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# WELDON SPRING SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1998

WELDON SPRING SITE REMEDIAL ACTION PROJECT  
WELDON SPRING, MISSOURI

**JULY 1999**

**REV. 0**

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

Prepared by MK-Ferguson Company and Jacobs Engineering Group



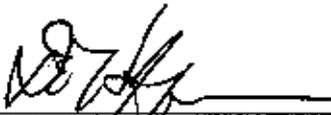
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Weldon Spring Site Remedial Action Project  
 Contract No. DE-AC05-86OR21548

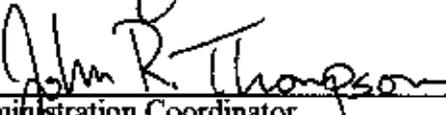
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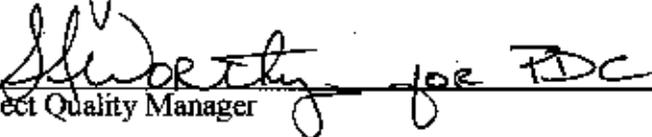
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## EXECUTIVE SUMMARY

This *Weldon Spring Site Environmental Report for Calendar Year 1998* has been prepared to provide information about the public safety and environmental protection programs conducted by the Weldon Spring Site Remedial Action Project (WSSRAP). The Weldon Spring site is located in southern St. Charles County, Missouri, approximately 48 km (30 mi) west of St. Louis. The site consists of two main areas, the Weldon Spring Chemical Plant and raffinate pits and the Weldon Spring Quarry. The chemical plant, raffinate pits, and quarry are located on Missouri State Route 94, southwest of U.S. Route 40/61.

The objective of the *Site Environmental Report* are to present a summary of data from the environmental monitoring program, to identify trends and characterize environmental conditions at the site, and to confirm compliance with environmental and health protection standards and requirements. The report also presents the status of remedial activities and the results of monitoring these activities to assess their impacts on the public and environment.

This report includes monitoring data from route radiological and nonradiological sampling activities and summarizes special environmental study findings. These data include estimates of dose to the public from the Weldon Spring site, estimates of effluent releases, and trends in groundwater contaminant levels. Additionally, applicable compliance requirements, quality assurance programs, and special studies conducted in 1998 to support environmental protection programs are discussed.

Dose estimates presented in this report are based on hypothetical exposure scenarios for public use of areas near the site. In addition, release estimates have been calculated on the basis of 1998 National Pollutant Discharge Elimination System (NPDES) and air monitoring data. Effluent discharges from the site under routine NPDES and National Emission Standards for Hazardous Air Pollutants (NESHAPs) monitoring were below permitted levels for radionuclides.

## MONITORING OVERVIEW

WSSRAP environmental management programs are designed to ensure that releases from the site are at levels demonstrably and consistently "as low as reasonably achievable" (ALARA). The ALARA principle drives the work activities related to site remediation and contaminant cleanup programs under U.S. Environmental Protection Agency (EPA) enforcement of the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA).

Effluent and environmental monitoring programs provide early detection of contaminants, assessment of potential impacts to the environment, and data needed to implement the ALARA strategy. Routine monitoring also demonstrates compliance with applicable State and Federal permits and regulations.

## REGULATORY COMPLIANCE

The Weldon Spring site is listed on the National Priorities List (NPL) and is governed by the CERCLA. Under the CERCLA, the WSSRAP is subject to meeting or exceeding applicable or relevant and appropriate requirements of Federal, State, and local laws. Primary regulations include the *Resource Conservation and Recovery Act (RCRA)*, *Clean Water Act (CWA)*, *Clean Air Act (CAA)*, *Toxic Substances Control Act (TSCA)*, the *National Historic Preservation Act (NHPA)* and, because the U.S. Department of Energy (DOE) is the lead agency for the site, the incorporation of the *National Environmental Policy Act (NEPA)* values into CERCLA documents as outlined in the Secretarial Policy statement on NEPA.

The Weldon Spring Quarry Residuals Operable Unit record of decision was officially completed in September 1998 with the submission of the *Record of Decision for the Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site, Weldon Spring, Missouri* to the U.S. Environmental Protection Agency, Region VII.

Phase I of the disposal cell was completed in early 1998 and waste placement activities commenced in March 1998. A total of 701,656 cu yd of material was placed in the cell through December 1998. Phase II of the disposal cell was substantially complete in 1998.

Full-scale chemical stabilization/solidification (CSS) plant construction was completed in February 1998. On November 13, 1998, the CSS plant completed dredging and processing sludge from the raffinate pits. Approximately 122,000 cu yd of sludge were treated through the CSS and piped directly to the cell as grout.

Treatment of the site treatment plan mixed waste inventory at the WSSRAP was completed in October 1998.

In November, six containers of RCRA waste were shipped to ENSCO for treatment and disposal.

Nine NPDES permit exceedences occurred in 1998. Site storm water exceeded permitted limits three times, once for pH and twice for settleable solids. Hydrostatic test water from CSS construction exceeded permitted limits four times, once for pH and three times for TSS. In addition, the sewage treatment plant effluent was out of compliance two times for fecal coliform during 1998.

## MONITORING SUMMARY

Environmental monitoring data showed that dose estimates were below the DOE guidelines of 100 mrem (1 mSv) annual total effective dose equivalent for all exposure pathways. NESHAPs air monitoring results for radioactive air particulates showed that dose estimates were all well below the NESHAPs standard of 10 mrem (0.1 mSv) per year. The 1998 Rn-220 and Rn-222 total release estimate were 14.2 Ci (5.3E11 Bq) and 2.8 Ci (1.0E11 Bq), respectively.

Release estimates for total uranium in water (which include storm water and water from the treatment plants) increased slightly from the 1997 release estimate of 0.015 Ci (5.6E8 Bq) to 0.016 Ci (5.9E8 Bq) in 1998; however, the annual release of total uranium for 1998 is a 95% reduction of the 1987 annual estimate. Effluent releases were below the DOE derived concentration guide level of 600 pCi/l. Data from groundwater and surface water monitoring indicated no measurable impact on drinking water sources from Weldon Spring site contaminants.

### Dose Estimates

In 1998, the maximum total effective dose equivalent to a hypothetical individual employed full-time at the Weldon Spring Ordnance Works (WSOW) remediation project was 7.6 mrem (0.076 mSv). This scenario assumed an individual working near the western perimeter of the WSSRAP 2,000 hours/year. The total effective dose equivalent to a maximally exposed individual at the vicinity properties from consumption of water was 0.62 mrem (6.2E-3 mSv). This scenario assumed an individual walking past Burgermeister Spring once per week and drinking one cup (0.237 l) of spring water each visit. These estimates are below the DOE guideline of 100 mrem (1 mSv) annual total effective dose equivalent for all exposure pathways. By comparison, the annual total effective dose equivalent in the United States due to naturally occurring sources of radioactivity is approximately 300 mrem (3 mSv).

The collective population effective dose equivalent for the population assumed to frequent the Busch Memorial Conservation Area and employees of the Missouri Highway and Transportation Department (MHTD) facility, WSOW remediation project, and WSSRAP administration building was 1.43 person-rem (0.0143 person-Sv). The Busch Conservation Area estimate was based on an affected population of 160,000 persons assumed to have potential for exposure through ingestion of fish, water, sediments. The WSOW worker estimate was based upon an assumption of 150 workers exposed to above background levels of Rn-220 gas, radioactive airborne particulates, and gamma radiation. The MHTD estimate was based on a staff of nine full-time employees exposed to above-background levels of radioactive airborne particulates and gamma radiation. The WSSRAP administration building estimate was based on a staff of 300 employees being exposed to elevated concentrations of radioactive airborne particulates.

### Air Monitoring

During 1998, airborne releases from the Weldon Spring Chemical Plant area included Rn-220, Rn-222 gas, their progeny, and radioactive airborne particulates. Radioactive airborne particulates were assumed to include Ra-226, Ra-228, Th-228, Th-230, Th-232, and total uranium.

The estimated off-site Rn-220 and Rn-222 releases were 14.2 Ci (5.2E11 Bq) and 2.8 Ci (1.0E11 Bq), respectively. Statistical analysis of integrated radon track etch data indicates that the concentrations at one perimeter and one interior station near the raffinate pits were greater than background levels. Statistical analysis of modified track etch detector data indicates that two stations at the raffinate pits, and four stations along the chemical plant perimeter exceeded background levels of Rn-220. All track etch results were below the derived concentration guide (DCG) for Rn-222 and Rn-220 of 3 pCi/l (0.11 Bq/l).

The results of NESHAPs monitoring for radioactive particulate indicated that all doses to the public at critical receptor locations were, at the 95% confidence level, less than the NESHAPs standard of 10 mrem (0.1 mSv) per year. Critical receptor locations included the Missouri Highway Maintenance Facility, Busch Memorial Conservation Area, Francis Howell High School and Annex, the WSSRAP administration building, the nearest quarry residence, and the Department of the Army Weldon Spring Training Area (Figure 6-1). Statistical analysis of NESHAPs monitoring results indicated that all stations were indistinguishable from background.

All environmental asbestos monitoring results were below the EPA limit of 0.01 fiber/ml. Asbestos monitoring was conducted in 1998 at Francis Howell High School and three site perimeter stations.

### NPDES Monitoring

In 1998, surface water runoff at the chemical plant transported uranium from the site through six major discharge routes that are identified in Section 7 of this report. Radionuclide release estimates were calculated on the basis of the activity of uranium. The estimate of uranium released to water was 7.94E-4 Ci (2.9E7 Bq) (0.1 g) for U-234, 3.73E-4 Ci (1.4E7 Bq) (170 g) for U-235, and 7.87E-4 Ci (2.9E7 Bq) (24 kg) for U-238. Section 11, Special Studies, provides additional details regarding release of uranium in surface water.

Annual average uranium concentrations decreased at storm water Outfalls NP-0003 and NP-0005. The decrease at NP-0005 is attributable to natural variations in precipitation and substantial remediation of the watershed. The reduction at Outfall NP-0003 is due to the management of discharges from Ash Pond and the removal of contaminated materials from Ash Pond during 1998. Annual averages increased at Outfalls NP-0002 and NP-0010. The slight increases are attributable to natural variations and precipitation patterns. Outfalls NP-0004 and

NP-0005 were added to the permit during 1998 so there is no past relevant data for comparison purposes.

Missouri River sediment was monitored during 1998 in support of site and quarry water treatment plant operations. Sediment samples were taken from the river both up and downstream of the treatment plant discharges and analyzed for uranium. The sample results indicate that the treatment plant discharges have caused no increase in uranium concentrations in river sediment.

### Surface Water

Surface water monitoring in 1998 indicated that contaminant concentrations were within historic ranges. No nitroaromatic compounds have been detected at the Femme Osage Slough in the last three years; thus nitroaromatic monitoring will cease at the slough locations.

### Groundwater

The groundwater monitoring program included extensive monitoring for radiological and chemical compounds. Radiological results for the St. Charles County well field remained within background levels. No detectable concentrations of the six nitroaromatic compounds of concern were found in groundwater monitoring wells south of the Femme Osage Slough, including the well field, which is near the quarry.

Environmental groundwater monitoring indicates that nitroaromatic and uranium contamination is still present in the bedrock of the quarry rim and in the alluvial materials and bedrock north of the Femme Osage Slough. Most sample locations near the quarry continue to show decreases in nitroaromatic compounds and radiological parameters since the 1995 completion of quarry bulk waste removal.

During 1998, chemical plant groundwater total uranium, nitrate, and nitroaromatic compound concentrations remained within historic ranges at most monitoring locations. All contaminant transport at the site continues to be confined to the uppermost, weathered portion of the bedrock aquifer. Six monitoring locations north of Raffinate Pits 3 and 4 and in the Ash Pond vicinity had elevated total uranium and nitrate concentrations. These are likely temporary responses to remediation activities in the raffinate pits and Ash Pond. Trichloroethene levels are dropping at several locations south of Raffinate Pits 3 and 4. A special study was conducted in this area during 1998.

Biological

The U.S. Department of Energy (DOE) has completed the second year of wetland monitoring at the DOE-funded mitigation wetland complex located on the August A. Busch Conservation area. Monitoring of this wetland will continue through 1999. Total uranium monitoring results for sunfish collected from Busch Lakes 33 and 35 were well within background ranges.

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*Weldon Spring Site Remedial Action Project*

Weldon Spring Site Environmental Report for Calendar Year 1998

Revision 0

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Oak Ridge Operations Office  
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## ABSTRACT

This *Site Environmental Report for Calendar Year 1998* describes the environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). The objectives of these programs are to assess actual or potential exposure to contaminant effluents from the project area by providing public use scenarios and dose estimates, to demonstrate compliance with Federal and State permitted levels and regulations, and to summarize trends and/or changes in contaminant concentrations identified through environmental monitoring.

In 1998, the maximum total effective dose equivalent (TEDE) to a hypothetical individual who was employed full-time at the nearby Weldon Spring Ordnance Works (WSOW) remediation project was 7.6 mrem (0.076 mSv). The maximum TEDE to a hypothetical individual who frequents the Weldon Spring Vicinity Properties was 0.62 mrem (6.2E-3 mSv). These estimates are below the U.S. Department of Energy requirements of 100 mrem (1 mSv) annual total effective dose equivalent for all exposure pathways.

The combined collective population dose equivalent for the population assumed to frequent the Busch Memorial Conservation Area (160,000 individuals) and employees of the MHTD facility (nine individuals) and WSSRAP administration building (300 individuals) was 1.43 person-rem (1.43E-2 person-Sv). Results from radiological air monitoring for the National Emission Standards for Hazardous Air Pollutant (NESHAPs) program indicated that all estimated total effective dose equivalents were less than the U.S. Environmental Protection Agency (EPA) standard of 10 mrem (0.1 mSv) per year.

Comprehensive monitoring indicated that emissions of radiological compounds in airborne and surface discharges from the Weldon Spring site consisted primarily of Rn-220 gas, Rn-222 gas, isotopes of thorium and radium and natural uranium. Airborne Rn-220 and Rn-222 emissions were estimated to be 14.2 Ci (5.2E11 Bq) and 2.8 Ci (1.0E11 Bq), respectively. There was no measurable impact to any drinking water source from radionuclides.

Concentration limits are set for water pollutants in the NESDES permits. Parameters were in compliance with the permit limits except on nine occasions. The pH limit was exceeded twice and the settleable solids limit was exceeded five times. There were also two exceedences of the fecal coliform limit at NP-0006 (sewage treatment plant) during 1998.

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## 1. INTRODUCTION

The Weldon Spring Site Remedial Action Project (WSSRAP) is part of the U.S. Department of Energy (DOE) Environmental Restoration Program, one of the remedial action programs under the direction of the DOE Office of Environmental Management. This *Weldon Spring Site Environmental Report for Calendar Year 1998* summarizes the environmental monitoring results obtained in 1998 and presents the status of Federal and State compliance activities.

DOE requirements for environmental monitoring and protection of the public, the mandate for this document, are designated in DOE Order 5400.1, *General Environmental Protection Program*; DOE Order 5400.5, *Radiation Protection of the Public and Environment*, and the implementation guide for DOE Order 5400.5, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*.

In 1998, environmental monitoring activities were conducted to support remedial action under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA), the *Clean Air Act* (CAA), the *National Environmental Policy Act* (NEPA), the *Clean Water Act* (CWA), and other applicable regulatory requirements. The monitoring program at the WSSRAP has been designed to protect the public and to evaluate the effects on the environment, if any, from remediation activities.

The purposes of the *Weldon Spring Site Environmental Report for Calendar Year 1998* include:

- Providing general information on the WSSRAP and the current status of remedial activities.
- Presenting summary data and interpretations for the 1998 environmental monitoring program.
- Providing information regarding ongoing remedial actions.
- Reporting compliance with Federal, State, and local requirements and DOE standards.
- Providing dose estimates for radiological compounds as appropriate for the WSSRAP.

- Summarizing trends and/or changes in contaminant concentrations to support remedial actions, ensure public safety, and maintain surveillance monitoring requirements.

### 1.1 Site Description

The Weldon Spring site is located in southern St. Charles County, Missouri approximately 48 km (30 mi) west of St. Louis (Figure 1-1). The 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 site and quarry is restricted by locked chain link fences with on-site security.

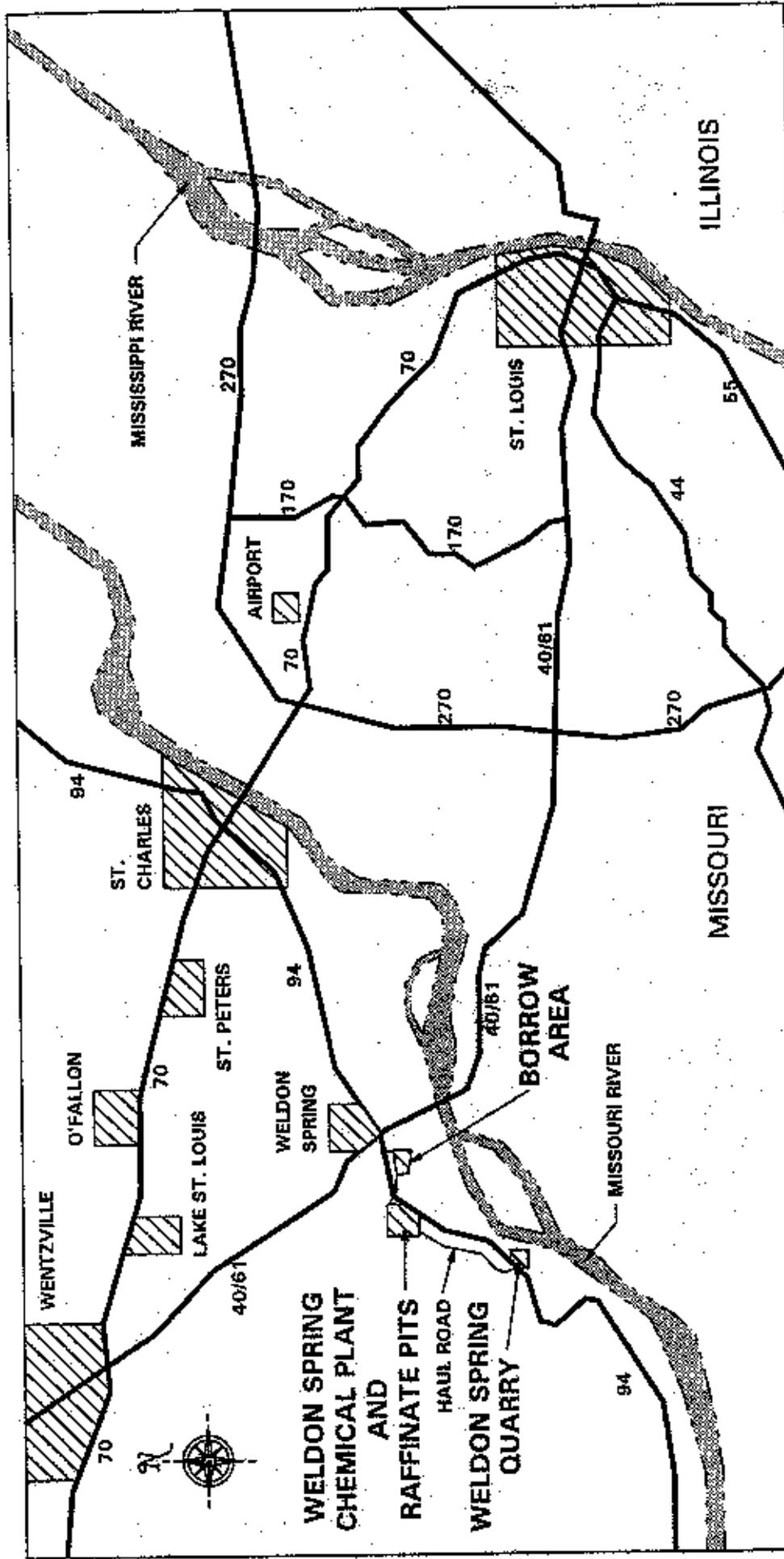
The Weldon Spring Chemical Plant is a 67.2 ha (166 acre) area that operated as the Weldon Spring Uranium Feed Materials Plant (WSUFMP) until 1966. Buildings were contaminated with asbestos, hazardous chemical substances, uranium, and thorium. (Building dismantlement was completed in 1994.) Radiological and chemical (polychlorinated biphenyls [PCBs], nitroaromatic compounds, metals and inorganic ions) contaminants can also be found in the soil in several areas around the site. The raffinate pits are located on the chemical plant site and consist of four settling basins that cover approximately 10.5 ha (26 acres) (Figure 1-2). These pits are radiologically contaminated with uranium and thorium residues and chemical contaminants including nitrate, fluoride, PCBs, and various heavy metals.

The Weldon Spring Quarry is a former 3.6 ha (9 acre) limestone quarry located south-southwest of the chemical plant area (Figure 1-3). The quarry is essentially a closed basin; surface water within the rim flows to the quarry floor and into a sump. The amount of water in the sump varies in response to quarry water treatment plant operations and precipitation. The quarry bulk waste removal operation was completed in 1995. The bulk waste contained radiological and chemical contaminants including uranium, radium, thorium, metals, nitrates, PCBs, semivolatile organic compounds, nitroaromatics, and asbestos.

### 1.2 Site History

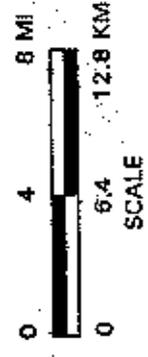
From 1941 to 1945, the U.S. Department of the Army produced trinitrotoluene (TNT) and dinitrotoluene (DNT) at the Weldon Spring Ordnance Works, which covered 6,974 ha (17,233 acres) of land that now includes the Weldon Spring site. By 1949, all but about 809 ha (2,000 acres) had been transferred to the State of Missouri (August A. Busch Memorial Conservation Area) and to the University of Missouri (agricultural land). Except for several small parcels transferred to St. Charles County, the remaining property became the Army training area.

Through a Memorandum of Understanding between the Secretary of the Army and the General Manager of the Atomic Energy Commission (AEC), 83 ha (205 acres) of the former

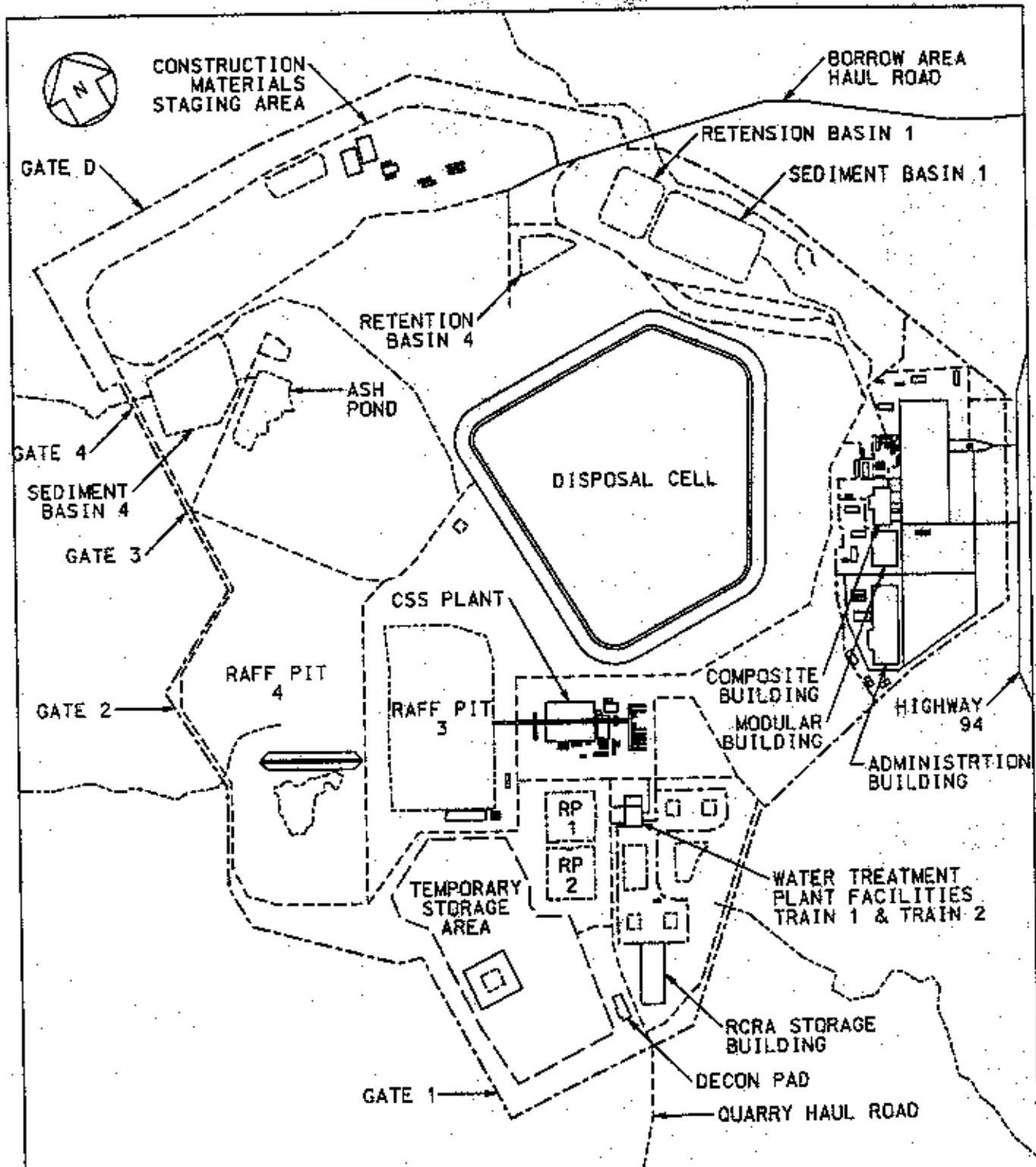


LOCATION OF THE WELDON SPRING SITE

FIGURE 1-1

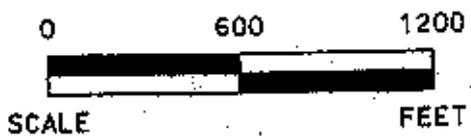


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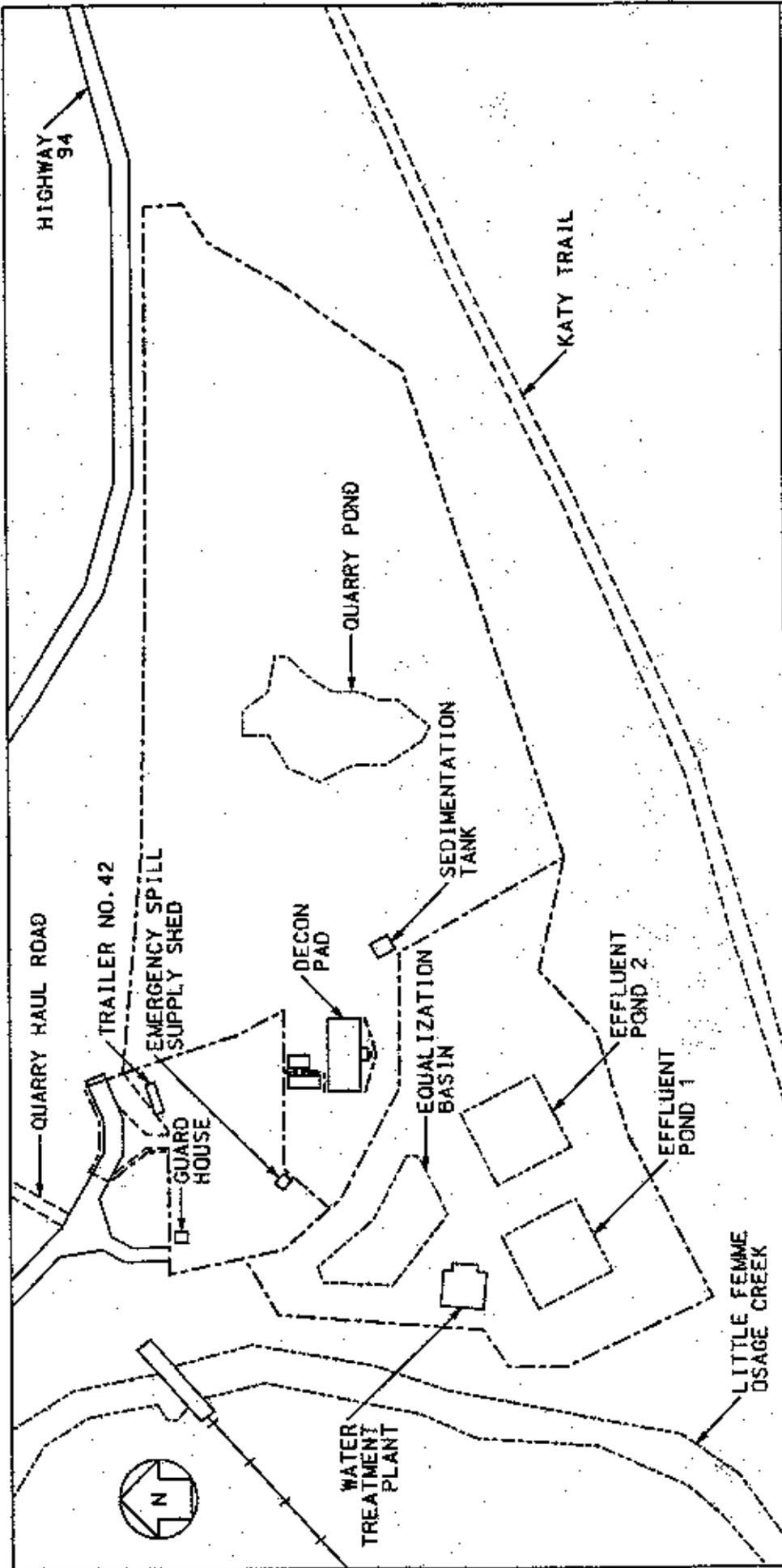


WELDON SPRING CHEMICAL PLANT  
AND RAFFINATE PIT AREAS

FIGURE 1-2



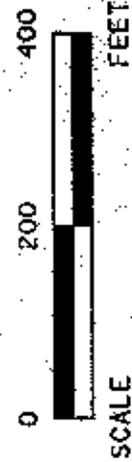
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WELDON SPRING QUARRY AREA

FIGURE 1-3

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	DATE: 5/3/99



ordnance works property were transferred in May 1955 to the 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 the Atlas Powder Company and the Army prior to WSUFMP construction. 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 was also processed. Wastes generated during these operations were stored in the four raffinate pits.

In 1958, the AEC acquired title to the Weldon Spring Quarry from the Army. The Army had used it since 1942 for burning wastes from the manufacture of TNT and DNT and disposal of TNT-contaminated rubble during the operation of the ordnance works. Prior to 1942, the quarry was mined for limestone aggregate used in the construction of the ordnance works. The AEC used the quarry from 1963 to 1969 as a disposal area for uranium residues and a small amount of thorium residue. Material disposed of in the quarry during this time consisted of building rubble and soils from the demolition of a uranium ore processing facility in St. Louis. These materials were contaminated with uranium and radium. Other radioactive materials in the quarry include drummed wastes, uncontained wastes, and contaminated process equipment.

The WSUFMP was shut down in 1966, and in 1967 the AEC returned the facility to the Army for use as a defoliant production plant to be known as the Weldon Spring Chemical Plant. The Army started removing equipment and decontaminating several buildings in 1968. However, the defoliant project was canceled in 1969 before any process equipment was installed. The Army retained responsibility for the land and facilities of the chemical plant, but the 20.6 ha (51 acre) tract encompassing the Weldon Spring raffinate pits was transferred back to the AEC.

The Weldon Spring site was placed in caretaker status from 1981 through 1985, when custody was transferred from the Army to the Department of Energy. In 1985, the DOE proposed designating control and decontamination of the chemical plant, raffinate pits, and quarry as a major project. A Project Management Contractor (PMC) for the Weldon Spring Site Remedial Action Project was selected in February 1986. In July 1986, a DOE project office was established on site, and the PMC, MK-Ferguson 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.

A more detailed presentation of the production, ownership, and waste history of the Weldon Spring site is available in the *Remedial Investigation for Quarry Bulk Wastes* (Ref. 1) and the *Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site* (Ref. 2).

### 1.3 Geology and Hydrogeology

The Weldon Spring site is situated near the boundary between the Central Lowland and the Ozark Plateau physiographic provinces. This boundary nearly coincides with the southern edge of Pleistocene glaciation that covered the northern half of Missouri over 10,000 years ago (Ref. 3).

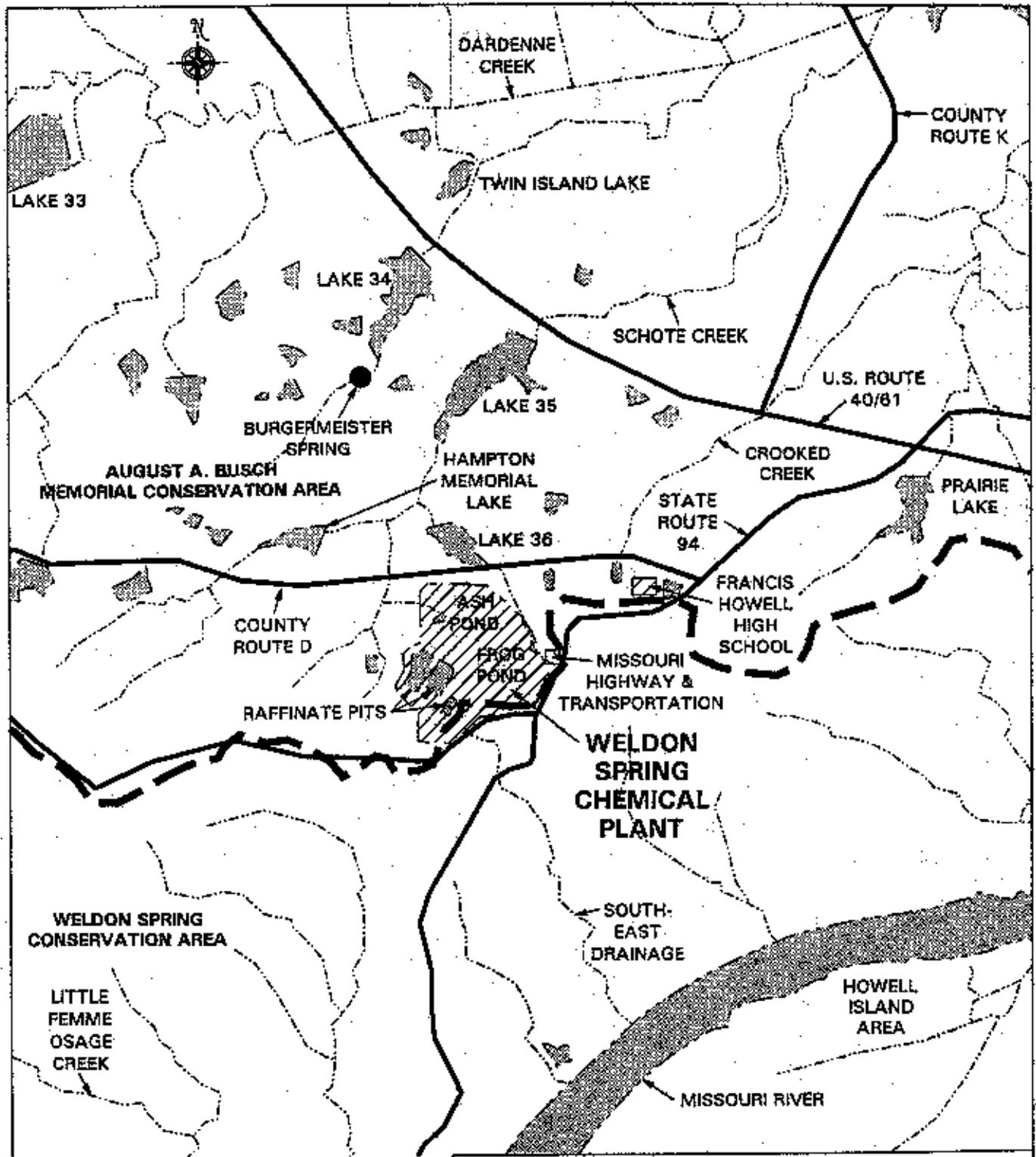
The uppermost bedrock units underlying the Weldon Spring Chemical Plant are the Mississippian Burlington and Keokuk Limestone. Overlying the bedrock are unlithified units consisting of fill, top soil, loess, glacial till and limestone residuum of thicknesses ranging from a few feet to several tens of feet.

There are three bedrock aquifers underlying St. Charles County. The shallow aquifer consists of Mississippian Limestones and the middle aquifer consists of the Ordovician Kimmswick Limestone. The deep aquifer includes formations from the top of the Ordovician St. Peter Sandstone to the base of the Cambrian Potosi Dolomite. Alluvial aquifers of Quaternary age are present near the Missouri and Mississippi Rivers.

The Weldon Spring Quarry is located in low limestone hills near the northern bank of the Missouri River. The mid-Ordovician bedrock of the quarry area includes in descending order, the Kimmswick Limestone, Decorah Formation, and Platin Limestone. These formations are predominantly limestone and dolomite. Near the quarry, the carbonate rocks dip to the northeast at a gradient of 11 m/km to 15 m/km (58 ft/mi to 79 ft/mi) (Ref. 4). Massive quaternary deposits of Missouri River alluvium cover the bedrock to the south and east of the quarry.

### 1.4 Surface Water System and Use

The chemical plant and raffinate pits area is located on the Missouri-Mississippi River surface drainage divide (Figure 1-4). Elevations on the site range from approximately 185.4 m (608 ft) above mean sea level (msl) near the northern edge of the site to 205 m (673 ft) above msl near the southern edge. The topography of the site is gently undulating in the upland areas, typical of the Central Lowlands physiographic province. South of the site, the topography changes to the narrow ridges and valleys and short, steep streams common to the Ozark Plateau physiographic province (Ref. 3). There were eight surface water bodies at the chemical plant area during 1997: four raffinate pits, Ash Pond, Frog Pond, the chipped wood storage area pond, and the material staging area (MSA) pond. Portions of Ash Pond were capped in late 1994, and as a result, Ash Pond does not accumulate water unless the valve on the discharge structure is closed. The capacity of Frog Pond was permanently reduced in 1995 when the water level was lowered to allow remediation adjacent to the pond.



**LEGEND**

-  SURFACE WATER DIVIDE BETWEEN MISSISSIPPI RIVER AND MISSOURI RIVER
-  CREEK OR SURFACE DRAINAGE
-  POND OR LAKE



**PHYSICAL FEATURES OF WELDON SPRING AREA**

**FIGURE 1-4**

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No natural drainage channels traverse the site, although remnants of a channel through the Ash Pond area are present. Drainage from the southeastern portion of the site generally flows southward to a tributary referred to as the Southeast Drainage (5300 Drainageway) that flows to the Missouri River.

In the surrounding areas, man-made lakes in the August A. Busch Memorial Conservation Area are used for public fishing and boating. No swimming is allowed in the conservation area, although some may occur. No surface water is used for irrigation or as a public drinking water supply. The northern and western portions of the site, including the Frog Pond and Ash Pond areas, drain to tributaries of Busch Lakes and Schote Creek, which in turn enter Dardenne Creek, which ultimately drains to the Mississippi River.

Four sedimentation basins minimize the discharge of sediment from the site during remediation efforts. One basin is downstream of Ash Pond and collects Ash Pond runoff water as well as all waters that discharge at Outfall NP-0003 (see Section 7). A second basin collects most water from the northeast section of the site and discharges to Outfall NP-0002. The third basin collects water from the site water treatment plant area and discharges to Outfall NP-0005. The fourth is just upstream of NP-0010 and collects runoff from a portion of the CMSA.

The Weldon Spring Quarry is situated on a bluff of the Missouri River valley about 1.6 km (1 mi) northwest of the Missouri River at approximately River Mile 49. No direct surface water runoff enters or exits the quarry due to the topography of the area. A 0.07 ha (0.2 acre) pond within the quarry proper acts as a sump that accumulates both direct rainfall within the quarry and the groundwater. Past dewatering activities in the quarry suggest that the sump interacts directly with the local groundwater. Bulk waste removal, which included removal of some sediment from the sump area, was completed at the quarry during 1995. The surface area of the sump remains at 0.07 ha (0.2 acres). The quarry pond is not used for any operational or public water supply and is maintained by the DOE within an access-controlled and restricted area.

The Femme Osage Slough, located approximately 213 m (700 ft) south of the quarry, is a 2.4 km (1.5 mi) section of the original Femme Osage Creek and Little Femme Osage Creek. The University of Missouri dammed portions of the creeks between 1960 and 1963 during construction of a levee system around the University's experimental farms (Ref. 4). The slough receives contaminated groundwater migrating from the quarry, causing increased uranium concentrations in the slough. The slough is used for recreational fishing.

### 1.5 Ecology

The Weldon Spring site is surrounded primarily by State Conservation Areas that include the 2,828 ha (6,988 acre) Busch Conservation Area to the north, the 2,977 ha (7,356 acre) Weldon Spring Conservation Area to the east and south, and the Howell Island Conservation

Area, an island in the Missouri River which covers 1,031 ha (2,548 acres) (Figure 1-4). The wildlife areas are managed for multiple uses, including timber, fish and wildlife habitat, and recreation. Fishing comprises a relatively large portion of the recreational use. Seventeen percent of the area is open fields that are leased to sharecroppers for agricultural production. In these areas, a percentage of the crop is left for wildlife use. The main agricultural products are corn, soybeans, milo, winter wheat, and legumes (Ref. 5). The Busch and Weldon Spring Conservation Areas are open year-round, and the number of annual visits to both areas totals about 1,200,000.

The quarry is surrounded by the Weldon Spring Conservation Area, which consists primarily of forest with some old field habitat. Prior to bulk waste removal, the quarry floor consisted of old-field habitat containing a variety of grasses, herbs, and scattered wooded areas. Since bulk waste removal began this habitat has been disturbed. The rim and upper portions of the quarry still consist primarily of slope and upland forest including cottonwood, sycamore, and oak (Ref. 4).

## 1.6 Climate

The climate in the Weldon Spring area is continental with warm to hot summers and moderately cold winters. Alternating warm/cold, wet/dry air masses converging and passing through the area cause frequent changes in the weather. Although winters are generally cold and summers hot, prolonged periods of very cold or very warm to hot weather are unusual. Occasional mild periods with temperatures above freezing occur almost every winter and cool weather interrupts periods of heat and humidity in the summer (Ref. 6).

The National Oceanic and Atmospheric Administration has published the following information based on analysis of long-term meteorological records for the St. Louis area. Taking into account the past 30 years of data, the average annual temperature is 13.4 C (56.1°F). The average daily maximum and minimum temperatures are 18.6°C (65.4 F) and 8.2°C (46.7°F), respectively. Maximum temperatures above 32.2°C (90 F) occur 35-40 days per year. Minimum daily temperatures below 0°C (32 F) occur about 100 days of the year. Temperatures below -18°C (0°F) are infrequent, occurring only 2-3 days per year. Mean annual precipitation in the area is approximately 95.0 cm (37.5 in.).

Wind data recorded on site since 1994 indicate that prevailing winds are from the south and southwest. The average recorded wind speed is 2.9 m/s (6.6 mph) from the south-southwest.

The meteorological station located at the chemical plant provides data to support site environmental monitoring programs. The station provides data on wind speed, wind direction, ambient air temperature, relative humidity, solar radiation, barometric pressure, and precipitation accumulation. Data from this station are used to assess meteorological conditions and air transport and diffusion characteristics, which help determine possible impacts of airborne

contaminant releases. In addition, precipitation data are used to correlate water level fluctuations and contaminant concentrations in surface water and groundwater wells.

On-site meteorological data recovery exceeded 99% in 1998. The quality of all data was assured by a qualified off-site meteorologist. Averages and totals are presented in Table 1-1. An annual wind rose is presented as Figure 1-5. Figures 1-6 through 1-9 are wind roses for each quarter of 1998.

Table 1-1 Monthly Meteorological Monitoring Results for 1998

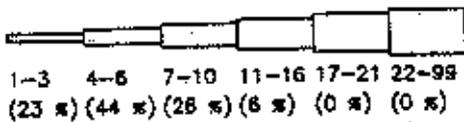
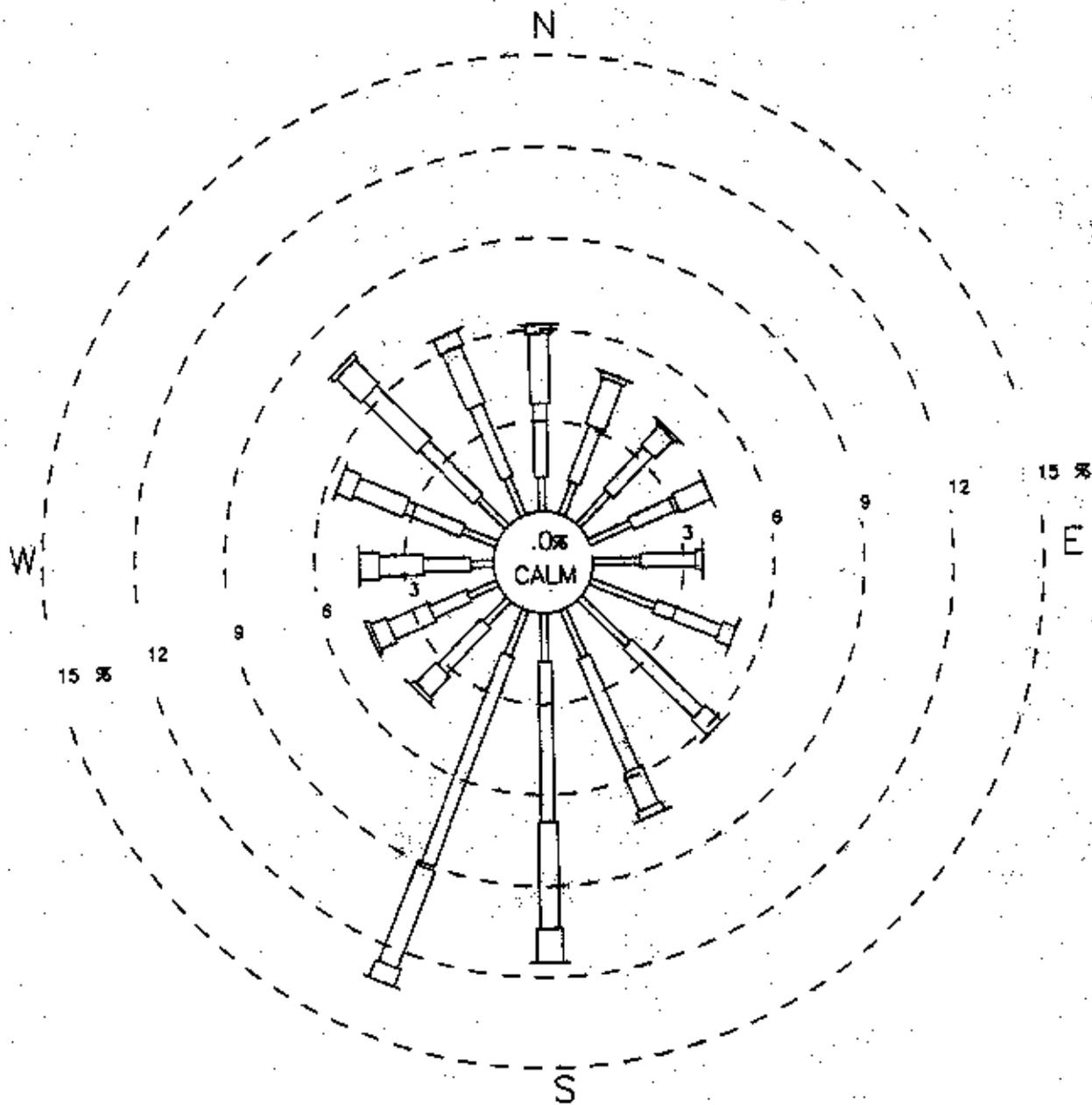
MONTH	TOTAL PRECIP (CM)	AVERAGE TEMP (DEGREES C)	AVERAGE WIND SPEED (M/SEC)	PREDOMINANT WIND DIRECTION
January	8.7	2.2	2.8	S
February	11.5	5.6	3.0	N
March	15.7	6.0	3.6	NW,S
April	10.8	12.9	3.5	NW
May	7.1	21.1	2.5	S
June	21.7	23.3	2.9	SSW
July	15.4	25.0	1.9	SSW
August	3.9	24.8	1.8	SSW
September	11.1	22.6	2.0	SSW
October	10.1	14.8	2.2	SSW
November	7.4	9.7	3.1	SSW
December	2.6	2.6	2.7	SSW
Annual Average/Total	126.0 (49.61 in.)	14.2 (57.6°F)	2.7 (5.99 mph)	SSW 12.8%

### 1.7 Land Use and Demography

The population of St. Charles County in 1997 was 264,275. Twenty percent of the population lives in the city of St. Charles, approximately 22.4 km (14 mi) northeast of the Weldon Spring site. The population in St. Charles County increased by 20% from 1990 to 1997. The two communities closest to the site are Weldon Spring and Weldon Spring Heights, about 3.2 km (2 mi) to the northeast. The combined population of these two communities in 1996 was 1,265. No private residences exist between Weldon Spring Heights and the site. Urban areas occupy about 6% of county land, and nonurban areas occupy 90%; the remaining 4% is dedicated to transportation and water uses (Appendix A).

Francis Howell High School (FHHS) and the Missouri Highway and Transportation Department (MHTD) Weldon Spring maintenance facility are both within 1 km (0.6 mi) of the site (Figure 1-4). Francis Howell High School is about 1 km (0.6 mi) northeast of the site along Missouri State Route 94. The school employs approximately 140 faculty and staff, and about 1,660 students attend school there (Appendix A). Students and staff generally spend about

# Wind Direction and Speed Distribution



WIND SPEED SCALE ( MPH )

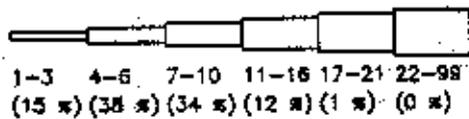
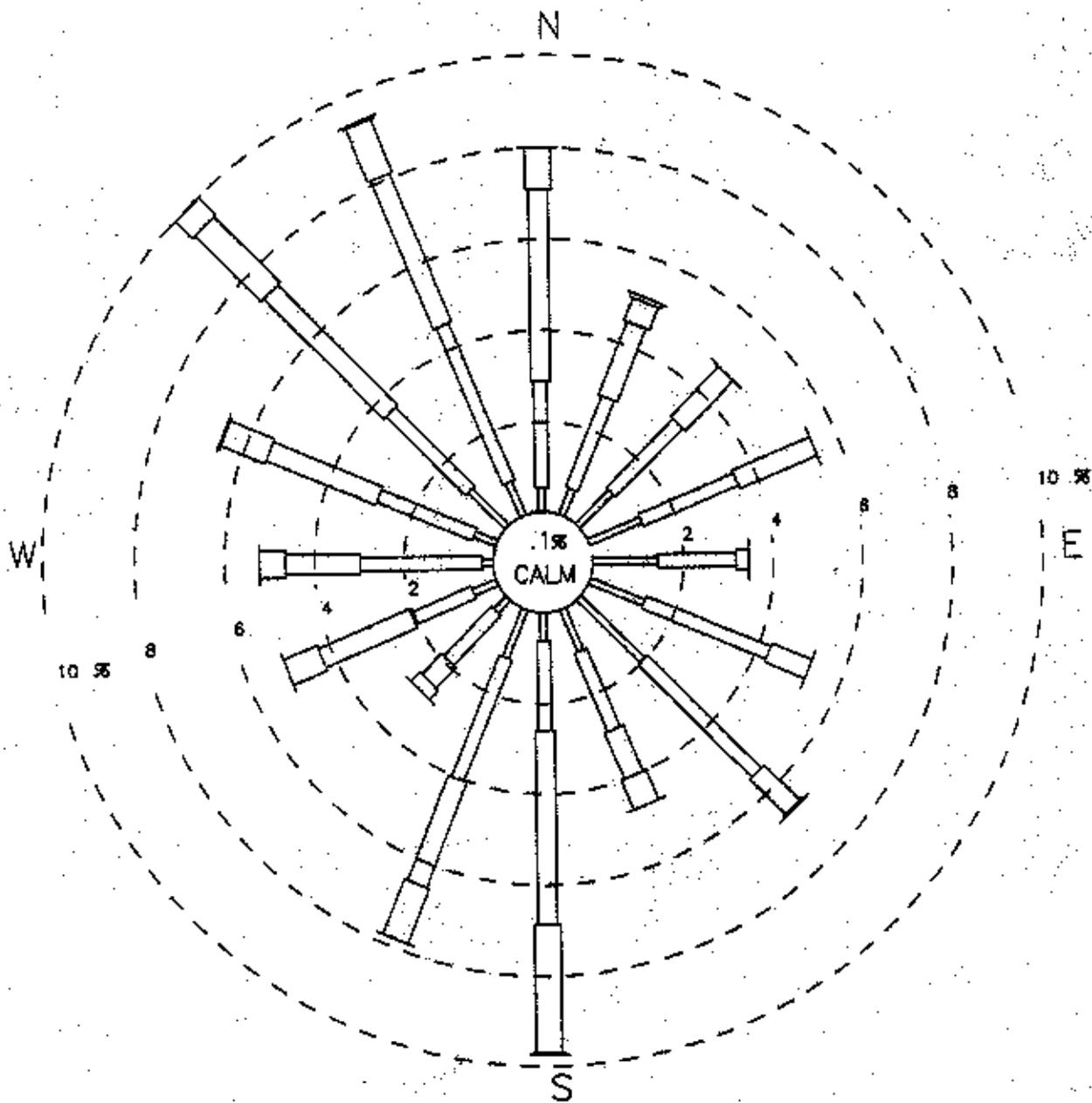
NOTE - WIND DIRECTION IS THE DIRECTION WIND IS BLOWING FROM

1998  
WINDROSE FOR THE  
WELDON SPRING SITE  
METEOROLOGICAL STATION

FIGURE 1-5

REPORT NO.:	DOE/OR/21548-773	PROJECT NO.:	A/PI/018/0498
ORIGINATOR:	TD	DRAWN BY:	GLN
		DATE:	5/4/99

# Wind Direction and Speed Distribution



WIND SPEED SCALE ( MPH )

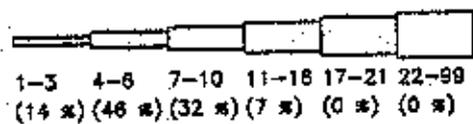
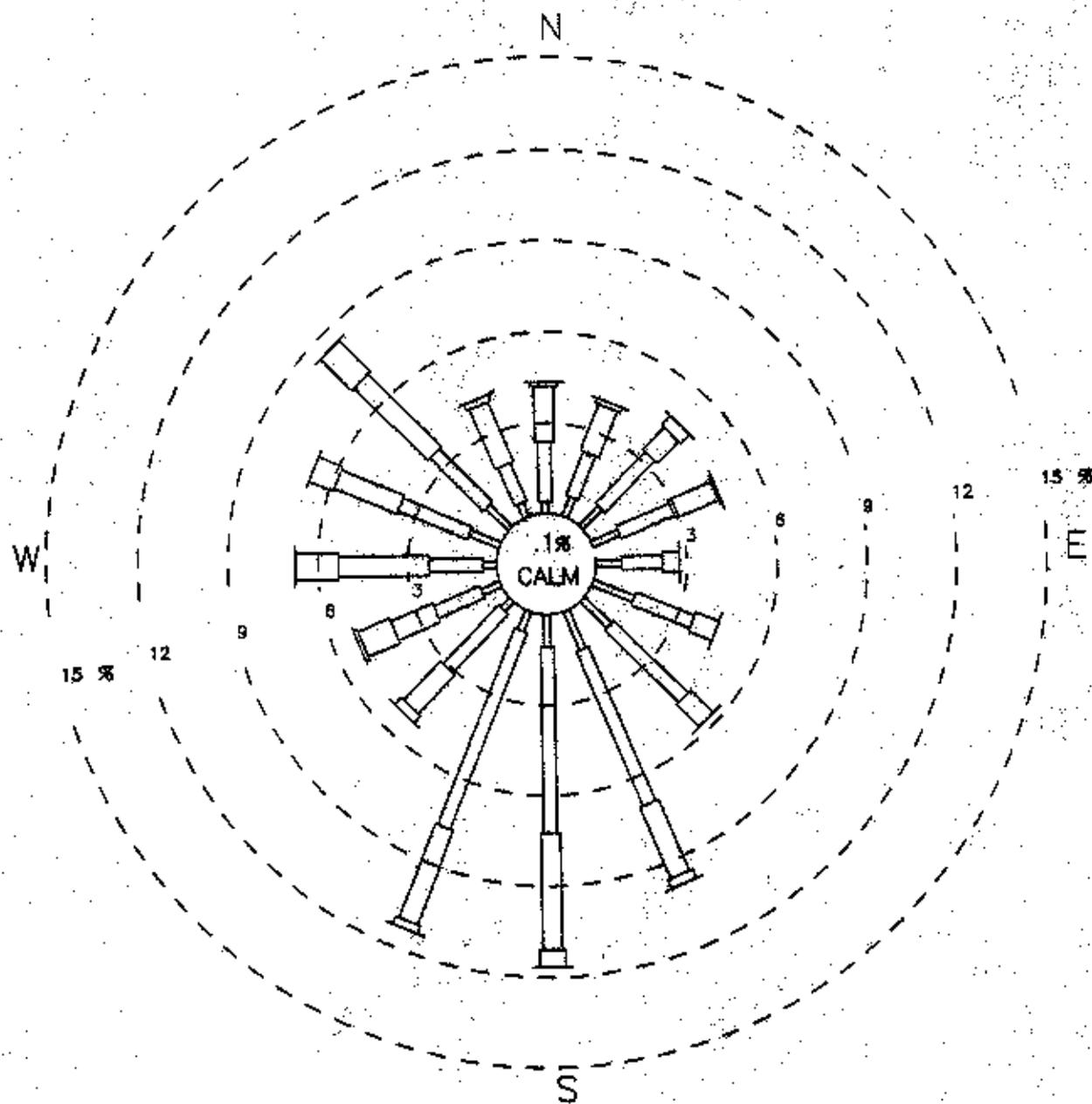
NOTE - WIND DIRECTION IS THE DIRECTION WIND IS BLOWING FROM

1st QUARTER 1998  
 WINDROSE FOR THE  
 WELDON SPRING SITE  
 METEOROLOGICAL STATION

FIGURE 1-6

REPORT NO.:	DOE/OR/21548-773	FIGURE NO.:	A/PI/003/0599
ORIGINATOR:	TD	DRAWN BY:	GLN
		DATE:	5/4/99

# Wind Direction and Speed Distribution



WIND SPEED SCALE ( MPH )

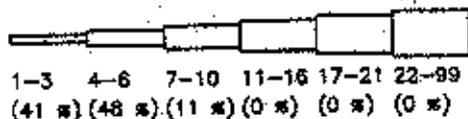
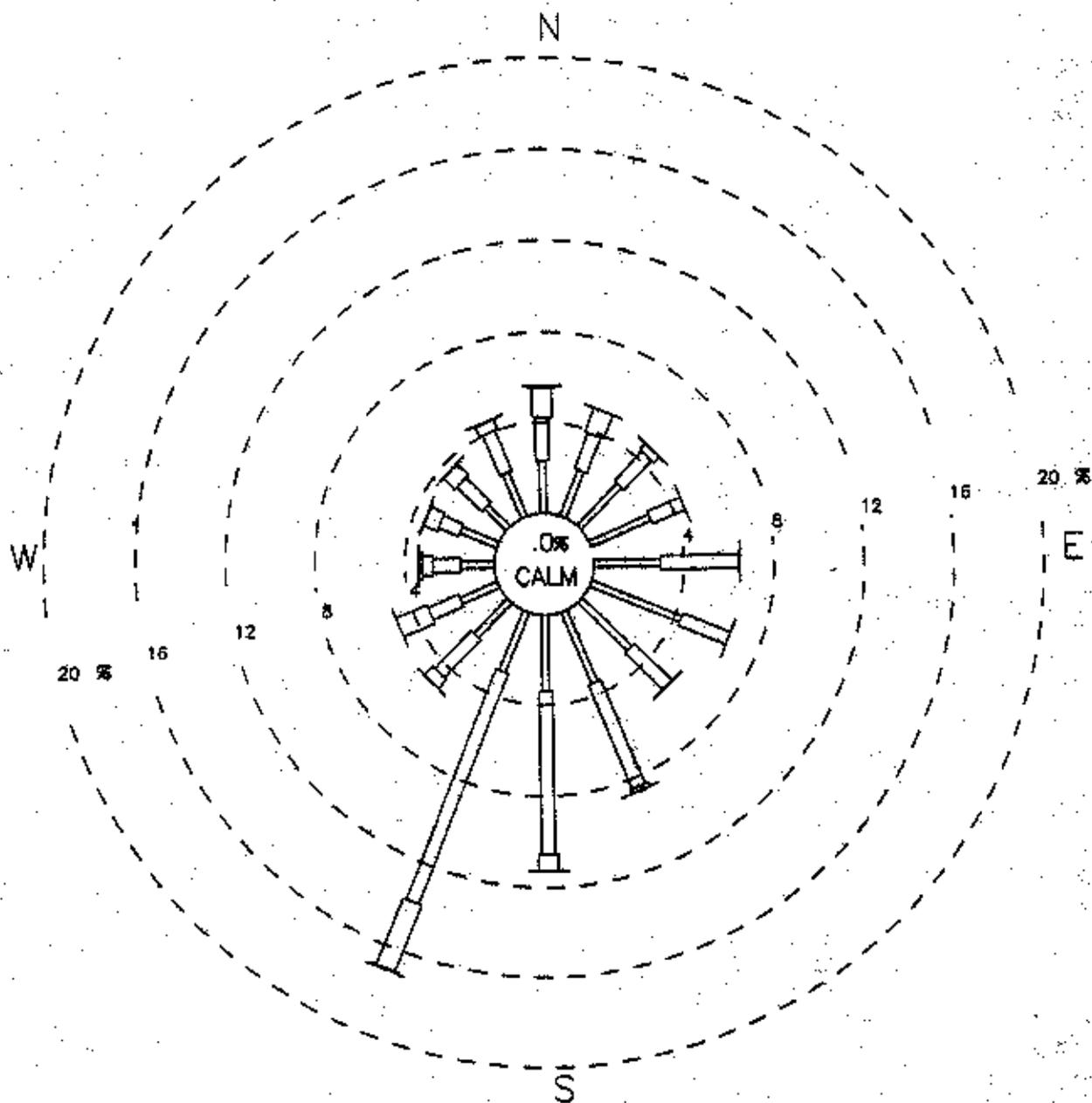
NOTE - WIND DIRECTION IS THE DIRECTION WIND IS BLOWING FROM

2nd QUARTER 1998  
 WINDROSE FOR THE  
 WELDON SPRING SITE  
 METEOROLOGICAL STATION

FIGURE 1-7

REPORT NO.:	DOE/OR/21548-773	ORDER NO.:	A/PI/004/0599
OPERATOR:	TD	DRAWN BY:	GLN
		DATE:	5/4/99

# Wind Direction and Speed Distribution



WIND SPEED SCALE (MPH)

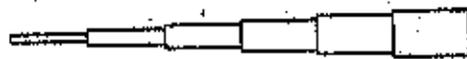
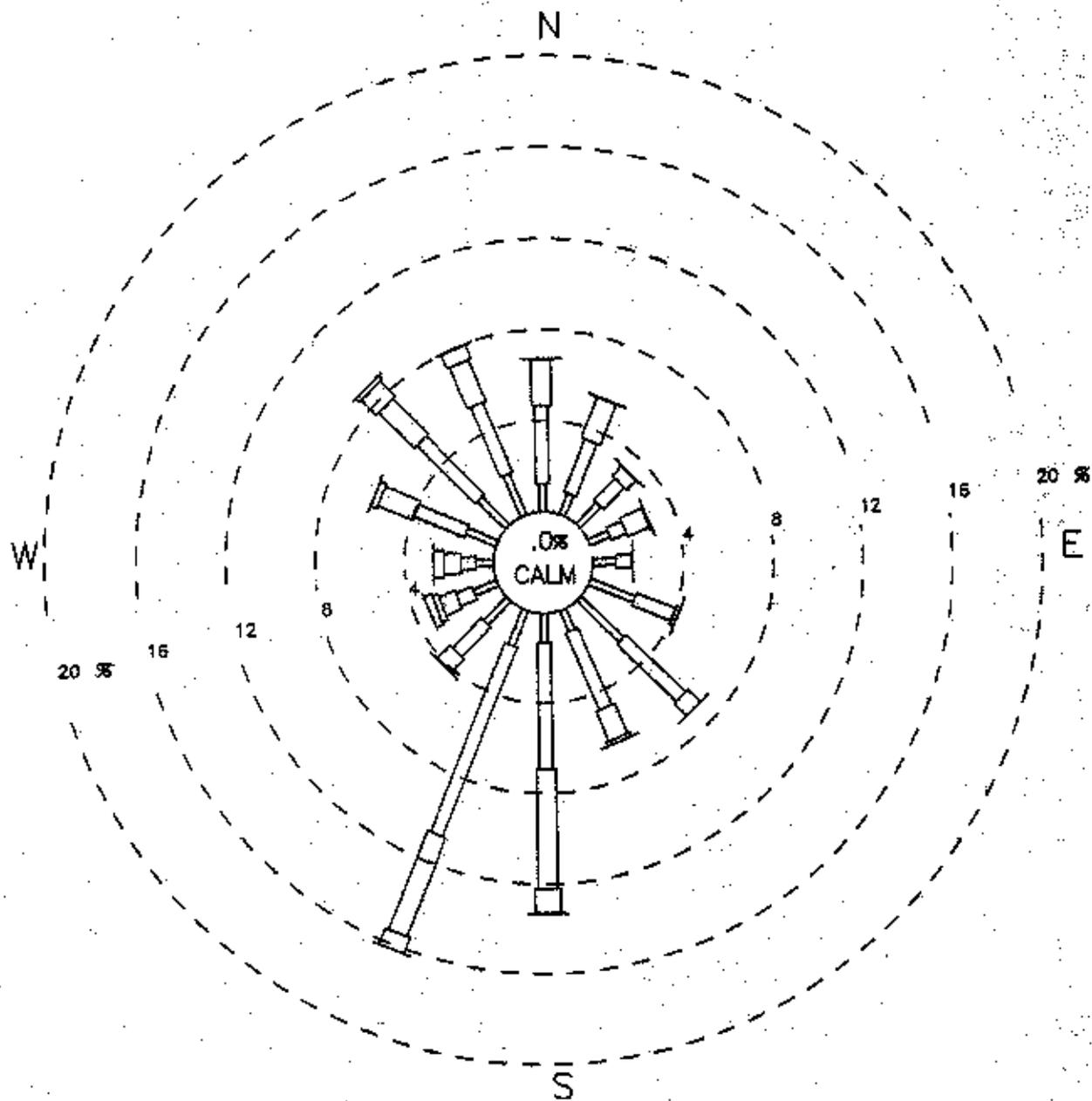
NOTE - WIND DIRECTION IS THE DIRECTION WIND IS BLOWING FROM

3rd QUARTER 1998  
 WINDROSE FOR THE  
 WELDON SPRING SITE  
 METEOROLOGICAL STATION

FIGURE 1-8

REPORT NO.:	DOE/OR/21548-773	EDDSET NO.:	A/PI/00B/0599
OPERATOR:	TD	DRAWN BY:	GLN
		DATE:	5/4/89

# Wind Direction and Speed Distribution



(23 %) (45 %) (28 %) (5 %) (1 %) (0 %)

WIND SPEED SCALE (MPH)

NOTE -- WIND DIRECTION IS THE DIRECTION WIND IS BLOWING FROM

4th QUARTER 1998  
WINDROSE FOR THE  
WELDON SPRING SITE  
METEOROLOGICAL STATION

FIGURE 1-9

REPORT NO.:	DOE/OR/21548-773	REPORT NO.:	A/PI/006/0599
ORIGINATOR:	TD	DRAWN BY:	GLN
		DATE:	5/4/99

7 hours to 8 hours per day, 36 weeks per year, at the school. At least 9 employees work at the school year-round. The buildings are also used for other activities, such as athletic events and school meetings. In addition, there were approximately 45 full-time employees worked at the high school annex during 1998. The MTFD facility, located adjacent to the north side of the chemical plant, employs nine full-time employees (Appendix A).

About 300 ha (741 acres) of land east and southeast of the high school is owned by the University of Missouri. The northern third of this land is being developed into a high-technology research park. The conservation areas adjacent to the WSSRAP are operated by the Missouri Department of Conservation and employ about 45 employees. The Army Reserve Training Area is located to the west of the WSSRAP and periodically visited by the Department of Army (DOA) trainees. One DOA full time employee works at the office on the reserve property. During 1998, approximately 130 to 150 subcontract workers were involved in remedial operations (Appendix A).

## 2. ENVIRONMENTAL PROTECTION/RESTORATION PROGRAM OVERVIEW

### 2.1 Project Purpose

The U.S. Department of Energy (DOE) is responsible for the remedial action activities at the Weldon Spring site. The project is known as the Weldon Spring Site Remedial Action Project (WSSRAP). The major goals of the WSSRAP are to eliminate potential hazards to the public and the environment posed by the waste materials on the Weldon Spring site and, to the extent possible, make surplus real property available for other uses.

Remedial actions are subject to U.S. Environmental Protection Agency (EPA) oversight under the *Comprehensive Environment Response, Compensation and Liability Act (CERCLA)*. Remedial actions at the site are subject to CERCLA requirements because the site is listed on the EPA National Priorities List (NPL). Section 3 of this document further discusses applicable Federal, State, and local compliance requirements and the current status of compliance activities at the Weldon Spring site and incorporating *National Environment Policy Act (NEPA)* values into CERCLA documents as outlined in the secretarial policy statement on NEPA.

### 2.2 Project Management

In order to manage the WSSRAP under the CERCLA, the proposed strategy for remedial activities at the Weldon Spring site is organized into the following four separate operable units: Weldon Spring Quarry Bulk Waste, Weldon Spring Chemical Plant, Groundwater, and Quarry Residuals. The Weldon Spring Quarry Bulk Waste Operable Unit included all wastes deposited in the quarry and their removal. The Weldon Spring Chemical Plant Operable Unit includes the buildings, soils, raffinate pits, quarry bulk wastes that have been relocated to the temporary storage area (TSA), and surface waters within the chemical plant boundary and vicinity properties. The Groundwater Operable Unit includes the groundwater at the chemical plant and vicinity areas. The Quarry Residuals Operable Unit includes the quarry proper (post-bulk waste removal), surrounding areas, surface waters, and groundwater.

### 2.3 Environmental Monitoring Program Overview

The overall goal of the WSSRAP is different from that of most operating and production facilities for which DOE Order 5400.1, *General Environmental Protection Program*, was developed. At the WSSRAP, environmental monitoring is conducted as required by DOE Order 5400.1 to measure and monitor effluents and to provide surveillance of effects on the environment and public health. In addition to these objectives, environmental monitoring activities support remedial activities under CERCLA. This requires a careful integration of WSSRAP activities to implement all the environmental and public health requirements of the CERCLA, DOE orders, and other relevant Federal and State regulations.

The WSSRAP also complies with DOE Order 5400.1 requirements for preparation and maintenance an *Environmental Monitoring Plan* (EMP) (Ref. 8). The EMP details the schedule and analyses for performing effluent monitoring and surveillance activities.

The WSSRAP environmental protection program involves radiological and chemical environmental monitoring and is separated into two distinct functions: effluent monitoring and environmental surveillance. Effluent monitoring assesses the quantities of substances in environmental media at the facility boundary, in contaminant migration pathways, and in pathways subject to compliance with applicable regulations (e.g., National Emission Standards for Hazardous Air Pollutants [NESHAPs]). Environmental surveillance consists of analyzing environmental conditions within or outside the facility boundary for the presence and concentrations of site contaminants. The purpose of this surveillance is to detect and/or track the migration of contaminants. Surveillance data are used to assess the presence and magnitude of radiological and chemical exposures and to assess the potential effects to the general public and the environment.

The WSSRAP radiological environmental monitoring program involves sampling various media for radiological constituents; primarily U-234, U-238, Ra-226, Ra-228, Th-230 and Th-232. These radionuclides are the primary radiological contaminants of concern at the Weldon Spring site. Radiological monitoring is conducted routinely at perimeter locations and at off-site locations near the chemical plant and quarry for air particulates, ambient gamma radiation, and radon. Radiological monitoring is also conducted on National Pollutant Discharge Elimination System (NPDES) discharges, streams, lakes, ponds, groundwater and springs.

Chemical environmental monitoring is primarily conducted at the chemical plant and quarry areas, but also includes monitoring at off-site locations to confirm that no releases have occurred. The nonradiological compounds included in the routine 1998 monitoring program are metals, inorganic ions (nitrate and sulfate) and nitroaromatic compounds. Other non-radiological parameters monitored as part of the environmental monitoring program include asbestos at site perimeter air monitoring locations.

#### **2.4 Project Accomplishments in 1998**

Several activities were completed in 1998 under the overall plan for remediation of the site. Major accomplishments for the units are detailed below.

## 2.4.1 Weldon Spring Chemical Plant Operable Unit

### 2.4.1.1 Site Water Treatment Plant

Ongoing discharges of treated water into the Missouri River have consistently been below the effluent standards set forth in the conditions of the chemical plant's NPDES permit. During 1998, 167,676,000 liters (44.3 million gallon) of contaminated water were treated and discharged.

### 2.4.1.2 RCRA/TSCA Storage

The *Resource Conservation and Recovery Act (RCRA)* and *Toxic Substances Control Act (TSCA)* facilities include Building 434 and the TSA.

Activities at Building 434 included the compaction of radiological waste, compaction of polychlorinated biphenyl (PCB) waste, organic waste treatability study using solvated electron technology (SET), preparation of PCB capacitor materials for SET treatment, full-scale macroencapsulation treatment for 38 containers of RCRA inorganic debris, and the inspection and preparation of wastes for treatment and/or disposal.

Activities at the TSA included emptying of filtercake containers, full-scale chemical stabilization treatment of 295 containers of RCRA inorganic solids, full-scale macroencapsulation treatment for 151 containers of RCRA inorganic debris, full-scale waste oil stabilization treatment, and staging of nonhazardous and hazardous wastes prior to treatment and/or placement in the disposal cell.

### 2.4.1.3 Disposal Cell

Phase I of the disposal cell was completed in early 1998 and waste placement activities commenced in March 1998. In total, 701,656 cu yd of contaminated material were placed in the cell through December 1998. Placed material included CSS grout, containers of macroencapsulated RCRA hazardous debris, nitroaromatically contaminated soils that had been treated by an in situ CSS process, construction debris, shredded metal debris, and contaminated soil.

Phase II of the disposal cell was substantially complete in 1998. Activities included starter dike and berm construction, and placement of liners, leachate collection removal system (LCRS) piping, and gravel layers. Leachate is currently being discharged to Retention Basin 2.

The WSSRAP-Modified Toxicity Characteristic Leaching Procedure (TCLP) sampling effort was extended to include proposed treatment strategies for residual sludge from Raffinate Pit 4. An updated report is currently under development.

Semi-annual groundwater compliance monitoring for the disposal cell was initiated in July 1998. The second sampling event occurred in December 1998. Analytical data for this effort can be found in Section 8, *Groundwater Monitoring*.

#### **2.4.1.4 Chemical Stabilization/Solidification Full Scale**

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 *Record of Decision* (ROD) (Ref. 9), on-site CSS was identified as the most effective technology for treatment of the contaminated sludges. In this process, fly ash and Portland cement are mixed with the sludges to produce a grout product that is 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.

The full scale plant began construction in May 1997 and was completed in February 1998. Commissioning and functional testing took place in the next couple months and full-scale operations began in July 1998. The plant resembles a concrete plant engineered to efficiently handle sludge and binder to produce grout while controlling particulate and radon emissions. On November 13, 1998, the CSS plant completed dredging and processing sludge from the raffinate pits. Approximately 122,000 cu yd of sludge was treated through the CSS and piped directly to the cell as grout.

#### **2.4.1.5 Raffinate Pits**

Biodenitrification activities in Raffinate Pits 1, 2, and 3 destroyed 370 tons of nitrates that were bonded in raffinate pit sludges. The north end of Raffinate Pit 4 was remediated and confirmed clean. The 28,863 cu yd of sludge in the southern end were treated and removed. A report on the *Results of the Engineering Soil Sampling for Weldon Spring Raffinate Pits 1 and 2* was completed, and a report titled the *Results of Engineering Soil Sampling Weldon Spring Raffinate Pits 3 and 4* is currently being written and includes all the berms and northern bottom of Raffinate Pit 4.

#### **2.4.1.6 Mixed Waste**

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 3 years for Land Disposal Restriction (LDR) storage prohibition violations for the DOE's mixed wastes and required the DOE to prepare plans for developing the

required treatment capacity for its mixed waste at each site where it stored or generated mixed waste. Each plan was required to be approved by the State or EPA by October 1995. The *WSSRAP Site Treatment Plan* (Ref. 10) was completed and approved by the required deadline.

The mixed waste inventory at the WSSRAP, which was the subject of the *Site Treatment Plan*, included reactivities, oxidizers, organic liquids and sludges, PCB contaminated wastes, soils, wastewaters, liquid mercury, toxic metal contaminated wastes, and sludges, and debris. The quantity included 898 drums; three 96-cu yd containers; 92 20-cu yd containers; nine containers ranging in size from 3, 4 and 10-cu yd containers; 4,600 gal of bulk wastewater, and 4,700 cu yd of soil.

Table 2-1 lists the types and quantities of wastes, treatment technologies, milestones, and treatment dates.

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

#### **2.4.2 Weldon Spring Quarry Bulk Wastes Operable Unit**

This operable unit was officially closed out in April 1997.

##### **2.4.2.1 Quarry Water Treatment Plant**

During 1998, the quarry water treatment plant (QWTP) treated and discharged to the Missouri River approximately 17,411,052 liters (4.6 million gallon) of water that met the effluent standards set forth in the NPDES permit for the Weldon Spring Quarry.

#### **2.4.3 Weldon Spring Quarry Residuals Operable Unit**

In September 1998, the *Record of Decision for Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site* (Ref. 11) was signed by the EPA and the DOE. The selected remedy for the Quarry Residuals Operable Unit is long-term groundwater monitoring with institutional controls on groundwater usage in the vicinity of the quarry proper. In conjunction with this action, additional field studies will be performed to support the decision for long-term monitoring and to evaluate the need for, and effectiveness of, removal of uranium from the groundwater north of the slough. Included in this field study will be the installation of an interceptor trench to be operated for a period of up to 2 years. Soil characterization in the northeast corner and ditch near the transfer station will be conducted. If additional soil removal is warranted, it will be performed under a subsequent response action.

Table 2-1 WSSRAP Mixed Waste Treatment Summary

TREATABILITY GROUP	QUANTITY (m <sup>3</sup> )	QUANTITY (CONTAINERS)	TREATMENT TECHNOLOGY	START-MILESTONE START-ACTUAL	END-MILESTONE END-ACTUAL
Aqueous Liquids	7.5	36 55-gal	Chemical Precipitation, Carbon Absorption, Neutralization	3 QFY95 02/08/95	4 QFY95 02/08/95
Inorganic Sludges	62.9	287 55-gal	Stabilization	3 QFY96 03/22/96	3 QFY96 08/20/98
Inorganic Debris	1700.1	180 55-gal 3 86-cu yd 92 20-cu yd 3 4-cu yd 5 3-cu yd 1 10-cu yd	Macroencapsulation	3 QFY99 05/12/98	3 QFY99 10/26/98
Contaminated Debris	.2	1 55-gal	Stabilization	4 QFY96 07/11/96	3 QFY96 07/11/96
Liquid Mercury	4	2 55-gal	Amalgamation	1 QFY86 03/13/95	Complete 03/14/95
Reactives/Oxidizers	6.9	33 55-gal	Deactivation	3 QFY96 04/02/96	3 QFY97 06/18/97
Organic Liquids	66.4	319 55-gal	Incineration	4 QFY96 01/10/96	2 QFY97 05/14/96
Organic Sludges	5.0	21 55-gal	Incineration, SET	4 QFY96 05/07/96	10/01/98 08/20/98
Nitroaromatic Soils	3,593	NA	Stabilization	3 QFY99 09/28/97	1 QFY01 02/14/98
Organic Liquids 2	4.0	19 55-gal	Incineration, Chemical Oxidation, DSSI	4 QFY97 09/08/97	10/01/98 05/28/98
Selenium Water	17.45	NA	Chemical Precipitation	2 QFY98 12/01/97	2 QFY98 01/08/98

NA Not Applicable.

#### 2.4.4 Weldon Spring Groundwater Operable Unit

A long-term pumping test was performed in the area of trichloroethylene (TCE) impact to evaluate potential groundwater remediation methods (Ref. 12). Results indicate that the transmissivity of the aquifer in the area impacted by the TCE was higher than expected, but due to structural controls on the recharge to this area, dewatering of the aquifer occurred. Evaluation of conventional pump-and-treat technologies indicates that this may not be the most effective method for possible remediation of this area. This data was utilized in the issuance of the *Proposed Plan* (Ref. 13).

The final *Feasibility Study* (Ref. 14) was issued in December 1998. The preferred alternative outlines long-term monitoring in conjunction with in situ treatment of portions of the shallow aquifer impacted by TCE.

#### 2.5 Incident Reporting - Environmental Occurrences in 1998

In accordance with DOE Order 5400.1, Chapter II, 2.(b), field organizations are required to prepare annual summary reports on environmental occurrence activities and to report this information in the annual site environmental report.

In 1998, 17 off-normal occurrences of an environmental nature were reported under DOE Order 232.1A, *Occurrence Reporting and Processing of Operations Information*. Table 2-2 lists these environmental occurrences for 1998, and a short description of each occurrence is provided in the following paragraphs.

Table 2-2 Environmental Occurrences CY 1998

OCCURRENCE REPORT NUMBER	OCCURRENCE DATE	SUBJECT OF OCCURRENCE
1998-0004	02/16/98	NPDES permit exceedence
1998-0009A	03/08/98	NPDES permit exceedence
1998-0009B	03/11/98	NPDES permit exceedence
1998-0011	03/26/98	Failure to report interim Tier II EPCRA report.
1998-0014	06/05/98	NPDES permit exceedence.
1998-0017	06/28/98	Process grout sprayed contamination into a uncontrolled area.
1998-0023	07/22/98	NPDES permit exceedence.
1998-0024	07/24/98	NPDES permit exceedence.
1998-0025	07/29/98	Grout released outside the controlled area.
1998-0028	07/31/98	NPDES permit exceedence.
1998-0029	08/12/98	Material box slid off truck.

Table 2-2 Environmental Occurrences CY 1998 (Continued)

OCCURRENCE REPORT NUMBER	OCCURRENCE DATE	SUBJECT OF OCCURRENCE
1998-0031	09/03/98	Unexpected chemical reaction occurred during waste oil stabilization process
1998-0033	09/24/98	Contaminated sludge water spilled on roadway in uncontrolled area.
1998-0035	10/07/98	Diesel spill from water truck fuel line.
1998-0036	10/07/98	NPDES permit exceedence.
1998-0038	10/29/98	NPDES permit exceedence.
1998-0039	11/04/98	NPDES permit exceedence.

Occurrence 1998-0004 involved a sample of hydrostatic test water from the CSS production facility on February 9, 1998. Sampling personnel neglected to measure the pH as required by the permit. The samples were analyzed at an off-site laboratory for pH and TSS. The sample results showed the upper limit for pH was 9.08, which is over the permitted limit. The Project Management Contractor (PMC) suspected that the potable water from the water district ranges above 9.0, which may be the reason for the above normal pH. The PMC contacted the water company and, they were informed that the pH of the water from the plant ranged from 8.8 to 9.1, indicating that the above 9.0 is most likely due to the supply. A notification letter was submitted to the Missouri Department of Natural Resources (MDNR).

Occurrence 1998-0009A involved a sample of hydrostatic test water from the CSS production facility on March 6, 1998. The sample results showed total suspended solids were 113 mg/l. This is over the permitted limit for total suspended solids; therefore, a notification letter was submitted to the MDNR.

Occurrence 1998-0009B involved an additional sample of hydrostatic test water from the CSS production facility. The sample results showed total suspended solids were 141 mg/l. This is over the permitted limit for total suspended solids; therefore, a notification letter was submitted to the MDNR.

Occurrence 1998-0011 involved submitting Tier II reports in compliance with the *Emergency Planning and Community Right-To-Know Act (EPCRA)*. It was discovered that while the annual reports have been submitted, the interim reports have not been submitted since 1995. The Interim Tier II reports contain the same information as the Annual Tier II reports; however, the information did not get sent to the Missouri Emergency Response Commission (MERC), the Local Emergency Planning Commission (LEPC- St. Charles County Emergency Management Agency), and the Cottleville Fire Department within the specified time period. A letter was sent to the MERC from the DOE Project Manager regarding these discrepancies. The letter was carbon copied to the LEPC and the Cottleville Fire Department.

Occurrence 1998-0014 involved a sample collected from Outfall NP-0003 after a 1 in. rainfall event on June 4, 1998. The sample result showed settleable solids were 125 ml/l/hr with a flow of 300 gal per minute. This is over the permitted limit for settleable solids; therefore, a notification letter was submitted to the MDNR.

Occurrence 1998-0017 involved grout samples that were taken at the CSS plant. The samples were being collected in a 5-gallon bucket with a lid. The lid has a hole in the top to allow the sample line to penetrate the opening to prevent splattering. As the sampler opened the valve, the grout line surged and released grout into the bucket. The lid of the bucket popped up allowing grout to be splattered on the sampling personnel. No contamination was detected on personnel. Contaminated grout was detected in the uncontrolled area.

Occurrence 1998-0023 involved a sample collected from Outfall NP-0003 after a 1 in. rainfall event on June 4, 1998. The sample result showed settleable solids were 125ml/l/hr and total suspended solids were 514 mg/l. Arsenic and lead were above baseline, but below 100 µg/l. The chromium level for the sample was 111 µg/l. The notification level in Special Condition C.1 of NPDES Permit MO-0107701 is 100 µg/l, and the baseline value is 11.65 µg/l. Because of the high metal levels at the outfall in conjunction with the high solids levels, it is suspected that the elevated levels are the result of the high solids levels. The elevated chromium level may also be a result of soil and debris removal from Ash Pond. These data were analyzed on June 16, 1998; however, the chromium exceedence was not recognized until July 20, 1998 (turnaround of data from the laboratory). Therefore, this is a roll-up to a previously approved occurrence report (Occurrence 1998-0014).

Occurrence 1998-0024 involved a compliance sample for sewage treatment plant effluent. The instantaneous flow was 10 gal/minute and the water clarity was slightly turbid. Total Residual Chlorine was 0.06 mg/l. Biochemical Oxygen Demand and Total Suspended Solids samples were composite samples and pH and fecal coliform were grab samples as required by the permit. The fecal coliform was 1,200 colonies per 100 ml with a duplicate yielding 1,160 colonies per 100ml. The permitted daily maximum is 1,000 colonies per 100 ml. The required letter was sent to the Missouri Department of Natural Resources.

Occurrence 1998-0025 involved pumping grout from the CSS plant into the disposal cell from boom trucks A and B. The boom trucks were releasing grout in a semicircular manner in order to construct a berm for continued grout placement advancing northward. As the A boom truck in the southwest region of the cell was releasing grout from the boom in an east to west direction, the operator fell asleep. The boom traveled outside of the designated placement area and onto the temporary road and continued to release grout. Treated grout was deposited outside of the Restricted/Contamination Area into an uncontrolled area. The grout was approximately 8 ft outside the Restricted/Contamination Area, but did not flow outside of the disposal cell berm. At the time of the incident, an employee was in the immediate area performing an inspection on the B boom truck. On noticing the A boom truck traversing outside the restricted

area, the employee proceeded to the A boom truck and woke the operator. The area where the treated grout was deposited outside the Restricted/Contamination Area was immediately roped off and redesignated as a "Restricted/Contamination Area." The contamination exceeded 10 CFR 835, Occupational Radiation Protection levels.

Occurrence 1998-0028 involved an NPDES compliance collected from Outfall NP-0004. The watershed flowing to the outfall includes the remediated portion of Raffinate Pit 4 as well as 5 acres outside the pit that includes roadways and the outside of the remaining Pit 4 berm. The sample was collected during heavy rains and the flow was estimated at 1,000 gpm. The water was very turbid and the settleable solids were 6.0 ml/l/hr. The permit limit for settleable solids is 1.0ml/l/hr; therefore, the sample was out of compliance with the permit limit for settleable solids. The MDNR was notified of the permit violation.

Occurrence 1998-0029 involved an oversized material box (4 cu yd box) that had been filled about two-thirds full with contaminated debris and was loaded onto the back of a stakebed truck. The box was being transported to the disposal cell for placement inside of the contamination area. The bed of the truck was lined with plastic to prevent the potential for cross-contamination. Due to a protruding drain pipe on the material box, the sideboards of the bed were removed. While enroute, the truck turned on a rock road ramp leading to the cell and the material box slid and fell off the left side of the truck bed. The box spilled approximately 70 gal of contaminated material onto the ground in an uncontrolled area. The area was immediately roped off and the spill was contained. No personnel were contaminated. The primary contaminant in the sludge was Th-230. The contamination exceeded 10 CFR 835 criteria.

Occurrence 1998-0031 involved stabilizing drums of waste oil at the TSA with granular clay. Four roll-off boxes with 8,000 lbs of oil dry were set up and the laborers proceeded to mix waste oil with oil dry in the first roll-off box. After adding the contents of the first drum, a smoke with fizzing was observed coming from the mixture. The PMC suggested stirring the mixture; however, the smoke got worse. Water was then poured on the mixture and the smoke dissipated. One laborer had some of the waste material from the drum splash on the top of his right thigh and felt heat through his personal protective clothing. Once the smoke had dissipated, the workers notified the construction engineer of the incident and stopped work. In addition, two laborers working at an adjacent location reported seeing a smoky/dusty cloud over at the TSA and complained of irritated throats to the Construction Engineer. There were no personal injuries or illness associated with this occurrence.

Occurrence 1998-0033 involved a container carrying oversize material from the scalping screens that was being hauled by a forklift to the disposal cell. A lid was on the container to keep the rainwater from entering the box during storage (the lid was in the up position during transportation). On the return trip back to the CSS facility, both the operator and laborer noticed several areas of spilled material on the roadway (uncontrolled area). The contamination exceeded 10 CFR 835 criteria.

Occurrence 1998-0035 involved a mechanic discovering that a fuel line had been damaged on a Kenworth water truck and had leaked approximately 75 gal of fuel. The spill occurred while the truck was parked in the Ash Pond equipment staging area. The spill occurred outside a permitted containment area and was greater than 42 gal.

Occurrence 1998-0036 involved a sample that was collected from Outfall NP-0004 shortly after a very heavy rain event. The off-site laboratory analyzed the sample on August 14, 1998; however, the results were not reported to the site until October 7. The results showed total suspended solids were 13,000 mg and settleable solids were 6.0 ml/l/hr. The concentrations for total metals were above the 100 µg/l notification level for toxic pollutants. The MDNR was notified of the permit violation.

Occurrence 1998-0038 involved a quarterly compliance sample that was collected from the sewage treatment plant outfall (NP-0006). Fecal coliform was out of compliance at 3,900 colonies/100 ml with a duplicate result of 4,680 colonies/100 ml. The daily maximum limit is 1,000 colonies /100 ml. A letter was sent to the MDNR reporting the exceedence.

Occurrence 1998-0039 involved a quarterly NPDES compliance storm water sample that was collected at NPDES outfall NP-0004. Settleable solids and pH analyses were conducted on site. The settleable solids were in compliance at <0.1 ml/l/hr (limit is 1.0), but pH was out of compliance at 9.34 units (permitted range is 6.0 to 9.0). The sample was analyzed again with a result of 9.24 and a third time on a different meter with a result of 9.75 (after an extended time). A gross analysis with a pH strip also supported the pH being above 9.0. A letter was sent to the MDNR reporting the exceedence.

## **2.6 Special DOE Order Related Programs**

In addition to the direct program requirements and documentation required under DOE Order 5400.1, the DOE order specifically requests that other programs be presented in the annual site environment report, including the groundwater protection management program, the meteorological monitoring program, and the waste minimization and pollution prevention program. This section also addresses other programs, under DOE Order 5482.1B, such as self assessments, the radiological control program, and the surface water management program at the WSSRAP.

### 2.6.1 Groundwater Protection Management Program

The WSSRAP has a formal groundwater protection and management program in place. The policies and practices are documented in the *Groundwater Protection Program Management Plan* (Ref. 15). The plan outlines how monitoring programs will be developed to assess the nature and extent of contaminants in the groundwater, to evaluate potential impacts on public health, and to gather data for remedial decisions. All policies pertaining to groundwater monitoring, including well installation, decontamination, construction, sampling methods, and abandonment methods, are detailed in this plan. The plan outlines the hydrogeological characterization program conducted as part of CERCLA activities. These include groundwater sampling, water level monitoring, slug tests, tracer tests, and geologic logging.

The plan is currently in revision and will be referred to as the *WSSRAP Groundwater Protection Management Program*, which will be finalized in 1999. The revised program will include those practices and policies described above, as well as recently developed strategies for implementing site-wide groundwater protection practices and interdepartmental integration of these practices during all aspects of project management and development.

### 2.6.2 Meteorological Monitoring Program

A meteorological station is located at the chemical plant to provide data to support the environmental monitoring programs. The meteorological station provides data on wind speed, wind direction, ambient air temperature, relative humidity, barometric pressure, solar radiation, and precipitation accumulation. Data from this station are used to assess meteorological conditions and air transport and diffusion characteristics, which determine possible impacts of airborne releases. In addition, precipitation data are used to correlate water level fluctuations and contaminant concentrations in surface water and groundwater wells.

Since the completion of a system upgrade in August 1994, meteorological data recovery has exceeded 99%. An off-site meteorologist provides monthly data reviews and semiannual maintenance and performance checks for the station.

### 2.6.3 Surface Water Management Program

The WSSRAP maintains a surface water management program to ensure effective implementation of policies detailed in DOE Order 5400.5 and documented in the *Surface Water Management Plan* (Ref. 16) and ES&H 9.1.2, *Surface Water Management*. This program also incorporates the as low as reasonably achievable (ALARA) concept in the execution of the program.

This plan identifies existing and potential water sources, water quality categories, and provides the requirements and methodologies for proper control, management, and disposition of

site waters. Erosion and water control, and water management for the quarry and site water treatment plants are also discussed. The key elements of the plan are source identification, characterization, monitoring, engineering controls, and management methods.

#### **2.6.4 Radiation Protection Program**

The U.S. Department of Energy issued 10 CFR 835 (*Occupational Radiation Protection*), in December 1993 in the Federal Register; 10 CFR 835 sets the minimum acceptable occupational radiological control standards for DOE facilities. The regulation includes requirements for contamination control; ALARA practices; internal and external dosimetry; facility design and control; internal surveillances; instrumentation and calibration; worker training, posting and labeling, and release of materials from radiological areas.

As of December 31, 1998, the WSSRAP is in full compliance with all applicable sections of 10 CFR 835.

#### **2.6.5 Waste Management Program**

The waste management program encompasses all waste-related activities (both interim and long term) including characterization, treatment, storage, minimization, and disposal performed at the Weldon Spring site by project personnel, subcontractors, and sub-tier contractors. Hazardous, radioactive, toxic, mixed, special and uncontaminated waste produced as a direct result of project cleanup activities, are within the scope of this program. Garbage and refuse generated as a result of the project administration are excluded.

Waste management activities for 1998 include:

- Waste ranging in size, reagent quantities, and polychlorinated biphenols (PCB) concentrations were treated via the Solvated Electron Technology. Activities were completed in September.
- Investigated nine gas cylinders previously discovered in Raffinate Pit 4. Seven of the nine were found to contain no gas. Treatment of the remaining two is pending.
- In June, full-scale treatment of RCRA toxic metals and the chemical stabilization of hazardous waste began at the CSS pilot plant. The activities were completed by November.
- In situ treatment of the nitroaromatic soils from the quarry was completed at the TSA.

- In October 1998, a subcontractor removed 136 ft of 6 in. TNT wastewater line. Line removal started at Gate 4 and proceeded to the east. Approximately 50 gal of water from within the line was containerized along with 735 cu ft of soil contaminated with water from the line. Radiological surveys of the line indicated radiological contamination above background levels. Characterization of representative samples indicated that the material did not exceed the regulatory threshold for 2,4-Dinitrotoluene. The concentration of TNT in the waste is insufficient to meet the definition of a characteristically reactive hazardous waste. The waste is currently stored in Building 434, awaiting a decision on how it should be managed.
- Macroencapsulation of RCRA debris began in the second quarter and were completed by the end of the fourth quarter.
- Waste acids were treated via neutralization and chemical stabilization.
- Liquid mercury was treated by mercury amalgamation while mercury contaminated wastewater was treated by stabilization.
- Chromium contaminated wastewater and sodium dichromate waste were treated by reduction and chemical stabilization.
- TCE tainted monitoring well purge water was treated with carbon absorption.
- Sodium chloride waste was treated by chemical stabilization.
- In October, placement in the cell was complete for the following: over 1,000 drums from Building 434, the treated nitroaromatic soils, the treated brine bags, all metal debris, and the fine grain soils.

The waste management program also includes transportation activities such as the packaging and shipping of hazardous and nonhazardous wastes and samples. The following transportation activities took place in 1998:

- Eleven RCRA containers of organic liquids and waste oils were shipped to DSS1 for off-site treatment and disposal. Three containers were rejected and sent back due to PCB levels not previously detected.
- In November, six containers of RCRA waste were shipped to ENSCO for treatment and disposal.
- A shipment of various types of light bulbs was sent off site for recycling.

- Shipments of lead and Ni-cad batteries were sent off site for recycling.
- Approximately 156 shipments of hazardous materials were sent off site through the compliance shipping group.
- Seventeen shipments of used oil were sent off site for recycling.
- Approximately 908 shipments of environmental/non-hazardous materials were sent off site through the shipping group.

#### 2.6.6 Waste Minimization/Pollution Prevention Program

The WSSRAP Waste Minimization Program is outlined in the *Waste Minimization/Pollution Prevention Awareness Plan* (Ref. 17) in accordance with the requirements of DOE Order 5400.1. Because long-term, volume-specific goals for waste minimization are not appropriate for nonoperational facilities, the WSSRAP has adopted ALARA goals.

The program is primarily geared toward material substitution and source or volume reduction minimization methods. This is accomplished by evaluating and reviewing all hazardous chemicals (as defined by 29 CFR 1926.59) before they are purchased or arrive on site, and recommending alternate materials or applying use restrictions. Additional methods routinely employed at the WSSRAP include removing packaging materials from products before they enter the radioactive materials management areas, limiting waste-generating activities during remediation and treatment, consolidating waste during storage, reviewing design specifications for possible methods to minimize waste generation, and segregating waste by waste types. The following is a detailed list of the waste minimization activities conducted during 1998.

- The WSSRAP donated approximately 65 workstations, 10 laptops and 104 miscellaneous pieces of computer equipment to a local high school under Executive Order 12821, which allows agencies to transfer educationally related Federal equipment to secondary schools.
- One hundred and eight nickel/cadmium and 37 lead batteries were sent back to the manufacturer for recycling.
- Five hundred and seventy-two cu yd of paper/cardboard, 2,100 lb of newspaper and 20,800 aluminum cans were collected by a recycler.
- Approximately 135 used tires were sent to a recycler.

- Approximately 300 toner cartridges were sent back to the manufacturer. Money from recycling cartridges will be donated to the Forestry Department.
- Cotton coveralls used for personal protection are being laundered and reused.
- One hundred incandescent lamps and 1,080 fluorescent lamps were shipped to a recycler.
- One switch locomotive was released to the St. Louis Museum of Transportation.
- A total of 8,090 gal of used oil was sent to a recycler.
- Reused approximately 30,060 lcy (53,357 ton) of aggregate from the TSA and MSA in treating the Raffinate Pit 4 sludge material. Cost of this material if purchased from off-site sources would be \$426,856.

### 3. COMPLIANCE SUMMARY

#### 3.1 Compliance Status for 1998

The Weldon Spring site is listed on the National Priorities List (NPL), and therefore the Weldon Spring Site Remedial Action Project (WSSRAP) is governed by the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) process. Under the CERCLA, the WSSRAP is subject to meeting or exceeding the applicable or relevant and appropriate requirements of Federal, State, and local laws and statutes, such as the *Resource Conservation and Recovery Act* (RCRA), the *Clean Water Act* (CWA), the *Clean Air Act* (CAA), the *National Historic Preservation Act* (NHPA), the *Safe Drinking Water Act* (SDWA), *Endangered Species Act*, and Missouri State regulations. Because the U.S. Department of Energy (DOE) is the lead agency for the site, the *National Environmental Policy Act* (NEPA) values must be incorporated. The requirements of DOE Orders must also be met. Section 3.1.1 is a summary of WSSRAP compliance with applicable Federal and State regulations, and Section 3.1.2 is a summary of the WSSRAP compliance with major DOE Orders.

##### 3.1.1 Federal and State Regulatory Compliance

###### *Comprehensive Environmental Response, Compensation and Liability Act*

The WSSRAP has integrated the procedural and documentation requirements of the CERCLA, as amended by the *Superfund Amendments and Reauthorization Act* (SARA), and the NEPA, as required by the policy stated in DOE Order 5400.4.

###### *Resource Conservation and Recovery Act*

Hazardous wastes at the Weldon Spring site are managed as required by the RCRA as substantive applicable or relevant and appropriate (ARARs). This includes characterization, consolidation, inventory, storage, treatment, disposal, and transportation of hazardous wastes that remained on site after closure of the Weldon Spring Uranium Feed Materials Plant (WSUFMP) and wastes that are generated during remedial activities.

A RCRA treatment, storage, and disposal permit is not required at the site since remediation is being performed in accordance with decisions reached under the CERCLA. Section 121(e) of the CERCLA states that no Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely on site.

The RCRA was amended by the *Federal Facility Compliance Act* (FFCA), which was enacted on October 6, 1992. The site treatment plan for mixed waste, which was required by the FFCA was finalized with a consent agreement with the MDNR in October 1995. The *1998 Annual Update to the Site Treatment Plan for the Weldon Spring Site* (Ref. 18) was submitted to

the MDNR October 15, 1998. In the update the WSSRAP reported that most of the mixed wastes had been treated. The actual completion of treatment of the site treatment plan mixed wastes was accomplished on October 23, 1998.

RCRA groundwater monitoring for regulated units is discussed in detail in Chapter 8.

### *Clean Air Act*

CAA compliance requirements pertaining to the site are found in Title I - Nonattainments, Title III - Hazardous Air Pollutants (including National Emission Standards for Hazardous Air Pollutants (NESHAPS) and Title VI - Stratospheric Ozone Protection. NESHAPs dose calculations for 1998 indicate the highest receptor activity was below the NESHAPs standard of 10mrem (0.1mSv).

St. Charles County is classified in the Federal Register of November 6, 1991, 56 FR 215 as a moderate nonattainment area for ozone. As a moderate ozone nonattainment area, the requirements would affect sources emitting nitrogen oxides (NO<sub>x</sub>) and volatile organic compounds (VOCs). At present, these sources do not exist at the WSSRAP.

Under Title III, asbestos and radionuclides are hazardous air pollutants. These standards establish criteria for the control of radionuclide and asbestos emissions. WSSRAP programs for radionuclides and asbestos are described in detail in Sections 4 and 6, along with the 1998 status of monitoring.

### *Clean Water Act*

Effluents discharged to waters of the United States are regulated under the *Clean Water Act* (CWA) through regulations promulgated and implemented by the State of Missouri. The Federal government has granted regulatory authority for implementation of CWA provisions to those states with a regulatory program that is at least as stringent as the Federal program.

Compliance with the CWA at the WSSRAP included meeting parameter limits set in four National Pollutant Discharge Elimination System (NPDES) permits. Under these permits, both effluent and erosion-control monitoring are performed. Section 7 includes additional details on the NPDES programs.

### Floodplain Management

Excavation activities performed in the Southeast Drainage in 1998 were authorized under Section 404 of the *Clean Water Act* by an existing Department of the Army nationwide permit.

### *Rivers and Harbors Act*

No work activity was conducted during this reporting period that would fall under the Act.

### *Federal Insecticide, Fungicide, and Rodenticide Act*

The WSSRAP maintains compliance with the *Federal Insecticide, Fungicide, and Rodenticide Act*. Material Safety Data Sheets are reviewed for all pesticides before they are purchased. The WSSRAP does not currently use restricted-use pesticides as they do not possess the proper permit/license to purchase these materials. The WSSRAP must also meet State requirements for pesticide application which outline specific licenses for specific uses of any pesticide. All applications are reviewed for State licensing requirements.

### Department of Transportation

Pursuant to U.S. Department of Transportation (DOT) training requirements, the WSSRAP continues to conduct on-site training on hazardous material transportation. The training targets personnel with responsibilities for hazardous materials transportation. The training covers classification of hazardous materials by shipping names, performance based packaging requirements, requirements for marking, labeling and placarding, and proper segregation and modes of transportation. Retraining is required every 3 years.

### *Safe Drinking Water Act*

Currently, the *Safe Drinking Water Act* (SDWA) is not an applicable and/or relevant and appropriate requirement at the WSSRAP. The SDWA is currently being evaluated for its applicability to the groundwater and Quarry Residuals Operable Units.

### *Emergency Planning and Community Right-to-Know Act*

The 1998 *Emergency Planning and Community Right-to-Know Act* (EPCRA) Tier II report was completed and provided on February 25, 1999, to the local emergency planning committee (LEPC) and to the Missouri State Emergency Response Commission (MERC).

The Toxic Release Inventory (TRI) report was not required.

### *Cultural Resources/National Historic Preservation Act*

The annual Federal Archaeological report for 1998 was submitted on January 30, 1999.

### *Endangered Species Act*

There was no activity this reporting period.

### *Engineering Evaluation/Cost Analysis(EE/CA) for the Southeast Drainage*

Soil excavation activities began in November 1997 and the removal of contaminated soil was completed on February 19, 1998, 5 months ahead of the U. S. Department of Energy-Headquarters (DOE-HQ) milestone target date of July 1998. A total of 1,931 bank cubic yards of soil were excavated from selected locations within the drainage. Approximately 14 loads of soil were removed from the upper portion of the drainage, and 90 loads of soil were removed from the lower portion of the drainage. All contaminated soil was taken to the Ash Pond storage area with final disposal within the disposal cell. Post-remediation samples revealed that the soil removal activities satisfactorily met the Engineering Evaluation/Cost Analysis (EE/CA) decision document risk reduction goals.

Following soil removal activities, a subsequent evaluation was postponed to determine the potential hazard in two areas. It was determined that even though the drainage met the risk reduction criteria, the two areas would be remediated in 1999 under a limited removal effort conducted by Work Package 505 Task J.

### **3.1.2 DOE Order Compliance**

#### **3.1.2.1 DOE Order 5400.5, Radiation Protection of the Public and the Environment**

DOE Order 5400.5 establishes primary standards and requirements for DOE operations to protect members of the public and the environment against undue risk from radiation. The DOE operates its facilities and conducts its activities so that radiation exposures to members of the public are maintained within established limits.

The annual dose to the maximally exposed member of the public as a result of activities at the Weldon Spring site was below the 100 mrem (1mSv) guideline for all potential exposure modes. The 10mrem (0.1mSv) annual dose limit for public exposure to airborne emissions, excluding radon and its respective decay products as specified in 40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants*, was not exceeded in 1998. The appropriate dose evaluation techniques were used to assess 1998 environmental monitoring and surveillance data in compliance with this requirement.

The annual average uranium concentrations at all NPDES outfalls were below the derived concentration guideline (DCG) of an annual average of 600 pCi/l (22.2Bq/l).

Records of all environmental monitoring and surveillance activities conducted at the Weldon Spring site in 1998 are being maintained in accordance with the requirement of this order. All reports and records generated at the WSSRAP in 1998, pursuant to DOE order requirements, presented data in the units specified by the applicable regulation or order.

### **3.1.2.2 DOE Order 5820.2A, Radioactive Waste Management**

DOE Order 5820.2A establishes policies, guidelines, and minimum requirements by which the DOE manages its radioactive and mixed waste and contaminated facilities. The Weldon Spring site was in compliance with the applicable portions of Chapter IV management of waste containing 11e(2) by-product material and naturally occurring and accelerator produced radioactive material, Chapter V (decommissioning of radioactively contaminated facilities), and Chapter VI (administrative activities related to the *Waste Management Plan* [Ref. 19]). The types of wastes addressed in Chapters I, II, and III of the Order were not present at the site.

### **3.1.2.3 DOE Order 5400.1, General Environmental Protection Program**

The WSSRAP conducted both radiological and nonradiological environmental monitoring programs at the site and vicinity properties. Environmental monitoring required by DOE Order 5400.1 was conducted to measure and monitor effluents and to provide surveillance of their effects on the environment and public health.

The WSSRAP was in compliance with Order 5400.1 requirements for preparation of an *Environmental Monitoring Plan* (Ref. 8) that is reviewed annually and revised as necessary.

In addition to the plans developed for overall environmental monitoring and protection, the WSSRAP annually reviews and revises, as necessary, the *Groundwater Protection Program Management Plan* (Ref. 15) and the *Waste Minimization and Pollution Prevention Awareness Plan* (Ref. 17). Refer to Section 2.6.6 for additional details.

### 3.2 Current Issues and Actions

#### 3.2.1 Current Issues

##### 3.2.1.1 National Emission Standards for Hazardous Air Pollutants Compliance

The WSSRAP has developed a critical receptor monitoring program for compliance with the requirements of 40 CFR 61 Subpart H. Point source and environmental monitoring have been mandated per 40 CFR 61.93(b)(5), whereby air concentrations are monitored at seven designated critical receptor locations on and around the Weldon Spring site. The WSSRAP plan is contained in the *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 20), which has been approved by the U.S. Environmental Protection Agency (EPA). The WSSRAP reports annual monitoring results and effective dose equivalents at critical receptor locations via the annual NESHAPs Report.

### 3.3 Summary of Permits for 1998

Various permits were maintained by the WSSRAP for remedial activities including NPDES, excavation, and floodplain permits. Table 3-1 provides a summary of all NPDES permits. Four active NPDES permits covered discharges from the site water treatment plant (MO-0107701), quarry water treatment plant (MO-0108987), storm water discharges from the Borrow Area and Borrow Area haul road (MO-R100B69), and hydrostatic test water from the site (MO-G670203). An NPDES construction permit for the leachate collection removal system of the cell was issued in January 1997.

Table 3-1 Summary of WSSRAP NPDES and Construction Permits

PERMIT NO.	(a)	DATE ISSUED	DATE EXPIRED	(b)	DATE RENEWAL OR EXTENSION REQUEST DUE	SCOPE AND COMMENTS
MO-0107701	O	03/03/94	03/04/99	Y	09/04/98	Covers storm water, sanitary, and SWTP discharges.
MO-0108987	O	07/17/98	07/16/03	N	01/16/03	Covers QWTP discharge.
MO-R100B69	O	05/29/98	01/02/02	N	07/02/01	Storm water discharges from the Borrow Area and haul road operations.
MO-G670203	O	12/05/97	10/23/02	N	02/23/02	Covers hydrostatic test water at site.
MO-22-5186	C	01/08/97	01/07/02	N	12/07/01	Covers construction of cell leachate collection system.

(a) Permit type, O = Operating, C = Construction

(b) Permit renewal application submitted N = No, Y = Yes.

QWTP Quarry water treatment plant

SWTP Site water treatment plant.

### 3.4 Site Mitigation Action Plan

The progress of the mitigative actions for the remediation of the Weldon Spring site is reported annually in the site environmental report in accordance with DOE Order 5440.1E. The *Mitigation Action Plan (MAP) for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 21), was developed to present mitigation actions planned in order to provide protection for human health and the environment during remediation activities. The MAP is reviewed and updated annually, as necessary, to reflect site conditions.

Construction activities at the Weldon Spring site are managed by using good engineering practices for control of surface water runoff at, and from, the site. During 1997, four sedimentation basins and two retention ponds were in place at the chemical plant area during soil excavation activities. Surface water protection during 1997 included erosion prevention and sediment control and monitoring. Monitoring was conducted at four outfall locations at the chemical plant, and the requirements of three NPDES permits and the *Missouri Clean Water Act* were met during 1997. Further information on compliance issues are provided in Section 7.

The wetlands mitigation agreement with the Corps of Engineers (COE) was signed in 1994 to establish a replacement wetland area. Remedial activities at the site have eliminated some wetlands during 1997. The construction of the replacement wetland area was completed in August 1997 at the Busch Memorial Conservation Area in accordance with the mitigation plan. Wetlands monitoring was conducted by the DOE at the mitigation area starting in 1997. Results of 1998 monitoring are reported in the *Wetlands Monitoring Report for the Weldon Spring Site Remedial Action Project* (Ref. 22). Monitoring activities are continuing and will conclude in 1999.

Topsoils and subsoils from the Borrow Area that are being stored for restoration have been stockpiled at the Borrow Area. Stockpile heights and slopes have been limited to 2.5:1 and stockpiles have been seeded and mulched to control erosion. In 1997, 60 acres at the Borrow Area have been reclaimed and seeded with a top seed mix. Erosion control measures are implemented at the Borrow Area and the haul road. Stockpiles are routinely inspected for erosion. Two sedimentation ponds have been constructed at the Borrow Area, and surface water has been monitored to measure the effective removal of settleable materials. Specific NPDES compliance details for the Borrow Area are provided in Section 7.

Air, surface water, and groundwater have been monitored as part of the routine environmental activities at the chemical plant area. Results of that monitoring are detailed extensively in this report.

Eligibility surveys for archeological or historic sites were conducted on the 30.5m (100 ft) site perimeter around the chemical plant site, and no sites were found that would require avoidance or data recovery. Confirmation letters in regard to this decision have been received by the State Historic Preservation Officer.

## 4. AIR MONITORING PROGRAMS

The Weldon Spring Site Remedial Action Project (WSSRAP) operates its environmental airborne monitoring and surveillance program in accordance with U.S. Department of Energy (DOE) Orders and with the *Environmental Monitoring Plan* (Ref. 8). This section describes monitoring results for radon, gamma exposure, airborne radioactive particulates, airborne asbestos, and fine particulate matter at various site perimeter and off-site locations. A program overview, summary of applicable standards, actual monitoring results, and an assessment of any associated environmental impacts are provided below for each parameter mentioned in the plan.

### 4.1 Highlights of Air Monitoring

- Statistical analysis at the 95% confidence level indicated that one integrated radon track etch monitoring station along the chemical plant perimeter and one station in the raffinate pits area (within the site boundary) exceeded annual average background levels in 1998. No annual integrated radon track etch results at critical receptor locations were statistically greater than background levels. The highest above background integrated radon concentration along the site perimeter was 7% of the derived concentration guide (DCG) for radon occurring at Station RD-3002 (west of Raffinate Pit 4).
- Statistical analysis at the 95% confidence level indicated that six modified Rn-220 (thoron) track etch monitoring locations exceeded 1998 average background levels, including four along the chemical plant perimeter and two within the site boundary. The highest above background thoron concentration along the site perimeter was 13% of the derived concentration guide (DCG) for thoron, occurring at Stations RD-3002 and RD-3003 (west of Raffinate Pit 4 and west of the temporary storage area (TSA), respectively).
- Environmental thermoluminescent dosimeter (TLD) results for 1998 at the chemical plant perimeter, quarry perimeter, and off-site locations ranged from 51 mrem/year (0.51 mSv/year) to 80 mrem/year (0.80 mSv/year). These results are inclusive of background levels, which totaled 58 mrem (0.58 mSv) for the year. Statistical analysis of the results indicate that, at the 95% confidence level, four chemical plant/raffinate pit perimeter stations exceeded background levels. These four stations exceeded the annual background exposure by 3 mrem (0.03 mSv) to 22 mrem (0.22 mSv).
- Statistical analysis at the 95% confidence level indicated that seven low-volume radioactive airborne particulate monitoring stations along the chemical plant perimeter had annual average concentrations that exceeded the 52-week background average. These seven stations, which measure gross alpha airborne concentrations, exceeded the 52-week background average by  $2.5E-16$   $\mu\text{Ci/ml}$  ( $9.25E-12$  Bq/ml) to  $8.5E-16$   $\mu\text{Ci/ml}$  ( $3.15E-11$  Bq/ml). When results were compared to a 104-week background average, nine

stations were found to be statistically significant. These stations exceeded the 104-week background average by  $3.0E-16$   $\mu\text{Ci/ml}$  ( $1.11E-11$  Bq/ml) to  $9.0E-16$   $\mu\text{Ci/ml}$  ( $3.33E-11$  Bq/ml). In future reports, only comparisons to the 52-week background average will be made.

- All 1998 radiological air monitoring results at Francis Howell High School (including radon, gamma exposure, and airborne radioactive particulates) were indistinguishable from background.

## 4.2 Radon Gas Monitoring Program

### 4.2.1 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 found in the U-238 and Th-232 decay series, respectively. A fraction of the radon produced from the 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 at the site.

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. 23).

Two types of track etch detectors are used at the 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 track etch 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.

In 1998, a pair of standard F-type track etch detectors was deployed quarterly at each of 32 permanent monitoring locations: 11 at the Weldon Spring Chemical Plant perimeter, two at the Weldon Spring Quarry perimeter, 12 at the raffinate pits, TSA, chemical stabilization/solidification (CSS), and site water treatment plant areas, and seven at off-site locations. Track etch monitoring locations are identified with an "RD" prefix in Figures 4-1 through 4-4.

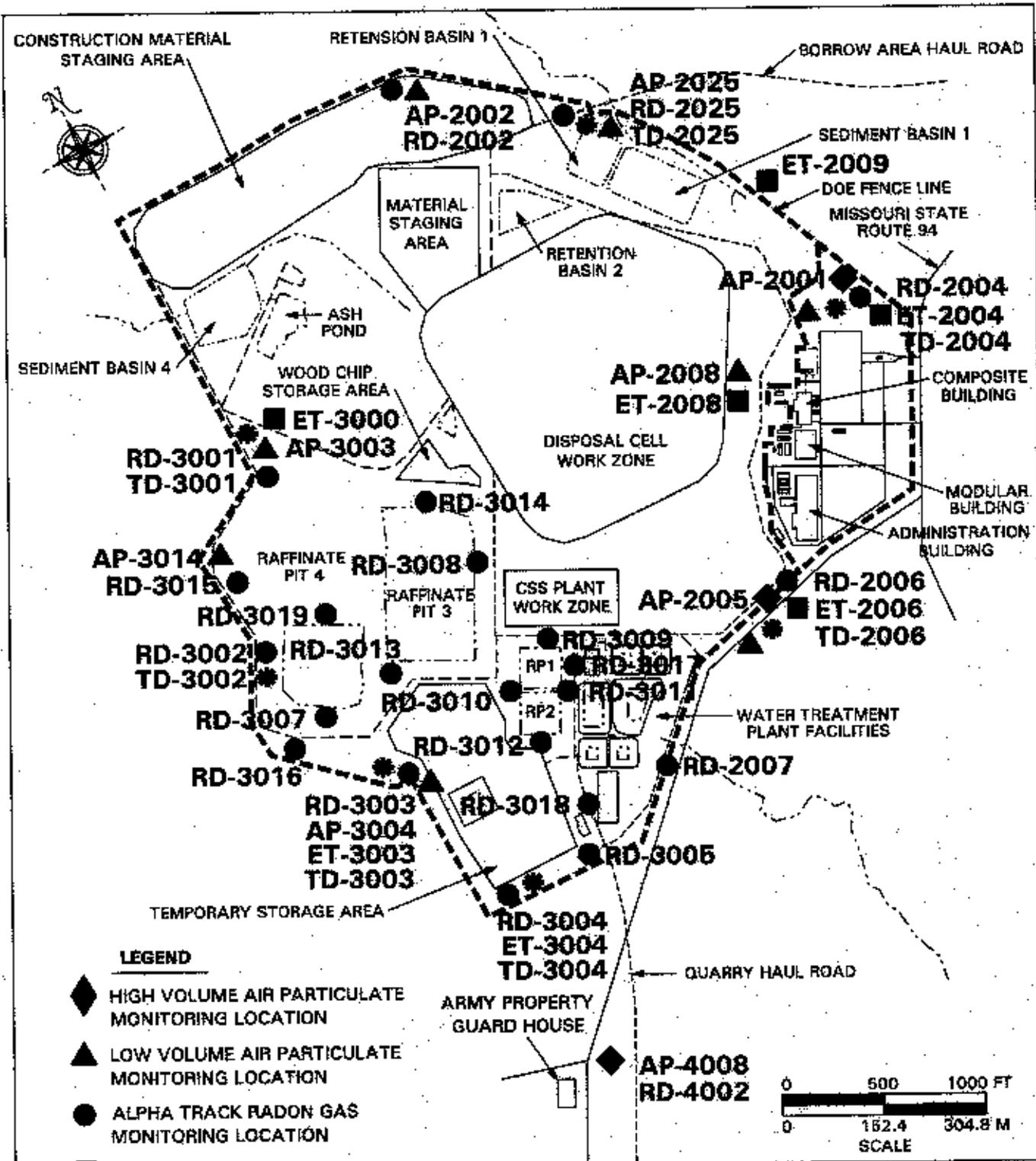
Monitoring locations are distributed around the chemical plant, raffinate pits, and quarry perimeters to ensure adequate detection of radon and thoron under varying meteorological conditions. Locations RD-4005 and RD-4009 monitor background radon and thoron concentrations. F-type track etch detectors are sensitive to all isotopes of radon and are deployed quarterly.

Paired M-type alpha etch detectors were deployed quarterly in 1998 at 25 monitoring locations: 11 at the chemical plant perimeter; one at the quarry perimeter, six at the raffinate pits, TSA, CSS, and site water treatment plant (SWTP) areas, and seven at off-site locations (including two background locations, RD-4005 and RD-4009). Specific locations are identified on Figures 4-1 through 4-4. These detectors were placed in conjunction with F-type track etch detectors to distinguish radon from thoron concentrations. Using Pearson's method (Ref. 24), separate concentrations of radon and thoron were calculated for these stations.

The WSSRAP radon monitoring program also uses electret detectors, which provide more timely data (biweekly) than the track etch detectors. Like track etch detectors, electret detectors provide a passive means of measuring radon and thoron gas concentrations in air. Twenty-eight pairs of electret detectors that measure radon only were placed at the following monitoring locations: 25 in the chemical plant and raffinate pits area (including seven along the chemical plant perimeter), one at the quarry perimeter, and two off site. Seventeen pairs of electrets that indicate thoron concentrations were deployed at the following locations: 14 in the vicinity of the chemical plant, raffinate pits, and TSA, one at the quarry perimeter, and two off site (including one background location, ET-4009). Electrets are exchanged and read biweekly. These locations, designated by an "ET" prefix, are shown in Figures 4-1 through 4-5.

Continuous radon gas monitors and working level monitors (which measure radon and thoron daughters in the air) complete the environmental radon monitoring network. Continuous radon gas monitors are sensitive to both radon and thoron. Continuous radon gas monitors were placed in on-site work zones throughout the year to evaluate local airborne levels of radon and thoron present as a result of remediation activities. On-site locations included the raffinate pits and TSA.

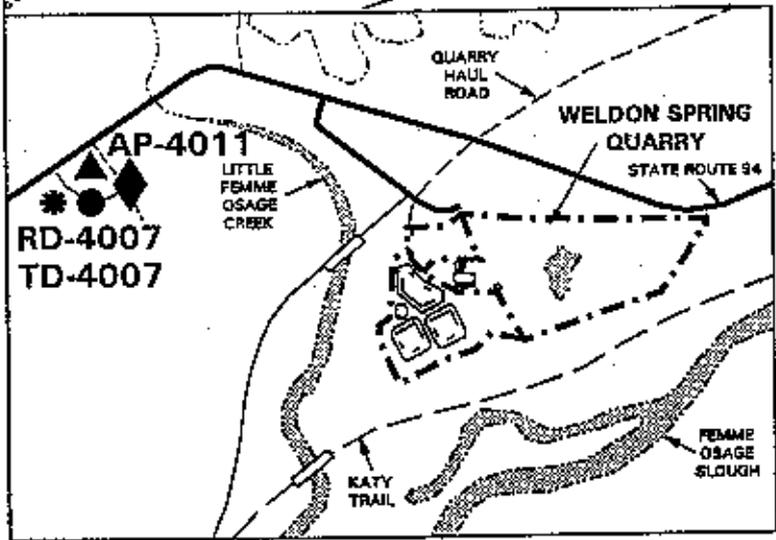
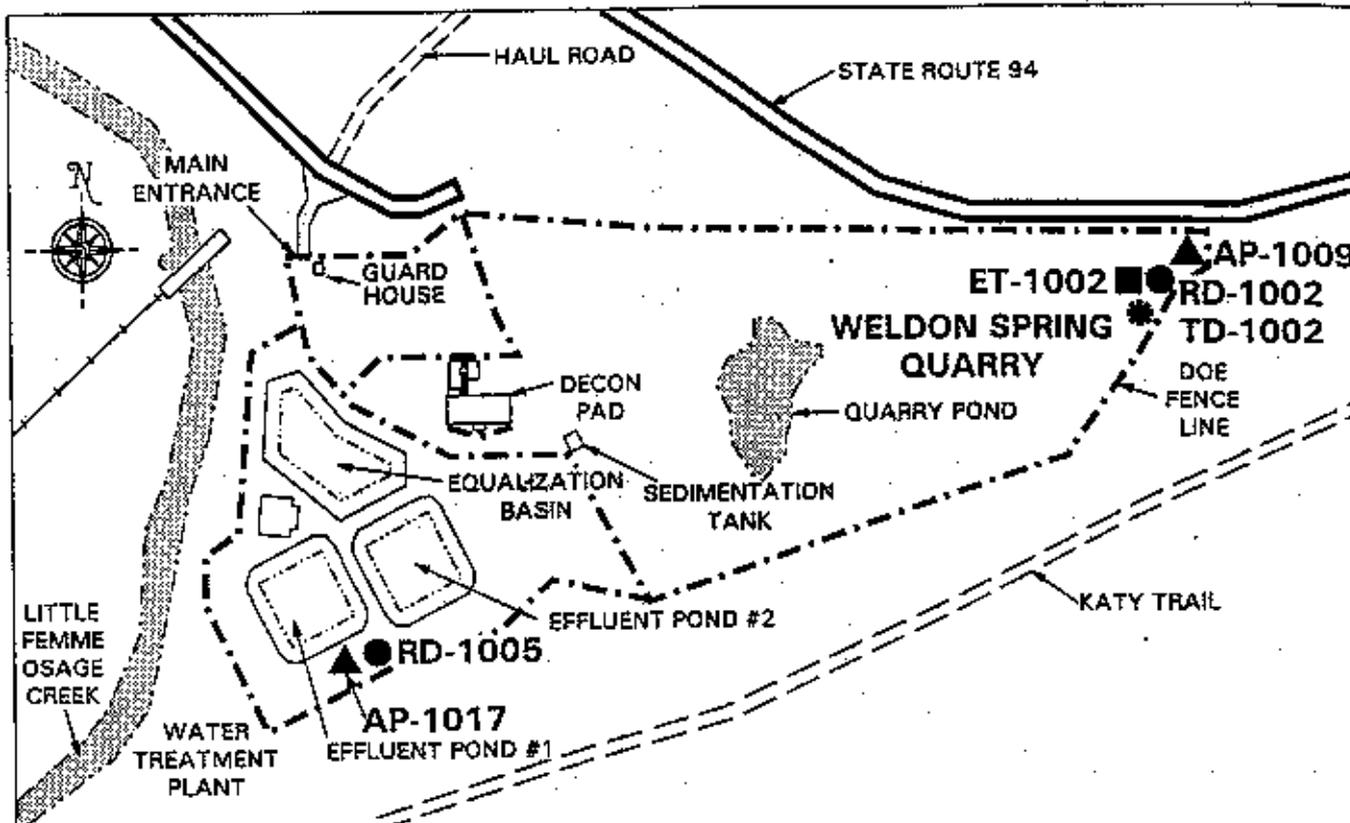
Working level monitors are sensitive to the short-lived decay products of radon and thoron. Results are recorded in milli-working levels (mWL). Working level monitors are used in work zones in conjunction with continuous radon gas monitors to determine the degree of equilibrium of radon (or thoron) gas with its decay products and the potential radon or thoron progeny dose to workers. The working level monitors operated in 1998 at the raffinate pits during periods of remedial action work.



**RADON AND AIR PARTICULATE MONITORING LOCATIONS AT THE CHEMICAL PLANT AREA**

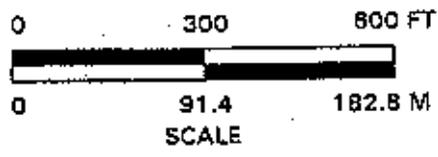
**FIGURE 4-1**

REPORT NO.:	DOE/OR/21548-773	PROJECT NO.:	A/CP/042/0894
ORIGINATOR:	EKA	DRAWN BY:	GLN
		DATE:	6/21/99



**LEGEND**

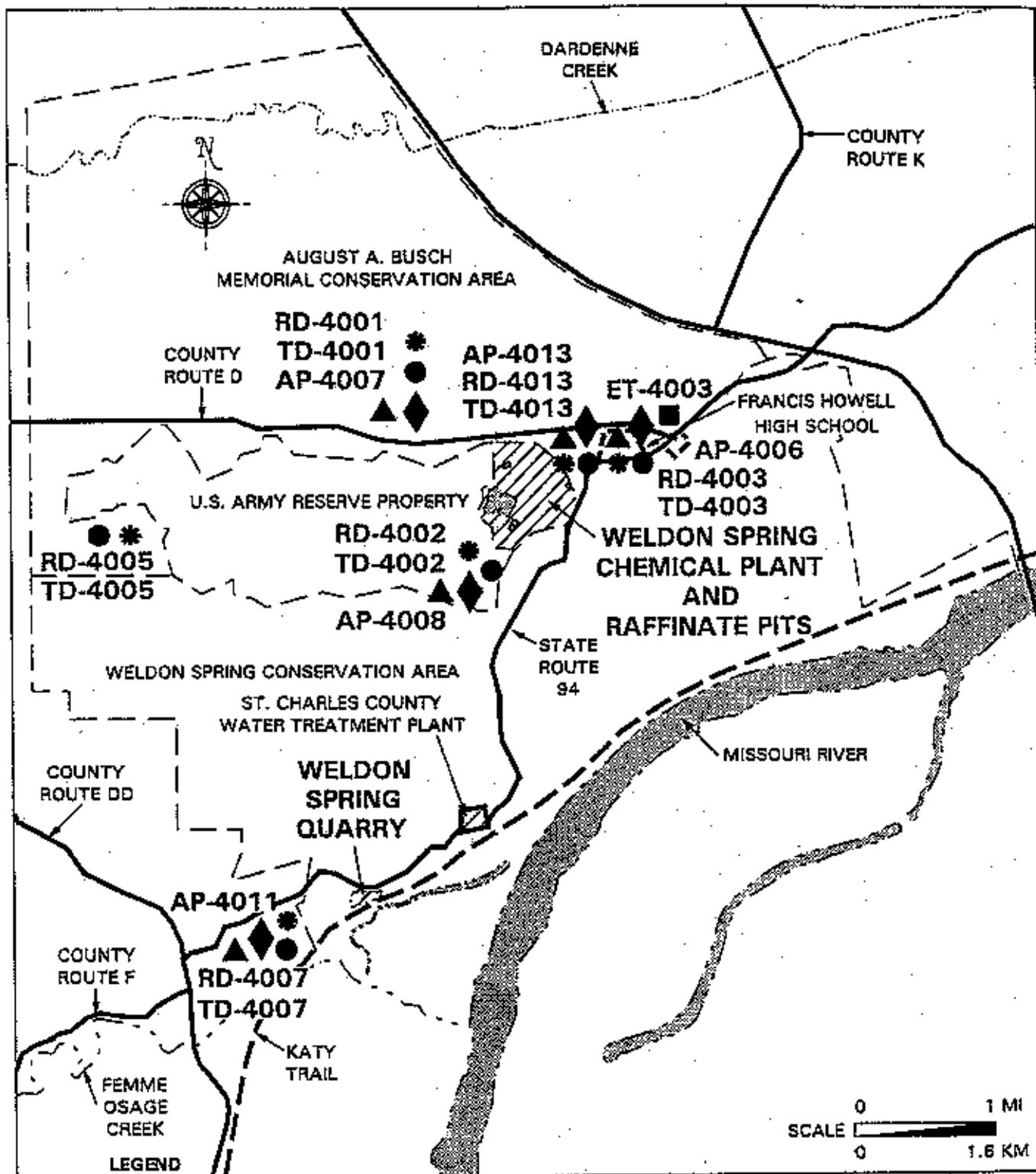
- ◆ HIGH VOLUME AIR PARTICULATE MONITORING LOCATION
- ▲ LOW VOLUME AIR PARTICULATE MONITORING LOCATION
- ALPHA TRACK RADON GAS MONITORING LOCATION
- ELECTRET RADON GAS MONITORING LOCATION
- \* GAMMA RADIATION MONITORING LOCATION



**AIR MONITORING LOCATIONS AT THE WSQ AREA**

**FIGURE 4-2**

REPORT NO.:	DOE/OR/21548-773	EXHIBIT NO.:	A/OY/059/1194
ORIGINATOR:	EKA	DRAWN BY:	GLN
		DATE:	5/3/99



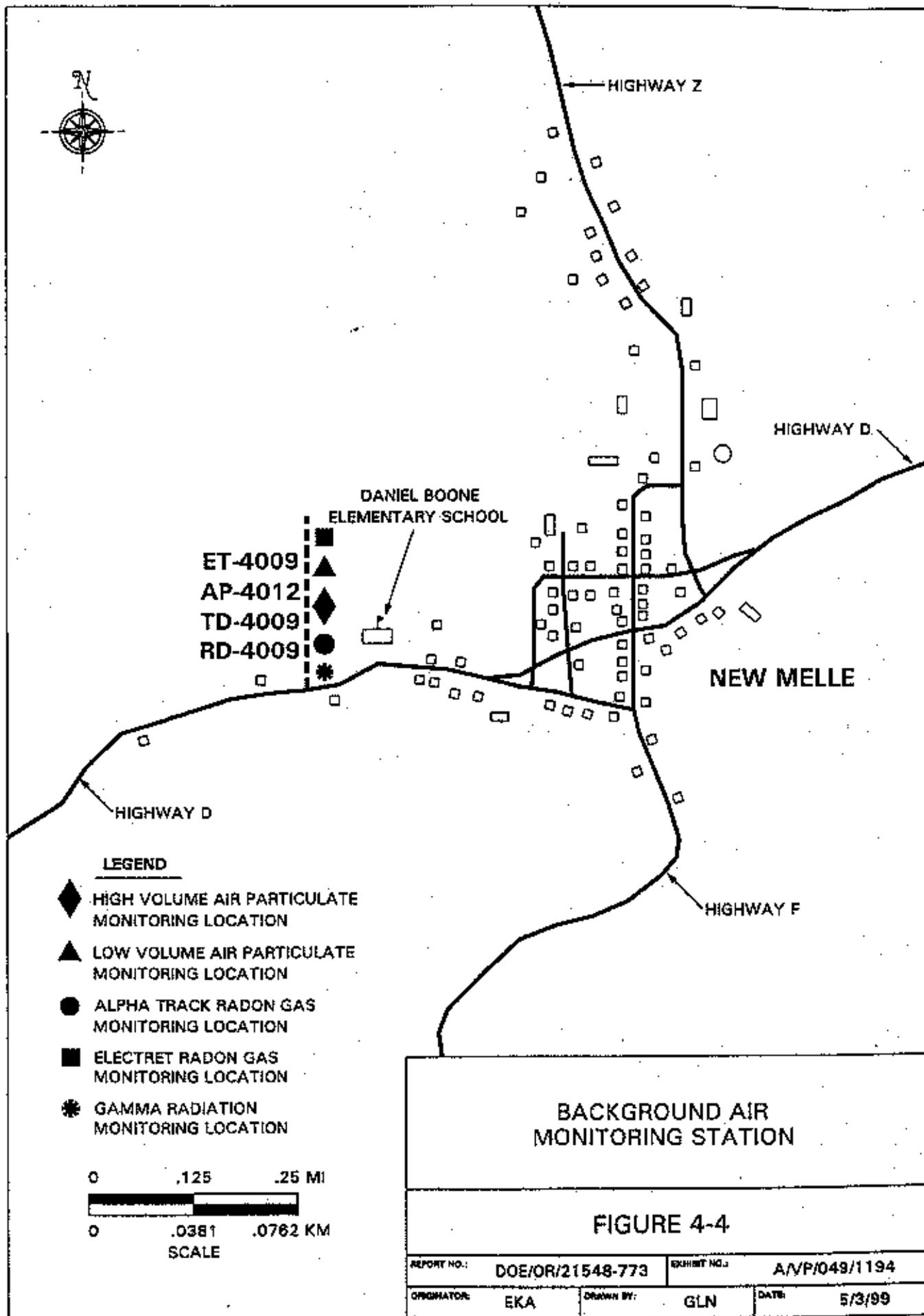
**LEGEND**

- ◆ - HIGH VOLUME AIR PARTICULATE MONITORING LOCATION
- - ALPHA TRACK RADON GAS MONITORING LOCATION
- ▲ - LOW VOLUME AIR PARTICULATE MONITORING LOCATION
- - ELECTRET RADON GAS MONITORING LOCATION
- ⊛ - GAMMA RADIATION MONITORING LOCATION

**OFF-SITE AIR MONITORING LOCATIONS**

**FIGURE 4-3**

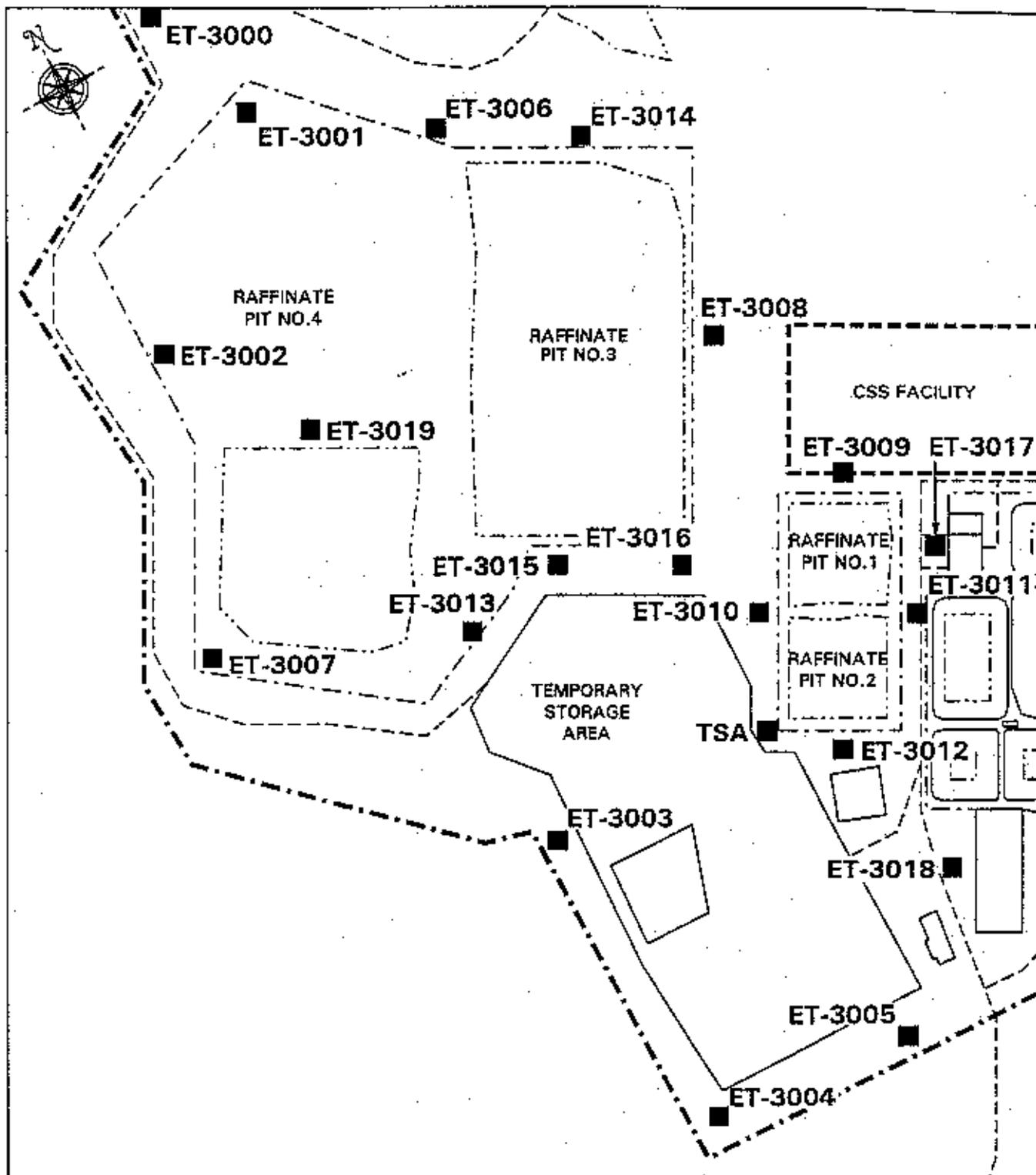
REPORT NO.:	DOE/OR/21548-773	DOCKET NO.:	A/VP/048/1194
ORIGINATOR:	EKA	DRAWN BY:	GLN
		DATE:	5/28/99



**BACKGROUND AIR MONITORING STATION**

**FIGURE 4-4**

REPORT NO.:	DOE/OR/21548-773	EXHIBIT NO.:	A/NP/049/1194
ORIGINATOR:	EKA	DRAWN BY:	GLN
		DATE:	5/3/99



■ ELECTRET RADON GAS MONITORING LOCATION

NOT TO SCALE

ELECTRET MONITORING LOCATIONS AT THE WELDON SPRING RAFFINATE PITS AREA

FIGURE 4-5

REPORT NO.:	DOE/OR/21548-773	DO-BET NO.:	A/RP/O10/0894
ORIGINATOR:	EKA	DRAWN BY:	GLN
		DATE:	5/3/99

#### 4.2.2 Applicable Standards

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

Dose limits for the 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 DCG, which is a limiting airborne concentration of a specified radionuclide, is specified by DOE 5400.5 to be 3 pCi/l (100 Bq/m<sup>3</sup>) above background for both radon and thoron in unrestricted (off-site) areas.

#### 4.2.3 Monitoring Results

Table 4-1 summarizes quarterly and annual average integrated radon concentrations as measured by F-type track etch 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 track etch 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 track etch background concentration was calculated using the arithmetic average of the two background locations. The data yielded an annual background average integrated radon concentration in 1998 of 0.2 pCi/l (7.4 Bq/m<sup>3</sup>). This result is consistent with previous years' monitoring results.

Based on measurements from F-type and M-type track etch detectors at locations where the potential for a combined release of radon and thoron was suspected, thoron concentrations were estimated using Pearson's method. Locations with thoron concentrations statistically greater than background at the 95% confidence level were compared with the DCG for thoron. Results are presented in Table 4-2.

The annual thoron background concentration was determined to be 0.1 pCi/l (4 Bq/m<sup>3</sup>) and was calculated using the arithmetic average of the two background locations. This result is consistent with previous years' monitoring results.

Table 4-1 1988 Track Etch Integrated Radon Results<sup>(a)</sup>

LOCATION ID	1ST QUARTER pCi/l <sup>(b)</sup>	2ND QUARTER pCi/l <sup>(b)</sup>	3RD QUARTER pCi/l <sup>(b)</sup>	4TH QUARTER pCi/l <sup>(b)</sup>	ANNUAL AVERAGE pCi/l <sup>(b)</sup>	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT(X) <sup>(c)</sup>	PERCENT OF GUIDELINE <sup>(d)</sup>
WELDON SPRING QUARRY								
RD-1002	0.3	0.2	0.2	0.1	0.2	0.08		N/A
RD-1005	0.3	0.1	0.3	0.2	0.2	0.10		N/A
WELDON SPRING CHEMICAL PLANT								
RD-2002	0.1	0.1	0.2	0.1	0.1	0.05		N/A
RD-2004	0.2	0.1	0.2	0.2	0.2	0.05		N/A
RD-2006	0.2	0.1	0.3	0.2	0.2	0.08		N/A
RD-2007	0.3	0.1	0.3	0.2	0.2	0.10		N/A
RD-2025	0.1	0.2	0.1	0.2	0.2	0.06		N/A
WELDON SPRING RAFFINATE PITS								
RD-3001	0.2	0.3	0.4	0.2	0.3	0.10		N/A
RD-3002	0.3	0.5	0.5	0.2	0.4	0.15	X	7
RD-3003	0.4	0.3	0.3	0.1	0.3	0.13		N/A
RD-3004	0.2	0.1	0.3	0.1	0.2	0.10		N/A
RD-3005	0.2	0.1	0.5	0.1	0.2	0.19		N/A
RD-3007	0.4	-	-	-	0.4	N/A		N/A
RD-3008	0.2	0.3	1.0	-	0.5	0.44		N/A
RD-3009	0.3	0.2	0.5	0.2	0.3	0.14		N/A
RD-3010	0.5	-	-	-	0.5	N/A		N/A
RD-3011	0.3	-	-	-	0.3	N/A		N/A
RD-3012	0.6	-	-	-	0.6	N/A		N/A
RD-3013	0.9	-	-	0.4	0.7	0.35	X	N/A <sup>(e)</sup>
RD-3014	0.5	-	-	-	0.5	N/A		N/A
RD-3015	0.2	-	-	-	0.2	N/A		N/A
RD-3016	-	0.2	0.4	0.1	0.2	0.15		N/A
RD-3017	-	0.2	0.3	0.3	0.3	0.06		N/A
RD-3018	-	0.1	0.7	0.1	0.3	0.35		N/A
RD-3019	-	-	-	0.2	0.2	N/A		N/A

Table 4-1 1988 Track Etch Integrated Radon Results <sup>(a)</sup> (Continued)

LOCATION ID	1ST QUARTER pCi/l <sup>(b)</sup>	2ND QUARTER pCi/l <sup>(b)</sup>	3RD QUARTER pCi/l <sup>(b)</sup>	4TH QUARTER pCi/l <sup>(b)</sup>	ANNUAL AVERAGE pCi/l <sup>(b)</sup>	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT (X) <sup>(c)</sup>	PERCENT OF GUIDELINE <sup>(d)</sup>
RD-4001	0.2	0.1	0.2	0.2	0.2	0.05		N/A
RD-4002	0.1	0.1	0.4	0.1	0.2	0.15		N/A
RD-4003	0.1	0.1	0.2	0.1	0.1	0.05		N/A
*RD-4005	0.2	0.1	0.3	0.2	0.2	0.08		N/A
RD-4007	0.2	0.1	0.3	0.2	0.2	0.08		N/A
*RD-4009	0.2	0.1	0.3	0.1	0.2	0.10		N/A
RD-4013	0.1	0.1	0.3	0.1	0.2	0.10		N/A

(a) Results include natural background levels except where otherwise noted.

(b) To convert from pCi/l to Bq/m<sup>3</sup>, multiply by 37.

(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the annual background average concentration, using a one-tailed Student's t-test at the 95% confidence level.

(d) Percent of 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 (100 Bq/m<sup>3</sup>) annual average above background for uncontrolled areas.

(e) Missing detectors.

(f) No percentage calculation performed for above-background monitoring locations within the site boundary.

N/A No percentage calculation performed for background locations or locations not statistically greater than background.

— No measurement taken.

Table 4-2 1998 Thoron Concentrations as Determined Using Paired F-type and M-type Track Etch Detectors<sup>(a)</sup>

STATION ID	1ST QUARTER (pCi/l) <sup>(b)</sup>	2ND QUARTER (pCi/l) <sup>(b)</sup>	3RD QUARTER (pCi/l) <sup>(b)</sup>	4TH QUARTER (pCi/l) <sup>(b)</sup>	ANNUAL AVERAGE (pCi/l)	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT (X) <sup>(c)</sup>	PERCENT OF GUIDELINE <sup>(d)</sup>
RD-1002	0.0	0.3	0.1	0.2	0.2	0.13		N/A
Weldon Spring Quarry								
RD-2002	0.0	0.1	0.0	0.2	0.1	0.1		N/A
RD-2004	0.0	0.1	0.0	0.0	0.1	0.06		N/A
RD-2006	0.0	0.1	0.0	0.0	0.0	0.05		N/A
RD-2007	0.1	0.0	0.0	0.0	0.0	0.05		N/A
RD-2025	0.0	0.1	0.4	0.3	0.2	0.18		N/A
Weldon Spring Refrinate Pits								
RD-3001	0.0	0.4	0.3	0.2	0.2	0.17	X	7
RD-3002	0.0	0.8	0.3	0.5	0.4	0.34	X	13
RD-3003	0.3	0.4	0.1	0.6	0.4	0.21	X	13
RD-3004	0.0	0.1	0.0	0.0	0.0	0.05		N/A
RD-3005	0.0	0.4	0.1	0.2	0.2	N/A		N/A
RD-3009	-	-	-	0.5	0.5	N/A		N/A <sup>(e)</sup>
RD-3010	0.3	0.2	-	-	0.3	0.07	X	N/A <sup>(e)</sup>
RD-3013	-	-	-	3.2	3.2	N/A		N/A
RD-3014	0.1	-	-	-	0.1	N/A		N/A <sup>(e)</sup>
RD-3016	-	0.3	-	0.2	0.3	0.07	X	10
RD-3017	-	0.2	0	0.1	0.1	0.10		
RD-3018	-	0.1	0.1	0.3	0.2	0.12	X	N/A <sup>(e)</sup>
Off-Site								
RD-4001	0.0	0.0	0.0	0.0	0.0	0		N/A
RD-4002	0.0	0.1	0.1	0.0	0.0	0.05		N/A
RD-4003	0.0	0.0	0.0	0.0	0.0	0		N/A
RD-4005*	0.0	0.0	0.0	0.0	0.0	0		N/A
RD-4007	0.0	0.1	0.0	0.0	0.1	0.05		N/A
RD-4009*	0.0	0.1	0.0	0.1	0.1	0.06		N/A
RD-4013	0.0	0.1	0.0	0.1	0.1	0.06		N/A

Table 4-2 1998 Thoron Concentrations as Determined Using Paired F-type and M-type Track Etch Detectors <sup>(a)</sup> (Continued)

*	Background station
(a)	Results include natural background levels.
(b)	To convert from pCi/l to Bq/m <sup>3</sup> , multiply by 37.
(c)	Statistical significance is determined by comparing the annual average concentration for a monitoring location with the annual average background concentration, using a one-tailed Student's t-test at the 95% confidence level.
(d)	Percent of guideline is calculated by taking the annual station average minus the annual average of the background station, divided by the DCG for Rn-220 of 3 pCi/l (100 Bq/m <sup>3</sup> ), annual average above background for uncontrolled areas.
(e)	No percentage calculation performed for above-background monitoring locations within site boundary.
N/A	No percent of guideline calculated for background stations or stations not statistically greater than background.
-	Discontinued or new monitoring location; no data for this quarter.

Although results in Tables 4-1 and 4-2 may appear inconsistent for a given monitoring location, this is to be expected since F-type detectors have a higher response function for radon than for thoron. The supplemental thoron measuring technique using the M-type detectors provides a better estimate of the thoron contribution to the total radon concentration. Therefore, for monitoring stations where virtually all of the integrated radon concentration is contributed by thoron (for example, see results for RD-3013, Tables 4-1 and 4-2), the thoron results using Pearson's method are larger than the respective integrated results.

Radon and thoron concentrations measured by the electret monitors are summarized in Tables 4-3 and 4-4. Because electret results are obtained biweekly rather than quarterly (as with the track etch detectors), they are used primarily as advance indicators of trends in radon/thoron levels at a given monitoring location. Therefore, track etch results, rather than electret results, are used in performing off-site dose calculations.

Historical average background concentrations of radon and thoron gas near the site are both typically 0.2 pCi/l (7 Bq/m<sup>3</sup>). Based on continuous radon, thoron, and radon/thoron progeny measurements in selected on-site work zones, elevated concentrations are evident, particularly in localized areas where remedial actions involve the disturbance of raffinate sludge or other radium-laden wastes. The maximum hourly radon and thoron concentrations recorded on site in 1998 were approximately 171 pCi/l (6.3E3 Bq/m<sup>3</sup>) and 59 pCi/l (2.2E3 Bq/m<sup>3</sup>), respectively. These concentrations were measured in August at the CSS plant. These values are higher than comparable measurements taken using track etch and electret detectors because the continuous monitors are placed inside work zones, while track etch and electret detectors are placed along the periphery of work zones and the site perimeter fence. Data collected with continuous radon and working level monitors are sporadic throughout the year because they are collected only during activities that have the potential to result in significant worker doses due to inhalation of radon and thoron progeny.

#### 4.2.4 Data Analysis

Statistical analysis of the F-type track etch integrated radon results indicated that, at the 95% confidence level, measured concentrations at two of the 32 monitoring locations were greater than the combined background station result. One of these stations, RD-3002, is located along the site perimeter west of Raffinate Pit 4. The other station, RD-3013, is located on the southwest berm of Raffinate Pit 3. The results for other stations were not statistically distinguishable from background levels.

Table 4-3 1998 Electret Radon-222 Results<sup>(a)</sup>

LOCATION ID	1ST QUARTER (pCi/l) <sup>(b)</sup>	2ND QUARTER (pCi/l) <sup>(b)</sup>	3RD QUARTER (pCi/l) <sup>(b)</sup>	4TH QUARTER (pCi/l) <sup>(b)</sup>	ANNUAL AVERAGE (pCi/l) <sup>(b)</sup>	ANNUAL STANDARD DEVIATION
ET-1002	0.3	--	--	--	0.3	0.06
ET-2004	0.3	0.2	0.4	0.3	0.3	0.10
ET-2006	0.2	0.3	0.6	0.2	0.3	0.24
ET-2008	0.2	0.1	0.3	0.1	0.2	0.15
ET-2009	0.3	0.3	0.6	0.5	0.4	0.16
ET-3000	0.2	--	--	--	0.2	0.10
ET-3001	0.2	--	--	--	0.2	0.14
ET-3002	0.2	0.2	--	--	0.2	0.09
ET-3003	0.4	0.2	0.4	0.3	0.3	0.19
ET-3004	0.2	0.2	0.3	0.2	0.2	0.09
ET-3005	0.3	0.2	0.3	0.2	0.3	0.12
ET-3006	0.2	--	--	--	0.2	0.12
ET-3007	0.2	0.2	0.2	0.2	0.2	0.10
ET-3008	0.3	0.3	1.2	0.3	0.5	0.54
ET-3009	0.2	0.1	--	--	0.2	0.09
ET-3010	0.5	0.1	0.2	0.3	0.3	0.31
ET-3011	0.3	--	--	--	0.3	0.06
ET-3012	0.2	--	--	--	0.2	0.09
ET-3013	0.3	0.1	0.2	0.2	0.2	0.10
ET-3014	0.2	0.2	0.5	0.5	0.4	0.26
ET-3015	0.3	--	--	--	0.3	0.08
ET-3016	0.2	--	--	--	0.2	0.13
ET-3017	0.1	0.2	0.2	0.1	0.2	0.12
ET-3018	0.7	0.3	0.5	0.2	0.4	0.33
ET-3019	--	--	0.5	0.3	0.4	0.31
ET-4003	0.4	0.4	0.5	0.3	0.4	0.10
ET-4009*	0.2	0.2	0.4	0.3	0.3	0.10
TSA <sup>(c)</sup>	0.2	--	0.4	--	0.3	0.17

(a) Results include natural background levels.

(b) To convert from pCi/l to Bq/m<sup>3</sup>, multiply by 37.

(c) Temporary monitoring station established for monitoring of TSA waste removal.

\* Background station.

-- Measurement not collected.

N/A No standard deviation calculated.

Table 4-4 1998 Electret Radon-220 Results<sup>(a)</sup>

LOCATION ID	1ST QUARTER (pCi/l) <sup>(b)</sup>	2ND QUARTER (pCi/l) <sup>(b)</sup>	3RD QUARTER (pCi/l) <sup>(b)</sup>	4TH QUARTER (pCi/l) <sup>(b)</sup>	ANNUAL AVERAGE (pCi/l) <sup>(b)</sup>	ANNUAL STANDARD DEVIATION
ET-1002	0.4	0.4	--	--	0.4	0.21
ET-2004	0.2	0.2	0.3	0.2	0.2	0.17
ET-2009	0.3	0.4	0.4	0.4	0.4	0.27
ET-3000	0.3	--	--	--	0.3	0.24
ET-3001	0.2	--	--	--	0.2	0.19
ET-3002	0.4	0.8	--	--	0.6	0.40
ET-3003	0.6	0.5	0.7	0.4	0.5	0.27
ET-3006	0.7	--	--	--	0.7	0.33
ET-3007	1.7	3.0	1.9	2.9	2.4	1.54
ET-3010	0.4	0.5	0.4	0.7	0.5	0.22
ET-3013	1.3	2.5	2.2	4.0	2.5	1.90
TSA <sup>(c)</sup>	0.3	--	1.6	--	0.8	0.52
ET-3015	0.9	--	--	--	0.9	0.26
ET-3016	0.4	--	--	--	0.4	0.14
ET-3019	--	--	3.9	14.6	8.9	10.64
ET-4003	0.2	0.6	0.6	0.3	0.4	0.43
ET-4009*	0.4	0.3	0.3	0.3	0.3	0.23

(a) Results include natural background levels.

(b) To convert from pCi/l to Bq/m<sup>3</sup>, multiply by 37.

(c) Temporary monitoring station established for removal of TSA waste.

\* Background station.

N/A No standard deviation calculated.

-- Discontinued or new monitoring location; no data for this quarter.

Statistical analysis of track etch thoron results indicated that, at the 95% confidence level, the annual average concentration at six of the 25 monitoring locations exceeded background levels. Four of these stations, RD-3001, RD-3002, RD-3003, and RD-3016 are located along the site perimeter near Raffinate Pit 4. Two stations, RD-3010 and RD-3018, are located near the TSA. Results for all other stations were statistically indistinguishable from background levels.

#### 4.2.4.1 Chemical Plant and Raffinate Pits

Statistical analysis of two radon track etch monitoring locations, RD-3002 and RD-3013, indicated results greater than background levels. The annual average concentrations for these stations exceeded background levels by 0.2 pCi/l (7.4 Bq/m<sup>3</sup>) and 0.5 pCi/l (19 Bq/m<sup>3</sup>), respectively. These results were lower than in previous years, and are likely due to the removal of most of the sludge from Raffinate Pit 4. The quarterly measured radon concentrations for all stations ranged from 0.1 pCi/l (3.7 Bq/m<sup>3</sup>) to 1.0 pCi/l (37 Bq/m<sup>3</sup>).

Statistical analysis of six thoron track etch monitoring locations, RD-3001, RD-3002, RD-3003, RD-3010, RD-3016, and RD-3018 indicated annual average results greater than background levels. The annual average concentration for these stations exceeded the annual average background by 0.2 pCi/l (7.4 Bq/m<sup>3</sup>) to 0.4 pCi/l (15 Bq/m<sup>3</sup>). The quarterly thoron

measurements for all stations ranged from 0 pCi/l (0 Bq/m<sup>3</sup>) to 3.2 pCi/l (119 Bq/m<sup>3</sup>). Just as the integrated radon results, these results are lower than in previous years due to the removal of most sludge from the raffinate pits.

#### 4.2.4.2 Quarry

Statistical analysis of track etch radon and thoron monitoring results from the two quarry stations indicated that there was no reason to suspect, at the 95% confidence level, that these results exceeded background levels. The quarterly measured results for integrated radon from both quarry stations ranged from 0.1 pCi/l (3.7 Bq/m<sup>3</sup>) to 0.3 pCi/l (11 Bq/m<sup>3</sup>). Quarterly Rn-220 results at the quarry station ranged from 0 pCi/l (0 Bq/m<sup>3</sup>) to 0.3 pCi/l (11 Bq/m<sup>3</sup>).

#### 4.2.4.3 Off-Site Locations

Statistical analysis of both track etch integrated radon and thoron monitoring results from off-site locations (shown in Figure 4-3) indicated that there was no reason to suspect, at the 95% confidence level, 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 (3.7 Bq/m<sup>3</sup>) to 0.4 pCi/l (15 Bq/m<sup>3</sup>). Quarterly results for thoron at the off-site stations ranged from 0 pCi/l (0 Bq/m<sup>3</sup>) to 0.1 pCi/l (3.7 Bq/m<sup>3</sup>). These results are similar to results obtained during previous years.

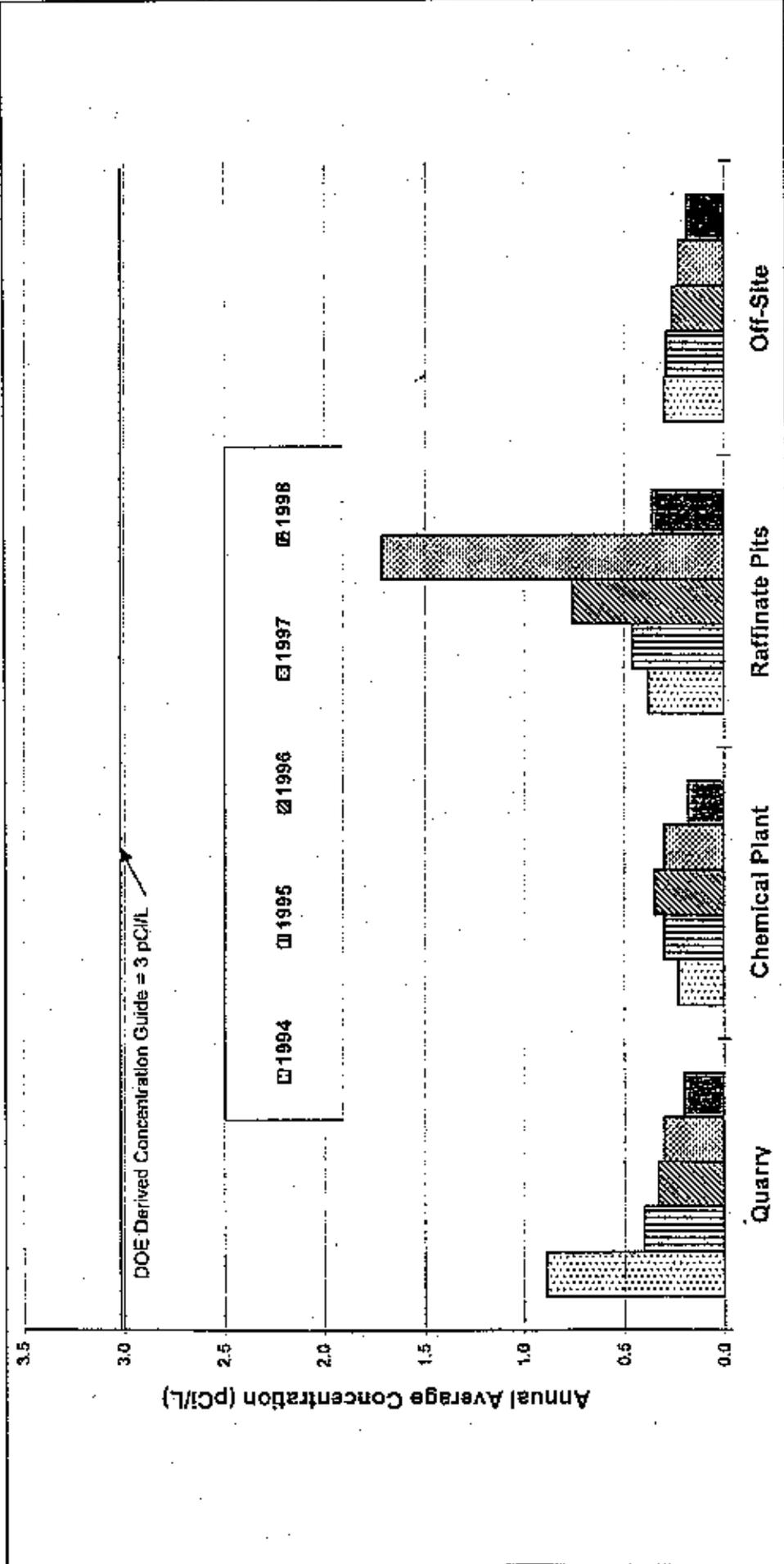
#### 4.2.4.4 Five-Year Trend Analysis of Integrated Radon Gas

Figure 4-6 shows 5 years of annual average track etch 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 gas levels at all locations trended downward in 1998, coincident with the placement of most raffinate sludge and TSA waste in the disposal facility.

### 4.3 Gamma Radiation Monitoring

#### 4.3.1 Program Overview

Gamma radiation is emitted from natural, cosmic, and manmade 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 the majority of natural gamma background radiation. The National Council on Radiation Protection and Measurements (NCRP) estimates the typical gamma radiation dose is 28 mrem/year (0.28 mSv/year) from terrestrial sources and



RADON TRACK ETCH DETECTOR  
5-YEAR TRENDS

FIGURE 4-6

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27 mrem/year (0.27 mSv/year) from cosmic sources (Ref. 25). The total estimated background radiation dose equivalent due to gamma exposure is thus 55 mrem/year (0.55 mSv/year).

Gamma radiation was monitored in 1998 using TLDs at 15 monitoring stations: seven at the site perimeter, one at the quarry perimeter, and seven off site. The locations are denoted by a "TD" prefix on Figures 4-1 through 4-5. Stations TD-4005 and TD-4009 measure natural background at locations unaffected by the site. The TLDs are exchanged and read every calendar quarter.

#### 4.3.2 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 (1.0 mSv/year) total effective dose equivalent (TEDE) from DOE operations for all exposure pathways, excluding exposure to natural background radiation.

#### 4.3.3 Monitoring Results

Table 4-5 summarizes quarterly and annual total gamma radiation monitoring results. The table includes quarterly and annual totals, the annual sample standard deviation for each station, and 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 1998 were determined by averaging the annual total measurement from the two background stations. The annual average result from these stations was 58 mrem/year (0.58 mSv/year) with a standard deviation of 1 mrem/year (0.01 mSv/year). This average background is within 10% of the NCRP 94 estimate of 55 mrem/year (0.55 mSv/year) (Ref. 25).

#### 4.3.4 Data Analysis

Statistical analysis of TLD results revealed that, at the 95% confidence level, four stations had annual results greater than background levels. These stations included TD-2004 and TD-2025, located along the northeastern perimeter of the chemical plant; and TD-3002 and TD-3003, located around the raffinate pits and TSA. Results for all other stations were indistinguishable from background levels.

Table 4-5 1998 Environmental TLD Results<sup>(a)</sup>

LOCATION	1ST QUARTER (mrem) <sup>(b)</sup>	2ND QUARTER (mrem) <sup>(b)</sup>	3RD QUARTER (mrem) <sup>(b)</sup>	4TH QUARTER (mrem) <sup>(b)</sup>	ANNUAL TOTAL (mrem/yr) <sup>(b)</sup>	STANDARD DEVIATION	STATISTICALLY SIGNIFICANT (X) <sup>(c)</sup>
<b>WELDON SPRING QUARRY</b>							
TD-1002	14.0	12.3	15.4	15.0	57	1.4	
<b>WELDON SPRING CHEMICAL PLANT</b>							
TD-2004	16.6	15.4	17.7	16.6	66	0.9	X
TD-2006	14.5	13.7	16.3	15.7	60	1.2	
TD-2025	15.9	14.8	16.6	15.8	63	0.7	X
<b>WELDON SPRING RAFFINATE PITS</b>							
TD-3001	15.4	14.0	18.6	16.2	64	1.9	
TD-3002	16.2	14.6	19.6	21.3	72	3.1	X
TD-3003	19.8	17.1	22.4	20.9	80	2.2	X
TD-3004	15.6	13.2	16.2	15.9	61	1.4	
<b>OFF SITE</b>							
TD-4001	16.0	14.2	17.9	15.2	63	1.6	
TD-4002	12.3	11.2	14.1	13.1	51	1.2	
TD-4003	12.0	12.9	13.5	12.7	51	0.6	
*TD-4005	14.7	12.5	15.8	14.2	57	1.4	
TD-4007	14.5	12.5	15.3	15.3	58	1.3	
*TD-4009	14.7	13.1	15.2	14.8	58	0.9	
TD-4013	15.6	13.0	15.0	15.1	59	1.2	

\* Denotes background location.

(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 total annual concentration for a monitoring location with the total annual background concentration, using a one-tailed Student's t-test at the 95% confidence level.

#### 4.3.4.1 Chemical Plant/Raffinate Pits

The annual effective dose equivalent from external gamma radiation measured by TLDs at the chemical plant and raffinate pits ranged from 60 mrem (0.6 mSv) to 80 mrem (0.8 mSv). These results are lower than previous years for these areas due to the completion of remediation of most of Raffinate Pit 3 and removal of much of the temporarily stored waste to the disposal cell.

#### 4.3.4.2 Quarry

The annual effective dose equivalent from external gamma radiation measured by TLDs at the quarry was 57 mrem (0.57 mSv). This result is comparable to previous years for this area.

#### 4.3.4.3 Off-Site Locations

The annual effective dose equivalent from external gamma radiation measured by TLDs at off-site locations ranged from 51 mrem (0.51 mSv) to 63 mrem (0.63 mSv). These results are comparable to previous years for these areas.

#### 4.3.4.4 Five-Year Trend Analysis of TLDs

Gamma radiation exposure monitoring results for the last 5 years are depicted in Figure 4-7. The graph shows yearly monitoring result totals for the chemical plant, raffinate pits, quarry, and off-site locations. The results include the natural background dose rate. Results indicate a downward trend in measurements around the raffinate pits due to completion of much of the remediation work in this area. No other trends are evident.

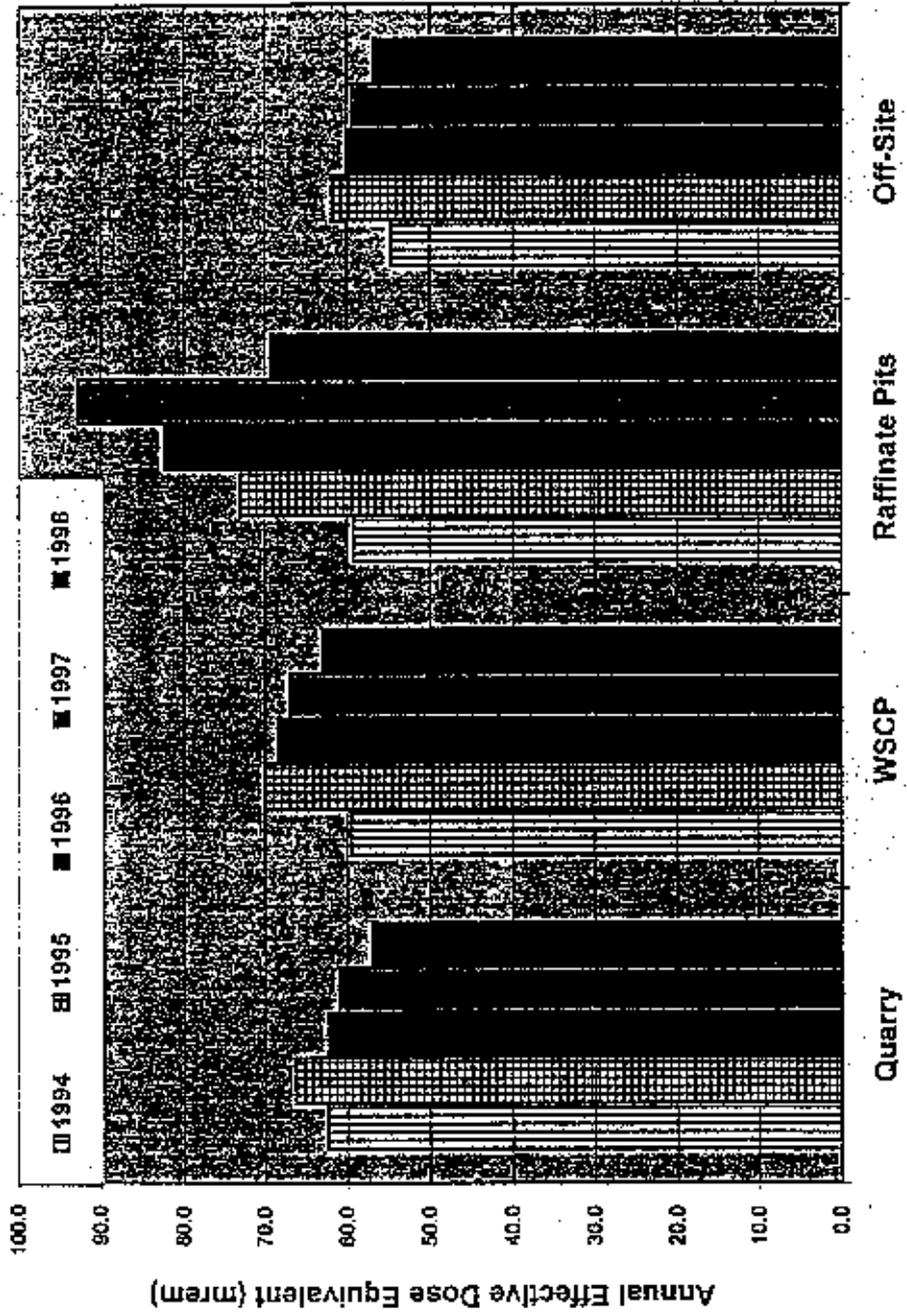
### 4.4 Radioactive Air Particulate Monitoring

#### 4.4.1 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. Many areas on site contain above background concentrations of soil contamination, which can result in increased airborne radioactive particulate concentrations. Increased airborne radioactive particulate emissions from the site can result from wind erosion of contaminated soils piles or remedial work activities, such as moving equipment and vehicles in contaminated areas.

In 1998, the WSSRAP monitored radioactive air particulates weekly at 16 continuous permanent low volume air sampling stations: eight at the chemical plant perimeter, two at the quarry, and six at off-site locations. These locations are denoted by an "AP" prefix on Figures 4-1, 4-2, 4-3, and 4-4. 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 liters/minute 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 present 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) 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 NESHAPs monitoring are in Section 6, NESHAPs Program.



ENVIRONMENTAL TLD  
5-YEAR TRENDS

FIGURE 4-7

REPORT NO.: DOE/OR/21548-773	EMISIT NO.: API/015/0497
ORIGINATOR: ED	DRAWN BY: GLN
	DATE: 5/4/99

#### 4.4.2 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.

#### 4.4.3 Monitoring Results

The annual average long-lived gross alpha concentrations and standard deviations for the 16 permanent low volume stations are summarized in Table 4-6. 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. 26) requires the use of uncensored data to minimize any bias in arithmetic averages and standard deviation calculations. Annual results represent the average of up to 52 weeks of data for each monitoring station. During 1998, background station AP-4012 was transitioned from a 104-week (2-year) average to a 52-week (1-year) average. Although results of both methods of comparison are listed in the table, in the future only the 52-week background averages will be considered to increase the robustness of the statistical comparison.

The typical MDC for low volume air particulate sampling at the WSSRAP is  $3.3\text{E-}16$   $\mu\text{Ci/ml}$  ( $1.2\text{E-}11$  Bq/ml). This MDC is low enough to allow detection of Th-232, which has the lowest DCG at the site of  $7.0\text{E-}15$   $\mu\text{Ci/ml}$  ( $2.6\text{E-}10$  Bq/ml) (DOE 5400.5). If an individual inhales airborne contaminants at the DCG for 1 year, the resulting committed effective dose equivalent is 100 mrem (1 mSv).

#### 4.4.4 Data Analysis

Statistical analysis of the annual results from the low volume airborne particulate samplers indicated that seven monitoring stations were greater than the 52-week background concentrations, and nine monitoring stations exceeded the 104-week average. Station AP-4012 indicated annual averages at 52-week and 104-week background average concentrations of  $1.27\text{E-}15$   $\mu\text{Ci/ml}$  ( $4.70\text{E-}11$  Bq/ml) and  $1.22\text{E-}15$   $\mu\text{Ci/ml}$  ( $4.51\text{E-}11$  Bq/ml), respectively.

Table 4-6 1998 Radioactive Air Particulate Gross Alpha Results

MONITORING STATION IDENTIFICATION NUMBER	ANNUAL AVERAGE LONG-LIVED GROSS ALPHA CONCENTRATION (X1E-15 $\mu$ Ci/ml) <sup>(b)(d)</sup>	STANDARD DEVIATION (X1E-15 $\mu$ Ci/ml)	NUMBER OF SAMPLES/TOTAL NUMBER OF WEEKS	STATISTICALLY SIGNIFICANT (X) <sup>(c)</sup>	
				52-WEEK BACKGROUND COMPARISON	104-WEEK BACKGROUND COMPARISON
<b>Weldon Spring Quarry</b>					
AP-1009	1.35	0.660	52/52		
AP-1017	1.29	0.491	52/52		
<b>Weldon Spring Chemical Plant/Raffinate Pit Perimeter</b>					
AP-2001	1.46	0.661	52/52		X
AP-2002	1.84	1.02	52/52	X	X
AP-2005	1.58	0.829	52/52	X	X
AP-2008	1.82	0.823	42/52	X	X
AP-2025	1.60	0.941	52/52	X	X
AP-3003	1.77	0.916	52/52	X	X
AP-3004	2.12	1.68	52/52	X	X
AP-3014	1.52	0.721	52/52	X	X
<b>Off-Site</b>					
AP-4006	1.34	0.536	50/52		
AP-4007	1.31	0.400	52/52		
AP-4008	1.43	0.597	52/52		X
AP-4011	1.33	0.487	52/52		
AP-4012 <sup>(a)</sup>	1.27, 1.22	0.552, 0.540	52/52, 104/104		
AP-4013	1.24	0.616	52/52		

- (a) indicates background monitoring station. Background concentration was transitioned from a 2-year average to a 1-year average in 1998. The first number of the two is based on 52-weeks of data, while the second number is based on 104-weeks 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 both the 1-year (52-week) and 2-year (104-week) background average concentration, using a one-tailed Student's t-test at the 95% confidence level.
- (d) To convert from  $\mu$ Ci/ml to Bq/ml, multiply by 37,000.

#### 4.4.4.1 Chemical Plant/Raffinate Pits

The average annual concentrations at the chemical plant/raffinate pits perimeter ranged from 1.46E-15  $\mu$ Ci/ml (5.40E-11 Bq/ml) to 2.12E-15  $\mu$ Ci/ml (7.84E-11 Bq/ml). All monitoring stations except AP-2001 were statistically greater than the 52-week average background. All eight stations exceeded the 104-week background average. Overall, the chemical plant and raffinate pits results are slightly higher than those measured in 1997. This is believed to be a result of extensive waste excavation and hauling activities associated with disposal cell operations.

#### 4.4.4.2 Quarry

The average concentrations at the quarry perimeter ranged from  $1.29\text{E-}15$   $\mu\text{Ci/ml}$  ( $4.77\text{E-}11$  Bq/ml) to  $1.35\text{E-}15$   $\mu\text{Ci/ml}$  ( $5.00\text{E-}11$  Bq/ml). These results are comparable to those measured during 1997.

#### 4.4.4.3 Off-Site Locations

The average concentrations at off-site locations ranged from  $1.24\text{E-}15$   $\mu\text{Ci/ml}$  ( $4.59\text{E-}11$  Bq/ml) to  $1.43\text{E-}15$   $\mu\text{Ci/ml}$  ( $5.29\text{E-}11$  Bq/ml). One station, AP-4008, located at the Weldon Spring Training Area, was statistically greater than the 104-week background average (but not the 52-week background average). The elevated results at AP-4008 are believed to be attributable to work in the TSA and vicinity properties (e.g., Da-1) located near the station. All other results are similar to those measured during previous years.

### 4.5 Airborne Asbestos Monitoring

During 1998, environmental monitoring for asbestos was conducted at the Francis Howell High School (AP-4006) and at the Weldon Spring site perimeter (AP-2001, AP-2002, and AP-2005). These locations are identified in Figures 4-1 and 4-3. Filters were collected weekly and shipped off-site biweekly 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 the site environmental action level (0.01 fibers per milliliter of air), the sample is then resubmitted to the off-site laboratory for TEM analysis.

The results of environmental samples collected at Francis Howell High School and the site perimeter are provided in Table 4-7. A total of 65 PCM samples were collected with 48 samples indicating results above the detection limits. The range of samples above the detection limit (generally 7 fibers/ $\text{mm}^2$ ) was 0.0003 fibers per milliliter of air (f/ml) to 0.022 f/ml. Seven samples were resubmitted for TEM analysis, but only one of the samples contained detectable asbestos fibers. This sample, collected at the Francis Howell High School, had an asbestos concentration of 0.0004 f/ml of air, which is 4% of the limit of 0.01 f/ml established by the EPA for schools. All results of the environmental air samples collected from the site perimeter and Francis Howell High School were below the fiber concentration limits of 0.01 ml. These results indicate that asbestos fibers were effectively contained during the year.

Table 4-7 Summary of Asbestos Air Monitoring Results

LOCATION	NUMBER OF SAMPLES/SAMPLES ABOVE DETECTION LIMIT	RANGE (f/ml)	AVERAGE (f/ml)
AP-2001	18/12	0.0005-0.0157*	0.0042
AP-2002	18/12	0.0003-0.0168*	0.0046
AP-2005	12/12	0.0012-0.017*	0.0049
AP-4006	17/12	0.00046-0.022*	0.0063

\* At least one sample resubmitted for TEM analysis.

## 4.6 PM-10 Monitoring

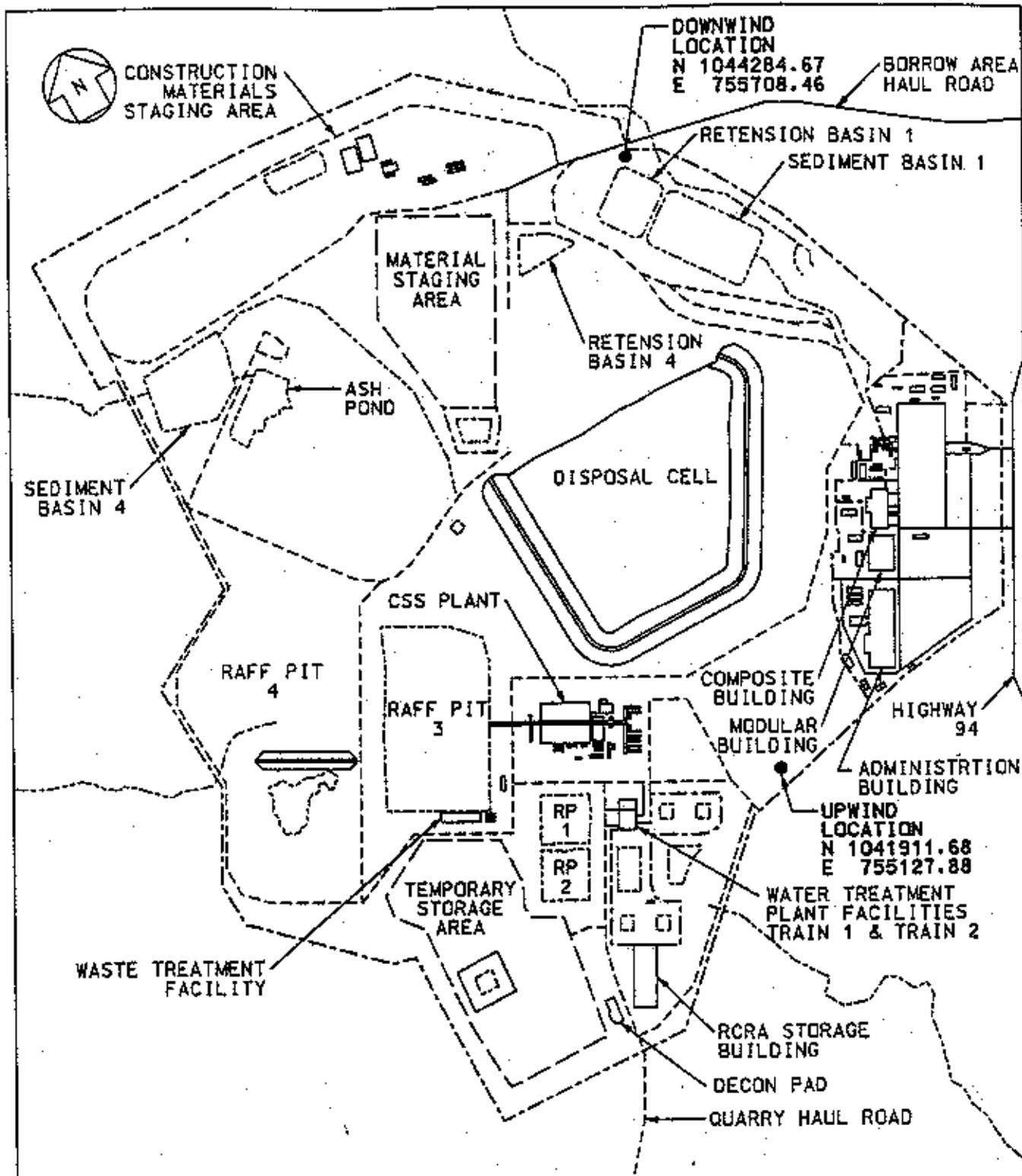
### 4.6.1 Program Overview

PM-10 consists of airborne particulate matter (PM) with an aerodynamic equivalent diameter of less than 10  $\mu\text{m}$ . 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:

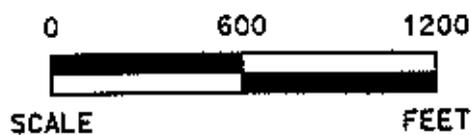
- Pulverization or abrasion of surface materials by mechanical means (e.g., soil excavation or treatment).
- Loading or unloading of bulk dry material (e.g., transfer of fly ash from trucks to storage silos).
- Movement of turbulent air currents over exposed surfaces (e.g., wind erosion of stockpiles).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

During 1998, the WSSRAP monitored ambient PM-10 levels at the perimeter of both the chemical plant area and the Borrow Area, and along the Borrow Area haul road. Portable monitoring stations, consisting of real-time aerosol monitors (RAMs) fitted with PM-10 impactor heads, were used to monitor upwind and downwind of work activities, concurrently. The chemical plant area map in Figure 4-8 shows the permanent locations established to monitor



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

FIGURE 4-8



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ORIGINATOR:	BWD	DRAWN BY:	GLN
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PM-10 emissions from disposal cell operations, 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 4-9 shows the 16 designated locations along the Borrow Area perimeter where monitors could be placed, depending on predicted wind directions for the monitoring period.

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

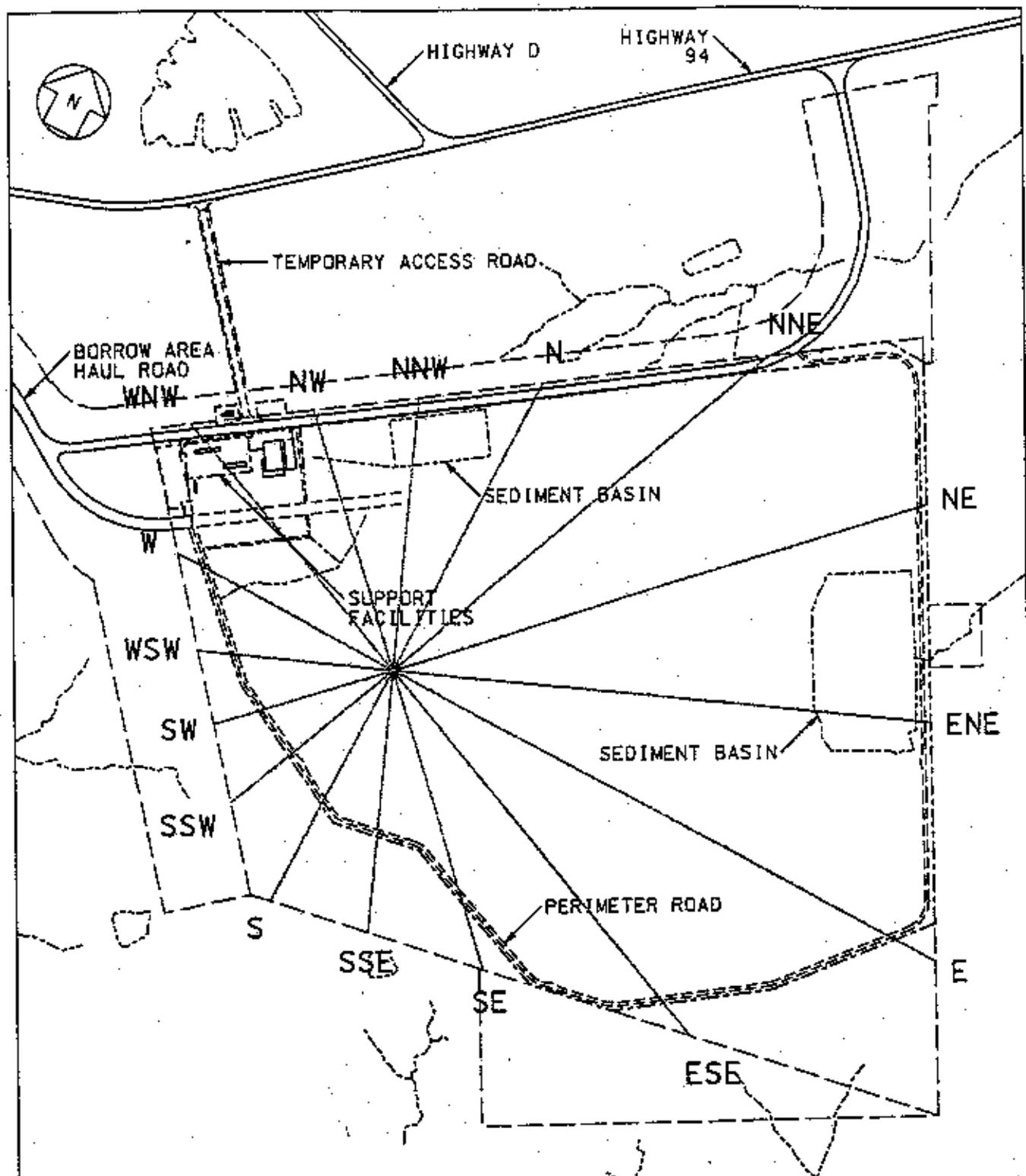
#### 4.6.2 Applicable Standards

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. 9). 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).

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  $150 \mu\text{g}/\text{m}^3$  has been established for 24-hour average concentrations of PM-10 at the WSSRAP perimeter. Any exceedences of this limit would trigger the actions outlined in Table 4 of Procedure ES&H 1.1.7, *Environmental Data Review and Above Normal Reporting*.

#### 4.6.3 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



PLAN LAYOUT OF THE  
WELDON SPRING BORROW AREA

FIGURE 4-9

0 500 1000  
SCALE FEET

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DESIGNATOR: BWD	DRAWN BY: GLN
	DATE: 6/1/99

Table 4-8 1998 PM-10 Data for the Weldon Spring Site Remedial Action Project

	NUMBER OF SAMPLING EVENTS (UPWIND/DOWNWIND)	24-HR AVERAGE MEASURED CONCENTRATION ( $\mu\text{g}/\text{m}^3$ )	
		UPWIND	DOWNWIND
<b>WSCP</b>			
April	1/1	11	11
May	4/6	26	57
June	5/5	23	31
July	3/3	8	13
August	3/8	36	32
September	3/6	18	22
October	5/7	16	26
November	4/7	14	16
December	3/6	19	12
<b>BORROW AREA</b>			
May	4/4	29	28
June	4/4	14	26
July	4/4	31	42
August	5/9	44	39
September	2/3	6	6
October	3/5	11	16
<b>HAUL ROAD</b>			
September	1/0	6	No data
October	1/0	27	No data

concentrations were all below the site action level of  $150 \mu\text{g}/\text{m}^3$ . Table 4-8 shows the monthly average concentrations measured at the chemical plant, Borrow Area, and haul road.

The Army measured ambient PM-10 concentrations during operation of the hazardous waste incinerator at the Weldon Spring Ordnance Works (WSOW). These data, collected from July through December of 1998, were reviewed to evaluate the potential PM-10 contribution from the incinerator operations to measurements made at the Weldon Spring site. Measured levels at the WSOW monitoring network were comparable to those measured in the chemical plant area for the same time period, and were all below the action level of  $150 \mu\text{g}/\text{m}^3$  for each 24 hour average.

#### 4.6.4 Data Analysis

The highest 24-hour average concentrations of PM-10 recorded at the chemical plant in 1998 were  $62 \mu\text{g}/\text{m}^3$  at the upwind site and  $150 \mu\text{g}/\text{m}^3$  at the downwind site. The highest 24-hour average concentrations at the Borrow Area were  $52 \mu\text{g}/\text{m}^3$  at the upwind site and  $63 \mu\text{g}/\text{m}^3$  at the downwind site. The highest haul road concentration was  $27 \mu\text{g}/\text{m}^3$ .

## 5. RADIATION DOSE ANALYSIS

This section evaluates the effects of atmospheric releases and surface and groundwater discharges of radiological contaminants from the Weldon Spring Site Remedial Action Project (WSSRAP). Potential annual dose equivalents to the general public have been calculated and are presented here. These calculations are compared against U.S. Department of Energy (DOE) limits contained in DOE Order 5400.5.

Dose calculations are presented in this section for a hypothetical maximally exposed individual and a collective population. The exposure conditions used in the dose calculations are further discussed in respective environmental monitoring sections of this report.

Dose calculations related to airborne emissions as required by 40 CFR 61, Subpart H (*National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities*) are presented in Section 6, National Emission Standards for Hazardous Air Pollutants (NESHAPS) Program.

### 5.1 Highlights

- The largest total effective dose equivalent (TEDE) to a maximally exposed individual from all pathways combined was 7.6 mrem (0.076 mSv), estimated for an individual who works full-time on the Weldon Spring Ordnance Works (WSOW) remediation project. This value represents 7.6% of the DOE limit of 100 mrem (1 mSv) above background levels.
- The collective population effective dose equivalent (CPEDE) was estimated to be 1.43 person-rem (0.0143 person-Sv) for users of the Busch Memorial Conservation Area, and employees of the WSOW remediation project, Missouri Highway and Transportation Department (MHTD), and WSSRAP offices.

### 5.2 Pathway Analysis

In developing specific elements of the WSSRAP environmental monitoring program, potential exposure pathways and health effects of the radioactive and chemical materials present on site are reviewed annually to determine which pathways are complete. This pathway analysis is detailed in the site *Environmental Monitoring Plan* (Ref. 8). As required by DOE Order 5400.1, evaluation of each exposure pathway is based on the sources, release mechanisms, types, and probable environmental fates of contaminants, and the locations and activities of potential receptors. Pathways are then reviewed to determine whether a link exists between one or more contaminant sources, or between one or more environmental transport processes, to an exposure point where human or ecological receptors are present. If it is determined that a link exists, the pathway is termed complete. Complete pathways are used to assess radiological and

nonradiological exposures. Each complete pathway is reviewed to determine whether a potential for exposure was present during the time frame of concern. If this is the case, the pathway is termed applicable. Only applicable pathways are considered in estimates of dose.

Table 5-1 lists the six complete pathways for exposure from radiological contaminants evaluated by the WSSRAP environmental monitoring program. These pathways are used to evaluate monitoring requirements and to determine radiological exposures from the site. Of the six complete pathways, five were applicable in 1998 and were thus incorporated into radiological dose estimates. These are Liquid (B), Liquid (C), Airborne (A), Airborne (B), and External. Assessments of potential exposure routes in the *Feasibility Study for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 27) have shown that the dose potential for pathways not listed in Table 5-1 is miniscule.

Table 5-1 Complete Radiological Exposure Pathways for the Weldon Spring Site

EXPOSURE PATHWAY	PATHWAY DESCRIPTION	APPLICABLE TO 1998 DOSE ESTIMATE
Liquid(A)	Ingestion of groundwater from local wells downgradient from the site.	N
Liquid(B)	Ingestion of game and fish inhabiting wildlife area.	Y
Liquid(C)	Ingestion of surface water and sediments.	Y
Airborne(A)	Inhalation of particulates dispersed through wind erosion and remedial action.	Y
Airborne(B)	Inhalation of radon and radon decay products emitted from contaminated soils/wastes.	Y
External	Direct gamma radiation from contaminated soils/wastes.	Y

As shown in Table 5-1, the Liquid (A) pathway is not applicable to the 1998 dose estimate for the WSSRAP. Concentrations of radioactive contaminants in the production wells near the Weldon Spring Quarry are currently comparable to background concentrations (see Section 8.5). In addition, no drinking water wells are located in the vicinity of the chemical plant and raffinate pits area.

The applicable radiological public dose guidelines for the WSSRAP are as follows:

- NESHAPs standard of 10 mrem (0.10 mSv) effective dose equivalent annually due to airborne emissions other than radon at off-site receptor locations.
- DOE limit of 100 mrem (1 mSv) total effective dose equivalent for all exposure pathways on an annual basis (excluding background).

## 5.3 Radiological Release Estimates

### 5.3.1 Airborne Radiological Releases

Estimates of radiological releases to air and surface water were calculated for radioactive particulates and radon and thoron gas. Table 5-2 shows the estimated activity release of radionuclides to the environment, the corresponding mass released, and the half-life for each radionuclide.

As shown in Table 5-2, the estimated total off-site airborne Rn-222 and Rn-220 releases were approximately 2.8 Ci (1.04E11 Bq) and 14.2 Ci (5.27E11 Bq). Raffinate Pit 4 was assumed to be the primary source of Rn-222 and Rn-220 emissions at the Weldon Spring site. A series of box models was used to estimate the Rn-222 and Rn-220 releases from the chemical plant. The release estimates were based on the annual results of one F-type and four M-type radon monitoring stations at the chemical plant perimeter that exceeded the annual average background concentration for Rn-222 and Rn-220 in 1998. Calculations and assumptions are provided in Appendix B.

Airborne particulate release estimates were calculated based on site characterization data and low volume monitoring results at eight stations located at the chemical plant perimeter. A series of box models was used to predict the airborne particulate release rate from the chemical plant. The assumptions used in estimating airborne releases are shown in Appendix B.

### 5.3.2 Waterborne Radiological Releases

During 1998, intermittent surface water runoff transported isotopes of uranium, thorium, and radium from the site through six major discharge routes. These include two water treatment plant outfalls and four storm water outfalls (see Section 7). These outfalls were monitored monthly as required under the site National Pollutant Discharge Elimination System (NPDES). Natural uranium concentrations measured in runoff water were multiplied by the natural uranium activity ratios for U-234, U-235, and U-238 (49.1%, 2.3%, and 48.6%, respectively) to determine the waterborne releases of those isotopes. (All release estimates are based on data in Tables 7-3 and 7-5). All results are listed in Table 5-2.

## 5.4 Exposure Scenarios

Dose calculations were performed for maximally exposed individuals, collective population, and critical receptor locations for applicable exposure pathways (see Table 5-1) to assess dose due to radiological releases from the Weldon Spring site. First, conditions were set

Table 5-2 Radionuclide Emissions to the Environment

RADIONUCLIDE	ACTIVITY OF RADIONUCLIDES RELEASED TO AIR (Ci)	ACTIVITY OF RADIONUCLIDES RELEASED TO WATER (Ci)	MASS OF RADIONUCLIDE RELEASED (grams)	HALF-LIFE (Yrs)
U-238	6.10E-6	7.87E-4	2.4E4	4.47E09
U-235	4.89E-7	3.73E-4	170	7.04E08
U-234	6.80E-6	7.94E-4	0.1	2.46E05
Ra-226	4.26E-7	1.58E-4	1.58E-4	1,600
Ra-228	3.28E-7	3.42E-4	1.3E-6	5.76
Th-230	3.45E-5	2.09E-4	0.012	7.54E04
Th-228	3.43E-6	1.12E-4	1.4E-7	1.91
Th-232	3.55E-6	1.06E-4	970	1.40E10
Rn-222	2.8	N/A	N/A	3.82 days
Rn-220	14.2	N/A	N/A	55.6 seconds
Total Activity	17	2.88E-3	2.5E4	N/A

N/A Not analyzed for this radionuclide.

- Not distinguishable from background at perimeter monitoring locations.

Multiply by 3.7E10 to convert Ci to Bq.

to determine the total effective dose equivalent to a maximally exposed individual at each of the main site areas: the chemical plant and raffinate pits area, the quarry, and vicinity properties. A second dose equivalent for a collective population was calculated. A third set of dose equivalent calculations was performed to meet NESHAPs requirements (see Section 6).

Calculations using perimeter and off-site monitoring data determined the collective population dose equivalent to be approximately 1.43 person-rem per year (0.014 person-Sv) from all pathways combined. Since all air monitoring stations (other than the background station) are within a 13 km (8.1 mi) radius of the site, and all results measured within this radius are well below NESHAPs and DOE limits, incorporating a dose calculation for a population within 80 km (49.6 mi) of the site is unnecessary. Rather, the collective population dose equivalent was calculated for specific target populations where complete exposure pathways were found to exist.

The scenarios and models used to evaluate these radiological exposures are conservative but appropriate. Although radiation doses can be calculated or measured for individuals, it is not appropriate to predict the health risk to a single individual using the methods prescribed here. Estimates of health risks are based on statistical models using epidemiological data collected from large groups of people exposed to radiation under various circumstances; therefore, they are not applicable to single individuals. Dose equivalents to a single individual are estimated by hypothesizing a maximally exposed individual and placing this individual in a reasonable but conservative scenario. This method is acceptable when the magnitude of the dose to a hypothetical maximally exposed individual is small, as is the case for the WSSRAP. The scenarios and resulting estimated doses used in the calculations are outlined in Table 5-3. In addition, the percentage of the DOE limit of 100 mrem (1.0 mSv) TEDE is provided.

The collective population dose equivalent estimate, provided in units of person-rem (person-Sv), is the product of the effective dose equivalent estimate at an exposure point and the number of persons exposed. For the WSSRAP, exposure points are locations where members of the public are potentially exposed to above-background levels of airborne radioactive particulates, radon gas, external gamma radiation, or above-background radionuclide concentrations in water or food. The committed effective dose equivalent is calculated by estimating radionuclide concentrations in the air, water, and food at a given exposure point and applying standard breathing rates, ingestion rates, and dose equivalent conversion factors. These concentrations and reasonable exposure scenarios are used to estimate the amount of radioactivity ingested or inhaled by the potentially exposed population. The contribution from exposure to gamma radiation is then factored into the collective population dose equivalent.

All ingestion calculations were performed using the methodology described in *International Commission on Radiation Protection (ICRP) Reports 26 (Ref. 28) and 30 (Ref. 29)* for a 50-year committed effective dose equivalent (CEDE). Dose conversion factors were obtained from the *EPA Federal Guidance Report No. 11 (Ref. 30)*.

### 5.5 Dose Equivalent Estimates

Dose equivalent estimates for the exposure scenarios were calculated using 1998 monitoring data. Calculations for dose scenarios are provided in Appendix B. Dose equivalent estimates are well below the standards set by the DOE for annual public exposure and U.S. Environmental Protection Agency (EPA) NESHAPs limits.

The 1998 TEDEs for hypothetical maximally exposed individuals near the chemical plant/raffinate pits and vicinity properties are 7.6 mrem (0.076 mSv) and 0.62 mrem (6.2  $\mu$ Sv), respectively. These values represent less than 8% of the DOE standard of 100 mrem (1 mSv) above background for all exposure pathways. In comparison, the annual average exposure to natural background radiation in the United States results in a TEDE of approximately 300 mrem (3 mSv). The collective population effective dose equivalent is 1.43 person-rem (0.0143 person-Sv) for recreational users of the Busch Memorial Conservation Area and employees of the Weldon Spring Ordnance Works remediation project, Missouri Highway and Transportation Department facility, and WSSRAP offices. Assumptions are detailed in the following sections.

Table 5-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates

EXPOSURE SCENARIO	PATHWAY	ACTIVITY	MEDIA	EXPOSURE DURATION	EXPOSURE/INTAKE RATE	CONCENTRATION	ESTIMATED EFFECTIVE DOSE EQUIVALENT (mrem)	PERCENT OF DOE LIMIT
WSCP/WSRP Hypothetical Individual	Liquid(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid(C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	External	Working at WSOW	Direct Exposure	2,000 hr	22 mrem/yr	N/A	5.0	5.0%
	Airborne(A)	Working at WSOW	N/A	2,000 hr	1.2 m <sup>3</sup> /hr <sup>(B)</sup>	9.0E-16 $\mu$ Ci/ml	0.9	0.8%
WSQ Hypothetical Individual	Airborne(B)	Working at WSOW	N/A	2,000 hr	1.2 m <sup>3</sup> /hr <sup>(B)</sup>	Rn-220 0.4 pCi/l; 0.5% equilibrium	1.65	1.65%
	Liquid(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid(C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	External	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WSVP Hypothetical Individual	Airborne(A)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Airborne(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid(C)	Drinking water from Burgermeister Spring	Water	N/A	0.237 l/week	See Appendix B for list of radionuclide concentrations	0.62	0.62%
	External	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Airborne(A)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Airborne(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

Table 5-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates (Continued)

EXPOSURE SCENARIO	PATHWAY	ACTIVITY	MEDIA	EXPOSURE DURATION	EXPOSURE/INTAKE RATE	CONCENTRATION	COLLECTIVE POPULATION DOSE EQUIVALENT (person-rem)	PERCENT OF DOE LIMIT
Collective Population	Liquid(B)	Fishing at Busch Lake 35 (population = 80,000)	Fish	N/A	0.55 g/day	0.019	0.082	N/A
	Liquid(C)	Swimming at Busch Lake 35 (population = 5,985)	Sediments	0.285 hr/person	200 mg/day	26.6 pCi/g	0.0001	N/A
	External	Working at MHTD Facility (8 persons)	Water Direct Exposure	0.285 hr/person 2,000 hours	0.05 liters/hour 8 mrem/year	8.3 pCi/l N/A	0.0002 0.016	N/A N/A
	External	Working at WSCOW (150 persons)	Direct Exposure	2,000 hours	22 mrem/yr	N/A	0.753	N/A
	Airborne(A)	Working at WSSRAP Administration Building (300 persons)	Air	2,500 hours	1.2 m <sup>3</sup> /hr <sup>(a)</sup>	6.0E-16 µCi/ml	0.191	N/A
	Airborne(A)	Working at MHTD Facility (9 persons)	Air	2,000 hours	1.2 m <sup>3</sup> /hr	2.4E-16 µCi/ml	0.0018	N/A
		Working at WSSRAP (300 persons)	Air	2,500 hours	1.2 m <sup>3</sup> /hr	9.0E-16 µCi/ml	0.135	N/A
	Airborne(B)	Working at WSCOW (150 persons)	Air	2,000 hours	0.4 pCi/l	Rn-220 0.4 pCi/l; 0.5% equilibrium	0.25	N/A

NA Scenario is not applicable to the hypothetical individual.

WSCP Weldon Spring Chemical Plant.

WSRP Weldon Spring raffinate pits.

WSQ Weldon Spring Quarry.

WSVP Weldon Spring vicinity properties.

WSOW Weldon Spring Ordnance Works

Multiply by 0.037 to convert pCi to Bq.

Multiply by 0.01 to convert mrem to mSv.

Multiply by 0.01 to convert person-rem to person-Sv.

(a) A breathing rate of 1.2 m<sup>3</sup>/hour is used for an adult male engaged in light activity.

### 5.5.1 Radiation Dose Equivalent From the Chemical Plant and Raffinate Pits to a Hypothetical Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical individual assumed to frequent the perimeter of the chemical plant and raffinate pits and receive a radiation dose by the exposure pathways identified above. No private residences are adjacent to the site. Therefore, all calculations of dose equivalent assume a realistic residence time that is less than 100%. A full-time employee at the Weldon Spring Ordnance Works (WSOW) remediation project was considered to be the maximally exposed individual to releases of radionuclides from the chemical plant area.

The low volume sampler and radon detectors near the WSOW facility indicated above-background concentrations of airborne radioactive particulates and thoron gas. Also, the annual average environmental TLD result (Station TD-3003) exceeded background levels for the year; therefore, a dose estimate was calculated based on these measurements.

The exposure scenario assumptions are as follows:

- External exposure occurs to the maximally exposed individual while working at the WSOW near the Weldon Spring Chemical Plant perimeter for a total of 2,000 hours per year.
- Net radioactive airborne particulate concentration of  $9.0E-16$   $\mu\text{Ci}/\text{ml}$  comprised of a mixture of radionuclides present at the WSSRAP temporary storage area (TSA).
- Net Rn-220 concentration of 0.4 pCi/l measured at Station RD-3003 and a daughter equilibrium ratio of 0.5%.
- Net annual gamma exposure rate of 22 mrem/year (for continuous exposure), measured at TD-3003 at the western boundary of the chemical plant. For 1998, continuous exposure time is 8,760 hours.
- Breathing rate of  $1.2 \text{ m}^3/\text{hour}$ .

Based on the exposure scenario and assumptions described above, a maximally exposed individual working at the WSOW received a total effective dose equivalent of 7.6 mrem (0.076 mSv) from inhalation of radioactive particulates and thoron gas and external exposure.

### 5.5.2 Radiation Dose From the Weldon Spring Quarry to a Hypothetical Maximally Exposed Individual

Because all monitoring results at the quarry were indistinguishable from background levels during 1998, no dose estimate is necessary for a maximally exposed individual at the quarry.

### 5.5.3 Radiation Dose From Vicinity Properties to a Hypothetical Maximally Exposed Individual

This section discusses the estimated total effective dose equivalent to a hypothetical individual assumed to frequent the Burgermeister Spring area of the Busch Memorial Conservation Area. This scenario provides a conservative but plausible exposure assessment. No private residences are adjacent to Burgermeister Spring (it is situated on land currently managed by the Missouri Department of Conservation [MDC]); therefore, the calculation of dose equivalent due to the applicable pathway of water ingestion (Liquid C) assumes a realistic occupancy time of one day per week. This scenario is based on a hypothetical individual who drank from Burgermeister Spring on a weekly basis in 1998.

Exposure scenario assumptions particular to this dose calculation include the following:

- Annual average radioactive particulate concentrations at the Busch Memorial Conservation Area were indistinguishable from background; therefore, no inhalation dose due to radioactive air particulates was calculated for an individual at Burgermeister Spring.
- No contribution to the estimated dose was included from radon or radon progeny concentrations associated with the Airborne (B) pathway, because annual alpha-track results in the area were at background levels.
- No contribution to the estimated dose was included for the external pathway, because environmental TLD results at the Busch Memorial Conservation Area indicated background levels.
- Maximum radionuclide concentrations in water samples taken from Burgermeister Spring during 1998 (see Appendix B) were assumed to be present in the water ingested by the maximally exposed individual (MEI).
- Dose equivalent conversion factors for ingestion, as follows: total soluble uranium,  $2.69\text{E-}4$  mrem/pCi; Ra-226,  $1.33\text{E-}3$  mrem/pCi; Ra-228,  $1.44\text{E-}3$  mrem/pCi; Th-228,  $3.96\text{E-}4$  mrem/pCi; Th-230,  $5.48\text{E-}4$  mrem/pCi; Th-232,

2.73E-3 mrem/pCi; Ra-224, 3.66E-4 mrem/pCi; and Pb-212, 4.56E-5 mrem/pCi (Ref. 30).

The estimated total effective dose equivalent to the maximally exposed individual at the vicinity properties from consumption of water from Burgermeister Spring was 0.62 mrem (6.2  $\mu$ Sv).

#### 5.5.4 Collective Population Dose

This section discusses the estimated CPEDE to the populations assumed to be exposed to radioactive emissions from the WSSRAP. Of the seven perimeter monitoring stations that exceeded background levels for radioactive particulates, the locations likely to be frequented by members of the public are AP-2001, AP-2005, AP-2008, and AP-3004. These stations are located along the northeast chemical plant perimeter near the MHTD facility, near the WSSRAP offices (AP-2005 and AP-2008), and near the WSOW, respectively. Another exposure scenario was developed for WSOW remediation workers based on the above background average thoron concentration measured along the western chemical plant perimeter (RD-3003).

Measurements made by environmental thermoluminescent dosimeters (TLDs) indicated above background results of gamma exposure at the MHTD facility and the WSOW, necessitating the development of general population direct exposure scenarios for these locations.

Another potential general population exposure is from the consumption of water, sediment, and fish from the August A. Busch Memorial Conservation Area. Two lakes at the conservation area receive runoff from the Weldon Spring site and are used for fishing and boating. The scenario used for the Busch Memorial Conservation Area is based on recreational use for fishing, boating, and swimming activities. Only the ingestion pathways Liquid (B) and Liquid (C) were considered plausible for this assessment. Exposure scenario assumptions particular to this dose calculation are as follows:

- The MDC estimates that approximately 160,000 persons per year use the Busch Memorial Conservation Area (Ref. 31), which is adjacent to the chemical plant and raffinate pits area, while another 5,895 persons participate in recreational boating activities. Busch Lakes 34 and 35 receive runoff from the chemical plant and raffinate pits area, and both lakes are used for fishing and boating. Therefore, a population of 165,895 persons was assumed to have potential for exposure through ingestion of fish, water, and sediment from these lakes.
- The average time per fishing trip was 2.5 hours.

- The fish caught to time spent ratio is 0.4 fish/hour, and the ratio of fish kept to fish caught is 0.5. If each fish caught is consumed by a different person, the affected population would be 80,000 persons.
- The highest average total uranium concentration in a composite sunfish sample collected from Lake 35 in 1998 was 0.019 pCi/g (5.1E-4 Bq/g).
- The average time spent at the Busch Conservation Area per boating trip was approximately 5.7 hours (Ref. 31).
- Each of 5,895 visitors made only one visit to the area and spent 5% of the time swimming.
- Average water and sediment concentrations of total uranium were 8.3 pCi/l (0.22 Bq/l) (see Table 7-11) and 26.6 pCi/g (0.99 Bq/g), respectively (Ref. 32).
- No contribution from airborne pathways was included in the Busch Memorial Conservation Area dose estimates. Results from the measurements near the lakes indicated that there was no reason to suspect, at the 95% confidence level, that concentrations of airborne radioactive particulates or Rn-222 or Rn-220 gas were greater than background levels.

For 1998, the estimated population effective dose equivalent for the Busch lakes scenario was 0.082 person-rem (8.2E-4 person-Sv).

The scenario used for the WSOW is the same as that listed in Section 5.5.1. Assuming 150 individuals worked full-time on the project in 1998, the collective population effective dose equivalent for the WSOW is 1.14 person-rem (0.0114 person-Sv).

The scenario used for the MHTD facility includes both inhalation of radioactive particulates and direct exposure. The population at the MHTD facility includes nine employees who work approximately 2,000 hours per year. Based on an annual net gross alpha concentration of 2.4E-16  $\mu$ Ci/ml (8.88E-12 person-Sv) and a net direct exposure rate of 8 mrem/year, the collective population effective dose equivalent for employees at the MHTD facility is 0.0178 person-rem (1.78E-4 person-Sv).

The scenario for the WSSRAP offices includes only inhalation of above-background concentrations of radionuclides as measured by low volume monitoring Station AP-2008 in 1998. The population at the WSSRAP offices includes approximately 300 employees who work an estimated 2,500 hours/year. Based on an annual net gross alpha concentration of 6.0E-16  $\mu$ Ci/ml (2.22E-11 Bq/ml), and assuming that the source is the disposal cell, the

collective population effective dose equivalent for employees at the administration building is 0.191 person-rem (0.00191 person-Sv).

The estimated total collective population effective dose equivalent from all three scenarios combined is 1.43 person-rem (0.0143 person-Sv) for 1998. Calculations are presented in Appendix B, Section D.

## 6. NESHAPS PROGRAM

This section provides information on 1998 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 and dose assessment and compliance information related to sources of radioactive particulate emissions at the Weldon Spring Site Remedial Action Project (WSSRAP).

### 6.1 NESHAPs Monitoring and Dose Assessment Highlights

- Results of National Emission Standards for Hazardous Air Pollutants (NESHAP) monitoring at the seven critical receptor monitoring locations indicated that there was no reason to suspect that any member of the public received greater than the effective dose equivalent limit of 10 mrem/yr.
- The highest dose assessments were for a maximally exposed individual working at the WSSRAP administration building or residing continuously at the Busch Memorial Conservation Area. Results indicated an annual committed effective dose equivalent (CEDE) of  $0.0194 \pm 0.0143$  mrem and  $0.0198 \pm 0.0475$  mrem, respectively for these individuals in 1998.
- The 1998 collective population dose equivalent estimate for a combined population consisting of employees of the Missouri Highway Transportation Department (MHTD), employees at the WSSRAP, and users of the Busch Memorial Conservation Area was 1.43 person-rem (0.0143 person-Sv).
- Total Rn-222 and Rn-220 emissions from the Weldon Spring site were estimated to be 2.8 Ci (1.04E11 Bq) and 14.2 Ci (5.25E11 Bq), respectively in 1998.

### 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)*. It no longer operates as a uranium and thorium processing plant and has been in mothball status since about 1966. Therefore, radionuclides are no longer emitted from the original uranium processing plant sources (i.e., stacks, vents, or pipes described in 40 CFR 61, Subpart H).

Specific remedial activities at the site that may have contributed to airborne emissions of radionuclides in 1998 include the following:

- Transfer of bulk waste from Ash Pond, the temporary storage area (TSA), and material storage area (MSA) to the permanent disposal cell.
- Removal and treatment of sludge from Raffinate Pit 3.
- Production of grout at the chemical stabilization/ solidification (CSS) facility.
- Placement of grout in the permanent disposal cell.
- Consolidation and remediation of Raffinate Pit 4.
- Treatment of contaminated soils at the TSA and Raffinate Pit 4.
- Excavation of contaminated soils from various locations around the site.

Bulk waste that was placed in the disposal cell in 1998 included demolition debris from the chemical plant buildings that were contaminated with asbestos, hazardous chemical substances, and isotopes of uranium, radium, and thorium. Concentrations in bulk samples collected from the buildings range from background levels to 20,000 pCi/g (740 Bq/g) U-238, 190 pCi/g Ra-226, 5,400 pCi/g (200 Bq/g) Ra-228, and 540 pCi/g (20 Bq/g) Th-230 (Ref. 2).

The quarry bulk waste, which was located at the TSA, contained radiological and chemical contaminants including uranium, radium, thorium, metals, nitrates, polychlorinated biphenyls (PCBs), semivolatile organic compounds, nitroaromatics, and asbestos. The radionuclide concentrations range from 3.0 pCi/g to 1,600 pCi/g (0.11-59.2 Bq/g) U-238, <1 pCi/g to 2,780 pCi/g (<0.037 to 103 Bq/g) Ra-226, 0.7 pCi/l to 36 pCi/g (0.026 to 1.33 Bq/g) Th-232, <1 pCi/l to 2,200 pCi/g (0.037 to 8.14 Bq/g) Ra-228, and <1.0 pCi/l to 6,800 pCi/g (0.037 to 252 Bq/g) Th-230 (Ref. 1). This waste was removed from the TSA and placed in the disposal cell in 1998.

The raffinate pits were radiologically contaminated with uranium and thorium residues and chemical contaminants including nitrate, fluoride, PCBs, and various heavy metals. Radionuclide concentrations found in raffinate pit sludge range from <10 to 3,400 pCi/g (0.37 to 126 Bq/g) total uranium, <8 pCi/g to 34,000 pCi/g (0.30 to 1,260 Bq/g) Th-230, <1 pCi/g to 1,700 pCi/g Ra-226, <4 pCi/g to 1,400 pCi/g (0.15 to 51.8 Bq/g) Th-232, <4 pCi/g to 1,400 pCi/g (0.15 to 51.8 Bq/g) Ra-228, and <3 pCi/g to 1,100 pCi/g (0.11 to 40.7 Bq/g) Th-228 (Ref. 33). In 1998, contaminated sludge was consolidated in the southern end of Raffinate Pit 4 and treated in situ. The resulting mixture was excavated and placed in the disposal cell.

Radiological and chemical contaminants (i.e., PCBs, nitroaromatic compounds, and metals) have been found in soil from several areas around the site. Most of the 88 ha (217 acres)

of the chemical plant area have above background concentrations of uranium ( $>1$  pCi/g). Radionuclide concentrations range from 0.3 pCi/g to 2,259 pCi/g U-238, 0.2 pCi/g to 452 pCi/g Ra-226, 0.1 pCi/g to 155 pCi/g Ra-228 and 0.3 pCi/g to 123 pCi/g Th-230 (Ref. 2).

### 6.3 Air Emission Data

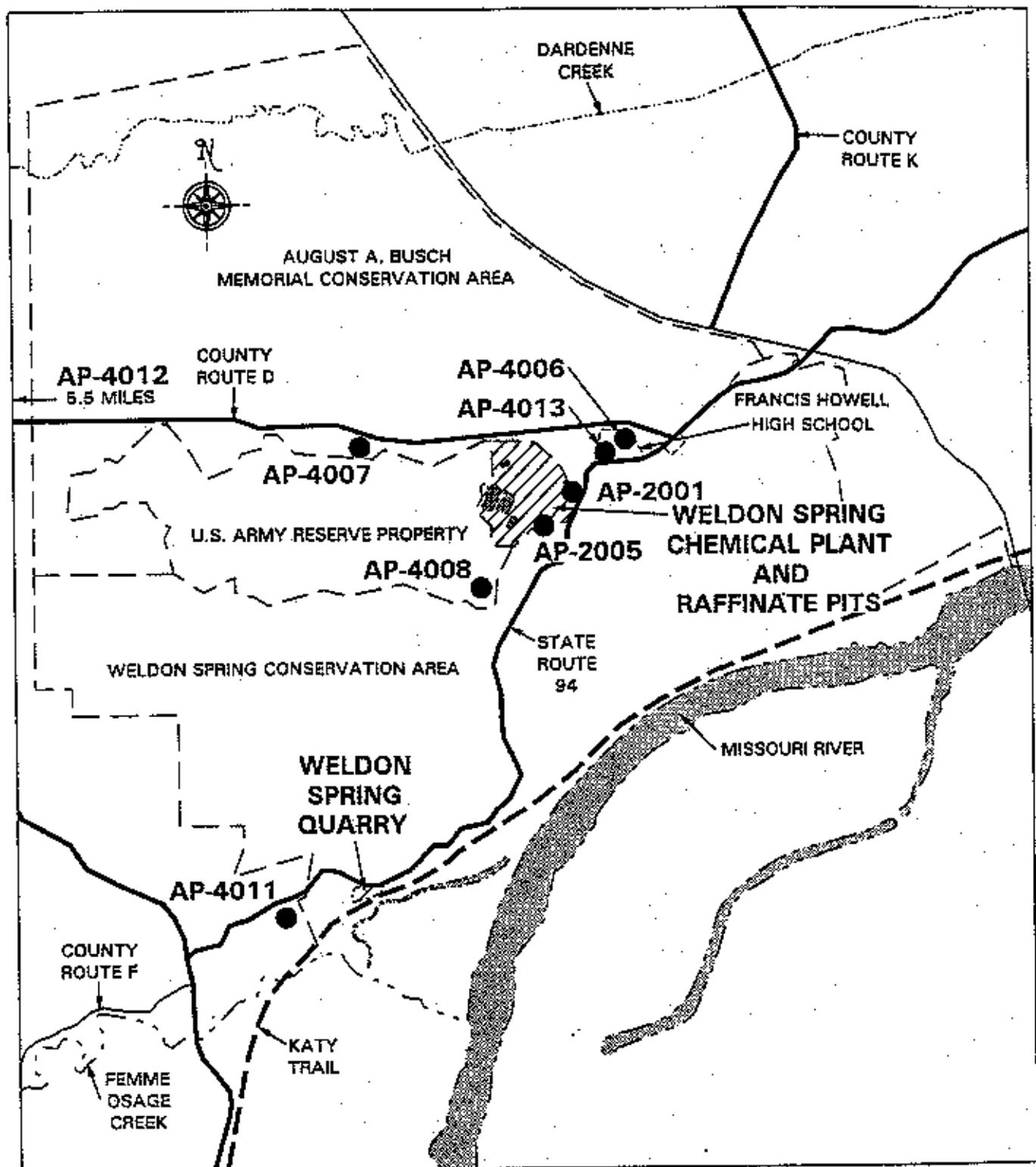
Most airborne emissions of radionuclides at the Weldon Spring site result from wind dispersion of surface soils, temporary waste storage areas, or dust and dirt from building debris and fugitive dust generated during remedial actions. However, the site and quarry water treatment plants, as well as the chemical stabilization/solidification (CSS) facility, constitute potential point sources of radionuclide emissions other than radon. All on-site point sources that have the potential to emit radioactive airborne particulates are filtered using high efficiency particulate air (HEPA) exhaust systems.

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 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 (Ref. 20).

The WSSRAP uses an alternate method of tracking emissions from the site, as allowed by 40 CFR 61, Subpart H and approved by U.S. Environmental Protection Agency (EPA) Region VII (Ref. 20). 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 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. The design of the critical receptor network is summarized in Table 6-1. Locations of the monitors are shown on Figure 6-1.

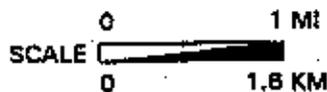
Table 6-1 Design of Critical Receptor Monitoring Network

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



NESHAPS CRITICAL RECEPTOR  
MONITORING LOCATIONS

FIGURE 6-1



REPORT NO.:	DOE/OR/21548-773	ESRMT NO.:	A/VP/001/0195
ORIGINATOR:	SX	DRAWN BY:	GLN
		DATE:	5/28/99

### 6.3.1 Point Sources

Table 6-2 briefly describes airborne effluent control at the chemical plant water treatment plant, the quarry water treatment plant, and the CSS facility, along with the nearest receptor locations. Because critical receptor monitoring is performed at the WSSRAP, no source-specific effluent monitoring is required by either 40 CFR 61 Subpart H or U.S. Department of Energy (DOE) Order 5400.5. Engineering calculations have been performed to estimate releases from the quarry and chemical plant water treatment plants and resulting dose equivalents to members of the public. These results indicate an effective dose equivalent of less than 0.1 mrem (0.001 mSv) at the nearest receptor location.

Table 6-2 WSSRAP Point Sources

POINT SOURCE ID	EFFLUENT CONTROL		NEAREST RECEPTOR	
	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
CSS Facility	High efficiency air particulate (HEPA) filtered	99.97% for 0.3 micron DOP	Administration Building	500 m

\* DOP - Dioctylphthalate

### 6.3.2 Grouped Sources

The WSSRAP has not defined any grouped sources.

### 6.3.3 Non-Point Sources

The primary sources of airborne emissions at the WSSRAP are diffuse sources in two general areas: the chemical plant area and the quarry area. Due to the many different and constantly changing activities within these areas, emissions are difficult, if not impossible, to quantify. The discussion below describes the characteristics and likelihood of potential airborne emissions, rather than attempting to quantify them.

The quarry diffuse source is a 3.6 ha (9 acre) limestone quarry located approximately 6.4 km (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 0.07 ha (0.2 acre). The quarry was used as a disposal area for dinitrotoluene (DNT) and trinitrotoluene (TNT) process wastes; uranium, radium, and thorium residues; the associated decay products from on-site and off-site processing of uranium and thorium; and building rubble and soils from the demolition of a uranium processing facility in St. Louis,

Missouri. A major remediation project involving the removal and controlled temporary storage of approximately 110,000 m<sup>3</sup> (144,000 yd<sup>3</sup>) of contaminated bulk waste was started in 1993 and completed at the end of 1995. Residual radioactive contamination remains at the quarry and could be a potential source of airborne particulates.

The Weldon Spring Chemical Plant diffuse source encompasses 87 ha (215 acres) on which the Ash Pond storage area (APSA), four raffinate pits, the CSS, the temporary storage area (TSA), the material staging area (MSA), and the disposal cell are located. Airborne emissions from the chemical plant result from windblown resuspension of radioactive particulates from site soils and chemical plant building material and debris. Emissions also occur during mechanical operations such as soil excavation and hauling, transfer of waste material to the permanent disposal cell, treatment and mixing of soils and sludge at the TSA and raffinate pits, and grout production operations at the CSS.

The emission control strategy for all the above activities was to make efficient use of resources by minimizing the quantity of fine grain soil that was to be relocated, selecting equipment that would minimize dust generated during operations, limiting surface exposure of contaminated soils, minimizing hauling distances, and using water sprays to suppress dust.

#### **6.4 Dose Assessment**

The net measured concentrations of radionuclides at each critical receptor location are used to assess the annual committed effective dose equivalent (CEDE) to members of the public. The exposure scenarios listed in Table 6-3 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 6-3.

This section describes further details of the critical receptor monitoring network, and how it is used to estimate CEDEs and demonstrate compliance with the NESHAPs requirements.

##### **6.4.1 Sampling Procedure**

The seven designated critical receptor locations surrounding the Weldon Spring site have been selected based on their proximity to the site (less than 1 km {0.62 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 6-1. 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

Table 6-3 Exposure Scenarios and NESHAPs Dose Estimates for 1998

STATION ID	LOCATION OF MONITOR	EXPOSURE SCENARIO			COMMITTED EFFECTIVE DOSE EQUIVALENT (mrem/person)
		DESCRIPTION	NUMBER OF PERSONS	DURATION (hr/yr)	
AP-2001	Highway Maintenance Facility	Employee	9	2,000	0.0085 +/- 0.0086
AP-2005	WSSRAP Administration Building	Employee	300	2,500	0.0194 +/- 0.0143
AP-4006	Francis Howell High School	Faculty or Student	1,800	1,620	0.0031 +/- 0.0059
AP-4006	Francis Howell High School	Staff Members	9	2,250	0.0043 +/- 0.0081
AP-4007	Busch Memorial Conservation Area	Employee	45	2,000	0.0046 +/- 0.0109
AP-4007	Busch Memorial Conservation Area	Resident	3	8,760	0.0198 +/- 0.0475
AP-4007	Busch Memorial Conservation Area	Visitor	450,000	2	0.0000 +/- 0.0000
AP-4008	Army Reserve Training Area	Employee	150	2,000	0.0119 +/- 0.0110
AP-4011	Nearest Quarry Residence	Resident	3	8,760	0.0107 +/- 0.0390
AP-4013	Francis Howell High School Annex	Employee	45	2,000	0.0084 +/- 0.0132

NOTE: 1 mrem/person = 0.01 Sv/person

Department of the Army property (AP-4008); 150 m (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 includes a low volume air particulate sampler (~40 lpm) and a high volume air sampler (~950 lpm). Low volume samples are collected on mixed cellulose ester membrane filters approximately 1.5 m (5 ft) above the ground, and are exchanged and analyzed for gross alpha activity on a weekly basis. High volume samples are collected on large glass fiber filters approximately 1.2 m (4 ft) above the ground, and are also exchanged weekly but composited and analyzed quarterly for isotopic radionuclides. It is the high volume sampling results that are used to demonstrate NESHAPs compliance at the WSSRAP.

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

#### 6.4.2 Net Measured Radionuclide Concentrations

Based on the sample analysis results obtained from the critical receptors, net measured concentrations for each radionuclide during each quarter are listed in Table 6-4. The resulting annual averages are compared to the limiting levels listed in Subpart H of 40 CFR 61, Appendix E, Table 2. As shown on Table 6-4, there were no exceedences of the NESHAPs limits for net concentrations in 1998.

The net concentrations in Table 6-4 are also expressed in terms of percentage of the NESHAPs limit for each radionuclide. To demonstrate compliance with 40 CFR 61, Subpart H requirements, the sum of the fractions obtained from dividing each radionuclide concentration by the listed NESHAPs limit must be less than one. The maximum value for this sum is 13.75%, or 0.14, as measured at the WSSRAP administration building.

Table 6-4 1998 Isotopic Air Monitoring Results (Net Concentration at Each Critical Receptor)

AP-2001 Radionuclide	Net Concentration (uCi/m <sup>3</sup> )					NESHAPs Limit (Ci/m <sup>3</sup> )	Concentration (%) of Limit
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average		
Ra-226	6.80E-12 +/- 5.54E-11	5.78E-11 +/- 2.38E-11	-2.63E-11 +/- 1.51E-11	1.39E-11 +/- 1.55E-11	1.30E-11 +/- 6.41E-11	3.30E-15	0.39%
Ra-228	3.69E-12 +/- 6.57E-11	1.92E-09 +/- 2.53E-10	-6.66E-10 +/- 6.59E-11	5.07E-11 +/- 3.74E-11	3.29E-10 +/- 2.72E-10	5.90E-15	5.56%
Th-228	2.19E-13 +/- 1.31E-11	9.93E-12 +/- 5.00E-11	-3.73E-12 +/- 4.41E-11	3.72E-12 +/- 2.82E-12	2.54E-12 +/- 6.80E-11	3.10E-15	0.05%
Th-230	8.23E-13 +/- 3.17E-11	7.45E-12 +/- 1.10E-10	2.76E-11 +/- 1.23E-10	3.68E-12 +/- 2.72E-11	9.88E-12 +/- 1.70E-10	3.40E-15	0.29%
Th-232	2.69E-13 +/- 1.33E-11	5.53E-12 +/- 3.35E-11	-2.25E-11 +/- 6.79E-11	-3.00E-12 +/- 1.90E-11	-4.99E-12 +/- 7.91E-11	6.20E-16	-0.80%
U, total	-2.04E-11 +/- 4.41E-20	-4.73E-11 +/- 1.30E-11	4.56E-11 +/- 6.02E-12	7.81E-11 +/- 8.66E-13	1.40E-11 +/- 1.44E-11	7.98E-15	0.18%
Total:							5.70%

AP-2005 Radionuclide	Net Concentration (uCi/m <sup>3</sup> )					NESHAPs Limit (Ci/m <sup>3</sup> )	Concentration (%) of Limit
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average		
Ra-226	6.38E-12 +/- 5.31E-11	9.37E-11 +/- 5.07E-11	7.51E-12 +/- 2.34E-11	1.61E-11 +/- 1.08E-11	3.09E-11 +/- 7.78E-11	3.30E-15	0.94%
Ra-228	3.09E-12 +/- 5.14E-11	3.07E-09 +/- 5.00E-10	-5.33E-10 +/- 8.01E-11	7.23E-11 +/- 2.87E-11	6.82E-10 +/- 5.10E-10	5.90E-15	11.09%
Th-228	-5.93E-14 +/- 1.90E-11	6.84E-12 +/- 5.39E-11	3.24E-11 +/- 9.05E-11	2.85E-12 +/- 1.83E-11	1.04E-11 +/- 1.09E-10	3.10E-15	0.34%
Th-230	3.44E-11 +/- 5.78E-11	5.09E-11 +/- 1.52E-10	3.04E-11 +/- 1.19E-10	9.00E-12 +/- 4.39E-11	3.11E-11 +/- 2.03E-10	3.40E-15	0.92%
Th-232	8.79E-13 +/- 1.87E-11	2.09E-11 +/- 5.88E-11	-1.16E-11 +/- 8.52E-11	-1.85E-12 +/- 1.71E-11	1.88E-12 +/- 1.08E-10	6.20E-16	0.32%
U, total	-2.00E-11 +/- 0.00E+00	-1.34E-11 +/- 1.04E-11	3.78E-11 +/- 1.41E-11	5.28E-11 +/- 9.75E-12	1.43E-11 +/- 2.00E-11	7.98E-15	0.18%
Total:							13.76%

AP-4008 Radionuclide	Net Concentration (uCi/m <sup>3</sup> )					NESHAPs Limit (Ci/m <sup>3</sup> )	Concentration (%) of Limit
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average		
Ra-226	1.14E-12 +/- 5.49E-11	5.98E-11 +/- 4.35E-11	-1.89E-11 +/- 2.17E-11	2.88E-12 +/- 1.21E-11	1.12E-11 +/- 7.43E-11	3.30E-15	0.34%
Ra-228	-7.35E-13 +/- 3.48E-11	3.88E-10 +/- 1.59E-10	-7.05E-10 +/- 5.88E-11	7.40E-11 +/- 5.29E-11	-6.60E-11 +/- 1.80E-10	5.90E-15	-1.12%
Th-228	-3.61E-12 +/- 1.37E-11	1.50E-11 +/- 6.89E-11	-3.93E-12 +/- 3.25E-11	1.03E-12 +/- 2.40E-11	2.13E-12 +/- 8.05E-11	3.10E-15	0.07%
Th-230	1.00E-11 +/- 4.02E-11	-7.84E-12 +/- 6.57E-11	-1.98E-11 +/- 1.26E-10	2.30E-11 +/- 5.48E-11	1.41E-12 +/- 1.58E-10	3.40E-15	0.04%
Th-232	2.98E-13 +/- 1.04E-11	1.15E-11 +/- 5.33E-11	-3.83E-11 +/- 3.11E-11	-1.38E-12 +/- 1.71E-11	-6.97E-12 +/- 6.50E-11	6.20E-16	-1.12%
U, total	-2.05E-11 +/- 4.16E-20	-3.11E-11 +/- 8.00E-11	-5.92E-11 +/- 1.23E-12	2.23E-11 +/- 6.08E-12	-2.21E-11 +/- 6.03E-11	7.98E-15	-0.28%
Total:							-2.07%

AP-4007 Radionuclide	Net Concentration (uCi/m <sup>3</sup> )					NESHAPs Limit (Ci/m <sup>3</sup> )	Concentration (%) of Limit
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average		
Ra-226	1.31E-12 +/- 4.04E-11	3.67E-12 +/- 3.22E-11	-2.20E-11 +/- 2.37E-11	8.72E-12 +/- 9.17E-12	-2.09E-12 +/- 5.78E-11	3.30E-15	-0.06%
Ra-228	2.18E-12 +/- 5.51E-11	1.70E-10 +/- 1.89E-10	-6.61E-10 +/- 1.40E-10	2.03E-11 +/- 3.47E-11	-1.17E-10 +/- 2.44E-10	5.90E-15	-1.99%
Th-228	-4.08E-12 +/- 2.07E-11	1.16E-11 +/- 1.85E-11	4.01E-11 +/- 8.42E-11	3.65E-12 +/- 4.68E-12	1.26E-11 +/- 8.83E-11	3.10E-15	0.41%
Th-230	1.76E-11 +/- 3.89E-11	-2.42E-11 +/- 3.19E-11	3.50E-11 +/- 1.20E-10	3.55E-12 +/- 3.27E-11	7.97E-12 +/- 1.83E-10	3.40E-15	0.23%
Th-232	8.97E-12 +/- 2.57E-11	5.51E-12 +/- 2.89E-11	-3.93E-12 +/- 9.74E-11	-3.21E-12 +/- 1.62E-11	1.84E-12 +/- 1.06E-10	6.20E-16	0.30%
U, total	-7.80E-12 +/- 2.12E-12	-2.17E-11 +/- 1.38E-11	1.54E-11 +/- 1.69E-12	5.72E-11 +/- 4.05E-12	1.09E-11 +/- 1.46E-11	7.98E-15	0.14%
Total:							-0.97%

Table 6-4 1998 Isotopic Air Monitoring Results (Net Concentration at Each Critical Receptor) (continued)

AP-4008 Radionuclide	Net Concentration (uCi/m3)					Annual Average	NESHAPs Limit (Ci/m3)	Concentration (% of Limit)
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average			
Ra-226	2.76E-13 +/- 3.22E-11	6.90E-11 +/- 3.67E-11	-1.09E-12 +/- 2.49E-11	6.19E-12 +/- 1.37E-11	1.88E-11 +/- 5.65E-11	3.30E-15	0.56%	
Ra-228	4.56E-13 +/- 5.93E-11	7.03E-10 +/- 3.85E-10	-2.66E-10 +/- 1.63E-10	-4.58E-12 +/- 2.33E-11	1.08E-10 +/- 4.23E-10	5.90E-15	1.83%	
Th-228	-1.51E-12 +/- 1.68E-11	2.39E-11 +/- 6.91E-11	5.82E-11 +/- 9.54E-11	1.89E-12 +/- 2.48E-11	2.06E-11 +/- 1.21E-10	3.10E-15	0.66%	
Th-230	-1.74E-12 +/- 2.05E-11	7.62E-11 +/- 2.15E-10	1.09E-10 +/- 1.99E-10	1.45E-11 +/- 5.02E-11	4.92E-11 +/- 2.77E-10	3.40E-15	1.45%	
Th-232	3.98E-12 +/- 2.09E-11	7.70E-12 +/- 4.31E-11	1.19E-11 +/- 7.87E-11	-2.42E-12 +/- 2.28E-11	5.30E-12 +/- 9.48E-11	6.20E-16	0.85%	
U, total	3.21E-11 +/- 3.28E-12	-2.97E-11 +/- 8.18E-13	1.66E-10 +/- 2.53E-11	6.92E-11 +/- 1.17E-11	5.94E-11 +/- 2.81E-11	7.96E-15	0.74%	
Total:								5.11%

AP-4011 Radionuclide	Net Concentration (uCi/m3)					Annual Average	NESHAPs Limit (Ci/m3)	Concentration (% of Limit)
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average			
Ra-226	-9.07E-14 +/- 3.93E-11	2.24E-12 +/- 3.08E-11	-2.20E-11 +/- 2.32E-11	6.90E-12 +/- 1.04E-11	-3.22E-12 +/- 5.60E-11	3.20E-15	-0.10%	
Ra-228	-1.34E-13 +/- 3.20E-11	6.57E-11 +/- 1.24E-10	-7.04E-10 +/- 8.55E-11	1.24E-11 +/- 4.06E-11	-1.59E-10 +/- 1.50E-10	5.90E-15	-2.65%	
Th-228	-1.23E-12 +/- 1.22E-11	-1.97E-12 +/- 2.69E-11	-1.22E-12 +/- 5.38E-11	1.91E-12 +/- 2.28E-11	-6.29E-13 +/- 8.50E-11	3.10E-15	-0.02%	
Th-230	9.93E-12 +/- 2.98E-11	3.82E-12 +/- 8.84E-11	-2.66E-11 +/- 1.08E-10	2.02E-11 +/- 4.37E-11	1.83E-12 +/- 1.48E-10	3.40E-15	0.05%	
Th-232	-5.62E-13 +/- 1.06E-11	-6.41E-13 +/- 1.94E-11	-1.84E-11 +/- 7.31E-11	7.89E-12 +/- 3.67E-11	-3.03E-12 +/- 8.48E-11	6.20E-16	-0.49%	
U, total	1.94E-11 +/- 4.62E-13	-6.81E-11 +/- 2.43E-12	-8.50E-11 +/- 5.71E-12	7.51E-11 +/- 9.60E-12	-9.84E-12 +/- 1.14E-11	7.96E-15	-8.12%	
Total:								-3.33%

AP-4013 Radionuclide	Net Concentration (uCi/m3)					Annual Average	NESHAPs Limit (Ci/m3)	Concentration (% of Limit)
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average			
Ra-226	-5.34E-13 +/- 2.82E-11	6.42E-11 +/- 5.65E-11	-2.43E-12 +/- 2.81E-11	-6.95E-13 +/- 6.37E-12	1.51E-11 +/- 6.89E-11	3.30E-15	0.48%	
Ra-228	-6.84E-13 +/- 5.93E-11	5.28E-10 +/- 2.54E-10	-6.21E-10 +/- 7.98E-11	2.98E-11 +/- 2.76E-11	-1.62E-11 +/- 2.73E-10	5.90E-15	-0.27%	
Th-228	-1.01E-12 +/- 2.29E-11	1.17E-11 +/- 4.31E-11	3.88E-11 +/- 8.81E-11	3.78E-12 +/- 2.42E-12	1.32E-11 +/- 1.01E-10	3.10E-15	0.43%	
Th-230	4.88E-13 +/- 3.31E-11	5.11E-11 +/- 1.35E-10	1.91E-11 +/- 1.35E-10	4.88E-12 +/- 3.63E-11	1.89E-11 +/- 2.17E-10	3.40E-15	0.50%	
Th-232	2.25E-12 +/- 2.18E-11	2.45E-11 +/- 6.11E-11	-1.76E-11 +/- 9.29E-11	-2.89E-12 +/- 1.30E-11	1.60E-12 +/- 1.26E-10	6.20E-16	0.25%	
U, total	5.02E-11 +/- 2.41E-12	-2.63E-11 +/- 3.40E-12	1.48E-10 +/- 4.62E-13	1.49E-10 +/- 3.35E-12	7.97E-11 +/- 5.37E-12	7.96E-15	1.00%	
Total:								2.42%

AP-4012 (Bq/m3) Radionuclide	Net Concentration (uCi/m3)					Annual Average	NESHAPs Limit (Ci/m3)	Concentration (% of Limit)
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average			
Ra-226	2.81E-11 +/- 2.30E-11	2.28E-11 +/- 1.92E-11	3.52E-11 +/- 2.49E-11	1.89E-11 +/- 6.94E-12	2.63E-11 +/- 4.00E-11	NA	NA	
Ra-228	4.88E-11 +/- 4.82E-11	5.16E-11 +/- 6.12E-11	7.47E-10 +/- 4.58E-10	1.89E-11 +/- 3.03E-11	2.16E-10 +/- 4.57E-10	NA	NA	
Th-228	1.15E-11 +/- 1.49E-11	1.42E-11 +/- 2.97E-11	2.08E-11 +/- 5.81E-11	1.16E-11 +/- 2.63E-12	1.45E-11 +/- 6.70E-11	NA	NA	
Th-230	1.58E-11 +/- 2.40E-11	4.95E-11 +/- 8.79E-11	9.13E-11 +/- 1.11E-10	1.10E-11 +/- 2.92E-11	4.18E-11 +/- 1.48E-10	NA	NA	
Th-232	6.16E-12 +/- 1.38E-11	9.27E-12 +/- 1.95E-11	5.20E-11 +/- 8.63E-11	1.05E-11 +/- 2.50E-11	1.95E-11 +/- 9.30E-11	NA	NA	
U, total	2.33E-11 +/- 1.61E-12	2.03E-10 +/- 1.86E-11	2.43E-10 +/- 5.71E-12	1.86E-10 +/- 3.06E-12	1.64E-10 +/- 1.98E-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.

### 6.4.3 Dose Estimates

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

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

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 EPA's *Federal Guidance Report No. 11* (Ref. 30).
- Exposure duration represents the maximum time an individual is expected to be in the vicinity of a particular critical receptor.
- Breathing rate of 1.2 m<sup>3</sup>/hr (42.4 ft<sup>3</sup>/hr) is assumed, as provided in ICRP Report No. 23, *Report of the Task Group on Reference Man* (Ref. 25).

Table 6-5 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 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 dose equivalent to a member of the public is estimated to be 0.0198 +/- 0.0475 mrem, based on the exposure scenario of an individual residing near the Busch Memorial Conservation Area.

Table 6-5 1998 Isotopic Air Monitoring Results (Effective Dose Equivalent Contributions at Each Critical Receptor)

AP-2001 Radionuclide	Effective Dose Equivalent (mrem)						
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual		
Ra-226	0.0000 +/- 0.0003	0.0003 +/- 0.0001	0.0000 +/- 0.0001	0.0001 +/- 0.0001	0.0004 +/- 0.0003		
Ra-228	0.0000 +/- 0.0002	0.0055 +/- 0.0007	0.0000 +/- 0.0002	0.0001 +/- 0.0001	0.0057 +/- 0.0008		
Th-228	0.0000 +/- 0.0002	0.0001 +/- 0.0007	0.0000 +/- 0.0007	0.0001 +/- 0.0000	0.0002 +/- 0.0010		
Th-230	0.0000 +/- 0.0006	0.0001 +/- 0.0021	0.0005 +/- 0.0024	0.0001 +/- 0.0005	0.0008 +/- 0.0033		
Th-232	0.0000 +/- 0.0013	0.0005 +/- 0.0033	0.0000 +/- 0.0067	0.0000 +/- 0.0019	0.0008 +/- 0.0078		
U, total	0.0000 +/- 0.0000	0.0000 +/- 0.0001	0.0003 +/- 0.0000	0.0005 +/- 0.0000	0.0009 +/- 0.0001		
Total EDE	0.0001 +/- 0.0015	0.0066 +/- 0.0041	0.0009 +/- 0.0071	0.0009 +/- 0.0019	0.0085 +/- 0.0086		

AP-2005 Radionuclide	Effective Dose Equivalent (mrem)						
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual		
Ra-226	0.0000 +/- 0.0003	0.0008 +/- 0.0003	0.0000 +/- 0.0002	0.0001 +/- 0.0001	0.0008 +/- 0.0005		
Ra-228	0.0000 +/- 0.0002	0.0110 +/- 0.0018	0.0000 +/- 0.0003	0.0003 +/- 0.0001	0.0113 +/- 0.0018		
Th-228	0.0000 +/- 0.0004	0.0001 +/- 0.0010	0.0006 +/- 0.0017	0.0001 +/- 0.0004	0.0008 +/- 0.0020		
Th-230	0.0008 +/- 0.0014	0.0012 +/- 0.0037	0.0007 +/- 0.0028	0.0002 +/- 0.0011	0.0030 +/- 0.0050		
Th-232	0.0001 +/- 0.0023	0.0026 +/- 0.0072	0.0000 +/- 0.0105	0.0000 +/- 0.0021	0.0027 +/- 0.0131		
U, total	0.0000 +/- 0.0000	0.0000 +/- 0.0001	0.0004 +/- 0.0001	0.0005 +/- 0.0001	0.0009 +/- 0.0002		
Total EDE	0.0010 +/- 0.0027	0.0155 +/- 0.0064	0.0018 +/- 0.0110	0.0011 +/- 0.0024	0.0194 +/- 0.0143		

AP-4006 Radionuclide	Effective Dose Equivalent (mrem)						
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual		
Ra-226	0.0000 +/- 0.0003	0.0003 +/- 0.0003	0.0000 +/- 0.0001	0.0000 +/- 0.0001	0.0004 +/- 0.0004		
Ra-228	0.0000 +/- 0.0001	0.0012 +/- 0.0005	0.0000 +/- 0.0002	0.0002 +/- 0.0002	0.0014 +/- 0.0006		
Th-228	0.0000 +/- 0.0002	0.0003 +/- 0.0012	0.0000 +/- 0.0005	0.0000 +/- 0.0004	0.0003 +/- 0.0014		
Th-230	0.0002 +/- 0.0009	0.0000 +/- 0.0015	0.0000 +/- 0.0028	0.0005 +/- 0.0012	0.0007 +/- 0.0035		
Th-232	0.0000 +/- 0.0012	0.0013 +/- 0.0059	0.0000 +/- 0.0034	0.0000 +/- 0.0019	0.0013 +/- 0.0072		
U, total	0.0000 +/- 0.0000	0.0000 +/- 0.0005	0.0000 +/- 0.0000	0.0002 +/- 0.0001	0.0002 +/- 0.0005		
Total EDE	0.0003 +/- 0.0016	0.0031 +/- 0.0062	0.0000 +/- 0.0045	0.0010 +/- 0.0023	0.0043 +/- 0.0081		

AP-4007 Radionuclide	Effective Dose Equivalent (mrem)						
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual		
Ra-226	0.0000 +/- 0.0009	0.0001 +/- 0.0007	0.0000 +/- 0.0005	0.0002 +/- 0.0002	0.0003 +/- 0.0013		
Ra-228	0.0000 +/- 0.0007	0.0021 +/- 0.0024	0.0000 +/- 0.0018	0.0003 +/- 0.0004	0.0024 +/- 0.0031		
Th-228	0.0000 +/- 0.0014	0.0008 +/- 0.0011	0.0028 +/- 0.0055	0.0002 +/- 0.0003	0.0036 +/- 0.0058		
Th-230	0.0015 +/- 0.0032	0.0000 +/- 0.0027	0.0030 +/- 0.0102	0.0003 +/- 0.0028	0.0048 +/- 0.0114		
Th-232	0.0009 +/- 0.0111	0.0024 +/- 0.0124	0.0000 +/- 0.0419	0.0000 +/- 0.0070	0.0062 +/- 0.0455		
U, total	0.0000 +/- 0.0001	0.0000 +/- 0.0005	0.0005 +/- 0.0001	0.0019 +/- 0.0001	0.0024 +/- 0.0005		
Total EDE	0.0054 +/- 0.0116	0.0063 +/- 0.0130	0.0061 +/- 0.0436	0.0029 +/- 0.0075	0.0198 +/- 0.0475		

Table 6-5 1998 Isotopic Air Monitoring Results (Effective Dose Equivalent Contributions at Each Critical Receptor) (continued)

AP-4008 Radionuclide	Effective Dose Equivalent (mrem)					Total Annual
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
Ra-226	0.0000 +/- 0.0002	0.0004 +/- 0.0002	0.0000 +/- 0.0001	0.0000 +/- 0.0001	0.0004 +/- 0.0003	
Ra-228	0.0000 +/- 0.0002	0.0020 +/- 0.0011	0.0000 +/- 0.0005	0.0000 +/- 0.0001	0.0020 +/- 0.0012	
Th-228	0.0000 +/- 0.0002	0.0004 +/- 0.0010	0.0009 +/- 0.0014	0.0000 +/- 0.0004	0.0013 +/- 0.0018	
Th-230	0.0000 +/- 0.0004	0.0015 +/- 0.0042	0.0021 +/- 0.0032	0.0003 +/- 0.0010	0.0039 +/- 0.0064	
Th-232	0.0004 +/- 0.0021	0.0008 +/- 0.0042	0.0012 +/- 0.0077	0.0000 +/- 0.0022	0.0023 +/- 0.0093	
U, total	0.0002 +/- 0.0000	0.0000 +/- 0.0000	0.0012 +/- 0.0002	0.0005 +/- 0.0001	0.0020 +/- 0.0002	
Total EDE	0.0006 +/- 0.0021	0.0050 +/- 0.0062	0.0054 +/- 0.0085	0.0009 +/- 0.0025	0.0119 +/- 0.0110	

AP-4011 Radionuclide	Effective Dose Equivalent (mrem)					Total Annual
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
Ra-226	0.0000 +/- 0.0009	0.0001 +/- 0.0007	0.0036 +/- 0.0005	0.0002 +/- 0.0002	0.0002 +/- 0.0013	
Ra-228	0.0000 +/- 0.0004	0.0008 +/- 0.0016	0.0006 +/- 0.0008	0.0002 +/- 0.0006	0.0010 +/- 0.0019	
Th-228	0.0000 +/- 0.0008	0.0000 +/- 0.0017	0.0000 +/- 0.0035	0.0001 +/- 0.0015	0.0001 +/- 0.0043	
Th-230	0.0008 +/- 0.0026	0.0009 +/- 0.0076	0.0000 +/- 0.0081	0.0017 +/- 0.0037	0.0029 +/- 0.0127	
Th-232	0.0000 +/- 0.0047	0.0000 +/- 0.0083	0.0000 +/- 0.0315	0.0034 +/- 0.0158	0.0034 +/- 0.0365	
U, total	0.0008 +/- 0.0000	0.0000 +/- 0.0001	0.0000 +/- 0.0002	0.0025 +/- 0.0003	0.0031 +/- 0.0004	
Total EDE	0.0015 +/- 0.0055	0.0012 +/- 0.0115	0.0000 +/- 0.0330	0.0080 +/- 0.0163	0.0107 +/- 0.0390	

AP-4013 Radionuclide	Effective Dose Equivalent (mrem)					Total Annual
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
Ra-226	0.0000 +/- 0.0001	0.0003 +/- 0.0003	0.0000 +/- 0.0001	0.0000 +/- 0.0000	0.0003 +/- 0.0004	
Ra-228	0.0000 +/- 0.0002	0.0015 +/- 0.0007	0.0000 +/- 0.0002	0.0001 +/- 0.0001	0.0016 +/- 0.0008	
Th-228	0.0000 +/- 0.0003	0.0002 +/- 0.0006	0.0006 +/- 0.0013	0.0001 +/- 0.0000	0.0008 +/- 0.0015	
Th-230	0.0000 +/- 0.0006	0.0010 +/- 0.0030	0.0004 +/- 0.0026	0.0001 +/- 0.0007	0.0015 +/- 0.0041	
Th-232	0.0002 +/- 0.0021	0.0024 +/- 0.0080	0.0000 +/- 0.0091	0.0000 +/- 0.0013	0.0026 +/- 0.0124	
U, total	0.0004 +/- 0.0000	0.0000 +/- 0.0000	0.0011 +/- 0.0000	0.0011 +/- 0.0000	0.0026 +/- 0.0009	
Total EDE	0.0006 +/- 0.0022	0.0054 +/- 0.0086	0.0020 +/- 0.0086	0.0014 +/- 0.0015	0.0094 +/- 0.0132	

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 FGR11.
- 3) No dose is calculated for AP-4012, since it represents background conditions.
- 4) Assume breathing rate of 1.2 m<sup>3</sup>/hr, as provided in 1CRP 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.

#### 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 NESHAPs dose calculations. In addition, ingestion of radionuclides other than radon is not an applicable pathway for a potentially maximally exposed individual at any critical receptors. Thus, for the purpose of demonstrating NESHAPs compliance, the EDE as defined in 40 CFR 61 is assumed to equal the CEDE from internal deposition by the inhalation pathway. The contribution of dose due to external sources to the EDE is discussed separately in Section 6.6 and Appendix B.

Results of isotopic radionuclide monitoring at critical receptor locations demonstrate that airborne emissions from the WSSRAP contributed a maximum committed effective dose equivalent of 0.0198 +/- 0.0475 mrem/yr. This value, which represents the maximum dose equivalent calculated for all critical receptor locations, is significantly below the NESHAPs limit of 10 mrem/yr.

All 1998 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 6.4.2, net measured concentrations of individual radioisotopes are all below the limiting levels and proportional limits specified in the Code of Federal Regulations (CFR).

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. 20), have been achieved for all four quarters of the year. Based on verification and validation of each reported value, overall completeness of the data is greater than 95%. One-tailed Student's t-tests performed at the 95% confidence level indicate that no quarterly or annual concentrations are statistically above background at any of the critical receptors.

#### 6.5 Additional Information

No unplanned releases to the atmosphere occurred in 1998.

Releases from the WSSRAP are primarily due to diffuse sources. Effective dose equivalent estimates are based on critical receptor monitoring, and therefore account for both point source and diffuse source emissions.

## 6.6 Supplemental Information

Although not required by 40 CFR 61, this supplemental information is provided to assist the DOE in guidance development and in future interactions with the EPA. Information includes the following: collective population dose equivalent and airborne releases of radionuclides, status of compliance with 40 CFR 61 Subparts Q and T, details of non-storage radon emissions, a discussion of radionuclide emission points, and the status of the site quality assurance program for radionuclide emissions measurements.

### 6.6.1 Collective Population Dose and Airborne Release Estimates

**Dose Estimates.** Statistical tests performed at the 95% confidence level for each NESHAPS monitoring result indicated no above-background concentrations. However, a total 1998 collective population dose equivalent was calculated for locations that were considered exposure points. Exposure points are defined as locations where there is a potential for members of the public to be exposed to above-background concentrations of airborne radioactive particulate, radon gas concentrations, external gamma radiation, and radionuclides in food or water. All four pathways are addressed for the collective population dose estimate.

Using a 52-week background average, statistical testing at the 95% confidence level for radon gas and gamma exposure measurements at perimeter and critical receptor monitoring locations indicated above background levels at the following locations: radon monitoring stations RD-3001, RD-3002, and RD-3003; and gamma monitoring stations TD-2004 and TD-3003. When compared with the 104-week background average, all seven low volume air particulate chemical plant perimeter monitoring stations and critical receptor Station AP-4008 exceeded background levels. The high volume monitoring results, however, indicated no above background concentrations of airborne radionuclides.

Environmental thermoluminescent dosimeter (TLD) stations TD-2004 and TD-3003, which monitor direct exposure, are located along the Weldon Spring Chemical Plant perimeter adjacent to the Missouri Highway Maintenance facility, just northeast of the chemical plant perimeter, and west of the TSA near the Weldon Spring Ordnance Works (WSOW), respectively. Of the seven perimeter monitoring stations that exceeded the average background radioactive particulate concentration, those likely to be frequented by members of the public are AP-2001 (MHTD facility), AP-2005 and AP-2008 (WSSRAP offices), and AP-3004 (WSOW). Of the three above-background perimeter radon monitoring stations, only RD-3003 (western perimeter) is in an area likely to be frequented by members of the public. The Rn-220

concentration at RD-3003 was assumed to represent the Rn-220 concentration inhaled over the course of 1998 by WSOW remediation workers.

Another potential general population exposure is from the consumption of water, sediment, and fish from the August A. Busch Memorial Conservation Area. Three lakes at the conservation area receive runoff from the Weldon Spring site and are used for fishing and boating. The 1998 collective population dose calculation included assessments for nine employees of the Missouri Highway and Transportation Department (MHTD) facility, 300 employees at the WSSRAP, 150 employees at the WSOW, and 165,895 users of the Busch Memorial Conservation Area. The estimated total collective population dose equivalent was 1.43 person-rem (0.0143 person-Sv) for 1998. Calculations are presented in Appendix B, Section D.

**Airborne Release Estimates.** During 1998, statistical analysis of annual average high volume monitoring results used for the NESHAPs report indicated no locations where airborne radionuclide concentrations were greater than background. However, all seven low volume monitoring stations along the chemical plant perimeter (see Figure 4-1) indicated annual average concentrations that were statistically greater than the 104-week average background concentration. The net annual average gross alpha concentrations at these stations were incorporated into a series of box models to estimate the total radioactive airborne particulate release from the site for 1998. The box model approach provides conservative results and is used in place of Gaussian plume dispersion modeling, which is generally inappropriate for estimating ambient pollutant concentrations at receptors close to a source such as the perimeter monitors at the WSSRAP. Calculations are presented in Appendix B, Section E to estimate the radionuclide-specific activity releases during 1998. Specific radionuclide release activities are listed in Table 5-2.

#### 6.6.2 Subparts Q and T of 40 CFR 61

The regulations contained in Subpart Q pertain to Rn-222 emissions from radium-containing storage or disposal facilities. Initial radon flux measurements at the disposal cell are currently planned for the year 200 construction season.

The regulations contained in 40 CFR 61 Subpart T apply only to sites that are "...listed in, or designated by, the Secretary of Energy under Title I of the *Uranium Mill Tailings Control Act of 1978* or regulated under Title II of the *Uranium Mill Tailings Control Act of 1978*." Subpart T does not apply to the Weldon Spring site since it does not fall into the applicable categories.

### 6.6.3 Radon Emissions from WSSRAP Non-Storage Sources

#### 6.6.3.1 Rn-220 Emissions

Potential Rn-220 sources at the Weldon Spring site are the TSA, which was used for the storage of the quarry bulk wastes, and the four raffinate pits used for the storage of wastes from past uranium refinery operations. Radiological characterization of the raffinate pits waste indicated Ra-228 concentrations ranging from 4 pCi/g (0.148 Bq/g) to 1,400 pCi/g (51.8 Bq/g). Remediation activities included dredging/dewatering of the raffinate pits, sludge consolidation in Raffinate Pit 4, excavation of sludge from the Raffinate Pits 3 and 4, chemical solidification and stabilization of the sludge in the CSS facility, and subsequent disposal of the stabilized sludge in the disposal cell. These activities all resulted in increased Rn-220 emissions to the atmosphere.

The chemical plant perimeter is monitored for radon gas at 10 locations using alpha track radon monitors. Statistical analysis of the results at the 95% confidence level indicated that three monitoring locations, RD-3001, RD-3002, and RD-3003, had annual Rn-220 concentrations greater than background levels. To estimate the airborne Rn-220 emissions from the chemical plant during 1998, the above background alpha-track radon detector Rn-220 results were incorporated into a series of box models. The estimated off-site Rn-220 release from the chemical plant was 14.2 Ci (5.25E11 Bq). Calculations and assumptions are provided in Appendix B, Part F.

#### 6.6.3.2 Rn-222 Emissions

The primary non-storage source of Rn-222 during 1998 was the four raffinate pits that were used for the storage of waste resulting from past uranium refinery operations. Radiological characterization of the raffinate pits waste indicated Ra-226 concentrations ranging from 1 pCi/g (0.037 Bq/g) to 1,700 pCi/g (63 Bq/g). As stated in Section 6.6.3.1, the raffinate pit remedial activities have exposed radium-bearing waste to the atmosphere.

The chemical plant perimeter is monitored for radon gas at 10 locations. Statistical analysis of the monitoring results during 1998 indicated that the average radon concentration was greater than background levels at Station RD-3002. Based on box modeling, the estimated off-site Rn-222 release from the chemical plant was 2.8 Ci (1.04E11 Bq). Calculations and assumptions are provided in Appendix B, Part F.

### 6.6.4 Effluent Monitoring Requirements

The site water treatment plant, quarry water treatment plant, and chemical stabilization/solidification plant were in operation during 1998 and were potential point sources of radioactive airborne particulates. The WSSRAP has developed a plan to continuously monitor air concentrations of radioactive particulates resulting from remedial activities, at designated critical

receptor locations in accordance with 40 CFR 61.93, Paragraph (b)(5). This approach is contained in the *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 20), which has been approved by EPA Region VII. The report includes a discussion of the WSSRAP quality assurance program and data quality objectives for measurement of radionuclide emissions from the Weldon Spring site. This program conforms to the requirements of 40 CFR 61, Appendix B, Method 114, and ensures that emission measurements are representative and are of known precision and accuracy.

## 7. SURFACE WATER PROTECTION

### 7.1 Highlights of the Surface Water Program

The following are highlights of the 1998 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, 23.8 kg/yr (52.4 lb/yr), was only slightly greater than the 1997 mass of 22.2 kg/yr (48.9 lb/yr) (see Tables 7-5 and 11-1). The increase was the result of greater precipitation during 1998.
- Forty-seven batches of water were released from the site and quarry water treatment plants during 1998, in compliance with all National Pollutant Discharge Elimination System (NPDES) permit conditions.
- The overall results of the whole effluent toxicity (WET) tests indicate that the site and quarry water treatment plant effluent was not toxic to test organisms during 1998.
- Total uranium levels in the Femme Osage Slough were within historical ranges.

### 7.2 Program Overview

The environmental monitoring and protection program for surface waters at the Weldon Spring Site Remedial Action Project (WSSRAP) is prescribed in the *Environmental Monitoring Plan* (Ref. 8) and includes monitoring discharge points permitted under the NPDES program and streams, ponds, and lakes under the surface water monitoring program.

The effluent, or NPDES, monitoring program at the Weldon Spring site establishes sampling requirements for discharge points (outfalls) at both the chemical plant and the quarry. 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 WSSRAP policy, that all surface water be closely monitored and treated (as necessary) to meet Federal and State requirements, the Project Management Contractor (PMC) uses the water sample data to develop strategies to minimize the discharge of waterborne contaminants from the site.

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's goal to clean up the site with no long-term increase in contaminant discharge or degradation of the off-site water bodies.

### 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 1998 were authorized by four 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. Sampling frequencies and reporting requirements for the two major permits, MO-0107701 and MO-0108987, are summarized in Tables 7-1 and 7-2. These permits were reissued on March 4, 1994, and June 17, 1998, respectively. An application to renew Permit MO-0107701 was submitted on September 1, 1998, and renewal is pending.

The Borrow Area land disturbance storm water permit, MO-R100B69, issued 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. 8) for monitoring settleable solids and, under certain circumstances, oil and grease. The results of this monitoring were used to measure the effectiveness of erosion control and to improve controls, if required.

Permit MO-G670203 was issued on December 5, 1997, for the discharge of hydrostatic test water from the chemical plant site. Sampling frequency and reporting requirements and results are discussed in Section 7.6.1.2.4.

Effluent discharges are also regulated by Department of Energy (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 [22.2 Bq/l]). Measures are also taken to keep uranium concentrations as low as reasonably achievable (ALARA).

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 8.

Table 7-1 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 <sup>(a)</sup> , NP-0004, NP-0005, NP-0010, NP-1005	NP-0006
Sampling Frequency	once/quarter	once/quarter
Flow	GPD (monitor only)	GPD (monitor only) <sup>(a)</sup>
Settleable Solids	1.0 ml/whr	—
TSS	mg/l (monitor only) <sup>(b)</sup>	30/45 mg/l <sup>(c)</sup>
Nitrate and Nitrite as N <sup>***</sup>	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 <sup>(e)</sup>
BOD	—	30/45 mg/l <sup>(e)</sup>

NOTE: Refer to Figure 7-1 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.
- \*\* Gross beta was added to the permit on June 17, 1998.
- \*\*\* Does not apply to quarry storm water Outfall NP-1005.
- (a) Frequency is once/month.
- (b) Limit is 50 mg/l if erosion control is not designed for a one in 10 year, 24-hour storm.
- (c) Monthly average/daily maximum.
- (d) NPDES permit MO-0107701 includes sampling of creosote constituents, Cu and Zn in the chipped wood storage area pond prior to discharge to Outfall NP-0003. See Table 7-2 for limits.
- (e) Monthly average/weekly average.
- Not Applicable.

Table 7-2 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	PARAMETER	LOCATION
	NP-0007/NP-1001		NP-0007/NP-1001
Gross $\alpha$	pCi/l <sup>(a)</sup>	Pb, total	0.20/0.10 mg/l
Gross $\beta$	pCi/l <sup>(a)</sup>	Mn, total	0.50/0.10 mg/l
Uranium, total	pCi/l <sup>(a),(b)</sup>	Hg, total	0.005/0.004 mg/l
Ra-228 <sup>(c)</sup>	pCi/l <sup>(a)</sup>	Se, total	0.05/0.02 mg/l**
Ra-226 <sup>(c)</sup>	pCi/l <sup>(a)</sup>	Cyanide, Amenable	0.05/0.0075 mg/l**
Th-230 <sup>(c)</sup>	pCi/l <sup>(a)</sup>	2,4-DNT	1.1/0.22 $\mu$ g/l
Th-232 <sup>(c)</sup>	pCi/l <sup>(a)</sup>	Fluoride, total	12/4.0 mg/l**
Flow	GPD <sup>(d)</sup>	Nitrate and Nitrite as N	100 mg/l <sup>(f)</sup>
COD	90 (80) mg/l <sup>(g)</sup>	Sulfate as SO <sub>4</sub>	1000/500 mg/l
TSS	50 (30) mg/l <sup>(g)</sup>	Chloride	mg/l <sup>(g)**</sup>
pH	6-9 standard units	Priority Pollutants <sup>(i)</sup>	mg/l <sup>(a),(h),(i)</sup>
As, total	0.20/0.10 mg/l**	Whole Effluent Toxicity	<sup>(j)</sup>
Cr, total	0.40/0.10 mg/l**	Po-210 <sup>(k)</sup>	pCi/l <sup>(a),(h)**</sup>
Cu <sup>(a),(c)</sup>	N/A/1.00 mg/l**	Ac-227 <sup>(k)</sup>	pCi/l <sup>(a),(h)**</sup>
Cu-Site	1.0(0.86) mg/l <sup>(a),(i)</sup>	Radon <sup>(l)</sup>	pCi/l <sup>(a),(h)**</sup>
Zn-Site	5.0(3.33) mg/l <sup>(a),(i)</sup>	Creosote-site <sup>(m)</sup>	<sup>(n),(o)</sup>

NOTE: Refer to Figures 7-2 and 7-3 for NPDES monitoring locations.

- \* Frequency = once per batch unless otherwise noted.
- \*\* Deleted from quarry permit (MO-0108987) on July 17, 1998.
- (a) Monitoring only.
- (b) Water treatment plants designed for an average concentration of 30 pCi/l (1.11 Bq/l) and never to exceed concentrations of 100 pCi/l (3.7 Bq/l). Leachate receiving primary treatment only is not subject to this plant design goal.
- (c) Once/month.
- (d) Quarry only.
- (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) Once per batch for each batch sampled within a period of 30 days following introduction of CWSA water (which has failed these limits) to the SWTP.
- (l) Includes: acenaphthylene, acenaphthene, benzo(a)anthracene, dibenzo(a,h)anthracene, benzo(a)pyrene, benzo (k) fluoranthene, chrysene, fluoranthene, fluorene, Indeno (1,2,3-cd) pyrene, naphthalene, and phenanthrene.
- (m) Daily maximum - 2.5 x Q.L., monthly average - 1.5 x Q.L. Q.L. - quantification level as set by most recent edition of Standard Methods (Q.L. taken as practical quantification limit [PQL]).
- (n) Polychlorinated biphenyls (PCBs) have a limit of 1  $\mu$ g/l.

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.

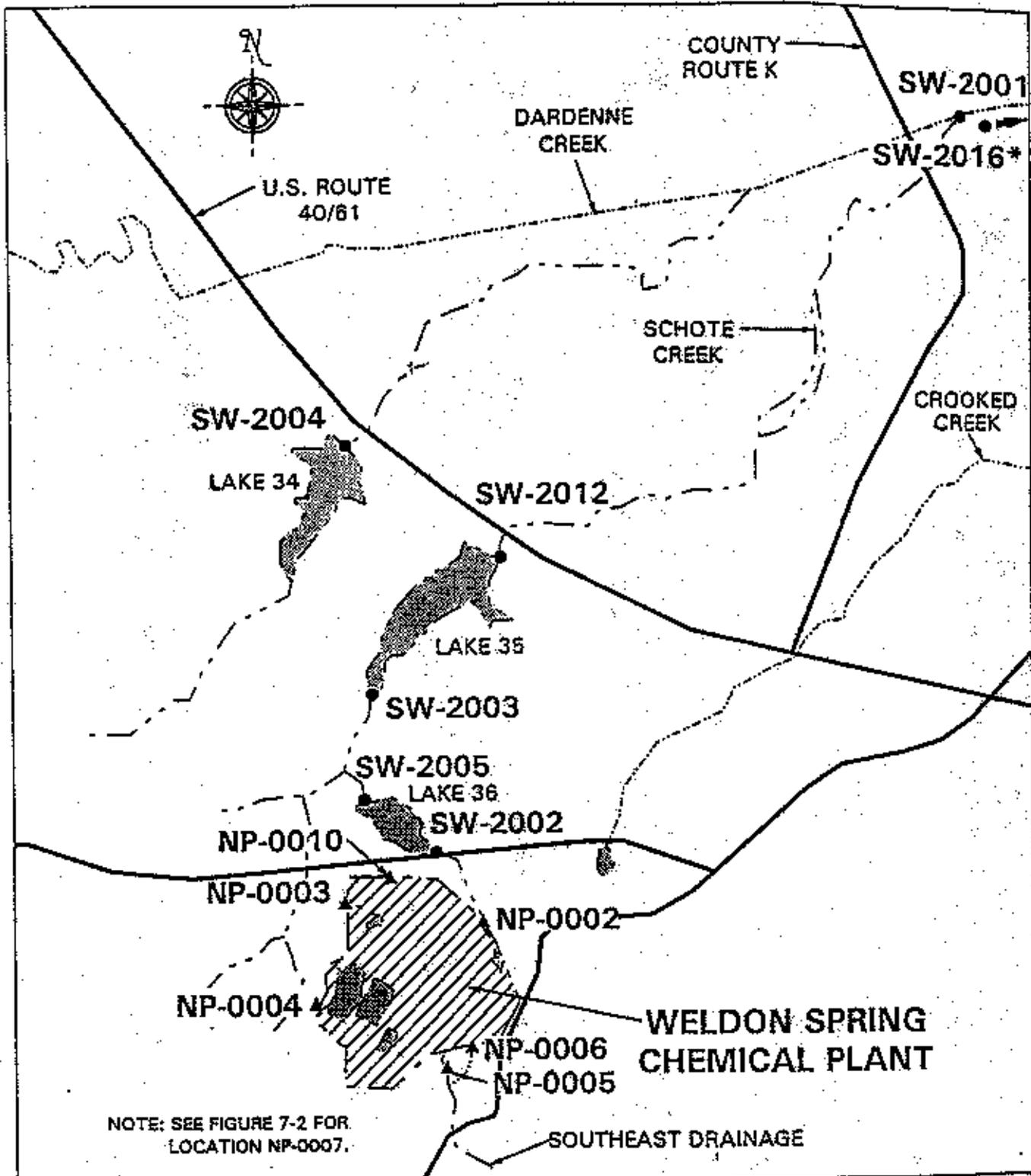
#### 7.4 Hydrology Description of the Site and Quarry

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.

##### 7.4.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits

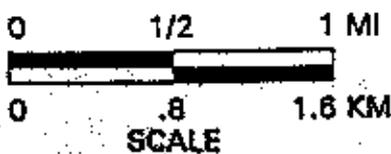
The chemical plant area is located on the Missouri-Mississippi River surface drainage divide (Figures 7-1 and 7-2). The topography is gently undulating and generally slopes northward to the Mississippi River and, more steeply, southward to the Missouri River. Streams do not run through the property, 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 includes Ash Pond, the chipped wood storage area (CWSA), and areas adjacent to the temporary storage area (TSA) 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 7-1). Ash Pond accumulates water when a valve is closed in the discharge structure. If Ash Pond water has a uranium concentration greater than 600 pCi/l (22.2 Bq/l), the valve remains closed. If the ponded water is below 600 pCi/l after the runoff event, it may be released; otherwise it is stored in the pond or transferred for treatment. The MSA basin (SW-2015) was a temporary holding pond that collected storm water runoff from the material staging area. This basin was eliminated, along with the entire MSA, early in 1998. The CWSA basin is operated by sampling for parameters prescribed in permit MO-0107701. If the parameters are within the limits the water is discharged to the Ash Pond diversion channel, if not, the water is transferred for treatment. All water that discharges at Outfall NP-0003 flows through Sedimentation Basin 4 before reaching Outfall NP-0003.

Surface water drainage from the north and east sections of the chemical plant, which includes part of the disposal cell outer berm, discharges to Dardenne Creek from Schote Creek after first flowing through Busch Lakes 36 and 35 (Figures 7-1 and 7-2). Frog Pond and the asbestos storage area were removed from the watershed during August 1998 and the area was remediated. Storm water runoff and leachate from the interior of the cell is collected in Retention Basins 1 and 2 for sampling and/or treatment.



**LEGEND**

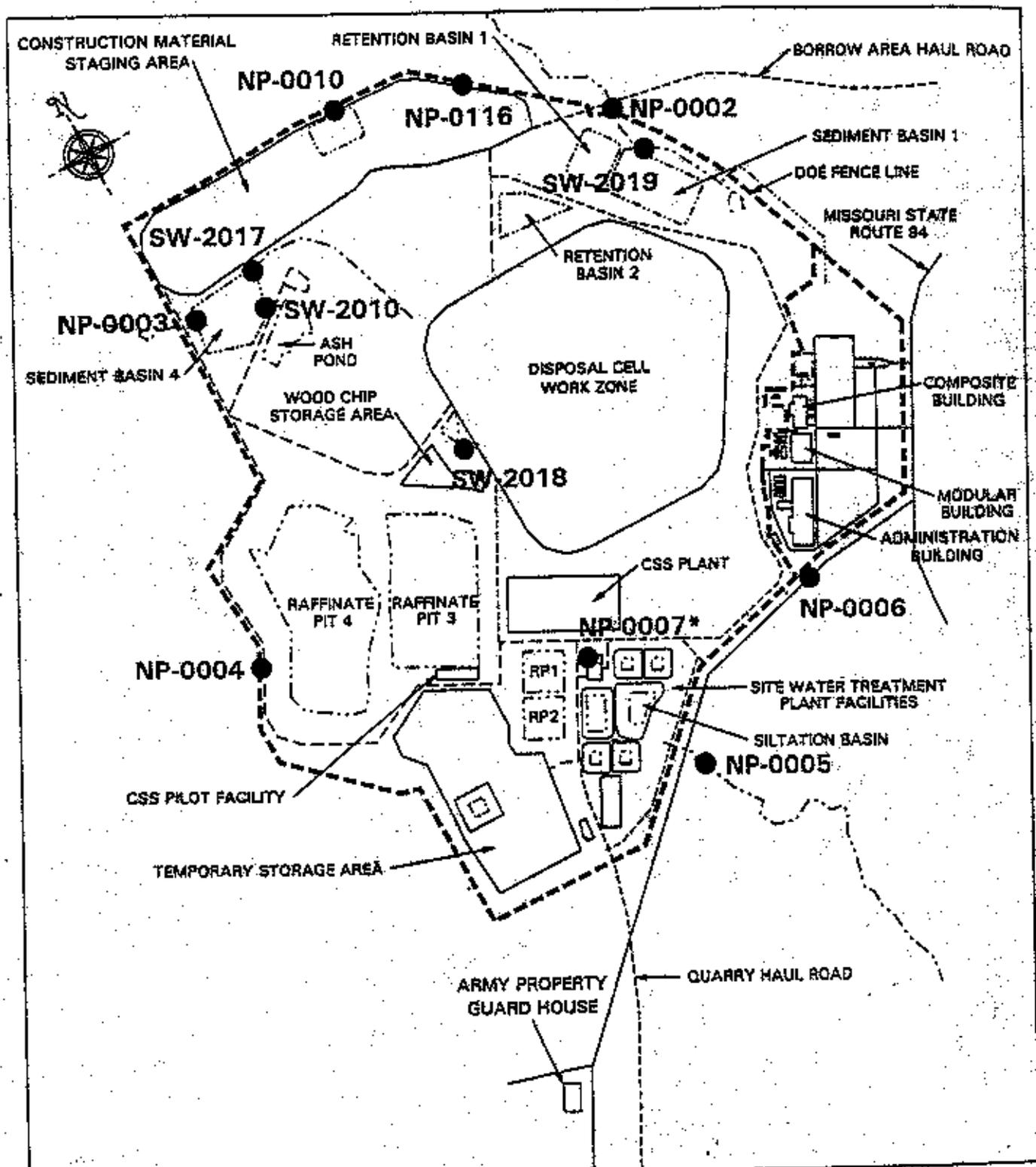
- - SURFACE WATER LOCATION
- ▲ - NPDES LOCATION
- \* - AT COUNTY ROUTE N, APPROXIMATELY 2 MILES



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

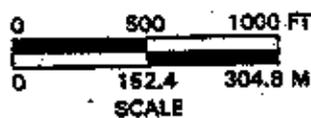
**FIGURE 7-1**

REPORT NO. J	DOE/OR/21548-773	CONTRACT NO.	A/NP/079/1193
OPERATOR	TW	DRAWN BY	GLN
		DATE	5/3/99



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

● - SAMPLE LOCATION



### NPDES SURFACE WATER SAMPLING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT

FIGURE 7-2

REPORT NO.:	DOE/OR/21548-773	CONTRACT NO.:	A/CP/086/0993
OPERATOR:	TW	DRAWN BY:	GLN
		DATE:	5/28/99

Runoff from a large portion of this area entered Sedimentation Basin 1 until Frog Pond was removed and the area remediated during August 1998. Subsequently, flow to the sedimentation basin was from a much reduced area.

Runoff from the southern portion of the chemical plant site (Figures 7-1 and 7-2) that includes the site water treatment plant, Building 434, and parking and equipment areas for the Chemical Stabilization and Solidification (CSS) Facility, flows southeast to the Missouri River via the Southeast Drainage (Valley 5300). All storm water runoff from this area, except for minor flows from the Building 434 area and some roadside ditches, flowed through a sedimentation basin just upstream of Outfall NP-0005 during 1998.

The four raffinate pits, located in the southwestern portion of the chemical plant area do not discharge to the surface and collect only direct precipitation. Water from the raffinate pits has been, and will continue to be, treated at the site water treatment plant before release. A portion of Raffinate Pit 4 was remediated and confirmed clean during 1998. Storm water from the remediated portion flows to Outfall NP-0004.

#### 7.4.2 Weldon Spring Quarry

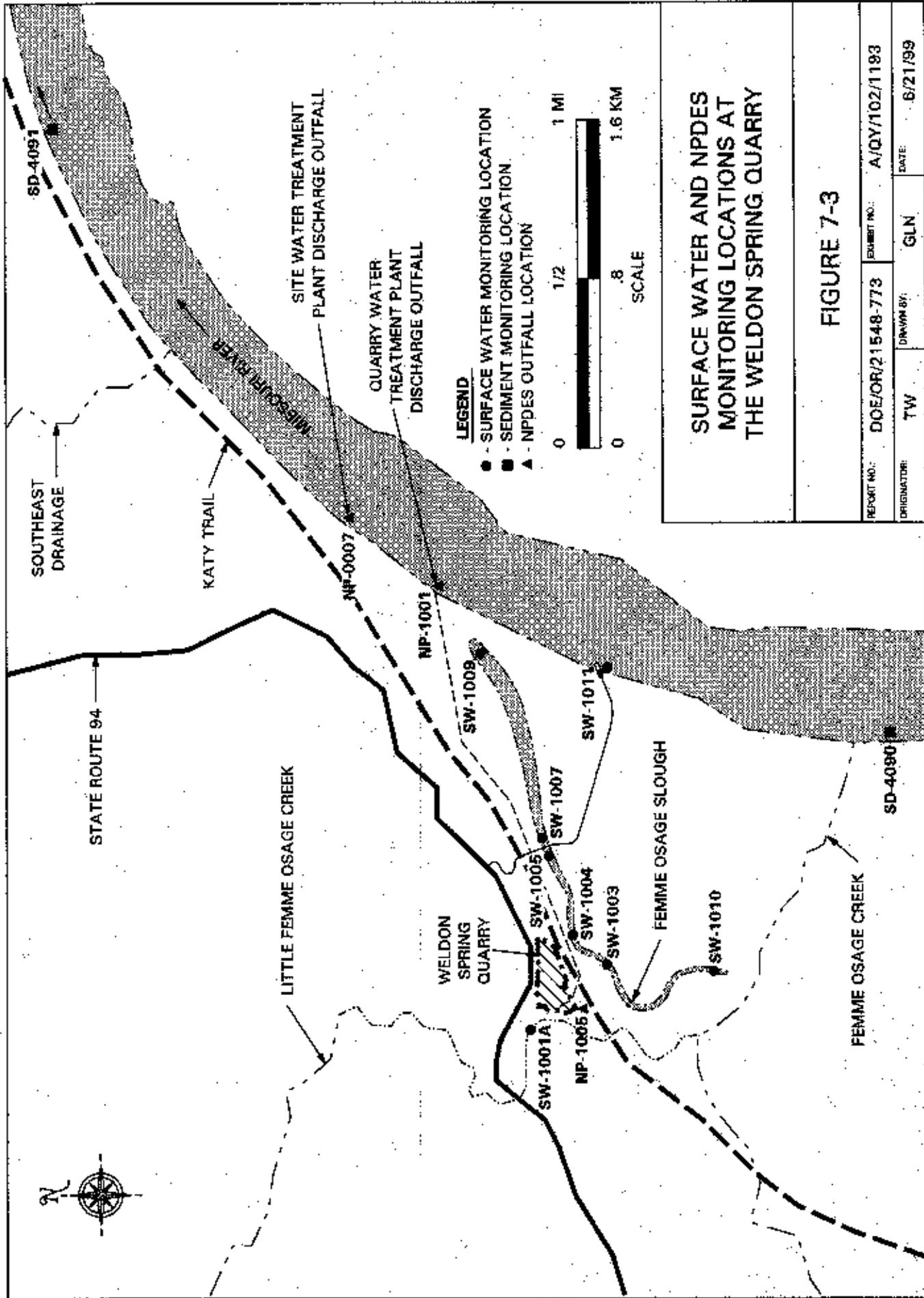
Surface water bodies in the quarry area are the Femme Osage Slough, the Little Femme Osage Creek, and the Femme Osage Creek (Figure 7-3). These water bodies do not receive direct runoff from the quarry, but are sampled to monitor potential changes due to the movement of contaminated groundwater from the fractured bedrock of the quarry through the fine-grained alluvial materials.

The Femme Osage Slough is located 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. The Little Femme Osage Creek is located west of the quarry and discharges into the Femme Osage Creek approximately 0.5 km (0.3 mi) southwest of the quarry. The Femme Osage Creek then 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 any changes in the system.

The quarry decontamination pad is no longer used and was demonstrated to have no surface contamination. Storm water runoff from the quarry decontamination pad area is directed to storm water outfall NP-1005 (Figure 7-3). If the pad is used in the future, all water will again be treated until it is again demonstrated as having no surface contamination.

### 7.5 Monitoring

Sections 7.5.1 and 7.5.2 discuss monitoring requirements at NPDES outfalls and surface water locations at the chemical plant site and the quarry.



**SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING QUARRY**

**FIGURE 7-3**

### 7.5.1 National Pollutant Discharge Elimination System Monitoring

The NPDES permits issued to the site identify the parameters to be monitored. The permit requirements for the two major permits are shown in Tables 7-1 and 7-2 and the requirements for the two minor permits are discussed in the text. Physical, chemical, and radiological parameters were monitored at all storm water outfalls, the quarry water treatment plant and site water treatment plant outfalls. The *Environmental Monitoring Plan* (Ref. 8) also reflects the requirements of the NPDES permits.

In addition to the permitted outfalls, samples were collected upstream of NPDES storm water Outfall NP-0002 from sampling location SW-2019 (Sedimentation Basin No. 1), and upstream of NPDES storm water Outfall NP-0003 from location SW-2010 (Ash Pond) and SW-2017 (Ash Pond diversion channel). Quarterly samples were also collected from Ash Pond, when possible, to monitor the effects of materials stored in those areas on contaminant levels in the storm water runoff. The MSA pond was eliminated during 1998. Prior to elimination, samples were collected for uranium analysis before the accumulated pond water was discharged.

### 7.5.2 Surface Water Monitoring

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

#### 7.5.2.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits

Under the surface water monitoring program, Dardenne Creek, and Busch Lakes 34, 35, and 36 were sampled quarterly for total uranium (Ref. 8). Samples were analyzed on the site Kinetic Phosphorescent Analyzer (KPA). This monitoring was conducted to measure the effects of surface water discharges from the site on downstream surface water. The raffinate pits were previously monitored as surface water, but are now monitored under treatment plant operations sampling.

#### 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 7-3) were monitored quarterly for total uranium because of past significant contaminant levels in these areas, fluctuations in concentrations due to changes in water levels in the slough and groundwater potentiometric surface, and the potential for these surface water contaminants to impact groundwater south of the slough. The remaining locations (SW-1007, SW-1008, and SW-1009) were sampled quarterly to provide sufficient data to determine any changes in these areas. Locations SW-1003, SW-1004, and SW-1005 were also monitored

semiannually for nitroaromatic compounds because these locations are downgradient from the area of greatest nitroaromatic groundwater contamination.

## 7.6 Monitoring Results

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

### 7.6.1 National Pollutant Discharge Elimination System Program Monitoring Results

Radiochemical, chemical, and physical analytical results for NPDES outfalls are presented in subsections 7.6.1.1 and 7.6.1.2.

#### 7.6.1.1 Radiochemical Analysis

The 1998 average uranium concentrations at the storm water discharge points ranged from 1.0 pCi/l (0.037 Bq/l) at NP-1005 to 83.1 pCi/l (3.07 Bq/l) at NP-0003, which are 0.15% and 12.2%, respectively, of the DCG for natural uranium. Average annual gross alpha concentrations ranged from 1.8 pCi/l (0.067 Bq/l) at NP-1005 to 61.2 pCi/l (2.26 Bq/l) at NP-0003. The annual average radionuclide concentrations for all the permitted storm water outfalls are shown in Table 7-3. Uranium concentration averages were calculated on a flow weighted basis for all storm water outfalls except for Outfall NP-1005. Only two samples were collected for Outfall NP-1005, and both were non-detect for uranium. Flow weighted averages (rather than straight averages) were calculated for uranium levels at the outfalls to estimate the total uranium that migrated off site during 1998. The averages were flow weighted by summing the total daily flows (liters) for the days the samples were collected and summing the total activity (pCi) for the days the samples were collected. The sum of the activity for all samples was then divided by the sum of the flow for all samples, to give the flow-weighted average for the year.

The site water treatment plant (SWTP) and quarry water treatment plant (QWTP) were both in operation during 1998. Four batches were discharged from the QWTP and 43 batches were discharged from the SWTP. No daily maximum or monthly average limits are established for uranium; however, the design of the treatment plant is based on achieving an average of 30 pCi/l (1.11 Bq/l) uranium with a maximum never to exceed 100 pCi/l (3.7 Bq/l). The average uranium concentrations for the site and quarry water treatment plants were well below this level at 3.11 pCi/l (0.12 Bq/l) and 0.38 pCi/l (0.01 Bq/l), respectively (Table 7-5). In addition, the SWTP averaged 10.15 pCi/l (0.38 Bq/l) for gross alpha and 23.68 pCi/l (0.88 Bq/l) for gross beta. The QWTP averaged 0.75 pCi/l (0.03 Bq/l) and 3.85 pCi/l (0.14 Bq/l), respectively for these same parameters (Table 7-4). In addition to effluent monitoring, the NPDES permit for the quarry, MO-0108987, required that river sediment sampling be conducted annually upstream and downstream of the quarry water treatment plant outfall (NP-1001). The river sediment was

Table 7-3 1998 Annual Average NPDES Results for the Weldon Spring Chemical Plant and Quarry Storm Water Outfalls

PARAMETERS	LOCATIONS					
	NP-0002	NP-0003	NP-0004	NP-0005	NP-0010	NP-1005
Number of sample events	12	12	7	12	12	2
pH range	(a)	(a)	(b)	(a)	(a)	(a)
Nitrate (as N) mg/l	1.69	3.4	9.7	0.55	0.12	NS
Total suspended solids mg/l	447	90	1,935	63	46	17.4
Settleable solids ml/hr	12/0(c)	13/1(c)	7/1(c)	12/0(c)	8/0(c)	2/0(c)
Arsenic mg/l	0.006(10) <sup>(d)</sup>	0.005	0.037(4)	0.004(2)	<0.003(1)	NS
Chromium mg/l	0.002(10)	0.018	0.106(4)	0.004(2)	0.004(1)	NS
Lead mg/l	0.010(10)	0.008	0.049(4)	0.002(2)	<0.013(1)	NS
Thallium mg/l	0.003(10)	0.002	0.003(4)	0.002(2)	<0.006(1)	NS
Total uranium pCi/l	22.3*	83.1*	23.4(6)*	10.0*	10.7*	1.0
Gross alpha pCi/l	24.1	61.2	20.7(6)	11.0	8.6	1.8
Gross beta	24.5(7)	14.8(7)	20.3(6)	7.7(7)	6.7(7)	7.5
Radium-226 pCi/l	0.23(2)	0.80	<0.72(1)	0.91(1)	0.30(1)	NS
Radium-228 pCi/l	0.90(2)	0.90	<0.94(1)	<0.94(1)	1.34(1)	NS
Thorium-228 pCi/l	0.25(2)	0.34	0.68(1)	<0.48(1)	<0.43(1)	NS
Thorium-230 pCi/l	0.24(2)	1.07	1.89(1)	<0.51(1)	<0.46(1)	NS
Thorium-232 pCi/l	0.24(2)	0.30	0.77(1)	<0.55(1)	<0.50(1)	NS

(a) All pH readings were in the permitted range of 6.0 to 9.0.

(b) One pH measurement was above the upper limit of 9.0.

(c) Top number is number of samples, bottom number is number of results above daily maximum limit of 1.0 ml/hr.

(d) 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.

NS Not Sampled.

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

sampled for uranium at locations SD-4090 (upstream) and SD-4091 (downstream) (see Figure 7-3). The one-time sampling results were 0.81 pCi/g (0.03 Bq/g) at SD-4090 and 0.67 pCi/g (0.02 Bq/g) at SD-4091.

Radium and thorium were monitored once per month, (as required by the permit) in both site and quarry water treatment plant batches. While there were some isolated incidents at the site water treatment plant of levels elevated above past averages, (Ra-226 had a maximum value of 7.56 pCi/l [0.28 Bq/l], Ra-228 had a maximum value of 5.83 pCi/l [0.22 Bq/l], Th-228 had a maximum value of 2.72 pCi/l [0.10 Bq/l], Th-230 had a maximum value of 2.8 pCi/l [0.10 Bq/l], and Th-232 was less than 1.0 pCi/l [0.037 Bq/l] for all samples), they were below DCG levels and returned to within normal range in subsequent samples. Annual averages for radium and thorium at the SWTP and QWTP are shown in Table 7-4.

Table 7-4 Site and Quarry Water Treatment Plant Annual Averages for Radium and Thorium (pCi/l)

PARAMETER	QUARRY WTP (NP-1001)	SITE WTP (NP-0007)
Ra-226	0.28 (1/4)*	1.14 (1/15)
Ra-228	1.75 (1/4)	1.99 (5/15)
Th-228	0.08 (4/4)	0.36 (12/15)
Th-230	0.26 (4/4)	0.56 (6/15)
Th-232	0.11 (4/4)	0.12 (14/15)
Gross alpha	0.75 (2/4)	10.15 (18/43)
Gross beta	3.85 (1/4)	23.68 (7/43)

\* Number of results below detection limit (including uncensored values)/total number of samples.

Note: 1 pCi/l = 0.037 Bq/l

Ac-227 and Rn-222 were monitored once and Po-210 twice for 1998 in the quarry effluent. Ac-227 had an uncensored value of 2.3 pCi/l (0.09 Bq/l) with a detection limit of 16.0 pCi/l (0.59 Bq/l); Po-210 was detected at 0.9 pCi/l (0.033 Bq/l) in one sample and was not detected at a detection limit of 0.130 pCi/l (0.005 Bq/l) in the other; and Rn-222 was not detected at a detection limit of 24.7 pCi/l (0.91 Bq/l).

Estimated quantities of total natural uranium released off site through surface water runoff and treatment plant discharges are presented in Table 7-5. The total volume of storm water at the three major outfalls was measured with totalizing flow meters. Where flow meters were not available, the flow was determined by total precipitation and runoff curve numbers cited in the U.S. Department of Transportation *Design of Roadside Drainage Channels* (Ref. 34). When flow meters were not operational for a period of time, runoff curve numbers were calculated using flow and precipitation data from periods when the meter was operational. Total uranium released from the treatment plants was calculated using flow meter and effluent concentration data. Outfall NP-1005 is not included because only two samples were collected during 1998 and no uranium was detected. The estimated mass of uranium released off site in storm water and treated effluent during 1998 was 23.8 kg (52.47 lb). This is a slight increase over the calculated amount released during 1997 (22.15 kg (48.83 lb)). This may be attributed to the increased precipitation during 1998 (over 1997).

Table 7-6 shows the annual average uranium concentrations of NPDES outfalls from 1991 to 1998. Concentrations in 1998 increased at Outfalls NP-0002, NP-0010 and NP-0007 and decreased from 1997 concentrations at Outfalls NP-0003, NP-0005 and NP-1001. Historical trending of uranium for Outfalls NP-0002, NP-0003, and NP-0005 is discussed in Section 11.1. 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 succeeding paragraphs.

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

The average uranium concentration for Outfall NP-0002 in 1998 was 22.3 pCi/l (0.83 Bq/l), slightly increased over the 1997 average of 14.4 pCi/l (0.53 Bq/l). This slight increase may be the result of increased precipitation in 1998. No radiological contaminants were detected above baseline values. Baseline values for contaminants in storm water were set before soil and foundation removal started. Baseline monitoring and values are discussed in Section 11.2. All levels were below the DCGs. Annual average NPDES results for Outfall NP-0002 are shown in Table 7-3.

Table 7-5 1998 Estimated Annual Release of Natural Uranium from NPDES Outfalls

OUTFALL	DRAINAGE AREA HECTARES (ACRES)	ESTIMATED % OF PRECIPITATION AS RUNOFF	AVERAGE URANIUM CONCENTRATION (pCi/l)	TOTAL RAINFALL VOLUME MI/yr (Mgal/yr)	TOTAL RUNOFF VOLUME MI/yr (Mgal/yr)	TOTAL U RELEASE (Ci/yr)	TOTAL U RELEASE (kg/yr)
NP-0002	30.4 (75.1)	<sup>(a)</sup>	22.3*	382.91 (101.17)	255.30 (67.36)	5.70x10 <sup>-3</sup>	8.385
NP-0003	30.2 (74.6)	<sup>(a)</sup>	83.1*	380.38 (100.49)	108.67 (28.71)	9.04x10 <sup>-3</sup>	13.300
NP-0004	5.7 (14)	40 <sup>(b)</sup>	23.35*	41.86 (11.06)	16.74 (4.42)	0.391x10 <sup>-3</sup>	0.575
NP-0005	8.2 (20.2)	<sup>(a)</sup>	10.0*	102.89 (27.21)	38.86 10.25	0.39x10 <sup>-3</sup>	0.571
NP-0010	2.0 (5.0)	40 <sup>(b)</sup>	10.7*	25.49 (6.74)	10.20 (2.69)	0.109x10 <sup>-3</sup>	0.160
NP-0007	N/A	N/A	3.11	N/A	174.74 (46.17)	0.543x10 <sup>-3</sup>	0.799
NP-1001	N/A	N/A	0.38	N/A	17.26 (4.56)	0.007x10 <sup>-3</sup>	0.010
TOTAL	N/A	N/A	N/A	933.21 (246.54)	621.77 (164.26)	16.18x10 <sup>-3</sup>	23.8

(a) Runoff curve number estimated from U.S. Department of Transportation *Design of Roadside Drainage Channels* (Ref. 34).

(b) Total runoff measured from flow meters.

N/A Not Applicable.

Note: To convert from Ci/yr to Bq/yr multiply Ci/yr by 3.7 x 10<sup>10</sup>

\* Flow-weighted average.

Table 7-6 Eight-Year Annual Average Uranium Concentrations at NPDES Outfalls

OUTFALL	ANNUAL AVERAGE TOTAL URANIUM (pCi/l)							
	1991	1992	1993	1994	1995	1996	1997	1998
NP-0001	475	516	1003*	1226*	(a)	(a)	(a)	(a)
NP-0002	158	228	230*	182*	124*	54*	14*	22*
NP-0003	456	478	607*	332*	67*	88*	143*	83*
NP-0004	8	6	9	12	(b)	(b)	(b)	23*
NP-0005	581	296	133*	347*	128*	107*	19*	10*
NP-0010	--	--	--	82	107	50	2.7	10.7*
NP-0007	--	--	0.363	0.74	0.46	1.37	1.50	3.11
NP-1001	--	<0.0003	1.881	1.60	1.76	1.09	0.51	0.38
NP-1005	--	--	--	--	--	--	--	1.0(c)

- \* 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.

The average uranium concentration for Outfall NP-0003 was 83.1 pCi/l (3.07 Bq/l), which was much less than the 1997 average of 142.5 pCi/l (5.27 Bq/l). The decrease may be the result of the controlled release of the runoff from Ash Pond and upstream remediation. Ash Pond is used to store materials removed from other areas of the site until they can be placed in the cell. Ash Pond is managed to avoid discharging water from the pond that is over 600 pCi/l. Except for Ra-226 and Ra-228 in one sample and Th-228 and Th-230 in another single sample, radium and thorium concentrations were below baseline values (see Tables 11-2 and 11-3). All values were well below the DCGs for radium and thorium. Annual average values for uranium, radium, thorium, gross alpha, and gross beta are shown in Table 7-3. Baseline values are discussed in Section 11.1.3. One major contributor to NP-0003 is water from upstream of NP-0003 that flows around Ash Pond in a diversion channel before entering Sedimentation Basin 4. The diversion channel was sampled just before it entered Sedimentation Basin 4 to determine the uranium contribution to Outfall NP-0003 from the upstream area. The annual average at SW-2017 was 68.5 pCi/l (2.5 Bq/l), which was lower than the Outfall NP-0003 average of 83.1 pCi/l (3.07 Bq/l). Location SW-2017 results are located in Table 7-7.

Outfall NP-0004 was eliminated from NPDES permit MO-0107701 on March 4, 1994, but was re-permitted on May 22, 1998. The outfall was re-permitted because a portion of Raffinate Pit 4 was remediated upstream of the outfall and storm water from the area flows to Outfall NP-0004. There was no immediate flow from the outfall after permitting because remediation was not yet complete. Some contaminants were elevated in initial discharges because the area was not yet adequately stabilized and vegetated. These initial discharges skewed the annual averages to higher levels than they otherwise would have been. After vegetation was established contaminant levels were greatly reduced.

The annual average uranium concentration at Outfall NP-0005 for 1998 was 10.0 pCi/l (0.37 Bq/l), which was much less than the 1997 average of 18.9 pCi/l (0.70 Bq/l). In addition,

radium and thorium concentrations were below baseline values. Annual average NPDES results are shown in Table 7-3 and baseline values are discussed in Section 11.2.

Outfall NP-0010 was added to NPDES Permit MO-0107701 when it was reissued on March 4, 1994. This outfall is located near the west end of the north perimeter fence in the construction material staging area (CMSA), and drains a portion of the CMSA. The CMSA is used to store clean soil, gravel, and other construction material. Contaminated soil was removed and the CMSA was completed early in 1996. The annual average uranium concentration for 1998 was 10.7 pCi/l (0.37 Bq/l), well below the DCG of 600 pCi/l (22.2 Bq/l) and slightly higher than the 1997 average of 2.7 pCi/l (0.10 Bq/l). The slight increase may be attributed to the use of an area in the watershed for cell vehicle parking and maintenance. Radium and thorium were not suspected, and therefore, were not measured at NP-0010. The annual average NPDES results are reported in Table 7-3.

Table 7-7 Ash Pond, Sedimentation Basin 1 and Diversion Channel - 1998 Annual Average Radiological Concentrations (pCi/l)

LOCATION PARAMETER	ASH POND SW-2010	SED. BASIN 1 SW-2016	DIVERSION CHANNEL SW-2017
Ra-226	1.0	NS	NS
Ra-228	1.5	NS	NS
Th-228	0.7	NS	NS
Th-230	1.3	NS	NS
Th-232	0.3	NS	NS
U	464	5.5	68.5
Gross alpha	398	NS	NS
Gross beta	87	NS	NS

NS Not Sampled.

Ash Pond (SW-2010) was sampled quarterly, when water was flowing, for gross alpha, uranium, Ra-226, Ra-228, Th-228, Th-230, and Th-232 to monitor the effects of demolition debris and soil stored in Ash Pond on Ash Pond runoff and subsequently, on the downstream outfall, NP-0003. The pond was also monitored for uranium when the monthly NPDES sample was collected at Outfall NP-0003. The uranium average (based on the quarterly sampling) at Ash Pond was 464 pCi/l (17.2 Bq/l), slightly less than the 1997 average of 484 pCi/l (17.9 Bq/l) and below the DCG of 600 pCi/l (22.2 Bq/l). Several samples were collected at the outlet pipe while the Ash Pond valve was closed. Those results were high because seepage into the pipe between Ash Pond and Sedimentation Basin 4 is usually low in volume but high in concentration. Water was not being released from Ash Pond at the time the samples were collected. These values caused the average to be higher than it might have been. Radium and thorium were measurable, but at levels well below the DCG. Table 7-7 contains the annual average radiological concentrations for location SW-2010.

Frog Pond was not an upstream monitoring location during 1998 because it was not a significant source of water to Outfall NP-0002. Frog Pond was removed and the area remediated during August 1998. The outlet of Sedimentation Basin 1 (SW-2019) was monitored. Sedimentation Basin 1 discharges to the channel that leads to Outfall NP-0002 and made up most of the flow at NP-0002 before Frog Pond was remediated. After remediation, most flow bypassed Sedimentation Basin 1 and went directly to Outfall NP-0002. The sedimentation basin effluent was monitored to determine the contribution of the watershed flowing to the basin to NP-0002 uranium levels. The annual average for uranium was 5.5 pCi/l (0.2 Bq/l), which is below the NP-0002 average of 22 pCi/l (0.8 Bq/l). Table 7-7 contains the annual average radiological concentrations.

#### 7.6.1.2 Physical and Chemical Results

Analytical results for physical and chemical (as opposed to radiochemical) parameters at NPDES outfalls and other sample locations are presented in Subsections 7.6.1.2.1 through 7.6.1.2.4.

##### 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, and NP-1005 are shown in Table 7-3. In addition to the permitted parameters, arsenic, chromium, lead, and thallium were periodically monitored at some outfalls. Some parameters were periodically present above baseline levels (see Section 11.1.3). There were also instances of metals that do not have permit limits but were above the 100 µg/l reporting levels for toxic pollutants. These were chromium for one sample at NP-0003; and arsenic, chromium, lead, copper, nickel, and zinc for one sample at NP-0004. There were also two samples at Outfall NP-0004 that were above permitted limits. One sample was above the limit for pH and the other for settleable solids (SS).

The initial discharges from NP-0004 occurred before the watershed was stabilized and solids were high in the effluent. This caused high solids and metals levels which skewed the annual averages to a higher level than they otherwise would have been. The above limit pH was the result of concrete wash water discharged to the watershed.

Ash Pond (SW-2010) was sampled quarterly for polycyclic (or polynuclear) aromatic hydrocarbons (PAH), As, Cr, Pb, Tl, PCBs, 2,4-Dinitrotoluene (DNT), and 2,4,6-Trinitrotoluene (TNT) to monitor the effect of demolition debris and soils in Ash Pond on contaminants in the Ash Pond storm water runoff. Nitrate (as N) was also monitored. Had contaminant concentrations appeared to be increasing, monitoring frequencies would have been increased. If increased monitoring were to indicate that Ash Pond water would cause contaminant levels at Outfall NP-0003 to exceed permit limits or reporting levels, a valve in the Ash Pond discharge structure would be closed and the water retained. Analytical results are shown in Table 7-8.

The chipped wood storage area pond (SW-2018) was sampled, and results received, before each discharge from the pond. All parameters were in compliance with the permitted limits. The results are not tabulated because they were all within permitted limits. Outfall NP-0003 results also reflect the contribution from the chipped wood storage area basin.

Table 7-8 Ash Pond - 1998 Annual Average Chemical Concentrations ( $\mu\text{g/l}$ )

PARAMETER	LOCATION
	ASH POND (SW-2010)
PAHs	2.6*
As	3.9
Cr	11.0
Tl	2.3
Pb	9.6
PCBs	0.43**
2,4-DNT	0.05*
2,4,6-TNT	0.05*
Nitrate (as N)	3.3 mg/l

NS Not sampled

\* All non-detect or at the detection limit.

\*\* All non-detect. D.L. for one parameter was 2.1, all others were <1.0.

#### 7.6.1.2.2 Administration Building Sewage Treatment Plant

Monitoring results for the sewage treatment plant Outfall NP-0006 are given in Table 7-9. For the second and third quarters, fecal coliform was out of compliance due to plant upsets. In each instance, the initial compliance sample disclosed the upset and subsequent samples collected demonstrated compliance after the plant was brought into proper operation. All other parameters were in compliance during the year.

#### 7.6.1.2.3 Site and Quarry Water Treatment Plant Physical and Chemical Parameters

Physical and chemical parameters were all within permitted limits (where limits were assigned) for the site and quarry water treatment plants. Since treatment plant effluent is not discharged if parameter levels are above permitted limits, the parameter levels are not summarized here.

During 1998, WET tests were required quarterly for both the site and quarry water treatment plant effluent. Because the quarry water treatment plant was not in operation for two quarters during the year, there are only two sample results. 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 effluent samples failed the WET tests during 1998, indicating that the site and quarry water

treatment plant effluents did not cause the receiving stream to be toxic to test organisms (see Table 7-2). Whole effluent toxicity test results are summarized in Table 7-10.

Table 7-9 NP-0006, Sewage Treatment Plant Outfall, Monthly Averages of Permitted Parameters

MONTH (QUARTER)	PARAMETER(a) (PERMIT LIMITS)			
	TSS (30/45 mg/l)*	BOD (30/45 mg/l)*	FC(b) (400/1000 col/100 ml)**	pH (6.0-9.0 SU)
January(1)	9.0	<2	<1	(c)
April(2)	8.0	3.1	***	(c)
May(2)	-	-	18	-
July(3)	6.0	<5	1,200	(c)
August(3)	-	-	<10	-
October(4)	25.0	<5	3,900	(c)
November(4)	-	-	<1	-

(a) One sample analysis required for each calendar quarter.

(b) F.C - fecal coliform.

(c) pH values were between 6.0 and 9.0.

\* Monthly average/weekly average.

\*\* Monthly average/daily maximum

\*\*\* Not sampled for June because laboratory was not under contract.

Table 7-10 1998 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
S104	01/05/98	0	2.5	0.0	0.0
S112	03/30/98	0	5	0.0	0.0
S124	07/13/98	0	0	0.0	0.0
S137	10/12/98	0	0	0.0	0.0
Q051	01/22/98	0	0	0.0	0.0
Q052	05/08/98	0	0	0.5	0.0

S Site

Q Quarry

P Pimephales

D Daphnia (Ceriodaphnia)

\* Each test is on four replicates of 10 organisms. % mortality is based on 40 organisms.

#### 7.6.1.2.4 Hydrostatic Test Water Results

NPDES permit MO-G670203 was issued on December 5, 1997, for the discharge of hydrostatic test water. The permit requires that a sample be collected during the first 60 minutes of each discharge. The permit requires that flow, total petroleum hydrocarbons (TPH), TSS and pH be monitored. There is a daily maximum and monthly average for TSS and TPH; however, the monthly average and daily maximum are the same. The limit for TPH is 10 mg/l and for TSS 100 mg/l. The pH is limited to a range of 6.0 to 9.0. The discharge monitoring report is required

to be submitted annually with the first report due October 28, 1998, for the period October 1, 1997, to September 31, 1998. During 1998, there were 18 discharges of hydrostatic test water. Three samples had at least one parameter that was reported above the permit limit. TSS was above the limit in the three batches and one of the batches was slightly above the limits for pH. The TSS elevated levels were determined to result from a sump that the hydrostatic test water was pumped from. The pump also accommodated storm water runoff, but the storm water was removed before the hydrostatic test water was drained to the sump. The sump had a rock bottom that allowed sediments to accumulate from the storm water runoff and then be pumped out with the hydrostatic test water. The elevated pH is suspected to be the result of the potable water used for testing being above 9.0. The use of the sump was discontinued and TSS results were subsequently in compliance. Hydrostatic results are not tabulated because each discharge is from a different piece of equipment and all samples, except those instances noted above, were in compliance with permitted limits.

#### 7.6.1.2.5 Borrow Area Land Disturbance Results

NPDES permit MO-R100B69 was reissued on May 29, 1998, and has no specified monitoring or reporting requirements. The 1998 *Environmental Monitoring Plan* (Ref. 8), 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. Oil and grease were not sampled during 1998 because there was no evidence of a problem or potential problem. Settleable solids results are shown in Table 7-11. Except for two instances, settleable solids were less than 1.0 ml/l/hr, which is the standard permit limit when limits are set. One result was above the 2.5 ml/l/hr reporting level (Ref. 8) and was reported in the quarterly discharge monitoring report. Another result was below the 2.5 ml/l/hr reporting level but above 1.0 ml/l/hr.

#### 7.6.2 Surface Water Monitoring Results

Analytical results for surface water monitoring locations at the chemical plant site and quarry are presented in Subsections 7.6.2.1 and 7.6.2.2.

Table 7-11 Borrow Area Settleable Solids (ml/l/hr)

DATE	LOCATIONS	
	NP-0040*	NP-0046**
04/03/98	<0.1	No flow
06/04/98	<0.1	<0.1
07/30/98	4.0	2.0
08/17/98	<0.1	<0.1
10/29/98	<0.1	<0.1

\* North Borrow Area sedimentation basin.

\*\* East Borrow Area sedimentation basin.

### 7.6.2.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits

Average uranium levels at off-site surface water locations were slightly lower than the 1997 annual averages at two locations, slightly higher at four locations, and appreciably higher at one location. Average annual uranium concentrations for surface water are shown in Table 7-12, along with the 1997 figures and the historic high for the location for comparison. Surface water locations are shown in Figure 7-1. Overall, the uranium levels at the downstream sampling locations, except for location SW-2005, have remained in the range of the 1997 results. Location SW-2002 is at the inlet of Lake 36 and is downstream of Outfall NP-0002. The increase of the 1998 results, compared to the 1997 results, is believed to be due to three factors. The location is just downstream of a small area that was discovered to be contaminated and is scheduled for remediation; several of the samples were collected during extremely low flows, which could have resulted in the water having long contact with the contaminated area; and Lake 36 had been drained and there would be no water backing up from the lake to provide dilution. The Outfall NP-0002 average for 1998 was 22.4 pCi/l (0.829 Bq), which indicates that the site did not directly contribute to the elevated levels.

Table 7-12 Annual Averages for Total Uranium (pCi/l) Concentrations at Weldon Spring Chemical Plant Area Surface Water Locations\*

LOCATION	AVERAGE	MAXIMUM	MINIMUM	HISTORIC HIGH
SW-2001	1.5 (2.4)	1.5 (3.4)	1.1 (1.6)	10 (1993)
SW-2002**	55.5 (8.2)	123.7 (11.4)	14.1 (5.4)	390 (1994)
SW-2003	8.8 (6.7)	11.9 (10.4)	6.6 (3.9)	69 (1988)
SW-2004	10.8 (10.0)	13.6 (11.2)	7.9 (8.2)	39 (1989)
SW-2005**	21.8 (13.3)	42.3 (18.7)	0.8 (8.8)	53.7 (1996)
SW-2012	7.8 (6.3)	8.6 (9.5)	6.0 (3.6)	326 (1991)
SW-2016	1.5 (2.2)	1.6 (3.0)	0.9 (1.1)	7.8 (1994)

\* 1997 results are given in parentheses.

\*\* Lake 36 was empty for all or part of 1998. Samples collected of water flowing in and out.

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

Note 2: Four samples were collected from each location during the year.

### 7.6.2.2 Weldon Spring Quarry

#### Total Uranium.

The average total uranium values continue to indicate that the highest levels are found in the portion of the Femme Osage Slough (SW-1003, SW-1004 SW-1005 and SW-1010) down-gradient of the quarry. The annual averages for the surface water locations are summarized in Table 7-13. The uranium levels in the Femme Osage Slough are within historical ranges. No new historic total uranium high concentrations were reported for quarry surface water during 1998.

Table 7-13 Annual Averages for Total Uranium (pCi/l) at Weldon Spring Quarry Surface Water Monitoring Locations\*

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM	HISTORIC HIGH
SW-1003	29.76 (30.27)	32.55 (42.29)	25.88 (21.10)	252 (1989)
SW-1004	43.68 (28.44)	63.35 (55.81)	28.43 (23.34)	4,000 (1993)
SW-1005	22.98 (23.87)	29.65 (29.80)	13.77 (18.52)	118 (1991)
SW-1007	10.88 (5.84)	14.97 (7.78)	7.56 (4.11)	69 (1992)
SW-1009	9.91 (4.37)	14.16 (8.41)	5.13 (3.34)	28.6 (1991)
SW-1010	26.92 (19.83)	28.46 (21.20)	25.38 (19.07)	156 (1991)

\* 1997 results given in parentheses

Note: 1 pCi/l = 0.037 Bq/l

### Nitroaromatic Compounds

Nitroaromatic compounds were analyzed at SW-1003, SW-1004, and SW-1005 in the Femme Osage Slough. No detectable levels were observed for any of the six compounds monitored during 1998. Nitroaromatics will not be monitored at these locations for the 1999 Environmental Monitoring Plan (EMP).

## 8. GROUNDWATER MONITORING

### 8.1 Highlights of the Groundwater Monitoring Program

The following are highlights of the 1998 groundwater monitoring program. These items, and others, are discussed in detail in this chapter.

- With exception of the Ash Pond vicinity, contaminant levels generally remained within historic ranges at all chemical plant locations.
- Groundwater detection monitoring for the disposal cell was initiated in June 1998.
- Raffinate pit area enhanced monitoring indicated slightly increased nitrate concentrations in groundwater at six monitoring locations resulting from raffinate pit remedial action. Nitrate concentrations decreased at three locations. No other impacts were detected.
- New historic uranium high concentrations were recorded in groundwater monitoring locations in the vicinity of Ash Pond. These may be attributable to recent remedial action in Ash Pond. An enhanced monitoring schedule will be implemented in these locations in 1999.
- Statistical evaluations of total uranium concentrations near the raffinate pits suggest no upward trends attributable to remedial action efforts.
- Monitoring results for Burgermeister Spring were within historical ranges. No new highs or lows were recorded, and no significant changes are apparent.
- Volatile organic compounds (VOC) trichloroethene and dichloroethene detected in groundwater in 1996 at the chemical plant continued to be under investigation during 1998 to determine the extent of contamination. The VOC concentrations decreased in monitor wells nearest the raffinate pits and were essentially constant at locations south of the pits. A groundwater pumping test was conducted to determine feasibility of remediation options.
- With the exception of MW-1031 (for uranium) nitroaromatic compounds and total uranium concentrations in groundwater continued to decrease at locations previously described as having downward trends at the quarry.
- Samples from quarry rim wells in 1998 averaged greater than 10% lower uranium concentrations than in 1997 for locations that were historically high, with the

exception of MW-1031. Locations with historic low uranium concentrations showed apparent increases in 1998. This suggests that groundwater continues to equilibrate in response to bulk waste removal.

- Data for 1998 indicated that the level of nitroaromatic compounds continues to decrease in the groundwater at the quarry as a result of bulk waste removal. Average reductions of 40% of trinitrotoluene (TNT) and 18% of dinitrotoluene (DNT) were recorded for quarry rim wells from 1997 to 1998. Statistical analysis of the data indicates continued downward trends at most monitoring locations.
- Environmental monitoring indicated that the greatest amount of radiochemical and nitroaromatic contamination in the groundwater is present in the bedrock of the quarry rim and the alluvial materials and bedrock north of the Femme Osage Slough. Overall concentration decreases in these parameters occurred during 1998.
- South of the slough and in the St. Charles County production wells, total uranium concentrations in groundwater remained within background ranges, and no detectable concentrations of nitroaromatic compounds were identified.

## 8.2 Program Overview

The groundwater monitoring and protection program at the Weldon Spring Site Remedial Action Project (WSSRAP) includes sampling and analysis of water collected from wells at the Weldon Spring Chemical Plant and raffinate pits, the Weldon Spring Quarry, vicinity properties, and from selected springs in the vicinity of the Weldon Spring site. The groundwater protection program is formally defined in the *Groundwater Protection Program Management Plan* (Ref. 15). The groundwater monitoring portion of the program is detailed in the *Environmental Monitoring Plan* (EMP) (Ref. 8).

Due to lithologic differences, including those 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 the two sites. Generalized geologic and hydrologic descriptions of the two sites are found in Section 1.3. A generalized stratigraphic column for reference is provided in Figure 8-1, and hydrogeologic descriptions of lithologies monitored for the program are in Section 8.4.

## 8.3 Referenced Standards

Two criteria 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. 35), which is intended to protect public groundwater resources, and (2) the Missouri Drinking Water

SYSTEM	SERIES	STRATIGRAPHIC UNIT	TYPICAL THICKNESS (FT.) (1)	LITHOLOGY	PHYSICAL CHARACTERISTICS	HYDROSTRATIGRAPHIC 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 BEDDING FROM WEATHERED BEDROCK.	(UNSATURATED) (2)
MISSISSIPPIAN	MERAMECIAN	SALEM FORMATION (3)	0 - 15		LIMESTONE, LIMY DOLOMITE, FINELY TO COARSELY CRYSTALLINE, MASSIVELY BEDDED, AND THIN BEDDED SHALE.	SHALLOW AQUIFER SYSTEM
		WARSAW FORMATION (3)	60 - 80		SHALE AND THIN TO MEDIUM BEDDED FINELY CRYSTALLINE LIMESTONE WITH INTERBEDDED CHERT.	
	OSAGEAN	BURLINGTON AND REOKUR LIMESTONES	100 - 200		CHERT LIMESTONE, VERY FINE TO VERY COARSELY CRYSTALLINE, FOSSILIFEROUS, THICKLY BEDDED TO MASSIVE.	UPPER LEAKY CONFINING UNIT
		FERN GLEN LIMESTONE	45 - 70		CHERT LIMESTONE, DOLOMITIC IN PART, VERY FINE TO VERY COARSELY CRYSTALLINE, MEDIUM TO THICKLY BEDDED.	
		CHOUTEAU LIMESTONE	20 - 60		DOLOMITIC, ARGILLACEOUS LIMESTONE, FINELY CRYSTALLINE, THIN TO MEDIUM BEDDED.	
DEVONIAN	UPPER	SULPHUR SPRINGS GROUP (4)	40 - 55		QUARTZ ABERNETHY, FINE TO MEDIUM GRAINED, FRIABLE.	MIDDLE AQUIFER SYSTEM
		LOWER PART OF SULPHUR SPRINGS GROUP (4)	10 - 30		CALCAREOUS SILTSTONE, SANDSTONE, COLTIC LIMESTONE, AND HARD CARBONACEOUS SHALE.	
DROOVICIAN	CINCINNATIAN	MAQUOKETA SHALE (5)	10 - 30		CALCAREOUS TO DOLOMITIC SILTY SHALE AND MUDSTONE, THINLY LAMINATED TO MASSIVE.	LOWER CONFINING UNIT
		KIMSWICK LIMESTONE	70 - 100		LIMESTONE, COARSELY CRYSTALLINE, MEDIUM TO THICKLY BEDDED, FOSSILIFEROUS AND CHERT NEAR BASE.	
	CHAMPLAINIAN	DEGRAH GROUP	30 - 60		SHALE WITH THIN INTERBEDS OF VERY FINELY CRYSTALLINE LIMESTONE.	DEEP AQUIFER SYSTEM
		PLATTIN LIMESTONE	100 - 130		DOLOMITIC LIMESTONE, VERY FINELY CRYSTALLINE, FOSSILIFEROUS, THINLY BEDDED.	
		JOACHIM DOLOMITE	60 - 105		INTERBEDDED VERY FINELY CRYSTALLINE, THINLY BEDDED DOLOMITIC LIMESTONE, AND SHALE, SANDY AT BASE.	
CAMBRIAN	CANADIAN	ST. PETER SANDSTONE	120 - 150		QUARTZ ABERNETHY, FINE TO MEDIUM GRAINED, MASSIVE.	DEEP AQUIFER SYSTEM
		POWELL DOLOMITE	50 - 60		SANDY DOLOMITE, MEDIUM TO FINELY CRYSTALLINE, WITH CHERT AND SHALE.	
	COTTER DOLOMITE	200 - 250		ARGILLACEOUS, CHERT DOLOMITE, FINE TO MEDIUM CRYSTALLINE, INTERBEDDED WITH SHALE.		
	JEFFERSON CITY DOLOMITE	160 - 180		DOLOMITE, FINE TO MEDIUM CRYSTALLINE.		
	ROUIDOUX FORMATION	150 - 170		DOLOMITIC SANDSTONE.		
EMINENCE DOLOMITE	200		CHERT DOLOMITE AND ARGILLACEOUS DOLOMITE (UNIT MEMBER).			
UPPER	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 REOKUR THROUGH JOACHIM DOLOMITE BASED ON USGS WELLS MW-6502 AND GS-08. ST. PETER SANDSTONE AND BELOW FROM KLEESCHMATE AND EMWELL (REF 54). WARSAW AND SALEM FORMATIONS FROM MISSOURI OUR-DELS GEOLOGIC MAP OF 49-252-61 (REF 53).

(2) GLACIAL DRIFT UNIT SATURATED IN NORTHERN PORTION OF ORDINANCE 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 8-1

REPORT NO. 00E/OR/21548-773 EXHIBIT NO. A/PI/047/0391  
 DATE 5/4/99  
 INITIATOR MET DRAWN BY SRS

Standards (Ref. 36). These standards are mainly used for comparison of levels observed in the St. Charles County well field. Table 8-1 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. The affected groundwater does not represent a public drinking water supply as defined in 40 CFR, Part 141, Subpart A - General.

Table 8-1 Referenced Federal and State Water Standards

PARAMETER		LEVEL	REFERENCE STANDARD	PARAMETER		LEVEL	REFERENCE STANDARD
Radio-chemical	Uranium total(a,c)	20 µg/l (13.6 pCi/l)	EPA	Metals	Fe(d)	300 µg/l	MDWS
	Gross alpha (adjusted) (c)	15 pCi/l	MDWS		Pb(e)	15 µg/l	MDNR
	Ra-226(b,c)	5 pCi/l	MDWS		Mn(d)	50 µg/l	MDWS
	Rn-222(a,c)	300 pCi/l	EPA		Hg(c)	2.0 µg/l	MDWS
Misc.	2,4-DNT(e)	0.11 µg/l	MDNR		Ni(c)	100 µg/l	MDWS
	TDS(d)	500 mg/l	MDWS		Se(c)	50 µg/l	MDWS
Metals	Sb(c)	6.0 µg/l	MDWS		Ag(d)	100 µg/l	MDWS
	As(c)	50 µg/l	MDWS		Zn(d)	5.0 mg/l	MDWS
	Ba(c)	2 mg/l	MDWS	Anions	Cl-(d)	250 mg/l	MDWS
	Be(c)	4.0 µg/l	MDWS		F-(d)	2.0 mg/l	MDWS
	Cd(c)	5 µg/l	MDWS		NO3(c)	10 mg/l	MDWS
	Cr(c)	100 µg/l	MDWS		SO4(d)	250 mg/l	MDWS
	Cu(d)	1.0 mg/l	MDWS				

(a) Proposed.

(b) Standard for combined Ra-226 and Ra-228.

(c) Primary maximum contaminant level.

(d) Secondary maximum contaminant level.

(e) Water Quality Standard for Groundwater.

EPA EPA Drinking Water Standards for Radionuclides.

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 (1.0 mSv) effective dose equivalent, based on the consumption of 730 liters/year (193 gal/year) (Table 8-2). As specified in Department of Energy Order 5400.5, liquid effluent from U.S. Department of Energy (DOE) activities may not cause private or public drinking waters to exceed the radiological limit of an effective dose equivalent greater than 4 mrem (0.04 mSv/year) per year or 4% of the DCG.

Table 8-2 Derived Concentration Guidelines for Discharge Waters

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

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

## 8.4 Weldon Spring Chemical Plant

### 8.4.1 Hydrogeologic Description

The Weldon Spring Chemical Plant is located 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 chemical plant is located on a groundwater divide from which groundwater flows north toward Dardenne Creek and then ultimately to the Mississippi River, or south to the Missouri River. Regional groundwater flow for St. Charles County is towards 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 pit 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 6.1 m to 15.3 m (20 ft to 50 ft) (Ref. 2).

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 underlain 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.

Approximately 100 monitoring wells have been used for groundwater observations and sampling since 1987. Many of these have been deactivated and abandoned. Fifteen wells were abandoned during 1998. Active monitoring was performed in 60 wells in 1998.

All monitoring wells are completed in the Burlington-Keokuk Limestone. Some wells that are screened in the unweathered zone of the Burlington-Keokuk Limestone are used to assess the vertical migration of contaminants. The majority of the wells are completed in the weathered unit of the bedrock where groundwater has the greatest potential for contaminant impact. Where possible, monitoring wells within the boundaries of the chemical plant are located close to 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 8-2).

Upgradient-downgradient water quality comparisons are not practical for the chemical plant site because it straddles the regional groundwater divide (Ref. 37). Background values for uranium, nitrate, and sulfate were developed by the U.S. Geological Survey (USGS) for the shallow aquifer (Ref. 37) and are used in lieu of these comparisons.

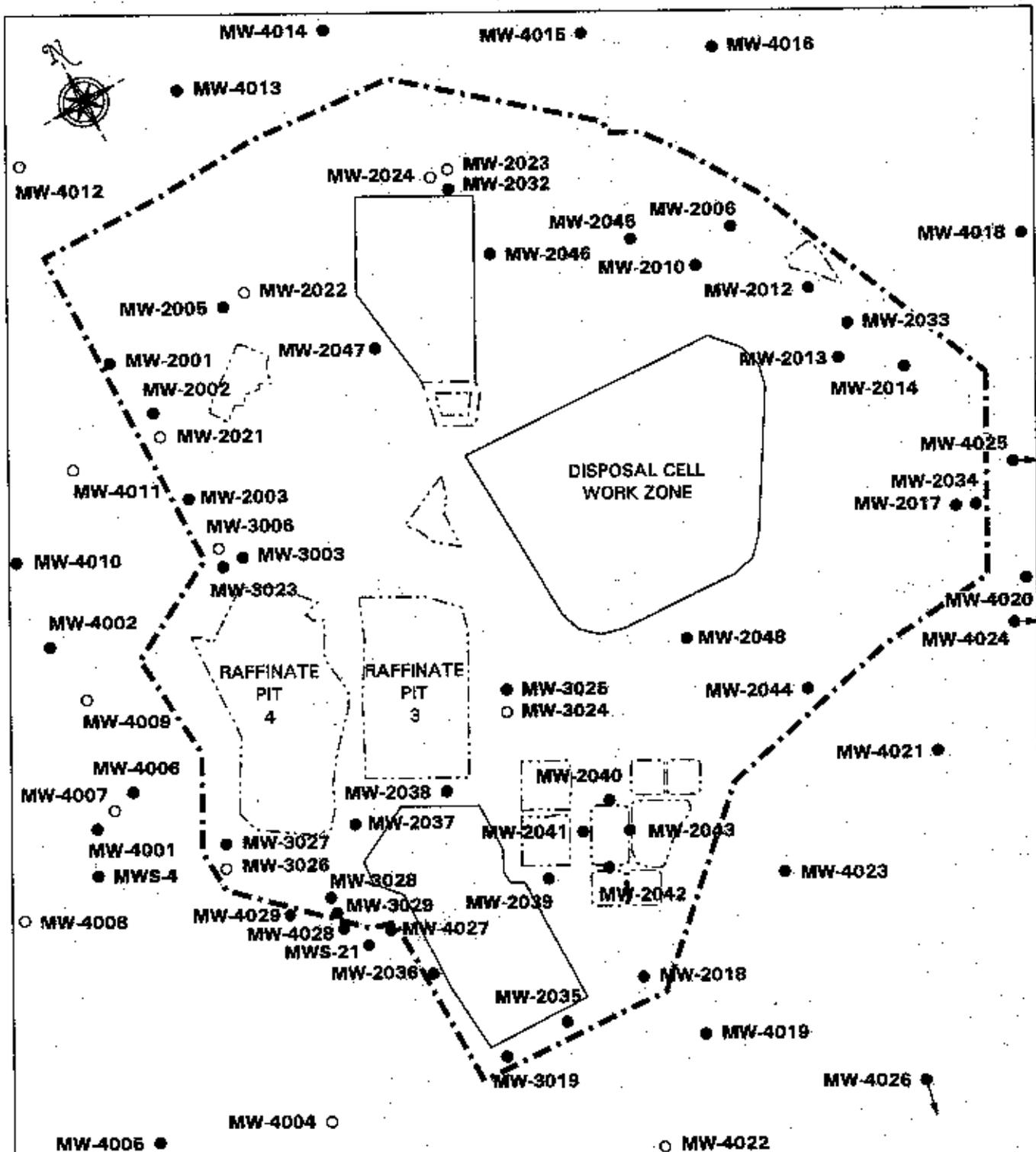
Springs, a common feature in carbonate terrains, are present in the vicinity of the Weldon Spring site. Four springs are known to have been historically influenced by chemical plant discharge water potentially containing one or more of the contaminants of concern (Figure 8-3). Currently, Burgermeister Spring (SP-6301 on Figure 8-3) is monitored to determine contaminant off-site migration potential via spring transport.

The presence of elevated total uranium and nitrate levels at Burgermeister Spring, which is located 1.9 km (1.2 mi) north of the site, indicates that discrete flow paths are present in the vicinity of the site. A groundwater tracer test performed in 1995 (Ref. 54) also indicates that a hydraulic connection between the WSSRAP and Burgermeister Spring exists.

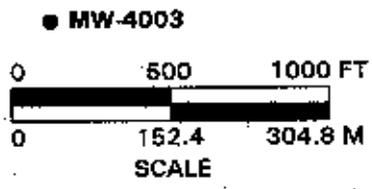
## **8.4.2 Monitoring Program**

### **8.4.2.1 Purpose**

The 1998 groundwater monitoring program at the chemical plant and raffinate pits focused on monitoring known contaminants and determining any groundwater impacts which may result from remedial action (soil excavation and sludge removal) at the site. Total uranium, nitroaromatic compounds, sulfate, volatile organic compounds, and nitrate were monitored annually at selected locations. Total uranium in groundwater was analyzed under the environmental monitoring program at the chemical plant to monitor potential groundwater uranium migration and to further establish baseline uranium concentrations prior to source removal during remedial action. Due to the heterogeneity of uranium distribution in soils across



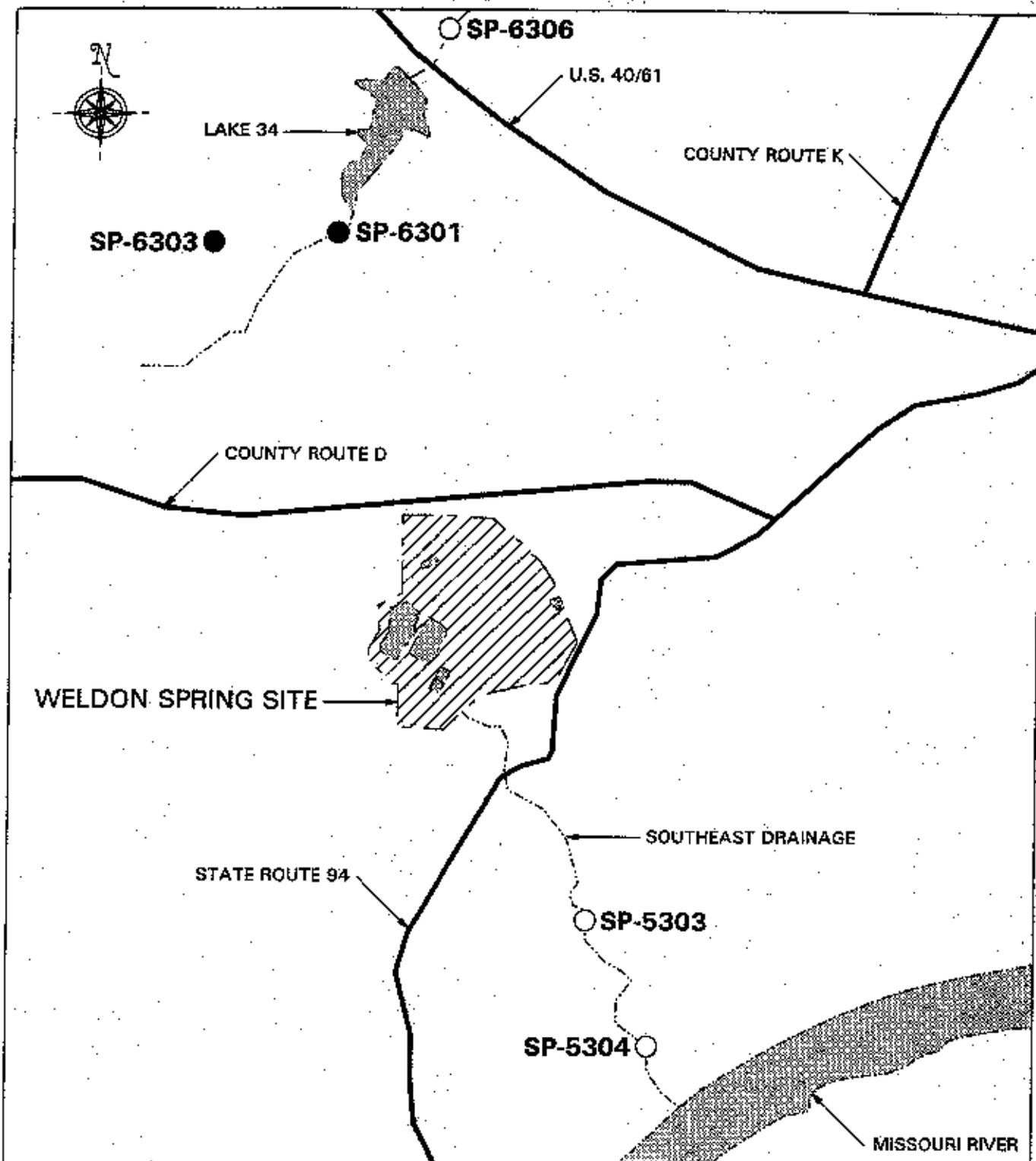
**LEGEND**  
 ● WEATHERED ZONE  
 ○ UNWEATHERED ZONE



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

**FIGURE 8-2**

REPORT NO.:	DOE/OR/21548-773	EXHIBIT NO.:	A/CP/077/1295
ORIGINATOR:	MT	DRAWN BY:	GLN
		DATE:	6/21/99



**LEGEND**

- - SPRING SAMPLE LOCATION
- - OTHER SAMPLE LOCATION

NOT TO SCALE

**SPRING MONITORING LOCATIONS IN THE WELDON SPRING SITE AREA**

**FIGURE 8-3**

REPORT NO.:	DOE/OR/21548-773	EXHIBIT NO.:	A/VP/080/1193
ORIGINATOR:	MGL	DRAWN BY:	GLN
		DATE:	5/3/99

the site, all active locations in the chemical plant groundwater monitoring network were analyzed for total uranium. Analytical results for all monitored parameters are summarized and discussed in Section 8.4.3.

Groundwater in the vicinity of the raffinate pits is impacted with elevated nitrate concentrations. The pits contain ore-refining impurities from uranium ore concentrates that were digested with nitric acid. Some of the wastes generated and disposed of as raffinate contained isotopes of thorium and radium. Therefore, groundwater samples from selected locations near the raffinate pits have historically been analyzed for nitrate, thorium, and radium isotopes, and total uranium. Enhanced monitoring (initiated during 1997) designed to detect any groundwater contaminant impact resulting from raffinate pit remediation efforts continued through 1998. The enhanced program included bi-monthly monitoring for nitrate, sulfate, metals, and radiological parameters at 11 locations in the vicinity of the raffinate pits.

Prior to construction of the chemical plant, the site was part of a Department of Army Ordnance Works complex developed for the production of the nitroaromatic compounds TNT and DNT for explosives. 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 are known (from previous sampling) to be impacted with nitroaromatics. Those locations, which were previously determined to have detectable concentrations of nitroaromatics in groundwater, were sampled and analyzed for these compounds in 1998.

The volatile organic compound (VOC) trichloroethene (TCE) was detected in groundwater south and east of Raffinate Pits 3 and 4 during 1996. VOC monitoring was scheduled for monthly monitoring during 1998 to determine lateral and vertical extents of the TCE and to assess the mobility of the contaminant. Unscheduled VOC monitoring was conducted at many locations during a groundwater pumping test in 1998.

Groundwater moves by both diffuse and discrete flow components under the chemical plant. In order to monitor the discrete flow component, Burgermeister Spring and two springs in the Southeast Drainage were monitored during 1998 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.

### 8.4.2.2 Scope

All monitoring wells (except those completed in the unweathered zone) were sampled annually and analyzed for total uranium. Monitoring wells around the raffinate pits were also analyzed annually for Ra-226, Ra-228, Th-228, Th-230, Th-232, and nitrate. Nitroaromatics were analyzed in groundwater from locations that have historically shown detectable concentrations of these compounds. A summary of monitoring locations and analytes may be found in the 1998 *Environmental Monitoring Plan* (EMP) (Ref. 8).

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. Unscheduled groundwater sampling was initiated in support of the pumping tests in the TCE contaminated groundwater area during 1998.

Burgermeister Spring (SP-6301) was monitored quarterly for metals, nitrate, sulfate, and geochemical constituents. The spring was monitored at low flow to measure the groundwater component of spring discharge. It was sampled twice at high flow for uranium, nitrate, and sulfate to evaluate the differences between low flow and high flow. Volatile organic compounds were monitored monthly at SP-5303, SP-5304, and SP-6303 during 1998.

## 8.4.3 Chemical Plant and Raffinate Pit Monitoring Results

### 8.4.3.1 Groundwater Monitoring Wells

In 1998, the measured concentrations for uranium, nitrate, sulfate, and nitroaromatic compounds generally remained within historical ranges at all monitoring wells and springs in the chemical plant area. Volatile organic compounds which were first detected during 1996 in groundwater in the vicinity of the raffinate pits were monitored throughout 1998.

Data for all parameters analyzed during the 1998 monitoring period are presented in the *Quarterly Environmental Data Summaries*. The monitoring data for contaminants of concern (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. Data values are presented as reported by the analytical laboratories. Comparisons to drinking water standards are not intended to imply that groundwater from WSSRAP monitoring wells must be in compliance with drinking water standards.

**Radiochemical Parameters.** Total uranium, which is measured at all monitoring wells, continues to impact groundwater near the raffinate pits. In 1998, groundwater from 30 monitoring well locations exceeded the average background level of 2.9 pCi/l (0.11 Bq/l) as calculated by the USGS (Ref. 37). These values can be found in Table 8-3. A new historic high

for uranium was recorded during 1998 at MW-3024 (54.9 pCi/l or 2.03 Bq/l). Monitoring well MW-3024 was damaged in early 1997 and restoration of this well included drilling out the casing and screen to facilitate installation of new well construction materials. Elevated uranium values above the proposed MCL standard have been detected in this location since the well repair completion. It is possible that the seal above the well screen was not properly set. Further investigation of MW-3024 may be implemented in 1999.

New historic uranium high values were reported for 10 additional locations. These are located within the northern one-third of the chemical plant and along the northern bordering properties. Five of these locations (MW-2001, MW-2003, MW-2005, MW-2021, MW-4013) are in the vicinity of, or downgradient from, Ash Pond. One additional location (MW-2002) near Ash Pond was reported with a 5-year high concentration. The elevated uranium values may be attributable to remediation efforts in the area.

An enhanced groundwater monitoring schedule for total uranium will be implemented during 1999 to further assess the potential groundwater impacts from Ash Pond area remedial action. Statistical trending will be performed on selected sets of data from monitoring wells in the Ash Pond area for the 1999 annual site environmental report.

Table 8-3 Annual Total Uranium Activities (pCi/l) Above Background at the Weldon Spring Chemical Plant

LOCATION	AVERAGE (pCi/l)	LOCATION	AVERAGE (pCi/l)	LOCATION	AVERAGE (pCi/l)
MW-2017	11.80	MW-2033	6.16*	MW-4021	6.27
MW-3003	18.85	MW-3023	9.57	MW-4010	3.48
MW-4011	8.42	MW-3024	54.9	MW-4022	6.84
MW-4020	20.3	MW-3026	6.33	MW-4024	9.40
MW-2001	7.48*	MW-2012	4.36*	MW-2042	4.01
MW-4018	5.35*	MW-2002	3.25	MW-2014	9.72
MW-4013	5.14*	MW-4023	9.48	MW-2003	5.97*
MW-2021	5.70*	MW-4015	3.20	MW-4025	3.59
MW-2005	6.80*	MW-2034	4.98	MW-4016	7.34*
MW-2006	4.53*	MW-2041	4.91	MW-4018	6.15*

Note 1: Background uranium concentration equals 2.9 pCi/l.

Note 2: 1 pCi/l = 0.037 Bq/l.

\* New historic high value.

The other radiological parameters (Ra-226, Ra-228, isotopic thorium, gross alpha, and gross beta) that are measured annually in the raffinate pit wells (MW-3000 series and MW-2044) were within historic values. These annual averages can be found in Table 8-4. Total uranium trends for nine locations are discussed in Section 8.4.4.

New three-year maximum uranium concentrations were reported at locations MW-3003, MW-3023, MW-3026, MW-3027, MW-4001, and MW-4002. The elevated levels are likely due

to raffinate pit and Ash Pond remediation. Data from these raffinate pit area locations were statistically evaluated. No upward trends are suggested.

Table 8-4 Annual Radiological Isotope Activities (pCi/l) at the Weldon Spring Chemical Plant

LOCATION	Ra-226 (pCi/l)	Ra-228 (pCi/l)	Th-228 (pCi/l)	Th-230 (pCi/l)	Th-232 (pCi/l)	GROSS ALPHA (pCi/l)	GROSS BETA (pCi/l)
MW-2035	0.13	0.31	<0.10	<0.10	<0.10	NA	NA
MW-2036	0.27	<0.1	<0.10	<0.10	<0.10	NA	NA
MW-2037	0.20	0.70	<0.15	0.40	0.10	NA	NA
MW-2038	1.20	1.70	0.20	0.30	0.20	NA	NA
MW-2039	0.50	0.50	0.10	<0.10	0.20	NA	NA
MW-2040	0.10	0.30	0.10	<0.10	<0.10	NA	NA
MW-2041	0.55	0.29	<0.18	<0.10	<0.10	NA	NA
MW-2042	0.21	0.23	<0.10	<0.15	<0.10	NA	NA
MW-2043	<0.10	0.42	<0.10	<0.12	<0.10	NA	NA
MW-2032	0.30	0.39	<0.10	0.24	<0.10	NA	NA
MW-2045	0.15	0.51	<0.10	0.17	<0.10	NA	NA
MW-2046	0.22	0.53	<0.10	0.22	<0.10	NA	NA
MW-2047	0.44	0.44	0.10	0.16	<0.10	NA	NA
MW-2048	0.11	0.26	<0.10	<0.10	<0.10	NA	NA
MW-3003	0.30	<0.10	0.10	0.30	0.20	NA	NA
MW-3019	0.87	0.71	<0.10	0.15	<0.10	1.93	7.94
MW-3023	<0.10	0.20	0.20	<0.10	0.10	NA	NA
MW-3024	0.76	0.82	0.21	0.12	<0.10	32.8	18.9
MW-3025	0.16	0.44	<0.10	0.11	<0.10	2.85	15.2
MW-3026	1.44	1.21	2.72	4.92	2.85	10.8	20.9
MW-3027	0.50	0.60	0.30	<0.10	0.30	NA	NA

NA Not Analyzed.

**Nitrate and Sulfate.** In 1998, nitrate and sulfate were measured at 24 monitoring wells in the chemical plant area that previously exceeded the reference levels. Nitrate levels exceeded the drinking water standard (10 mg/l) at 21 of those locations (Table 8-5). Average sulfate levels exceeded background (32 mg/l) at five locations. None of these were above the secondary water quality standard (250 mg/l) (Table 8-6).

The 1998 nitrate data indicate statistically significant increases in nitrate levels for six monitored locations (MW-2002, MW-2003, MW-2005, MW-3003, MW-3023 and MW-4011) north of Raffinate Pits 3 and 4 since 1997. Three locations south and east of the raffinate pits (MW-2037, MW-3024, MW-3025) decreased in nitrate average concentrations during 1998. Increases are likely due to soil disturbances during remediation of Raffinate Pit 4. Nitrate is included in the raffinate pit area enhanced monitoring program.

Table 8-5 Annual Values of Nitrate (mg/l) Levels Exceeding Drinking Water Quality Standard at the Weldon Spring Chemical Plant

LOCATION	AVERAGE	LOCATION	AVERAGE	LOCATION	AVERAGE
MW-2001	80.5	MW-2002	91.2	MW-2003	384
MW-2005	162	MW-2032	15.3	MW-2037	297
MW-2038	861	MW-2039	77.4	MW-2040	149
MW-2041	133	MW-4001	47.3	MW-3025	307
MW-3003	376	MW-3023	217	MW-3024	298
MW-3026	170	MW-3027	37.2	MW-4011	284
MW-4006	21.4	MW-3028	277	MW-2047	98.2

Note 1: Drinking water quality standard equals 10 mg/l.

Table 8-6 Annual Values of Sulfate (mg/l) Above Background at the Weldon Spring Chemical Plant

LOCATION	AVERAGE	LOCATION	AVERAGE	LOCATION	AVERAGE
MW-2037	117	MW-2038	80.7	MW-2041	33.0
		MW-2046	51.4	MW-2048	220

Note 1: Background sulfate concentration equals 32 mg/l.

Nitrate trending was not considered necessary for 1998 data, but was performed for selected locations for 1997. The groundwater results are not trended annually for the chemical plant because, at most monitoring locations, sampling frequency has been decreased (annual) to a level that cannot justify frequent trending.

Sulfate monitoring was reduced during 1998. Sulfate analytical results show no significant (>5%) increases at any of the monitored locations during 1998. Sulfate monitoring will be discontinued at the chemical plant because no groundwater impacts have been observed.

**Nitroaromatic Compounds.** Nitroaromatic compounds, which are not naturally occurring compounds, were detected in 27 monitoring wells (Table 8-7). No new highs were recorded during 1998, and with the exception at MW-2012, values were within the normal range of variation for all locations. Increases at MW-2012, which were significant in 1997, were not observed at this location during 1998.

The drinking water standard for 2,4-DNT of 0.11 µg/l was equaled or exceeded in 13 locations at the chemical plant (see Table 8-7), the majority of which are in the northern one-third of the site or along the western perimeter. Elevated nitroaromatics in groundwater underlying the northern portion of the site are most likely attributable to a wastewater impoundment which was located along the northern site perimeter during the early active production of TNT and DNT during the 1940s.

Table 8-7 Annual 1998 Averages for Monitoring Locations with at Least One Detectable Concentration of Nitroaromatic Compounds ( $\mu\text{g/l}$ ) at the Weldon Spring Chemical Plant

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-2001	0.062	<0.090	<0.030	0.073	0.062	<0.030
MW-2002	<0.030	<0.090	<0.030	0.046	0.28	<0.030
MW-2003	<0.030	<0.090	<0.030	0.080	0.46	<0.030
MW-2005	0.041	<0.090	<0.030	0.044	0.11	<0.030
MW-2006	6.90	(0.078)	<0.030	0.10	1.30	0.030
MW-2012	7.2	<0.090	25.0	1.50	8.70	<0.030
MW-2013	4.3	<0.090	0.54	0.15	2.00	<0.030
MW-2014	2.8	(0.071)	<0.030	0.16	0.45	<0.030
MW-2032	0.05	<0.090	0.15	0.05	0.15	<0.030
MW-2033	1.60	<0.090	0.64	0.12	1.50	<0.030
MW-2037	0.09	(0.05)	<0.030	0.44	0.07	<0.030
MW-2038	0.13	(0.05)	<0.030	0.95	0.18	0.05
MW-2043	<0.030	<0.090	<0.030	0.08	<0.010	<0.030
MW-2045	0.03	0.16	<0.030	0.13	0.76	<0.030
MW-2046	3.16	(0.05)	2.88	0.18	12.06	<0.030
MW-2047	<0.030	<0.090	<0.030	0.36	0.81	<0.030
MW-3003	<0.030	<0.090	<0.030	0.13	0.19	<0.040
MW-3023	<0.030	<0.090	<0.060	0.70	2.30	<0.040
MW-3025	<0.030	<0.090	<0.030	0.10	0.21	<0.040
MW-3028	0.095	<0.090	<0.030	0.10	0.06	<0.040
MW-3027	0.077	<0.090	<0.030	0.04	0.04	<0.040
MW-3028	0.40	(0.08)	<0.030	0.79	0.13	<0.030
MW-4001	52.0	<0.090	2.40	0.12	1.90	<0.06
MW-4002	<0.030	<0.090	<0.013)	(0.015)	0.023	<0.040
MW-4006	13.0	<0.090	<0.030	0.10	2.2	<0.040
MW-4011	<0.030	<0.090	<0.030	<0.030	0.061	<0.040
MW-4015	7.10	<0.090	<0.030	0.062	0.83	<0.030

**Volatile Organic Compounds.** The VOC groundwater investigation was initiated during 1996 when dewatering activities in Raffinate Pit 4 exposed approximately 2,000 previously-submerged drums of waste. Whether the wastes from the drums impacted groundwater remains uncertain. The uncertainty is due to the small quantity of pre-1996 groundwater data for VOCs from monitoring wells in the vicinity of Raffinate Pits 3 and 4. The TCE investigation continued through 1998 in order to further define the extent of contamination. The 1998 analytical results are summarized in Table 8-8.

VOCs were first detected in 1996 at seven locations in groundwater at the chemical plant and the Weldon Spring Training Area (WSTA) during 1996. The chlorinated solvent compounds TCE and 1,2-DCE, which do not naturally occur, were reported above detection limits; TCE was reported east and south of Raffinate Pits 3 and 4 (MW-2037 MW-2038, MW-3025, and MW-S021); and DCE south of the former Frog Pond location (MW-2013). VOCs below quantification limits were reported at two monitoring locations, MW-2032 (west-northwest of

Frog Pond) and MW-4001 (west of Raffinate Pit 4). Monitoring continued throughout 1997 and 1998.

Groundwater sampling for VOC analysis at the above-listed locations and additional locations continued during 1998. The VOC sampling program was initiated to determine the lateral and vertical extents of VOC contamination, and to assess mobility of the contaminant. The lateral extents of TCE were approximately identified to be bounded to the north by the north perimeter of Raffinate Pits 3 and 4, to the south by Army Property monitoring well MWS-21, to the east by Raffinate Pits 1 and 2, and to the west by monitoring well MWS-04. The vertical extent of the TCE is limited to the weathered bedrock of the Burlington-Keokuk with no TCE detection in the unweathered zone.

A groundwater pumping investigation was performed in mid-1998. The pumping test investigation included drilling, well installation, and aquifer testing conducted in the trichloroethene (TCE)-impacted area south of the raffinate pits from May 18, 1998, through August 31, 1998. A large diameter pumping well and four smaller observation wells were drilled, installed, and developed during this time period. A series of aquifer tests was then performed in the pumping well to reach the following objectives:

- Determine the aquifer responses to groundwater withdrawal in the area of TCE contamination. No previous data of this type existed for this part of the site.
- Provide data such as aquifer parameters which are required to evaluate potential groundwater remediation techniques.
- Obtain groundwater samples to further delineate the distribution of TCE in groundwater.

Aquifer characteristics obtained from the pumping test were used to evaluate the practicality and effectiveness of techniques considered for remediation of TCE in groundwater for the groundwater operable unit.

Table 8-8 1998 TCE Analytical Results (µg/l) Summary

	Jan 98	Feb 98	Mar 98	Apr 98	May 98	Jun 98	Jul 98	Aug 98	Sept 98	Oct 98	Nov 98	Dec 98
MW-2001	-	-	-	-	-	-	-	ND	-	-	-	-
MW-2002	-	-	-	-	-	-	-	ND	-	-	-	-
MW-2003	-	-	-	-	-	-	-	ND	-	-	-	-
MW-2005	-	-	-	-	-	-	-	ND	-	-	-	-
MW-2008	-	-	-	-	-	-	-	ND	-	-	-	-
MW-2012	-	-	-	-	-	-	-	ND	-	-	-	-
MW-2013	1	-	0.7	-	-	1	-	0.9	-	ND	-	ND
MW-2014	-	-	-	-	-	-	-	ND	-	-	-	-
MW-2017	-	-	-	-	-	-	-	ND	-	-	-	-
MW-2018	-	-	-	-	-	-	ND	-	-	-	-	-
MW-2019	-	-	-	-	-	-	ND	-	-	-	-	-
MW-2021	-	-	-	-	-	-	-	ND	-	-	-	-
MW-2023	-	-	-	-	-	-	-	ND	-	-	-	-
MW-2024	-	-	-	-	-	-	-	ND	-	-	-	-
MW-2032	ND	-	ND	0.3	-	ND	-	ND	-	ND	ND	ND
MW-2034	-	-	-	-	-	-	-	ND	-	-	-	-
MW-2035	-	-	-	-	ND	-	-	ND	-	-	-	-
MW-2036	-	ND	-	-	ND	-	-	-	-	-	-	-
MW-2037	-	960	-	865	1000	590	-	-	1000	700	-	-
MW-2038	-	410	-	390	-	280	-	-	150	170	-	150
MW-2039	-	ND	-	ND	-	ND	-	ND	-	ND	-	ND
MW-2040	-	-	-	-	ND	-	-	ND	-	-	-	-
MW-2041	-	-	-	-	ND	-	-	ND	-	-	-	-
MW-2042	-	-	-	-	ND	-	-	ND	-	-	-	-
MW-2043	-	-	-	-	ND	-	-	ND	-	-	-	-
MW-2044	-	-	-	-	-	-	ND	-	-	-	-	-
MW-2045	ND	-	-	1.38	-	ND	-	-	-	-	ND	ND
MW-2046	ND	-	-	1.01	-	ND	-	-	-	-	ND	ND
MW-2047	ND	-	-	ND	-	ND	-	-	-	-	ND	ND
MW-2048	ND	-	-	ND	-	ND	-	-	-	-	ND	ND
MW-3003	-	-	-	-	-	-	-	ND	-	-	-	-
MW-3006	-	-	-	-	-	-	-	ND	-	-	-	-
MW-3013	-	-	-	-	-	-	ND	-	-	-	-	-

Table 8-8 1998 TCE Analytical Results ( $\mu\text{g/l}$ ) Summary (Continued)

	Jan 98	Feb 98	Mar 98	Apr 98	May 98	Jun 98	Jul 98	Aug 98	Sept 98	Oct 98	Nov 98	Dec 98
MW-3019	-	-	-	-	-	-	ND	-	-	-	-	-
MW-3023	-	-	-	-	-	-	ND	-	-	-	-	-
MW-3024	-	-	ND	-	ND	-	ND	-	-	ND	-	-
MW-3025	-	-	0.6	-	18	-	16	-	-	17	-	-
MW-3026	-	-	-	-	-	-	-	ND	-	-	-	-
MW-3027	-	-	-	-	-	-	-	ND	-	-	-	-
MW-3028	-	-	-	-	-	486	517	-	-	-	-	-
MW-4001	-	5	5	-	5	-	-	5	-	5	-	4.6
MW-4002	-	-	-	-	-	-	-	ND	-	-	-	-
MW-4004	-	-	ND	-	ND	-	-	ND	-	ND	-	ND
MW-4005	-	ND	ND	-	ND	-	-	ND	-	ND	-	ND
MW-4006	-	-	-	-	-	-	-	ND	-	-	-	-
MW-4007	-	0.2	ND	-	0.2	-	-	ND	-	ND	-	ND
MW-4008	-	-	-	-	-	-	-	ND	-	-	-	-
MW-4009	-	-	-	-	-	-	-	ND	-	-	-	-
MW-4010	-	-	-	-	-	-	-	ND	-	-	-	-
MW-4011	-	-	-	-	-	-	-	ND	-	-	-	-
MW-4013	-	-	-	-	-	-	-	-	ND	-	-	-
MW-4014	-	-	-	-	-	-	-	-	ND	-	-	-
MW-4015	-	-	-	-	-	-	-	-	ND	-	-	-
MW-4016	-	-	-	-	-	-	-	-	ND	-	-	-
MW-4018	-	-	-	-	-	-	-	-	ND	-	-	-
MW-4019	-	-	-	-	-	-	-	-	ND	-	-	-
MW-4020	-	-	-	-	-	-	-	-	ND	-	-	-
MW-4021	-	-	-	-	-	-	-	-	ND	-	-	-
MW-4022	-	-	-	-	-	-	-	-	ND	-	-	-
MW-4023	-	-	-	-	-	-	-	-	ND	-	-	-
MW-4024	-	-	-	-	-	-	-	-	ND	-	-	-
MW-4025	-	-	-	-	-	-	-	-	ND	-	-	-
MW-4027	-	-	-	-	-	-	4	-	-	-	-	-
MW-4029	-	-	-	-	-	-	-	420	-	-	-	-

- Not Sampled  
 ND None Detected

A better understanding of the hydrostratigraphy and hydraulic dynamics in the TCE-impact area was attained during the drilling and well installation. It is evident from the tests that the stratigraphy and structure of the weathered Burlington-Keokuk Limestone have significant influence on the permeability and direction of groundwater flow in the shallow aquifer beneath and chemical plant.

The source of the VOCs remained unknown as the investigation continued throughout 1998. It is suspected that these solvent components are trapped in pockets of soil or sludge that isolate the VOCs from volatilization or microbial degradation and have migrated to groundwater via discrete fracture flow. Due to the limited areal extent of groundwater impact and low concentrations of TCE degradation products, it is possible that the VOC introduction to groundwater is a recent event that may be a response to remedial action in Raffinate Pit 4 or sludge dredging in Raffinate Pit 3. The results of the 1998 pumping test investigation were also used to assess whether groundwater remedial action in this area should be considered.

Metals. Eleven locations were monitored monthly for metals (TCLP metals) for the enhanced groundwater monitoring in the vicinity of the raffinate pits. The 1998 data from these locations were compared to historical metals data to assess groundwater impacts resulting from raffinate pit remediation. No elevated metals were detected during 1998 for this enhanced monitoring program.

Groundwater Overview. With few exceptions for nitrate, contaminant levels remained within historical ranges at the monitoring wells sampled under the environmental monitoring program. Because contaminant levels have displayed only minor variability over the historical monitoring period, trend analysis is not conducted annually for the chemical plant monitoring wells. Select 1998 chemical plant locations were trended and are discussed in Section 8.4.4. Uranium, sulfate, and nitrate contamination continue to be concentrated in the area surrounding the raffinate pits with a small area of elevated uranium and sulfate located near the eastern boundary of the site. Pockets 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 Weldon Spring Ordnance Works property. The source of VOC contamination south and east of Raffinate Pit 3 remains under investigation. The enhanced groundwater monitoring in the raffinate pits vicinity suggested no significant impact to groundwater quality attributable to raffinate pit remediation has occurred.

#### 8.4.3.2 Springs

Springs located in Valley 6300 and Valley 5300 were monitored for the 1998 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 throughout the year, with the highest concentrations of contaminants occurring during base flow stages. During high flow conditions, surface water recharge along

the path of the subsurface flow mixes with contaminated flow from the site, and the concentrations are effectively lowered. The spring was monitored during both high and base stages during 1998.

Burgermeister Spring samples for uranium, nitrate, and nitroaromatics were within expected (historical) ranges during 1998. The mean concentrations for nitrate and sulfate during base flow are 5.21 mg/l and 38.7 mg/l, respectively. These concentrations for high stage flow are 3.61 mg/l and 39.2 mg/l, respectively. Base flow concentrations for nitrate ranged between 2.39 mg/l and 9.30 mg/l. Nitrate concentrations are also greater during base flow conditions. The mean concentration has decreased from 8.07 mg/l in 1997 to 4.18 mg/l in 1998. Base flow sulfate ranged between 22.4 mg/l and 92.3 mg/l for 1998. Uranium concentrations analyzed in samples from the spring were between 16.6 pCi/l (0.61 Bq/l) and 154 pCi/l (5.70 Bq/l), with a mean value of 62.4 pCi/l (2.31 Bq/l). These values are within the historical range for uranium. Nitroaromatic compounds were analyzed in samples from base stage flow only. The concentrations of detected nitroaromatic compounds are within historical ranges. These compounds include 2,4,6-TNT (0.02 µg/l to 0.13 µg/l), 2,4-DNT (0.06 µg/l) and 2,6-DNT (0.04 µg/l to 0.40 µg/l).

VOCs were monitored at SP-5303, SP-6301, and SP-6303 during 1998 to assess the potential for off-site migration of TCE that was detected in groundwater in the vicinity of the raffinate pits. TCE was detected at a concentrations 1.1 µg/l during two VOC sampling events at SP-6303. There were no TCE detections at any of the other springs.

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 impact the local groundwater quality.

#### 8.4.4 Groundwater Trending

##### Statistical Methods

Statistical tests for time-dependent trends of uranium concentrations were performed on historical and 1998 groundwater data representing groundwater in the raffinate pit areas. These trend analyses were performed for total uranium for each selected monitoring well. The specific locations, parameters, and time periods selected for trending analyses are presented in Table 8-9. The selected locations and time periods were based on the historical site environmental remediation activities, historical groundwater monitoring data, and knowledge of the site processes. The number of observations and number of data reported as below the detection limit for each data set are also shown in the summary tables.

Table 8-9 Chemical Plant Groundwater Wells Total Uranium Trend Analysis Summary

WELL ID	LOCATION	NO. OF OBSERVATIONS	NO. OF NON-DETECT DATA	TREND DIRECTION (ALPHA = 0.5) 1995-1998	SLOPE (pCi/yr) 1995-1998	85% UPPER AND LOWER CONFIDENCE INTERVALS ON SLOPE (pCi/yr) 1995-1998	1998 NEW HIGH CONCENTRATION (pCi/l) 1995 TO DATE
MW-3003	North RAF Pit 4	11	0	S	0.533	-0.896, 2.787	21.50
MW-3023	North RAF Pit 4	11	0	S	0.100	-1.794, 2.728	15.00
MW-3024	East Berm RAF Pit 3	7	0	S	17.320	0.025, 25.495	54.90
MW-3025	East RAF Pit 5	12	1	S	0.173	-0.320, 0.410	No
MW-3026	Southwest Corner RAF Pit	7	0	S	0.385	-1.145, 1.882	6.33
MW-3027	Southwest RAF Pit 4	12	0	S	0.83	-0.060, 0.334	3.20
MW-4001	West Perimeter, RAF Pit 4	8	3	S	0.029	-0.061, 0.555	2.40
MW-4002	West Perimeter, RAF Pit 4	8	3	S	0.000	-0.121, 0.476	2.01
MW-4006	Offsite West Perimeter	13	1	S	-17.060	-20.452, 3.125	No

S

Stationary.

The computer program TREND, developed at Pacific Northwest Laboratory, was used to perform the formal groundwater trend testing. The trend method employed was the nonparametric Mann-Kendall test. This program was selected because it can easily facilitate missing data and does not require the data to conform to a particular distribution. The nonparametric method is valid for scenarios where there are a high number of non-detect data points.

The results of the TREND analyses indicate the potential presence of statistically-significant trends and their direction upward or downward. The slope of each identified trend was also estimated with the results reported in concentration units per year. A 95% confidence interval about each slope line was calculated to indicate the variability (variance) in the values about this trend line. The trend testing output data are to be interpreted as screening indicators based on existing cumulative data. The results of the analyses are not intended to be used for the prediction of future concentrations. Rather, the data are to be used to indicate areas that should be more closely monitored in the future.

The TREND program was selected because it can easily facilitate missing data and 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 the site 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. Likewise, a negative value of  $Z$  indicates a downward trend. The alpha value (or error limit) selected for testing was 0.05. In the two-tailed test at the 0.05 alpha level of significance, 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. Thus, 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.

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 for non-detect data 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.

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.

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. The estimates of the trend slope for all data sets with identified trends are provided in Table 8-9. A  $100(1-\alpha)\%$  two-sided confidence interval about the true slope was also obtained by the nonparametric technique. The upper and lower 95% confidence limit estimates of the slope are included in the far right columns of the summary table.

Trend analyses are intended to statistically indicate the presence of an upward or downward trend in contaminant concentration and should not be used as predicting future concentrations. The trend analyses should be used to identify site locations which may require close scrutiny during future monitoring.

### Chemical Plant Trend Results

The selected wells from the chemical plant that were included in the enhanced raffinate pit vicinity groundwater monitoring schedule were trended for total uranium to investigate impacts, positive or negative, from pit remediation. Cumulative results for 1995 through 1998 were evaluated using the TREND program and are summarized below.

Nine locations in the chemical plant area were selected for total uranium trending analyses. Total uranium trends for 1995 through 1998 data were stationary at all of the tested locations. Data sets and estimated trend slopes are summarized in Table 8-9.

Seven of the nine locations evaluated for 1995-1998 reported concentrations in 1998 that exceeded all past 1994, 1995, 1996, and 1997 data for the specific sampling location. These total uranium levels ranged from 2.01 pCi/l to 54.90 pCi/l. The 1998 new high concentrations for these locations are presented in the far right column of Table 8-9.

## 8.5 Weldon Spring Quarry

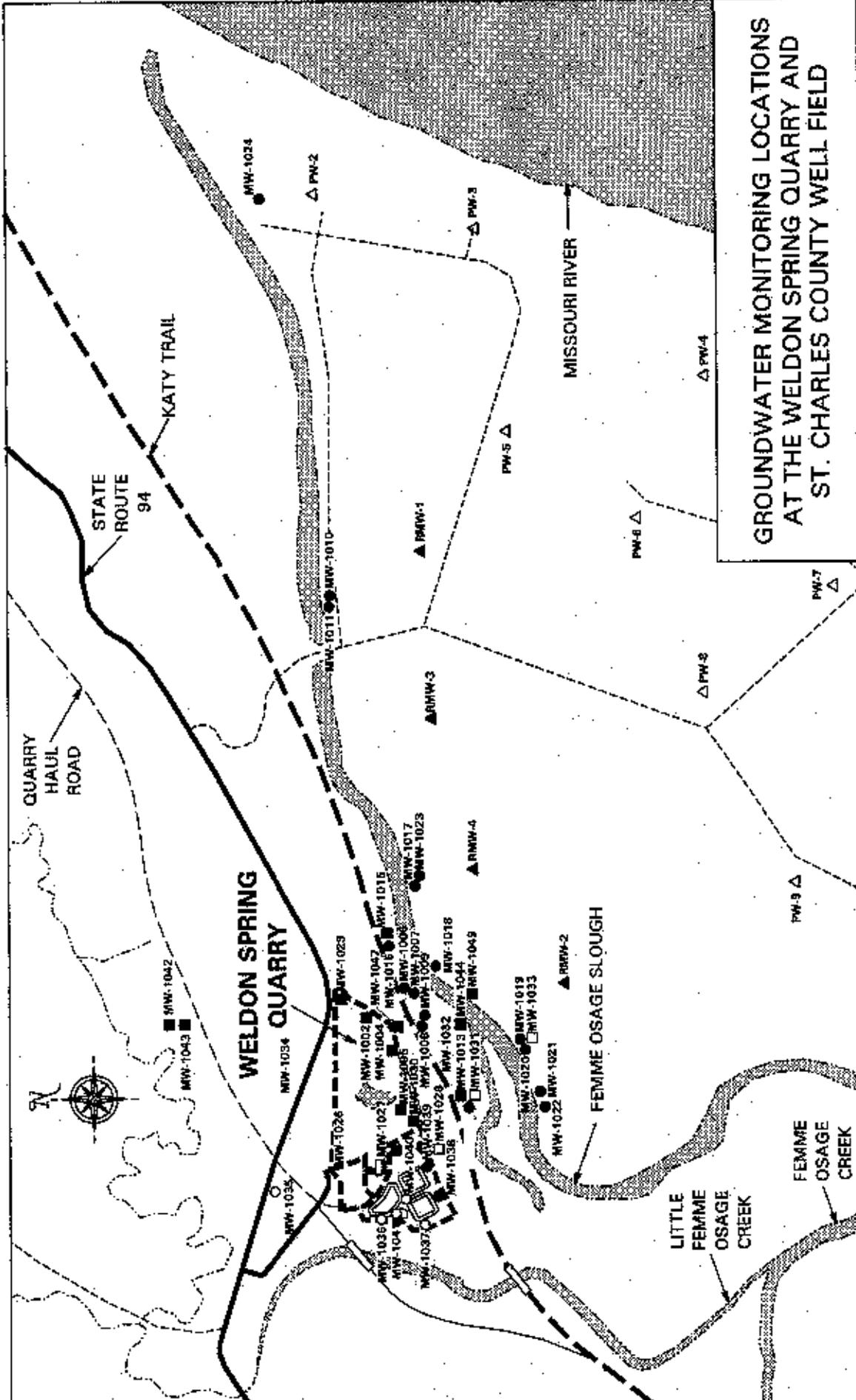
### 8.5.1 Hydrogeology

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 9.2 m (30 ft) of silty clay soil and loess deposits and is not saturated (Ref. 1). Three Ordovician-age formations comprise the bedrock at the quarry: 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 31 m (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 inorganic and organic intermixed and interlayered clays, silts, and sands with some organics.

The uppermost groundwater flow systems at the quarry 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 8-4). Twelve monitoring wells were installed to monitor contaminants within the Kimmswick-Decorah Formations comprising and surrounding the quarry. Three other monitoring wells are located south of the quarry within the Plattin Limestone to assess vertical contaminant migration. Two monitoring wells, one in the Kimmswick-Decorah Formation and one in the Plattin Formation, were installed north of the quarry to monitor upgradient groundwater quality.

There are 36 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. The alluvium monitoring wells 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. 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 1.6 km (1 mi) southwest of the St. Charles County well field by the U.S. Geological Survey are utilized to study the upgradient characteristics of the Missouri River alluvium in the vicinity of the



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

**FIGURE 8-4**

REPORT NO.:	DOE/OR/21548-773	EXHIBIT NO.:	A/QY/103/1193
DATE:	6/21/99	DATE:	6/21/99
ORIGINATOR:	MGL	DRAWN BY:	GLN

0 600 1600 FT  
 0 243.8 487.6 M  
 SCALE

- LEGEND**
- - DOE ALLUVIUM/UNCONSOLIDATED MATERIALS
  - - DOE QWTP EQUALIZATION BASIN/EFFLUENT PONDS
  - - DOE KIMMSWICK/DECORAH FORMATIONS
  - - DOE PLATTIN FORMATION
  - ▲ - ST. CHARLES COUNTY MONITORING WELL
  - △ - ST. CHARLES COUNTY WATER PRODUCTION WELL

quarry. These wells provide a reference for background values in the well field area and have been sampled by both the USGS (1992) and the DOE (1994). A summary of background values used at the quarry is provided in Table 8-10.

Table 8-10 Mean Background Values for Quarry Groundwater Monitoring Locations

PARAMETER		KIMMSWICK/ DECORAH FORMATIONS(a)	ALLUVIAL/ UNCONSOLIDATED MATERIALS(b)	MISSOURI RIVER ALLUVIUM(c)
Total Uranium (pCi/l)	Mean	2.35	0.67	2.03
	95% C.I.*	-1.18; 5.88	-0.83; 2.16	-2.71; 6.78
Radium-226 (pCi/l)	Mean	0.18	0.50	1.41
	95% C.I.*	±0.78**	±0.77**	±1.71**
Radium-228 (pCi/l)	Mean	0.77	0.48	1.59
	95% C.I.*	±2.06**	±2.06**	±13.1**
Thorium-228 (pCi/l)	Mean	0.26	0.39	0.24
	95% C.I.*	±0.94**	±1.03**	±1.72**
Thorium-230 (pCi/l)	Mean	0.93	0.32	0.69
	95% C.I.*	±0.55**	±0.94**	±2.93**
Thorium-232 (pCi/l)	Mean	0.26	0.12	0.20
	95% C.I.*	±0.92**	±0.86**	±1.68**
Gross α (pCi/l)	Mean	6.75	1	1.54
	95% C.I.*	±6.85**	±3.5**	±18.6**
Gross β (pCi/l)	Mean	5.77	5.9	3.0
	95% C.I.*	±5.08**	±2.5	±13.9**
Nitroaromatic Compounds	Mean	No detects	No detects	Not analyzed
Arsenic (µg/l)	Mean	1.38	1.53	4.08
	95% C.I.*	-0.94; 3.70	-0.99; 4.04	-1.29; 9.46
Barium (µg/l)	Mean	144.9	232.0	408.6
	95% C.I.*	110.0; 179.8	178.4; 285.8	137.1; 680.0
Nitrate (mg/l)	Mean	1.06	0.11	0.46
	95% C.I.*	-0.62; 2.73	-0.05; 0.26	-2.33; 3.24
Sulfate (mg/l)	Mean	82.3	38.8	37.1
	95% C.I.*	32.6; 132.0	23.1; 54.5	6.31; 68.0

(a) MW-1034 (DOE)

(b) MW-1035 (DOE)

(c) Darst Bottom Wells (USGS and DOE)

\* 95% Confidence Interval about the mean

\*\* Average radiological error

## 8.5.2 Monitoring Program

Groundwater monitoring is performed in both the alluvial and bedrock aquifers at the quarry (Figure 8-4). Three separate monitoring programs were employed for the quarry in 1998. The first program addressed sampling the Department of Energy wells and monitoring the quarry area to determine contaminant migration and the effects of quarry dewatering and bulk waste removal, which 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. Monitoring wells on the quarry rim were sampled bimonthly for total uranium and nitroaromatic compounds, due to the changes in concentrations over time, 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.

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's public drinking water treatment plant were sampled quarterly or semiannually for selected parameters. This portion of the monitoring program was developed by representatives of the Department of Energy, several State regulatory agencies, and St. Charles County.

The third program monitors the equalization basin and the two effluent ponds at the quarry water treatment plant (Figure 8-4). 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 the monitoring of contaminants of concern in the groundwater beneath storage facilities. The contaminants of concern were derived from the *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 38) and the *Baseline Risk Evaluation for Exposure to Bulk Waste at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 39). Background concentrations of naturally occurring analytes were determined from upgradient location south and west of the quarry (Ref. 55).

## 8.5.3 Weldon Spring Quarry Monitoring Results

### 8.5.3.1 Quarry

**Radiochemical Parameters.** Groundwater monitoring wells at the quarry were sampled for the following radiochemical parameters: total uranium, Ra-226, Ra-228, isotopic thorium, gross alpha, and gross beta. The uranium values continue 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. However, uranium concentrations decreased more than 10% in the historically

high uranium impacted (>100 pCi) quarry rim bedrock monitoring locations, indicating that quarry bulk waste remediation was successful in contaminant source removal. Locations shown with apparently significant uranium increases historically have been relatively low in uranium activity. These phenomena suggest that groundwater conditions at the quarry are continuing to improve as a result of bulk waste removal. It should be noted on Table 8-11 that apparent increased concentrations at some locations may be due to laboratory error. Sample replicates collected for on-site KPA analysis were within 1997 ranges. Elevated results could not be duplicated and no evidence suggests increasing uranium concentrations at these locations. The 1998 annual averages for the locations that exceed background are summarized in Table 8-11.

Table 8-11 Annual Averages for Total Uranium (pCi/l) Above Average Background at the Weldon Spring Quarry

LOCATION	1998 ANNUAL AVERAGE	ANNUAL AVERAGE ±% CHANGE 1997 to 1998
MW-1002	18.0*	+270%
MW-1004	2,200	-11.8%
MW-1006	1,935	-4.9%
MW-1007	62.0*	+30.8%
MW-1008	1600	-32.9%
MW-1009	8.7*	+432%
MW-1011	4.2	NC
MW-1013	520	-24.4%
MW-1014	562	-35.0%
MW-1015	216	NC
MW-1016	145	-17.2%
MW-1018	6.8*	+500%
MW-1019	3.9*	+315%
MW-1021	4.7*	+88%
MW-1022	5.8*	+746%
MW-1023	12*	+1000%
MW-1027	118	-21.9%
MW-1028	6.9*	+123%
MW-1029	5.8	+112%
MW-1030	28	+14.8%
MW-1031	160	+36.8%
MW-1032	1100	-14.1%
MW-1033	6.2*	+185%

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

NC No change, ± = % increase or decrease from 1997 averages

\* Values that suggested annual average uranium increases could not be duplicated or confirmed by on-site KPA analysis. No increasing trends are suggested.

The proposed U.S. Environmental Protection Agency total uranium drinking water standard of 20 µg/l (13.6 pCi/l or 0.5 Bq/l) (40 CFR 192.02) was exceeded at MW-1002, MW-1004, MW-1006, MW-1007, MW-1008, MW-1013, MW-1014, MW-1015, MW-1016, MW-1027, MW-1030, MW-1031, and MW-1032. All of these monitoring wells are located north of the Femme Osage Slough and have no direct impact on the drinking water sources in the Missouri River alluvium. The proposed standard is not applicable to groundwater north of the slough because it is not considered a usable groundwater source.

Ra-226, Ra-228, and isotopic thorium (Th-228, Th-230, and Th-232) were analyzed at all groundwater monitoring locations at the quarry. Elevated radium levels were observed at seven locations in 1998. It is likely the elevated isotopic values in these wells resulted from bulk waste removal activities. Early 1994 operational data from the quarry pond had shown elevated levels of isotopes of radium and thorium in the runoff from waste removal operations and groundwater collected in the pond, which likely was due to disturbance of bulk wastes in the quarry. These levels began to decrease late in 1995 when bulk waste activities were completed and levels continued to decrease in 1998. The 1998 annual averages above mean background concentrations plus two standard deviations are summarized in Table 8-12.

Table 8-12 Isotopic Radionuclide (pCi/l) Concentration Annual Averages That Exceeded Two Standard Deviations (Upper 95% Confidence Interval) of Mean Background at the Weldon Spring Quarry

LOCATION	RA-226	RA-228	TH-230	TH-232
MW-1002	--	--	2.0	--
MW-1004	--	--	3.5	--
MW-1013	--	7.74	--	--
MW-1023	7.51	--	5.9	3.4
MW-1029	--	--	1.9	--
MW-1033	--	--	3.0	--

-- Did not exceed two standard deviations of mean background values.

Note 1: Values reported in activity.

Note 2: 1 pCi/l = 0.037 Bq/l.

**Nitroaromatic Compounds.** In 1998, samples from quarry monitoring wells were analyzed for nitroaromatic compounds. Six locations yielded detectable concentrations of at least one of the six compounds analyzed during the 1998 sampling period. None of these concentrations indicate increasing impacts. These monitoring wells, which have historically been impacted with nitroaromatics, are situated in the alluvial materials or bedrock downgradient of the quarry and north of the Femme Osage Slough. Significant decreases in nitroaromatic compounds were observed in samples from quarry rim bedrock wells during 1997 and 1998. A 40% decrease in TNT and 18% decrease in DNT (total) from 1996 values were reported for 1997, and from 1997 to 1998 these decreases were 35% and 30% respectively. No detectable concentrations were observed south of the Femme Osage Slough. A summary of the annual averages for these locations is provided in Table 8-13.

Table 8-13 Annual Averages for Detectable Concentrations of Nitroaromatic Compounds ( $\mu\text{g/l}$ ) at the Weldon Spring Quarry

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-1002	19.0	0.13	5.27	0.06	5.00	<0.03
MW-1004	0.21	<0.09	1.06	0.10	0.32	<0.03
MW-1006	29.34	<0.09	1.44	0.09	0.64	<0.03
MW-1015	2.65	<0.09	1.15	<0.03	0.16	<0.03
MW-1016	0.12	<0.09	0.08	<0.03	0.03	<0.03
MW-1027	<0.03	<0.09	1.38	0.46	1.13	<0.03

The Missouri drinking water quality standard for 2,4-DNT ( $0.11 \mu\text{g/l}$ ) was exceeded only at MW-1027 north of the Femme Osage Slough. No MCLs have been established for the other nitroaromatic compounds.

**Sulfate.** Groundwater analyses in 1998 indicated 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. Ten wells exceeded average background levels for sulfate. These wells are situated north of the slough, downgradient of the area of greatest groundwater impact. Only one location (MW-1037) exceeded the secondary MCL of 250 mg/l. The annual averages for these wells are summarized in Table 8-14.

Table 8-14 Annual Averages for Sulfate (mg/l) Above Average Background at the Weldon Spring Quarry

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM
MW-1006*	173	237	101
MW-1008	99.7	153	65
MW-1009	117	136	96
MW-1014	98.2	101	94.0
MW-1016	134	148	122
MW-1032	207	214	189
MW-1037	262*	285*	217
MW-1038	203	248	142
MW-1042	141	150	131
MW-1047	144	183	104

\* Exceeded secondary MCL of 250 mg/l.

### 8.5.3.2 St. Charles County Well Field

**Radiochemical Parameters.** The St. Charles County production wells and the RMW-series monitoring wells were sampled semiannually for the radiochemical parameters Ra-226, Ra-228, and isotopic thorium. Gross alpha, and total uranium were analyzed quarterly. A summary of the radiochemical annual averages is provided in Table 8-15. The annual averages for total uranium in the well field remain at background. No production well exceeded the proposed groundwater standard of  $20 \mu\text{g/l}$  ( $13.6 \text{ pCi/l}$ ).

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. The annual averages for these locations are within the statistical variation of background ranges for groundwater occurring in the Missouri River alluvium.

Table 8-15 Summary of Annual Averages of Radiochemical Parameters (pCi/l) for the St. Charles County Well Field

LOCATION	TOTAL URANIUM	GROSS ALPHA	RA-226	RA-228	TH-228	TH-230	TH-232
MW-1024	0.70	3.21	0.31	0.62	0.21	0.19	0.10
MW-RMW1	0.72	NA	0.43	1.07	0.06	0.10	<0.10
MW-RMW2	4.53	5.44	1.03	<0.8	0.09	0.10	0.07
MW-RMW3	0.62	2.01	0.57	1.31	<0.07	<0.07	<0.02
MW-RMW4	1.58	2.50	0.58	0.74	<0.20	0.08	<0.08
MW-PW02	<0.67	2.03	0.75	1.23	<0.25	<0.45	<0.18
MW-PW03	<0.67	3.54	0.38	1.78	<0.07	<0.08	<0.06
MW-PW04	0.62	1.22	0.30	1.06	<1.4	<1.0	<0.6
MW-PW05	0.43	1.96	0.92	1.77	<0.1	<0.04	<0.04
MW-PW06	0.55	3.76	0.78	1.39	<0.2	0.46	<0.08
MW-PW07	0.47	3.45	0.49	1.76	<0.46	0.10	<0.40
MW-PW08	0.88	3.46	0.58	1.33	0.03	0.34	<0.04
MW-PW09	0.25	2.29	0.85	1.92	<0.28	0.10	<0.16
MW-RAWW	0.21	1.76	0.56	0.49	<0.23	0.01	<0.16
MW-FINW	0.28	1.47	0.41	1.15	<0.10	<0.04	<0.101

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

The Missouri Drinking Water Standard of 15 pCi/l (0.555 Bq/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 Department of Energy Order 5400.5.

The Missouri Drinking Water Standard of 5 pCi/l (0.185 Bq/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 the 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 sulfate concentrations in the well field were slightly elevated above pre-1995 levels for 1998 at MW-PW02, MW-PW03, MW-PW04, and MW-PW06 as they were in 1996 and 1997. Most likely these levels are not related to any quarry operations. The elevated sulfate values are thought to reflect natural

increases across the quarry area because a location upgradient monitoring location, MW-1035, has also been increasing in sulfate since 1994. The 1998 annual averages for the well field are summarized in Table 8-16. The secondary MCL for sulfate is 250 mg/l; this standard was not exceeded at any location in the well field.

**Metals.** Arsenic and barium were the only metals monitored during 1998 at the St. Charles County well field. The primary MCL for arsenic (50 µg/l) was exceeded at location RMW-2. The MCL for barium (2,600 µg/l) was not exceeded at any location. None of the values for either metal exceeded their respective MCL's in samples from the public water supply wells or from the St. Charles County water treatment plant (Table 8-16).

Table 8-16 Annual Averages for Sulfate (mg/l), Arsenic (µg/l), and Barium (µg/l) in the St. Charles County Well Field

LOCATION	SULFATE	ARSENIC	BARIUM
MW-1024	6.01	NS	NS
MW-RMW1	23.7	8.57	462
MW-RMW2	20.1	124	342
MW-RMW3	34.0	37.0	492
MW-RMW4	29.4	12.1	228
MW-PW02	117	<2.40	315
MW-PW04	120	<2.40	308
MW-PW05	98.8	<2.40	335
MW-PW06	126	<2.40	341
MW-PW07	91.5	<2.40	450
MW-PW08	34.7	2.85	474
MW-PW09	35.5	2.80	490
MW-RAWW	101	<2.40	366
MW-FINW	105	<2.40	83.9

NS Not Sampled

#### 8.5.4 Trend Analysis

Statistical tests for time-dependent trends at the Weldon Spring Quarry were performed on historical data from select groundwater wells. Trending was performed on total uranium, nitroaromatic, and sulfate data in 1998.

Trend analyses were performed at 16 monitoring locations based on historical data or 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. Sulfate trend analyses were performed for locations down-gradient of bulk waste sources and all locations adjacent to the south side of the slough, due to recent changes in levels in sulfate in this area.

The computer program TREND, previously described in detail in Section 8.4.4, was used to perform the formal groundwater trend testing. The trend method employed was the nonparametric Mann-Kendall test. The results of the TREND testing are shown in Tables 8-17 through 8-19.

### Quarry Trend Results

Cumulative results for each analyte that was evaluated from 1995 through 1998 using the TREND program are summarized below. Remedial actions that addressed contamination source areas at the site were completed in 1995. The trending results for the quarry area from 1995 through 1998 were also compared to past trending results performed in 1998 for 1994 through 1997. The results of these analyses are also summarized below by analyte.

#### Nitroaromatic Compounds

Ten locations near the quarry were selected for trend analyses of nitroaromatic compounds. Of these locations, six are bedrock wells and two are alluvial wells. The results of the nitroaromatic analyses for the monitoring wells near the quarry are presented in Table 8-17. In total, 39 trend analyses were performed on the nitroaromatic compounds at the 10 groundwater monitoring well locations.

Based on the results of the analyses, no upward trends were identified in groundwater from the bedrock wells or alluvial wells that were analyzed for the 1995 to 1998 period. The results of the recent analyses are the same as indicated in the previous tests conducted using 1994 through 1997 data, with the following exceptions. All of the nitroaromatic compounds at MW-1004 and one nitroaromatic compound (2,4-DNT) at MW-1027 changed from a stationary to a downward trend. Two nitroaromatic compounds (2,4-DNT and 2,6-DNT) at MW-1015, one nitroaromatic compound (2,4,6-TNT) at MW-1027, and two nitroaromatic compounds (2,4-DNT and 2,6-DNT) at MW-1030 changed from a downward trend to a stationary trend.

Downward trends were indicated for at least one nitroaromatic compound at five of the locations that were tested using the 1995 through 1998 data. The decreasing trends are most likely the result of bulk waste removal at the quarry.

As shown in Table 8-17, one location (MW-1015) had a reported concentration of 0.04 mg/l of 2,4-DNT and one location (MW-1027) had a reported concentration of 3.90 mg/l of 2,4,6-TNT in 1998. These concentrations for 2,4-DNT and 2,4,6-TNT exceeded all past 1994, 1995, 1996, and 1997 data for the respective sampling locations.

Table 8-17 Quarry Groundwater Wells Nitroaromatics Trend Analysis Summary

WELL ID	LOCATION	COMPOUND	NO. OF OBSERVATIONS	NO. OF NON-DETECT DATA	TREND DIRECTION (ALPHA = 0.5)	SLOPE (µg/lyr)	SLOPE (µg/lyr) 1995-1998	95% UPPER & LOWER CONFIDENCE INTERVALS ON SLOPE (µg/lyr) 1995-1998	1995 NEW HIGH CONCENTRATION (µg/l) 1995 TO DATE
MW1002	Bedrock-East rim	2,4-DNT	26	0	D	-0.024	-0.029, -0.020	No	
		2,6-DNT	26	0	D	-2.233	-2.850, -1.600	No	
		1,3-DNB	26	1	D	-0.091	-0.110, -0.072	No	
		2,4,6-TNT	26	0	D	-7.800	-10.985, -6.000	No	
		1,3,5-TNB	26	0	D	-38.250	-52.441, -30.333	No	
		2,4-DNT	26	0	D	-0.015	-0.020, -0.010	No	
MW1004	Bedrock - rim	2,6-DNT	26	0	D	-0.065	-0.110, -0.040	No	
		1,3-DNB	26	25	(a)	(a)	(a)	No	
		2,4,6-TNT	26	0	D	-1.000	-1.885, -0.603	No	
		1,3,5-TNB	26	0	D	-0.090	-0.209, -0.020	No	
		2,4-DNT	18	1	S	-0.028	-0.150, 0.043	No	
		2,6-DNT	18	0	S	-0.089	-0.602, 0.196	No	
		1,3-DNB	18	10	S	0.000	0.000, 0.000	No	
		2,4,6-TNT	18	0	S	-1.000	-3.548, 0.367	No	
		1,3,5-TNB	18	0	S	-0.360	-34.030, 10.403	No	
MW1015	Bedrock - North of Slough	2,4-DNT	16	0	S	0.000	-0.006, 0.004	0.04	
		2,6-DNT	16	0	S	-0.010	-0.024, 0.002	No	
		1,3-DNB	16	2	S	-0.002	-0.022, 0.016	No	
		2,4,6-TNT	16	0	D	-0.317	-0.500, -0.100	No	
		1,3,5-TNB	16	0	D	-0.675	-1.453, -0.300	No	
		2,4-DNT	16	16	(a)	(a)	(a)	No	
NW1016	Alluvium - North of Slough	2,6-DNT	16	0	S	-0.002	-0.011, 0.005	No	
		2,4,6-TNT	16	2	S	-0.030	-0.085, 0.015	No	
		1,3,5-TNB	16	3	S	-0.061	-0.183, 0.034	No	

Table 8-17 Quarry Groundwater Wells Nitroaromatics Trend Analysis Summary (Continued)

WELL ID	LOCATION	COMPOUND	NO. OF OBSERVATIONS 1995-1998	NO. OF NON-DETECT DATA 1995-1998	TREND DIRECTION (ALPHA = 0.5) 1995-1998	SLOPE ( $\mu\text{g/yr}$ ) 1995-1998	95% UPPER & LOWER CONFIDENCE INTERVALS ON SLOPE ( $\mu\text{g/yr}$ ) 1995-1998	1998 NEW HIGH CONCENTRATION ( $\mu\text{g/l}$ ) 1995 TO DATE
MW1027	Bedrock - rim	2,4-DNT	16	1	D	-1.300	-1.505, -0.627	No
		2,6-DNT	16	1	S	-0.220	-0.628, 0.200	No
		2,4,6-TNT	16	1	S	0.027	-0.086, 0.214	3.90
MW-1030	Bedrock - rim	2,4-DNT	16	8	S	0.000	-0.002, 0.000	No
		2,6-DNT	16	9	S	0.000	-0.001, 0.000	No
		2,4,6-TNT	16	15	(a)	(a)	(a)	No
MW-1032	Bedrock - North Of Slough	2,4-DNT	16	10	D	0.000	0.000, 0.000	No
		2,6-DNT	16	6	S	0.000	-0.008, 0.000	No
		2,4,6-TNT	16	15	(a)	(a)	(a)	No
MW-1034	Bedrock - Background	2,4-DNT	8	8	(a)	(a)	(a)	No
		2,6-DNT	8	8	(a)	(a)	(a)	No
		2,4,6-TNT	8	8	(a)	(a)	(a)	No
MW-1035	Alluvium - Background	2,4-DNT	16	16	(a)	(a)	(a)	No
		2,6-DNT	16	16	(a)	(a)	(a)	No
		2,4,6	16	16	(a)	(a)	(a)	No

D Downward  
S Stationary  
U Upward

(a) No of only one detectable concentration reported for time period; therefore, no trending performed.

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

Table 8-18 Quarry Groundwater Wells-Total Uranium Trend Analysis Summary

WELL ID	LOCATION	NO. OF OBSERVATIONS	NO. OF NON-DETECT DATA	TREND DIRECTION (ALPHA = 0.5)	SLOPE (pCi/yr)	95% UPPER & LOWER CONFIDENCE INTERVALS ON SLOPE (pCi/yr) 1995-1988	1988 NEW HIGH CONCENTRATION 1995 TO DATE (pCi/l)
MW1004	Bedrock - rim	12	0	D	-205.00	-4,73,484, -60,451	No
MW1006	Alluvium-North of Slough	8	0	S	-225,000	-889,047, 116,189	No
MW1007	Alluvium-North of Slough	8	0	S	9,000	-14,257, 20,234	No
MW1008	Alluvium-North of Slough	8	0	S	-70,000	-997,534, 1,143,088	No
MW1009	Alluvium-North of Slough	8	1	S	-0,500	-4,207, 3,721	No
MW1013	Bedrock-North of Slough	8	0	S	-96,667	-188,773, 21,380	No
MW1014	Alluvium-North of Slough	8	0	S	-124,000	-205,413, 5,240	No
MW1015	Bedrock-North of Slough	8	0	S	-31,000	-75,427, -0,467	No
MW1016	Alluvium-North of Slough	8	0	S	-10,500	-20,000, 2,000	No
MW1023	Alluvium-South of Slough	8	1	S	0,148	-0,684, 3,806	No
MW1027	Bedrock-rim	8	0	D	-78,333	-121,239, -44,195	No
MW1030	Bedrock-rim	12	0	S	-8,667	-16,473, 0,173	No
MW1031	Bedrock-North of Slough	10	0	S	21,500	-11,054, 64,757	No
MW1032	Bedrock-North of Slough	10	0	U	193,000	42,830, 394,341	No
MW1034	Bedrock-background	7	0	S	0,142	-0,479, 0,828	No
MW1035	Alluvium-background	16	3	S	-0,004	-0,059, 0,115	No

D Downward  
S Stationary  
U Upward

Table 8-19 Quarry Groundwater Wells Sulfate Trend Analysis Summary

WELL ID	LOCATION	NO. OF OBSERVATIONS	NO. OF NON-DETECT DATA	TREND DIRECTION (ALPHA = 0.5)	SLOPE (mg/lyr)	95% UPPER & LOWER CONFIDENCE INTERVALS ON SLOPE (mg/lyr) 1995-1998	1998 NEW HIGH CONCENTRATION (mg/l) 1995 TO DATE
MW1002	Bedrock - East rim	16	0	U	8.100	5.470, 10.927	104.00
MW1004	Bedrock - rim	15	0	S	-11.800	-25.498, -1.000	No
MW1006	Alluvium - North of Slough	15	0	D	-84.167	-80.005, -39.996	No
MW1007	Alluvium - North of Slough	14	2	S	-5.918	-18.962, 0.002	No
MW1008	Alluvium-North of Slough	15	0	D	-47.500	-70.000, -28.126	No
MW1009	Alluvium-North of Slough	15	0	D	-29.000	-35.941, -21.000	No
MW1013	Bedrock-North of Slough	15	0	S	1.167	-2.798, 2.466	No
MW1014	Alluvium-North of Slough	15	0	S	1.500	-3.448, 3.633	No
MW1015	Bedrock-North of Slough	15	0	S	-6.000	-10.971, -1.000	No
MW1016	Alluvium-North of Slough	15	0	S	-4.000	-9.000, 0.986	No
MW1018	Alluvium-South of Slough	10	0	D	-18.658	-23.663, -11.773	No
MW1020	Alluvium - South of Slough	10	1	D	-3.120	-15.235, -1.285	No
MW1021	Alluvium - South of Slough	9	3	S	0.109	-0.942, 0.650	No
MW1023	Alluvium-South of Slough	10	4	D	-0.870	-1.182, -0.365	No
MW1027	Bedrock-rim	16	0	S	1.500	-1.786, 6.236	No
MW1029	Bedrock - East rim	15	0	U	14.550	11.636, 18.000	123.00
MW1030	Bedrock-rim	16	0	D	-3.267	-7.680, -1.520	No
MW1031	Bedrock-North of Slough	15	0	S	-4.450	-14.749, 0.792	No
MW1032	Bedrock-North of Slough	14	0	S	-8.000	-13.951, 3.935	No
MW1034	Bedrock-background	16	0	D	-4.200	-8.412, -1.413	No
MW1035	Alluvium-background	17	0	S	0.050	-2.680, 1.811	No

D Downward  
S Stationary  
U Upward

### Total Uranium

Sixteen locations near the quarry were selected for total uranium trend analyses. Of these locations, eight are bedrock wells and eight are alluvial wells. The sampling locations included one bedrock well and one alluvial well estimated to represent background conditions.

Total uranium trends for 1995-1998 data were stationary at all locations except three locations as shown in Table 8-18. The three locations with upward or downward trends are all bedrock monitoring wells. An upward trend is indicated based on the 1995 through 1998 data for MW-1032. The previous data for MW-1032 also indicated an upward trend based on the 1994 through 1997 data.

The recent data for MW-1031, previously reported as indicating an upward trend based on the 1994 through 1997 data, appear to indicate a change to a stationary trend.

A downward trend is indicated based on the 1995 through 1998 data for MW-1004 and MW-1027. A stationary trend was previously reported for both of these wells, based on the analysis of the 1994 through 1997 data.

The recent data for MW-1015 and MW-1030, previously reported as indicating a downward trend based on the 1994 through 1997 data, appear to indicate a change to a stationary trend.

One of the 16 locations that was evaluated for the 1995-1998 time frame had reported concentrations in 1998 that exceeded all past 1994, 1995, 1996, and 1997 data for the specific sampling location. This uranium level was 12.00 pCi/l at MW-1023. The 1998 new high concentration for this location could not be substantiated in a replicate sample and the 12.00 pCi/l value was not considered a new historic high for uranium.

### Sulfate

Twenty-one locations near the quarry were selected for sulfate trend analyses. Of these locations, 10 are bedrock wells and 11 are alluvial wells. The sampling locations included one bedrock well and one alluvial well estimated to represent background conditions.

As shown in Table 8-19, sulfate sampling data for 1995 through 1998 for two locations indicated an upward trend. Both of these locations displayed an upward trend based on the prior analysis using the data for 1994 through 1997. The locations with upward trends are both bedrock wells. The apparent increases at these locations may be sulfate returning to natural concentrations following dilution due to flooding in the last few years.

The recent data for three sampling locations (MW-1016, MW-1031, and MW-1035), previously reported as indicating an upward trend based on the 1994 through 1997 data, appear to indicate a change to a stationary trend.

The 1995 through 1998 data for eight well locations indicated downward trends. Two of these wells are bedrock wells, including the estimated background well, MW-1034. Of the eight locations currently displaying downward trends, two of these locations (MW-1018 and MW-1023) were previously estimated to be stationary based on the 1994 through 1997 data.

The results for the remaining 11 sampling locations for the period of 1995 through 1998 indicated stationary trends.

Two of the 21 locations that were evaluated for the 1995-1998 time frame had reported concentrations in 1998 that exceeded all past 1994, 1995, 1996, and 1997 data for the specific sampling location. These sulfate levels were 104 mg/l at MW-1002 and 123 mg/l at MW-1029. The 1998 new high concentrations for these locations are presented in the far right column of Table 8-19.

## 8.6 Waste Treatment Facilities

### 8.6.1 Monitoring Program

Groundwater monitoring wells have been placed around four waste management units: the quarry and site water treatment plant equalization basins, the temporary storage area, and the disposal cell (see Figures 8-2 and 8-4). These wells were installed to detect contaminants in the uppermost water units beneath these storage facilities in order to comply with the requirements of 40 CFR 264, Subpart F, and 10 CSR 264, Subpart F. The monitoring parameters were derived from previous evaluations performed and documented in the *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 38), the *Baseline Risk Evaluation for Exposure to Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 39), and the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (Ref. 40).

The detection monitoring program consists 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.

Annual sampling is performed for the following parameters:

- Radiochemical parameters (Ra-226, Ra-228, Th-230, Th-232, U-234, and U-238).
- Polychlorinated biphenyls (PCBs).
- Polynuclear aromatic hydrocarbons (PAH).
- Pesticides (endrin, lindane, methoxychlor, toxaphene, 2,4-D, and 2,4,5-TP Silvex).

Constituent concentrations at the monitoring wells for 1998 were compared with previously determined baseline concentrations for each well. If there was statistically significant evidence of contamination (concentration exceeds baseline by three standard deviations), a program of increased monitoring and/or an evaluation of the leachate collected within the liners of the basins or storage area was initiated.

### 8.6.2 Site Water Treatment Plant and Temporary Storage Area Monitoring Results

Collection of baseline data for the wells surrounding the equalization basin for the site water treatment plant and the temporary storage area was completed in December of 1994. The baseline dataset for each monitoring well was established with a minimum of eight samples collected on a quarterly basis. A summary of these baseline data for wells MW-2035 through MW-2043 can be found in Table 8-20. Monitoring data collected during 1998 were compared with the baseline data to identify significant changes in groundwater quality potentially attributable to operation of these facilities.

Baseline concentration for the metal barium was slightly exceeded at MW-2039. Despite the changes in the groundwater barium values, there is no evidence that the integrity of the water treatment facilities or TSA basins has been compromised. There were no elevated metals detected in collected leachate and no increased volume of leachate at these facilities.

Uranium was slightly elevated above baseline at MW-2042. No impact from the water treatment plant equalization basin is suspected. The values are below the proposed drinking water standard of 13.6 pCi/l (0.5 Bq/l).

Nitrate baseline was not exceeded at any location at the site water treatment facility equalization basin. All locations at the water treatment plant and TSA are stable or decreasing in nitrate concentrations. Sulfate baseline was exceeded at MW-2042. None of the locations exceeded the secondary drinking water standard of 250 mg/l in 1998.

Table 8-20 Baseline for the Detection Monitoring System at the Weldon Spring Site Water Treatment Plant and Temporary Storage Area

PARAMETER	MW-2035	MW-2036	MW-2037	MW-2038	MW-2039	MW-2040	MW-2041	MW-2042	MW-2043
Arsenic (µg/l)	2.25	2.09	1.82	5.77	2.43	4.12	4.35	3.41	2.10
Barium (µg/l)	107	333	250	563	240	962	347	590	344
Cadmium (µg/l)	3.91	3.89	3.67	3.67	6.98	4.04	4.20	3.80	3.79
Chromium (µg/l)	4.21	4.33	3.83	3.83	14.1	14.1	18.4	6.62	4.52
Lead (µg/l)	4.08	2.17	1.65	1.65	1.50	3.30	8.53	2.40	2.81
Mercury (µg/l)	0.14	0.14	3.40	4.37	0.15	0.12	0.59	0.13	0.15
Selenium (µg/l)	4.71	1.86	20.0	24.9	24.5	9.42	96.6	4.11	7.11
Silver (µg/l)	5.78	6.07	6.08	6.08	13.8	5.40	10.3	6.18	4.96
Uranium (pCi/l)	1.93	1.64	2.17	2.32	4.12	4.64	8.35	3.33	2.34
Nitrate (mg/l)	2.05	5.03	668	2271	117	455	2256	13.8	8.03
Sulfate (mg/l)	6.89	5.64	177	132	54.6	27.9	196	39.5	20.8
1,3,5-TNB (µg/l)	0.02	0.02	0.29	0.37	0.02	0.02	0.02	0.02	0.02
TNT (µg/l)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2,4-DNT (µg/l)	0.02	0.02	0.79	2.14	0.02	0.02	0.02	0.02	0.09
2,6-DNT (µg/l)	0.01	0.01	0.19	0.41	0.01	0.01	0.01	0.01	0.01

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

Nitroaromatic compounds were detected at locations MW-2037, MW-2038, and MW-2043. These detectable nitroaromatics were below baseline concentrations at all monitoring locations. No PCBs or pesticides were detected at any of the detection monitoring locations. No locations exceeded uranium baselines. All 1998 data for the site water plant and temporary storage area are summarized in Table 8-21.

### 8.6.3 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 waste storage unit. Baseline was established for these newer wells utilizing 1994 and 1995 quarterly data. Monitoring wells MW-1038 and MW-1039 were deleted from this monitoring program because they were located cross gradient from the equalization basin at a distance too far to adequately monitor the basin and are possibly downgradient of contaminant sources in the quarry.

The concentrations in the wells were compared to baseline for the parameters. The baseline parameters for each well are presented in Table 8-22 and the summary of 1998 detection monitoring results is presented in Table 8-23. Samples were also analyzed for nitroaromatic compounds, pesticides, and PCBs. The baselines and analytical results are not shown in either table because these compounds do not naturally occur and have not been detected in the monitoring system.

The 1998 results of the comparison of the monitoring data to baseline indicated that no radiological parameter was above baseline during the year. Total uranium and metals levels were within baseline for all wells in the water treatment facility detection monitoring network. The ions chloride, fluoride, and sulfate were slightly elevated above baseline concentrations. These values are not believed to be attributable to any quarry operations. Ion values are similarly increasing at the upgradient monitoring locations.

Monitoring wells MW-1037 and MW-1040 had levels that exceeded baseline for sulfate during 1998. These increases reflect a regional sulfate increase in the quarry vicinity and are not believed to be due to contamination.

Table 8-21 Summary of the 1998 Detection Monitoring Data for the Weldon Spring Site Water Treatment Plant and Temporary Storage Area

PARAMETERS	MW-2035	MW-2038	MW-2037	MW-2038	MW-2039	MW-2040	MW-2041	MW-2042	MW-2043
Arsenic µg/l	<3.00	<1.90	<3.00	<3.00	<3.30	<4.00	<4.00	<2.00	<2.00
Barium µg/l	96.9	287	88.8	291	354	649	272	434	394
Cadmium µg/l	<0.50	<0.60	<1.2	<0.50	0.23	<1.14	<1.14	<0.60	<0.60
Chromium µg/l	0.44	0.70	1.23	0.65	3.56	6.43	0.79	1.60	2.25
Lead µg/l	<1.60	0.84	<2.00	<2.50	<2.50	1.20	0.98	0.98	<1.6
Mercury µg/l	<0.10	<0.10	0.76	0.21	<0.10	<0.10	<0.10	<0.10	<0.10
Selenium µg/l	<3.10	<3.10	3.09	12.2	7.03	5.20	13.2	1.84	2.39
Silver µg/l	<0.9	<1.30	1.36	0.97	<1.30	<0.90	<0.9	<1.3	<1.30
Total Uranium pCi/l	<0.68	0.80	1.65	2.06	3.42	2.92	4.91	4.01	1.66
Nitrate Mg/l	0.47	1.77	297	862	77.4	149	133	5.39	5.61
Sulfate Mg/l	1.85	3.65	117	60.7	26.5	10.3	33.0	41.7	14.9
1,3,5-TNB µg/l	<0.03	<0.03	0.09	0.13	<0.03	<0.03	<0.03	<0.03	<0.03
TNT µg/l	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
2,4-DNT µg/l	<0.03	<0.03	0.44	0.95	<0.03	<0.03	<0.03	<0.03	0.08
2,6-DNT µg/l	<0.01	<0.01	0.07	0.18	<0.01	<0.01	<0.01	<0.01	<0.01

Table 8-22 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)	3.25	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)	0.26	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 ( $\mu$ g/l)	6.09	4.71	5.50	9.83	6.64
Barium ( $\mu$ g/l)	315	351	752	330	553
Cadmium ( $\mu$ g/l)	3.18	3.61	3.44	3.88	3.67
Chromium ( $\mu$ g/l)	4.81	7.57	7.57	19.6	15.5
Lead ( $\mu$ g/l)	1.59	2.06	2.06	2.72	5.84
Mercury ( $\mu$ g/l)	0.18	0.20	0.17	0.42	0.58
Selenium ( $\mu$ g/l)	7.81	3.63	5.08	5.63	5.26
Silver ( $\mu$ g/l)	4.99	4.78	4.78	5.89	8.46

(a) No data available for determination of baseline.

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

Table 8-23 Summary of the 1988 Detection Monitoring Data for the Weldon Spring Quarry Water Treatment Plant

PARAMETER	MW-1035	MW-1036	MW-1037	MW-1040	MW-1041
Uranium, total (pCi/l)	0.47	9.36	1.46	8.80	6.11
Ra-226 (pCi/l)	0.21	0.15	0.26	0.17	0.23
Ra-228 (pCi/l)	0.53	<0.67	0.52	0.58	0.54
Th-230 (pCi/l)	<0.16	<0.12	0.20	<0.14	<0.11
Th-232 (pCi/l)	<0.12	<0.09	0.43	<0.09	0.08
Chloride (mg/l)	26.4	105	3.14	32.6	5.89
Fluoride (mg/l)	0.22	0.28	0.41	0.21	<0.20
Nitrate (mg/l)	0.35	0.05	0.47	0.06	0.07
Sulfate (mg/l)	46.3	61.8	262	248	51.2
Arsenic (µg/l)	<2.00	1.88	1.46	<4.00	<4.00
Barium (µg/l)	260	197	86.4	147	335
Cadmium (µg/l)	<3.30	<3.30	<1.14	<1.14	<1.14
Chromium (µg/l)	1.04	1.74	1.10	1.00	1.05
Lead (µg/l)	<1.10	<1.60	<1.60	<1.60	0.88
Mercury (µg/l)	<0.10	<0.10	<0.10	<0.10	<0.10
Selenium (µg/l)	<3.10	<3.10	<2.52	<3.10	<3.10
Silver (µg/l)	1.28	<0.90	<0.90	<0.90	<0.90

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

Chloride baseline concentrations were exceeded in samples collected from monitoring wells MW-1035, MW-1036, and MW-1040. The sources of these excursions are unknown, but it is unlikely that the water treatment facility is contributing to the chloride concentrations because one of the wells, MW-1035, is hydraulically upgradient from the facility. Monitoring wells MW-1037 and MW-1041 do not exceed baseline and are located closer to the treatment facility than MW-1035. A potential source of chloride is the deicing agent applied to Missouri State Route 94, which is routed along the northern perimeter upgradient of the quarry water treatment facility.

The remainder of the monitoring parameters remained within baseline for each well. No detectable concentrations of nitroaromatic compounds, PCBs, polycyclic (or polynuclear) aromatic hydrocarbons, or pesticides were reported for 1998.

#### 8.6.4 Disposal Cell Groundwater Monitoring

In the *Record of Decision for the Chemical Plant Area of the Weldon Spring Site* (Ref. 9), substantive requirements of Federal and State hazardous and/or solid waste regulations have been 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) were 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. There is no set number of wells required under the RCRA, but the Missouri Sanitary Landfill regulations (10 CSR 80.3) specify a minimum of one upgradient and three downgradient wells.

Monitoring wells MW-2045 through MW-2048 (installed during 1996), and previously existing well MW-2032, comprise the disposal cell groundwater detection monitoring network. These detection monitoring wells were sampled quarterly during all of 1997 and early 1998 to provide baseline data. A statistical summary of baseline data is presented in Table 8-24. Semi-annual detection monitoring began in mid-1998, after waste placement activities were initiated. In accordance with 10 CSR 25-7.264(2)(F), a surface water monitoring program is also included in the detection monitoring program. Spring 6301 (Burgermeister Spring) has been identified as the downgradient location for this program. Sampling of this spring will yield samples representative of the quality of surface water hydraulically downgradient of the disposal cell. The following subsections describe the methods of statistical comparisons used to assess the 1998 disposal cell groundwater detection monitoring data.

### 8.6.4.1 Data Summaries

Data from the semiannual sampling events of 1998 were tabulated according to parameters and sampling location. Non-detections were tabulated with the value of one-half the detection limit, with the exception of those locations where the entire data set were reported as non-detects. Volatile compounds, semi-volatile compounds, and PCBs were not tabulated because no detections were reported in either baseline or detection monitoring results. The detection monitoring data for the first and second semiannual sampling event for 1998 are summarized in Table 8-25 and Table 8-26, respectively.

### 8.6.4.2 Statistical Methods

The initial step was to select appropriate methods to statistically compare analytical results for each parameter from the compliance well locations (MW-2032, MW-2045, MW-2046, and MW-2047) to the upgradient location (MW-2048) results. Two major limiting factors in this selection process were: (1) the large variations in the number of non-detections between parameters, and (2) pre-existing contamination for some parameters at the compliance well locations.

Statistical method selections were initially based upon the number of non-detections as suggested in the EPA guidance document *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities* (Ref. 41). The second consideration for method selection was evidence of pre-existing contamination. Method selections for each parameter are summarized in the following.

Table 8-24 Baseline Statistical Summaries for the Disposal Cell Detection Wells and Burgermeister Spring

Parameter		MW-2032	MW-2045	MW-2046	MW-2047	MW-2048	SP-6301
Chloride (mg/l)	Mean	9.56	66.07	17.56	7.96	10.05	13.13
	Std Dev	4.25	5.67	0.70	1.13	1.09	2.83
Fluoride (mg/l)	Mean	0.26	0.07	0.09	0.17	0.12	0.19
	Std Dev	0.30	0.08	0.10	0.26	0.11	0.07
Nitrate (mg/l)	Mean	54.51	1.41	1.61	60.94	0.83	8.07
	Std Dev	34.02	0.37	0.40	22.78	0.22	8.40
Sulfate (mg/l)	Mean	36.94	31.97	53.70	30.13	178.90	53.18
	Std Dev	12.45	6.65	3.09	4.64	21.08	19.30
Aluminum (µg/l)	Mean	227.7	70.80	143.20	144.30	22.90	421.60
	Std Dev	155.7	44.76	78.34	131.50	17.82	234.70
Antimony (µg/l)	Mean	8.9	7.49	8.51	8.44	6.84	3.60
	Std Dev	7.51	8.32	8.70	8.77	7.56	1.76
Arsenic (µg/l)	Mean	1.31	1.24	1.75	1.33	1.22	1.69
	Std Dev	0.62	0.64	0.90	0.86	0.48	0.55
Barium (µg/l)	Mean	257.4	181.90	190.40	248.20	48.68	98.43
	Std Dev	61.08	22.98	34.44	43.75	4.91	31.92

Table 8-24 Baseline Statistical Summaries for the Disposal Cell Detection Wells and Burgermeister Spring (Continued)

Parameter		MW-2032	MW-2045	MW-2046	MW-2047	MW-2048	SP-8301
Beryllium	Mean	0.32	0.31	0.52	0.28	0.23	0.57
( $\mu\text{g/l}$ )	Std Dev	0.4	0.23	1.08	0.20	0.15	0.58
Cadmium	Mean	0.88	0.71	0.76	0.76	0.76	1.17
( $\mu\text{g/l}$ )	Std Dev	1.21	0.63	0.84	0.64	0.95	1.51
Calcium	Mean	123.1	97.05	139.50	125.40	106.00	53.69
( $\mu\text{g/l}$ )	Std Dev	38.31	7.57	16.00	17.03	6.59	26.82
Chromium	Mean	2.45	19.24	3.26	2.59	1.68	2.42
( $\mu\text{g/l}$ )	Std Dev	1.94	20.65	1.63	2.10	2.52	1.50
Lithium	Mean	9.44	8.16	6.94	45.62	7.30	10.72
( $\mu\text{g/l}$ )	Std Dev	6.04	8.27	3.85	18.65	3.40	6.87
Magnesium	Mean	40.18	40.53	44.20	76.08	36.25	13.09
( $\mu\text{g/l}$ )	Std Dev	8.21	4.60	6.07	7.47	3.01	7.13
Manganese	Mean	22.21	102.60	74.78	69.22	6.46	9.56
( $\mu\text{g/l}$ )	Std Dev	13.51	33.26	39.12	47.47	3.84	6.38
Mercury	Mean	0.13	0.09	0.30	0.08	0.12	0.06
( $\mu\text{g/l}$ )	Std Dev	0.2	0.07	0.97	0.08	0.18	0.02
Molybdenum	Mean	3.27	6.03	3.21	6.72	2.68	2.33
( $\mu\text{g/l}$ )	Std Dev	3.99	4.54	2.56	3.19	2.71	1.28
Nickel	Mean	5.78	370.90	6.88	15.25	2.53	2.68
( $\mu\text{g/l}$ )	Std Dev	0.47	94.26	1.16	3.61	1.25	2.92
Potassium	Mean	2.45	2.79	2.99	2.51	7.87	2.87
( $\mu\text{g/l}$ )	Std Dev	0.82	0.43	0.85	0.70	12.20	0.84
Selenium	Mean	3.88	1.64	1.81	2.79	10.75	1.81
( $\mu\text{g/l}$ )	Std Dev	1.93	0.80	0.77	1.45	1.49	0.71
Silver	Mean	3.44	1.48	1.71	1.57	1.46	0.64
( $\mu\text{g/l}$ )	Std Dev	8.47	1.04	1.14	1.14	1.03	0.41
Sodium	Mean	41.2	18.21	26.12	34.32	72.54	18.76
( $\text{mg/l}$ )	Std Dev	20.23	3.23	2.86	7.28	3.95	9.01
Thallium	Mean	2.78	1.90	1.93	2.05	2.41	2.81
( $\mu\text{g/l}$ )	Std Dev	1.56	1.58	1.45	1.22	1.42	1.48
Vanadium	Mean	2.32	3.45	5.20	4.29	2.52	3.87
( $\mu\text{g/l}$ )	Std Dev	3.28	5.46	6.02	5.78	4.02	3.57
Zinc	Mean	8.07	10.21	12.73	10.46	10.31	9.84
( $\mu\text{g/l}$ )	Std Dev	7.05	7.93	7.58	7.90	7.53	7.96
C.O.D.	Mean	2.53	4.59	2.72	2.81	3.37	6.37
( $\mu\text{g/l}$ )	Std Dev	0.12	5.29	1.19	1.13	1.78	4.19
Cyanide	Mean	2.5	1.60	1.25	1.32	1.34	1.53
( $\text{mg/l}$ )	Std Dev	4.2	1.26	0.74	1.08	1.27	0.49
T.D.S.	Mean	712.8	485.70	544.50	826.90	701.40	298.90
( $\mu\text{g/l}$ )	Std Dev	217.8	28.81	36.74	88.89	84.05	100.70
T.O.C.	Mean	5.31	6.93	9.73	8.41	7.15	7.89
( $\mu\text{g/l}$ )	Std Dev	8.37	11.77	15.90	15.09	8.68	6.81
T.O.X.	Mean	27.64	17.88	71.14	11.98	29.46	11.44
( $\mu\text{g/l}$ )	Std Dev	22.87	10.84	227.20	11.83	46.14	6.89
1,3,5-TNB	Mean	0.96	0.02	1.97	ND	ND	0.03
( $\mu\text{g/l}$ )	Std Dev	0.84	0.01	0.66	-	-	0.05
1,3-DNB	Mean	0.05	0.13	0.12	0.05	ND	0.05
( $\mu\text{g/l}$ )	Std Dev	0.01	0.02	0.10	0.01	-	0.02

Table 8-24 Baseline Statistical Summaries for the Disposal Cell Detection Wells and Burgermeister Spring (Continued)

Parameter		MW-2032	MW-2045	MW-2046	MW-2047	MW-2048	SP-8301
2,4,6-TNT	Mean	2.14	ND	1.95	ND	ND	0.13
(µg/l)	Std Dev	1.75	-	0.81	-	-	0.09
2,4-DNT	Mean	0.07	0.12	0.36	0.30	ND	0.05
(µg/l)	Std Dev	0.03	0.02	0.26	0.08	-	0.04
2,6-DNT	Mean	0.62	0.58	21.94	0.70	ND	0.18
(µg/l)	Std Dev	0.43	0.13	16.68	0.21	-	0.13
Nitrobenzene	Mean	ND	ND	ND	ND	ND	ND
(µg/l)	Std Dev	-	-	-	-	-	-
Ra-226	Mean	0.36	0.31	0.31	0.41	0.21	0.22
(pCi/l)	Std Dev	0.14	0.25	0.12	0.17	0.18	0.10
Ra-228	Mean	1.17	0.72	0.78	0.53	1.23	1.29
(pCi/l)	Std Dev	1.23	0.73	1.02	0.58	1.17	0.87
Th-228	Mean	0.09	0.23	0.08	0.09	0.08	0.27
(pCi/l)	Std Dev	0.06	0.66	0.05	0.06	0.04	0.29
Th-230	Mean	0.18	0.19	0.15	0.18	0.12	0.28
(pCi/l)	Std Dev	0.18	0.24	0.11	0.18	0.09	0.38
Th-232	Mean	0.09	0.06	0.04	0.05	0.05	0.16
(pCi/l)	Std Dev	0.14	0.08	0.04	0.05	0.04	0.23
Total Uranium	Mean	3.76	0.83	0.93	1.11	1.49	50.23
(pCi/l)	Std Dev	0.88	0.44	0.30	0.19	0.20	35.84
pH	Mean	7.16	7.01	7.08	7.33	7.11	6.82
(Std. Units)	Std Dev	0.26	0.18	0.10	0.19	0.10	0.12
Spec. Cond.	Mean	1191	919.50	828.50	1138.00	1060.00	380.80
(µmhos/cm)	Std Dev	329.3	77.31	52.77	161.70	24.87	64.33

ND Not Detected  
- Not Calculated

Table 8-25 Statistical Summaries for the Disposal Cell Detection Wells and Burgermeister Spring 1<sup>st</sup> Semiannual Sampling 1998

Parameter		MW-2032	MW-2045	MW-2046	MW-2047	MW-2048	SP-8301
Chloride	Mean	6.68	60.40	17.30	8.82	8.48	3.57
(mg/l)	Std Dev	0.27	3.71	0.33	0.66	0.62	0.02
Fluoride	Mean	0.23	0.12	0.09	0.17	0.38	0.19
(mg/l)	Std Dev	0.02	0.01	0.04	0.08	0.02	0.01
Nitrate	Mean	18.60	1.85	2.00	97.08	1.33	2.55
(mg/l)	Std Dev	2.78	0.09	0.06	42.12	0.12	0.06
Sulfate	Mean	27.30	21.55	49.70	25.53	220.00	22.48
(mg/l)	Std Dev	0.48	2.00	1.46	2.15	8.29	0.10
Aluminum	Mean	100.70	32.50	76.00	111.00	8.30	2.00
(µg/l)	Std Dev	45.09	23.86	37.49	23.16	4.20	0.13
Antimony	Mean	ND	ND	ND	ND	ND	ND
(µg/l)	Std Dev	-	-	-	-	-	-
Arsenic	Mean	ND	ND	ND	ND	3.10	ND
(µg/l)	Std Dev	-	-	-	-	1.27	-
Barium	Mean	201.80	191.30	178.50	328.00	42.40	89.60
(µg/l)	Std Dev	6.08	13.72	12.40	22.67	1.95	1.83

Table 8-25 Statistical Summaries for the Disposal Cell detection Wells and Burgermeister Spring, 1<sup>st</sup> Semiannual Sampling 1998 (Continued)

Parameter		MW-2032	MW-2045	MW-2046	MW-2047	MW-2048	SP-6301
Beryllium	Mean	0.47	0.64	0.39	0.56	0.10	ND
(µg/l)	Std Dev	0.19	0.24	0.17	0.17	0.08	-
Cadmium	Mean	ND	ND	ND	ND	ND	ND
(µg/l)	Std Dev	-	-	-	-	-	-
Calcium	Mean	95.70	99.60	13.50	14.30	11.40	36.50
(mg/l)	Std Dev	2.12	5.85	0.41	2.23	0.39	0.84
Chromium	Mean	4.38	46.13	3.08	2.75	1.30	ND
(µg/l)	Std Dev	1.55	26.65	1.95	1.30	0.23	-
Cobalt	Mean	ND	5.10	ND	ND	ND	ND
(µg/l)	Std Dev	-	2.78	-	-	-	-
Copper	Mean	6.40	6.06	3.93	4.13	2.28	4.28
(µg/l)	Std Dev	6.60	2.00	1.65	2.05	0.28	2.35
Iron	Mean	157.00	362.80	244.80	298.80	9.60	1895.00
(µg/l)	Std Dev	49.77	147.81	125.30	91.84	6.64	132.29
Lead	Mean	ND	ND	ND	ND	ND	ND
(µg/l)	Std Dev	-	-	-	-	-	-
Lithium	Mean	8.65	ND	4.43	49.13	7.53	1.98
(µg/l)	Std Dev	1.68	-	2.40	22.68	0.48	0.95
Magnesium	Mean	32.13	47.25	41.70	86.15	42.95	7.64
(mg/l)	Std Dev	0.57	2.13	1.31	9.53	1.18	0.19
Manganese	Mean	9.65	67.15	29.73	33.75	1.53	26.43
(µg/l)	Std Dev	1.38	29.82	11.77	2.33	0.33	0.39
Mercury	Mean	ND	ND	ND	ND	ND	ND
(µg/l)	Std Dev	-	-	-	-	-	-
Molybdenum	Mean	ND	9.38	ND	ND	1.40	ND
(µg/l)	Std Dev	-	6.71	-	-	0.88	-
Nickel	Mean	ND	669.80	ND	ND	ND	ND
(µg/l)	Std Dev	-	256.17	-	-	-	-
Potassium	Mean	2.30	1.70	35.80	1.70	2.50	2.39
(mg/l)	Std Dev	1.08	0.56	6.12	0.92	0.11	1.08
Selenium	Mean	3.33	1.88	2.55	4.60	12.20	1.30
(µg/l)	Std Dev	1.54	1.15	0.89	1.49	1.02	0.00
Silver	Mean	3.83	ND	3.83	ND	ND	ND
(µg/l)	Std Dev	1.65	-	1.65	-	-	-
Sodium	Mean	25.10	13.70	30.10	36.30	65.70	8.37
(mg/l)	Std Dev	1.11	2.60	0.39	9.40	3.18	0.20
Thallium	Mean	2.24	ND	ND	ND	ND	ND
(µg/l)	Std Dev	1.18	-	-	-	-	-
Vanadium	Mean	8.03	8.93	12.00	13.05	ND	6.28
(µg/l)	Std Dev	1.48	0.76	1.14	0.54	-	0.15
Zinc	Mean	14.15	11.43	16.95	14.85	6.08	12.68
(µg/l)	Std Dev	4.15	4.01	4.00	3.99	3.48	2.58
C.O.D.	Mean	ND	14.80	7.60	ND	ND	24.50
(µg/l)	Std Dev	-	13.35	10.25	-	-	9.15
Cyanide	Mean	ND	0.57	ND	ND	3.79	ND
(mg/l)	Std Dev	-	0.28	-	-	2.91	-
T.D.S.	Mean	474.00	483.00	586.00	960.00	632.00	187.50
(µg/l)	Std Dev	22.00	40.00	19.00	231.80	19.00	12.40

Table 8-25 Statistical Summaries for the Disposal Cell Detection Wells and Burgermeister Spring, 1<sup>st</sup> Semiannual Sampling 1998 (Continued)

Parameter		MW-2032	MW-2045	MW-2046	MW-2047	MW-2048	SP-8301
T.O.C.	Mean	0.99	0.95	1.75	0.97	3.52	4.24
(µg/l)	Std Dev	0.34	0.31	0.11	0.32	0.57	0.06
T.O.X.	Mean	246.80	9.39	30.23	21.46	32.00	5.58
(µg/l)	Std Dev	349.60	6.88	6.09	25.83	26.75	2.31
1,3,5-TNB	Mean	0.07	0.03	3.08	0.03	ND	ND
(µg/l)	Std Dev	0.01	0.01	0.26	0.02	-	-
1,3-DNB	Mean	ND	0.16	0.05	0.06	ND	ND
(µg/l)	Std Dev	-	0.01	0.01	0.01	-	-
2,4,6-TNT	Mean	0.17	ND	2.78	ND	ND	ND
(µg/l)	Std Dev	0.03	-	0.13	-	-	-
2,4-DNT	Mean	0.07	0.14	0.19	0.38	ND	ND
(µg/l)	Std Dev	0.01	0.01	0.04	0.05	-	-
2,6-DNT	Mean	0.21	0.81	9.58	0.84	ND	ND
(µg/l)	Std Dev	0.03	0.02	2.96	0.09	-	-
Nitrobenzene	Mean	ND	ND	ND	ND	ND	ND
(µg/l)	Std Dev	-	-	-	-	-	-
Ra-226	Mean	0.60	0.19	0.15	0.23	0.37	0.13
(pCi/l)	Std Dev	0.70	0.20	0.11	0.18	0.39	0.05
Ra-228	Mean	0.58	1.12	0.51	0.49	0.81	1.55
(pCi/l)	Std Dev	0.30	0.71	0.08	0.10	0.11	1.53
Th-228	Mean	0.06	0.06	0.04	0.08	0.16	0.11
(pCi/l)	Std Dev	0.01	0.00	0.01	0.06	0.08	0.03
Th-230	Mean	0.24	0.11	0.04	0.19	0.09	0.35
(pCi/l)	Std Dev	0.06	0.06	0.01	0.07	0.02	0.07
Th-232	Mean	0.02	0.03	0.03	0.01	0.09	0.11
(pCi/l)	Std Dev	0.00	0.01	0.01	0.00	0.01	0.02
Total Uranium	Mean	3.20	0.70	1.00	1.00	1.70	20.50
(pCi/l)	Std Dev	1.31	0.23	0.60	0.06	0.11	2.59
pH	Mean	7.49	6.95	6.98	6.86	7.19	6.93
(Std. Units)	Std Dev	0.28	0.60	0.18	0.26	0.18	0.26
Spec. Cond.	Mean	777.00	922.00	927.00	1329.00	1046.00	158.00
(µmhos/cm)	Std Dev	325.00	12.00	19.00	263.20	33.00	8.00

ND Not detected  
- Not Calculated

Table 8-26 Statistical Summaries for the Disposal Cell Detection Wells and Burgermeister Spring 2<sup>nd</sup> Semiannual Sampling 1998

Parameter		MW-2032	MW-2045	MW-2046	MW-2047	MW-2048	SP-8301
Chloride	Mean	4.16	73.43	19.15	5.22	7.90	14.00
(mg/l)	Std Dev	0.66	7.80	1.29	3.40	0.15	3.38
Fluoride	Mean	0.25	0.25	0.25	0.25	0.14	0.25
(mg/l)	Std Dev	0.00	0.00	0.00	0.00	0.01	0.00
Nitrate	Mean	6.70	1.87	1.78	97.35	0.79	9.23
(mg/l)	Std Dev	4.60	0.10	0.70	72.76	0.19	0.05
Sulfate	Mean	19.23	24.06	49.85	25.25	245.50	44.20
(mg/l)	Std Dev	0.98	2.51	2.30	3.00	5.92	0.54

Table 8-26 Statistical Summaries for the Disposal Cell Detection Wells and Burgemeister Spring, 2<sup>nd</sup> Semiannual Sampling 1998 (Continued)

Parameter		MW-2032	MW-2045	MW-2048	MW-2047	MW-2046	SP-6301
Aluminum	Mean	183.25	55.50	58.33	142.00	28.01	287.30
(µg/l)	Std Dev	56.84	14.38	27.14	17.46	12.62	48.86
Antimony	Mean	ND	ND	ND	ND	ND	ND
(µg/l)	Std Dev	-	-	-	-	-	-
Arsenic	Mean	2.74	ND	1.99	ND	ND	ND
(µg/l)	Std Dev	1.72	-	1.28	-	-	-
Barium	Mean	159.50	197.30	189.80	290.50	41.55	127.00
(µg/l)	Std Dev	17.48	9.88	13.33	33.57	0.28	2.58
Beryllium	Mean	0.23	0.21	0.19	0.20	0.47	ND
(µg/l)	Std Dev	0.29	0.33	0.29	0.31	0.15	-
Cadmium	Mean	ND	ND	ND	ND	ND	ND
(µg/l)	Std Dev	-	-	-	-	-	-
Calcium	Mean	66.45	95.65	130.50	116.50	106.30	74.43
(mg/l)	Std Dev	5.18	5.52	3.00	7.59	3.10	2.11
Chromium	Mean	4.78	289.43	1.60	1.98	ND	1.10
(µg/l)	Std Dev	1.17	294.89	1.75	2.21	-	0.24
Cobalt	Mean	ND	3.01	ND	ND	ND	0.54
(µg/l)	Std Dev	-	2.27	-	-	-	0.38
Copper	Mean	4.98	9.93	2.80	4.45	ND	3.73
(µg/l)	Std Dev	1.50	6.73	0.89	0.86	-	0.56
Iron	Mean	447.30	1051.00	184.80	439.80	50.53	282.30
(µg/l)	Std Dev	184.45	949.37	83.27	163.10	17.84	85.65
Lead	Mean	1.51	ND	1.73	1.39	0.67	1.16
(µg/l)	Std Dev	0.81	-	1.20	1.08	0.27	0.63
Lithium	Mean	8.05	7.13	7.95	35.48	16.23	11.68
(µg/l)	Std Dev	4.40	7.65	2.38	9.73	1.67	0.36
Magnesium	Mean	29.75	46.15	40.73	71.38	42.08	18.93
(mg/l)	Std Dev	1.44	1.87	0.64	4.02	1.32	0.38
Manganese	Mean	24.93	36.90	24.88	40.63	5.03	9.55
(µg/l)	Std Dev	6.79	25.83	7.32	13.20	0.66	6.87
Mercury	Mean	ND	ND	ND	ND	ND	ND
(µg/l)	Std Dev	-	-	-	-	-	-
Molybdenum	Mean	3.86	35.70	2.03	3.06	ND	2.35
(µg/l)	Std Dev	1.40	30.69	2.43	1.75	-	0.38
Nickel	Mean	6.15	492.50	8.60	4.93	ND	1.11
(µg/l)	Std Dev	1.52	284.58	2.99	2.03	-	0.73
Potassium	Mean	6.51	2.32	3.51	2.45	2.83	3.00
(mg/l)	Std Dev	5.49	0.05	0.42	0.88	1.48	0.08
Selenium	Mean	1.71	2.39	1.71	1.71	11.60	2.90
(µg/l)	Std Dev	0.18	1.42	0.18	0.18	0.88	1.27
Silver	Mean	ND	ND	ND	ND	ND	ND
(µg/l)	Std Dev	-	-	-	-	-	-
Sodium	Mean	14.53	14.83	30.00	27.35	60.80	20.08
(mg/l)	Std Dev	1.37	0.48	0.59	2.49	2.46	0.33
Thallium	Mean	ND	2.78	2.13	ND	4.26	2.38
(µg/l)	Std Dev	-	1.63	1.45	-	1.69	1.14
Vanadium	Mean	3.40	6.38	4.38	4.65	15.63	1.24
(µg/l)	Std Dev	5.47	9.45	7.90	8.70	0.26	0.45

Table 8-26 Statistical Summaries for the Disposal Cell Detection Wells and Burgermeister Spring, 2<sup>nd</sup> Semiannual Sampling 1998 (Continued)

Parameter		MW-2032	MW-2045	MW-2046	MW-2047	MW-2048	SP-6301
Zinc	Mean	17.15	12.43	20.85	31.00	11.40	9.73
(µg/l)	Std Dev	3.39	6.32	5.19	24.55	0.34	1.89
C.O.D.	Mean	6.38	4.33	5.65	4.85	ND	25.85
(µg/l)	Std Dev	3.86	3.18	3.70	2.71	-	34.72
Cyanide	Mean	ND	ND	ND	2.42	2.97	ND
(mg/l)	Std Dev	-	-	-	0.17	0.88	-
T.D.S.	Mean	340.00	466.70	463.50	697.50	529.80	332.50
(µg/l)	Std Dev	34.64	11.55	109.59	95.35	348.72	55.00
T.O.C.	Mean	0.74	1.57	1.80	0.93	1.96	2.13
(µg/l)	Std Dev	0.19	0.90	0.26	0.19	0.31	0.22
T.O.X.	Mean	7.75	7.38	39.10	5.13	10.03	13.00
(µg/l)	Std Dev	2.87	1.89	31.34	1.75	2.07	5.35
1,3,5-TNB	Mean	0.03	0.04	3.40	0.04	ND	ND
(µg/l)	Std Dev	0.01	0.02	0.23	0.02	-	-
1,3-DNB	Mean	ND	0.16	ND	0.07	ND	ND
(µg/l)	Std Dev	-	0.02	-	0.01	-	-
2,4,6-TNT	Mean	0.06	ND	2.78	ND	ND	ND
(µg/l)	Std Dev	0.01	-	0.21	-	-	-
2,4-DNT	Mean	ND	0.14	0.18	0.37	ND	ND
(µg/l)	Std Dev	-	0.01	0.03	0.08	-	-
2,6-DNT	Mean	0.10	0.81	9.43	0.72	ND	0.40
(µg/l)	Std Dev	0.02	0.06	1.55	0.13	-	0.01
Nitrobenzene	Mean	ND	ND	ND	ND	ND	ND
(µg/l)	Std Dev	-	-	-	-	-	-
Ra-226	Mean	0.25	0.19	0.24	0.79	ND	0.15
(pCi/l)	Std Dev	0.11	0.05	0.10	0.48	-	0.10
Ra-228	Mean	ND	ND	0.38	ND	ND	ND
(pCi/l)	Std Dev	-	-	0.29	-	-	-
Th-228	Mean	0.23	0.12	0.20	0.23	ND	0.27
(pCi/l)	Std Dev	0.14	0.08	0.13	0.15	-	0.14
Th-230	Mean	0.36	0.23	0.37	0.20	0.13	0.36
(pCi/l)	Std Dev	0.27	0.09	0.16	0.16	0.09	0.07
Th-232	Mean	0.10	0.09	0.11	0.08	0.04	0.11
(pCi/l)	Std Dev	0.05	0.02	0.09	0.00	0.02	0.05
Total Uranium	Mean	ND	ND	ND	ND	ND	101.98
(pCi/l)	Std Dev	-	-	-	-	-	34.70
pH	Mean	7.46	7.32	7.37	7.49	7.10	6.90
(Std. Units)	Std Dev	0.52	0.39	0.16	0.11	0.28	0.12
Spec. Cond.	Mean	562.00	874.00	884.00	1,359.00	1,058.00	1,114.00
(µmhos/cm)	Std Dev	64.00	12.00	7.00	307.00	42.00	12.00

ND Not Detected  
- Not Calculated

### 8.6.4.3 Parametric Analysis of Variance

Compliance well parameters for which at least 85% of the data set results were quantified were compared to the upgradient well using a parametric one-way Analysis of Variance (ANOVA) method. The parameters meeting this criterion are listed in Table 8-27. The parametric ANOVA procedure is used to determine whether differences between the mean concentrations of the compliance wells and the mean concentration of the upgradient well are statistically significant. Compliance wells that failed this comparison were further analyzed to determine if the failures could be attributable to pre-existing concentrations in the upgradient well. Pre-existing condition determinations were made by making ANOVA statistical comparisons to upgradient wells using baseline data collected prior to cell waste placement. The data sets analyzed with the ANOVA method and results are summarized according to parameter in Table 8-27.

### 8.6.4.4 Nonparametric Analysis of Variance

Parameter data sets in which 50% to 85% of the results were quantified were analyzed using the one-way nonparametric ANOVA Kruskal-Wallis test (Ref. 41). The nonparametric ANOVA procedure is used to determine whether differences between the median concentrations of the compliance wells and the median concentration of the upgradient well are statistically

Table 8-27 Parameters Analyzed Using Parametric ANOVA

PARAMETER	% RESULTS QUANTIFIED	SEMI-ANNUAL, 1998 DATA ANOVA FAILURES	PRE-EXISTING LEVELS ABOVE UPGRADIENT CONDITIONS*
Chloride	100	MW-2045, MW-2046	MW-2045, MW-2046
Fluoride	85	No compliance well	None
Nitrate	100	MW-2047	MW-2032, MW-2047
Sulfate	100	No compliance wells	None
Barium	100	All compliance wells	All compliance wells
Calcium	100	MW-2032, MW-2045	MW-2032, MW-2046, MW-2047
Iron	95	MW-2045, MW-2046, MW-2047	All compliance wells
Magnesium	100	MW-2047	All compliance wells
Manganese	100	MW-2045, MW-2046, MW-2047	MW-2045, MW-2046, MW-2047
Sodium	100	No compliance wells	None
Vanadium	100	All compliance wells (MW-2045)	MW-2032, MW-2046, MW-2047
Zinc	100	MW-2046, MW-2047	MW-2046
TDS	100	MW-2047	MW-2032, MW-2047
TOC	90	No compliance wells	MW-2046
TOX	90	MW-2046	None
Uranium	95	MW-2032	MW-2032
pH	100	No compliance wells	None
Spec. Cond.	100	No compliance wells	None

\* As determined from Baseline ANOVA Statistical Analysis, 1997-1998.  
**Bold-Listed Locations** Failures which cannot be shown to be attributable to pre-existing elevated concentrations.

significant. Compliance wells that did not successfully pass comparisons to upgradient mean concentrations were further analyzed to determine if the failures could be attributable to pre-existing concentrations in the upgradient well. Pre-existing condition determinations were made by making ANOVA statistical comparisons to the upgradient well using baseline data collected prior to cell waste placement. The parameters analyzed using the nonparametric ANOVA method and the comparison results are summarized in Table 8-28.

#### 8.6.4.5 Test of Proportions

Parameter data sets in which only 10% to 50% of the results were quantified were analyzed using a test of proportions tests. These tests are used to determine whether differences in proportions of nondetections between the compliance wells and the upgradient well are statistically significant. Compliance wells that did not successfully pass comparisons to upgradient mean concentrations were further analyzed to determine if the failures could be attributable to pre-existing concentrations in the upgradient well. Pre-existing condition determinations were made using comparisons to upgradient baseline data collected prior to cell waste placement. The data sets analyzed using the test of proportion method and comparison results are summarized in Table 8-29.

Table 8-28 Parameters Analyzed Using Nonparametric ANOVA

PARAMETER	% RESULTS QUANTIFIED	SEMI-ANNUAL, 1998 DATA NON-PARAMETRIC ANOVA FAILURES	PRE-EXISTING LEVELS ABOVE UPGRADIENT CONDITIONS*
Aluminum	75	MW-2032	MW-2032, MW-2046, MW-2047
Chromium	65	MW-2032, MW-2045	MW-2045, MW-2046, MW-2047
Lithium	75	No compliance wells	MW-2047
Molybdenum	50	MW-2045	MW-2045, MW-2047
Potassium	80	No compliance wells	None
Selenium	75	No compliance wells	None
1,3,5-TNB	65	MW-2032, MW-2047	MW-2032, MW-2046
2,4-DNT	80	MW-2046, MW-2047	MW-2046, MW-2047
2,6-DNT	80	MW-2046, MW-2047	MW-2047
Ra-226	70	No compliance wells	MW-2047
Ra-228	75	MW-2045	MW-2032
Th-230	70	No compliance wells	MW-2047

\* As determined from Baseline ANOVA Statistical Analysis, 1997-1998.

**Bold-Listed Locations** Failures which cannot be shown to be attributable to pre-existing elevated concentrations

Table 8-29 Parameters Analyzed Using Tests of Proportions

PARAMETER	% RESULTS QUANTIFIED	SEMI-ANNUAL, 1998 DATA NON-PARAMETRIC ANOVA FAILURES	PRE-EXISTING LEVELS ABOVE UPGRADIENT CONDITIONS*
Beryllium	40	No compliance wells	None
Cobalt	15	No compliance wells	MW-2045
Copper	50	No compliance wells	MW-2045, MW-2047
Silver	10	<b>MW-2032, MW-2046</b>	None
Thallium	10	<b>MW-2032</b>	None
COD	20	No compliance wells	MW-2045, MW-2056, MW-2047
Cyanide	20	No compliance wells	MW-2032
1,3-DNB	40	No compliance wells	MW-2032, MW-2045, MW-2046
2,4,6-TNT	40	No compliance wells	MW-2032, MW-2046

\* As determined from Baseline ANOVA Statistical Analysis, 1997-1998.

**Bold-Listed Locations** Failures which cannot be shown to be attributable to pre-existing elevated concentrations

#### 8.6.4.6 Pre-Existing Contamination Parameters

Sample sets in which the first semiannual 1998 results of parameters failed upgradient comparisons, and that did not have baseline data comparisons that suggest that elevated concentrations pre-existed (listed in bold-faced type in the third columns of Table 8-27, 8-28, and 8-29) were not further compared to upgradient results. These were individually compared to the location-specific baseline results for the parameter established during 1997 and early 1998 prior to waste placement into the disposal cell. This was done to determine if the 1998 data results above baseline are statistically significant. The statistical method selection was also (as described above) based upon the percentage of quantified data points: parametric ANOVA for 85% to 100%; nonparametric ANOVA for 50% to 85%; and, test of proportions for less than 50% quantified data points per data set, respectively. The parameters, locations, selected statistical comparison and results are listed in Table 8-30.

Table 8-30 Summary of Semiannual 1998 Results Requiring Baseline Data Intra Well Comparisons

PARAMETER	LOCATIONS	STATISTICAL METHOD FOR INTRA WELL COMPARISON	INTRA WELL BASELINE COMPARISON RESULTS
Calcium	MW-2045	ANOVA	MW-2045 FAILED
Chromium	MW-2032	Nonparametric ANOVA	MW-2032 PASSED
Silver	MW-2032, MW-2046	Test of Proportion	MW-2032 and MW-2046 PASSED
Thallium	MW-2032	Test of Proportion	MW-2032 PASSED
Vanadium	MW-2046, MW-2047	ANOVA	MW-2045 and MW-2047 FAILED
Zinc	MW-2047	ANOVA	MW-2047 PASSED
1,3,5-TNB	MW-2047	Nonparametric ANOVA	MW-2047 FAILED
TOX	MW-2046	Nonparametric ANOVA	MW-2046 PASSED
Ra-228	MW-2045	Nonparametric ANOVA	MW-2045 PASSED

#### **8.6.4.7 No Statistical Comparisons**

Parameters that had no detection reported for any compliance well location were not statistically compared to upgradient values. These parameters included antimony, arsenic, cadmium, lead, mercury, nitrobenzene, PCBs, semivolatile and volatile compounds (with the exception of 1,2-DCE).

#### **8.6.4.8 Disposal Cell Detection Monitoring Summary**

Due to previously existing contamination, difficulties are encountered when making statistical comparisons of detection wells to upgradient wells. The contaminants are heterogeneously dispersed, further complicating the statistical comparisons.

Locations that were identified as having pre-existing contamination and that did not pass interwell comparisons were selected for intra-well comparisons. With the exception of the monitored analytes listed as failures in the right-hand column of Table 8-28, all statistical comparisons indicate no detection of contaminant increases for the first semiannual 1998 sampling event.

Streamlining the statistical reviewing process is currently under consideration. This includes decreasing the complexity of the analysis by reducing the number of analytes and using alternative comparisons exclusively for all locations. The streamlining elements are expected to be considered and implemented incrementally.

## 9. BIOLOGICAL MONITORING PROGRAM

### 9.1 Biological Program Highlights

- The U.S. Department of Energy (DOE) conducted its second year of monitoring the establishment of wetlands created as mitigation for disturbance of wetland habitat at the Weldon Spring Site Remedial Action Project (WSSRAP) Borrow Area (see Section 9.4.2).
- Total uranium results for sunfish collected from Busch Lakes 33 and 35 were well within background ranges (see Section 9.4.1).

### 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. 8). 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 the human ingestion pathways and dose calculations to native aquatic organisms. The remaining pathways are monitored to support biological risk assessment studies and compliance with environmental surveillance requirements.

### 9.3 Applicable Standards

DOE Order 5400.5 addresses the protection of native aquatic organisms from the 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.

The biological monitoring program provides supporting data on the possible ingestion of biota by humans for the dose estimates in Section 5. These calculations were based on the guideline from DOE Order 5400.5 stating that members of the public should not be exposed to

radiation sources as a consequence of all routine DOE activities in any one year that could cause an annual effective dose equivalent greater than 100 mrem (1 mSv).

#### 9.4 Aquatic Monitoring

Biota are primarily exposed to radionuclides and other contaminants of concern at the Weldon Spring 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 on biota at on-site and off-site properties. Uranium is the main contaminant monitored in off-site surface water.

##### 9.4.1 Fish Monitoring

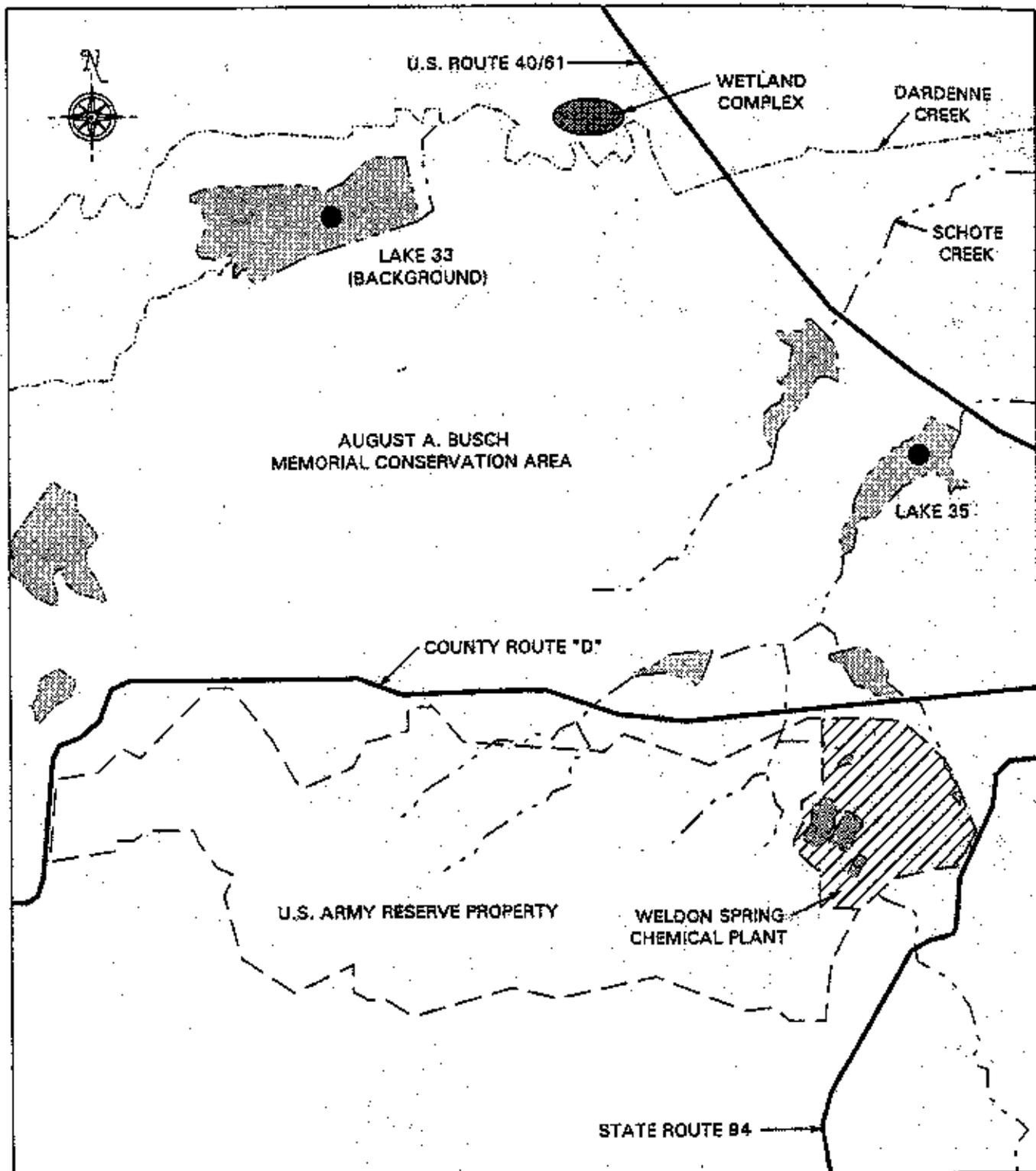
The *Environmental Monitoring Plan* (Ref. 8) requires that sunfish samples from Busch Lake 35 be collected every other year or if annual average uranium concentrations in the lake waters are found to be statistically higher than the average concentration found in previous years. Sunfish samples were collected from Busch Lakes 33 and 35 during 1998. Busch Lake 33 will be used as a background location. Sampling locations are shown on Figure 9-1.

Total uranium results for Busch Lakes 33 and 35 sunfish samples were 0.0008 pCi/g and 0.0154 pCi/g, respectively. Both of these results are well within background ranges. Laboratory quality control results were also within acceptable limits.

##### 9.4.2 Wetland Monitoring

As mitigation for the disturbance of approximately 2.2 acres of wetland habitat at the Borrow Area, the DOE has partially funded the construction of a 57 acre wetland complex. These wetlands are located within the August A. Busch Memorial Conservation Area, northeast of Lake 33. Figure 9-1 shows the wetland complex location.

In accordance with the Wetland Project Plan for COE Permit Application (Ref. 42), the DOE is responsible for establishing five acres of replacement wetlands. Monitoring the establishment of these replacement wetlands began in 1997, and will continue through calendar year 1999. The monitoring includes the collection of hydrological data (water depth, duration, extent, and saturation) and biological data (vegetation, avifauna, and herpetofauna) from the constructed wetlands. Results of the monitoring conducted in 1998 indicate that the site is highly suitable for development of a sustainable wetland. Further discussion and results can be found in the *1998 Wetlands Monitoring Report for the Weldon Spring Site Remedial Action Project* (Ref. 22).



● - BIENNIAL FISH SAMPLING LOCATIONS

**ENVIRONMENTAL MONITORING LOCATIONS**

NOT TO SCALE

**FIGURE 9-1**

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ORIGINATOR:	ED	DRAWN BY:	GLN
		DATE:	5/3/89

### 9.5 Terrestrial Monitoring

The *Environmental Monitoring Plan* (Ref. 8) stipulated that monitoring of terrestrial foodstuffs would 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, foodstuff sampling did not take place in 1998.

## 10. ENVIRONMENTAL QUALITY ASSURANCE PROGRAM INFORMATION

### 10.1 Quality Assurance Highlights

- Average relative percent differences calculated for groundwater, surface water, National Pollutant Discharge Elimination System (NPDES) samples and springs were within the 20% criterion recommended by the Contract Laboratory Program (CLP).
- The data validation program accepted 99.7% of the data selected for validation qualifying in 1998.

### 10.2 Program Overview

The environmental quality assurance program includes management of the quality assurance and quality control programs, plans, and procedures governing environmental monitoring activities at the Weldon Spring Site Remedial Action Project (WSSRAP) and at the subcontracted off-site laboratories. This section discusses the environmental monitoring standards at the WSSRAP and the goals for these programs, plans, and procedures.

The environmental quality assurance program provides the WSSRAP with reliable, accurate, and precise monitoring data. The program furnishes guidance and directives to detect and prevent quality problems from the time a sample is collected until the associated data are evaluated and utilized. Key elements in achieving the goals of this program are compliance with the quality assurance program and environmental quality assurance program procedures; personnel training; compliance assessments; use of quality control samples; complete documentation of field activities and laboratory analyses; and review of data documentation for precision, accuracy, and completeness.

#### 10.2.1 Quality Assurance Program

The *Project Management Contractor Quality Assurance Program (QAP)* (Ref. 43) establishes the quality assurance program for activities performed by the Project Management Contractor (PMC). The QAP requires compliance with the criteria of DOE Order 414.1.

#### 10.2.2 Environmental Quality Assurance Project Plan

The quality assurance requirements for WSSRAP environmental data operations are addressed in the *WSSRAP Environmental Quality Assurance Project Plan (EQAPjP)* (Ref. 44). The EQAPjP outlines the appropriate requirements of U.S. Environmental Protection Agency (EPA) QA/R-5 (Ref. 45) for characterization and routine monitoring at the WSSRAP. The EQAPjP does not supersede the QAP, but rather expands on the specific requirements of environmental monitoring and characterization activities.

The primary purpose of this document is to specify the quality assurance requirements for environmental data operations of the WSSRAP. The EQAPJP is also supported by standard operating procedures (SOPs), the *Sample Management Guide* (Ref. 46), the *Environmental Safety and Health Plan* (Ref. 47), the *Environmental Monitoring Plan* (EMP) (Ref. 8), and sampling plans written for specific environmental sampling tasks.

### 10.2.3 Sample Management Guide

The *Sample Management Guide* (SMG) (Ref. 46) summarizes the data quality requirements for collecting and analyzing environmental data. The SMG describes administrative procedures for managing environmental data and governs sampling plan preparation, data verification and validation, database administration, and data archiving. Guidance on developing data quality objectives for specific investigations is also detailed. The SMG details the specific requirements of the EQAPJP.

### 10.2.4 Environmental Monitoring and Quality Assurance Standard Operating Procedures

SOPs have been developed for routine activities at the WSSRAP. Environmental monitoring SOPs are generally administered by the Environmental Safety and Health (ES&H) Department, and Quality Assurance SOPs are administered by the Project Quality Department. These two departments are responsible for most SOPs used to administer the environmental quality assurance program described in this section. Controlled copies of SOPs are maintained in accordance with the document control requirements of the *Project Management Contractor Quality Assurance Program* (Ref. 43).

### 10.2.5 Evaluation and Presentation of Data

Analytical data are received from subcontracted analytical laboratories. Uncensored data have been used in reporting and calculations for this site environmental report where available. Uncensored data are those data that do not represent a ND (nondetect) and instead report instrument responses that quantitate to values below the reported detection limit. These types of data are designated by parentheses around the data value, for example "(1.17)". When there was no instrument response, nondetect data were used in calculations of averages at a value of one-half the detection limit (DL/2). The EPA recommends the use of the DL/2 value for statistical manipulation of data when the percentage of nondetects in the data set is small and uncensored data are not available (Ref. 48).

### **10.2.6 Independent Assessments and Appraisals**

The environmental programs are assessed by the Project Quality Department. They evaluate compliance by performing surveillances and independent assessments of the environmental programs and generate assessment reports to track deficiencies and corrective actions.

### **10.2.7 Subcontracted Off-Site Laboratories Programs**

Subcontracted off-site laboratories that performed analyses used for the preparation of this report use Contract Laboratory Program (CLP) methodologies when applicable. For certain analyses (such as radiochemical and wet chemistry) the laboratories are using EPA 600 (drinking water), or methods that are reviewed and approved by the Project Management Contractor (PMC) prior to analysis of each sample. Each of the subcontracted off-site laboratories has submitted a site-specific Quality Assurance Project Plan (QAPjP) to the WSSRAP and controlled copies of their standard operating procedures. The QAPjPs and SOPs are reviewed and approved by the PMC before any samples are shipped to the laboratory. Changes to the standard analytical protocols or methodology are documented in the controlled SOPs. All of the laboratories currently being used by the WSSRAP have had a preliminary assessment of their facilities to make sure that they have the capability to perform work according to the specifications of their contracts. Quality assurance assessments are performed routinely to inspect the laboratory facilities and operations, to ensure that the laboratories are performing analyses as specified in their contracts, and to check that WSSRAP data documentation and records are being properly maintained.

## **10.3 Applicable Standards**

Applicable standards for environmental quality assurance include: (1) use of the appropriate analytical and field measurement methodologies; (2) collection and evaluation of quality control samples; (3) accuracy, precision, and completeness evaluations; and (4) preservation and security of all applicable documents and records pertinent to the environmental monitoring programs.

### **10.3.1 Analytical and Field Measurement Methodologies**

Analytical and field measurement methodologies used at the WSSRAP comply with applicable standards required by the DOE, EPA, and the American Public Health Association. Analytical methodologies used by subcontracted laboratories for environmental monitoring follow the EPA CLP requirements (metal and organic methodologies) and the EPA drinking water and radiochemical methodologies or methods that are reviewed and approved by the PMC prior to analysis of each sample. Field measurement methodologies typically follow the

American Public Health Association Standard Methodologies for the Examination of Water and Wastewater (Ref. 49).

### **10.3.2 Quality Control Samples**

Quality control samples for environmental monitoring are collected in accordance with WSSRAP SOPs that specify the frequencies of quality control sample collection. Quality control samples are taken in accordance with guidelines in the EPA CLP (Ref. 30).

Descriptions of the QC samples collected at the WSSRAP are detailed in Table 10-1.

### **10.3.3 Accuracy, Precision, and Completeness**

At a minimum, the WSSRAP Data Validation Group determines the analytical accuracy, precision, and completeness of 10% of the environmental data collected. Data validation is required under DOE Order 5400.1.

### **10.3.4 Preservation and Security of Documents and Records**

Requirements for preservation and security of documents and records are specified in DOE Order 414.1. All documents pertinent to environmental monitoring are preserved and secured by the departments that produce them.

## **10.4 Quality Assurance Sample Results**

The quality assurance program is assessed by analyzing quality control sample results and comparing them to actual samples using the following methodology.

### **10.4.1 Duplicate Results Evaluation**

Two kinds of duplicate analyses were evaluated in 1998, matrix duplicates and secondary duplicates. The matrix duplicate analyses were performed at subcontracted laboratories from aliquots of original samples collected at the Weldon Spring site. A secondary duplicate is an additional aliquot of the original sample split by the WSSRAP and placed into a separate container and sent to a secondary laboratory. Matrix duplicates were used to assess the precision of analyses and also to aid in evaluating the homogeneity of samples or analytical interferences of sample matrixes.

Table 10-1 QC Sample Description

TYPE OF QC SAMPLE	DESCRIPTION
Water Blank (WB)	Monitors the purity of distilled water used for field blanks and decontamination of sampling equipment. Water blanks are collected directly from the distilled water reservoir in the WSSRAP laboratory.
Field Blank (FB)	Monitors potential contaminants, such as dust or volatile compounds, that may be introduced at the site of sample collection. Field blanks are collected in the field at the same time of sample collection activities.
Equipment Blank (EB)	Monitors the effectiveness of decontamination procedures used on non-dedicated sampling equipment. Equipment blanks include rinsate and filter blanks.
Trip Blank (TB)	Monitors volatile organic compounds that may be introduced during transportation or handling at the laboratory. Trip blanks shall be collected in the WSSRAP laboratory with prepurged distilled water.
Field Replicate (FR)	Monitors field conditions that may affect the reproducibility of samples collected from a given location. Field replicates are collected in the field at the same location.
Blind Duplicate	A duplicate that provides an unbiased measure of laboratory precision. Blind duplicates are additional aliquots of the routine sample taken in the field and given an altered identification code to conceal the samples identity from the laboratory.
Matrix Spike* (MS)	Assesses matrix and accuracy of laboratory measurements for a given matrix type. The results of this analysis and the routine sample are used to compute the percent recovery for each parameter.
Matrix Duplicate* (DU)	Assesses matrix and precision of laboratory measurements for inorganic parameters in a given matrix type. The results of the matrix duplicate and the routine sample are used to compute the relative percent difference for each parameter.
Matrix Spike Duplicate* (MD)	Assess matrix and precision of laboratory measurements for organic compounds. The matrix spike duplicate is spiked in the same manner as the matrix spike sample. The results of the matrix spike and matrix spike duplicate are used to determine the relative percent difference for organic parameters.
Secondary Duplicate (SD)	A duplicate that compares the primary laboratory with a secondary laboratory, providing an additional check on the performance of the primary laboratory. The secondary duplicate is an additional aliquot of the routine sample that is sent to a secondary laboratory.

\* A laboratory sample is split from the parent sample.

Generally, matrix duplicate samples were analyzed for the same parameters as the original samples at the rate of approximately one for every 20 samples. Secondary duplicate samples were collected on a monthly basis. Typically, duplicate samples were analyzed for more common parameters e.g., uranium, inorganic anions, and metals.

When matrix and secondary duplicate samples were available, the average relative percent difference was calculated. This difference represents an estimate of precision. The equation used (as specified in the USEPA Contract Laboratory Program, Inorganic Scope of Work, [Ref. 50]) was:

$$RPD = |S-D|/((S+D)/2) \times 100$$

where S = the normal sample  
D = the duplicate analysis

The relative percent difference was calculated only for samples whose analytical results exceeded five times the detection limit.

Table 10-2 summarizes the data of calculated relative percent differences for groundwater (including springs) and surface water (including National Pollutant Discharge Elimination System [NPDES]) samples. Both the matrix duplicates and the secondary duplicates are summarized together. Parameters that were not commonly analyzed for and/or were not contaminants of concern were not evaluated.

Table 10-2 Summary of Calculated Relative Percent Differences

PARAMETER	N(a)	AVG. RPD	MIN. RPD	MAX. RPD
Arsenic	27	9.88	0.00	44.7
Chemical oxygen Demand	37	6.69	0.00	22.2
Chloride	30	1.63	0.00	4.12
Chromium	34	9.31	0.00	71.00
Fluoride	30	2.06	0.00	9.60
Lead	24	7.00	0.00	51.00
Manganese	29	3.83	0.00	20.90
Mercury	6	5.48	0.00	15.10
Nitrate-N	41	1.55	0.00	7.00
Selenium	26	4.53	0.00	31.00
Sulfate	30	1.90	0.00	9.40
Total Suspended Solids	40	10.45	0.00	50.00
Uranium, Total	32	5.15	0.00	74.20

(a) Data Population

The results in Table 10-2 demonstrate that all average relative percent differences calculated were within the 20% criterion as recommended in the CLP (Ref. 50 and 51). As a result, duplicate sample analyses in 1998 were of acceptable quality.

#### 10.4.2 Blank Sample Results Evaluation

Various types of blanks are collected by the WSSRAP to assess the conditions and/or contaminants that may be present during sample collection and transportation. These conditions and contaminants are monitored by collecting samples to ensure routine samples are not being contaminated. Blank samples evaluate the:

- Environmental conditions under which the samples (i.e., volatile analyses) were shipped (trip blanks).

- Ambient conditions in the field that may affect a sample during collection (field/trip blanks).
- Effectiveness of the decontamination procedure for sampling equipment used to collect samples (equipment blanks).
- Quality of water used to decontaminate sampling equipment and/or assess the ambient conditions (distilled water blanks).
- Presence or absence of contamination potentially introduced through sample preservation and/or sample containers.

Sections 10.4.2.1 through 10.4.2.4 discuss the sample blank analyses and the potential impact of blank contamination upon the associated samples.

To consider whether samples were potentially impacted by blank contamination, all samples in the same analytical batch as the blank were reviewed. If the samples and blank had roughly the same concentration, the samples had been potentially contaminated. For all parameters except radiochemical parameters, the sample concentration had to be above the detection limit and be less than five times the blank concentration to be potentially contaminated. For radiochemical parameters to be potentially impacted by blank contamination, the concentration had to be above the detection limit and the normalized absolute difference (NAD) had to be less than 2.58.

$$NAD = \frac{|S - B|}{\sqrt{Err_S^2 + Err_B^2}}$$

where:

- S = concentration of the sample
- B = concentration of the blank
- Err<sub>S</sub> = error associated with the sample
- Err<sub>B</sub> = error associated with the blank

#### 10.4.2.1 Trip Blank Evaluation

Trip blanks are collected to assess the impact of sample collection and shipment on groundwater and surface water samples analyzed for volatile organic compounds. Trip blanks are sent to the laboratory with each shipment of volatile organic samples.

In 1998, 102 trip blanks were analyzed for volatile organic compounds. Detections for acetone were found in nine blanks, methylene chloride in six blanks, toluene in one blank and 2-butanane in two blanks. All environmental samples associated with the 18 blank detections listed above were evaluated. Thirty-one samples were potentially impacted, 14 samples detected acetone, and 17 samples detected methylene chloride. None of the other samples evaluated exceeded the recommended CLP criterion.

#### 10.4.2.2 Field Blank Evaluation

Field blank samples are collected at monitoring locations just prior to, or immediately after, actual samples are collected. The field blanks are collected to assess the ambient air conditions at the sample locations and are generally for the parameters of concern, such as uranium, anions, metals, and nitroaromatics.

In 1998, four field blanks were collected. Table 10-3 presents the ratio of detects to total number of blanks collected for each parameter having results above the detection limits. The table also presents the ratio of potentially impacted samples to the total number of samples analyzed with the blank. In cases where there were no detects in any blank, the ratio of potentially impacted samples to the total number of samples is not applicable.

Table 10-3 Summary of Field Blank Parameter Results

PARAMETER	NUMBER OF DETECTS/NUMBER OF BLANK ANALYSES	NUMBER OF POTENTIALLY IMPACTED SAMPLES
Arsenic	0 of 3 (0%)	N/A
Barium	1 of 3 (33%)	0 of 8 (0%)
Cadmium	0 of 1 (0%)	N/A
Chloride	0 of 1 (0%)	N/A
Chromium	1 of 1 (100%)	7 of 7 (100%)
Fluoride	0 of 1 (0%)	N/A
Gross Alpha	1 of 2 (50%)	13 of 15 (87%)
Gross Beta	2 of 2 (100%)	28 of 31 (90%)
Lead	0 of 1 (0%)	N/A
Nitrate as N	1 of 1 (100%)	0 of 4 (0%)
Nitroaromatics	0 of 4 (0%)	N/A
Radium-226	0 of 1 (0%)	N/A
Radium-228	0 of 1 (0%)	N/A
Selenium	0 of 1 (0%)	N/A
Silver	0 of 1 (0%)	N/A
Sulfate	1 of 4 (25%)	0 of 8 (0%)
Thorium-228	0 of 1 (0%)	N/A
Thorium-230	0 of 1 (0%)	N/A
Thorium-232	0 of 1 (0%)	N/A
Uranium, total	2 of 4 (50%)	13 of 14 (93%)
Volatiles	1 of 1 (100%)	1 of 6 (17%)
Semi-volatiles	0 of 1 (0%)	N/A

N/A Not applicable

### 10.4.2.3 Equipment and Bailer Blank Evaluation

Equipment and bailer blanks are collected by rinsing decontaminated equipment and bailers with distilled water, and collecting the rinse water. This procedure is used to determine the effectiveness of the decontamination process. At the WSSRAP, most of the groundwater samples are collected from dedicated equipment, and surface water is collected by placing the sample directly into a sample container. There were two equipment blanks collected in 1998 for non-soil sampling. There were no hits in either sample.

### 10.4.2.4 Distilled Water Blank Evaluation

Water blank samples are collected to evaluate the quality of the distilled water used to decontaminate sampling equipment and to assess whether contaminants are present in the water used for field and trip blanks. Water blank samples also serve as laboratory blanks. Generally, the water blanks were analyzed for contaminants of concern and were collected at the same time as field blanks.

In 1998, nine water blanks were collected. Table 10-4 presents the ratio of detects to the total number of blanks collected for each parameter that had results above the detection limit. The table also presents the ratio of potentially impacted samples to the total number of samples analyzed with the blank. In cases where there were no detects in any blank, the ratio of potentially impacted samples to the total number of samples is not applicable. In cases where there were no samples analyzed with the blank, a zero has been placed in that column and no percentage has been shown.

Table 10-4 Summary of Distilled Water Blank Parameter Results

PARAMETER	NUMBER OF DETECTS/NUMBER OF BLANK ANALYSES	NUMBER OF POTENTIALLY IMPACTED SAMPLES
Arsenic	1 of 8 (12%)	0
Barium	3 of 8 (38%)	0 of 9 (0%)
Cadmium	0 of 8 (0%)	N/A
Chloride	0 of 8 (0%)	N/A
Chromium	0 of 8 (0%)	N/A
Fluoride	0 of 8 (0%)	N/A
Lead	0 of 8 (0%)	N/A
Mercury	0 of 8 (0%)	N/A
Nitrate as N	8 of 9 (89%)	6 of 11 (54%)
Nitroaromatics	0 of 8 (0%)	N/A
PAHs	0 of 8 (0%)	N/A
PCBs	0 of 8 (0%)	N/A
Radium-226	3 of 8 (38%)	0
Radium-228	1 of 8 (12%)	0
Selenium	0 of 8 (0%)	N/A
Sulfate	0 of 8 (0%)	N/A
Thorium-228	0 of 8 (0%)	N/A

Table 10-4 Summary of Distilled Water Blank Parameter Results (Continued)

PARAMETER	NUMBER OF DETECTS/NUMBER OF BLANK ANALYSES	NUMBER OF POTENTIALLY IMPACTED SAMPLES
Thorium-230	4 of 8 (50%)	1 of 1 (100%)
Thorium-232	0 of 8 (0%)	N/A
Uranium, Total	4 of 8 (50%)	1 of 4 (25%)
Volatiles	1 of 6 (17%)	0

N/A Not Applicable

### 10.5 1998 Data Validation Program Summary

Data validation programs at the WSSRAP involve reviewing and qualifying at least 10% of the data collected during a calendar year. The data points represent the number of parameters analyzed (e.g., toluene), not the number of physical analyses performed (e.g., volatile organics analyses).

Table 10-5 identifies the number of quarterly and total data points that were selected for data validation, and indicates the percentage of those selected that were complete. Data points presented in this table include all sample types.

Table 10-5 WSSRAP Validation Summary for Calendar Year 1998

CALENDAR QUARTER	NO. OF DATA POINTS COLLECTED	NO. OF DATA POINTS SELECTED FOR VALIDATION	PERCENT SELECTED	NO. OF VALIDATED DATA POINTS REJECTED	COMPLETENESS <sup>(a)</sup>
Quarter 1	19,730	2,018	10.2%	0	100.0%
Quarter 2	17,070	2,279	13.3%	10	99.6%
Quarter 3	12,785	1,807	14.1%	2	99.9%
Quarter 4	23,444	2,087	8.9%	14	99.3%
1998 Total	73,034	8,191	11.2%	26	99.7%

(a) Completeness is a measure of acceptable data. The value is given by  
 Completeness =  $\frac{\# \text{ validated} - \# \text{ rejected}}{\# \text{ validated}}$

Reflects all validatable data for the calendar year.

Table 10-6 identifies validation qualifiers assigned to the selected data points as a result of data validation. The WSSRAP validation technical review was performed in accordance with the U.S. EPA *Contract Laboratory Program Statement of Work for Inorganics Analysis* (Ref. 50), the U.S. EPA *Contract Laboratory Program Statement of Work for Organic Analysis* (Ref. 48), and the *Laboratory Data Validation Guidelines for Evaluating Radionuclide Analysis* (Ref. 51). For calendar year 1998, 100.0% of data validation has been completed. Data points presented in this table include groundwater, surface water, spring and seep water, NPDES, and NESHAPs samples only.

Table 10-6 WSSRAP Validation Qualifier Summary for Calendar Year 1998

	NO. OF DATA POINTS								TOTAL
	ANIONS	METALS	MISC.	NITRO-AROMATICS	PESTICIDES /PCBs	RADIO-CHEMICAL	SEMI-VOLATILES	VOLATILES	
Accepted	74	853	187	229	616	2,558	1,565	2,085	8,165
Rejected	7	0	0	0	0	2	11	8	28
Not Validatable	0	0	0	0	0	0	0	0	0
<b>Total</b>	<b>81</b>	<b>853</b>	<b>187</b>	<b>229</b>	<b>616</b>	<b>2,558</b>	<b>1,576</b>	<b>2,091</b>	<b>8,191</b>
	PERCENTAGES								
Accepted	91.4%	100%	100.0%	100.0%	100.0%	99.9%	99.3%	99.7%	99.7%
Rejected	8.6%	0.0%	0.0%	0.0%	0.0%	0.1%	0.7%	0.3%	0.3%
Not Validatable	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>

Table 10-7 identifies the average accuracy and precision for anion, metals, nitroaromatic, radiochemical, and miscellaneous parameters. The accuracy values are based on the percent recoveries of the laboratory control samples, and the precision values are based on the relative percent difference between laboratory control sample duplicates. The data population size associated with each accuracy and precision value is listed as "N." Data points presented in this table include groundwater, surface water, spring and seep, and NPDES samples only.

Table 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1988

PARAMETER	N	LABORATORY ACCURACY			LABORATORY PRECISION		
		AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM
<b>IONS</b>							
Chloride	3	100.9	93.0	109.8	2.4	0.1	4.7
Fluoride	3	97.4	95.0	99.1	4.4	0.6	8.1
Nitrate-N	12	98.7	98.3	102.0	2.0	1.1	2.1
Sulfate	7	87.1	92.6	109.8	1.4	0.4	4.5
<b>METALS</b>							
Aluminum	1	102.5	102.5	102.5	3.5	3.5	3.5
Antimony	1	98.8	98.8	98.8	3.0	3.0	3.0
Arsenic	24	104.5	97.1	109.2	1.0	0.4	5.1
Arsenic (TCLP)	2	109.2	109.2	109.2	0.7	0.7	0.7
Barium	20	101.6	97.8	105.8	0.9	0.6	2.8
Barium (TCLP)	2	103.1	103.1	103.1	0.7	0.7	0.7
Beryllium	1	100.6	100.6	100.6	2.9	2.9	2.9
Cadmium	20	103.4	93.8	106.7	0.9	0.1	3.2
Cadmium (TCLP)	2	106.7	106.7	106.7	0.7	0.7	0.7
Calcium	1	101.5	101.5	101.5	2.5	2.5	2.5
Chromium	24	103.1	97.1	107.9	0.8	0.2	2.9
Chromium (TCLP)	2	107.9	107.9	107.9	0.8	0.8	0.8
Cobalt	1	96.8	99.8	99.8	3.1	3.1	3.1
Copper	1	100.5	100.5	100.5	3.4	3.4	3.4
Iron	1	105.8	105.8	105.8	1.9	1.9	1.9
Lead	24	103.3	96.5	108.8	0.6	0.4	3.0
Lead (TCLP)	2	108.8	108.8	108.8	0.5	0.5	0.5
Lithium	1	107.2	107.2	107.2	2.5	2.5	2.5
Magnesium	1	98.5	98.5	98.5	2.8	2.8	2.8
Manganese	1	97.8	97.8	97.8	2.5	2.5	2.5
Mercury	18	102.3	96.4	104.4	2.0	0.4	8.2
Mercury (TCLP)	2	104.4	104.4	104.4	0.4	0.4	0.4
Molybdenum	1	100.2	100.2	100.2	2.7	2.7	2.7
Nickel	1	101.8	101.8	101.8	3.4	3.4	3.4
Potassium	1	97.5	97.5	97.5	2.7	2.7	2.7
Selenium	20	100.2	96.1	103.1	0.9	0.3	2.7
Selenium (TCLP)	2	101.3	101.3	101.3	0.6	0.6	0.6

Table 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1998 (Continued)

PARAMETER	N	LABORATORY ACCURACY			LABORATORY PRECISION		
		AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM
<b>METALS (Continued)</b>							
Silver	20	98.5	83.1	103.1	1.9	0.4	10.2
Silver (TCLP)	2	102.8	102.8	102.8	0.4	0.4	0.4
Sodium	1	111.9	111.9	111.9	2.0	2.0	2.0
Thallium	5	95.8	93.2	101.1	1.4	0.8	2.8
Vanadium	1	99.5	99.5	99.5	3.2	3.2	3.2
Zinc	1	102.9	102.9	102.9	3.1	3.1	3.1
<b>MISC.</b>							
Alkalinity	1	93.0	93.0	93.0	0.8	0.8	0.8
Chemical Oxygen demand	1	98.4	98.4	98.4	0.0	0.0	0.0
Cyanide, Amenable	1	94.8	94.8	94.8	0.8	0.8	0.8
Cyanide, Total	1	102.4	102.4	102.4	2.3	2.3	2.3
Phenolics, Total	2	100.3	100.3	100.3	1.6	1.6	1.6
Total dissolved solids	1	105.7	105.7	105.7	0.6	0.6	0.6
Total organic carbon	1	105.0	105.0	105.0	0.2	0.2	0.2
TOX	1	85.3	85.3	85.3	0.8	0.8	0.8
<b>NITROAROMATICS</b>							
2,4,6-Trinitrotoluene	1	116.0	116.0	116.0	1.7	1.7	1.7
2,4-Dinitrotoluene	1	110.0	110.0	110.0	7.5	7.5	7.5
<b>PEST/PCBS</b>							
Aroclor-1016	3	86.0	86.0	86.0	1.5	1.5	1.5
Aroclor-1260	3	84.0	84.0	84.0	9.8	9.8	9.8
<b>RADIOCHEMICAL</b>							
Gross Alpha	10	91.1	61.0	107.0	8.6	0.3	27.7
Gross Beta	4	70.3	62.0	95.3	29.6	1.3	39.1
Radium-226	7	89.0	77.3	104.0	6.2	3.5	9.7
Radium-228	7	120.0	111.7	125.0	6.0	0.9	15.1
Thorium-228	8	104.6	97.0	150.3	3.3	0.6	21.5
Thorium-230	8	106.9	88.8	143.2	1.3	0.1	5.3
Thorium-232	9	99.7	93.2	130.4	2.4	0.3	13.8
Uranium, total	18	104.3	96.0	111.0	9.4	0.0	28.1
Uranium-234	1	86.0	86.0	86.0	0.4	0.4	0.4
Uranium-238	1	97.0	97.0	97.0	0.5	0.5	0.5

Table 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1998 (Continued)

PARAMETER	N	LABORATORY ACCURACY			LABORATORY PRECISION		
		AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM
<b>SEMI-VOLATILES</b>							
Acenaphthene	1	74.0	74.0	74.0	2.7	2.7	2.7
Acenaphthylene	1	80.0	80.0	80.0	2.5	2.5	2.5
Anthracene	1	89.0	89.0	89.0	1.1	1.1	1.1
Benzo(a)anthracene	1	85.0	85.0	85.0	7.9	7.9	7.9
Benzo(a)pyrene	1	70.0	70.0	70.0	6.9	6.9	6.9
Benzo(b)fluoranthene	1	77.0	77.0	77.0	8.7	8.7	8.7
Benzo(g,h,i)perylene	1	48.0	48.0	48.0	4.3	4.3	4.3
Benzo(k)fluoranthene	1	69.0	69.0	69.0	5.6	5.6	5.6
Chrysene	1	91.0	91.0	91.0	53.0	53.0	53.0
Dibenzo(a,h)anthracene	1	44.0	44.0	44.0	9.5	9.5	9.5
Fluoranthene	1	94.0	94.0	94.0	2.1	2.1	2.1
Fluorene	1	94.0	94.0	94.0	5.5	5.5	5.5
Indeno(1,2,3-CD)pyrene	1	50.0	50.0	50.0	2.0	2.0	2.0
Naphthalene	1	62.0	62.0	62.0	3.3	3.3	3.3
Phenanthrene	1	90.0	90.0	90.0	1.1	1.1	1.1
Pyrene	1	91.0	91.0	91.0	5.3	5.3	5.3
<b>VOLATILES</b>							
1,1-Dichloroethene	6	85.8	85.8	85.8	33.1	33.1	33.1
Benzene	6	89.8	89.8	89.8	9.6	9.6	9.6
Chlorobenzene	6	95.9	95.9	95.9	5.2	5.2	5.2
Toluene	6	96.3	96.3	96.3	2.8	2.8	2.8
Trichloroethene	6	91.1	91.1	91.1	2.2	2.2	2.2
Trichloroethene (TCE)	2	96.7	96.7	96.7	0.1	0.1	0.1

## 11. SPECIAL STUDIES

This section highlights significant activities and efforts at the Weldon Spring Site Remedial Action Project that support and assist in the implementation of environmental protection policies. In addition, short term environmental studies are described that support regulatory requirements not specifically covered by U.S. Department of Energy (DOE) Order 5400.1 or that were not planned in the *Environmental Monitoring Plan* (Ref. 8).

### 11.1 Off-Site Migration of Uranium in Storm Water

In an effort to determine the effect of site activities on the 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), the data for the years 1987 through 1994 were reviewed 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. 52).

These data have been updated with the inclusion of 1995, 1996, 1997, and 1998 data. This recent data did not require correction. The annual mass, annual precipitation, and mass per inch of precipitation are tabulated in Table 11-1. The annual precipitation and total annual mass discharged off site through 1998 are plotted in Figure 11-1, Figure 11-2 and Figure 11-3. The mass per inch of precipitation and annual precipitation are plotted for 1987 through 1998 for all three outfalls in Figure 11-4.

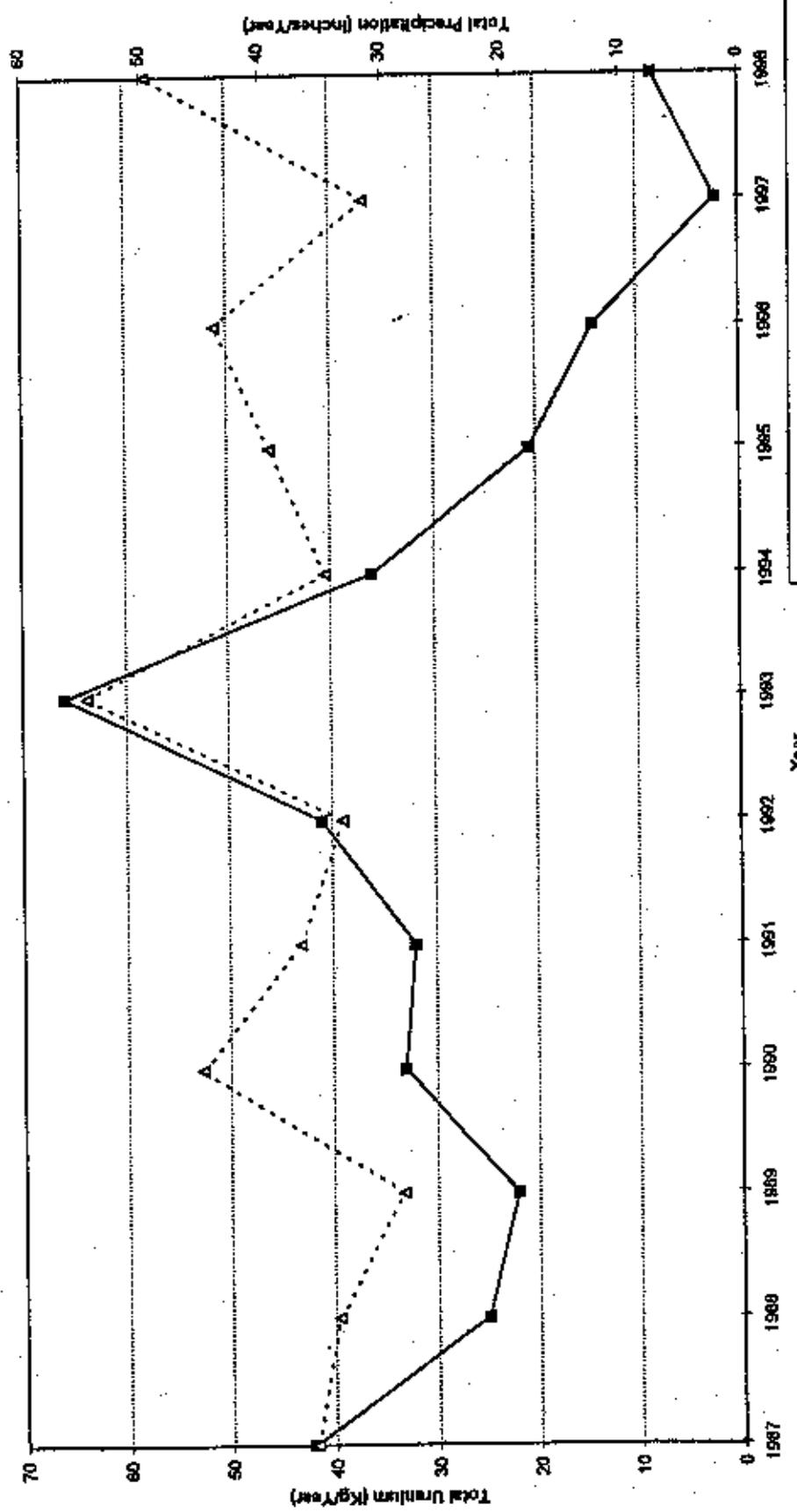
Table 11-1 Mass of Uranium Discharged from NPDES Storm Water Outfalls<sup>(a)</sup>

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
(PPT) (inches)	35.8	33.9	28.5	45.1	36.9	33.4	54.7	34.7	39.3	43.9	31.5	49.6
NP-0002 (kg)	42	25	22	33	32	41	66	36	20.6	14.3	2.3	8.4
Mass/Inch of PPT (kg/in)	1.17	0.74	0.77	0.73	0.87	1.23	1.21	1.03	0.52	0.33	0.07	0.17
NP-0003 (kg)	362	176	35	17.7	73	75	163	49	12.6	19.1	19.2	13.3
Mass/Inch of PPT (kg/in)	10.11	5.19	1.23	0.39	1.98	2.25	2.98	1.41	0.32	0.44	0.61	0.27
NP-0005 (kg)	38	26	15	25	27	16	31	12	5.0	4.0	0.5	0.57
Mass/Inch of PPT (kg/in)	1.06	0.77	0.53	0.55	0.73	0.48	0.57	0.34	0.13	0.09	0.02	0.01
Total Mass Kg(a)	442	227	72	75.7	132	132	260	97	38.2	37.4	22.0	22.3

PPT Precipitation

(a) Includes Outfalls NP-0002, NP-0003 and NP-0005. Other outfalls are negligible.

TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0002



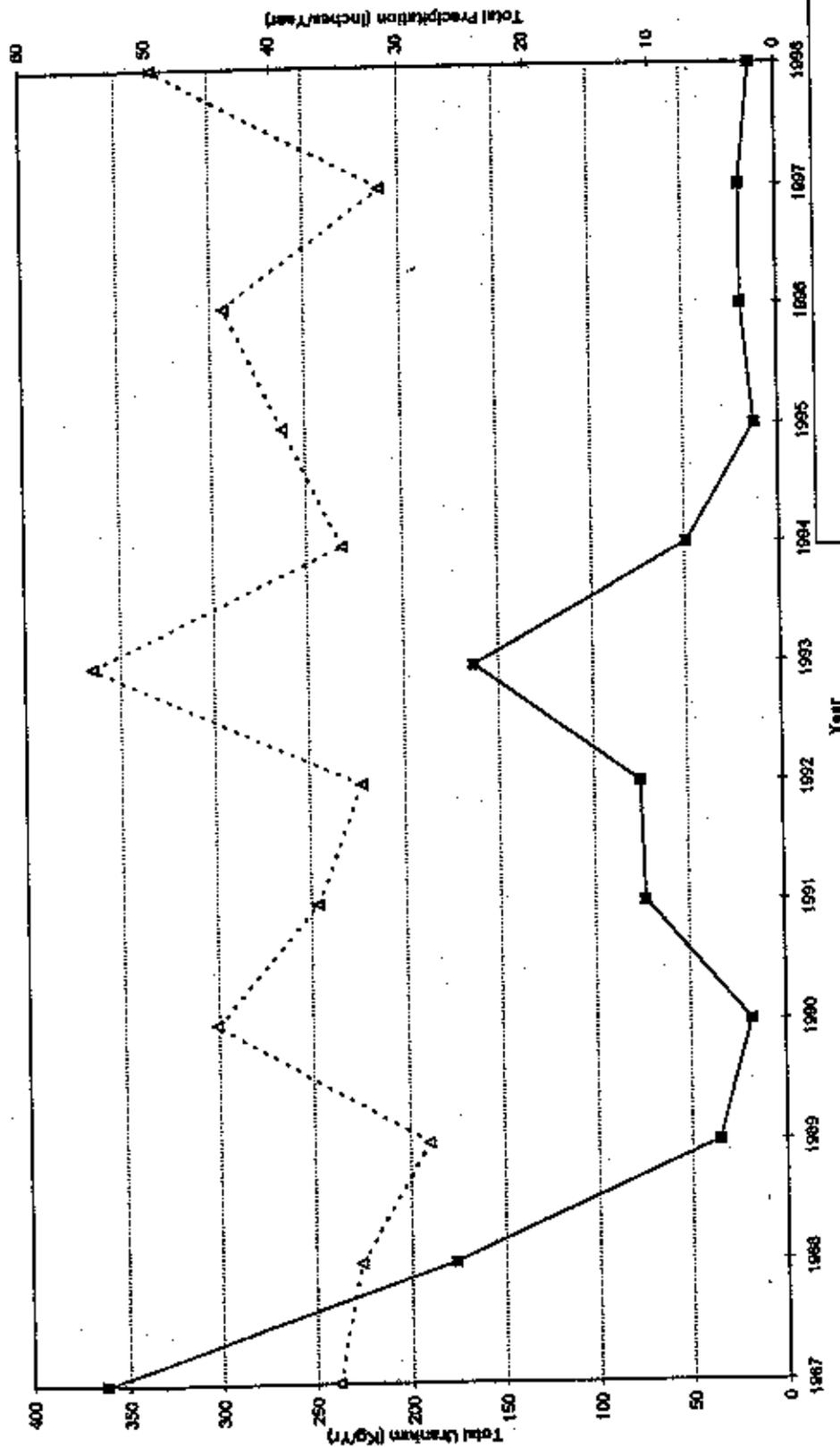
—■— MASS      - - - ▲ - - - PPT

TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0002

FIGURE 11-1

REPORT NO.:	DOE/OR/21548-773	EXHIBIT NO.:	A/PI/020/0598
ORIGINATOR:	ED	DRAWN BY:	GLN
		DATE:	5/4/99

TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0003



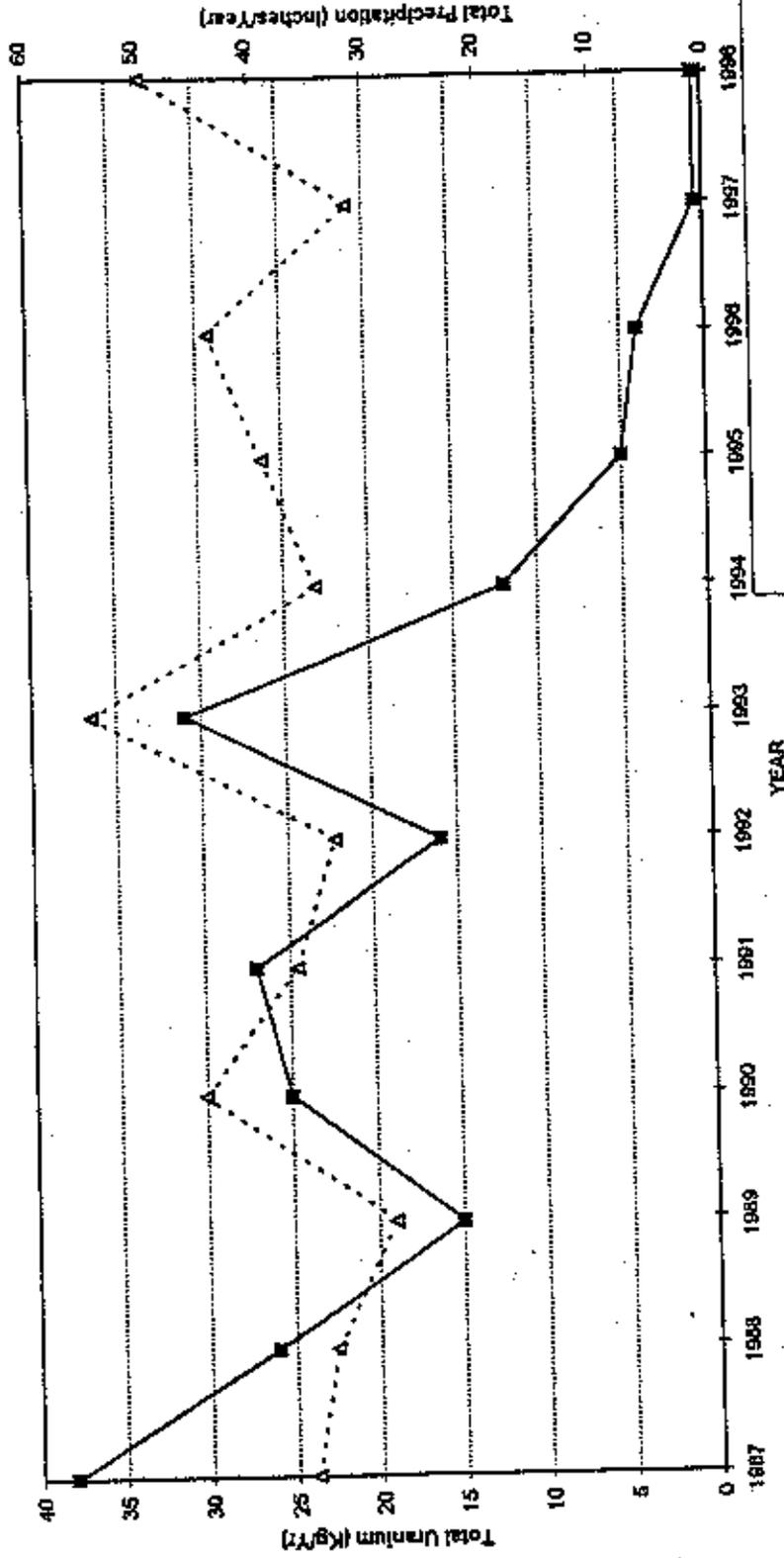
TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0003

FIGURE 11-2

—■— MASS    - - - ▲ - - - PPT

REPORT NO.: DOE/OR/21548-773	CURRENT NO.: A/P/O21/0598
OPERATOR: ED	DRAWN BY: GLN
	DATE: 5/4/99

TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0005



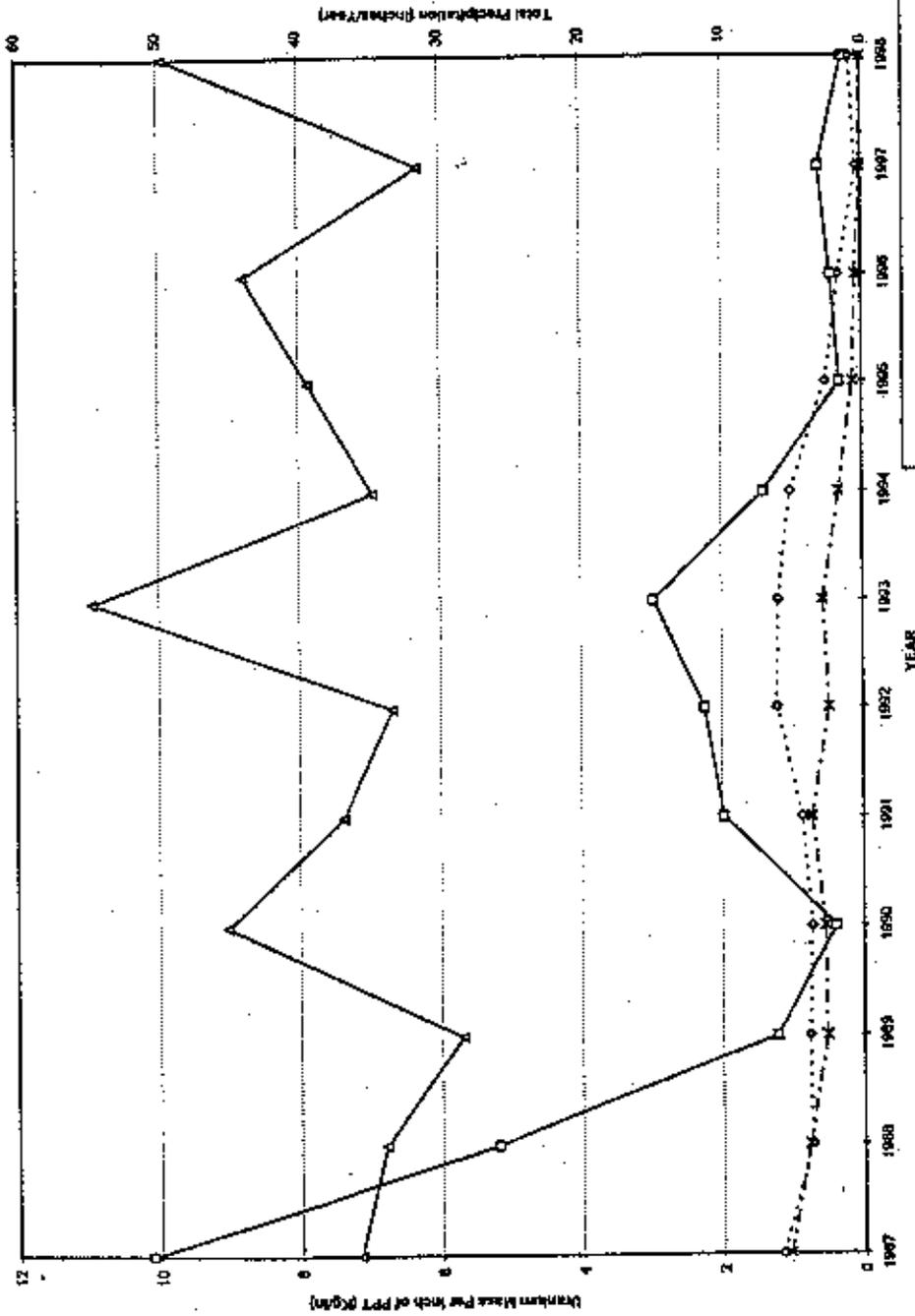
—■— MASS      - - △ - - PPT

TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0005

FIGURE 11-3

REPORT NO.: DOE/OR/21548-773	EXHIBIT NO.: A/P1/022/0598
ORIGINATOR: ED	DRAWN BY: GLN
	DATE: 5/28/99

KILOGRAMS OF URANIUM DISCHARGED PER INCH OF PRECIPITATION



KILOGRAMS OF URANIUM DISCHARGED PER INCH OF PRECIPITATION

FIGURE 11-4

REPORT NO: DOE/OR/21548-773	EXHIBIT NO: A/PI/023/0598
ORIGINATOR: ED	DRAWN BY: GLN
	DATE: 5/4/99

NP-0002 NP-0003 NP-0005 PPT

### Storm Water Outfall NP-0002

Outfall NP-0002 is downstream of the Frog Pond area and receives runoff from the eastern section of the chemical plant. Figure 11-1 indicates that uranium migrating off site initially decreased or increased in relative proportion to annual precipitation before remediation started. Building dismantlement occurred in 1992, which appears to have increased 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. During 1997, storm water was diverted around Frog Pond, and Frog Pond was removed in mid 1998. Total mass at Outfall NP-0002 increased slightly for 1998. Increase in precipitation during 1998 is suspected as the cause.

### Storm Water Outfall NP-0003

Figure 11-2 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 is 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 may be 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 have become saturated and precipitation amounts generally have been higher, 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). During 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 placed over the South Dump area of Ash Pond during 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 the 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 the storage of soil and debris in Ash Pond, the water is managed and is not discharged to the sedimentation basin unless it is less than the 600 pCi/l (22.2 Bq/l) Derived Concentration Guideline (DCG). With the storage of contaminated materials in Ash Pond, the mass of uranium at Outfall NP-0003 is expected to be highly dependent on precipitation and water discharged from Ash 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 Ash Pond. During 1998, total mass at Outfall NP-0003 was less than during 1997, even though precipitation was much higher. The decrease is assumed to be the result of management of Ash Pond water and the removal of contaminated materials from Ash Pond during 1998.

#### Storm Water Outfall NP-0005

Figure 11-3 indicates that the mass of uranium migrating off site at Outfall NP-0005 has been generally proportional with annual precipitation. Construction of the site water treatment plant, which began in 1992, appears 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. The storm water from the site water treatment plant siltation basin has historically been less than 10 pCi/l (0.37 Bq/l) for 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 during 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 is likely the result of precipitation patterns, because all three outfalls had similar reductions. The watershed for NP-0005 was remediated during 1996. This resulted in another reduction in uranium mass leaving the site in 1996. The mass of uranium migrating off site at Outfall NP-0005 for 1997 was much reduced over 1996 because 1997 was the first complete year where the watershed was almost completely

remediated. Uranium mass is expected to remain close to background levels at Outfall NP-0005. The total mass at Outfall NP-0005 remained low for 1998, despite the increased precipitation, because the area has been remediated and there was very little soil disturbance in the watershed during 1998.

#### Mass of Uranium Per Inch of Precipitation

Figure 11-4 and Table 11-1 indicate that mass of uranium migrating from the 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 contains Ash Pond, which is 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 down as a result of remediation efforts in the watershed. Outfall NP-0003 increased slightly for 1997 because of the storage of contaminated materials in Ash Pond, but decreased during 1998 despite the increase in precipitation. The mass per inch of precipitation is expected to trend downward with the completion of remediation in the watersheds of the major outfalls.

#### Annual Migration of Uranium Mass from the WSSRAP

The mass of uranium that migrated off site from the three major outfalls in 1987, before any remedial actions were taken, was 442 kg (972 lb). During 1998, 22.3 kg (49.2 lb) of uranium migrated off site, a 95% reduction from the 1987 mass. Table 11-1 shows the mass of uranium that migrated off site during 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 38.2 kg (84 lb) and 37.4 kg (82 lb). Because contaminated soil removal was completed for major sections of the site during 1996, levels for 1997 were reduced even further. The slight increase for 1998 over 1997 may be attributed to increased precipitation. Outfall NP-0003 mass has not followed this trend because the contaminated soil removed from other areas of the site is stored in Ash Pond, which is in the NP-0003 watershed. Ash Pond is managed to prevent water greater than 600 pCi/l (22.2 Bq/l) from discharging from Ash Pond; therefore, effluent at Outfall NP-0003 will not exceed 600 pCi/l (22.2 Bq/l). Additional efforts will be made, if required, to keep uranium migrating from Outfall NP-0003 as low as reasonably achievable.

#### **11.2 Baseline Monitoring at NPDES Outfalls NP-0002, NP-0003, and NP-0005**

The NPDES storm water Outfalls NP-0002, NP-0003, and NP-0005 were sampled once a month for Ra-226, Ra-228, Th-228, Th-230, Th-232, 2,4-dinitrotoluene (DNT),

2,4,6-trinitrotoluene (TNT), hazardous substance list (HSL) metals, polychlorinated biphenyls (PCBs), and polycyclic (or polynuclear) aromatic hydrocarbons (PAHs) starting in September 1994 and continuing through February 1995. These parameters were analyzed to establish baseline concentrations before removal of contaminated building foundations. The averages for the 6 months of baseline monitoring are shown in Tables 11-2 and 11-3. Radium and thorium were either detected at very low activities or not detected. The chemical parameters were also present at low levels. Baseline concentrations were calculated by using the averages in Tables 11-2 and 11-3 and adding two standard deviations. The baseline concentrations have been and will be used by data reviewers for comparison to sample data in conjunction with Procedure ES&H 1.1.7, *Environmental Data Review and Above Normal Reporting*.

Table 11-2 Average Radiological Concentrations (pCi/l) for Storm Water Outfalls NP-0002, NP-0003, NP-0005 Baseline Monitoring for September 1994 to February 1995

LOCATION	Ra-228	Ra-226	Th-228	Th-230	Th-232
NP-0002	0.45	0.88	0.53	0.34	0.35
NP-0003	0.40	0.63	0.37	0.39	0.35
NP-0005	0.48	0.94	0.31	0.29	0.26

Note: 1 pCi/l = 0.037 Bq/l

Table 11-3 Average Chemical Concentrations ( $\mu\text{g/l}$ ) for Storm Water Outfalls NP-0002, NP-0003, and NP-0005 Baseline Monitoring for September 1994 to February 1995

LOCATION PARAMETER	NP-0002	NP-0003	NP-0005
2,4-DNT	<0.20(a)	<0.20(a)	<0.20(a)
2,4,6-TNT	<0.26(a)	<0.26(b)	<0.26(a)
Al	1.840*	1.302*	3.892*
Sb	<11.67(a)	<11.67(a)	<11.67(a)
As	3.07	3.75	2.37
Ba	80.97	82.13	90.85
Be	0.48	0.37	0.37
Cd	1.42	1.42	1.42
Ca	81.100*	78.433*	67.600*
Cr	5.16	5.01	6.77
Co	3.40	3.40	3.93
Cu	7.20	5.92	7.03
Fe	1.603*	1.152*	2.888*
Pb	7.65	3.33	4.33
Li	14.23	4.95	4.33
Mg	12.215*	14.467*	12.352*
Mn	185.85	41.28	73.67
Hg	0.24	0.08	0.08
Mo	6.13	7.15	5.70
Ni	10.23	10.83	12.40
K	5.21*	5.03*	3.71*
Se	2.38	3.23	1.94
Ag	1.93	1.93	1.67
Tl	2.81	1.98	1.85

Table 11-3 Average Chemical Concentrations ( $\mu\text{g/l}$ ) for Storm Water Outfalls NP-0002, NP-0003, and NP-0005 Baseline Monitoring for September 1994 to February 1995 (Continued)

LOCATION PARAMETER	NP-0002	NP-0003	NP-0005
V	4.47	4.68	8.45
Zn	55.40	31.28	48.75
PCBs	(c)	1.0(d)	1.0(d)
PAHs	<20(e)	<20(e)	<20(e)

• mg/l.

(a) All nondetect.

(b) All nondetect with one detect of 0.0491  $\mu\text{g/l}$ .

(c) N.D. at <1.0 except 1 detect at 0.18  $\mu\text{g/l}$  and one Aroclor-1221 N.D. at D.L. of 2.0  $\mu\text{g/l}$ .

(d) Except one Aroclor-1221 N.D. at D.L. of 2.0  $\mu\text{g/l}$ .

(e) All N.D. with the maximum D.L. being 20  $\mu\text{g/l}$ .

### 11.3 Pilot Pumping Test in the TCE Area of the Chemical Plant

The volatile organic compound (VOC) trichloroethene (TCE) was detected in groundwater along the southern perimeter of the chemical plant. Initial TCE concentrations detected in 1996 in this area ranged from 0.5  $\mu\text{g/l}$  to 1,300  $\mu\text{g/l}$ . The maximum contaminant level (MCL) for TCE is 5  $\mu\text{g/l}$ . In order to evaluate potential response actions to the TCE contamination, pilot pumping tests of the upper Burlington-Keokuk were performed during 1998 in wells constructed in the TCE impacted area to:

- Determine the aquifer responses to groundwater withdrawal in the area of TCE contamination. No previous data of this type existed for this part of the site.
- Provide data such as aquifer parameters which are required to evaluate potential groundwater remediation techniques.
- Obtain groundwater samples to further delineate the distribution of TCE in groundwater.

#### 11.3.1 Scope

The following is intended to summarize the pumping test activities with primary emphasis on presenting environmental data gathered during the investigation. Detailed descriptions of aquifer tests, data analysis, hydrogeological findings and conclusions may be found in the *Completion Report for the Pilot Pumping Test for the Groundwater Operable Unit at the Weldon Spring Site* (Ref. 12).

### 11.3.2 Field Investigation

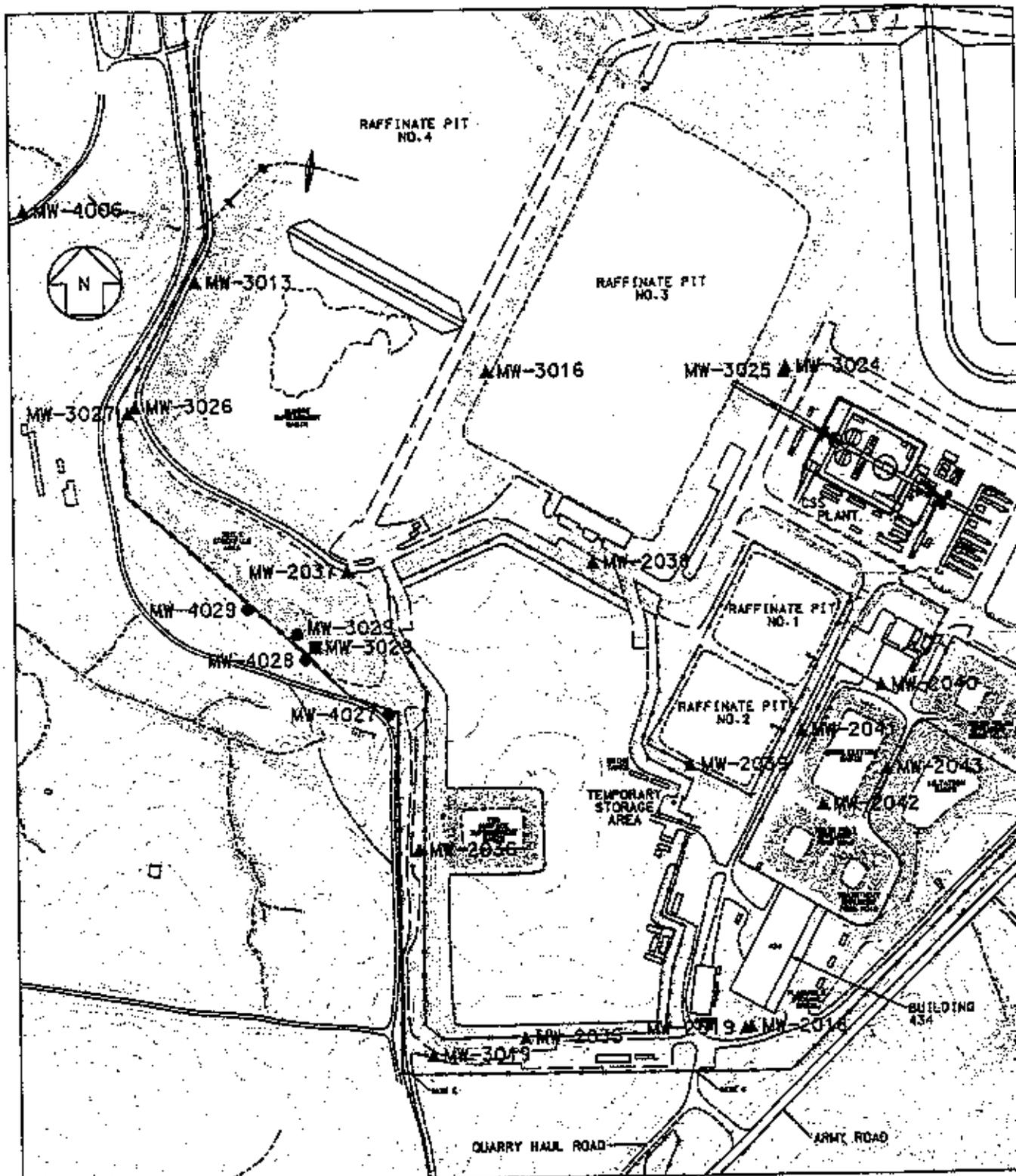
A large diameter pumping well (MW-3028) and four smaller observation wells (MW-3029, MW-4027, MW-4028, and MW-4029) were installed in the TCE impacted area beginning in May 1998. The wells were screened in the uppermost water bearing hydrostratigraphic unit at the chemical plant the weathered Burlington Keokuk Limestone. The pumping well was installed in a linear bedrock low, or paleochannel. Top of bedrock information gathered from previous investigations was used to select the most favorable location within the paleochannel. The four observation well locations were selected to optimize the monitoring of aquifer responses during the pumping tests. The locations at the pumping well and observation wells are shown on Figure 11-5. Constant head hydraulic conductivity tests were performed during installation of two of the wells (MW-3028 and MW-4027).

Pumping tests conducted during the investigation included a step drawdown test, a short term constant discharge test, and a long term constant discharge test. Groundwater drawdown and recovery were measured in the pumping well and at least four observation locations (up to 25 locations including previously existing wells, during long term pumping) during the tests. Approximately 280,000 gal of groundwater were pumped and treated at the SWTP during the tests.

Groundwater quality in the TCE area was evaluated during the pumping tests by sampling the pumped groundwater during various stages of the tests. Forty-seven samples were collected between June 10 and July 31, 1998. The majority of the samples were for TCE and dichloroethene (DCE) analyses. Other parameters analyzed included nitrate, sulfate, iron, manganese, nitroaromatic compounds and uranium. The TCE and DCE analyses were used to evaluate the potential for contaminant concentration changes or trends that may occur in response to aquifer pumping. The remaining parameters were analyzed to assess general groundwater quality in the vicinity.

### 11.3.3 Investigation Findings

During the pumping tests it was determined that a sustainable pumping rate in the TCE area is less than 10.7 gal/min. Hydraulic capture was observed over a large portion of the TCE area during long-term pumping, with drawdown response measured at an observation location 620 ft from the pumping well. Heterogeneous and anisotropic aquifer conditions were identified. The orientation of the paleochannel significantly influences groundwater hydraulics in the TCE area. A summary of aquifer hydraulic properties determined by radial flow are presented in Table 11-4. Detailed descriptions of the analyses as well as alternative methods of analysis and conclusions are found in the *Completion Report for the Pilot Pumping Test for the Groundwater Operable Unit at the Weldon Spring Site* (Ref. 12).



LEGEND

- - PUMPING WELL LOCATION
- - OBSERVATION WELL LOCATION
- ▲ - EXISTING MONITORING WELL LOCATION

0 300 600



SCALE FEET

TEST WELL LOCATIONS

FIGURE 11-5

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ORIGINATOR TO DRAWN BY GLN DATE 5/28/99

Table 11-4 Aquifer Properties by Radial Flow Analysis

Test	Method	Well	R (ft)	T (gpd/ft)	K (cm/sec) b = 19 ft
Step-Pumping	Birsoy and Summers (1980) (Ref. 10)	MW-3028	0	$7.6 \times 10^3$	$1.9 \times 10^{-2}$
Step-Recovery	Theis Recovery (1935) w/ Harrill's (1970) Correction (Refs. 12 and 13)	MW-3028	0	$6.4 \times 10^3$	$1.6 \times 10^{-2}$
Short-term Recovery	Theis Recovery (1935) (Ref. 12)	MW-3028	0	$4.9 \times 10^3$	$1.2 \times 10^{-2}$
Short-term Recovery	Theis Recovery (1935) (Ref. 12)	MW-3029	48.5	$4.9 \times 10^3$	$1.2 \times 10^{-2}$
Long-term Recovery	Theis Recovery (1935) (Ref. 12)	MW-3028	0- 204.5	$1.1 \times 10^3$ $- 1.5 \times 10^3$	$2.6 \times 10^{-3}$ $- 3.8 \times 10^{-3}$
Long-term Pumping	Cooper and Jacob (1946) - Distance-Drawdown (Ref. 25)	various	Various	$6.9 \times 10^3$	$1.7 \times 10^{-2}$

R = Radius of pumping influence  
T = Transmissivity  
K = Hydraulic conductivity  
b = Saturated thickness of aquifer

Groundwater samples were collected prior to, during, and after the conclusion of the pilot pumping test investigation. Groundwater collected prior to pumping tests included samples from the pumping well (MW-3028); two of the new observation wells (MW-4027 and MW-4029); four off-site monitoring locations (MWS-003, MWS-004, and MWS-112); and Burgermeister Spring (SP-6301). Analytical results of all groundwater samples collected during the investigation are summarized in Table 11-5.

The results for the off-site wells and Burgermeister Spring indicate that of the five locations, TCE was detected in monitoring well MWS-021 at 182  $\mu\text{g/l}$  and in MWS-004 at 0.69  $\mu\text{g/l}$ . MWS-021 is located approximately 51.8 m (170 ft) to the southwest of MW-3028 (Figure 8-2). The remaining locations were reported as non-detects. No pentachloroethene (PCE) was detected in the off-site wells or in Burgermeister Spring.

From the one-time sampling event for the observation wells, it was noted that MW-4029 exhibited a high level of TCE contamination (412  $\mu\text{g/l}$ ). No PCE was detected in this well. Results from observation well MW-4027 indicated TCE levels (4.0  $\mu\text{g/l}$ ) to be less than the MCL, while PCE was detected at 23  $\mu\text{g/l}$ . This well location is adjacent to the soil boring location where PCE was detected in soil gas at 185 parts per billion by volume (ppbv) during the 1997 soil gas survey.

Table 11-5 Analytical Data Results - Pilot Pumping Test

Date	Location/Time	TCE (µg/l)	PCE (µg/l)	DCE (µg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Iron (µg/l)	Manganese (µg/l)	Uranium (pCi/l)	Nitroaromatic Compounds (µg/l)
6/10/98	4027	4	23	*	*	*	*	*	*	*
6/10/98	3028-061098	420	ND@20	(8.0)	*	*	*	*	*	*
6/19/98	3028-STL1	470	ND@50	(15.0)	*	*	*	*	*	*
6/19/98	3028-STL2	530	ND@25	(9.0)	*	*	*	*	*	*
6/19/98	3028-STL3	530	(6.0)	(13.0)	*	*	*	*	*	*
6/19/98	3028-STL4	480	ND@25	(16.0)	*	*	*	*	*	*
7/1/98	3028-070198-01	403	21.0	*	*	*	*	*	*	*
7/1/98	3028-070198-02	532	(6.8)	*	253	*	430	25.7	0.996	0.024 - 0.77 <sup>(a)</sup>
7/1/98	3028-070198-03	517	ND@10.0	*	*	*	*	*	*	*
7/2/98	3028-070298-01	*	*	*	215	120	*	*	*	*
7/2/98	3028-070298-02	*	*	*	276	160	*	*	*	*
7/6/98	3028-070698	543	ND@6.7	*	*	*	*	*	*	*
7/6/98	6301-070698-L	ND	ND	*	*	*	*	*	*	*
7/6/98	S003-070698	ND	ND	*	*	*	*	*	*	*
7/6/98	S004-070698	(0.88)	ND	*	*	*	*	*	*	*
7/6/98	S021-070698	182	ND	*	*	*	*	*	*	*
7/6/98	S112-070698	ND	ND	*	*	*	*	*	*	*
7/10/98	4028-071098	421	ND	*	*	*	*	*	*	*
7/13/98	3028-071398-0853	435	(1.24)	*	*	*	*	*	*	*
7/13/98	3028-071398-1810	439	ND@25	*	*	*	*	*	*	*
7/14/98	3028-071498-0215	499	ND@25	*	*	*	*	*	*	*
7/14/98	3028-071498-1010	420	ND@25	*	222	110	*	*	*	*
7/14/98	3028-071498-1810	350	ND@25	*	*	*	*	*	*	*
7/15/98	3028-071598-0210	510	ND@25	*	*	*	*	*	*	*
7/15/98	3028-071598-1010	572	ND	*	174	110	*	*	*	*
7/15/98	3028-071598-2145	652	ND	*	*	*	*	*	*	*
7/16/98	3028-071698-1025	623	ND	*	*	*	*	*	*	*
7/16/98	3028-071698-2200	480	ND@10	*	*	*	*	*	*	*
7/17/98	3028-071798-1000	470	ND@10	*	*	*	*	*	*	*

Table 11-5 Analytical Data Results - Pilot Pumping Test (Continued)

Date	Location/Time	TCE (µg/l)	PCE (µg/l)	DCE (µg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Iron (µg/l)	Manganese (µg/l)	Uranium (pCi/l)	Nitroaromatic Compounds (µg/l)
7/18/98	3028-071898-0200	470	ND@10	*	*	*	*	*	*	*
7/19/98	3028-071898-0230	500	ND@10	*	*	*	*	*	*	*
7/20/98	3028-072098-0240	440	ND@10	*	*	*	*	*	*	*
7/20/98	3028-072098-1430	410	ND	*	*	*	*	*	*	*
7/21/98	3028-072198-0230	380	ND	*	*	*	*	*	*	*
7/21/98	3028-072198-1430	400	ND	*	*	*	*	*	*	*
7/22/98	3028-072298-0230	380	ND	*	*	*	*	*	*	*
7/22/98	3028-072298-1410	370	ND	*	*	*	*	*	*	*
7/23/98	3028-072398-1230	390	ND	*	*	*	*	*	*	*
7/24/98	3028-072498-1410	643	ND	*	*	*	*	*	*	*
7/25/98	3028-072598-1530	671	ND	*	*	*	*	*	*	*
7/26/98	3028-072698-0630	717	(1.53)	*	*	*	*	*	*	*
7/26/98	3028-072698-1430	701	(1.73)	*	*	*	*	*	*	*
7/27/98	3028-072798-1425	580	(1.0)	*	*	*	*	*	*	*
7/28/98	3028-072898-0956	600	ND	*	*	*	*	*	*	*
7/29/98	3028-072898-1115	510	ND	*	*	*	*	*	*	*
7/30/98	3028-073098-0940	580	ND	*	*	*	*	*	*	*
7/31/98	3028-073198-1240	590	ND	*	*	*	*	0.860	*	*
11/10/98	3028-111098	590	ND	*	*	*	*	*	*	*

(a) Individual parameters and concentrations as follows: 1,3,5-TNB= 0.33; 1,3-DNB = (0.081); 2,4,6-TNT = ND; 2,4-DNT = 0.77; 2,6-DNT = 0.12; NB = 0.024

( ) = estimated value

\* = Not analyzed

ND = Non detect

Groundwater was collected exclusively from the pumping well during the pumping tests. In monitoring well MW-3028, concentrations of TCE ranged from 370  $\mu\text{g/l}$  to 717  $\mu\text{g/l}$ , which is significantly greater than the MCL of 5  $\mu\text{g/l}$ . PCE was detected during the short-term pumping test at 21  $\mu\text{g/l}$ ; the remaining samples were primarily non-detects (82% of data). These data ranged from 1  $\mu\text{g/l}$  to 6.8  $\mu\text{g/l}$ . DCE was reported at estimated values ranging from 8  $\mu\text{g/l}$  to 16  $\mu\text{g/l}$ , well below the MCL of 100  $\mu\text{g/l}$  for this parameter.

It was observed that TCE concentrations decreased during Day 2 of the long-term pump test to the lowest value detected throughout the study (370  $\mu\text{g/l}$ ), then increased rapidly through Day 5. At this point, concentrations declined again, and during Days 8-10, concentrations were below the initial value detected during well development. After 10 days of pumping, however, TCE concentrations increased to the highest values seen throughout the study (717  $\mu\text{g/l}$ ) and remained well above 500  $\mu\text{g/l}$  for the remainder of the study. It was noted at this time "pink water" was observed during sampling of the well, indicating a connection with monitoring well MW-2037, which exhibits high levels of TCE. Rhodamine WT dye (which produces a pinkish tint to water) had been injected into MW-2037 on May 9, 1998, for the performance of a tracer test.

The observation wells have been scheduled to be routinely sampled for VOC and geochemical parameter analyses during 1999. Data from these samples will be included in subsequent annual site environmental reports.

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**DOE ORDERS**

5000.3B, *Occurrence Reporting and Processing of Information*  
5400.1, *General Environmental Protection Program*  
5400.3, *Hazardous and Mixed Waste Program*  
5400.5, *Radiation Protection of the Public and the Environment*  
5480.1B, *Environment, Safety and Health Program for Department of Energy Operations*  
5480.4, *Environmental Protection, Safety, and Health Protection Standards*  
5482.1B, *Safety Analysis and Review System*  
414.1, *Quality Assurance*  
5820.2A, *Radioactive Waste Management*

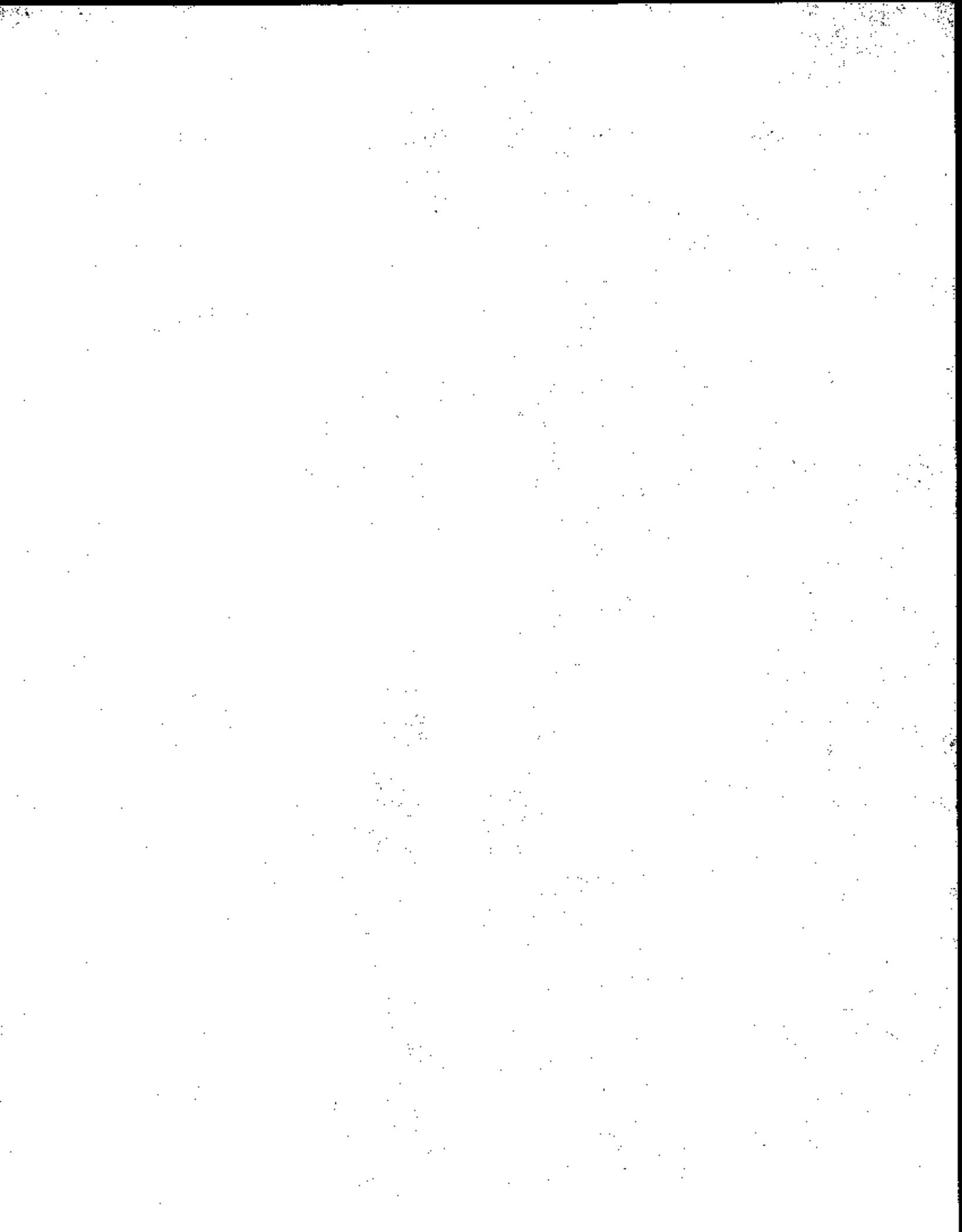
**REGULATIONS**

10 CFR 830.120, *Quality Assurance*  
10 CFR 1022, *Department of Energy, Compliance With Floodplain/Wetlands Environmental Review Requirements*  
36 CFR Part 800.5, *Protection of Historic and Cultural Properties*  
40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants*  
40 CFR Part 141, *National Primary Drinking Water Regulations*  
40 CFR 264, *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*  
40 CFR 761, *Polychlorinated Biphenyls, Manufacturing, Processing, Distribution in Commerce, and Use in Prohibitions*  
40 CFR 761.125, *Requirements for PCB Spill Cleanup*  
10 CSR 20-7.031, *Water Quality Standards*  
10 CSR 25-7, *Hazardous Waste Management Commission - Rules Applicable to Owners/Operators of Hazardous Waste Facilities*

**PROCEDURES**

ES&H 1.1.7, *Environmental Data Review and Above Normal Reporting*  
ES&H 9.1.2, *Surface Water Management*

**APPENDIX A**  
**Unpublished Documents**





UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII  
726 MINNESOTA AVENUE  
KANSAS CITY, KANSAS 66101

(action)  
Kern  
Hay  
File

AFF 26 1983

Mr. Stephen H. McCracken  
Project Manager  
Weldon Spring Site  
Route 2, Highway 94 South  
St. Charles, Missouri 63303

Dear Mr. McCracken:

As requested, we have reviewed the DOE "Draft Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors." The concept that you plan to follow meets the requirements of 40 C.F.R. 61 and you should proceed as planned.

Yearly determinations of airborne concentrations and assessments of effective dose equivalents at critical receptors meet the monitoring requirements of NESHAP. We also concur with your Quality Assurance Plan and the reporting plan you have set forth in the document.

When the temporary storage facility monitoring plan for radon is developed, we will be available to evaluate the draft if you so desire. Call me if I can be of any further assistance.

Sincerely,

Robert E. Dye  
Regional Radiation Representative



Campus Computing

8001 Natural Bridge Road  
St. Louis, Missouri 63121-4499  
Telephone: 314-516-6000  
Fax: 314-516-6007

Urban Information Specialist

May 21, 1998

Mr. Eric Danielson  
MK Ferguson  
7295 Highway 94 South  
St. Charles, MO 63304

Dear Mr. Danielson,

Following is the data you requested:

	1990	1991	1992	1993	1994	1995	1996	1997
St. Charles County	212,751	219,330	225,161	232,989	239,107	247,860	255,667	264,275
Cottleville city	453	485	509	581	774	911	1,016	
Weldon Spring city	1,034	1,056	1,079	1,104	1,114	1,144	1,170	
Weldon Spring Heights	97	97	97	98	96	96	95	

Please call me at 516-6035 if you have any questions.

Sincerely,

*Linda McDaniel*

Linda C. McDaniel  
Public Data Information Specialist

# TELECON

DATE AND TIME 11 A.M. 3/19/99

PERSON RECEIVING THE CALL Rich Kelley

CALLER John Ronchetto

ADDRESS Mo. State Highway Dept. - Weldon Springs

PHONE NUMBER 314-441-8471

CONCERN OR QUESTION Total # of employees at the  
Weldon Springs Maintenance Site

For 1998: # employees = 9

# weeks worked = 52

HOW IT WAS ADDRESSED \_\_\_\_\_

FOLLOW-UP NEEDED \_\_\_\_\_

SIGNED Rich Kelley

# TELECON

DATE AND TIME 10:44 am. 3/19/99

PERSON RECEIVING THE CALL Rick Kelley

CALLER Debbie Faber

ADDRESS Francis Howell High School

PHONE NUMBER 314-926-8773

CONCERN OR QUESTION Number of staff and students at Francis Howell High School

for 1998: # employees = approx. 140

# students = 1,660

# weeks in school = approx. 36 weeks

HOW IT WAS ADDRESSED \_\_\_\_\_

FOLLOW-UP NEEDED \_\_\_\_\_

SIGNED Rick Kelley



# Report of Telecon

To: NESHAP's file  
From: Barb Duletsky

Incoming:      Outgoing:  WP#:       
Date: 4/13/99 Time: 1030

Conversation With:  
Debbie Faber  
of: Francis Howell High School  
and:       
of:     

Phone: 314-926-8773  
Phone:     

Subject: Number of Individuals at FHHS

Summary of Conversation:

I called Debbie to clarify the information she gave  
Pick Kelley in a previous call. She confirmed that there  
was no longer a janitor residing on the high school  
grounds - he moved in 1997. She also said that  
even though school is in session only 36 weeks/year,  
the faculty spend more time than that on-site. At  
least 9 employees spend 52 weeks/year at  
the school.

Action of Follow-Up/Recommendations:

cc:       
      
    

By: Barb Duletsky

# TELECON

DATE AND TIME 10:25 A.M. 3/19/99

PERSON RECEIVING THE CALL Rick Kelley

CALLER Denise Lehmann

ADDRESS Rusch Wildlife Area

PHONE NUMBER 314-441-4554

## CONCERN OR QUESTION

For 1998: # employees = 45

# weeks worked = 52

\* visitors to site = Approx. 300,000 - 600,000

\* people at residence

across the road = 3 (employees)

Where is the residence? = Across road from  
new entrance

## HOW IT WAS ADDRESSED

## FOLLOW-UP NEEDED

SIGNED

Rick Kelley

# TELECON

DATE AND TIME 3/30/99 3pm.

PERSON RECEIVING THE CALL Rich Kelley

CALLER Karl Douber

ADDRESS Weldon Springs Training Area - Dept. of Army

PHONE NUMBER 314-441-8681

## CONCERN OR QUESTION

Met Karl at the Transition Group meeting. He gave me the following 1998 information:

# employees - Approximately 130-150

# weeks worked - 52 weeks

## HOW IT WAS ADDRESSED

## FOLLOW-UP NEEDED

SIGNED

Rich Kelley

# TELECON

DATE AND TIME 10:52 a.m. 3/19/99

PERSON RECEIVING THE CALL Rick Kelley

CALLER Jan Talbott

ADDRESS Francis Howell High School Annex Personnel

PHONE NUMBER 314-441-0088

CONCERN OR QUESTION What is the # of staff at the FHS  
Annex?

for 1998: # of employees = approx 45

# of weeks worked = 52

# residents = N/A

Whom is residence = N/A

HOW IT WAS ADDRESSED \_\_\_\_\_

FOLLOW-UP NEEDED \_\_\_\_\_

SIGNED Rick Kelley

# TELECON

DATE AND TIME 10:15 A.M. 3/19/99

PERSON RECEIVING THE CALL Rick Kelley

CALLER DANKline

ADDRESS St. Charles County Planning and Zoning

PHONE NUMBER 314-949-7335

CONCERN OR QUESTION What is the average number of people per household in St. Charles County?

DAU - explained the figure is determined every 10 years with the census. County P+Z says the 2.82 figure probably is too low now.

HOW IT WAS ADDRESSED \_\_\_\_\_

FOLLOW-UP NEEDED \_\_\_\_\_

SIGNED Rick Kelley

**APPENDIX B**  
**Assumptions and Scenarios for Dose Calculations**

## A. Dose from the Chemical Plant and Raffinate Pits to a Maximally Exposed Individual.

The following dose assessment is for a maximally exposed individual employed full-time (2,000 hours/year) at the former Weldon Spring Ordnance Works (WSOW) during 1998 located to the west of the chemical plant perimeter. This scenario was developed because 1998 monitoring results along the western site perimeter indicated above background levels of radioactive airborne particulates, radon gas, and external exposure. Remediation workers were assumed to work at the former WSOW for the entire year.

### 1. Inhalation :

- a. Airborne Radioactive Particulates: Low-volume radioactive airborne particulate monitoring results for 1998 exceeded the 52-week background average at six perimeter stations: AP-2002, AP-3003, AP-3004, AP-2005, AP-3014, and AP-2025. When compared to a 104-week background average, eight stations were found to be statistically significant: the six listed above, plus AP-4008 (Weldon Spring Army Training Area guardhouse) and AP-2001 (Missouri Highway and Transportation Department maintenance facility). The maximally exposed individual was conservatively assumed to be a WSOW remediation worker who was located near the western perimeter fence of the Weldon Spring Chemical Plant area. After subtracting the 104-week background average of  $1.22\text{E-}15$   $\mu\text{Ci/ml}$ , the highest net annual average radioactive airborne particulate concentration was  $9.0\text{E-}16$   $\mu\text{Ci/ml}$ , recorded at Station AP-3004 located just west of the TSA. The gross alpha monitoring result was assumed to consist of the radionuclides present at the TSA. An effective dose conversion factor (DCF) of  $5.0\text{E-}12$   $\mu\text{Ci/l/ml}$  per DAC was developed for the TSA, and was based on the radionuclide activity fraction assumptions listed in the *Internal Dosimetry Program Technical Basis Manual* (Ref. 56).

Inhalation dose conversion factors used to develop the effective DCF were obtained from EPA Federal Guidance Report No. 11 (Ref. 30). A breathing rate of  $1.2\text{ m}^3/\text{hr}$  was assumed for the dose estimate.

CEDE (inhalation of radioactive airborne particulates)	= net airborne particulate concentrations ( $\mu\text{Ci/ml}$ ) x 1 DAC/effective derived air concentration for the TSA ( $\mu\text{Ci/ml}$ ) x exposure time (hr) x 2.5 mrem/DAC-hr
	= $9.0\text{E-}16$ $\mu\text{Ci/ml}$ x 1 DAC/ $5.0\text{E-}12$ $\mu\text{Ci/ml}$ x 2,000 hr x 2.5 mrem/DAC-hr

$$= 0.9 \text{ mrem (0.009 mSv)}$$

- b. **Radon and Thoron Gas:** The annual average Rn-220 gas concentration measured by collocated F-type and M-type alpha-track detectors at monitoring station RD-3003 (collocated with AP-3004) was found to be statistically greater than the annual average background concentration. RD-3003 indicated a net Rn-220 concentration of 0.4 pCi/l (14.8 Bq/m<sup>3</sup>). Radon (Rn-222) gas levels did not exceed background levels at these monitoring locations during CY1998.

Radon concentrations are often expressed in terms of working levels. One working level is defined as any combination of radon decay products in one liter of air that will result in the ultimate emission of 1.3E5 MeV of alpha energy. For Rn-220, one working level (WL) is equal to 7.43 pCi/l at 100% equilibrium and results in a dose equivalent of 420 mrem. Realistically, however, only partial equilibrium can exist between Rn-220 gas and its decay products, and the daughter equilibrium ratio (the parameter that is used to quantify percent equilibrium) typically does not exceed 1% in an outdoor environment. The historical daughter equilibrium ratio for Rn-220 at the WSSRAP averages 0.5% (Ref. 53). Radon exposures can also be expressed in terms of working level months (WLM), where one WLM is defined as an exposure of one WL received in one working month (170 hours).

The committed effective dose equivalent (CEDE) to the maximally exposed individual is determined by separately considering the contribution to dose from both Rn-220 gas and Rn-220 decay products. Dose conversion factors for Rn-220 gas and decay products were taken from ICRP 32, *Limits for Inhalation of Radon Daughters by Workers* (Ref. 57).

$$\begin{aligned} \text{CEDE (Rn-220 gas)} &= \text{Rn-220 concentration} \times \text{breathing rate} \times \text{exposure} \\ &\quad \text{time} \times \text{Rn-220 dose conversion factor} \\ &= 0.4 \text{ pCi/l} \times 20 \text{ l/min} \times 2,000 \text{ hours} \times 60 \text{ min/hour} \times \\ &\quad 3.33\text{E-}7 \text{ mrem/pCi} \\ &= 0.32 \text{ mrem (0.0032 mSv)} \\ \\ \text{CEDE (Rn-220 decay} &= \text{Rn-220 concentration} \times \text{exposure time} \times \text{daughter} \\ \text{products)} &\quad \text{equilibrium ratio} \times 1 \text{ WL/7.43 pCi/l} \times 1 \text{ working} \\ &\quad \text{month/170 hours} \times 420 \text{ mrem/WLM} \\ &= 0.4 \text{ pCi/l} \times 2,000 \text{ hours} \times 0.005 \times 1 \text{ WL/7.43 pCi/l} \end{aligned}$$

$$\times 1 \text{ month}/170 \text{ hours} \times 420 \text{ mrem/WLm}$$

$$= 1.33 \text{ mrem (0.0133 mSv)}$$

$$\text{CEDE (Rn-220 gas + decay products)} = 1.65 \text{ mrem (0.0165 mSv)}$$

Summary results for a. and b., CEDE (inhalation) = 2.6 mrem (0.026 mSv).

2. External Gamma Pathway: Statistical analysis of environmental TLD results indicated that the annual exposure at station TD-3003 was greater than background (see Section 4.2). This station measured a gross annual dose equivalent of 80 mrem (0.80 mSv), based on 8,760 hours of continuous exposure. Given the background gamma dose equivalent of 58 mrem (0.58 mSv), the net annual gamma dose equivalent was 22 mrem (0.22 mSv). The effective dose equivalent (EDE) due to gamma exposure for a maximally exposed individual (MEI) at the WSOW area is thus:

$$\begin{aligned} \text{EDE (external)} &= (\text{gross TLD result} - \text{background TLD result}) \times \text{exposure time} \\ &= (80 - 58) \text{ mrem/y} \times 2,000 \text{ hr} \times 1 \text{ y}/8,760 \text{ hr} \\ &= 5.0 \text{ mrem (0.050 mSv)} \end{aligned}$$

3. Ingestion Pathway: Because no bodies of water exist at the WSOW area, fishing, swimming, and ingestion of contaminated water do not constitute realistic scenarios.

The total effective dose equivalent (TEDE) is therefore:

$$\begin{aligned} \text{TEDE} &= \text{CEDE (inhalation)} + \text{EDE (external)} \\ &= 7.6 \text{ mrem (0.076 mSv)} \end{aligned}$$

#### B. Dose from the Weldon Spring Quarry to a Maximally Exposed Individual

Because no air monitoring results at the quarry exceeded background levels in 1998, and ingestion pathways are implausible (access to the quarry area is restricted by a chain link fence), no dose assessment is necessary for an individual located near the quarry.

#### C. Dose from the Vicinity Properties to a Maximally exposed Individual

Burgermeister Spring, located at the Busch Memorial Conservation Area, contains elevated concentrations of radium, thorium, and uranium. It is assumed that an individual walked past

Burgermeister Spring once a week during 1998, stopping during each visit to drink one cup (0.237 l) of water from the spring. Since there are 52 weeks in a year, the individual ingests (52 x 0.237) liters of water, or 12.3 liters (3.24 gal). No radiological exposure is calculated for the individual for inhalation or external exposure because environmental monitoring results indicated radioactive air particulate, gamma exposure, and radon to be no greater than background levels at this location.

The maximum net concentrations recorded in 1998 for the radionuclides detected in Burgermeister Spring and their corresponding dose conversion factors (DCFs) for ingestion are:

RADIONUCLIDE	1998 MAXIMUM RECORDED CONCENTRATION (pCi/l) <sup>(a)</sup>	DOSE CONVERSION FACTOR FOR INGESTION (mrem/pCi)
Total Uranium	154	2.69E-4 (Soluble)
Ra-226	0.936	1.33E-3
Ra-228	3.85	1.44E-3
Th-228	0.383	3.98E-4
Th-230	0.457	5.48E-4
Th-232	0.184	2.73E-3
Ra-224	0.383	3.86E-4
Pb-212	0.383	4.58E-5

(a) Ra-224 and Pb-212 concentrations derived from measured Th-228 concentration, based on assumption of secular equilibrium.

The above DCFs are derived or taken directly from EPA's *Federal Guidance Report No. 11* (Ref. 30).

The total effective dose equivalent (TEDE) is calculated by summing the doses contributed by each radionuclide present in the water, as shown below:

$$\text{TEDE (ingestion of contaminated water)} = \text{TEDE (total uranium)} + \text{TEDE (Ra-226)} + \text{TEDE (Ra-228)} + \text{TEDE (Th-228)} + \text{TEDE (Th-230)} + \text{TEDE (Th-232)} + \text{TEDE (Ra-224)} + \text{TEDE (Pb-212)}$$

and

$$\text{TEDE (ingestion of contaminated water for a given radionuclide)} = \text{Concentration (pCi/l)} \times \text{Volume of Water Ingested (L)} \times \text{Dose Conversion Factor (mrem/pCi)}$$

$$\begin{aligned} \text{TEDE (total uranium)} &= 154 \text{ pCi/l} \times 12.3 \text{ l} \times 2.69\text{E-}4 \text{ mrem/pCi} \\ &= 0.51 \text{ mrem} \end{aligned}$$

TEDE (Ra-226)	= 0.936 pCi/l x 12.3 l x 1.33E-3 mrem/pCi
	= 0.0153 mrem
TEDE (Ra-228)	= 3.85 pCi/l x 12.3 l x 1.44E-3 mrem/pCi
	= 0.068 mrem
TEDE (Th-228)	= 0.383 pCi/l x 12.3 l x 3.94E-4 mrem/pCi
	= 0.0019 mrem
TEDE (Th-230)	= 0.457 pCi/l x 12.3 l x 5.48E-4 mrem/pCi
	= 0.0031 mrem
TEDE (Th-232)	= 0.184 pCi/l x 12.3 l x 2.73E-3 mrem/pCi
	= 0.0062 mrem
TEDE (Ra-224)	= 0.383 pCi/l x 12.3 l x 3.66E-3 mrem/pCi
	= 0.0172 mrem
TEDE (Pb-212)	= 0.383 pCi/l x 12.3 l x 4.56E-5 mrem/pCi
	= 0.0002 mrem

Thus, the TEDE for all radionuclides combined is  $(0.51 + 0.0153 + 0.068 + 0.0019 + 0.0031 + 0.0062 + 0.0172 + 0.0002)$  mrem, or 0.62 mrem ( $6.2E-3$  mSv).

#### D. Collective Population Effective Dose Equivalent (CPEDE)

Exposure points are locations where members of the public are potentially being exposed to above-background concentrations of (1) airborne radioactive particulates, (2) radon gas concentrations, (3) external gamma radiation, or (4) radionuclides in food or water. All four pathways are addressed for the CPEDE. Exposure to above-background radionuclide concentrations in food or water is applicable only for users of the Busch Conservation Area, a recreational area adjacent to the chemical plant/raffinate pits area.

Exposure points, by definition, must be located where there is potential for public exposure as a result of activities performed at the site or from materials stored at the site. If there is no

reason to suspect that environmental monitoring results are different from the appropriate background monitoring results, then the area surrounding the environmental monitoring station is not be considered an exposure point. Therefore, neither the population near that station nor the population beyond the station would be included in the CPEDE.

A collective population dose assessment is performed at the exposure points where above background environmental monitoring results are obtained and a potential for public exposure is suspected. All five applicable pathways are addressed for this estimate.

#### 1. Airborne Radioactive Particulates

In 1998, annual average airborne radionuclide concentrations (as measured by high volume monitors) at all critical receptor locations were indistinguishable from background. However, a statistical analysis of low volume monitoring results indicated that, at the 95% confidence level, seven chemical plant perimeter locations had ambient gross alpha concentrations greater than the 104-week background average. Four of these stations, AP-2001, AP-2005, AP-2008, and AP-3004, are in areas likely to be frequented by members of the public. Station AP-2001 is located near the Missouri Highway and Transportation Department Maintenance Facility, where nine employees worked approximately 2,000 hours each in 1998. Stations AP-2005 and AP-2008 are located near the WSSRAP office buildings and trailers, where approximately 300 employees work an assumed average of about 2,500 hours per year. Because the area is under DOE control, these individuals are not considered members of the public, but are treated as such for purposes of determining a collective population effective dose equivalent. Station AP-3004, west of the TSA, is near the Weldon Spring Ordnance Works (WSOW) remediation project, where approximately 150 employees were assumed to have worked 2,000 hours in 1998.

The annual gross alpha concentration at Station AP-2001 was  $2.4E-16$   $\mu\text{Ci/l}$  above the 104 week background average. The annual gross alpha concentration at Stations AP-2005 and AP-2008 were  $3.6 E-16$   $\mu\text{Ci/ml}$  and  $6.0E-16$   $\mu\text{Ci/ml}$ , respectively above the 104-week background average. The AP-2008 result is used in the calculation below for the CPEDE because it is higher than the result measured by AP-2005. It is assumed that the gross alpha concentration at AP-2001 and AP-2008 is contributed by the radionuclides common to the disposal cell. As stated earlier, it is assumed that the gross alpha concentration at AP-3004 is contributed by the radionuclides common to the TSA. The generic equation used to calculate CPEDE due to inhalation of radioactive airborne particulates is:

Collective Population Effective Dose Equivalent (inhalation of air particulates) = Net airborne particulate concentration ( $\mu\text{Ci/ml}$ ) x Appropriate Effective Derived Air

Concentration ( $\mu\text{Ci/ml}$ )-<sup>1</sup> Exposure time (hours) x 2.5 mrem/DAC-hr x number of individuals

$$\begin{aligned} \text{CPEDE (AP-2001)} &= 2.4\text{E-}16 \mu\text{Ci/ml} \times 1 \text{ DAC}/5.9\text{E-}12 \mu\text{Ci/ml} \times 2,000 \text{ hr} \times \\ &2.5 \text{ mrem/DAC-hr} \times 9 \text{ persons} \times 1\text{E-}3 \text{ rem/mrem} \\ &= 0.00183 \text{ person-rem (1.83E-5 person-Sv)} \end{aligned}$$

$$\begin{aligned} \text{CPEDE (AP-2008)} &= 6.0\text{E-}16 \mu\text{Ci/ml} \times 1 \text{ DAC}/5.9\text{E-}12 \mu\text{Ci/ml} \times 2,500 \text{ hours} \times \\ &2.5 \text{ mrem/DAC-hr} \times 300 \text{ persons} \times 1 \text{ E-}3 \text{ rem/mrem} \\ &= 0.191 \text{ person-rem (1.91 E-3 person-Sv)} \end{aligned}$$

$$\begin{aligned} \text{CPEDE (AP-3004)} &= 9.0\text{E-}16 \mu\text{Ci/ml} \times 1 \text{ DAC}/5.0\text{E-}12 \mu\text{Ci/ml} \times 2.5 \text{ mrem/DAC-hr} \\ &2,000 \text{ hr} \times 150 \text{ persons} \times 1\text{E-}3 \text{ rem/mrem} \\ &= 0.135 \text{ person-rem (1.35E-3 person-Sv)} \end{aligned}$$

## 2. Radon/Thoron Gas Exposures

Statistical analysis of annual integrated radon (Rn-220 and Rn-222) alpha track monitoring results indicated that all critical receptor stations had concentrations that were indistinguishable from the annual average background concentration. However, the annual average Rn-220 result at Station RD-3003 exceeded the background concentration by 0.4 pCi/l. Although not a critical receptor location, RD-3003 is collocated with AP-3004 on the western site perimeter near the TSA, and is near the WSOW remediation project.

Using the CEDE calculated in Section A of this Appendix and assuming that 150 full time employees worked on the WSOW remediation project during 1998, the CPEDE due to inhalation of Rn-220 and its decay products is:

$$\begin{aligned} \text{CPEDE (RD-3003)} &= 1.65 \text{ mrem} \times 150 \text{ persons} \times 1 \text{ rem}/1,000 \text{ mrem} \\ &= 0.248 \text{ person-rem (2.48E-3 person-Sv)} \end{aligned}$$

## 3. External Gamma Pathway

The two above-background gamma monitoring locations likely to be frequented by members of the public in 1998 were Station TD-2004, located near the MHTD facility, and Station TD-3003, located near the WSOW remediation project. The generic equation

used to calculate collective population effective dose equivalent due to external exposure is:

$$\text{CPEDE} = \text{Net measured exposure (mrem)} \times \text{exposure time hr}/8,760 \text{ hr} \times \# \text{ person} \times 1 \text{ rem}/1,000 \text{ mrem.}$$

$$\text{CPEDE (TD-2004)} = 8 \text{ mrem} \times 2,000 \text{ hr}/8,760 \text{ hr} \times 9 \text{ persons} \times 1 \text{ rem}/1,000 \text{ mrem}$$

$$= 0.016 \text{ person-rem (1.6E-4 person-Sv)}$$

$$\text{CPEDE (TD-3003)} = 22 \text{ mrem} \times 2,000 \text{ hr}/8,760 \text{ hr} \times 150 \text{ persons} \times 1 \text{ rem}/1,000 \text{ mrem}$$

$$= 0.753 \text{ person-rem (7.53E-3 person-Sv)}$$

#### 4. Ingestions of Food or Water

Exposure to above-background radionuclide concentrations in food or water by a significant human population is applicable only for visitors to the Busch Conservation Area, a recreational area adjacent to the chemical plant/raffinate pits area. Three of the lakes at the area (i.e., Lakes 34, 35, and 36) receive runoff from the Weldon Spring site and are used for fishing and boating activities. The Missouri Department of Conservation conducted a year long survey to determine the number of visitors to the area, the types of activities in which users participate, and the amount of time allocated for these activities (Ref. 30).

Fishing at the Busch Conservation Area averaged 2.5 hours per visit for the approximately 160,000 visits to the area for that purpose (assuming a fish-caught to time-spent ratio of 0.4 fish/hour and a 0.50 ratio of fish kept to fish caught for a total of 80,000 fish). Assuming that one person keeps one fish, the population of concern would be 80,000 persons. For the water and sediment ingestion scenarios, boating is the activity assumed to provide the potential for incidental water and sediment ingestion. An estimated 5,985 visits were made for the purpose of boating with an average of 5.7 hours per visit. Assuming that each visit constitutes one individual, the total population would be 5,985 persons. Each of these ingestion scenarios is further addressed in calculations a, b, and c below.

- a. Collective dose estimate due to ingestion of fish obtained at the Busch Memorial Conservation Area.

- Assuming that each person of the 80,000 population consumes one fish and that the edible portion of a fish has a mass of 200 g, the average consumption rate specific to the affected population is 0.55 g/person/day.
- Fish samples were collected in 1998 as part of the WSSRAP biological monitoring program. Based on a total uranium concentration of 0.019 pCi/g obtained from a composite of sunfish samples collected in Lake 35 and the population specific consumption rate derived from Missouri Department of Conservation data, the estimated population effective dose equivalent is:

#### Population Dose Equivalent (fish ingestion)

$$\begin{aligned}
 &= \text{consumption rate} \times \text{total uranium concentration in fish} \times \text{exposure time} \times \text{total} \\
 &\quad \text{soluble uranium dose conversion factor} \times \text{persons} \\
 &= 0.55 \text{ g/day} \times 0.019 \text{ pCi/g} \times 365 \text{ day} \times 2.69\text{E-4 mrem/pCi} \times 80,000 \text{ persons} \times \\
 &\quad 1 \text{ rem}/1,000 \text{ mrem} \\
 &= 0.082 \text{ person-rem (8.21E-4 person-Sv)}
 \end{aligned}$$

#### b. Dose estimate due to incidental ingestion of water at the Busch Conservation lakes:

- Assume that each person of the 5,985 population makes one boating visit on an annual basis and 5% of the visit is spent swimming (0.285 hours/visit).
- Using the average total uranium surface water content of 8.3 pCi/l obtained from Lake 35 in 1998, and an ingestion rate of 0.05 l/hour (Ref. 30) the estimated population dose equivalent is

#### Population Dose Equivalent (water ingestion)

$$\begin{aligned}
 &= \text{ingestion rate} \times \text{average total uranium concentration in Lake 35 water} \times \text{exposure} \\
 &\quad \text{time} \times \text{total soluble uranium dose conversion factor} \times \text{number of individuals} \\
 &= 0.05 \text{ l/hr} \times 8.3 \text{ pCi/l} \times 0.285 \text{ hr} \times 2.69\text{E-4 mrem/pCi} \times 5,985 \text{ persons} \times \\
 &\quad 1 \text{ rem}/1,000 \text{ mrem} \\
 &= 0.0002 \text{ person-rem (2.0E-6 person-Sv)}
 \end{aligned}$$

## c. Dose estimate due to ingestion of sediments at the Busch lakes:

- Assume that each person of the 5,985 population makes one boating visit on an annual basis and 5% of the visit is spent swimming (0.285 hours/visit).
- Using the average total uranium concentration of 26.6 pCi/g in sediment obtained from Lake 35 as part of a 3-year study (spanning 1991-94), (Ref. 15) and an ingestion rate of 200 mg/day, the estimated population dose equivalent is:

## Population Dose Equivalent (sediment ingestion)

$$\begin{aligned}
 &= \text{ingestion rate} \times \text{total uranium concentration in sediment} \times \text{exposure time} \times \text{total} \\
 &\quad \text{soluble dose conversion factor} \times \text{number of individuals} \\
 &= 200 \text{ mg/day} \times 26.6 \text{ pCi/g} \times 0.285 \text{ hr/person} \times 2.69\text{E-}4 \text{ mrem/pCi} \times 5,985 \text{ persons} \times \\
 &\quad 1 \text{ g/1,000 mg} \times 1 \text{ day/24 hr} \times 1 \text{ rem/1,000 mrem} \\
 &= 0.0001 \text{ person-rem (1.0E-6 person-Sv)}
 \end{aligned}$$

Therefore, the CPEDE obtained from ingestion of food or water at the Busch Memorial Conservation Area is:

## Dose (fish ingestion) + Dose (water ingestion) + Dose (sediment ingestion)

$$\begin{aligned}
 &= 0.082 + 0.0002 + 0.0001 \text{ person-rem} \\
 &= 0.0823 \text{ person-rem (8.23E-4 person-Sv)}
 \end{aligned}$$

The 1998 total collective population effective dose equivalent (CPEDE) for all applicable pathways addressed in this section is:

## CPEDE (airborne particulates) + CPEDE (Rn-220 gas and decay products) + CPEDE (gamma exposure) + CDEPE (ingested food, water, and sediment)

$$\begin{aligned}
 &= 0.328 + 0.248 + 0.769 + 0.0823 \text{ person-rem} \\
 &= 1.43 \text{ person-rem (0.143 person-Sv)}
 \end{aligned}$$

### E. Airborne Radioactive Release Estimates

During 1998, statistical analysis of annual average high volume monitoring results indicated no locations where airborne radionuclide concentrations were greater than background. However, seven low volume monitoring stations along the chemical plant perimeter indicated annual average concentrations that were statistically greater than the 104-week average background concentration. These stations were AP-2001, 2002, 2005, 2008, 3003, 3004, and 3014. The net annual average gross alpha concentrations at these stations were incorporated into a series of box models to estimate the total radioactive airborne particulate release from the site for 1998. Table B-1 summarizes the approximate activity ratios for the radionuclides contained in the waste common to each area of the site where an elevated annual average concentration was documented (see Section 4). The table also identifies the sources believed to be responsible for each station that indicated elevated readings for the year.

The box model approach provides conservative results and is used in place of Gaussian plume dispersion modeling, which is generally inappropriate for estimating ambient pollutant concentrations at receptors close to a source, which is the case for the perimeter monitors at the WSSRAP. Parameters required for inclusion in the box models include: net average gross alpha concentration (listed in Table B-1); the range of wind directions (measured out from the source) encompassing the area in which a given monitoring station is located, including the average wind speed and directional frequency (percentage of time that the wind blew toward those directions) for that range; the estimated release height at the fence line; and the box length, which is the distance between two points along the fence line drawn on either side of a monitoring station. (These two points are the midpoints between a given monitoring station and the next closest station along the site perimeter.) Table B-2 summarizes the parameters and assumptions used in the modeling.

The radioactive particulate release rate from the chemical plant is estimated by applying the following equation for each monitoring station result:

$$\text{Release Rate (Ci/y)} = \sum_i \sum_j [\text{Box Length (m)} \times \text{Release Height (m)} \times \text{Wind Speed (m/s)} \times \text{Net Annual Gross Alpha Concentration (Ci/m}^3\text{)} \times 3.1536 \text{ E7 sec/y} \times \text{Directional Frequency}]$$

where  $i$  = monitoring station  
and  $j$  = radionuclide

For example, for Station AP-2002, the total release rate is determined as follows:

$$\text{Total Radioactive Airborne Particulate Release Rate (AP-2002)} = 610 \text{ m} \times 3 \text{ m} \times 2.8 \text{ m/s} \times 0.62 \text{ E-15 Ci/m}^3 \times 3.1536 \text{ E7 sec/y} \times 0.369$$

$$= 1.13 \text{ E-5 Ci/y}$$

The radionuclide-specific airborne particulate release rates based on annual results from Station AP-2002 are subsequently determined by multiplying the total AP-2002 release rate by each activity ratio listed in Table B-1 for the contributing source. Radionuclide-specific activity releases calculated for all monitoring stations are shown in Table B-3. The total activity release for each radionuclide released from the chemical plant area is found by summing the results in each column of the table.

Table B-1 Sources and Activity Ratios Corresponding to Elevated Gross Alpha Concentrations at Perimeter Low Volume Monitoring Stations

Station ID	Net Concentration Above Background ( $\mu\text{Ci}/\text{m}^3$ )	WSSRAP Source Contributing to Elevated Concentrations	Activity Ratios							
			U-234	U-235	U-238	Th-228	Th-230	Th-232	Ra-226	Ra-228
AP-2001	0.24E-15	Disposal Cell	0.13	0.01	0.12	0.07	0.61	0.07	N/A	N/A
AP-2002	0.62E-15	Disposal Cell	0.13	0.01	0.12	0.07	0.61	0.07	N/A	N/A
AP-3003	0.55E-15	Raffinate Pit 4	0.13	0.01	0.12	0.07	0.61	0.07	N/A	N/A
AP-3004	0.9 E-15	TSA	0.069	0.003	0.064	0.022	0.752	0.036	0.052	0.040
AP-2005	0.36E-15	Disposal Cell	0.13	0.01	0.12	0.07	0.61	0.07	N/A	N/A
AP-2008	0.6E-15	Disposal Cell	0.13	0.01	0.12	0.07	0.61	0.07	N/A	N/A
AP-3014	0.3E-15	Raffinate Pit 4	0.13	0.01	0.12	0.07	0.61	0.07	N/A	N/A
AP-2025	0.36E-15	Disposal Cell	0.13	0.01	0.12	0.07	0.61	0.07	N/A	N/A

N/A Activity ratios for Ra-226 and Ra-228 are negligible as compared to the listed isotopes of uranium and thorium.

Table B-2 Parameters and Assumptions Used in Box Modeling to Determine Radioactive Airborne Particulate Release Rate from the WSSRAP for 1998

Box Model	Monitoring Station	Range of Wind Directions (Wind Blowing From)	Average Wind Speed for Range (m/s)	Directional Frequency	Box Length (m)	Release Height (m)
1	AP-2001	236.25° - 303.75° (WSW, W, WNW)	3.2	14.0%	286	3
2	AP-2002	146.25° - 213.75° (SSE, S, SSW, SW, WSW)	2.9	31.3%	652	3
3	AP-3003	168.75° - 191.25° (S)	3.1	11.2%	488	3
4	AP-3004	78.75° - 123.75° (E, ESE)	1.9	8.3%	610	3
5	AP-2005	303.75° - 11.25° (NE, NNW, N)	3.2	19.4%	423	3
6	AP-2008	281.25° - 303.75° (WNW)	3.1	5.4%	183	3
7	AP-3014	101.25° - 168.75° (ESE, SE, SSE)	2.2	18.4%	427	3
8	AP-2025	191.25° - 258.75° (SSW, SW, WSW)	2.9	21.2%	366	3

Table B-3 Radionuclide-Specific Activity Release Rates Corresponding to Monitoring Stations with Gross Alpha Results Greater Than Background for 1998

Station	Net Concentration (Ci/m <sup>3</sup> )	Release Rates							
		U-234	U-235	U-238	Th-228	Th-230	Th-232	Ra-226	Ra-228
AP-2001	2.91E-06	3.78E-07	2.91E-06	3.49E-07	2.04E-07	1.77E-06	2.04E-07	N/A	N/A
AP-2002	3.47E-05	4.51E-06	3.47E-07	4.17E-06	2.43E-06	2.12E-05	2.43E-06	N/A	N/A
AP-3003	8.82E-06	1.15E-06	8.82E-06	1.06E-06	6.17E-07	5.38E-06	6.17E-07	N/A	N/A
AP-3004	8.19E-06	5.65E-07	2.46E-08	5.24E-07	1.80E-07	6.16E-06	2.95E-07	4.26E-07	3.28E-07
AP-2005	8.94E-06	1.16E-06	8.94E-08	1.07E-06	6.26E-07	5.48E-06	6.26E-07	N/A	N/A
AP-2008	1.74E-06	2.26E-07	1.74E-08	2.09E-07	1.22E-07	1.06E-06	1.22E-07	N/A	N/A
AP-3014	491E-06	6.38E-07	4.91E-08	5.89E-07	3.43E-07	2.99E-06	3.43E-07	N/A	N/A
AP-2025	8.09E-6	1.05E-06	8.09E-07	9.71E-07	5.66E-07	4.93E06	5.66E-07	N/A	N/A
Total Release Rates		6.60E-06	4.89E-07	6.10E-06	3.43E-06	3.45E-05	3.55E-06	4.26E-07	3.28E-07

#### F. Radon-220 and Radon-222 Release Estimates

Annual average Rn-222 and Rn-220 concentrations at chemical plant track etch perimeter monitoring stations were calculated based on the results of paired F-type and M-type detectors. The results indicated that the average Rn-222 concentration at perimeter station RD-3002 was 0.2 pCi/l above background, while Rn-220 levels were statistically greater than background at perimeter stations RD-3001, RD-3002, RD-3003, and RD-3016, all located along the western chemical plant perimeter. The annual average Rn-220 concentrations at these three stations were 0.2 pCi/l, 0.4 pCi/l, 0.4pCi/l, and 0.3 pCi/l, respectively, above the combined background concentration of 0.1 pCi/l for the year (see Section 4, Table 4-2). A series of box models was used to calculate the total Rn-222 and Rn-220 release rate from the chemical plant based on these results, assuming that the major source of Rn-222 and Rn-220 emissions at the chemical plant during 1998 was Raffinate Pit 4 (based on the close proximity of Raffinate Pit 4 to the western perimeter).

Parameters required for inclusion in the box models include: net average Rn-222 and Rn-220 concentration; the range of wind directions (measured out from the source) encompassing the area in which a given monitoring station is located, including the average wind speed and directional frequency (percentage of time the wind blew in those directions) for that range; the estimated Rn-222 and Rn-220 release height at the fence line; and the box length, which is the distance between two points along the fence line drawn on either side of a monitoring station. (These two points are the midpoints between a given monitoring location and the next closest station along the site perimeter.) Table B-4 provides a summary of the parameters and assumptions used in the modeling scheme.

Table B-4 Parameters and Assumptions Used in Box Modeling to Determine Radon and Thoron Release Rates from the WSSRAP for 1998

BOX MODEL	MONITORING STATION	RANGE OF WIND DIRECTIONS (WIND BLOWING FROM)	AVERAGE WIND SPEED FOR RANGE (m/s)	DIRECTIONAL FREQUENCY	BOX LENGTH (m)	RELEASE HEIGHT (m)	NET RADON/THORON CONCENTRATION (pCi/l)
1	RD-3001 <sup>(a)</sup>	158.75°-141.25° (S)	3.1	11.2%	488	3	0.2
2	RD-3002	45° - 148.25° (NE-SE)	2.1	22.7%	305	3	0.2, 0.4
3	RD-3003 <sup>(a)</sup>	348.75° - 45° (N-NE)	2.8	14.5%	274	3	0.4
4	RD-3016 <sup>(a)</sup>	11.25° - 56.25° (NE-NNE)	2.6	8.7%	200	3	0.3

(a) Only Rn-220 considered because Rn-222 concentration was indistinguishable from background.

The following calculation is used to estimate the Rn-222 and Rn-220 release rate from the chemical plant for each model:

Release Rate (Ci/y) = Box Length (m) x Release Height (m) x Average Wind Speed (m/s) x Net Rn-222 + Rn-220 Concentration (pCi/l) x 1E-12 Ci/pCi x 1,000 l/m<sup>3</sup> x 3.1536E7 s/y x Directional Frequency

Box Model 1 (RD-3001):

Rn-220 Release Rate = 488 m x 3 m x 3.1 m/s x 0.2 pCi/l x 1E-12 Ci/pCi x 1,000 l/m<sup>3</sup> x 3.1536E7 s/y x 0.112

$$= 3.2 \text{ Ci/y (1.19E11 Bq/y)}$$

Box Model 2 (RD-3002):

Rn-222 + Rn-220 Release Rate = 305 m x 3 m x 2.1 m/s x (0.2 + 0.4) pCi/l x 1E-12 Ci/pCi x 1,000 l/m<sup>3</sup> x 3.1536E7 s/y x 0.227

$$= 8.3 \text{ Ci/y (3.05E11 Bq/y)}$$

Release Rate (Rn-222, RD-3002) = 2.75 Ci/y (1.02E11 Bq/y)

Release Rate (Rn-220, RD-3002) = 5.55 Ci/y (2.05E11 Bq/y)

Box Model 3 (RD-3003):

$$\text{Rn-220 Release Rate} = 274 \text{ m} \times 3 \text{ m} \times 2.8 \text{ m/s} \times 0.4 \text{ pCi/l} \times 1\text{E-}12 \text{ Ci/pCi} \times 1,000 \text{ l/m}^3 \times 3.1536\text{E}7 \text{ s/y} \times 0.144$$

$$= 4.2 \text{ Ci/y (1.56E11 Bq/y)}$$

Box Model 4 (RD-3016):

$$\text{Rn-220 Release Rate} = 200 \text{ m} \times 3 \text{ m} \times 2.6 \text{ m/s} \times 0.3 \text{ pCi/l} \times 1\text{E-}12 \text{ Ci/pCi} \times 1,000 \text{ l/m}^3 \times 3.1536\text{E}7 \text{ s/y} \times 0.087$$

$$= 1.28 \text{ Ci/y (4.75E10 Bq/y)}$$

The total estimated Rn-220 release rate from the chemical plant area is the sum of the results of the 4 box models, or approximately 14.2 Ci/y (5.27E11 Bq/y).

**APPENDIX C**  
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Weldon Spring Site Remedial Action Project**

**TRANSMITTAL OF CONTRACT DELIVERABLE**

Date: **July 15, 1999**

Transmittal No.: **CD-0179-00**

Title of Document: **Weldon Spring Site Environmental Report For Calendar Year 1998**

Doc. Num.: **773**

Rev. No.: **0**

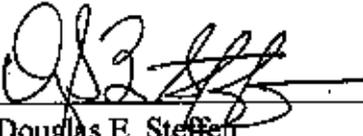
Date of Document: **July 1999**

**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.

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\_\_\_\_\_  
Douglas E. Steffen

Project Director

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About the front cover..., clockwise from the top left:

- After contaminated material is excavated, samples of the remaining soil are taken to confirm that remediation efforts were successful.
- An aerial view of the Chemical Stabilization and Solidification Plant in operation.
- A "walkover survey" being performed prior to mobilization of the sample crews.
- Bulldozer placing bedding material on a side slope of the cell.
- An aerial view looking south of the cell.