershed. Outfall NP-0003 increased slightly for 1997 because of the storage of contaminated materials in Ash Pond, but decreased in 1998 despite the increase in precipitation. With remediation of the Ash Pond area in 1999, the mass per inch of precipitation was reduced at Outfall NP-0003. The mass per inch of precipitation continued to trend downward during 2000 at outfalls NP-0003 and NP-0005 but increased at NP-0002. When the NP-0002 watershed is stabilized and vegetation established, this level is expected to be reduced to the same ranges as at the other two outfalls.

5.10.1.5 Annual Migration of Uranium Mass from the Chemical Plant Site

The mass of uranium that migrated off site from the three major outfalls in 1987, before any remedial actions were taken, was 972 lb. During 2000, 9.68 lb of uranium migrated off site, a 99% reduction from the 1987 mass. Table 5-51 shows the mass of uranium that migrated off site in the intervening years. Mass has fluctuated from year to year with precipitation levels, remedial actions, land disturbance, and foundation and contaminated soil removal. The masses during 1995 and 1996 were at similar levels of 84 lb and 82 lb, respectively. Because contaminated soil removal was completed for major sections of the chemical plant site in 1996, levels for 1997 were reduced even further. The slight increase in 1998 may be attributed to increased precipitation. The 2000 mass was at a historical low, which was the expected result of extensive site remediation and soil stabilization.



KILOGRAMS OF URNIUM DISCHARGED PER INCH OF PRECIPITATION

FIGURE 5-23

REPORT NO.:	[illegible]	EXHIBIT NO.:	[illegible]
ORIGINATOR:	TU	DRAWN BY: GLN	DATE: [illegible]

The total annual uranium discharged from NPDES outfalls during 1987 through 2000 is shown in Figure 5-24. These values include uranium discharged at the three major outfalls discussed above, as well as at other minor storm water outfalls and in the water treatment plant effluents. As shown on the graph, total uranium migrating off site in surface water has steadily decreased since 1987 and is expected to decrease further still when the site is vegetated and stabilized.

5.10.2 Radon Flux Monitoring Results for the WSSRAP Disposal Facility

This section summaries the results of Radon-222 (radon) flux monitoring performed on the top of the radon barrier of the WSSRAP disposal cell. Additional information can be found in *Completion Report for Radon Flux Monitoring of the WSSRAP Disposal Facility* (Ref. 66).

The *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 8) states that radon flux standards in 40 CFR 61, Subparts Q and T, and 40 CFR 192.32(b)(1)(ii) are applicable and/or relevant and appropriate. These standards require that Radon-222 (radon) flux from the disposal cell will not exceed an average of 20 pCi/m^2/sec.

The primary method approved by the U.S. Environmental Protection Agency (EPA) for measuring radon flux is in 40 CFR 61, Appendix B, Method 115. This method consists of deploying large-area activated charcoal collectors on the radon barrier proper for a 24-hr period during which time the radon emanating from the surface is adsorbed on the activated charcoal. The collectors are then returned to the vendor laboratory where they are analyzed by gamma spectroscopy to determine the amount of radon adsorbed. This was the monitoring method used to determine average radon flux from the WSSRAP disposal cell.

Originally, monitoring was going to be conducted in two phases, Phase 1 covering approximately 70% and Phase 2 covering that portion not included in Phase 1. However, due to favorable changes in construction sequencing, a 1-ft radon barrier surface was available over the entire cell by September 2000. Therefore, Phase 1 was conducted as detailed above and Phase 2 was rescheduled as a one-time monitoring effort covering the entire radon barrier area. The results are discussed below.

Phase 1 monitoring was conducted August 1-2, 2000, at 70 separate locations on top of the disposal cell. These locations included about two-thirds of the radon barrier area (i.e., all radon barrier area available at that time).

The requirements of both EPA Method 115 (40 CFR 61, Appendix B) and the *Radon Flux Monitoring Plan for the WSSRAP Disposal Faciltiy* (Ref. 79) were met during Phase 1 monitoring. The average measured radon flux on the disposal cell was 0.10 pCi/m^2/sec (standard deviation of 0.15 pCi/m^2/sec, maximum value was 1.255 pCi/m^2/sec). The average was well below the regulatory requirement of 20 pCi/m^2/sec. The individual measurements compared favorably to background radon flux levels, which can range from 0.005 to 1.4 pCi/m^2/sec, with

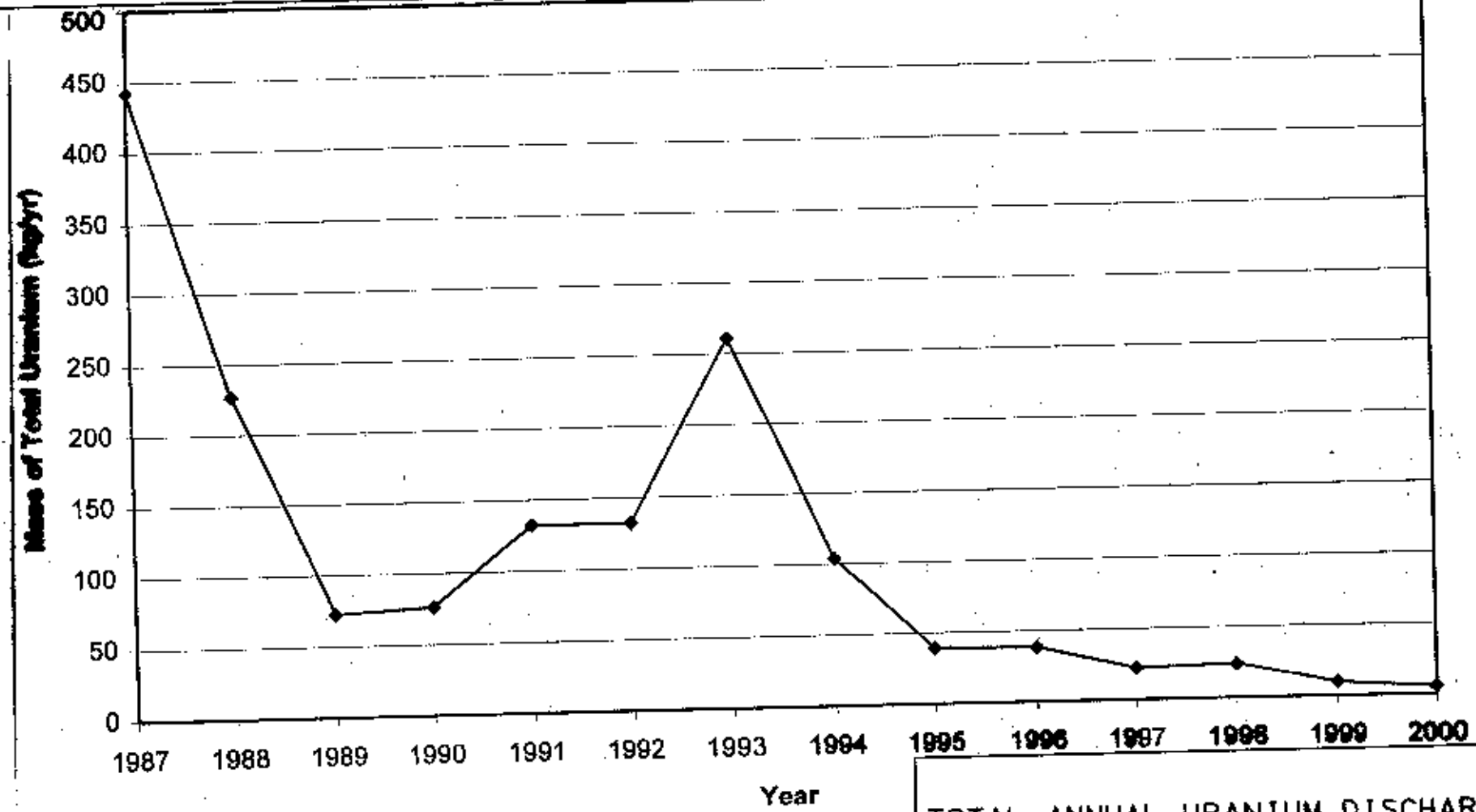
an average value of approximately 0.43 pCi/m^2/sec. In fact, none of the individual measurements exceeded this background range.

Phase 2 monitoring was conducted October 11-12, 2000, at 100 separate locations on top of the disposal cell. These locations included all of the radon barrier area except the "deep dimple," the approximately 0.7 acre (at current grade) area reserved for the remaining contaminated waste. At the time of sampling, the dimple had at its deepest point approximately 9.5 ft of clean fill above the cell waste. Two monitoring locations, WSSRAP IDs 10 and 23, were to have been placed directly above the dimple. However they were repositioned 28 ft southeast to avoid the possibility of biased low measurements.

The requirements of both EPA Method 115 (40 CFR 61 Appendix B) and the *Radon Flux Monitoring Plan for the WSSRAP Disposal Facility* (Ref. 79) were met during Phase 2 monitoring. The average measured radon flux on the disposal cell was 0.55 pCi/m^2/sec (standard deviation of 2.64 pCi/m^2/sec, maximum value was 26.4 pCi/m^2/sec). The average was well below the regulatory requirement of 20 pCi/m^2/sec. Only three of the 100 individual measurements exceeded the background range of 0.005 to 1.4 pCi/.

Additional monitoring was performed October 26-27, 2000, to confirm the 26.4 pCi/m^2/sec maximum flux measurement. This included four additional measurements: one at the original location (WSSRAP ID 56), the others within 3 ft of this location. Additional monitoring results were 0.2795, 0.5629, 6.9934, and 13.2819 pCi/m^2/sec. This was interpreted as confirmation of the original results. These additional results were not included in the calculated average since they were not part of the monitoring plan. However, they would have changed the average only slightly (from 0.55 to 0.74 pCi/m^2/sec).

In summary, the average measured radon flux during Phase 1 and Phase 2 were both less than 5% of the regulatory requirement of 20 pCi/m^2/sec.



TOTAL ANNUAL URANIUM DISCHARGED AT NPDES OUTFALLS

FIGURE 5-24

REPORT NO.: DOE/OR/21548-891		EXHIBIT NO.: A/PI/019/0401	
ORIGINATOR: TU	DRAWN BY: GLN	DATE: 8/23/01	

6. ARARs REVIEW

6.1 Chemical Plant Operable Unit

6.1.1 Location-Specific ARARs

Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in a specific location. The following standards were identified as location-specific applicable or relevant and appropriate requirements (ARARs) in the *Chemical Plant ROD* (Ref. 8). The standards were reviewed for changes that could affect the protectiveness of the remedy:

- Resource Conservation and Recovery Act
- Missouri Hazardous Waste Management Laws
- Antiquities Act
- Historic Sites Act
- National Historic Preservation Act
- Archeological and Historic Preservation Act
- Archeological Resources Protection Act
- Endangered Species Act
- Missouri Wildlife Code
- Fish and Wildlife Coordination Act
- Clean Water Act
- Farmland Protection Policy Act

No changes to the above standards in relation to the *Chemical Plant ROD* were made that would affect the protectiveness of the remedy. The above location-specific ARARs for the *Chemical Plant ROD* will not be reviewed in future five-year reviews; this type of ARAR applies to siting of the treatment and disposal facilities and the borrow area, and these actions have been completed.

6.1.2 Contaminant-Specific ARARs

Contaminant-specific ARARs are health- or risk-based numerical values that establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the environment. Contaminant-specific ARARs were analyzed to identify each environmental law or regulation pertinent to the types of contaminants that would be encountered during the remedial action. The following standards were identified as contaminant-specific ARARs in the *Chemical Plant ROD*. The standards were reviewed for changes that could affect the protectiveness of the remedy.

- Uranium and Thorium Mill Tailings Action (UMTRA) Regulations
- Resource Conservation and Recovery Act
- Missouri Radiation Regulations
- National Emission Standards for Hazardous Air Pollutants
- Clean Air Act
- Missouri Air Quality Standards
- Missouri Air Pollution Control Regulations
- Toxic Substance Control Act
- Clean Water Act

No changes in the above standards in relation to the *Chemical Plant ROD* were made that would affect the protectiveness of the remedy. The contaminant-specific ARARs for the *Chemical Plant ROD* will be reviewed in future five-year reviews as this type of ARAR applies to health and environmental protection standards which could be related to long-term monitoring at the site.

6.1.3 Action-Specific ARARs

Action-specific ARARs are technology- or activity-based requirements or limitations on actions taken that are triggered by the particular remedial activities selected to accomplish the remedy. The analysis of action-specific ARARs addressed the following tasks for the selected remedy in the *Chemical Plant ROD*: Storage, Excavation, Treatment and Disposal of wastes. The following standards were identified as action-specific standards in the *Chemical Plant ROD*. The standards were reviewed for changes that could affect protectiveness.

- Resource Conservation and Recovery Act
- Toxic Substance Control Act
- National Emission Standards for Hazardous Air Pollutants
- Missouri Hazardous Waste Management Laws
- Missouri Solid Waste Management Laws
- Solid Waste Disposal Act
- Uranium and Thorium Mill Tailings Action regulations
- Land Reclamation Act
- Clean Water Act

No changes in the above standards in relation to the *Chemical Plant ROD* were made that would affect the protectiveness of the remedy. The only action-specific ARARs for the *Chemical Plant ROD* that will be reviewed in the future five-year reviews will be the ARARs related to post-closure and long-term monitoring and maintenance. As stated above, the remaining ARARs applied to activities such as excavation, treatment, storage and disposal which have been completed.

6.2 Quarry Residuals Operable Unit

6.2.1 Location-Specific ARARs

The *Quarry Residuals ROD* (Ref. 32) did not list any location-specific ARARS.

6.2.2 Contaminant-Specific ARARs

- Missouri Water Quality Standards in Groundwater
  - Nitrobenzene (17 ug/l)
  - 2,4-Dinitrotoluene (0.11 ug/l)
  - 1,3-Dinitrobenzene (1.0 ug/l)
- 40 CFR 192.02: Total uranium = 30 pCi/l (The *Quarry Residuals ROD* states that this standard would likely be an ARAR for any remedial action considered for the usable groundwater source south of the slough in the unlikely event of contaminant migration from north of the slough).
- TBC: The *Quarry Residual ROD* discusses the maximum contaminant level (MCL) for uranium, which in 1991 was proposed at 20 ug/l. This standard was considered a TBC at the time because it was a proposed regulation and not promulgated at that time. The ROD stated that, " Although TBC, the proposed MCL is not useful for evaluating groundwater impact at this site, because it falls within the range of natural background concentrations of uranium in groundwater in this area. A more appropriate level of 30 pCi/l has been selected as a trigger level for reevaluating the decisions made regarding the QROU. The trigger level of 30 pCi/l total uranium is considered to be sufficiently above the natural variation of uranium in the aquifer to be indicative of site impact and is a level considered to be protective under hypothetical exposure assessment."

On December 7, 2000, the EPA published a Maximum Contaminant Level (MCL) for uranium at 30 ug/l (20.4 pCi/l). This MCL becomes effective on December 8, 2003, three years after the publication date. In reviewing this new standard with regard to the Quarry Residuals Operable Unit it has been determined that as stated in the *Quarry Residuals ROD* that "The trigger level of 30 pCi/l total uranium is considered to be sufficiently above the natural variation of uranium in the aquifer to be indicative of site impact and is a level considered to be protective under hypothetical exposure assessment." It has been determined that the revised MCL does not call into question the protectiveness of the remedy.

6.2.3 Action-Specific ARARs

- Uranium and Thorium Mill Tailings Action Regulations
- Missouri Radiation Regulations
- National Emissions Standards for Hazardous Air Pollutants
- Missouri Air Pollution Control Regulations

- Missouri Well Construction Regulations

No changes to the above standards in relation to the *Quarry Residuals ROD* were made that would affect the protectiveness of the remedy.

6.3 Interim Groundwater Operable Unit

6.3.1 Location-Specific ARARs

The *Interim Groundwater ROD* (Ref. 4) did not list any location-specific ARARs.

6.3.2 Contaminant-Specific ARARs

- Safe Drinking Water Act - Maximum Contaminant Level (MCL)
  - Trichloroethylene = 5 ug/l

No changes to the above standards in relation to the Interim GWOU ROD were made that would affect the protectiveness of the remedy.

6.3.3 Action-Specific ARARs

- Missouri Well Construction Regulations
- Resource Conservation and Recovery Act

No changes to the above standards in relation to the *Interim Groundwater ROD* were made that would affect the protectiveness of the remedy.

7. PROTECTIVENESS STATEMENTS

Quarry Bulk Waste Operable Unit: The remedy for the Quarry Bulk Waste Operable Unit is protective of human health and the environment. This remedial action was completed in June 1996. The action consisted of excavating the bulk waste from the quarry and placing it in controlled temporary storage pending a final decision on waste disposal as documented by the *Chemical Plant ROD* (Ref. 8). Excavating the wastes from the quarry and placing it in controlled storage mitigated the potential for exposure through direct contact with the waste material and removed the source of ongoing contaminant migration to groundwater. The final remedy for the quarry including groundwater is being addressed through the Quarry Residual Operable Unit.

Chemical Plant Operable Unit: The remedy for the Chemical Plant Operable Unit is expected to be protective of human health and the environment upon completion, and immediate threats have been addressed. Section 4 includes a description of the portions of the remedial action that have been completed. The source areas have all been remediated and placed in the on-site disposal cell. These areas have been confirmed to cleanup criteria that supports anticipated land use. The disposal cell was closed on June 5, 2001, and the only field activities remaining are completion of the cell cap and final grading.

Long term monitoring and maintenance of the cell and the site will be conducted and are described in *Long Term Monitoring and Maintenance Plan for the Weldon Spring Site* (Ref. 67). This plan provides specific instructions for conducting site inspections, erosion control, leachate management and groundwater monitoring, quality assurance activities and general site maintenance. The plan also discussed the need for and types of corrective actions to be taken if required.

Two additional post-closure documents have been developed to manage disposal cell operations and monitor areas of residual contamination.

The *Weldon Spring Site Stewardship Document for Operations and Maintenance* (Ref. 77) sets forth the implementation of a stewardship program for the site and defines the roles and responsibilities of stakeholders. Stewardship activities are required due to the presence of residual contamination. The plan outlines the need for long term monitoring and maintenance, implementation of institutional controls and identifies stakeholders and their respective roles under the program. *Institutional Controls Plan for the Weldon Spring Site* (Ref. 78) identifies and describes the institutional controls that will be implemented at the site. These controls will limit development or restrict access to areas of residual contamination. Types of controls currently envisioned for the site include proprietary (governmental) control of the disposal cell area and real estate agreements for the outlying chemical plant and quarry property.

An evaluation of the Applicable and/or Relevant and Appropriate Requirements (ARARs), which is included in Section 6, has determined that there have been no changes in the standards

identified as ARARs in the *Record of Decision* (ROD) that pertain to the protectiveness of the remedy.

At this time (1) the remedy is functioning as intended by the decision document, (2) the assumptions used at the time of remedy selection are still valid, and (3) no other information has come to light that could call into question the protectiveness of the remedy. Long term monitoring and maintenance of the cell and groundwater will ensure that the remedy continues to function as intended. Also, Argonne National Laboratory is performing a risk assessment which will determine the residual risk remaining at the chemical plant and vicinity properties. This risk assessment will be based on confirmation results and is scheduled to be completed in the fall of 2001.

The remedy for the Southeast Drainage is protective of human health and the environment. This remedial action was completed in 1999 under an EE/CA (Ref. 13) and is discussed in Section 4.2.3.7. The *Southeast Drainage Closeout Report: Vicinity Properties DA4 and MDC7* (Ref. 20) includes details of the remediation and the post-cleanup risk assessment.

Quarry Residual Operable Unit: The remedy for the Quarry Residuals Operable Unit is expected to be protective of human health and the environment upon completion. This response action follows up the Quarry Bulk Waste remedial action and constitutes the final remedy for the Quarry area. Residual contaminated soil has been removed from the quarry proper and backfilling of the quarry is underway, eliminating any remaining potential for exposure through direct contact with soil or waste material. Final reclamation of the quarry will be completed in 2002. In conjunction with this action, assessments were performed to evaluate the risks associated with potential exposure to contaminated surface water, sediments, and groundwater in the vicinity of the quarry. The results indicate that residual conditions in the quarry area are protective of public health and the environment under current and reasonably anticipated future uses. Although not a threat under existing conditions, the contaminated groundwater is in proximity to a drinking water source, and long-term monitoring will be performed to assure conditions remain protective.

An evaluation of the ARARs, which is included in Section 6, has determined that there have been no changes in the standards identified in the *Quarry Residuals ROD* (Ref. 32) as ARARs that bear on the protectiveness of the remedy. The *Quarry Residuals ROD* identifies the proposed Safe Drinking Water Act maximum contaminant level (MCL) for uranium as TBC for the usable and potentially usable groundwater. Since the *Quarry Residuals ROD*, the uranium standard has been finalized; however, this change has no material effect on the determination made in the ROD.

Groundwater Operable Unit: The final remedy for the Groundwater Operable Unit has not been selected at this time. The status of this operable unit is discussed in Section 4.4. A remedial action for trichloroethylene (TCE) treatment under an interim ROD (Ref. 4) is in the

design stages with actual field work planned for the fall of 2001. To support the final GWOU ROD, a study of pump-and-treat technology with artificial recharge has been completed. The results will lead to the final ROD for the site groundwater operable unit.

The potential threats to public health are based on hypothetical exposure through usage of groundwater as drinking water. The groundwater is protective of human health and the environment under current and expected use. If contaminants remain in the groundwater above health-based levels, use will be restricted and long-term monitoring and surveillance will be conducted.

8. REFERENCES

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EIC # 90499

MK-Ferguson Company
Weldon Spring Site Remedial Action Project

TRANSMITTAL OF CONTRACT DELIVERABLE

Date: AUGUST 30, 2001 Transmittal No.: CD- 0264 - 00

Title of Document: WSSRAP SECOND FIVE YEAR REVIEW

Doc. Num.: 891 Rev. No.: 0 Date of Document: AUGUST 2001

Purpose of Transmittal: Request for Department of Energy acceptance of contract deliverable.

In compliance with the Project Management Contract, MK-Ferguson Company hereby delivers the attached document to the U.S. Department of Energy, Weldon Spring Site Office. The document has been reviewed and approved by Project Management Contractor management.

The document will be considered accepted unless we receive written notification to the contrary within 30 days of the date of this transmittal.

Number of copies transmitted: 1

Douglas E. Steffen
Project Director

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