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# WSSRAP

## Weldon Spring Site Environmental Report for Calendar Year 2000

DOE/OR/21548-886  
Contract No. DE-AC05-86OR21548  
July 2001  
Rev. 0

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



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# WELDON SPRING SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 2000

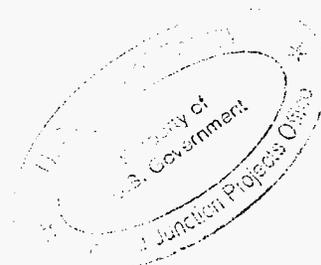
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WELDON SPRING SITE REMEDIAL ACTION PROJECT  
WELDON SPRING, MISSOURI

**JULY 2001**

**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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About the front cover..., clockwise from the top left:

- Demolition of Building 434, the last legacy building on-site.
- Routine environmental water sampling conducted at Burgermeister Spring.
- Construction of the Interceptor Trench at the quarry, near the Katy Trail.
- Demolition of the site water treatment plant. This water treatment plant operated between 1993 – 2000 and treated over 222 million gallons of contaminated water.
- Aerial view of the Disposal Cell taken on June 10, 2001. In this photo, all seven layers of the disposal cell cover can be seen in sequence from the bottom of the cap up – clay radon barrier, geocomposite liner, geotextile, drain gravel, drain sand, bedding material, and rip-rap.



**MORRISON KNUDSEN CORPORATION**  
**MK-FERGUSON GROUP**

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

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PLAN TITLE: Weldon Spring Site Environmental Report for Calendar Year 2000

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DOE/OR/21548-886

*Weldon Spring Site Remedial Action Project*

**EXECUTIVE SUMMARY**

Weldon Spring Site Environmental Report for Calendar Year 2000

Revision 0

July 2001

Prepared by

MK-FERGUSON  
and  
JACOBS ENGINEERING GROUP  
7295 Highway 94 South  
St. Charles, Missouri 63304

for the

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

## EXECUTIVE SUMMARY

This *Weldon Spring Site Environmental Report for Calendar Year 2000* 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 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 objectives 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 routine 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 2000 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 2000 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 (NESHAP) 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)*, *National Historic Preservation Act (NHPA)*, and because the U.S. Department of Energy (DOE) is the lead agency for the site, *National Environmental Policy Act (NEPA)* values are incorporated into CERCLA documents as outlined in the Secretarial Policy statement on NEPA.

The following major tasks were completed at the Weldon Spring site during 2000:

- Both the site and quarry water treatment plants completed water treatment during 2000. The site water treatment plant was dismantled during 2000, and the quarry water treatment plant will be dismantled in 2001.
- Building 434 and the TSA, both RCRA and TSCA facilities, were closed in accordance with 40 CFR 264 Subpart G, during calendar year 2000.
- With the exception of a small portion of the administration area storm sewer line (completed in 2001), all other remaining areas awaiting confirmation were remediated and confirmed clean during 2000.
- Radon flux monitoring for the disposal cell was completed in accordance with 40 CFR 61, Appendix B, Method 115. The average was well below the regulatory requirement of 20 pCi/m<sup>2</sup>/sec.
- The *Remedial Design/Remedial Action Work Plan for the Quarry Residuals Operable Unit* was finalized in January 2000.
- The *Interim Record of Decision for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site* was issued in September 2000.

## MONITORING SUMMARY

Environmental monitoring data showed that dose estimates were below the DOE guidelines for the public of 100 mrem (1 mSv) annual total effective dose equivalent for all exposure pathways. NESHAP air monitoring results for radioactive air particulates showed that dose estimates were all well below the NESHAP standard of 10 mrem (0.1 mSv) per year.

Radon monitoring at perimeter and critical receptor locations showed no Rn-220 or Rn-222 concentrations above background levels.

Release estimates for total uranium in water (which include storm water and water from the treatment plants) decreased from the 1999 release estimate of 9.56 kg/yr (21.08 lb/yr) to 5.38 kg/yr (11.84 lb/yr) in 2000. The annual release of total uranium for 2000 was a 98.8% reduction from 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

Radiation dose estimates are discussed in Section 5. A radiation dose equivalent from the chemical plant and raffinate pits to a hypothetical maximally exposed individual was not calculated. This was because all radon/thoron and gamma exposure results from critical receptors were not distinguishable from background, and the only radioactive air particulate station that was statistically above background was not in an area frequented by members of the public. A radiation dose equivalent from the quarry to a hypothetical maximally exposed individual was also not calculated since all monitoring results were indistinguishable from background.

The total effective dose equivalent to a maximally exposed individual at the vicinity properties from consumption of water was 0.35 mrem (0.0035 mSv). This estimate is well 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 was estimated to be 0.10 person-rem (0.0010 person-Sv) for users of the Busch Memorial Conservation Area.

### Air Monitoring

As discussed in Section 4, airborne releases from the Weldon Spring Chemical Plant area include Rn-220, Rn-222 gas, their progeny, and radioactive airborne particulates. Radioactive airborne particulates are assumed to include Ra-226, Ra-228, Th-228, Th-230, Th-232, and total uranium.

During 2000, no critical receptor or perimeter monitoring station recorded Rn-220 or Rn-222 concentrations above background levels. Statistical analysis of integrated radon track etch data indicated that the concentration at one interior station near the raffinate pits was greater than background levels. Statistical analysis of modified track etch detector data indicated that one station at the raffinate pits and two stations at the disposal cell 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 NESHAP monitoring for radioactive particulates, which are discussed in Section 6, indicated that all doses to the public at critical receptor locations were less than the NESHAP 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.

Asbestos monitoring was conducted in 2000 at Francis Howell High School and three site perimeter stations. All environmental asbestos monitoring results were below the EPA limit of 0.01 fiber/ml.

### NPDES Monitoring

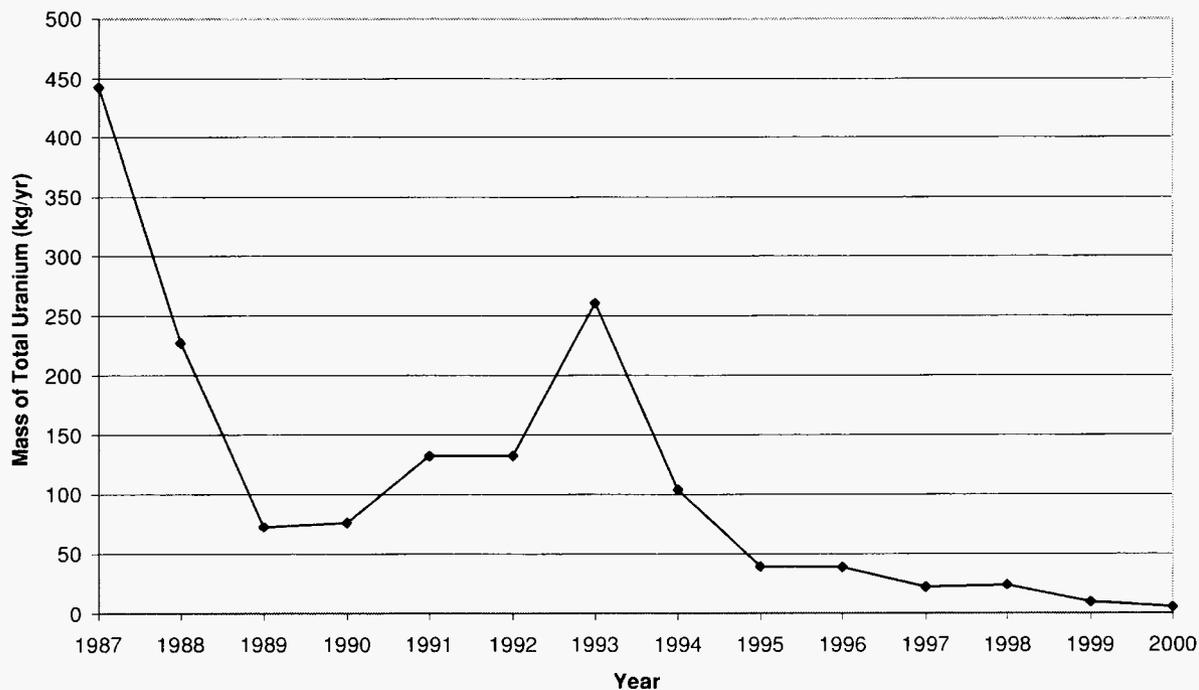
In 2000, surface water runoff at the chemical plant transported uranium from the site through six major discharge routes that are identified in Section 7 of this report. The total mass of uranium migrating off-site in storm water and treated effluent was 5.38 kg/yr (11.84 lb/yr). Based on natural uranium activity ratios, this is equivalent to an activity of 0.0037 Ci/yr (1.35E8 Bq/yr). The total mass of uranium was less than the 1999 mass of 9.56 kg/yr (21.08 lb/yr). The graph below, also presented as Figure 11-5 in Section 11, shows that the total mass of uranium migrating off site in storm water and treated effluent has decreased substantially since remedial activities began, and is expected to decrease further still when the site is vegetated and stabilized.

Annual average uranium concentrations at the NPDES outfalls were all well below the derived concentration guideline of 600 pCi/l. With respect to 1999 levels, average uranium concentrations increased at Outfalls NP-0004 and NP-0050(51), and decreased at Outfalls NP-0002, NP-0003, NP-0005, NP-0007, NP-0010, NP-1001, and NP-1005. The increases and decreases were generally slight. Historical uranium trends for the three major NPDES outfalls (i.e., NP-0002, NP-0003, and NP-0005) are discussed in Section 11.

Radiological parameters at the outfalls were in compliance with NPDES permit requirements during 2000. Other parameters were also in compliance with the exception of eight storm water settleable solids results and one sewage treatment plant result. Details of these exceedances are presented in Section 2.5.

Missouri River sediment was monitored during 2000 in support of site and quarry water treatment plant operations. Sediment samples were taken from the river both upstream and downstream of the treatment plant discharge sites and analyzed for uranium. The sample results indicated that the treatment plant discharges have caused no increase in uranium concentrations in river sediment.

### Total Annual Uranium Discharged at NPDES Outfalls



#### Surface Water

Surface water monitoring in 2000 indicated that contaminant concentrations were within historic ranges. Average uranium levels at four of the five off-site surface water locations downgradient of the chemical plant were lower than 1999 levels. One location slightly exceeded its 1999 average. Average uranium levels at five of the six off-site surface water locations near the quarry were lower than 1999 levels.

#### Groundwater

The groundwater monitoring programs included extensive monitoring for radiological and chemical compounds, as discussed in Section 8. Contaminant levels generally remained within historic ranges at all chemical plant and quarry groundwater locations.

At the quarry, radiological results for the St. Charles County well field remained within background levels, and no detectable concentrations of the six nitroaromatic compounds were observed. Detection monitoring for the quarry water treatment plant facility was discontinued

based upon an evaluation of the analytical data and completion of the equalization basin confirmation.

Chemical plant area monitoring continued to show high concentrations of nitroaromatic compounds in the former Frog Pond area. Three new monitoring wells were installed to further define the extent of contamination. In addition, TCE monitoring continued to be investigated during 2000. Several new monitoring wells were installed in this area also to further define the extent of contamination.

Monitoring data from wells placed around the permanent disposal cell showed no exceedances of baseline for radiological parameters. Several wells exceeded baseline levels for nonradiological contaminants, but these data are likely due to natural variations in the existing contamination plume underlying the site. Detection monitoring for the temporary storage area was discontinued based upon an evaluation of the analytical data and completion of confirmation.

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## ABSTRACT

This *Site Environmental Report for Calendar Year 2000* 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.

No critical receptor location had results which statistically exceeded background; therefore, no total effective dose equivalent (TEDE) was calculated. The maximum TEDE to a hypothetical individual who frequents the Weldon Spring Vicinity Properties was 0.35 mrem (0.0035 mSv). This estimate is below the U.S. Department of Energy (DOE) 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 and employees of the MHTD facility and WSSRAP administration building was 0.10 person-rem (0.0010 person-Sv).

Results from radiological air monitoring for the National Emission Standards for Hazardous Air Pollutants (NESHAP) program indicated that the maximally exposed individual, who resides continuously near the quarry, received an effective dose equivalent of 0.014 mrem (0.0001 mSv) during 2000. This is well below the U.S. Environmental Protection Agency (EPA) standard of 10 mrem (0.1 mSv) per year.

Comprehensive monitoring at the WSSRAP has 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. During 2000, no critical receptor or perimeter monitoring station recorded Rn-220 or Rn-222 concentrations above background levels. In addition, there was no measurable impact to any drinking water source from radionuclides.

Concentration limits are set for water pollutants in the NPDES permits. Parameters were in compliance with the permit limits except on nine occasions, eight for settleable solids in storm water and one for fecal coliform in sewage treatment plant effluent. The total mass of uranium migrating off site in storm water and treated effluent during 2000 was 5.38 kg (11.84 lb).

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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 2000* summarizes the environmental monitoring results obtained in 2000 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 2000, 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 2000* include:

- Providing general information on the WSSRAP and the current status of remedial activities.
- Presenting summary data and interpretations for the 2000 environmental monitoring program.
- Providing information regarding ongoing remedial actions.
- Reporting compliance with Federal, State, and local requirements and DOE standards.
- Providing dose estimates for public exposure to radiological compounds due to remedial activities at the WSSRAP.

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

## 1.1 Site Description

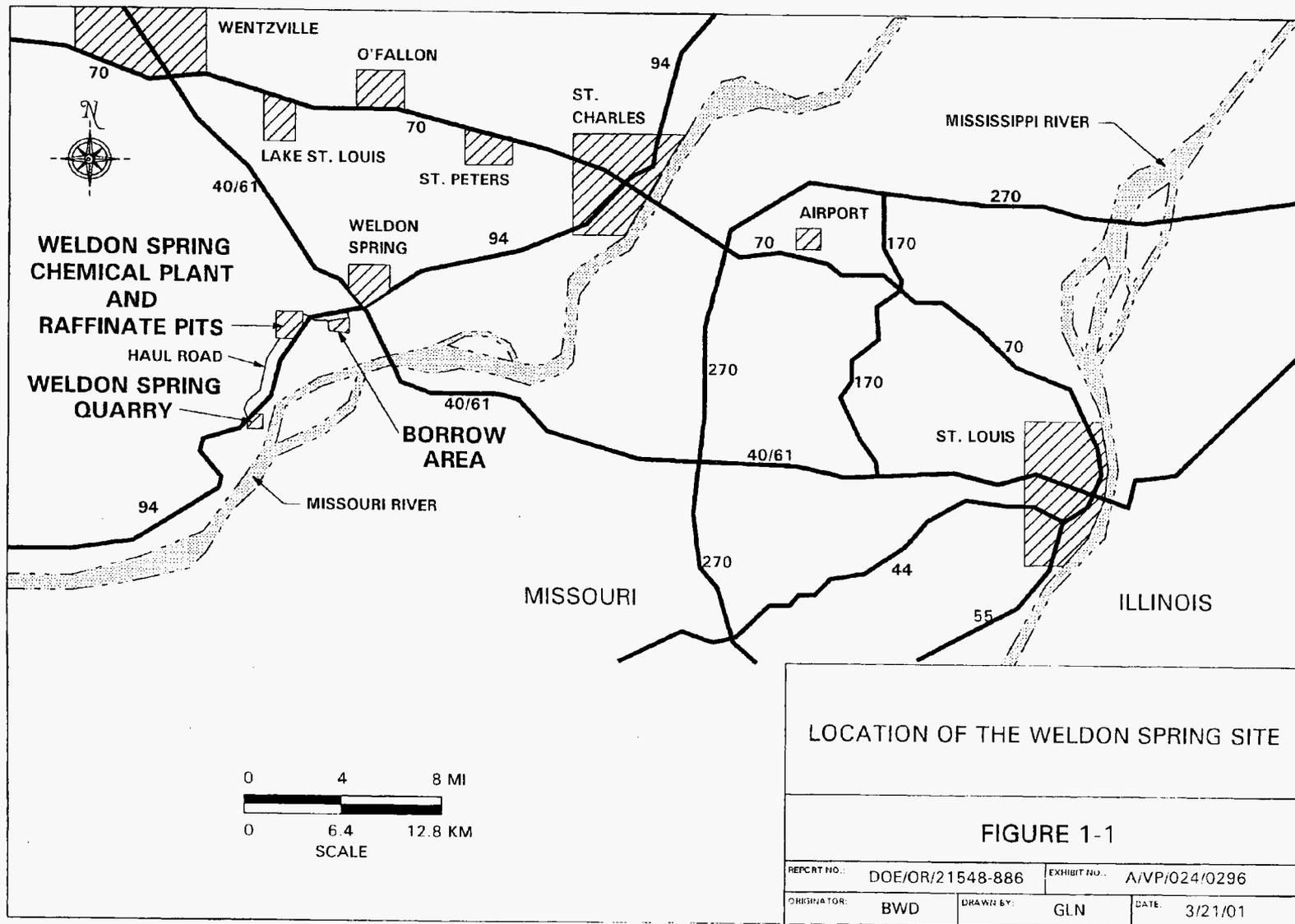
The Weldon Spring site is in southern St. Charles County, Missouri, approximately 48 km (30 mi) west of St. Louis, as shown in Figure 1-1. The site consists of two main areas, the Weldon Spring Chemical Plant and raffinate pits and the Weldon Spring Quarry, both located along Missouri State Route 94. 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 91 ha (226 acre) area that operated as the Weldon Spring Uranium Feed Materials Plant (WSUFMP) until 1966. Buildings were contaminated with asbestos, hazardous chemical substances, uranium, and thorium. (Building dismantlement was completed in 1994.) Radiological and chemical (polychlorinated biphenyls [PCBs], nitroaromatic compounds, metals and inorganic ions) contaminants were found in the soil in many areas around the site. Raffinate pits on the chemical plant site consisted of four settling basins that covered approximately 10.5 ha (26 acres), as shown in Figure 1-2. These pits were characterized as being contaminated with uranium and thorium residues and chemical contaminants including nitrate, fluoride, PCBs, and various heavy metals (Ref. 2). The four raffinate pits have all been remediated and backfilled as of 2000.

The Weldon Spring Quarry is a former 3.6 ha (9 acre) limestone quarry 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. Bulk waste stored in the quarry contained radiological and chemical contaminants including uranium, radium, thorium, metals, nitrates, PCBs, semivolatile organic compounds, nitroaromatics, and asbestos (Ref. 1). The quarry bulk waste removal operation was completed in 1995. Residual contamination was remediated during 2000, and backfilling of the quarry is scheduled to be begin in 2001.

## 1.2 Site History

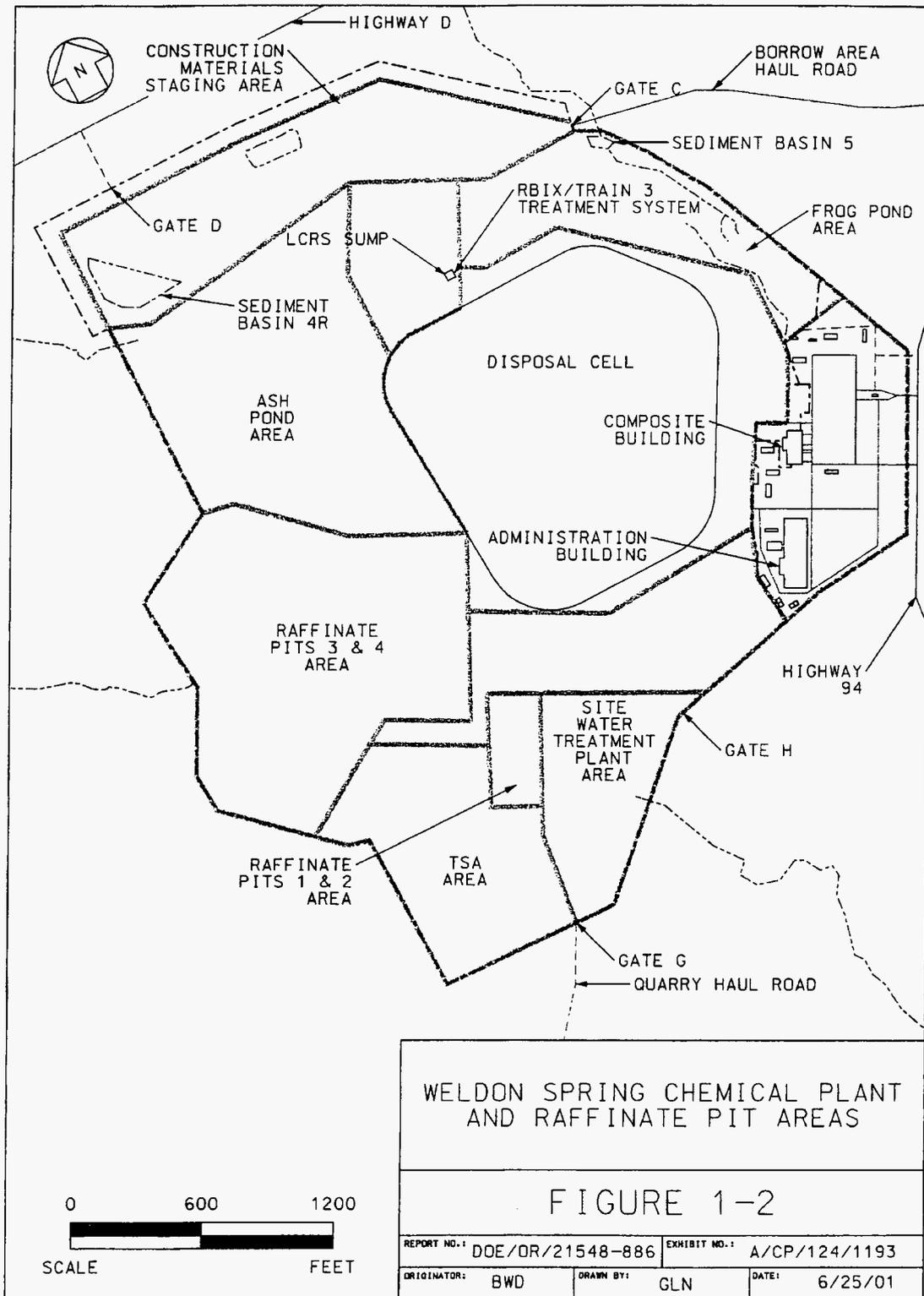
From 1941 to 1945, the U.S. Department of the Army produced trinitrotoluene (TNT) and dinitrotoluene (DNT) at the Weldon Spring Ordnance Works, which covered 6,974 ha (17,233 acres) of land that now includes the Weldon Spring site. By 1949, all but about 809 ha (2,000 acres) had been transferred to the 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.

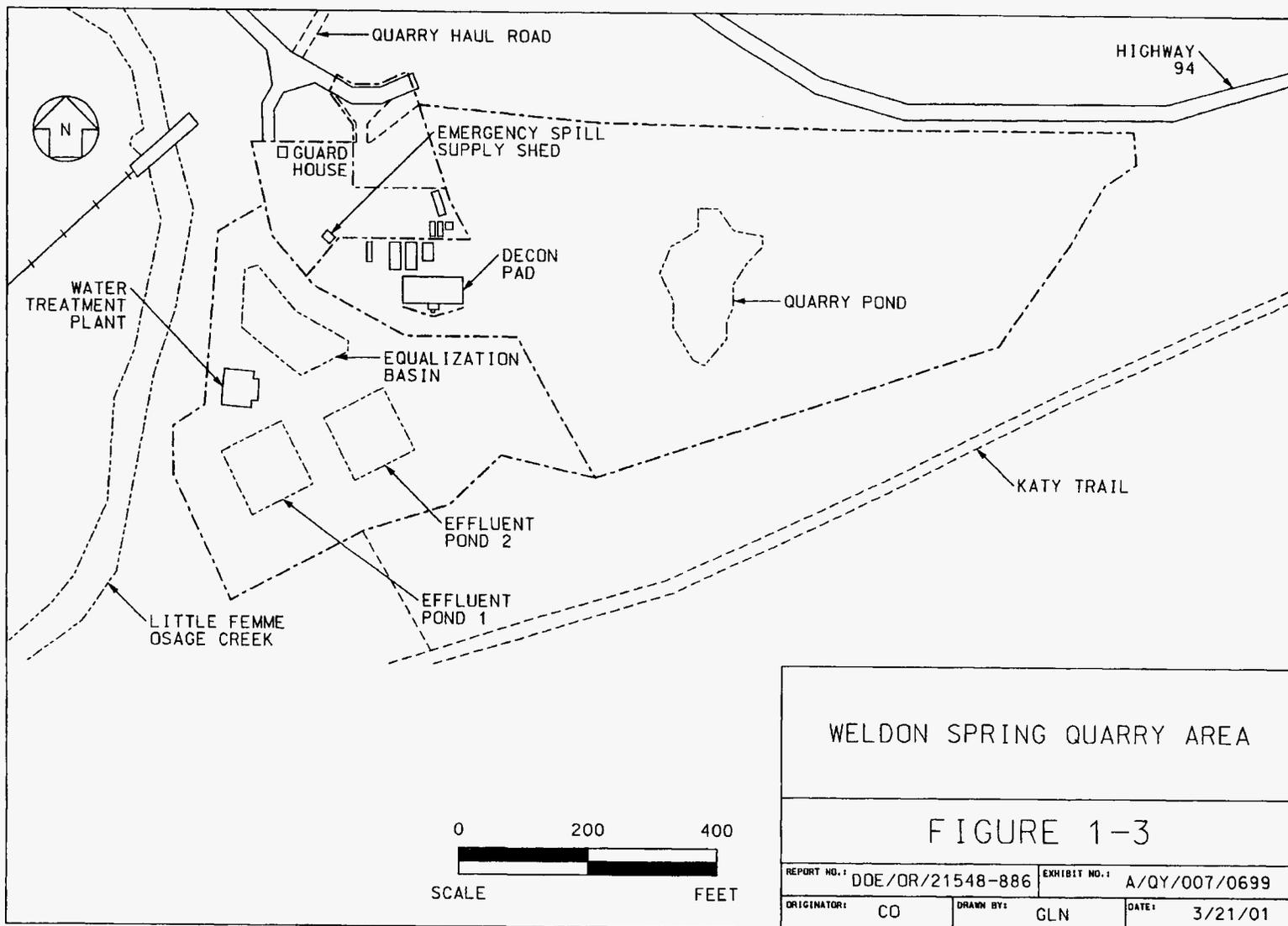


LOCATION OF THE WELDON SPRING SITE

**FIGURE 1-1**

REPORT NO.:	DOE/OR/21548-886	EXHIBIT NO.:	A/VP/024/0296
ORIGINATOR:	BWD	DRAWN BY:	GLN
		DATE:	3/21/01





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 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 included 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 Company and Jacobs Engineering Group, Inc., assumed control of the site on October 1, 1986. The quarry was placed on the Environmental Protection Agency's National Priorities List (NPL) in July 1987. The DOE redesignated the site as a Major System Acquisition in May 1988. The chemical plant and raffinate pits were added to the NPL in March 1989.

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 Plattin 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 on the Missouri-Mississippi River surface drainage divide, as shown in Figure 1-4. Elevations on the site range from approximately 185 m (608 ft) above mean sea level (msl) near the northern edge of the site to 223 m (730 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).

No natural drainage channels traverse the site. 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 chemical plant site drain

to tributaries to the Busch Lakes and Schote Creek, which in turn enter Dardenne Creek, which ultimately drains to the Mississippi River.

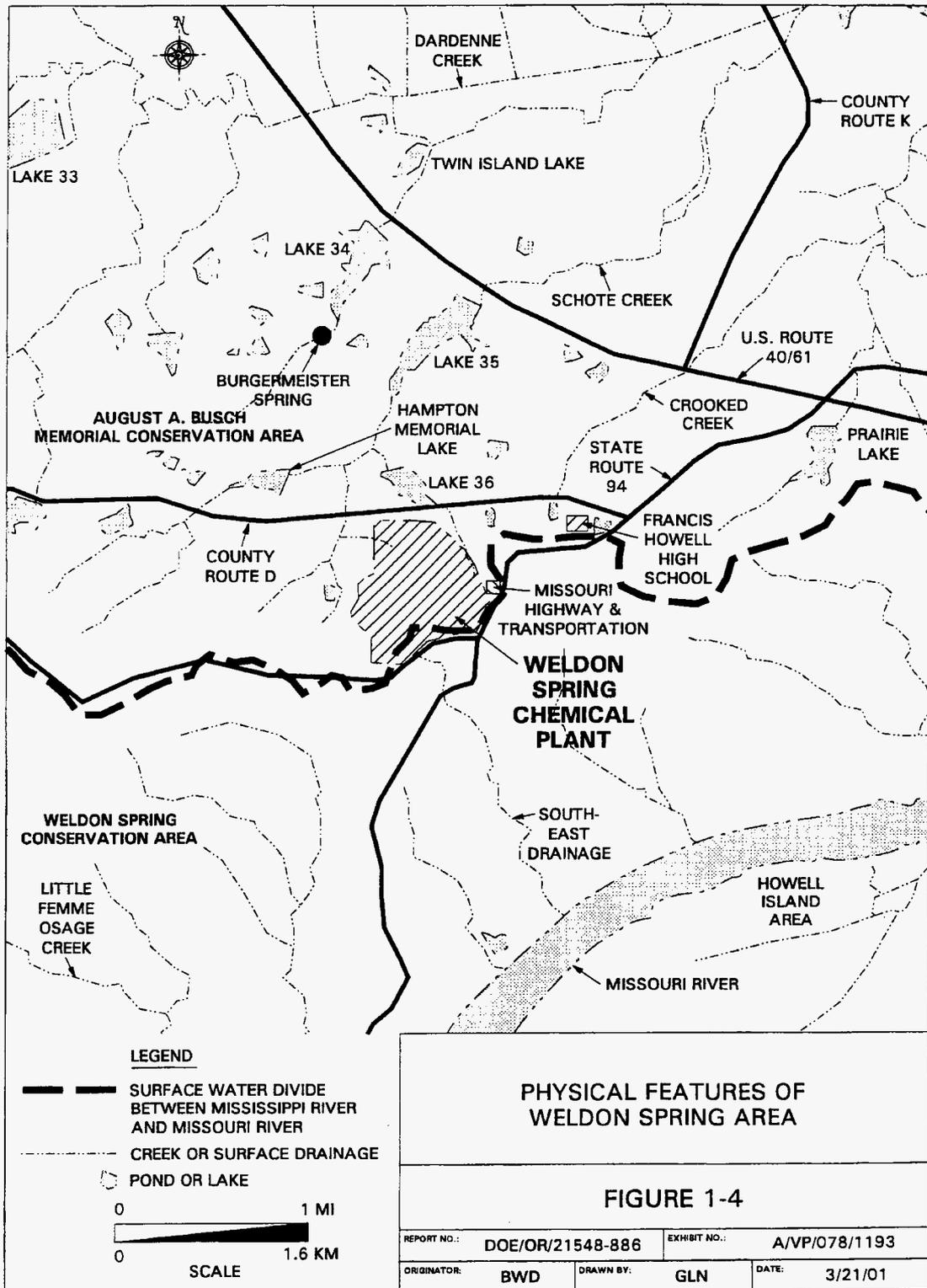
Four sedimentation basins were used to minimize discharge of sediment from the site during remediation efforts in 2000. One basin was downstream of the Ash Pond area and was relocated to allow remediation of Ash Pond and the sedimentation basin. The relocated basin collected water that had been diverted around the Ash Pond area. A second basin collected water from the northeast section of the site and discharged to outfall NP-0002. This basin was used as a retention basin during 2000 before it was remediated and removed. The sedimentation basin was reconstructed just upstream of outfall NP-0002 during 2000 to settle water from the NP-0002 watershed. A third basin was created when the site water treatment plant and associated basins were removed and remediated. This basin is the depression from the old Sedimentation Basin 5 and captures runoff from the site water treatment plant area that is then discharged, after settling, by pumping to outfall NP-0005. The fourth basin is just upstream of NP-0010 and collects runoff from a portion of the construction material staging area (CMSA). These basins are discussed in more detail in Section 7.

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 direct rainfall within the quarry. 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 is currently 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 consists of 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. When bulk waste removal began, this habitat was 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 about 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 less than 5 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 wind speed recorded during 2000 was 2.8 m/s (6.3 mph), and the predominant wind direction was 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 2000. Precipitation, temperature, wind speed, and wind direction results are in Table 1-1. These data were validated by an off-site meteorological specialist and met EPA quality assurance criteria. Precipitation was about 10% higher than normal for the St. Louis area; however, average recorded temperature, wind speed, and wind direction were all within historical ranges.

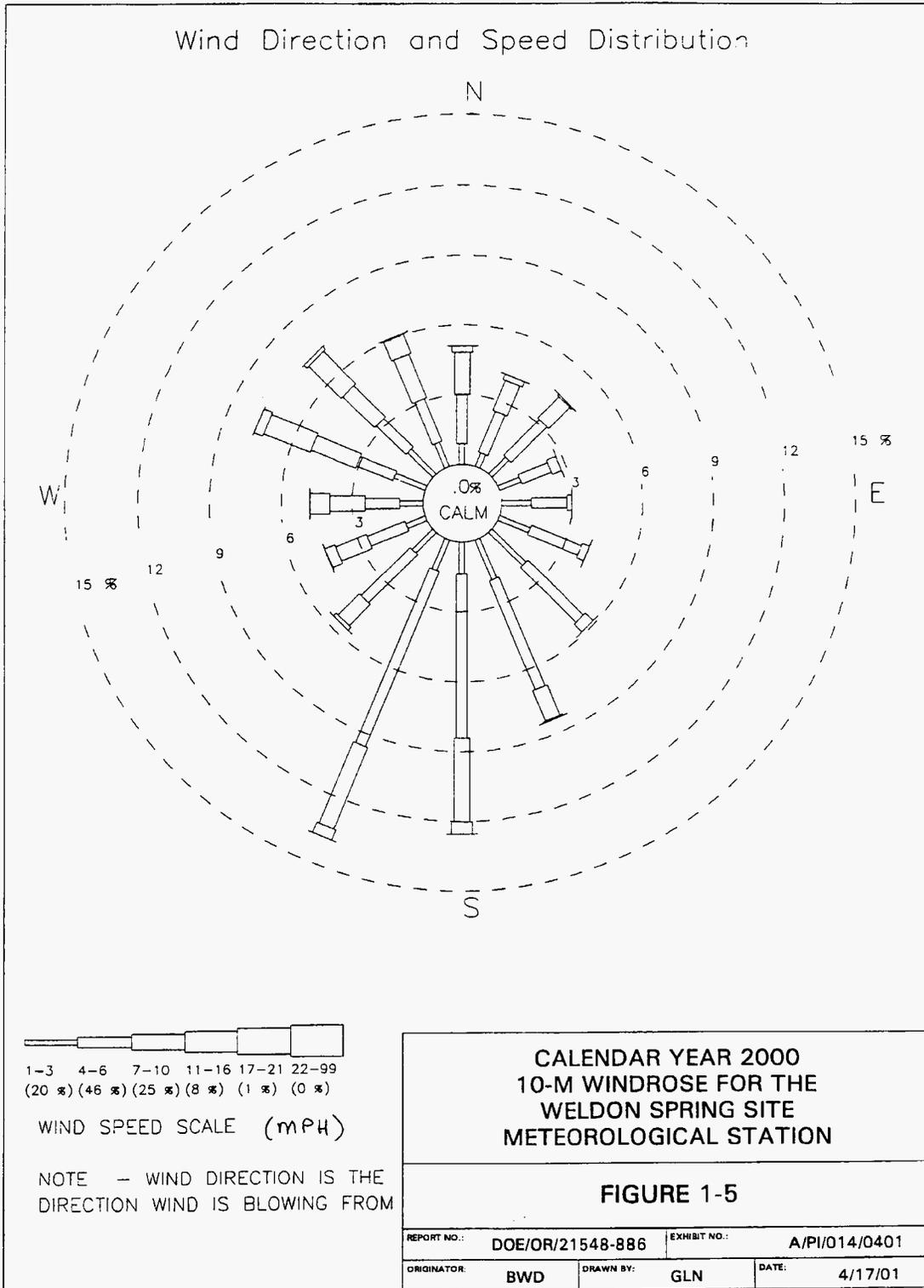
Table 1-1 Monthly Meteorological Monitoring Results for 2000

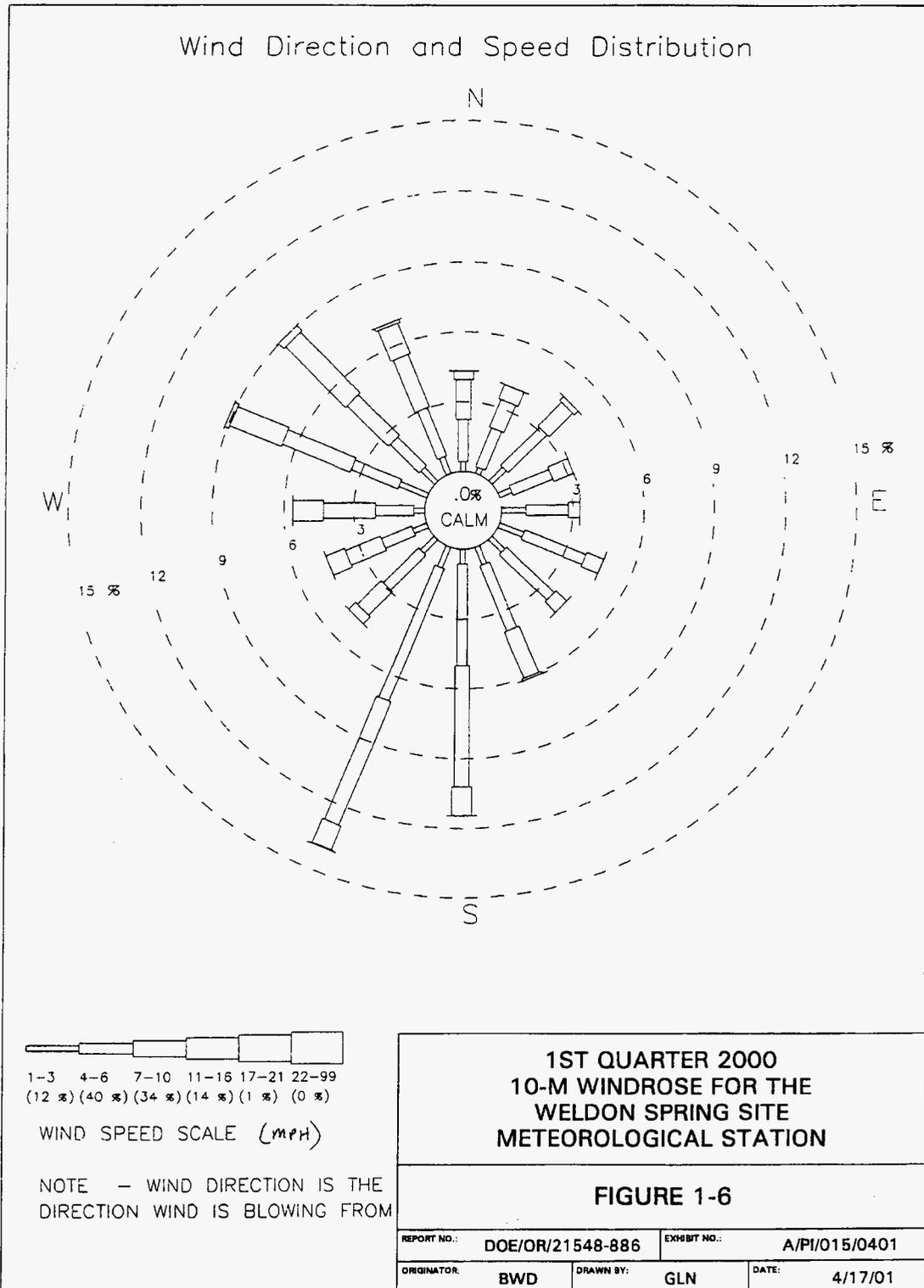
MONTH	TOTAL PRECIP (CM)	AVERAGE TEMP (DEGREES C)	AVERAGE WIND SPEED (M/SEC)	PREDOMINANT WIND DIRECTION
January	2.7	0.5	3.3	SSW – 13.1%
February	9.1	6.2	3.5	S – 16.9%
March	5.6	9.5	3.1	SSW – 12.7%
April	5.5	13.2	3.3	NW – 11.9%
May	19.6	19.9	2.8	S – 22.0%
June	23.9	21.7	2.5	SSW – 19.3%
July	7.8	24.2	1.9	SSW – 15.2%
August	7.9	25.7	2.1	SSW – 15.2%
September	6.5	20.0	2.4	S – 17.7%
October	6.1	15.6	2.3	SSW – 18.8%
November	6.1	4.7	3.2	WNW – 16.4%
December	3.4	-5.9	3.3	WNW – 16.7%
Annual Average/Total	104.2	12.9	2.8	SSW (13.7%)

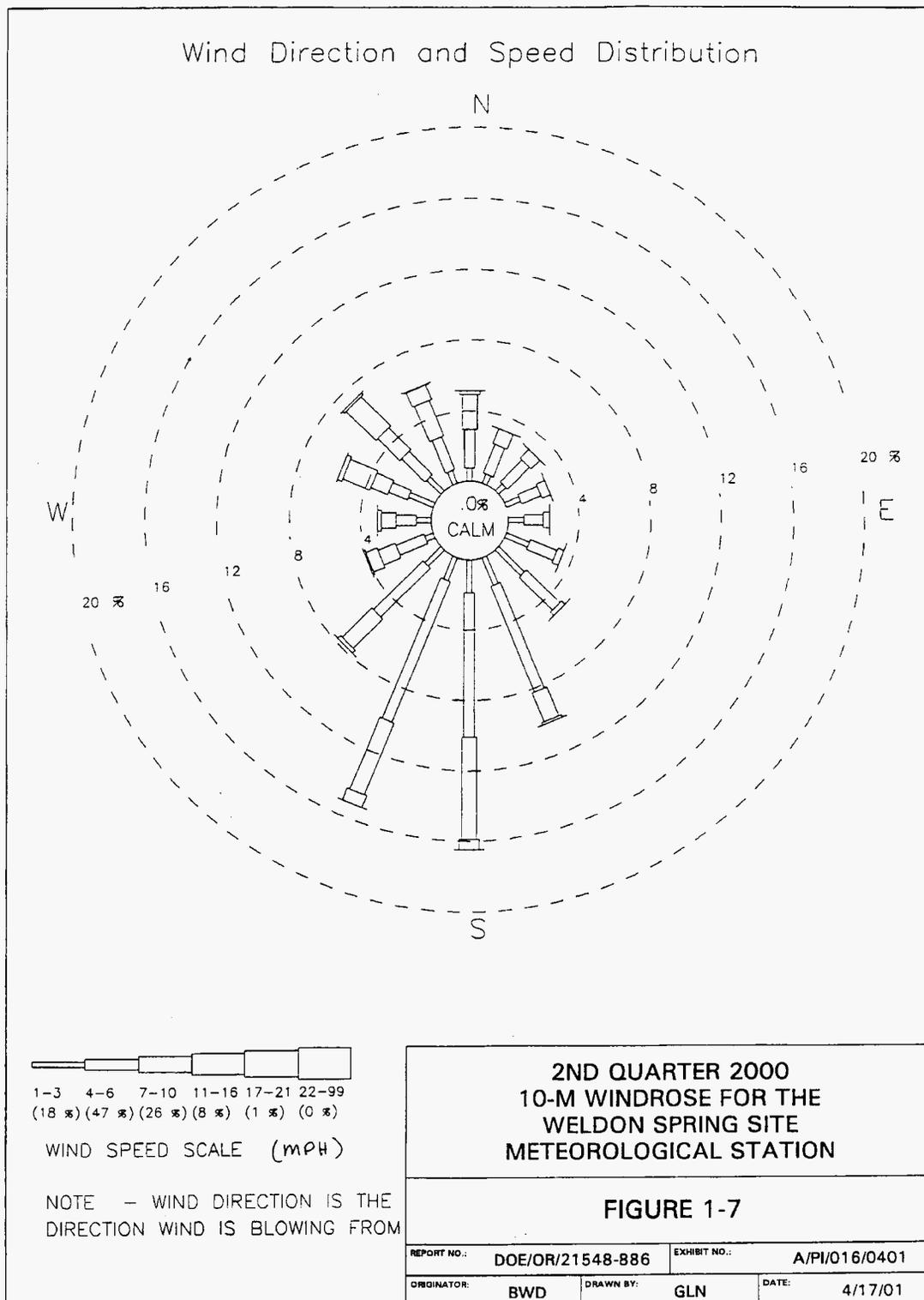
An annual wind rose is presented as Figure 1-5. Figures 1-6 through 1-9 are wind roses for each quarter of 2000.

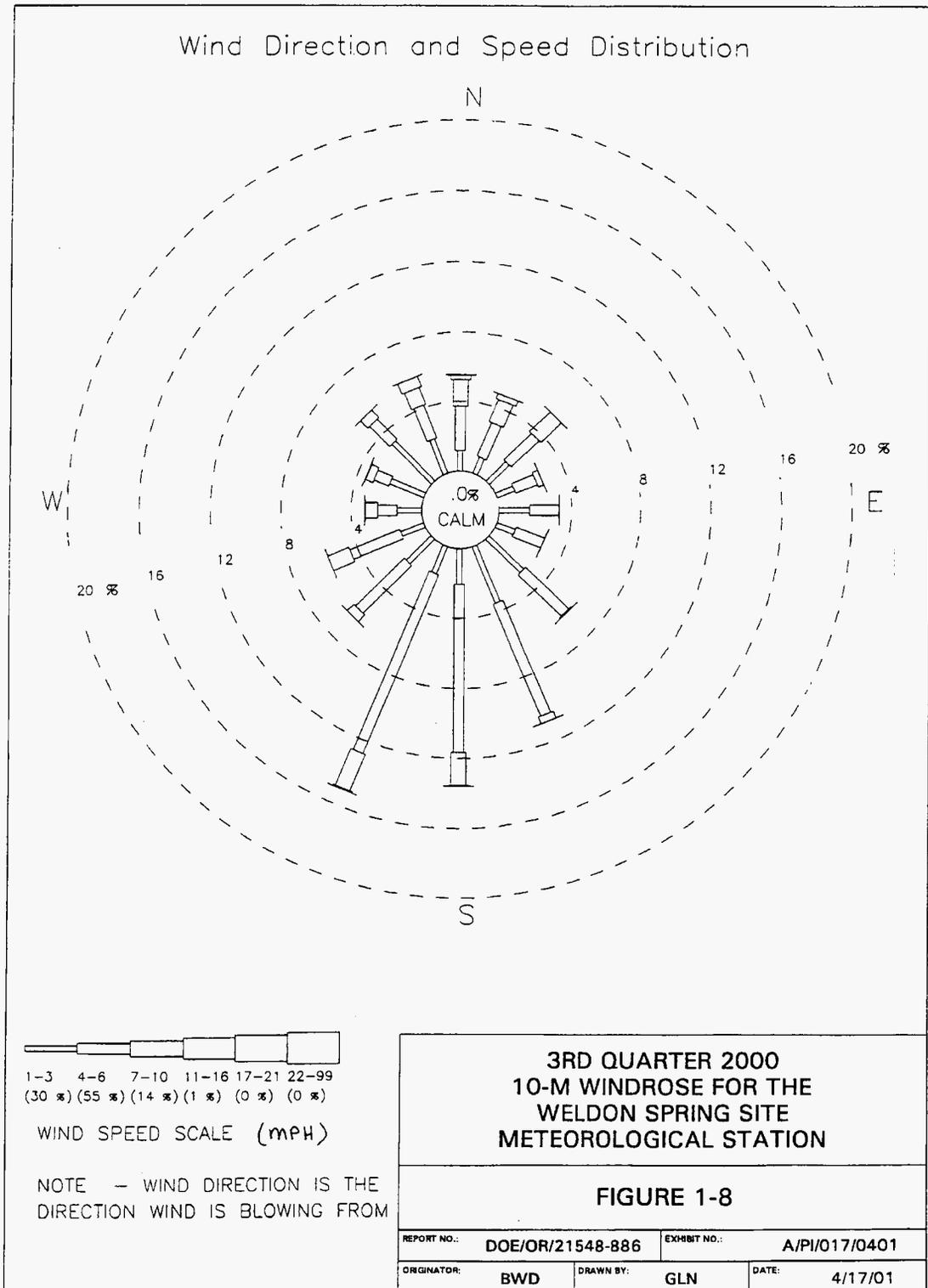
### 1.7 Land Use and Demography

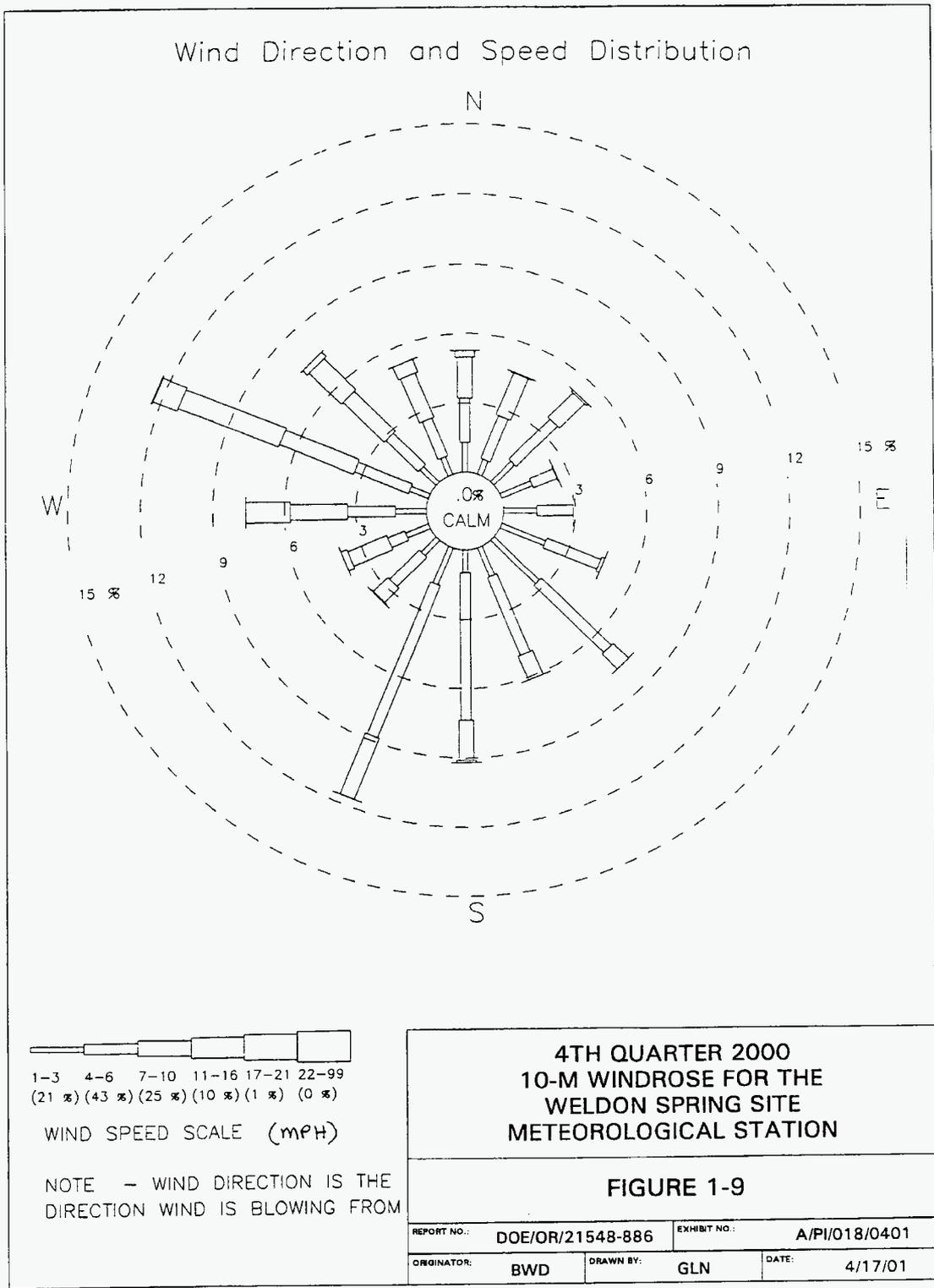
The population of St. Charles County in 2000 was 283,883. Twenty percent of the population lived in the city of St. Charles, approximately 22.4 km (14 mi) northeast of the Weldon Spring site. The population in St. Charles County has increased by about 30% over the past 10 years. The two communities closest 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 2000 was 5,349. 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 150 faculty and staff, and about 1,500 students attend school there (Appendix A). Students and staff generally spend about 7 hours to 8 hours per day, 36 weeks per year, at the school. At least 7 employees work at the school year-round. The buildings are also used for other activities, such as athletic events and school meetings. In addition, approximately 53 full-time employees worked at the high school annex, and about 50 bus drivers spent 3 hours/day at the annex during 2000. The MHTD facility, located adjacent to the north side of the chemical plant, employs 11 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 48 people.

The Army Reserve Training Area is to the west of the WSSRAP and periodically is visited by Department of the Army (DOA) trainees and law enforcement personnel. In addition, one full-time employee worked for 6 months and 10 full-time subcontract personnel worked for about 8 months at the Training Area in 2000. One DOA employee worked at the office on the reserve property 2 days per week for 52 weeks (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 Environmental 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 DOE Secretarial Policy Statement on NEPA.

### 2.2 Project Management

In order to manage the WSSRAP under 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 original chemical plant buildings, contaminated soils, raffinate pits, quarry bulk wastes that were staged at the temporary storage area (TSA), vicinity properties, and surface waters within the chemical plant boundary. 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), 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 CERCLA, DOE orders, and other relevant Federal and State regulations.

The WSSRAP also complies with DOE Order 5400.1 requirements for preparation and maintenance of 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 contaminants 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 [NESHAP]). 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 total uranium (U-234, U-235, and U-238), Ra-226, Ra-228, Th-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 and thoron gas. Radiological monitoring is also conducted on National Pollutant Discharge Elimination System (NPDES) discharges, streams, lakes, ponds, groundwater, and springs. Based on historic data and completion of virtually all radioactive waste handling activities, air monitoring at the perimeter and off-site locations ceased at the end of calendar year 2000.

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 2000 monitoring program are metals, inorganic ions (nitrate and sulfate), TCE, and nitroaromatic compounds. Other non-radiological parameters monitored as part of the environmental monitoring program include asbestos at site perimeter air monitoring locations and Francis Howell High School.

## **2.4 Project Accomplishments in 2000**

Several activities were completed in 2000 under the overall plan for remediation of the site. Major accomplishments for the operable units are detailed below.

## **2.4.1 Weldon Spring Chemical Plant Operable Unit**

### **2.4.1.1 Site Water Treatment Plant and Quarry Water Treatment Plant**

The site water treatment plant completed water treatment in May of 2000. The plant was demolished and placed in the cell. The quarry water treatment plant completed water treatment in December of 2000. Decommissioning of the plant was started in December of 2000. The plant is scheduled for demolition in April 2001. It will be placed in the cell.

Two mobile systems have been permitted to replace the quarry and site water treatment plants. These are the Retention Basin Ion Exchange (RBIX) System and the Train 3 Mobile Treatment System. The RBIX has a nominal treatment capacity of 250 gallons per minute, and Train 3 has a nominal capacity of 50 gallons per minute. Both systems utilize solid media cartridge filters to remove suspended solids and Dowex 21K XLT Ion Exchange media to remove dissolved uranium. Additional treatment technologies can be added to these units as needed.

### **2.4.1.2 RCRA/TSCA Storage**

Building 434 and the temporary storage area were *Resource Conservation Recovery Act* (RCRA) and *Toxic Substances Control Act* (TSCA) facilities. Both were closed in accordance with 40 CFR 264 Subpart G and the RCRA Closure Document (Ref. 7) during the year 2000. Demolition of Building 434 began on March 21, 2000, and cleanup confirmation was completed May 1, 2000. Remediation of the temporary storage area began in 1999, and cleanup confirmation was completed on May 16, 2000.

### **2.4.1.3 Disposal Cell**

With the exception of a small portion of the administration area sanitary sewer line, all remaining areas awaiting confirmation were remediated and confirmed clean during 2000.

All 3:1 slopes were completed, as was most of the "collar," or transition zone from the 3:1 slopes to the 4:1 slopes.

Placement of 99.5% of the total amount of waste, leaving a small depression (known as the "dimple") for minor amount of waste generated in 2001.

The cell cap was covered with soil and seeded for the winter to reduce erosion. This effort was successful, and erosion was greatly reduced from the upper portion of the disposal cell.

Radon flux monitoring was performed on the top of the first foot of disposal cell's radon barrier during 2000. The monitoring method used to determine the average radon flux from the

WSSRAP disposal cell is approved by the U.S. Environmental Protection Agency (EPA) and is found in 40 CFR 61, Appendix B, Method 115. The average was well below the regulatory requirement of 20 pCi/m<sup>2</sup>/sec. A summary of these results is in Section 11.2.

Semi-annual groundwater compliance monitoring for the disposal cell continued in 2000. Analytical data for this effort can be found in Section 8, *Groundwater Monitoring*.

#### **2.4.1.4 Raffinate Pits**

The remaining two raffinate pits, Raffinate Pits 1 and 2, were successfully remediated and confirmed during 2000. Raffinate Pits 3 and 4, which were confirmed during previous years, were brought to final grade.

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

This operable unit was officially closed in April 1997.

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

The *Remedial Design/Remedial Action Work Plan for the Quarry Residuals Operable Unit* (Ref. 49) was finalized in January 2000. This plan provides the transition from the environmental documentation phase (RI/FS/ROD) to final design and implementation of the selected remedial action and supporting field studies. Activities performed during calendar year 2000 included:

- Characterization of the northeast slope and Snake Pit Area.
- Construction of the Quarry Interceptor Trench System.
- Initiation of the Quarry Interceptor Trench System field study.
- Excavation of residually contaminated soils in the quarry proper.

#### **2.4.4 Weldon Spring Groundwater Operable Unit**

The *Interim Record of Decision for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site* (Ref. 20) was issued in September 2000. This document presents the selected interim remedial action for the Weldon Spring Groundwater Operable Unit. This action provides for remediation of trichloroethylene (TCE) contaminated groundwater in the chemical plant area. The other contaminants of concern will be addressed in the final Record of Decision that will be issued at a later time.

## 2.5 Incident Reporting - Environmental Occurrences in 2000

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 2000, eight off-normal occurrences of an environmental nature were reported under DOE Order 232.1A, *Occurrence Reporting and Processing of Operations Information*. Table 2-1 lists these occurrences and each is discussed in the following paragraphs.

Table 2-1 Environmental Occurrences Calendar Year 2000

OCCURRENCE REPORT NUMBER	OCCURRENCE DATE	SUBJECT OF OCCURRENCE
2000-0001	01/27/00	NPDES permit exceedance.
2000-0002	02/19/00	Release of reportable quantity.
2000-0003	02/21/00	NPDES permit exceedance.
2000-0005	02/24/00	Bypass of retention basin.
2000-0008	04/21/00	NPDES permit exceedance.
2000-0009	05/11/00	NPDES permit exceedance.
2000-0011	05/31/00	NPDES permit exceedance.
2000-0017	07/28/00	NPDES permit exceedance.

### Occurrence 2000-0001

On January 20, 2000, the quarterly compliance effluent sample for the sewage treatment plant outfall (NP-0006) was collected. The water was reported to appear slightly turbid with a light brownish color. The analytical data were received on January 27, 2000, and the results for fecal coliform were reported as TNTC (too numerous to count). The laboratory reported that an upper level for detection was approximately 15,000 colonies per 100 ml. The permitted daily maximum for outfall NP-0006 is 1,000 colonies per 100 ml. Standard conditions of the permit required the exceedance to be reported to the Missouri Department of Natural Resources within five days of discovery of the event.

A letter was sent to MDNR on January 28, 2000, reporting the exceedance of the fecal coliform permit limit.

### Occurrence 2000-0002

On February 17, 2000, during waste hauling operations between the adjacent Army site and the DOE-WSSRAP site, hauling operations into the engineered disposal facility were halted due to inclement weather. As a contingency, the lead phosphate contaminated soils were placed in a staging area adjacent to the disposal facility. All but 32 cy of the soil was immediately

transferred into the disposal cell using equipment capable of operating in those conditions. The remaining 32 cy were transferred to the cell the next day (February 18, 2000). However, the staging area was not an engineered facility; therefore, it was determined that as a result of placement of the soils in this area, a CERCLA reportable quantity (RQ) for lead phosphate had been exceeded. The RQ for lead phosphate is 10 pounds, and it was calculated that approximately 403 pounds had been placed in the staging area. This determination was made on February 19, 2000, and the National Response Center was called to report the reportable quantity exceedance.

### Occurrence 2000-0003

Storm water samples collected the morning of February 18, 2000, at two NPDES outfalls exceeded the permit limit of 1.0 ml/l/hr for settleable solids. There had been an overnight rainfall of approximately 3 in. Settleable solids for outfall NP-0002 were 50 ml/l/hr with a flow of 722 gpm. The water was noted as being very turbid and brown. Settleable solids for outfall NP-0003 were 2 ml/l/hr with a flow of 888 gpm. This water was also noted as being very turbid and brown.

The preliminary analytical results of outfall NP-0003 were received on March 1, 2000. Results indicated that arsenic, chromium, and lead exceeded the NPDES reporting level for each of these metals for the above sampling event.

For this event, Thorium-230 exceeded historical data. An investigation to determine the source concluded as follows:

“Results of various sampling efforts indicate that the contamination was transported to Outfall 3 along the diversion ditch, and that the source of the contamination was runoff from the contaminated haul road and parking area.

“The diversion ditch was designed to direct storm water runoff from contaminated areas such as the haul road and the contaminated equipment parking lot through the sedimentation basin prior to discharge. The purpose of this design was to remove potentially contaminated suspended solids. The diversion ditch contained sediments that exhibited thorium levels that were sufficiently above background to indicate that it was the contaminant transport route to Outfall 3.

“Efforts to characterize the potential sources of the contamination have been completed, and the potential source areas have been successfully located and bounded. Immediate steps have been taken to eliminate or reduce these contaminant sources in order to prevent recurrence of elevated thorium. Further, long-range plans are in place to perform regular monitoring and maintenance of the subject areas. The measures detailed in this report and appendixes apply a graded approach to managing contaminants along the haul route. These measures will minimize the contaminated solids available for mobilization

during runoff events, and therefore should maintain the concentrations at the outfall at an acceptable level throughout the remainder of contaminated haul operations.”

#### Occurrence 2000-0005

On February 22, 2000, at approximately 1040 hr a minor leak was discovered in the HDPE pipeline that carries retention basin water (disposal cell runoff and leachate) from the basins to the site water treatment plant. The leak occurred at the point where the pipe crosses under the entrance road near Gate H. At the time, water was being transferred from Retention Basin 1 to Holding Pond 3 at the treatment plant. The pump was shut off and locked out of service as soon as possible (within 10 minutes after discovery of the leak), and the pipe was drained as quickly as possible. Pumping had started at 1450 hr the day before (February 21, 2000) and continued until the leak was discovered. No leak was noticed on February 21. The leak occurred where it would naturally drain to outfall NP-0005.

Although it was suspected that the water met discharge limits at outfalls NP-0007 and NP-0005, this water was required to discharge at outfall NP-0007; therefore, the project was required to report the leak to the Missouri Department of Natural Resources under the bypass provisions in the NPDES Permit Standard Conditions Part 1, Section A.5.B.

The notification letter was sent to the State on March 1, 2000.

#### Occurrence 2000-0008

On April 20, 2000, a storm water sample was collected at outfall NP-0002. This outfall is the storm water outlet for the north portion of the site. The precipitation received over the previous 12 hours was 0.44 in., and the flow was 61 gpm. The water was very turbid and brown. The settleable solids were 36 ml/l/hr with a limit of 1.0 ml/l/hr. The pH was 7.86.

The suspected contributing cause was a large unvegetated area upstream of the outfall. The Frog Pond area had been filled and graded, but not yet seeded, in preparation for rock storage. Sedimentation Basin 1 had been cleaned out. Surface water from two-thirds or more of that area flows directly off site through NP-0002. Rock check dams were in place, but were not adequate to control fine clay particles. The Erosion and Sediment Control Officer was present at sampling and recommended that the area be seeded and strawed as soon as possible. The NPDES exceedance was required to be reported to MDNR in writing within 5 days.

A letter was sent to the MDNR on April 24, 2000, addressing the exceedance of the settleable solids level for NPDES permit MO-0107701.

### Occurrence 2000-0009

Over the weekend of May 6-7, 2000, approximately 5 in. of rain fell at the site. Sedimentation Basin 4 was filled with water, and on May 8 the basin valve was opened and the water sampled for NPDES permit monthly parameters. Settleable solids were in compliance at <1.0 ml/l/hr. The valve was left open and pumping was initiated to lower the pond level to gain capacity in anticipation of an additional expected storm. Pumping was stopped at the end of the day and restarted the next day, May 9. During the afternoon of May 9 it was observed that the liquid being pumped off site had a murky appearance, and a sample was taken at Outfall 3. The settleable solid sample results for the liquid were 80 ml/l/hr. (The NPDES permit limit is 1.0 ml/l/hr.) It was determined that the water in the pond had been pumped down to the top of the sediment layer. A letter dated May 12, 2000, was sent to the MDNR notifying them of the event.

### Occurrence 2000-0011

A storm water runoff sample was collected at outfall NP-0002 on May 26, 2000, at approximately 1430 hr. Precipitation had been approximately 1 in. over the previous 8 hours. The sample was collected in response to an observation by a Busch Wildlife Area employee that water flowing into Lake 36 was somewhat turbid. The settleable solids were reported at 50 ml/l/hr with an NPDES permit limit of 1 ml/l/hr.

There is a large unvegetated area upstream of the outfall. In addition, runoff from the cap of the disposal cell, which was under construction, flows to this drainage. The cell cap was unvegetated at that time. Rock check dams were in place, and a silt fence had been installed along the length of the channel where Sedimentation Basin 2 had been remediated.

Standard conditions of the NPDES permit required the exceedance to be reported to the MDNR in writing within 5 days of discovery of the event. A letter was sent on May 31, 2000, reporting the exceedance of the settleable solids level for NPDES permit MO-0107701. The Erosion Control Officer made a field inspection, and the PMC performed an Engineering Assessment. On the basis of the findings, the subcontractor initiated efforts to minimize erosion.

### Occurrence 2000-0017

This occurrence was an accumulation of three separate storm water sampling events.

- Occurrence 1 – A storm water sample was collected at outfall NP-0002 on July 28, 2000, at approximately 0908 hr. Flow was 198 gpm, and the water was very turbid. There were thunder showers before and during the sampling event. Settleable solids were 80 ml/l/hr with a permit limit of 1.0 ml/l/hr.

- Occurrence 2 – A storm water sample was collected at outfall NP-0002 on September 12, 2000. Flow was approximately 150 gpm, and the water was very turbid. There was a 0.94 in. rainfall the night before. Settleable solids were 20 ml/l/hr with a permit limit of 1.0 ml/l/hr.
- Occurrence 3 – A storm water sample was collected at outfall NP-0002 on October 5, 2000. There had been approximately 1.0 in. of rainfall overnight and during the next morning. Settleable solids were 1.2 ml/l/hr with a permit limit of 1.0 ml/l/hr.

Standard conditions of the NPDES permit required the permit exceedance to be reported to the MDNR in writing within 5 days of discovery of the event. Therefore, these occurrences were reported under Category 2, Environmental, E, Agreement/Compliance Activities.

A letter was sent to the MDNR after each occurrence reporting the exceedances of the settleable solids level for NPDES permit MO-0107701.

The Erosion Control Officer inspected the area after the first occurrence and noted that the watershed area had been seeded, and vegetation was becoming established. Silt fences and rock check dams were installed along the channel, which drains to NP-0002. Additional riprap was placed on the cell to cover the areas where storm water drains.

After the second occurrence, the Erosion Control Officer noted that water coming off the disposal cell (which was under construction) through the anchor trench and into the road (at a swale in the truck crossing) appeared very clear. It was observed that it was at the road where vehicles were driving through the water that it became turbid. The water was passing through several check dams downstream of this point prior to reaching the outfall. Once the anchor trench bedding and riprap placement was completed in this area, this swale in the road was filled to finish grade and water begin sheet flowing across the road (as opposed to concentrated flow in the swale). This was completed on August 22, 2000.

After Occurrence 3, the Erosion Control Officer stated that the corrective actions implemented after Occurrence 2 were effective. Construction of Sedimentation Basin 5 and the previous corrective actions controlled the water flowing to NP-0002 from upstream of Basin 5. It was water from a ditchline which was discharging below the sedimentation basin and just above the weir at NP-0002 that caused the elevated settleable solids during this rain event. Riprap, a rock check dam, and a diversion dam have been placed in this ditchline. The rock check dam will filter slower discharges of water and will divert the higher volume flows into the sedimentation basin.

## **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 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 *WSSRAP Weldon Spring Site Remedial Action Project Groundwater Protection Management Program Plan* (Ref. 12). 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 also describes 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, wind stability, 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 can be used to model impacts of potential airborne releases. In addition, precipitation data are used to correlate water level fluctuations and contaminant concentrations in surface water and groundwater wells.

Since completion of a system upgrade in August 1994, meteorological data recovery has exceeded 99% each year. An off-site meteorologist provides monthly data reviews and conducts annual 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. 14) 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 and 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; 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 to controlled areas.

As of December 31, 2000, 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 subtier 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 project administration are excluded.

Waste management activities for 2000 include:

- Shipment of incinerable waste to Diversified Scientific Services, Inc. (DSSI).
- Macroencapsulation treatment of radioactive Ni/Cd batteries and lead security seals.
- Carbon adsorption treatment of TCE-tainted monitoring well purge water.
- Stabilization of small quantities of miscellaneous hazardous waste.
- Treatment of 300 cy of nitroaromatic contaminated soil.

The waste management program also includes transportation activities such as packaging and shipping hazardous and nonhazardous wastes. The following transportation activities took place in 2000:

- Seven shipments of hazardous waste were shipped off-site. These shipments consisted of waste flammable liquids, waste oil, waste chemical kits, waste cartridges, hazardous waste solids, and waste corrosive liquids.
- Six hundred thirteen light bulbs of various types were sent off site for recycling.
- Eighty-five lead and 29 Ni-Cad batteries were sent off site for recycling.
- Nineteen shipments totaling 35,300 l (9,330 gal) of used oil were sent off site for recycling.

### **2.6.6 Waste Minimization/Pollution Prevention Program**

The WSSRAP Waste Minimization Program is outlined in the *Waste Minimization/Pollution Prevention Awareness Plan* (Ref. 15) 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 methods to achieve minimization. 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 2000.

- Approximately 241 personal computer workstations and 127 monitors were donated to a local high school under Executive Order 12821, which allows agencies to transfer educationally related Federal equipment to secondary schools.
- Twenty-nine Ni-Cad and 85 lead batteries were sent off site for recycling.
- Approximately 440 m<sup>3</sup> (570 cu yd) of paper/cardboard, 955 kg (2,100 lb) of newspaper and 20,800 aluminum cans were collected by a recycler.
- Approximately 100 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 were laundered and reused.
- Six hundred thirteen various types of light bulbs were shipped to a recycler.
- A total of 35,300 l (9,330 gal) of used oil was sent to a recycler.

### 3. COMPLIANCE SUMMARY

#### 3.1 Compliance Status for 2000

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 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), *Clean Water Act* (CWA), *Clean Air Act* (CAA), *National Historic Preservation Act* (NHPA), *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, *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 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 CERCLA, as amended by the *Superfund Amendments and Reauthorization Act* (SARA), and 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 RCRA as substantive, applicable, or relevant and appropriate requirements (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 CERCLA. Section 121(e) of CERCLA states that no Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely on site.

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. 16) 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 mixed wastes covered by the site treatment plan 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 (NESHAP), and Title VI - Stratospheric Ozone Protection.

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

St. Charles County is not subject to nonattainment area requirements for particulate matter (PM-10). However, the WSSRAP has instituted a voluntary program to monitor PM-10 on a regular basis in the vicinity of activities that generate dust. This program is discussed in Section 4.6.

Under Title III, asbestos and radionuclides are hazardous air pollutants that must be controlled in accordance with established standards. WSSRAP programs for radionuclides and asbestos are described in detail in Sections 4 and 6, along with the 2000 status of monitoring. NESHAP dose calculations for 2000 indicated the highest effective dose equivalent at a critical receptor location was 0.014 mrem (0.0001 mSv), which is well below the NESHAP standard of 10 mrem (0.1 mSv).

#### *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 states with regulatory programs that are 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.

### *Rivers and Harbors Act*

No work was conducted during this reporting period that would fall under the jurisdiction of this 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 and, therefore, does not possess a permit/license to purchase these materials. The WSSRAP meets State requirements for pesticide application, and reviews each application 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. It 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. The certified shipping officers maintain their required DOT training by attending courses off site.

### *Safe Drinking Water Act*

*Safe Drinking Water Act* (SDWA) regulations are not applicable because maximum contaminant levels (MCLs) are applicable only to drinking water at the tap, not in groundwater. However, under the National Contingency Plan, MCLs are relevant and appropriate to groundwater that is a potential drinking water source.

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

The 2000 *Emergency Planning and Community Right-to-Know Act* (EPCRA) Tier II report was completed and provided on February 26, 2001, to the local emergency planning committee (LEPC) and to the Missouri State Emergency Response Commission (MERC).

The Toxic Release Inventory (TRI) report for 2000 is due on July 1, 2001. At this time the WSSRAP expects to submit a TRI report.

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

The FY00 Federal Archeological Activities Questionnaire was submitted on March 1, 2001. No archeological evaluations were performed at the WSSRAP during FY00.

### *Endangered Species Act*

There was no activity this reporting period.

## **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 estimated total effective dose equivalent to the maximally exposed individual at the vicinity properties due to consumption of water from Burgermeister Spring was 0.35 mrem (0.0035 mSv) is well below the 100 mrem (1 mSv) guideline for all potential exposure pathways. The 10 mrem (0.1 mSv) 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 2000. The appropriate dose evaluation techniques were used to assess 2000 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 600 pCi/l (22.2 Bq/l).

Records of all environmental monitoring and surveillance activities conducted at the Weldon Spring site in 2000 are being maintained in accordance with the requirements of this Order. All reports and records generated at the WSSRAP in 2000, pursuant to DOE Order requirements, presented data in the units specified by the applicable regulation or Order.

### **3.1.2.2 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 *Weldon Spring Site Remedial Action Project Groundwater Protection Management Program Plan* (Ref. 12) and the *Waste Minimization/Pollution Prevention Awareness Plan* (Ref. 15). Refer to Section 2.6.6 for additional details.

## **3.2 Current Issues and Actions**

### **3.2.1 National Emission Standards for Hazardous Air Pollutants Compliance**

The WSSRAP has completed its critical receptor monitoring program for demonstrating compliance with the requirements of 40 CFR 61 Subpart H. No exceedances of the 10 mrem/yr standard were measured during the 11 years in which the program operated. Due to the remediation of site soils and debris and final placement of waste in the disposal cell, there are no longer any sources of radiological emissions with the potential to cause an effective dose equivalent greater than 1% of the 10 mrem/yr standard. Thus, the NESHAP monitoring program concluded at the end of 2000.

### **3.3 Summary of Permits for 2000**

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. Five active NPDES operating permits covered discharges from the site water treatment plant (MO-0107701) and quarry water treatment plant (MO-0108987), storm water discharges from the Borrow Area (MO-R100B69), hydrostatic test water from the site (MO-G670203) and quarry borrow area storm water land disturbance (MO-R104031). An NPDES construction permit for the cell leachate collection and removal system was issued in January 1997.

### **3.4 Site Mitigation Action Plan**

Progress of mitigative actions for 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 for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 19) was developed to present planned mitigation actions that provide protection for human health and the environment during remediation activities. The MAP is reviewed and updated, as necessary, to reflect site conditions.

Table 3-1 Summary of WSSRAP NPDES Operating 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	Renewal application submitted and pending	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 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-R104031	O	07/28/00	01/02/02	N	07/02/01	Covers quarry borrow area storm water land disturbance.
CP-22-5186	C	01/08/97	01/07/02	N	12/07/01	Covers construction of cell leachate collection system.
CP-22-5765	C	06/19/99	06/15/00	N	05/15/00	Covers construction of reverse osmosis unit.

- (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.

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. Surface water protection during 2000 included erosion prevention and sediment control and monitoring. Monitoring was conducted at eight outfall locations at the chemical plant, and the requirements of NPDES permits and the *Missouri Clean Water Act* were met during 2000. Further information on compliance issues is provided in Section 7.

Topsoils and subsoils from the Borrow Area that were being stored for use in restoration were stockpiled at the Borrow Area. Stockpile slopes were limited to 2.5:1 and stockpiles were seeded and mulched to control erosion. In 2000, exposed areas at the Borrow Area were reclaimed and seeded with a top seed mix. Erosion control measures were implemented at the Borrow Area and along the haul road. Stockpiles were routinely inspected for erosion. Two sedimentation ponds were constructed at the Borrow Area, and surface water was 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 were monitored as part of the routine environmental activities at the chemical plant area. The results of this monitoring are presented and discussed in the remaining sections of this report.

## 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 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 (RD-CE07) integrated radon alpha track monitoring station within the site boundary exceeded the annual average background concentration in 2000. No annual integrated radon alpha track results at perimeter or critical receptor locations were statistically greater than background levels.
- Statistical analysis at the 95% confidence level indicated that one (RD-CE07) modified Rn-220 (thoron) alpha track monitoring location exceeded 2000 average background levels. This station is within the site boundary.
- Environmental thermoluminescent dosimeter (TLD) results for 2000 at the chemical plant perimeter, quarry perimeter, and off-site locations ranged from 45.4 mrem/year (0.45 mSv/year) to 63.1 mrem/year (0.63 mSv/year). These results are inclusive of background, which totaled 54.2 mrem (0.54 mSv) for the year. Statistical analysis of the results indicated that, at the 95% confidence level, no stations exceeded background levels.
- Statistical analysis at the 95% confidence level indicated that one (AP-2025) low-volume radioactive airborne particulate monitoring station along the chemical plant perimeter had an annual average concentration that exceeded the 52-week background average. This station, which measures gross alpha airborne concentrations, exceeded the 52-week background average by  $1.7\text{E}-16$   $\mu\text{Ci/ml}$  ( $6.3\text{E}-12$  Bq/ml).
- All 2000 radiological air monitoring results at Francis Howell High School (including radon, gamma exposure, and airborne radioactive particulates) were indistinguishable from background.
- All asbestos monitoring conducted during 2000 indicated fiber concentrations of less than 0.01 fibers/ml air.

## 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 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. 21).

Two types of alpha track 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 alpha track detectors are used in conjunction to distinguish radon and thoron concentrations by analyzing the relative response of paired sets of these detectors at each monitoring location where they are deployed.

In 2000, a pair of standard F-type alpha track detectors was deployed quarterly at each of 19 permanent monitoring locations: seven at the Weldon Spring Chemical Plant perimeter, two at the Weldon Spring Quarry perimeter, three inside the site boundary, and seven at off-site locations. Alpha track monitoring locations are identified with an "RD" prefix in Figures 4-1 through 4-5. Two of the three locations inside the site boundary were discontinued after the first quarter.

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

Paired M-type alpha track detectors were deployed quarterly at 17 monitoring locations: six at the chemical plant perimeter, one at the quarry perimeter, three inside the site boundary, and seven at off-site locations (including two background locations, RD-4005 and RD-4009). Two of the three locations inside the site boundary were discontinued after the first quarter.

Specific locations are identified on Figures 4-1 through 4-5. These detectors were placed in conjunction with F-type alpha track detectors to distinguish radon from thoron concentrations. Using Pearson's method (Ref. 22), separate concentrations of radon and thoron were calculated for these stations.

The WSSRAP radon monitoring program also used electret detectors, which provided more timely data (bi-weekly) than the alpha track detectors (quarterly). Like alpha track detectors, electret detectors provide a passive means of measuring radon and thoron gas concentrations in air. The main purpose for the electret program was to assess short-term trends in radon and thoron gas concentrations in work areas on site. By May 2000, when most site areas had been remediated, and radon and thoron concentration in those areas had returned to near background levels, the electret program was discontinued. There was no longer a need for a large network of radon monitors to demonstrate compliance with DOE Order 5400.5. During the first quarter and half of the second quarter, 13 pairs of electret detectors that measure radon only were placed at the following monitoring locations: 10 in the chemical plant area (including 6 along the site perimeter), and three off site. Eight pairs of electrets that indicate thoron concentrations were deployed at the following locations: five in the chemical plant area, and three off site. The electrets were exchanged and read bi-weekly. These locations, designated by an "ET" prefix, are shown in Figures 4-1 through 4-5.

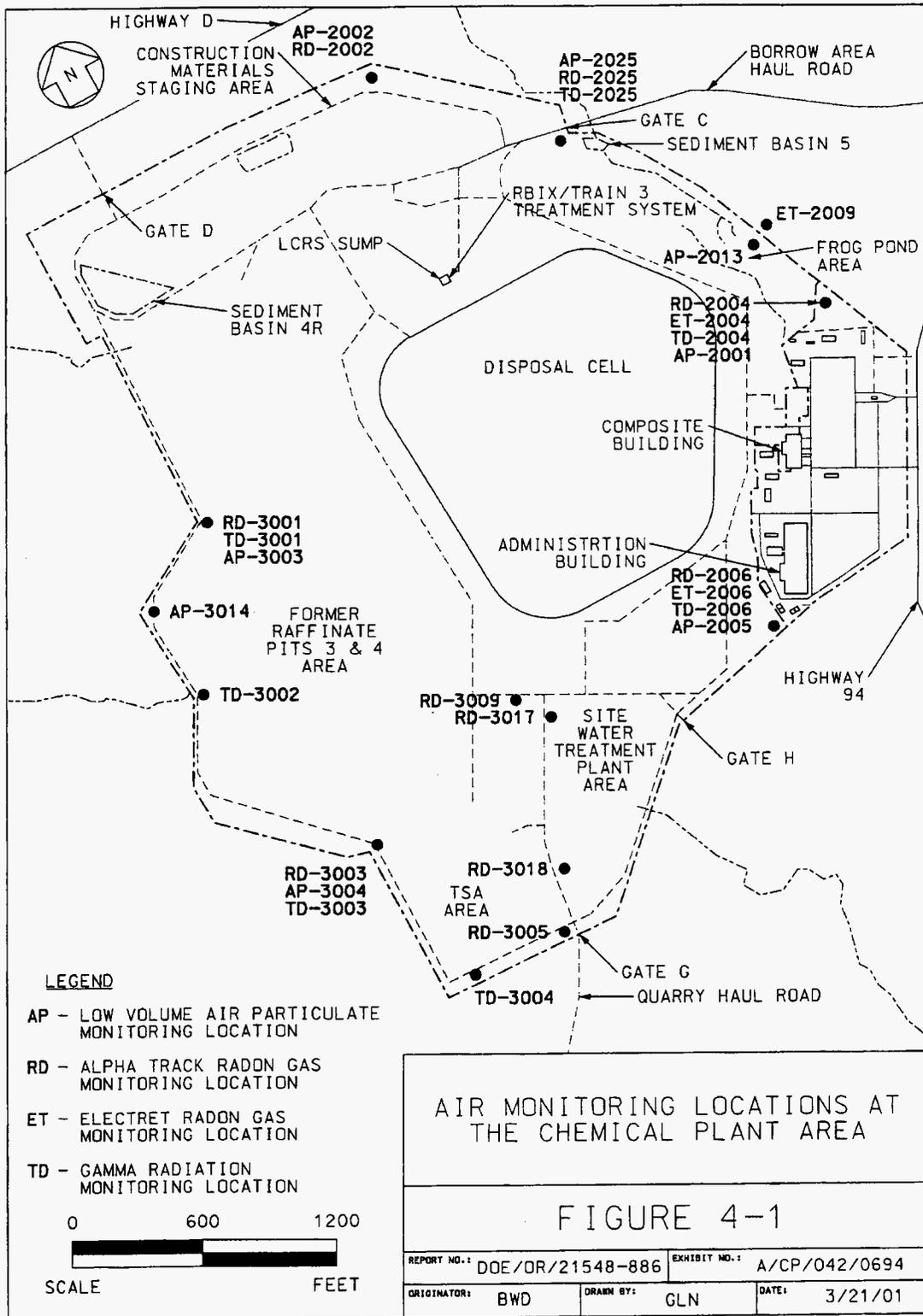
#### 4.2.2 Applicable Standards

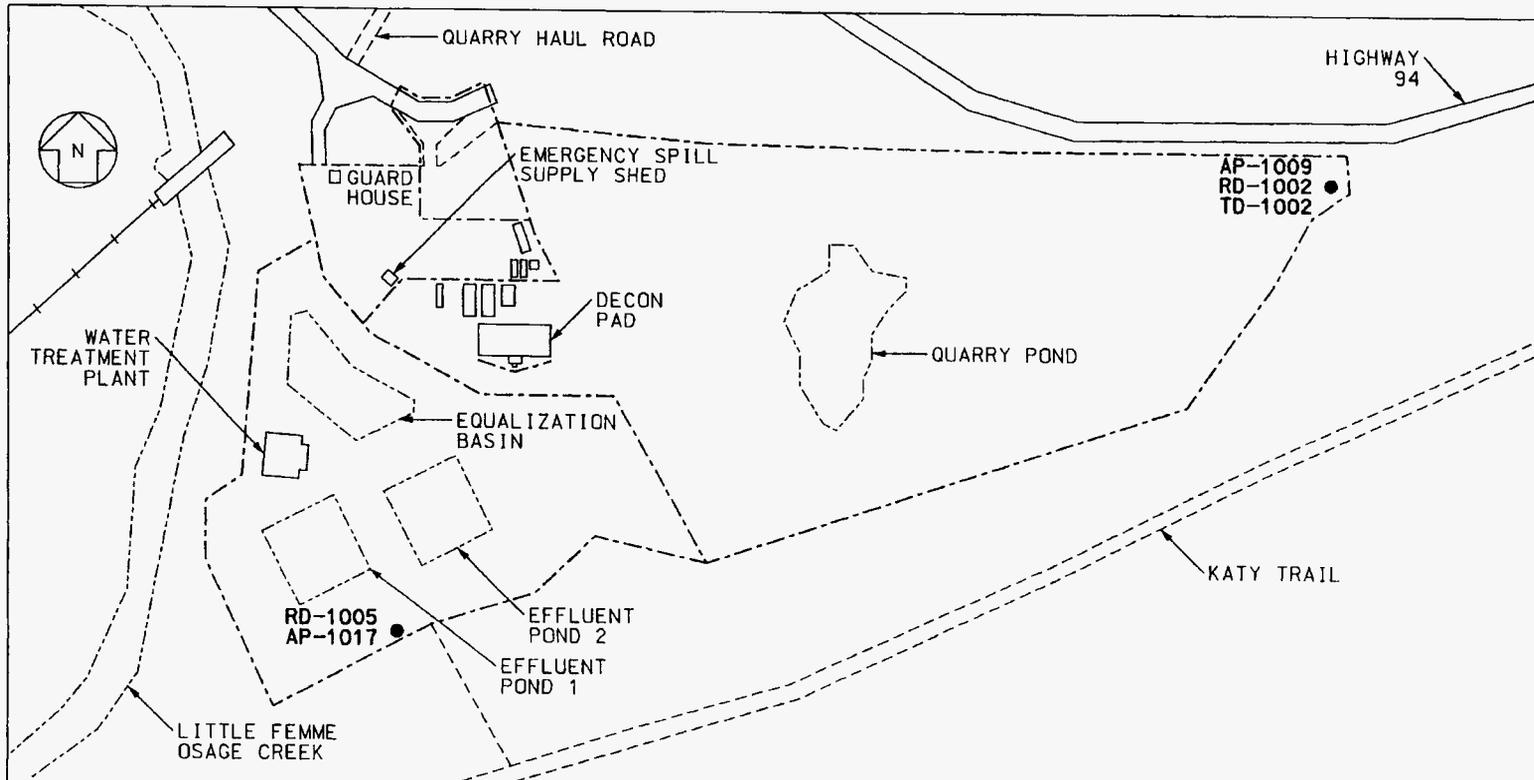
As established by DOE Order 5400.5, the DOE annual public dose equivalent limit is 100 mrem (1 mSv) total effective dose equivalent (TEDE).

Dose limits for inhalation of radon and thoron progeny and gas are based on working levels and concentrations in air, and are addressed independently in the Order. The Derived Concentration Guide (DCG) specified in DOE Order 5400.5, is a reference value for airborne concentrations of specific radionuclides. The DCG reference value for radon and thoron is 3 pCi/l (111 Bq/m<sup>3</sup>) 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 alpha track detectors. Since radon is naturally occurring, concentrations measured at each monitoring location were compared to measured background concentrations to determine whether any significant differences existed at the 95% confidence level. Only perimeter locations with integrated radon concentrations statistically greater than background



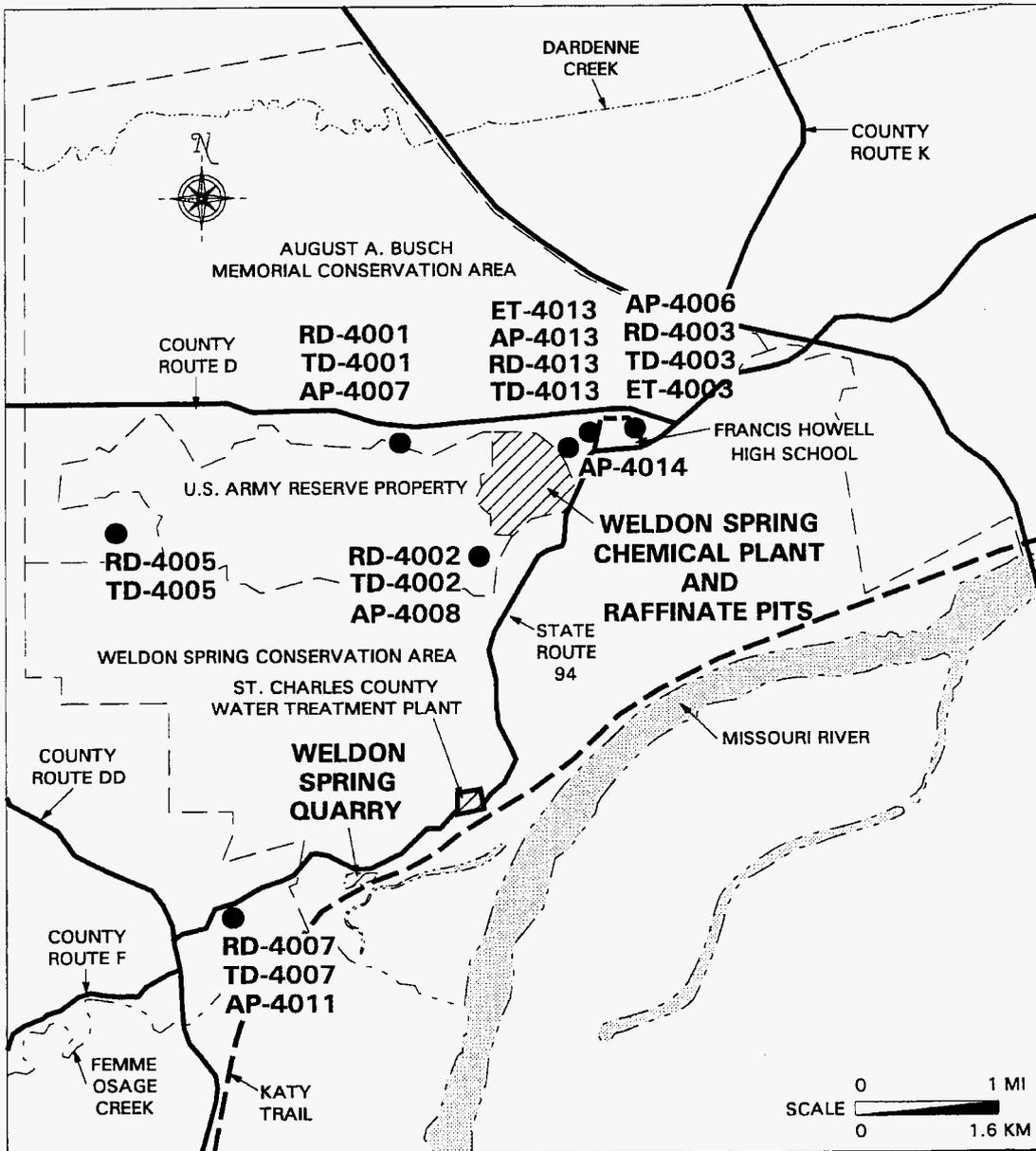


**LEGEND**

- AP - LOW VOLUME AIR PARTICULATE MONITORING LOCATION
- RD - ALPHA TRACK RADON GAS MONITORING LOCATION
- ET - ELECTRET RADON GAS MONITORING LOCATION
- TD - GAMMA RADIATION MONITORING LOCATION



<p>AIR MONITORING LOCATIONS AT THE QUARRY AREA</p>		
<p>FIGURE 4-2</p>		
<p>REPORT NO.: DOE/OR/21548-886</p>	<p>EXHIBIT NO.: A/QY/059/1194</p>	
<p>ORIGINATOR: EKA</p>	<p>DRAWN BY: GLN</p>	<p>DATE: 3/21/01</p>



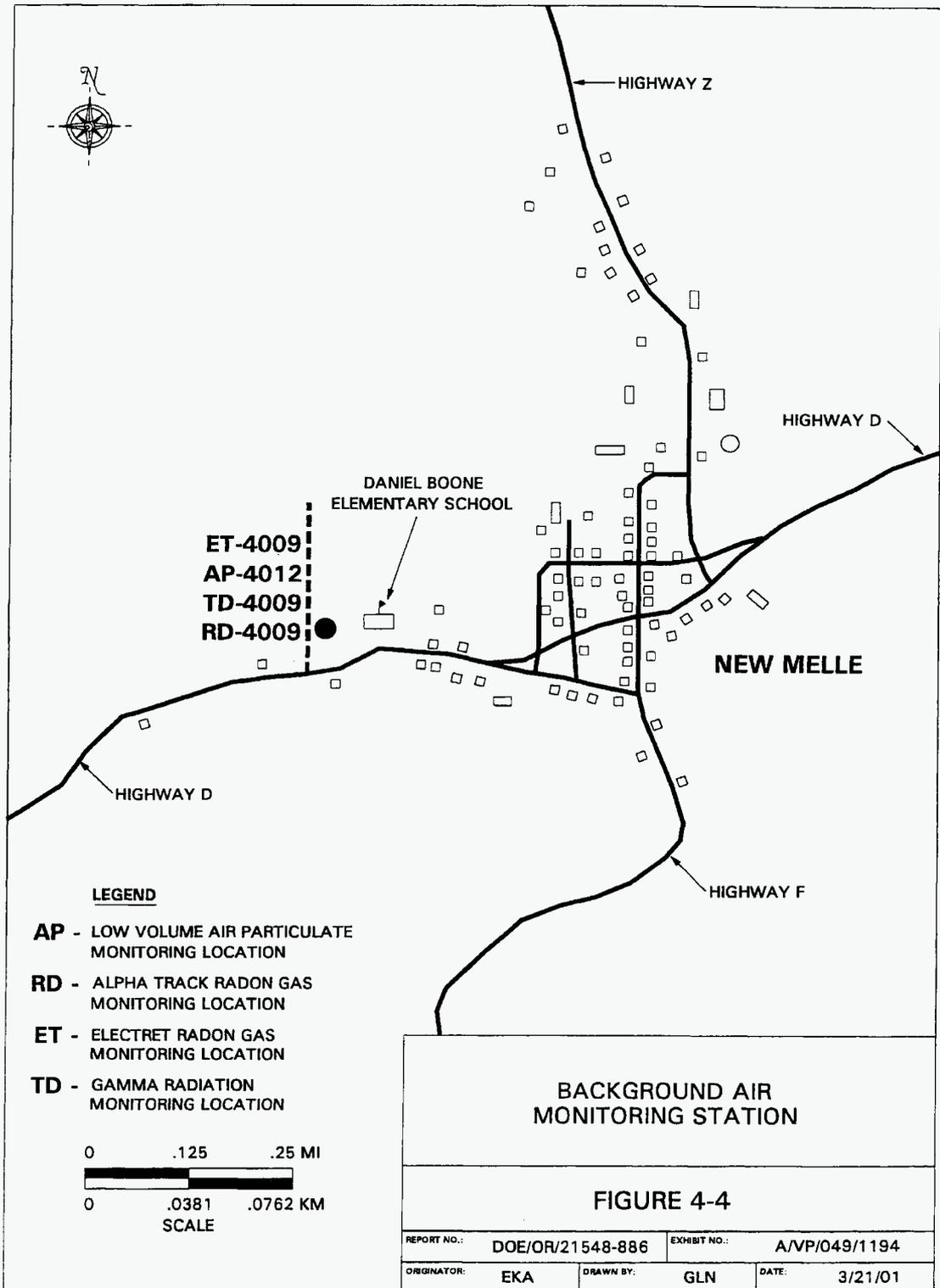
**LEGEND**

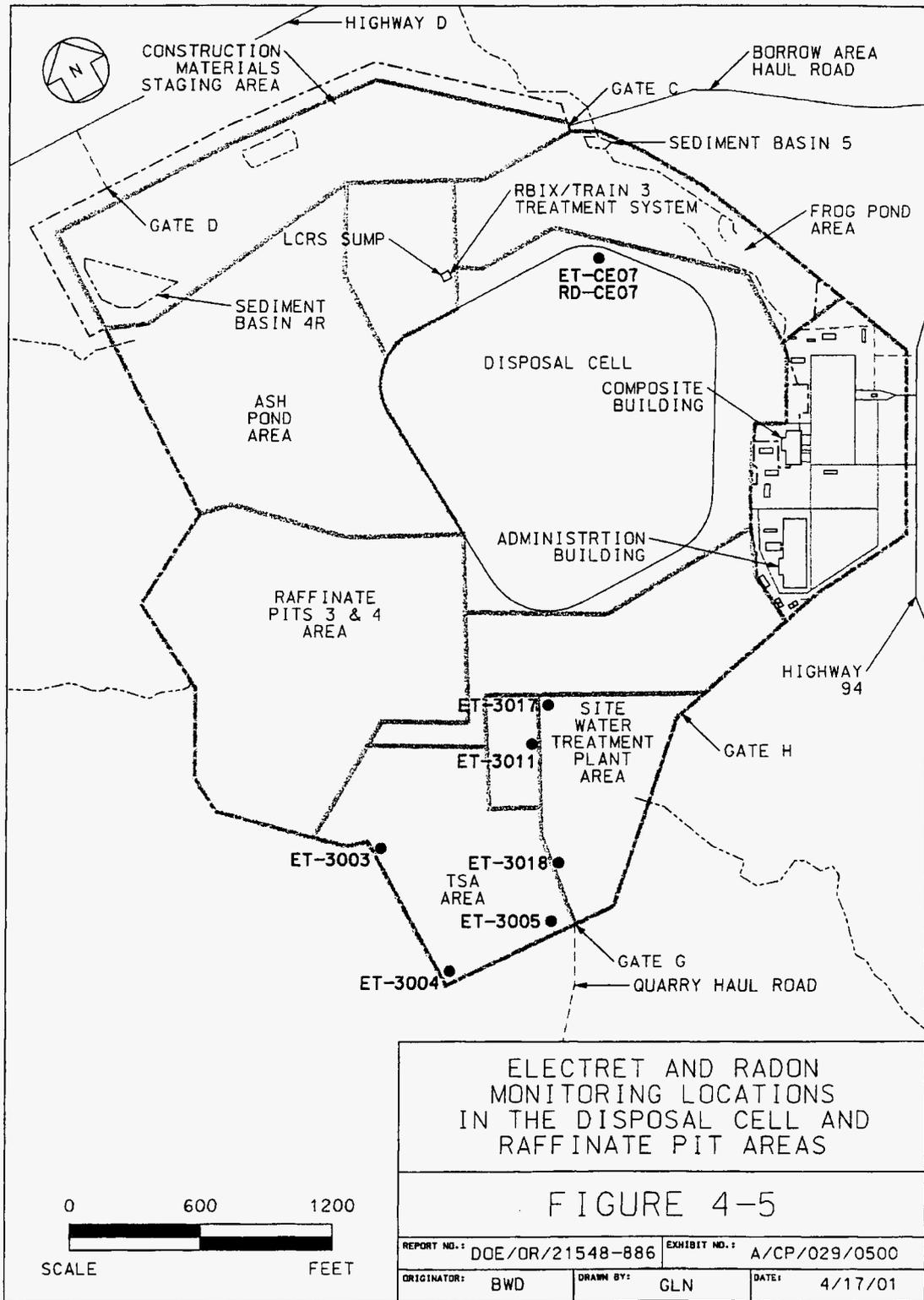
- AP** - LOW VOLUME AIR PARTICULATE MONITORING LOCATION
- RD** - ALPHA TRACK RADON GAS MONITORING LOCATION
- ET** - ELECTRET RADON GAS MONITORING LOCATION
- TD** - GAMMA RADIATION MONITORING LOCATION

**OFF-SITE AIR MONITORING LOCATIONS**

**FIGURE 4-3**

REPORT NO.:	DOE/OR/21548-886	EXHIBIT NO.:	A/VP/048/1194
ORIGINATOR:	EKA	DRAWN BY:	GLN
		DATE:	4/17/01





were compared to the DCG for radon by subtracting the average annual background concentration from the gross annual average concentration measured at a given location.

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

The annual F-type alpha track background concentration was calculated using the arithmetic average of the two background locations. The data yielded an annual background average integrated radon concentration in 2000 of 0.3 pCi/l (11.1 Bq/m<sup>3</sup>). This result is consistent with results in previous years.

Based on measurements from F-type and M-type alpha track detectors at locations where the potential for a combined release of radon and thoron was suspected, thoron concentrations were estimated using Pearson's method (Ref. 22). 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 results in previous years.

Concentrations measured by the electret monitors ranged from 0 to 0.89 pCi/l (32.9 Bq/m<sup>3</sup>) for radon and from 0 to 2.44 pCi/l (90.3 Bq/m<sup>3</sup>) for thoron. The highest results measured for both radon and thoron occurred at station CE07, which is located on top of the disposal cell. Because electret results were obtained bi-weekly rather than quarterly (as with the alpha track detectors), they were used primarily as advance indicators of trends in radon/thoron levels at a given monitoring location. Therefore, alpha track results, rather than electret results, are used in performing off-site dose calculations.

Table 4-1 2000 Alpha Track Integrated Radon Results<sup>(a)</sup>

Location ID	1st Quarter (pCi/l) <sup>(b)</sup>	2nd Quarter (pCi/l) <sup>(b)</sup>	3 <sup>rd</sup> 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 Guidelines <sup>(d)</sup>
Quarry Stations								
RD-1002	0.2	0.5	0.4	0.5	0.4	0.14		n/a
RD-1005	0.3	0.4	0.2	0.4	0.3	0.10		n/a
Chemical Plant Perimeter Stations								
RD-2002	0.2	0.5	0.3	0.4	0.4	0.13		n/a
RD-2004	0.2	0.4	0.2	0.4	0.3	0.12		n/a
RD-2006	0.2	0.4	0.2	0.4	0.3	0.12		n/a
RD-2025	0.2	0.7	0.4	0.4	0.4	0.21		n/a
RD-3001	0.2	0.5	0.5	0.4	0.4	0.14		n/a
RD-3003	0.2				0.2	n/a		n/a
RD-3005	0.2	0.4	0.3	0.3	0.3	0.08		n/a
Stations Inside Chemical Plant Boundary								
RD-3017	0.2	--	--	--	0.2	n/a		n/a
RD-3018	0.3	--	--	--	0.3	n/a		n/a
RD-CE07	0.7	0.5	0.3	0.3	0.5	0.19	X	n/a (e)
Off-Site Stations								
RD-4001	0.2	0.3	0.2	0.3	0.3	0.06		n/a
RD-4002	0.1	0.3	0.3	0.3	0.2	0.12		n/a
RD-4003	0.2	0.2	0.2	0.3	0.2	0.05		n/a
RD-4005 <sup>(f)</sup>	0.1	0.3	0.2	0.3	0.2	0.10		n/a
RD-4007	0.2	0.3	0.4	0.4	0.3	0.10		n/a
RD-4009 <sup>(f)</sup>	0.2	0.3	0.3	0.3	0.3	0.05		n/a
RD-4013	0.2	0.3	0.3	0.3	0.3	0.05		n/a

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

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

(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the 1-year background average concentration for a Student's t-test at the 95% confidence level.

(d) Percent guideline is calculated by taking the annual station average minus the average of the background stations, divided by the DOE Derived Concentration Guide Value for Rn-222 of 3 pCi/l (111 Bq/m<sup>3</sup>) annual average above background for uncontrolled areas.

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

Table 4-1 2000 Alpha Track Integrated Radon Results <sup>(a)</sup> (Continued)

(f) Background station. Average concentration: = 0.25 pCi/l (9.25 Bq/m<sup>3</sup>).  
n/a No percentage calculation performed for background locations or locations not statistically greater than background.  
-- No data for this quarter.

Table 4-2 2000 Alpha Track Rn-220 Concentrations <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 a Guideline <sup>(d)</sup>
Quarry Stations								
RD-1002	0.0	0.3	0.0	0.3	0.2	0.17		n/a
Chemical Plant Perimeter Stations								
RD-2002	0.0	0.1	0.0	0.2	0.1	0.10		n/a
RD-2004	0.0	0.1	0.0	0.2	0.1	0.10		n/a
RD-2006	0.0	0.2	0.0	0.4	0.2	0.19		n/a
RD-2025	0.0	0.4	0.0	0.1	0.1	0.19		n/a
RD-3001	0.0	0.0	0.0	0.4	0.1	0.20		n/a
RD-3005	0.0	0.2	0.0	0.4	0.2	0.19		n/a
Stations Inside Chemical Plant Boundary								
RD-3017	0	--	--	--	0.0	n/a		n/a
RD-3018	0.1	--	--	--	0.1	n/a		n/a
RD-CE07	0.4	0.4	0	0.3	0.3	0.19	X	n/a <sup>(e)</sup>
Off-Site Stations								
RD-4001	0	0	0	0.2	0.1	0.10		n/a
RD-4002	0	0	0	0	0.0	0.00		n/a
RD-4003	0	0	0	0.3	0.1	0.15		n/a
RD-4005 <sup>(f)</sup>	0	0	0	0	0.0	0.00		n/a
RD-4007	0	0	0	0.1	0.0	0.05		n/a
RD-4009 <sup>(f)</sup>	0	0.1	0	0.3	0.1	0.14		n/a
RD-4013	0	0	0	0	0.0	0.00		n/a

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

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

(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the 1-year background average concentration for a Student's t-test at the 95% confidence level.

(d) Percent guideline is calculated by taking the annual station average minus the average of the background stations, divided by the DOE Derived Concentration Guide Value for Rn-220 of 3 pCi/l (111 Bq/m<sup>3</sup>) annual average above background for uncontrolled areas.

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

(f) Background station. Average concentration = 0.05 pCi/l (1.85 Bq/m<sup>3</sup>).

n/a No percentage calculation performed for background locations or locations not statistically greater than background.

-- No data for this quarter.

#### 4.2.4 Data Analysis

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

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

##### 4.2.4.1 Chemical Plant and Raffinate Pits

Statistical analysis of one radon alpha track monitoring location, RD-CE07, indicated a result greater than background. The annual average concentration for this station exceeded background by 0.25 pCi/l (9.25 Bq/m<sup>3</sup>). With the exception of the immediate vicinity of the disposal cell, radon results in most areas were lower than in previous years, and are likely due to the removal of most contaminated materials to the disposal cell. The quarterly measured radon concentrations for all stations ranged from 0.1 pCi/l (3.7 Bq/m<sup>3</sup>) to 0.7 pCi/l (25.9 Bq/m<sup>3</sup>).

Statistical analysis of one thoron track etch monitoring location, RD-CE07, indicated an annual average result greater than the background level. The annual average concentration for this station exceeded the annual average background by 0.25 pCi/l (9.25 Bq/m<sup>3</sup>). The quarterly thoron measurements for all stations ranged from 0 pCi/l (0 Bq/m<sup>3</sup>) to 0.4 pCi/l (14.8 Bq/m<sup>3</sup>). Just as with the integrated radon results, these results are lower than in previous years due to the removal of most contaminated material to the disposal cell.

##### 4.2.4.2 Quarry

Statistical analysis of track etch radon and thoron monitoring results from the two quarry stations indicated that, at the 95% confidence level, these results did not exceed background levels. The quarterly measured results for integrated radon from both quarry stations ranged from 0.2 pCi/l (7.4 Bq/m<sup>3</sup>) to 0.5 pCi/l (18.5 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 (11.1 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 (14.8 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 0.2 pCi/l (7.4 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 alpha track integrated radon concentrations for the monitoring stations at the quarry, chemical plant, raffinate pits, and off-site locations. These monitoring results include natural background radon concentrations. Radon levels in the raffinate pits area reached a maximum in 1997 due to excavation of sludge pockets in Raffinate Pit 4. However, all results were well below the DCG of 3 pCi/l for radon and thoron gas. No other trends were evident.

### **4.3 Gamma Radiation Monitoring**

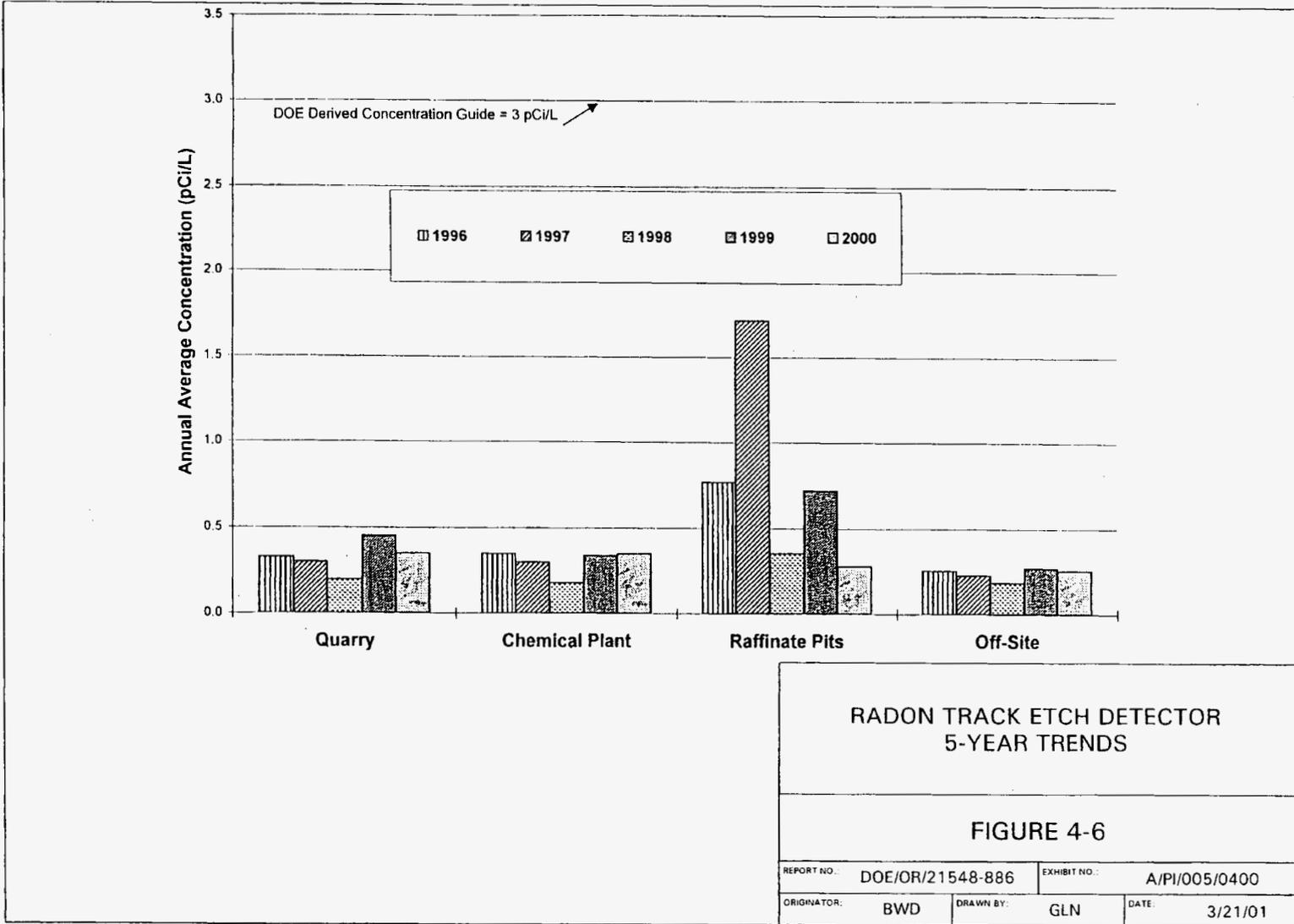
#### **4.3.1 Program Overview**

Gamma radiation is emitted from natural, cosmic, and man-made sources. The earth naturally contains gamma radiation-emitting substances, such as uranium, thorium, and potassium (K-40). Cosmic radiation originates in outer space and filters through the atmosphere to the earth. Together, these two sources comprise most natural gamma background radiation. The National Council on Radiation Protection and Measurements (NCRP) estimates the typical gamma radiation dose is 28 mrem/year (0.28 mSv/year) from terrestrial sources and 27 mrem/year (0.27 mSv/year) from cosmic sources (Ref. 13). 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 2000 using TLDs at 13 monitoring stations: five 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 4-4. 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 4-3 summarizes quarterly and annual total gamma radiation monitoring results. The table includes quarterly results, annual totals, and the annual sample standard deviation for each station, and indicates whether a station's annual monitoring results are statistically distinguishable from background levels as determined by a one-tailed Student's t-test at the 95% confidence level.

Gamma background levels for 2000 were determined by averaging the annual total measurement from the two background stations. The annual average result from these stations was 54.2 mrem/year (0.54 mSv/year) with a standard deviation of 3 mrem/year (0.03 mSv/year). This average background is within 10% of the NCRP 94 estimate of 55 mrem/year (0.55 mSv/year) (Ref. 13).

Table 4-3 2000 Environmental TLD Results<sup>(a)</sup>

Location ID	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) <sup>(b)</sup>	Annual Average (mrem) <sup>(b)</sup>	Annual Standard Deviation	Statistically Significant (X) <sup>(c)</sup>
Quarry Stations								
TD-1002	13.2	12.2	15.2	7.6	48.2	12.1	3.22	
Chemical Plant Perimeter Stations								
TD-2004	17.1	14.9	18.2	12.9	63.1	15.8	2.36	
TD-2006	14.8	12.8	15.4	7.4	50.4	12.6	3.64	
TD-2025	16.4	14.3	16.7	8.5	55.9	14.0	3.80	
TD-3001	15.8	12.5	17.4	7.5	53.2	13.3	4.37	
TD-3003	16.9	--	--	--	--	16.9	n/a	
Off-Site Stations								
TD-4001	14.8	12.8	16.4	7.2	51.2	12.8	4.01	
TD-4002	13.4	12	15.6	7.1	48.1	12.0	3.60	
TD-4003	12.8	11.1	14.4	7.1	45.4	11.4	3.14	
TD-4005 (d)	14.8	12.3	16.2	10	53.3	13.3	2.74	
TD-4007	15.1	13.3	16.1	9.6	54.1	13.5	2.86	
TD-4009 (d)	15	12.9	16.3	10.8	55.0	13.8	2.41	
TD-4013	15.9	14.1	17.7	7.6	55.3	13.8	4.40	

(a) Results include natural background gamma radiation.

(b) To convert from mrem to mSv, divide by 100.

(c) Statistical significance is determined by comparing the annual average for a monitoring location with the 1-year background average using a Student's t-test at the 95% confidence level.

(d) Background location. Average = 13.54 mrem (0.14 mSv).

#### **4.3.4 Data Analysis**

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

##### **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 50.4 mrem (0.50 mSv) to 63.1 mrem (0.63 mSv). These results are lower than previous years for these areas due to the completion of remediation of most of the chemical plant area.

##### **4.3.4.2 Quarry**

The annual effective dose equivalent from external gamma radiation measured by TLDs at the quarry was 48.2 mrem (0.48 mSv). This result is lower than previous years for this area and essentially represents background.

##### **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 45.4 mrem (0.45 mSv) to 55.3 mrem (0.55 mSv). Background concentrations ranged from 53.3 mrem (0.53 mSv) to 55.0 mrem (0.55 mSv). These results are lower than previous years for these areas and essentially represent background.

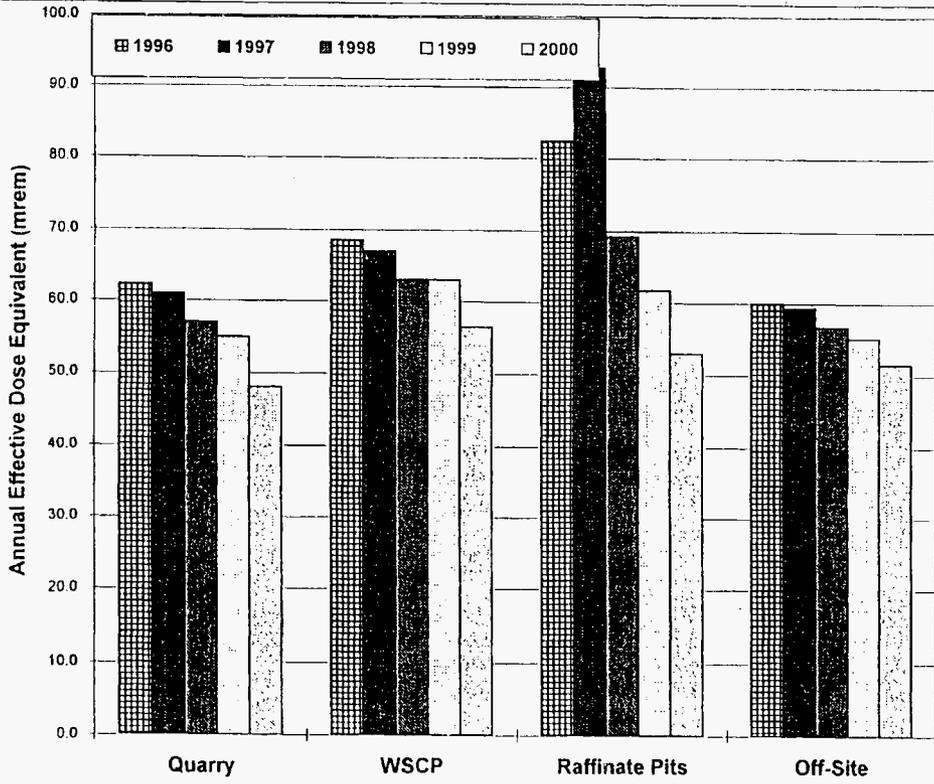
##### **4.3.4.4 Five-Year Trend Analysis of TLDs**

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 most of the remediation work in this area. Calendar year 2000 gamma radiation exposure is essentially at background levels.

#### **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. Increased airborne radioactive particulate emissions from



ENVIRONMENTAL TLD  
5-YEAR TRENDS

FIGURE 4-7

REPORT NO	DOE/OR/21548-886	EXHIBIT NO	A/PI/006/0400
ORIGINATOR	BWD	DRAWN BY	GLN
		DATE	3/21/01

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 2000, the WSSRAP monitored radioactive air particulates weekly at 18 continuous permanent low volume air sampling stations: nine at the chemical plant perimeter, two at the quarry, and seven at off-site locations. These locations are denoted by an "AP" prefix on Figures 4-1, 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 l/min (1.4 cfm) through mixed cellulose ester filters with a 0.80-micron pore size. The filters are then counted using a gas flow proportional counter to determine the amount of long-lived gross alpha activity in the particulates on the filter surface.

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

#### 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 18 permanent low volume stations are summarized in Table 4-4. Annual averages were calculated using uncensored weekly air particulate analytical results. Uncensored data refers to all results, including those near or below the minimum detectable concentration (MDC). The DOE *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (Ref. 24) requires the use of uncensored data to minimize any bias in arithmetic averages and calculation of standard deviation. Annual results represent the average of up to 52 weeks of data for each monitoring station.

The typical MDC for low volume air particulate sampling at the WSSRAP is  $2.0\text{E-}16$   $\mu\text{Ci/ml}$  ( $7.4\text{E-}12$  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). If an individual inhales airborne contaminants at the DCG for 1 year, the resulting committed effective dose equivalent

is 100 mrem (1 mSv). Thus, this MDC allows the WSSRAP to demonstrate compliance with the DOE Order 5400.5 limit of 100 mrem (1 mSv).

Table 4-4 2000 Radioactive Air Particulate Gross Alpha Results

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

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

#### 4.4.4 Data Analysis

Statistical analysis of the annual results from the low volume airborne particulate samplers indicated that one monitoring station (AP-2025) was greater than the 52-week background concentrations. Station AP-4012 indicated an annual average background concentration of 1.27E-15  $\mu$ Ci/ml (4.70E-11 Bq/ml).

#### 4.4.4.1 Chemical Plant/Raffinate Pits

The average annual concentrations at the chemical plant/raffinate pits perimeter ranged from  $1.13\text{E-}15$   $\mu\text{Ci/ml}$  ( $4.18\text{E-}11$  Bq/ml) to  $1.44\text{E-}15$   $\mu\text{Ci/ml}$  ( $5.33\text{E-}11$  Bq/ml). Statistical analysis of the gross alpha air monitoring results revealed at the 95% confidence level that one station had an annual average result greater than the annual background average. The station was AP-2025, on the northern site perimeter. Results for all other stations were indistinguishable from background levels. The chemical plant and raffinate pits results are similar to those measured in 1999.

#### 4.4.4.2 Quarry

The average concentrations at the quarry perimeter ranged from  $1.33\text{E-}15$   $\mu\text{Ci/ml}$  ( $4.92\text{E-}11$  Bq/ml) to  $1.39\text{E-}15$   $\mu\text{Ci/ml}$  ( $5.14\text{E-}11$  Bq/ml). These results are comparable to those measured during 1999.

#### 4.4.4.3 Off-Site Locations

The average concentrations at off-site locations ranged from  $1.15\text{E-}15$   $\mu\text{Ci/ml}$  ( $4.26\text{E-}11$  Bq/ml) to  $1.35\text{E-}15$   $\mu\text{Ci/ml}$  ( $5.0\text{E-}11$  Bq/ml). All results are similar to those measured during previous years.

### 4.5 Airborne Asbestos Monitoring

Environmental monitoring for asbestos fibers was conducted during May-June 2000 at Francis Howell High School (AP-4006) and at the chemical plant site perimeter (AP-2001, AP-2002, and AP-3004). These locations are identified in Figures 4-1 and 4-3. Filters were collected weekly and shipped off-site bi-weekly for analysis.

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

The results of environmental samples collected at Francis Howell High School and the site perimeter are provided in Table 4-5. A total of 22 PCM samples were collected with all samples indicating results above the detection limits. The range of samples above the detection limit (generally 7 fibers/ $\text{mm}^2$ ) was 0.0002 to 0.0007 fibers per milliliter of air (f/ml). Because all PCM results were less than the site environmental action level, no samples were resubmitted for TEM analysis. All results of the environmental air samples collected from the site perimeter and

Francis Howell High School were below the site environmental action level of 0.01 f/ml. These results indicate that asbestos fibers were effectively contained during the year.

Table 4-5 Summary of Asbestos Air Monitoring Results

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

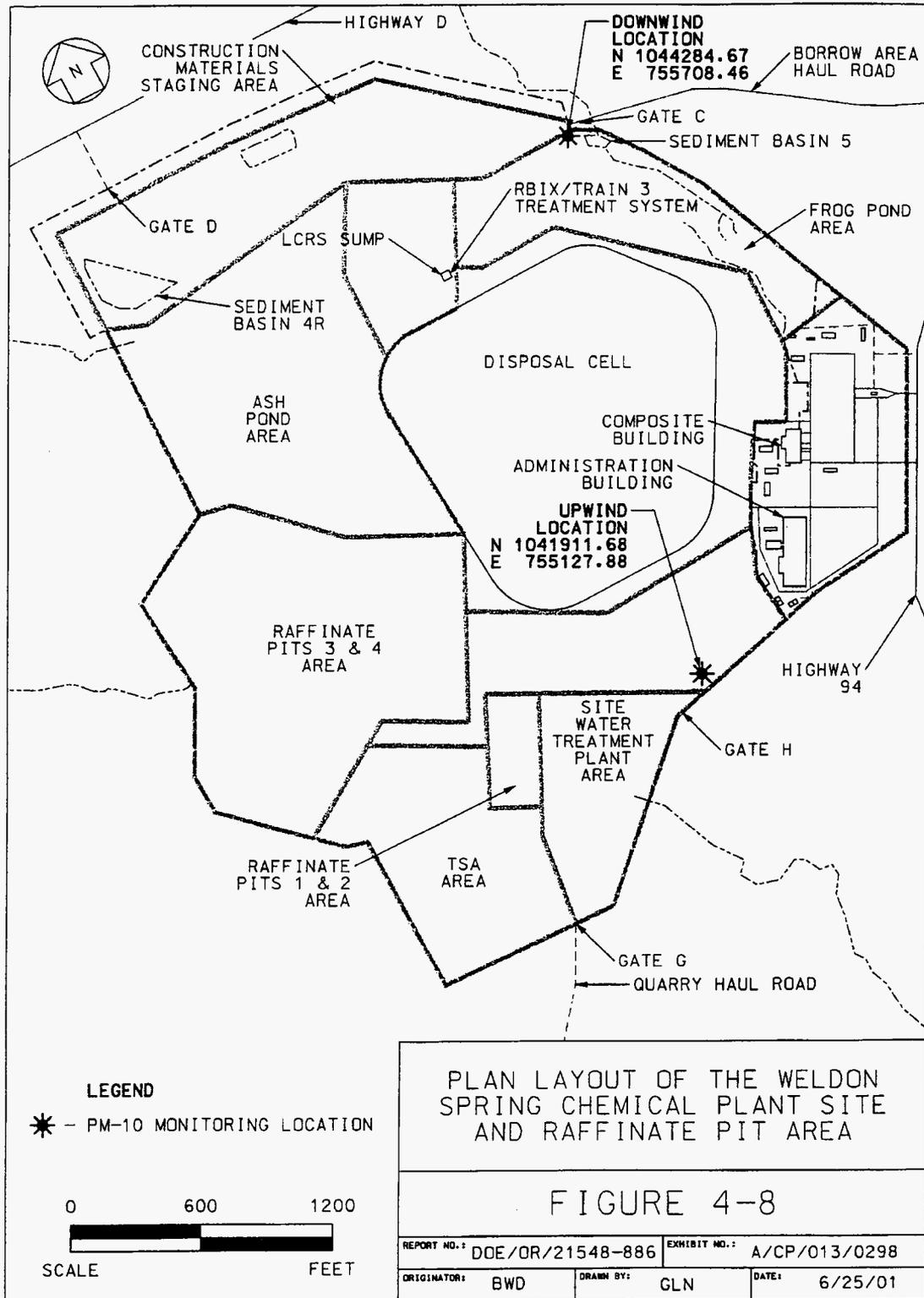
## 4.6 PM-10 Monitoring

### 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).



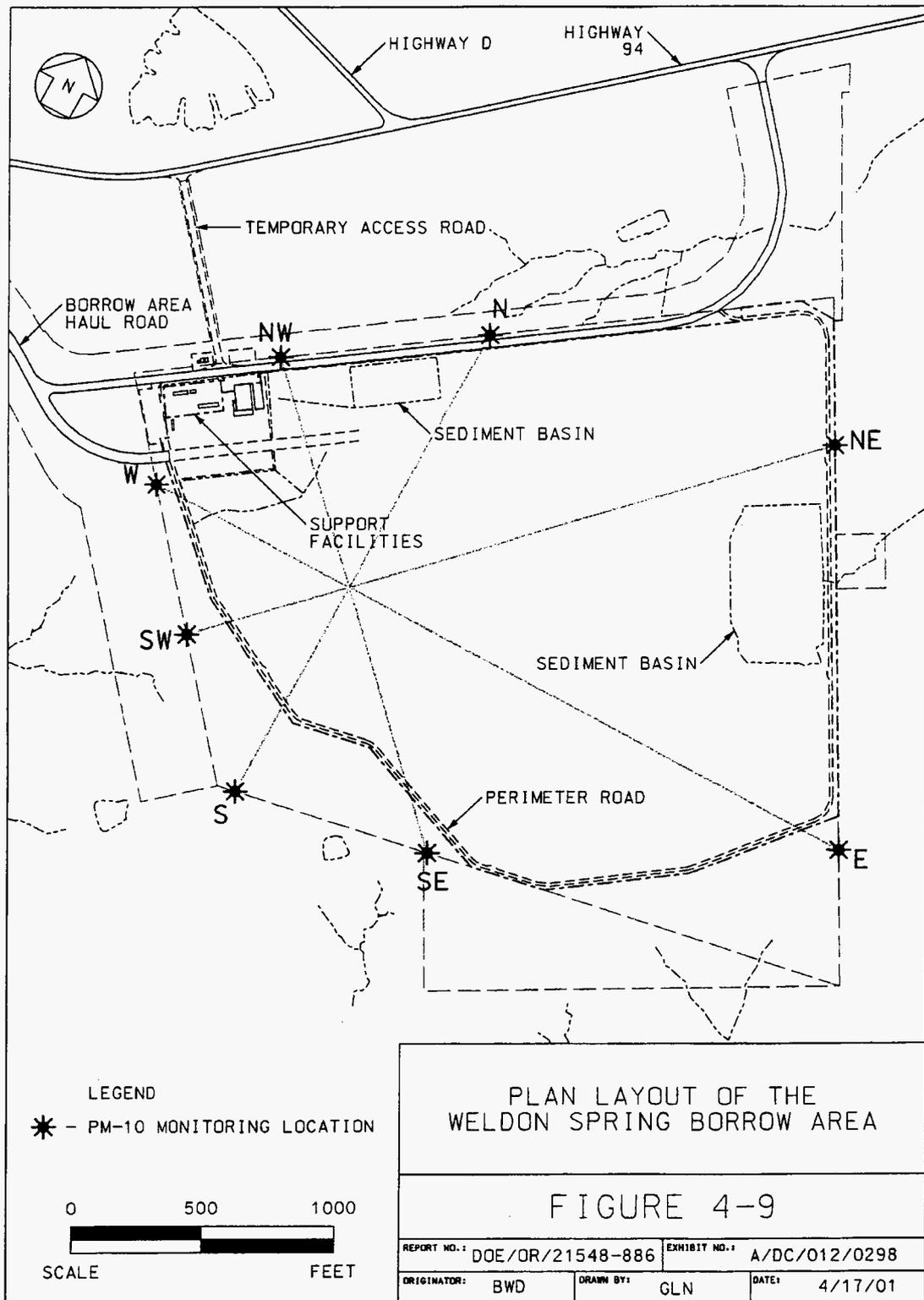
During 2000, the WSSRAP monitored ambient PM-10 levels at the perimeter of both the chemical plant area and the Borrow Area, along the Borrow Area haul road, and at the Weldon Spring Quarry. Portable monitoring stations, consisting of real-time aerosol monitors (RAMs) fitted with PM-10 impactor heads, were used to monitor concurrently upwind and downwind of work activities. The chemical plant area map in Figure 4-8 shows the permanent locations established to monitor PM-10 emissions from disposal cell operations. These locations are based on historical prevailing wind patterns. Borrow Area locations were determined each monitoring period, based on the National Weather Service local 24-hour forecast. Figure 4-9 shows the eight designated locations along the Borrow Area perimeter where monitors could be placed, depending on predicted wind directions for the monitoring period. Figure 4-10 shows the location at the Weldon Spring Quarry where monitors were placed.

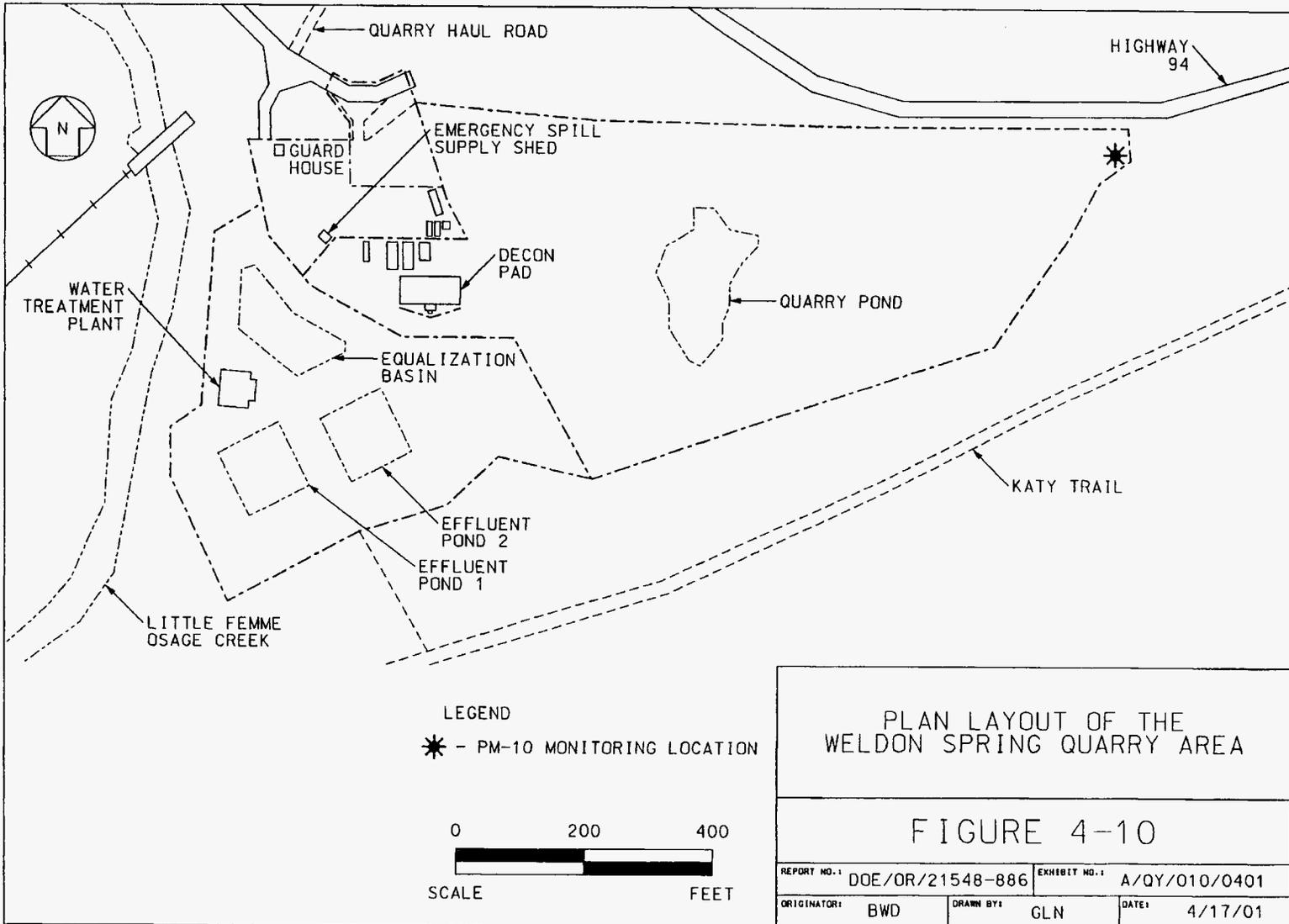
PM-10 monitoring was conducted weekly during the construction season (i.e., March to October) at both the chemical plant and Borrow Area perimeters. The chemical plant was also monitored once during November since construction activities were taking place in and around the disposal cell. In addition, monthly measurements were made along the haul road between the Borrow Area and the disposal cell and at the Weldon Spring Quarry. Occasionally, severe weather conditions such as high winds, below-freezing temperatures, or significant precipitation precluded the use of the monitoring equipment, and the affected monitoring period was skipped. Since this usually coincided with the curtailment of excavation and hauling activities, it is unlikely that any exceedances of 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 exceedances of this limit would trigger the actions outlined in Procedure ES&H 1.1.7, *Environmental Data Review and Above Normal Reporting*.





PLAN LAYOUT OF THE WELDON SPRING QUARRY AREA

FIGURE 4-10

Table 4-6 2000 PM-10 Data for the Weldon Spring Site Remedial Action Project

LOCATION	NUMBER OF SAMPLING EVENTS (UPWIND/DOWNWIND)	MONTHLY AVERAGE OF MEASURED 24-HOUR CONCENTRATIONS ( $\mu\text{g}/\text{m}^3$ )	
		UPWIND	DOWNWIND
<b>WSCP</b>			
February	1/2	18	23
March	4/8	25	31
April	2/4	35	22
May	2/4	24	20
June	4/3	21	31
July	2/2	37	8
August	2/2	15	21
September	4/5	17	14
October	2/2	18	23
November	1/0	12	ND
<b>BORROW AREA</b>			
February	1/2	45	93
March	2/2	15	19
April	2/4	19	22
May	2/6	27	28
June	3/5	16	23
July	3/3	25	22
August	2/2	30	31
September	3/3	9	17
October	3/2	16	24
<b>HAUL ROAD</b>			
April	2	27	N/A
May	1	25	N/A
June	1	5	N/A
July	2	11	N/A
August	2	25	N/A
September	2	12	N/A
October	1	33	N/A
<b>QUARRY</b>			
June	1	14	N/A
July	2	14	N/A
August	2	29	N/A

N/A Not applicable  
 ND No data recorded

#### 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 concentrations were all below the site action level of  $150 \mu\text{g}/\text{m}^3$ . Table 4-6 shows the monthly average concentrations measured at the chemical plant, borrow area, haul road, and quarry.

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

#### 4.6.4 Data Analysis

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

## 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. The calculations are compared to U.S. Department of Energy (DOE) limits contained in DOE Order 5400.5 to demonstrate compliance with regulatory requirements.

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 (NESHAP) Program.

### 5.1 Highlights

- Radiation dose equivalents from the chemical plant/raffinate pits and quarry to a hypothetical maximally exposed individual were not calculated since monitoring results were indistinguishable from background.
- The estimated total effective dose equivalent (TEDE) to the maximally exposed individual at the vicinity properties due to consumption of water from Burgermeister Spring was 0.35 mrem (0.0035 mSv).
- The collective population effective dose equivalent (CPEDE) was estimated to be 0.10 person-rem (0.0010 person-Sv) for users of the Busch Memorial Conservation Area.

### 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 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 period 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 to radiological contaminants evaluated under 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 2000 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. 25) 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 2000 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 activities.	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 2000 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:

- NESHAP 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

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

#### 5.3.1 Airborne Radiological Releases

The airborne radiological release estimates shown in Table 5-2 were calculated based on site characterization data and low volume monitoring results at eight stations 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 discussed in Appendix B.

#### 5.3.2 Waterborne Radiological Releases

During 2000, 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 in accordance with National Pollutant Discharge Elimination System (NPDES) requirements. 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). 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	2.04E-07	1.72E-03	5.13E+03	4.47E+09
U-235	8.39E-09	8.07E-05	3.74E+01	7.04E+08
U-234	2.07E-07	1.71E-03	2.75E-01	2.46E+05
Ra-226	--	3.37E-04	3.41E-04	1,600

Table 5-2 Radionuclide Emissions to the Environment (Continued)

RADIONUCLIDE	ACTIVITY OF RADIONUCLIDES RELEASED TO AIR (Ci)	ACTIVITY OF RADIONUCLIDES RELEASED TO WATER (Ci)	MASS OF RADIONUCLIDE RELEASED (grams)	HALF-LIFE (Yrs)
Ra-228	--	2.22E-04	1.02E-01	5.76
Th-230	1.90E-06	2.11E-03	8.16E-07	7.54E+04
Th-228	2.24E-07	2.96E-04	3.61E-07	1.91
Th-232	2.52E-07	3.17E-04	2.88E+03	1.40E+10
Total Activity	2.80E-06	6.79E-03	8.05E+03	N/A

N/A Not applicable.

-- 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, and a third set of dose equivalent calculations was performed to meet NESHAP requirements (see Section 6).

Calculations using perimeter and off-site monitoring data determined the collective population dose equivalent to be approximately 0.10 person-rem per year (0.0010 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 measurements recorded within this radius result in TEDEs that are well below NESHAP 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 determined 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 potentially 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 measuring 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 external gamma radiation is then factored into the collective population effective dose equivalent.

All ingestion calculations were performed using the methodology described in International Commission on Radiation Protection (ICRP) Reports 26 (Ref. 26) and 30 (Ref. 27) for a 50-year committed effective dose equivalent (CEDE). Dose conversion factors were obtained from the EPA Federal Guidance Report No. 11 (Ref. 28).

## **5.5 Dose Equivalent Estimates**

Dose equivalent estimates for the exposure scenarios were calculated using 2000 environmental 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) NESHAP limits.

In 2000, the TEDE for a hypothetical maximally exposed individual near the chemical plant/raffinate pits was not calculated because radon/thoron, gamma exposure, and radioactive air particulate monitoring results were not statistically above background. The TEDE for a hypothetical maximally exposed individual near the vicinity properties was 0.35 mrem (3.5  $\mu$ Sv). These values represent less than 0.4% of the DOE standard of 100 mrem (1 mSv) TEDE 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) (Ref. 52). The collective population effective dose equivalent is 0.10 person-rem (0.0010 person-Sv) for recreational users of the Busch Memorial Conservation Area and employees of the Missouri Highway and Transportation Department facility and WSSRAP offices. Assumptions upon which these doses are based are detailed in the following sections.

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

Because all radon/thoron and gamma exposure results from critical receptors were not distinguishable from background, and the only radioactive air particulate station that was statistically above background was not in an area frequented by members of the

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	--	--	--	--	--	--	--
	Airborne(A)	--	--	--	--	--	--	--
	Airborne(B)	--	--	--	--	--	--	--
WSQ 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	--	--	--	--	--	--	--
	Airborne(A)	--	--	--	--	--	--	--
	Airborne(B)	--	--	--	--	--	--	--
WSVP Hypothetical Individual	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	0.35	0.35%
	External	--	--	--	--	--	--	--
	Airborne(A)	--	--	--	--	--	--	--
	Airborne(B)	--	--	--	--	--	--	--

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)	Ingestion of fish from Busch Lake 35 (population = 100,000)	Fish	N/A	0.55 g/day	0.019 pCi/g- Natural Uranium	0.103	N/A
	Liquid(C)	Swimming at Busch Lake 35 (population = 7,480)	Water	0.285 hr/person	0.05 liters/hour	7.45 pCi/l- Natural Uranium	0.0002	N/A
	External	--	--	--	--	N/A	--	N/A
	Airborne(A)	--	--	--	--	--	--	N/A
	Airborne(B)	--	--	--	--	--	--	--

N/A Scenario is not applicable to the hypothetical individual.

-- Scenario not formulated because results were indistinguishable from background.

WSCP Weldon Spring Chemical Plant.

WSRP Weldon Spring raffinate pits.

WSQ Weldon Spring Quarry.

WSVP Weldon Spring vicinity properties.

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.

public, no dose estimate is necessary for a maximally exposed individual member of the public near the chemical plant/ raffinate pits area for 2000.

### **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 2000, 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 which 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 2000.

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

- Annual average radioactive air 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 no greater than background levels.
- Maximum radionuclide concentrations in water samples taken from Burgermeister Spring during 2000 (see Appendix B) were assumed to be present in the water ingested by the maximally exposed individual.

- The dose equivalent conversion factors for ingestion (Ref. 28) are as follows:
  - total soluble uranium, 2.69E-4 mrem/pCi
  - Ra-226, 1.33E-3 mrem/pCi
  - Ra-228, 1.44E-3 mrem/pCi
  - Th-228, 3.96E-4 mrem/pCi
  - Th-230, 5.48E-4 mrem/pCi
  - Th-232, 2.73E-3 mrem/pCi
  - Ra-224, 3.66E-4 mrem/pCi
  - Pb-212, 4.56E-5 mrem/pCi.

(Total soluble uranium was calculated using isotopic dose conversion factors for ingestion from Appendix B-1 and the natural uranium activity ratios listed in Section 5.3.2.)

The estimated total effective dose equivalent to the maximally exposed individual at the vicinity properties due to consumption of water from Burgermeister Spring was 0.35 mrem (0.0035 mSv).

#### 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. No perimeter monitoring locations for radon/thoron or gamma exposure had results which statistically exceeded background. Only one perimeter radioactive air particulate monitoring station (AP-2025) exceeded background levels. It was not located in an area that is frequented by members of the public and was not included in the CPEDE estimate.

The only 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 scenario used for the 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:

- It is estimated that there are approximately 200,000 fishing visits per year at the Busch Memorial Conservation Area (Ref. 29), which is adjacent to the chemical plant and raffinate pits area. In addition, approximately 7,480 persons per year participate in recreational boating activities. Busch Lakes 34, 35, and 36 receive runoff from the chemical plant and raffinate pits area, and they are all used for fishing and boating.

- The ratio of fish caught to time spent is 0.4 fish/hour, and the ratio of fish kept to fish caught is 0.5. The average duration of each visit is assumed to be 2.5 hours. If each fish caught is consumed by a different person, the affected population would be 100,000 persons.
- The highest average total uranium concentration in a composite sunfish sample collected from Lake 35 in 1998 (the last year for which data are available) was 0.019 pCi/g (7.0E-4 Bq/g).
- The average time spent at the Busch Conservation Area per boating trip was approximately 5.7 hours (Ref. 31).
- Each of 7,480 boaters made only one visit to the area and spent 5% of the time swimming.
- The maximum concentration of total uranium from the water of Lake 35 was 7.45 pCi/l (0.28 Bq/l) (Table 7-10, Appendix B-5).
- No contribution from airborne pathways was included in the 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 2000, the estimated population effective dose equivalent for the Busch lakes scenario was 0.10 person-rem (1.0E-3 person-Sv). Because the Busch lakes scenario is the only applicable exposure route, this is also the estimated total collective population effective dose equivalent for 2000. Calculations are presented in Appendix B, Section D.

## 6. NESHAP PROGRAM

This section provides information on 2000 annual atmospheric emissions of radionuclides, in accordance with the requirements of 40 CFR 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities*. Evaluations presented here include airborne emissions data as well as dose assessment and compliance information related to potential sources of radioactive particulate emissions at the Weldon Spring Site Remedial Action Project (WSSRAP).

### 6.1 NESHAP 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 no member of the public received greater than the effective dose equivalent limit of 10 mrem/yr.
- The highest dose assessment was for a maximally exposed individual residing continuously near the quarry. Results indicated an annual committed effective dose equivalent (CEDE) of 0.014 mrem (0.0001 mSv) for 2000.
- The NESHAP monitoring program was discontinued as of December 31, 2000, since there are no longer any sources of radiological emissions with the potential to cause an effective dose equivalent greater than 1% of the 10 mrem/yr standard.

### 6.2 Source Description

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

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

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

Radiological and chemical contaminants (i.e., PCBs, nitroaromatic compounds, and metals) were historically found in soil and sludge from several areas around the site. Most of the 91 ha (226 acres) of the chemical plant surface area had above background concentrations of uranium (>1 pCi/g) prior to remediation. Radionuclide concentrations measured in site soil and sludge ranged as shown in Table 6-1 (Ref. 2 and Ref. 30). Excavation, hauling, and disposal of these contaminated materials was completed in 2000.

Table 6-1 Contamination Levels in Site Soils and Raffinate Pit Sludge

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

N/A Not applicable

### 6.3 Air Emission Data

Most airborne emissions of radionuclides at the Weldon Spring site during 2000 were diffuse in nature, resulting from wind dispersion of surface soils, re-entrainment of dust and dirt from temporary waste storage areas, and generation of fugitive dust during remedial actions. The filter press rooms at the site and quarry water treatment plants constituted potential point sources of radionuclide emissions other than radon while the plants were in operation. These sources were controlled using high efficiency particulate air (HEPA) filter exhaust systems.

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

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

obtaining an accurate assessment of effective dose equivalents to maximally exposed members of the public.

The WSSRAP uses an alternate method of tracking emissions from the site, as allowed by 40 CFR 61, Subpart H, and approved by U.S. Environmental Protection Agency (EPA) Region VII (see Appendix A). 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. Details of this monitoring program are presented in the *Plan for Monitoring Radionuclide Emissions other than Radon at Weldon Spring Site Critical Receptors* (Ref. 18).

The design of the critical receptor network is summarized in Table 6-2. Locations of the monitors are shown on Figure 6-2.

Table 6-2 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

### 6.3.1 Point Sources

Table 6-3 summarizes airborne effluent control at the chemical plant water treatment plant and the quarry water treatment plant, along with the nearest critical receptor locations. Because critical receptor monitoring was performed at the WSSRAP, no source-specific effluent monitoring was required by either 40 CFR 61, Subpart H, or U.S. Department of Energy (DOE) Order 5400.5. Engineering calculations were performed to estimate releases from the quarry and chemical plant water treatment plants and resulting dose equivalents to members of the public. These results predicted an effective dose equivalent of less than 0.1 mrem/yr (0.001 mSv/yr) at the nearest critical receptor location.

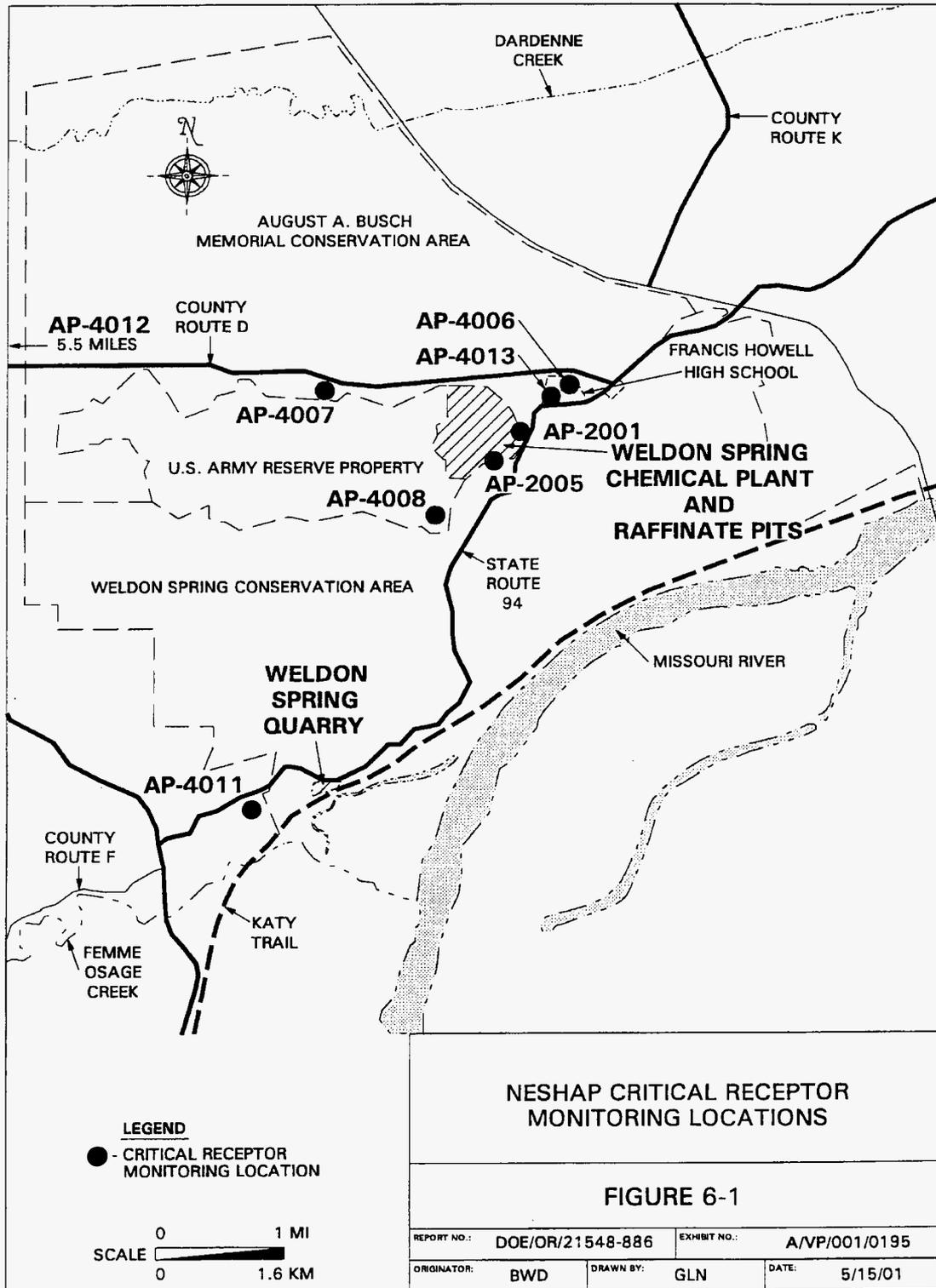


Table 6-3 WSSRAP Point Sources of Airborne Radionuclides

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

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

The quarry diffuse source is a 3.6 ha (9 acre) limestone quarry 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). Historically, the quarry was used as a disposal area for dinitrotoluene (DNT) and trinitrotoluene (TNT) manufacturing process wastes; uranium, radium, and thorium residues; decay products from on-site and off-site processing of uranium and thorium; and building rubble and soils from the demolition of a uranium processing facility in St. Louis, Missouri. A major remediation project involving removal and controlled temporary storage of approximately 110,000 m<sup>3</sup> (144,000 cu yd) of contaminated bulk waste was started in 1993 and completed at the end of 1995. Residual radioactive contamination was remediated in 2000 and was a potential source of radiological airborne particulate emissions.

The Weldon Spring Chemical Plant diffuse source encompasses 91 ha (226 acres) on which the Ash Pond storage area, four raffinate pits, the temporary storage area, the material staging area, and the disposal cell are or were located. Airborne emissions from the chemical plant area had the potential to occur during mechanical operations such as soil excavation and hauling, transfer of waste material to the permanent on-site disposal cell, and treatment and mixing of contaminated materials at the temporary storage area and raffinate pits. Emissions may also have resulted from windblown resuspension of radioactive particulates from site soils. The entire chemical plant area was confirmed clean by the end of 2000, thus eliminating any further potential to generate diffuse emissions of radioactive particulates.

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

## 6.4 Dose Assessment

The net measured concentrations of radionuclides at each critical receptor location have been used to assess the annual committed effective dose equivalent (CEDE) to members of the public. The exposure scenarios listed in Table 6-4 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 6-4.

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

### 6.4.1 Sampling Procedure

The seven designated critical receptor locations surrounding the Weldon Spring site were 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 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 included a low volume air particulate sampler (~40 lpm) and a high volume air sampler (~950 lpm). Low volume samples were collected on mixed cellulose ester membrane filters approximately 1.5 m (5 ft) above the ground. They were exchanged and analyzed for gross alpha activity on a weekly basis. High volume samples were collected on large 20 cm x 25 cm (8 in. x 10 in.) glass fiber filters approximately 1.2 m (4 ft) above the ground. They were also exchanged weekly, but composited and analyzed quarterly for

Table 6-4 Exposure Scenarios and NESHAP Dose Estimates for 2000

SCENARIO	LOCATION OF MONITOR	EXPOSURE SCENARIO			COMMITTED EFFECTIVE DOSE EQUIVALENT (mrem/person)
		DESCRIPTION	NUMBER OF PERSONS	DURATION (hr/yr)	
AP-2001	Highway Maintenance Facility	Employee	11	2,000	0.0055 ± 0.0005
AP-2005	WSSRAP Administration Building	Employee	160	2,500	0.0129 ± 0.0126
AP-4006-a	Francis Howell High School	Faculty or Student	1,600	1,620	0.0022 ± 0.0043
AP-4006-b	Francis Howell High School	Staff Members	7	2,250	0.0030 ± 0.0059
AP-4007-a	Busch Memorial Conservation Area	Employee	48	2,000	0.0021 ± 0.0042
AP-4007-b	Busch Memorial Conservation Area	Resident	2	8,760	0.0092 ± 0.0186
AP-4007-c	Busch Memorial Conservation Area	Visitor	450,000	2	0.0000 ± 0.0000
AP-4008-a	Army Reserve Training Area	Employee	1	832	0.0019 ± 0.0051
AP-4008-b	Army Reserve Training Area	Subcontractor	10	1,387	0.0031 ± 0.0084
AP-4008-c	Army Reserve Training Area	Maintenance Worker	1	1,040	0.0023 ± 0.0063
AP-4011	Nearest Quarry Residence	Resident	3	8,760	0.0142 ± 0.0267
AP-4013-a	Francis Howell High School Annex	Employee	53	2,000	0.0023 ± 0.0061
AP-4013-b	Francis Howell High School Annex	Bus Drivers	50	540	0.0006 ± 0.0016

NOTE: 1 mrem/person = 0.01 Sv/person

isotopic radionuclides. It is the high volume sampling results that were used to demonstrate NESHAP compliance at the WSSRAP.

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

#### 6.4.2 Net Measured Radionuclide Concentrations

Net measured radionuclide concentrations for 2000 are listed in Table 6-5. These values are based on the quarterly sample analysis results obtained at each critical receptor location. Annual average net concentrations of radionuclides are also listed in Table 6-5 for each critical receptor, along with the limiting levels prescribed in 40 CFR 61, Subpart H, Appendix E, Table 2. The NESHAP requires that there be no exceedances of the limiting levels for net concentration of each radionuclide, and that the sum of the fractions obtained by dividing the annual net concentration of each radionuclide by its limiting level be less than one. Both of these requirements were met during 2000.

#### 6.4.3 Dose Estimates

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

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

where:

- Concentration is the net airborne concentration measured for a specific radionuclide at a specific monitoring station.
- DCF is the 50-year radioisotopic dose conversion factor listed for the inhalation exposure pathway in the EPA Federal Guidance Report No. 11 (Ref. 28).
- Exposure duration represents the maximum time an individual is expected to be in the vicinity of a particular critical receptor location.

Table 6-5 2000 Isotopic Air Monitoring Results (Net Concentration at Each Critical Receptor)

AP-2001		Net Concentration (uCi/m3)					NESHAPs Limit (uCi/m3)	Concentration (%) of Limit)
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average			
Ra-226	-1.16E-11 +/- 4.05E-11	8.24E-12 +/- 2.62E-11	8.70E-12 +/- 4.11E-11	3.07E-12 +/- 2.38E-11	2.12E-12 +/- 6.77E-11	3.30E-09	0.06%	
Ra-228	4.33E-13 +/- 1.68E-11	1.73E-13 +/- 7.64E-12	6.25E-12 +/- 2.06E-11	4.76E-13 +/- 1.30E-19	1.83E-12 +/- 2.77E-11	5.90E-09	0.03%	
Th-228	9.42E-12 +/- 3.12E-11	1.20E-11 +/- 3.19E-11	6.55E-12 +/- 5.63E-11	6.93E-12 +/- 2.29E-11	8.73E-12 +/- 7.54E-11	3.10E-09	0.28%	
Th-230	-3.17E-12 +/- 1.19E-10	3.48E-11 +/- 3.37E-11	2.90E-12 +/- 8.98E-11	4.75E-11 +/- 8.00E-11	2.05E-11 +/- 1.73E-10	3.40E-09	0.60%	
Th-232	-1.32E-11 +/- 2.94E-11	1.39E-11 +/- 1.59E-11	-1.56E-11 +/- 3.97E-11	8.62E-12 +/- 2.75E-11	-1.56E-12 +/- 5.87E-11	6.20E-10	-0.25%	
U, total	-4.27E-12 +/- 4.38E-12	8.52E-11 +/- 8.57E-12	4.22E-11 +/- 5.59E-12	7.15E-13 +/- 2.75E-12	3.10E-11 +/- 1.15E-11	7.98E-09	0.39%	
Total :							1.12%	

AP-2005		Net Concentration (uCi/m3)					NESHAPs Limit (uCi/m3)	Concentration (%) of Limit)
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average			
Ra-226	-3.13E-12 +/- 2.89E-11	4.16E-12 +/- 1.57E-11	1.55E-11 +/- 5.46E-11	3.61E-13 +/- 1.17E-11	4.22E-12 +/- 6.48E-11	3.30E-09	0.13%	
Ra-228	-4.77E-13 +/- 1.50E-11	1.03E-12 +/- 7.51E-12	-3.10E-12 +/- 3.13E-12	-1.14E-13 +/- 2.49E-12	-6.65E-13 +/- 1.73E-11	5.90E-09	-0.01%	
Th-228	1.33E-13 +/- 2.52E-11	2.02E-11 +/- 5.82E-11	4.36E-11 +/- 1.41E-10	1.90E-11 +/- 6.64E-11	2.07E-11 +/- 1.68E-10	3.10E-09	0.67%	
Th-230	-3.03E-11 +/- 5.71E-11	7.76E-11 +/- 1.35E-10	8.82E-11 +/- 2.04E-10	3.58E-11 +/- 8.50E-11	4.28E-11 +/- 2.65E-10	3.40E-09	1.26%	
Th-232	-1.82E-11 +/- 2.25E-11	1.46E-11 +/- 2.60E-11	1.88E-11 +/- 7.38E-11	6.23E-12 +/- 2.13E-11	5.36E-12 +/- 8.41E-11	6.20E-10	0.86%	
U, total	2.16E-11 +/- 1.10E-11	6.33E-11 +/- 1.11E-11	6.14E-11 +/- 4.54E-12	1.86E-12 +/- 3.92E-12	3.70E-11 +/- 1.68E-11	7.98E-09	0.46%	
Total :							3.37%	

AP-4006		Net Concentration (uCi/m3)					NESHAPs Limit (uCi/m3)	Concentration (%) of Limit)
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average			
Ra-226	-6.72E-12 +/- 3.11E-11	-1.90E-12 +/- 1.21E-11	2.71E-11 +/- 7.15E-11	4.47E-13 +/- 2.84E-11	4.74E-12 +/- 8.38E-11	3.30E-09	0.14%	
Ra-228	4.86E-12 +/- 6.31E-12	-7.08E-13 +/- 7.95E-12	-3.80E-12 +/- 3.46E-12	8.97E-13 +/- 3.40E-12	3.12E-13 +/- 1.13E-11	5.90E-09	0.01%	
Th-228	1.42E-11 +/- 3.90E-11	2.65E-11 +/- 4.13E-11	3.76E-13 +/- 4.59E-11	7.67E-12 +/- 2.36E-11	1.22E-11 +/- 7.68E-11	3.10E-09	0.39%	
Th-230	2.36E-11 +/- 8.43E-11	1.01E-11 +/- 2.62E-11	-2.38E-11 +/- 5.42E-11	-5.90E-13 +/- 2.67E-11	2.33E-12 +/- 1.07E-10	3.40E-09	0.07%	
Th-232	-2.01E-11 +/- 3.59E-11	2.48E-12 +/- 1.27E-11	-2.11E-11 +/- 2.48E-11	4.17E-12 +/- 1.43E-11	-8.65E-12 +/- 4.77E-11	6.20E-10	-1.39%	
U, total	2.93E-11 +/- 8.00E-12	-5.06E-12 +/- 8.71E-12	2.72E-11 +/- 1.72E-12	7.67E-12 +/- 1.01E-11	1.48E-11 +/- 1.56E-11	7.98E-09	0.19%	
Total :							-0.60%	

AP-4007		Net Concentration (uCi/m3)					NESHAPs Limit (uCi/m3)	Concentration (%) of Limit)
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average			
Ra-226	-8.44E-12 +/- 3.00E-11	1.68E-11 +/- 5.24E-11	2.30E-11 +/- 7.60E-11	1.35E-11 +/- 4.12E-11	1.12E-11 +/- 1.05E-10	3.30E-09	0.34%	
Ra-228	1.65E-11 +/- 3.02E-11	-1.54E-12 +/- 7.59E-12	3.63E-13 +/- 1.04E-11	-4.83E-14 +/- 1.20E-19	3.81E-12 +/- 3.29E-11	5.90E-09	0.06%	
Th-228	-1.80E-12 +/- 2.12E-11	7.90E-12 +/- 1.93E-11	-6.97E-12 +/- 2.77E-11	-1.05E-12 +/- 2.14E-11	-4.82E-13 +/- 4.52E-11	3.10E-09	-0.02%	
Th-230	-3.76E-11 +/- 4.87E-11	8.11E-12 +/- 1.74E-11	-7.65E-12 +/- 4.54E-11	9.62E-12 +/- 4.26E-11	-6.88E-12 +/- 8.09E-11	3.40E-09	-0.20%	
Th-232	-2.16E-11 +/- 2.50E-11	5.97E-12 +/- 1.06E-11	-2.65E-11 +/- 2.18E-11	6.90E-13 +/- 1.75E-11	-1.04E-11 +/- 3.90E-11	6.20E-10	-1.67%	
U, total	6.06E-12 +/- 1.17E-11	7.42E-11 +/- 2.17E-11	8.40E-12 +/- 3.54E-12	2.05E-13 +/- 5.13E-12	2.22E-11 +/- 2.55E-11	7.98E-09	0.28%	
Total :							-1.20%	

Table 6-5 2000 Isotopic Air Monitoring Results (Net Concentration at Each Critical Receptor) (continued)

AP-4008		Net Concentration (uCi/m3)					NESHAPs Limit (uCi/m3)	Concentration (% of Limit)
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average			
Ra-226	7.05E-12 +/- 4.44E-11	6.25E-12 +/- 3.50E-11	6.37E-12 +/- 4.51E-11	1.67E-11 +/- 3.52E-11	9.10E-12 +/- 8.04E-11	3.30E-09	0.28%	
Ra-228	1.29E-12 +/- 1.50E-11	-1.62E-12 +/- 7.74E-12	5.94E-12 +/- 1.95E-11	-6.61E-14 +/- 1.20E-19	1.39E-12 +/- 2.57E-11	5.90E-09	0.02%	
Th-228	2.06E-11 +/- 8.50E-11	1.37E-11 +/- 2.57E-11	4.45E-11 +/- 9.27E-11	-2.44E-12 +/- 1.66E-11	1.91E-11 +/- 1.29E-10	3.10E-09	0.62%	
Th-230	1.20E-11 +/- 1.71E-10	8.90E-12 +/- 2.82E-11	-1.95E-11 +/- 8.88E-11	1.48E-11 +/- 3.97E-11	4.04E-12 +/- 1.99E-10	3.40E-09	0.12%	
Th-232	1.60E-11 +/- 1.10E-10	3.17E-12 +/- 1.29E-11	-2.69E-11 +/- 3.05E-11	1.72E-12 +/- 1.51E-11	-1.49E-12 +/- 1.16E-10	6.20E-10	-0.24%	
U, total	7.16E-12 +/- 6.15E-12	2.63E-11 +/- 3.55E-12	3.76E-12 +/- 2.63E-12	8.88E-12 +/- 4.22E-12	1.15E-11 +/- 8.67E-12	7.98E-09	0.14%	
Total :								0.94%

AP-4011		Net Concentration (uCi/m3)					NESHAPs Limit (uCi/m3)	Concentration (% of Limit)
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average			
Ra-226	2.17E-11 +/- 5.07E-11	-5.19E-13 +/- 1.65E-11	3.53E-11 +/- 6.08E-11	5.11E-12 +/- 2.94E-11	1.54E-11 +/- 8.60E-11	3.30E-09	0.47%	
Ra-228	4.82E-12 +/- 6.45E-12	-5.59E-13 +/- 8.14E-12	2.28E-12 +/- 1.30E-11	-8.80E-14 +/- 1.19E-19	1.61E-12 +/- 1.66E-11	5.90E-09	0.03%	
Th-228	3.53E-11 +/- 7.43E-11	1.20E-11 +/- 2.31E-11	-1.32E-11 +/- 1.61E-11	-3.68E-12 +/- 1.49E-11	7.63E-12 +/- 8.08E-11	3.10E-09	0.25%	
Th-230	2.95E-11 +/- 1.22E-10	1.29E-11 +/- 2.07E-11	-4.52E-11 +/- 4.06E-11	5.31E-12 +/- 2.60E-11	6.26E-13 +/- 1.33E-10	3.40E-09	0.02%	
Th-232	-1.88E-12 +/- 4.78E-11	4.23E-12 +/- 1.37E-11	-3.15E-11 +/- 1.85E-11	6.05E-12 +/- 1.29E-11	-5.78E-12 +/- 5.46E-11	6.20E-10	-0.93%	
U, total	1.23E-11 +/- 6.50E-12	1.47E-11 +/- 1.60E-11	-2.54E-11 +/- 9.58E-13	4.71E-12 +/- 2.20E-12	1.60E-12 +/- 1.74E-11	7.98E-09	0.02%	
Total :								-0.15%

AP-4013		Net Concentration (uCi/m3)					NESHAPs Limit (uCi/m3)	Concentration (% of Limit)
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average			
Ra-226	-4.24E-12 +/- 3.62E-11	4.12E-12 +/- 1.86E-11	1.50E-11 +/- 5.65E-11	4.22E-12 +/- 5.90E-11	4.78E-12 +/- 9.13E-11	3.30E-09	0.14%	
Ra-228	1.18E-10 +/- 1.66E-10	-1.68E-12 +/- 7.61E-12	-2.36E-12 +/- 5.08E-12	-5.19E-14 +/- 1.20E-19	2.85E-11 +/- 1.66E-10	5.90E-09	0.48%	
Th-228	-1.11E-12 +/- 2.58E-11	6.36E-12 +/- 2.26E-11	-3.89E-12 +/- 3.60E-11	-5.02E-12 +/- 1.33E-11	-9.15E-13 +/- 5.15E-11	3.10E-09	-0.03%	
Th-230	-3.08E-11 +/- 8.40E-11	1.55E-11 +/- 3.46E-11	-2.25E-12 +/- 9.61E-11	5.54E-12 +/- 2.54E-11	-3.00E-12 +/- 1.35E-10	3.40E-09	-0.09%	
Th-232	-1.44E-11 +/- 3.64E-11	5.39E-12 +/- 1.62E-11	-6.01E-12 +/- 3.34E-11	4.44E-12 +/- 1.60E-11	-2.64E-12 +/- 5.44E-11	6.20E-10	-0.43%	
U, total	-2.06E-11 +/- 1.28E-12	1.21E-11 +/- 1.46E-11	2.86E-11 +/- 1.89E-12	4.87E-12 +/- 9.51E-12	6.27E-12 +/- 1.76E-11	7.98E-09	0.08%	
Total :								0.16%

AP-4012 (bkg.)		Net Concentration (uCi/m3)					NESHAPs Limit (Ci/m3)	Concentration (% of Limit)
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average			
Ra-226	1.72E-11 +/- 3.96E-11	3.84E-12 +/- 1.83E-11	1.41E-11 +/- 2.84E-11	1.22E-11 +/- 1.59E-11	1.19E-11 +/- 5.44E-11	NA	NA	
Ra-228	1.42E-11 +/- 1.46E-11	2.05E-11 +/- 8.01E-12	1.16E-11 +/- 9.31E-12	6.33E-12 +/- 1.21E-19	1.31E-11 +/- 1.91E-11	NA	NA	
Th-228	7.54E-12 +/- 3.97E-11	4.36E-12 +/- 2.26E-11	1.75E-11 +/- 4.25E-11	7.70E-12 +/- 1.41E-11	9.27E-12 +/- 6.40E-11	NA	NA	
Th-230	1.12E-10 +/- 6.89E-11	2.21E-11 +/- 3.74E-11	7.73E-11 +/- 9.53E-11	2.12E-11 +/- 2.40E-11	5.82E-11 +/- 1.26E-10	NA	NA	
Th-232	4.14E-11 +/- 6.78E-11	4.77E-12 +/- 2.00E-11	3.84E-11 +/- 6.27E-11	5.32E-12 +/- 1.39E-11	2.25E-11 +/- 9.55E-11	NA	NA	
U, total	6.91E-11 +/- 4.55E-12	5.05E-11 +/- 4.07E-12	1.68E-10 +/- 7.99E-12	4.70E-11 +/- 2.36E-12	8.36E-11 +/- 1.03E-11	NA	NA	

- Notes:
- 1) Net concentrations are calculated by subtracting background levels (i.e., levels measured at Station AP-4012) from gross concentrations measured at each critical receptor.
  - 2) NESHAPs limits are extracted from 40 CFR 61, Subpart H, Appendix E, Table 2.
  - 3) To convert uCi/m3 to Bq/m3, multiply concentration by 37,000.

- Breathing rate of  $1.2 \text{ m}^3/\text{hr}$  (42.4 cu ft/hr) is assumed, as provided in ICRP Report No. 23, *Report of the Task Group on Reference Man* (Ref. 23).

Table 6-6 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 of the quarterly errors. The highest annual CEDE to a member of the public during 2000 is estimated to be 0.014 mrem (0.0001 mSv), based on the exposure scenario of an individual residing near the quarry.

#### 6.4.4 Compliance Assessment

Subpart H of 40 CFR 61 states the following: "*emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.*" According to DOE Order 5400.5, the total effective dose equivalent (TEDE) includes the 50-year CEDE from internal deposition of radionuclides and the effective dose equivalent (EDE) due to penetrating radiation from sources external to the body. Because the WSSRAP emits no radionuclides that could result in an appreciable submersion dose potential to members of the public, the external dose equivalent portion of the TEDE is not applicable to NESHAP dose calculations. In addition, ingestion of radionuclides other than radon is not an applicable pathway for a potentially maximally exposed individual at any critical receptor. Thus, for the purpose of demonstrating NESHAP compliance, the EDE specified in 40 CFR 61 is assumed to equal the CEDE from internal deposition by the inhalation pathway. The EDE contribution of dose due to external sources is discussed separately in Section 5 and Appendix B.

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

All 2000 critical receptor monitoring data used to calculate CEDEs and demonstrate compliance with the 10-mrem/yr standard meet the criteria specified in 40 CFR 61, Subpart H, for monitoring and test procedures (including a quality assurance program), compliance and

**Table 6-6 2000 Isotopic Air Monitoring Results (Committed Effective Dose Equivalent Contributions at Each Critical Receptor)**

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

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

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

<b>AP-4007-b</b>					
<b>Committed Effective Dose Equivalent (mrem)</b>					
<b>Radionuclide</b>	<b>1st Quarter</b>	<b>2nd Quarter</b>	<b>3rd Quarter</b>	<b>4th Quarter</b>	<b>Total Annual</b>
Ra-226	0.0000 +/- 0.0007	0.0004 +/- 0.0012	0.0005 +/- 0.0017	0.0003 +/- 0.0009	0.0012 +/- 0.0024
Ra-228	0.0002 +/- 0.0004	0.0000 +/- 0.0001	0.0000 +/- 0.0001	0.0000 +/- 0.0000	0.0002 +/- 0.0004
Th-228	0.0000 +/- 0.0014	0.0005 +/- 0.0013	0.0000 +/- 0.0018	0.0000 +/- 0.0014	0.0005 +/- 0.0030
Th-230	0.0000 +/- 0.0042	0.0007 +/- 0.0015	0.0000 +/- 0.0039	0.0008 +/- 0.0036	0.0015 +/- 0.0069
Th-232	0.0000 +/- 0.0108	0.0026 +/- 0.0046	0.0000 +/- 0.0094	0.0003 +/- 0.0076	0.0029 +/- 0.0168
U, total	0.0002 +/- 0.0004	0.0024 +/- 0.0007	0.0003 +/- 0.0001	0.0000 +/- 0.0002	0.0029 +/- 0.0008
<b>Total EDE</b>	<b>0.0004 +/- 0.0117</b>	<b>0.0066 +/- 0.0052</b>	<b>0.0008 +/- 0.0105</b>	<b>0.0014 +/- 0.0086</b>	<b>0.0092 +/- 0.0186</b>

Table 6-6 2000 Isotopic Air Monitoring Results (Committed Effective Dose Equivalent Contributions at Each Critical Receptor) (continued)

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

AP-4011		Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual	
Ra-226	0.0005 +/- 0.0011	0.0000 +/- 0.0004	0.0008 +/- 0.0014	0.0001 +/- 0.0007	0.0014 +/- 0.0019	
Ra-228	0.0001 +/- 0.0001	0.0000 +/- 0.0001	0.0000 +/- 0.0002	0.0000 +/- 0.0000	0.0001 +/- 0.0002	
Th-228	0.0023 +/- 0.0049	0.0008 +/- 0.0015	0.0000 +/- 0.0011	0.0000 +/- 0.0010	0.0031 +/- 0.0053	
Th-230	0.0025 +/- 0.0105	0.0011 +/- 0.0018	0.0000 +/- 0.0035	0.0005 +/- 0.0022	0.0041 +/- 0.0114	
Th-232	0.0000 +/- 0.0206	0.0018 +/- 0.0059	0.0000 +/- 0.0080	0.0026 +/- 0.0055	0.0044 +/- 0.0235	
U, total	0.0004 +/- 0.0002	0.0005 +/- 0.0005	0.0000 +/- 0.0000	0.0002 +/- 0.0001	0.0010 +/- 0.0006	
<b>Total EDE</b>	<b>0.0058 +/- 0.0236</b>	<b>0.0042 +/- 0.0064</b>	<b>0.0008 +/- 0.0089</b>	<b>0.0033 +/- 0.0061</b>	<b>0.0142 +/- 0.0267</b>	

AP-4013-a		Committed Effective Dose Equivalent (mrem)				
Radionuclide	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual	
Ra-226	0.0000 +/- 0.0002	0.0000 +/- 0.0001	0.0001 +/- 0.0003	0.0000 +/- 0.0003	0.0001 +/- 0.0005	
Ra-228	0.0003 +/- 0.0005	0.0000 +/- 0.0000	0.0000 +/- 0.0000	0.0000 +/- 0.0000	0.0003 +/- 0.0005	
Th-228	0.0000 +/- 0.0004	0.0001 +/- 0.0003	0.0000 +/- 0.0005	0.0000 +/- 0.0002	0.0001 +/- 0.0008	
Th-230	0.0000 +/- 0.0016	0.0003 +/- 0.0007	0.0000 +/- 0.0019	0.0001 +/- 0.0005	0.0004 +/- 0.0026	
Th-232	0.0000 +/- 0.0036	0.0005 +/- 0.0016	0.0000 +/- 0.0033	0.0004 +/- 0.0016	0.0010 +/- 0.0054	
U, total	0.0000 +/- 0.0000	0.0001 +/- 0.0001	0.0002 +/- 0.0000	0.0000 +/- 0.0001	0.0003 +/- 0.0001	
<b>Total EDE</b>	<b>0.0003 +/- 0.0040</b>	<b>0.0010 +/- 0.0018</b>	<b>0.0003 +/- 0.0038</b>	<b>0.0006 +/- 0.0017</b>	<b>0.0023 +/- 0.0061</b>	

**Notes:**

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

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 40 CFR 61, Subpart H, Appendix E, Table 2.

Data quality objectives for precision and accuracy, as outlined in the *Plan for Monitoring Radionuclide Emissions other than Radon at Weldon Spring Site Critical Receptors* (Ref. 18), were achieved in all four quarters of the year, except the third quarter accuracy results for uranium spikes. These samples exhibited high recovery rates for uranium, possibly due to matrix interference. Thus, it is likely that uranium values reported for the environmental samples from this quarter may overstate the actual concentrations of uranium.

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

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

## 7. SURFACE WATER PROTECTION

### 7.1 Highlights of the Surface Water Program

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

- The mass of uranium migrating off site in storm water and treated effluent, 5.38 kg/yr (11.84 lb/yr), was a 44% reduction from the 1999 mass of 9.56 kg/yr (21.08 lb/yr) (see Tables 7-5 and 11-1) and a 98.8% reduction from the 1987 mass of 442 kg.
- Twenty-three samples of treatment plant effluent were collected at the site and quarry during 2000. All parameters monitored in treatment plant effluent were in compliance with National Pollutant Discharge Elimination System (NPDES) permit conditions.
- The annual average for uranium in storm water was reduced to less than 16 pCi/l at all outfalls (Table 7-3).
- The overall results of the whole effluent toxicity (WET) tests indicated that the site and quarry water treatment plant effluents were not toxic to test organisms during 2000 (Table 7-8).
- All major contaminated water sources (i.e., Ash Pond, raffinate pits) have been remediated.
- Surface water bodies downstream of the chemical plant site continue to show a decline in uranium levels (Figure 7-1 and Table 7-10).

### 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 NPDES effluent monitoring program establishes sampling requirements for discharge points (outfalls) at the chemical plant, quarry, and site and quarry borrow areas. The goals of this program are to maintain compliance with the NPDES permit requirements and to protect the health of downstream water users and the environment by characterizing water released from the site. In accordance with the 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 and to measure the effectiveness of remediation.

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

### 7.3 Applicable Standards

The WSSRAP is subject to, and complies with, Executive Order 12088, which requires all Federal facilities to comply with applicable pollution control standards. Effluent discharges from the site for 2000 were authorized by five NPDES permits issued by the Missouri Department of Natural Resources (MDNR). The MDNR requires specific parameters to be monitored at outfalls listed in each permit. Each parameter is assigned either effluent limits or a "monitoring only" status, which means the concentrations are reported but not limited by the permit. In addition, the WSSRAP monitors and reports some parameters on an informational basis. Sampling frequencies and reporting requirements for the two major permits, MO-0107701 (at the chemical plant site) and MO-0108987 (at the quarry), are summarized in Tables 7-1 and 7-2. These permits were reissued on July 14, 2000, and June 17, 1998, respectively. Permit MO-0108987 was revised on April 21, 2000.

The Site Borrow Area land disturbance storm water permit, MO-R100B69, issued on September 1, 1994, and reissued on May 29, 1998, has no specified monitoring or reporting requirements. A program was developed in the *Environmental Monitoring Plan* (Ref. 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 controls and to improve them, if need be.

Permit MO-G670203 was issued on December 5, 1997, for discharge of hydrostatic test water from the chemical plant site. Hydrostatic test water is water used to test tanks, pipes, etc., for leaks. It may also be used to test pumps, valves, etc. Sampling frequency and reporting requirements and results are discussed in Section 7.6.1.2.4.

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

Effluent discharges are also regulated by 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 taken to keep uranium concentrations as low as reasonably achievable (ALARA), not just below the DCG.

The primary criteria used to develop the surface water monitoring program were the Missouri Water Quality Standards for drinking water supplies established under the Missouri Clean Water Commission Regulation 10 CSR 20-7.031 and the U.S. Environmental Protection Agency primary and secondary maximum contaminant level concentrations for drinking water. A table of applicable drinking water standards that includes contaminants routinely monitored in the surface water program can be found in Table 8-1.

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

Table 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, NP-0004, NP-0005, NP-0010, NP-0050 <sup>(a)</sup> NP-1005	NP-0006
Sampling Frequency	once/month	Once/quarter
Flow	GPD (monitor only)	GPD (monitor only) <sup>(b)</sup>
Settleable Solids	1.0 ml/hr	---
Total Suspended Solids	mg/l (monitor only) <sup>(c)</sup>	30/45 mg/l <sup>(d)</sup>
Nitrate and Nitrite as N**	mg/l (monitor only)	---
Uranium, total	mg/l (monitor only)*	---
Gross alpha, beta	pCi/l (monitor only)	---
pH	6 - 9 standard units	6 - 9 standard units
Fecal coliform	---	400/1000 colonies/ 100 ml <sup>(e)</sup>
Biochemical Oxygen Demand	---	30/45 mg/l <sup>(d)</sup>
Total Residual Chlorine	---	1.0 mg/l

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.
- \*\* Does not apply to quarry storm water Outfall NP-1005.
- (a) Outfall NP-0050 represents two outfalls from the TSA. The outfall was not permitted during the first half of 2000. Permission was given by MDNR to discharge at the outfall as long as it was monitored as at other storm water outfalls. The outfall was permitted when the permit was reissued on July 13,2000
- (b) Frequency is once/month.
- (c) Limit is 50 mg/l if erosion control is not designed for a one in 10 year, 24-hour storm.
- (d) Monthly average/weekly average
- (e) Monthly average/daily maximum.
- Not Applicable.

Table 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-226 <sup>(c)</sup>	pCi/l <sup>(a)</sup>		Se, total	0.05 mg/l/NA	
Ra-228 <sup>(c)</sup>	pCi/l <sup>(a)</sup>		Cyanide, amenable	0.05 mg/l/NA	
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 mg/l/NA	
Flow	GPD <sup>(a)</sup>		Nitrate and Nitrite as N	100 mg/l <sup>(g)</sup>	
COD	90 (60) mg/l <sup>(e)</sup>		Sulfate as SO <sub>4</sub>	1000/500 mg/l	
TSS	50 (30) mg/l <sup>(e)</sup>		Chloride	mg/l <sup>(a)</sup> /NA	
pH	6-9 standard units		Priority Pollutants <sup>(f)</sup>	mg/l <sup>(a)(h)(i)(j)</sup>	
Al, total	7.5 mg/l/NA <sup>(k)</sup>		Whole Effluent Toxicity	<sup>(j)(i)</sup>	
As, total	0.20 mg/l/NA				
Cr, total	0.40 mg/l/NA				

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

NA Not applicable

\* Frequency = once per batch unless otherwise noted.

(a) Monitoring only.

(b) Water treatment plants designed for an average concentration of 30 pCi/l (1.11 Bq/l) and never to exceed concentrations of 100 pCi/l (3.7 Bq/l).

(c) Once/month.

(d) Polychlorinated biphenyls (PCBs) have a limit of 1.0  $\mu$ g/l until July 14, 2000. After that the limit is 0.5  $\mu$ g/l.

(e) Daily maximum (monthly average).

(f) Priority pollutants are listed in 40 CFR 122.21 Appendix D, Tables II and III.

(g) Limit applies to chemical plant; monitoring only at quarry.

(h) Annual monitoring.

(i) Quarterly monitoring.

(j) "No statistical difference between effluent and upstream results at 95% confidence level."

(k) Added when permit reissued on July 14, 2000.

## 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 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 included Ash Pond, the south and north dump areas, the temporary storage area, and 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).

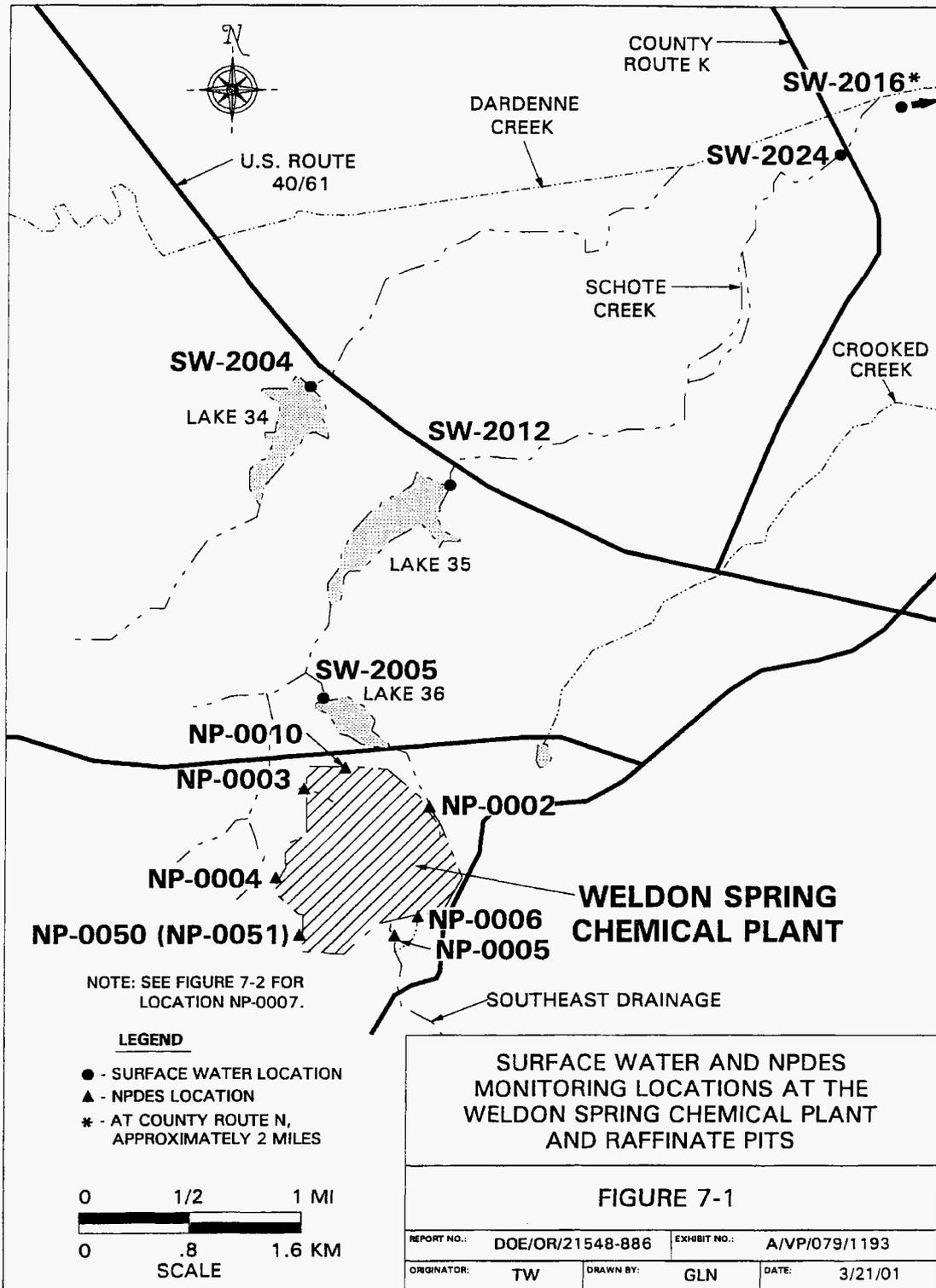
Ash Pond, Raffinate Pits 3 and 4, the chipped wood storage area, and the south end of the temporary storage area were completely remediated and confirmed clean during 1999. The remainder of the site was remediated and confirmed clean during 2000. A portion of the water that discharges at NP-0003 flows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

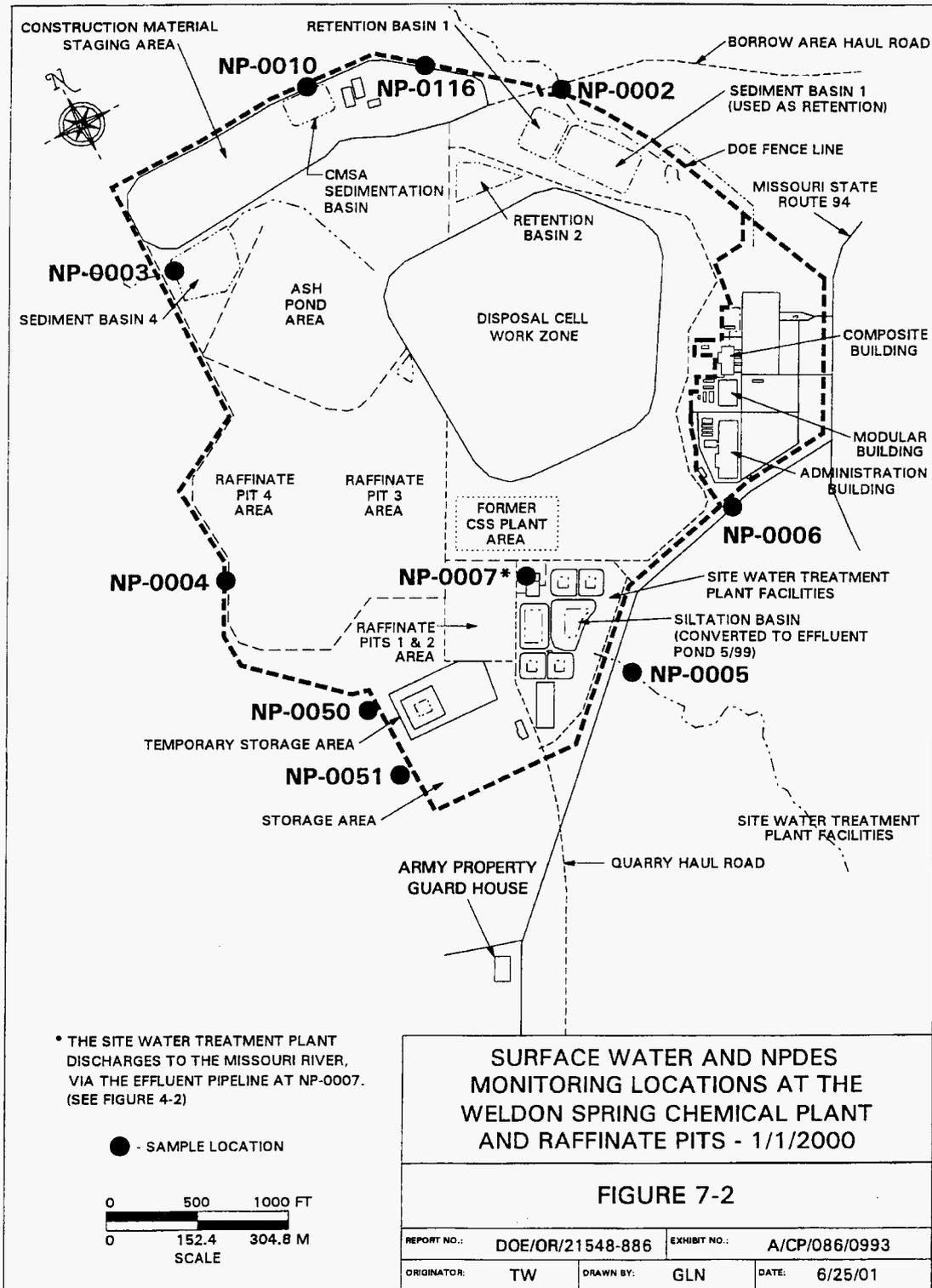
Surface water drainage from the north and east sections of the chemical plant site, which includes the administration parking lots, part of the disposal cell outer berm, and the construction material staging area, discharges to Dardenne Creek from Schote Creek after first flowing through Busch Lakes 36 and 35 (Figures 7-1 and 7-2). Leachate from the interior of the cell and storm water runoff from open portions of the cell were collected in Retention Basins 1 and 2 and Sedimentation Basin 1 (converted to a retention basin) for sampling and/or treatment. These basins were remediated during 2000. Retention Basin 2 was made smaller and may be used to store treated storm water from open portions of the cell when it is reopened for a brief period during 2001. Leachate is now collected in the Leachate Collection and Removal System (LCRS) sump. Runoff from the construction material staging area equipment area near the north decontamination pad was collected in the construction material staging area retention basin and sampled to ensure compliance before being discharged to Outfall NP-0010 during 2000. The equipment area, decontamination pad, and retention basin were removed, and the area was remediated during 2000.

Runoff from the southern portion of the chemical plant site (Figures 7-1 and 7-2), which included the site water treatment plant, Building 434, and parking and equipment areas for the former chemical stabilization and solidification facility, flows southeast to the Missouri River via the Southeast Drainage (Valley 5300). The site water treatment plant, effluent basins, equalization basin, Raffinate Pits 1 and 2, and Building 434 were removed and the area was remediated during 2000. By the end of 2000, all surface water runoff was from confirmed clean areas.

#### **7.4.2 Weldon Spring Quarry**

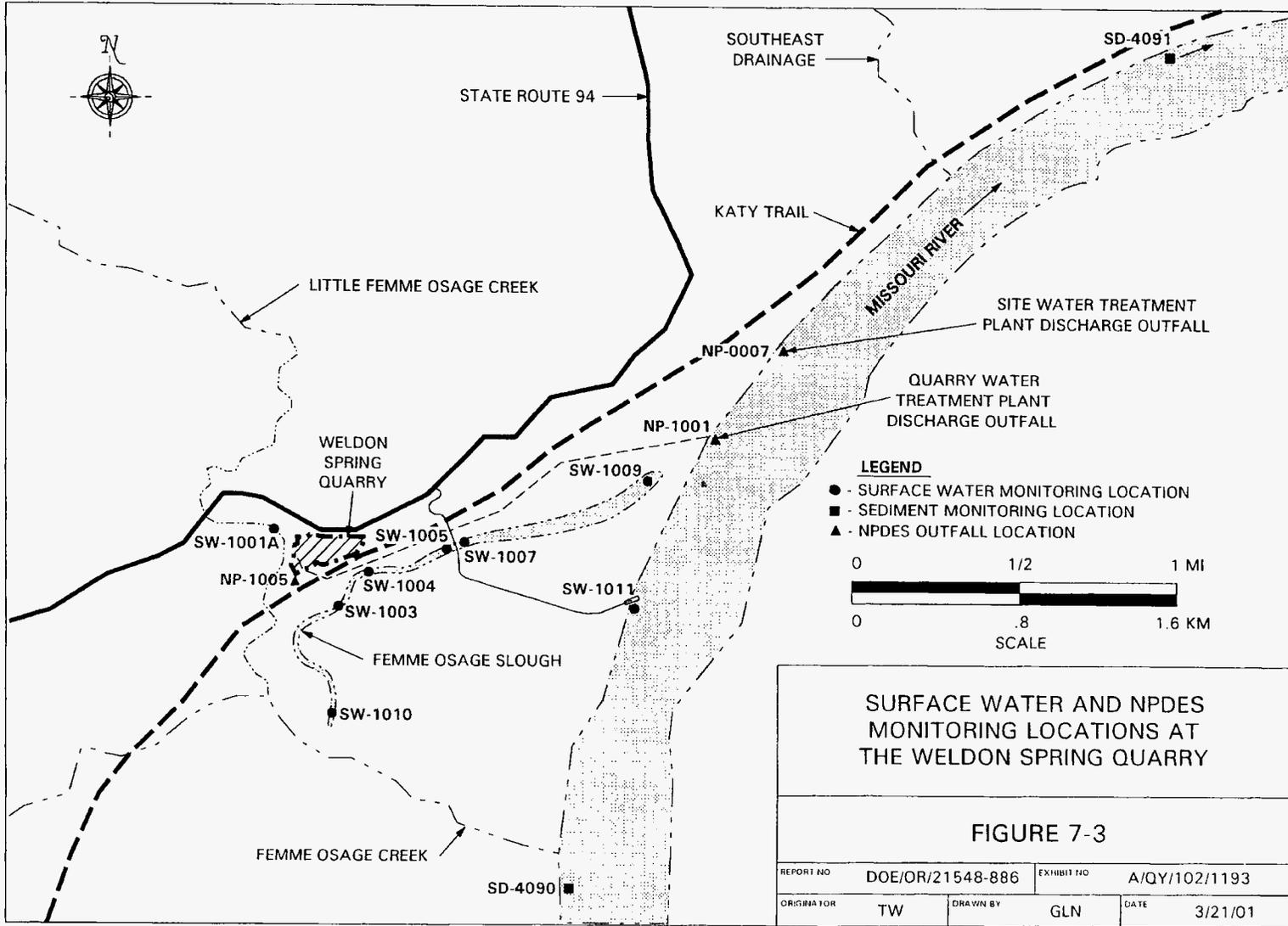
Surface water bodies in the quarry area are the Femme Osage Slough, Little Femme Osage Creek, and Femme Osage Creek (Figure 7-3). These water bodies do not receive direct runoff from the quarry, but are sampled to monitor potential changes due to movement of





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

**FIGURE 7-2**



contaminated groundwater from the fractured bedrock of the quarry through fine-grained alluvial materials.

The Femme Osage Slough is directly south of the quarry and is known to receive contaminated groundwater from the quarry through subsurface recharge. There is no natural surface flow from the slough; it is essentially land locked. Little Femme Osage Creek is located west of the quarry and discharges into Femme Osage Creek approximately 0.5 km (0.3 mi) southwest of the quarry. Femme Osage Creek flows into the Missouri River. Although there has been no evidence of impact from contaminated groundwater on the creeks via stream emergence, they are monitored to detect changes in the system.

## **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.

### **7.5.1 National Pollutant Discharge Elimination System Monitoring**

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

### **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 Raffinate Pits**

In accordance with the surface water monitoring program, Dardenne Creek, and Busch Lakes 34, 35, and 36 were sampled quarterly, at five locations (Figure 7-1) for total uranium (Ref. 8). Samples were split and analyzed by the site Kinetic Phosphorescent Analyzer (KPA) and an off-site lab. This monitoring was conducted to measure the effects of surface water discharges from the site on the quality of downstream surface water.

#### **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, SW-1007, SW-1009, and SW-1010 (Figure 7-3) were monitored quarterly by on-site

KPA for total uranium. Due to elevated total uranium concentrations detected at slough locations in 1999, uranium samples were analyzed by off-site laboratories semi-annually in support of on-site results.

## 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

For 2000, the annual average uranium concentrations at the storm water discharge points ranged from 1.0 pCi/l ( 0.04 Bq/l) at NP-1005 to 15.6 pCi/l ( 0.58 Bq/l) at NP-0003, which are 0.1% and 2.3%, respectively, of the DCG for natural uranium. Average annual gross alpha concentrations ranged from 2.5 pCi/l (0.09 Bq/l) at NP-1005 to 37.7 pCi/l ( 1.39 Bq/l) at NP-0005. The year 2000 annual average radionuclide concentrations for all the permitted storm water outfalls are shown in Table 7-3. Historical annual averages are tabulated in Table 1-6.

Uranium concentration averages were calculated on a flow weighted basis for storm water Outfalls NP-0002, NP-0003, NP-0004, NP-0005, NP-0010, and NP-1005. Flow was measured at these outfalls by flowmeters, v-notch weirs, or visual estimates. Beginning January 1, 2000, total flows were calculated using watershed areas, precipitation measurements, and runoff coefficients. Flow weighted averages (rather than straight averages) were calculated for uranium levels at these outfalls to estimate the total uranium that migrated off site during 2000. The flow-weighted average for the year was calculated by summing the total activity (pCi) for the days the samples were collected and dividing by the sum of the total daily flows (liters) for the same days. A straight average was used for outfall NP-0050 (and NP-0051) because the temporary storage area is relatively flat and the flow was diffuse, so it was difficult to get a flow measurement accurate enough for averaging.

Treatment plants at both the site and quarry were in operation during 2000. Eight batches were discharged from the quarry plant, and 15 batches were discharged from the site plant. Ten of the site and three of the quarry batches were continuous discharge, as opposed to batch discharge. A true batch discharge is treated water that is stored, then sampled, then discharged when compliance is demonstrated. A continuous discharge is discharged as it is treated and sampled at the discharge. Analytical results are received after the discharge. No daily maximum or monthly average limits are established for uranium in treated water; however, the design of the treatment plants is based on achieving an average of 30 pCi/l (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 2.7 pCi/l (0.10 Bq/l) and 0.84 pCi/l (0.03 Bq/l), respectively (Table 7-5). In addition, the site water treatment plant averaged 5.0 pCi/l (0.19 Bq/l) for gross alpha and 7.6 pCi/l (0.28 Bq/l) for gross beta. The quarry water treatment plant averaged 2.3 pCi/l (0.09 Bq/l) and 7.1 pCi/l (0.26 Bq/l), respectively for these same parameters (Table 7-4).

Table 7-3 2000 Annual Average NPDES Results for the Weldon Spring Chemical Plant and Quarry Storm Water Outfalls<sup>(c)</sup>

PARAMETER	LOCATIONS						
	NP-0002	NP-0003	NP-0004	NP-0005	NP-0010	NP-1005	NP-0050, 51
Number of sample events	12	11	11	13	9	8	10
pH range	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Nitrate as N (mg/l)	1.3	4.2	47.7**	4.5(13)	0.2	NS	2.4
Total suspended solids (mg/l)	1,029	282	175	282	142	42.4	602
Settleable solids (ml/l/hr)	15/6(b)	12/2(b)	11/0(b)	12/0(b)	9/0(b)	8/0(b)	10/0(b)
Arsenic (mg/l)	0.004(2)	0.022	NS	0.005(9)	NS	NS	0.017(2)
Chromium (mg/l)	0.012(2)	0.066	NS	0.014(9)	NS	NS	0.046(2)
Lead (mg/l)	0.020(2)	0.039	NS	0.009(9)	NS	NS	0.020(2)
Thallium (mg/l)	0.026(2)	0.003	NS	0.003(9)	NS	NS	0.003(2)
Total uranium (pCi/l)	5.6*	15.6*	6.0*	6.9*	6.1*	1.0*	8.4
Gross alpha (pCi/l)	35.2	27.8	15.9	37.7	12.3	2.5	14.9
Gross beta (pCi/l)	42.6	33.4	22.2	24.5	8.7	5.9	15.7
Radium-226 (pCi/l)	NS	1.86(10)	NS	0.42(7)	NS	NS	NS
Radium-228 (pCi/l)	NS	0.82(10)	NS	0.68(7)	NS	NS	NS
Thorium-228 pCi/l)	NS	1.72(10)	NS	0.28(7)	NS	NS	NS
Thorium-230 pCi/l)	NS	13.7(10)	NS	0.58(7)	NS	NS	NS
Thorium-232 pCi/l)	NS	1.84(10)	NS	0.30(7)	NS	NS	NS

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

(b) Number of samples/number of results above daily maximum limit of 1.0 ml/l/hr.

(c) The number in parentheses indicates the number of samples analyzed for the specified parameter, if it differs from the number of sample events.

\* Flow proportional averages.

\*\* Suspected outlier of 374 mg/l elevates average to this level. Next highest level is 46.8 mg/l.

NS Not Sampled.

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

In addition to effluent monitoring, the NPDES permit for the quarry, MO-0108987, required that river sediment sampling be conducted upstream and downstream of the quarry water treatment plant outfall (NP-1001) on an annual basis. The river sediment was sampled for uranium upstream at location SD-4090 and downstream at location SD-4091 (see Figure 7-3). The one-time sampling results were 3.06 pCi/g (0.11 Bq/g) at SD-4090 and 2.88 pCi/g (0.11 Bq/g) at SD-4091. These concentrations are an indication that discharges from the site have not had a deleterious effect on river sediment.

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

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

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

Note: 1 pCi/l = 0.037 Bq/l

Radium and thorium were monitored once per month, as required by the permit, in both site and quarry water treatment plant batches. Annual averages for radium and thorium at both plants are shown in Table 7-4. Radium and thorium levels were all well below the DCGs at annual averages less than 1.0 pCi/l.

Estimated quantities of total natural uranium released off site through surface water runoff and treatment plant discharges are in Table 7-5. The total volume of storm water at all the outfalls was calculated using watershed area, total precipitation, and runoff curve numbers. Runoff curve numbers are cited in the U.S. Department of Transportation *Design of Roadside Drainage Channels* (Ref. 31). Best professional judgement was used in determining runoff curve numbers. The estimated mass of uranium released off site in storm water and treated effluent during 2000 was 5.38 kg (11.83 lb) and was calculated by multiplying the total runoff volume by the average uranium concentration. This is a substantial decrease from the estimated amount released during 1999, which was 9.56 kg (21.08 lb). Table 7-6 shows the annual average uranium concentrations at NPDES outfalls from 1987 to 2000. Average uranium concentrations for 2000, in comparison to levels for 1999, decreased at all outfalls except NP-0004 and NP-0050(51). The uranium levels at outfalls NP-0004 and NP-0050(51) were very low in 1999, and although they increased during 2000, they were still below 10 pCi/l. This is suspected to be a natural variation due to soil disturbances and does not appear to be the start of an upward trend. Historical trends of uranium at Outfalls NP-0002, NP-0003, and NP-0005 are discussed in

Section 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 following paragraphs.

Table 7-5 2000 Estimated Annual Release of Natural Uranium from NPDES Outfalls

OUTFALL	DRAINAGE AREA HECTARES (ACRES)	ESTIMATED % OF PRECIPITATION AS RUNOFF(a)	AVERAGE URANIUM CONCENTRATION (pCi/l)	TOTAL RAINFALL VOLUME Ml/yr (Mgal/yr)	TOTAL RUNOFF VOLUME Ml/yr (Mgal/yr)	TOTAL U RELEASE (Ci/yr)	TOTAL U RELEASE (kg/yr)
NP-0002	31.8 (78.6)	60	5.6*	330.01 (87.19)	198.03 (52.32)	1.11E-3	1.631
NP-0003	26.3 (58.5)	40	15.6*	245.65 (64.90)	98.26 (25.96)	1.53E-3	2.254
NP-0004	11.3 (28)	40	6.0*	117.56 (31.06)	47.01 (12.42)	0.28E-3	0.415
NP-0005	12 (29.6)	40	6.9*	124.30 (32.84)	49.70 (13.13)	0.34E-3	0.504
NP-0010	5.7 (14)	30	6.1*	58.78 (15.53)	17.64 (4.66)	0.11E-3	0.158
NP-0050, 51 <sup>(b)</sup>	5 (12.4)	30	8.4	52.08 (13.76)	15.63 (4.13)	0.13E-3	0.193
NP-1005	0.5 (1.3)	60	1.0*	5.45 (1.44)	3.29 (0.87)	3.28E-6	0.005
NP-0007	N/A	N/A	2.7	NA	47.35 (12.51)	0.13E-3	0.188
NP-1001	N/A	N/A	0.8	NA	26.19 (6.92)	2.20E-5	0.032
TOTAL	N/A	N/A	NA	988.83 (246.72)	503.06 (132.91)	3.66E-3	5.380

\* Flow-weighted average.

(a) Runoff curve number estimated from U.S. Department of Transportation *Design of Roadside Drainage Channels* (Ref. 31).

(b) One outfall is monitored to represent both.

N/A Not Applicable.

Note: To convert from Ci/yr to Bq/yr, multiply Ci/yr by  $3.7 \times 10^{10}$

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

	NP-0001	NP-0002	NP-0003	NP-0004	NP-0005	NP-0010	NP-0007	NP-1001	NP-1005	NP-0050, NP-0051
1987	680	210	2240	9.5	780	---	---	---	---	---
1988	539	141	1178	6.2	497	---	---	---	---	---
1989	368	145	280	6.5	347	---	---	---	---	---
1990	413	139	89	7.6	364	---	---	---	---	---
1991	475	158	456	6.4	581	---	---	---	---	---
1992	516	228	478	6	296	---	---	<0.0003	---	---
1993	1003*	230*	607*	9	133*	---	---	1.9	---	---
1994	1226*	182*	332*	12	347*	82	0.74	1.6	---	---
1995	(a)	124*	67*	(b)	128*	107	0.46	1.8	---	---
1996	(a)	54*	88*	(b)	107*	50	1.37	1.1	---	---
1997	(a)	14*	143*	(b)	19*	2.7	1.50	0.5	---	---
1998	(a)	22*	83*	23	10*	10.7*	3.11	0.4	1.0(c)	---
1999	(a)	8.0*	38.3*	3.5*	20.3*	7.3	17.1	1.1	1.9	2.7 <sup>(d)</sup>
2000	(a)	5.6*	15.6*	6.0*	6.9*	6.1*	2.7	0.8	1.0*	8.4

\* Flow weighted average.

-- Not applicable.

(a) Outfall removed, flow diverted to NP-0005.

(b) Outfall removed from permit in 1995, added in 1998.

(c) Outfall added in 1998.

(d) Outfall added in 1999.

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

The average uranium concentration for Outfall NP-0002 in 2000 was 5.6 pCi/l (0.21 Bq/l), a decrease from the 1999 average of 8.0 pCi/l (0.30 Bq/l). No radiological contaminants were detected above baseline values. Baseline values for contaminants in storm water were set before soil and foundation removal started and the site was still stabilized with vegetation. Baseline monitoring and values are in table E-6, Appendix E, of the EMP (Ref. 8). All levels were well below the DCGs. Annual average NPDES results for Outfall NP-0002 are in Table 7-3.

The average uranium concentration for Outfall NP-0003 was 15.6 pCi/l (0.58 Bq/l), which was much less than the 1999 average of 38.3 pCi/l (1.42 Bq/l). The decrease may be the result of completing remediation and establishing vegetation in the watershed. Although numerous thorium and radium levels were above baseline levels, with the exception of one sample, they were well below the DCGs for the specific parameters. The exception was a sample collected on February 18, 2000. Radium and thorium levels were elevated, particularly Thorium-230, at 119 pCi/l. The sample was out of compliance for settleable solids and above the notification level of 100 µg/l for arsenic, chromium, and lead. The flow on February 18 was the result of a greater than 3 in. rainfall in the previous 24 hours. Two inches of rain fell during a 2-hr period. Elevated metals are typically seen with elevated solids; however, radium and thorium, especially Thorium-230 were also elevated. All the radiological levels were below their respective DCGs, but the unexpectedly high levels of both metals and thorium triggered an investigation to find the source. Soil and sediment samples were collected during the investigation, and the results indicated that the source was soil that had accumulated on the contaminated haul road (between the cell and Raffinate Pits 1 and 2) and, to a lesser extent, on the contaminated vehicle parking area in the old material staging area. Both of these areas shed storm water to the diversion channel that flows to Sedimentation Basin 4 (Figure 7-2). This normally allows settling of the solids in the basin before the storm water leaves the site. It was determined that the water management methods worked as designed, but could not accommodate the heavy rains in combination with the lack of vegetation. Corrective actions were taken as follows:

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

- The haul road and parking area were monitored more frequently to ensure that there was no build up of contaminated material.
- Monthly NPDES samples of effluent at Outfall NP-0003 were analyzed for arsenic, chromium, lead, thallium, radium, and thorium. Seven-day or faster turnaround times were requested.

Monitoring of sediment downstream of outfall NP-0003 indicated that all levels were below the cleanup criteria. Parameters for the storm water runoff sample collected during March were all in compliance with NPDES limits, below notification levels for metals, and below the DCGs for the radiological contaminants. Radium and thorium were reduced to levels that had been seen in the past. During the latter part of 2000, Sedimentation Basin 4 and the outfall NP-0003 area were remediated and confirmed clean. A new sedimentation basin was installed to slow water flow and retain settleable solids from the confirmed clean watershed. Baseline values are in Table E-6, Appendix E, of the EMP (Ref. 8). Annual average values for uranium, radium, thorium, gross alpha, and gross beta are shown in Table 7-3.

Outfall NP-0004 was eliminated from NPDES permit MO-0107701 on March 4, 1994, but was repermited on May 22, 1998, because a portion of Raffinate Pit 4 was being remediated upstream of the outfall, and storm water from the area flows to Outfall NP-0004. The annual average for uranium at NP-0004 was 6.0 pCi/l (0.22 Bq/l), slightly higher than the 1999 annual average of 3.5 pCi/l (0.13 Bq/l). The slight increase was most likely due to soil disturbance in the area and precipitation patterns.

The annual average uranium concentration at Outfall NP-0005 for 2000, which was less than the 1999 average of 20.3 pCi/l (0.75 Bq/l) was 6.9 pCi/l (0.26 Bq/l). There were instances of radium and thorium being above baseline values but still within levels seen during remediation and well below DCGs. Baseline monitoring and values are in Table E-6, Appendix E, of the EMP (Ref. 8). Annual average NPDES results are in Table 7-3.

Outfall NP-0010 was added to NPDES Permit MO-0107701 when it was reissued on March 4, 1994. This outfall is near the west end of the north perimeter fence in the construction material staging area, and drains a portion of that area (Figure 7-2). Clean soil, gravel, and other construction material are stored there. Contaminated soil was removed, and the construction material staging area was completed early in 1996. The annual average uranium concentration for 2000 was 6.1 pCi/l (0.23 Bq/l), well below the DCG of 600 pCi/l (22.2 Bq/l) and slightly less than the 1999 average of 7.3 pCi/l (0.27 Bq/l). The annual average NPDES results are in Table 7-3.

Outfall NP-0051 represents two outfalls on the west side of the temporary storage area. Outfall NP-0050 is the other outfall (Figure 7-2). Before the temporary storage area was remediated, these outfalls served its north and south ends. After the remediation, sheet flow was established, and only one outfall is now being sampled at the property line. The annual average

uranium concentration for 2000 was 8.4 pCi/l (0.31 Bq/l), well below the DCG of 600 pCi/l (22.2 Bq/l) and somewhat higher than the 1999 average of 2.7 pCi/l (0.10 Bq/l). The increase is suspected to be the result of soil disturbances and precipitation patterns. The annual average NPDES results are in Table 7-3.

Outfall NP-1005 is the storm water outfall at the quarry. During 2000 the flow was from a hillside and a ditch along the effluent ponds from the quarry water treatment plant. In the future this outfall will discharge water from the quarry area after it is backfilled and graded. The annual average uranium concentration for 2000 was 1.0 pCi/l (0.037 Bq/l), a decrease from the 1999 average of 1.9 pCi/l (0.07 Bq/l). The annual average NPDES results are reported in Table 7-3.

### **7.6.1.2 Physical and Chemical Results**

Analytical results for physical and chemical parameters at NPDES outfalls and other sample locations are discussed in Subsections 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, NP-0050, NP-0051, and NP-1005 are in Table 7-3. In addition to the permitted parameters, arsenic, chromium, lead, and thallium were periodically monitored at some outfalls. There were three instances at outfall NP-0003 of metals that do not have permit limits having levels above the 100 µg/l reporting levels for toxic pollutants. These elevated levels were noted in the sample collected on February 18, 2000. Radium and thorium were elevated in this same sample. The incident is discussed in Section 7.6.1.1.

There were also eight samples where settleable solids were above the 1.0 ml/l/hr limit. These results are shown in Table 7-3 and further discussed in Section 2.5.

#### **7.6.1.2.2 Administration Building Sewage Treatment Plant**

Monitoring results for the sewage treatment plant, Outfall NP-0006, are in Table 7-7. Except for one fecal coliform result in January, parameters were in compliance for the year. See Section 2.5, *Incident Reporting – Environmental Occurrences in 2000*, for further discussion.

#### **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 water treatment plants at the site and quarry. Therefore, the parameter levels are not summarized here.

During 2000, Whole Effluent Toxicity (WET) tests were required quarterly for effluent from both the site and quarry water treatment plants. Because neither the quarry nor the site plant was in operation during one quarter, there are only three sample results for each site. The WET test is a measure of toxicity without quantifying or identifying the toxic constituents. Tests were conducted on both *Ceriodaphnia dubia* (water flea) and *Pimephales promelas* (fathead minnow). The tests were conducted in effluents and in test controls of upstream river water and laboratory control water. No samples failed the WET tests during 2000, indicating that the site and quarry water treatment plant effluents did not cause the receiving stream to be toxic to test organisms (see Table 7-2). WET test results are summarized in Table 7-8.

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

MONTH (QUARTER)	PARAMETER (a) (PERMIT LIMITS)				TOTAL RESIDUAL CHLORINE (1.0/1.0 mg/l)**
	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)	11	6	TNTC	7.19	0.76
February (1)	N.S.	N.S.	4	N.S.	0.62
April (2)	N.S.	N.S.	<2	N.S.	1.0
May(2)***	<5	<5	N.S.	7.08	0.16
May(2)	<2	<5	4	7.09	0.14
August (3)	<5	<5	52	7.13	0.21
October (4)	<5	<5	33	6.08	0.15

(a) One sample analysis required for each calendar quarter. (b) F.C. – Fecal Coliform  
 \* - Monthly average/Weekly average \*\* Monthly average/daily maximum  
 \*\*\* - exceeded temperature requirements N.S. Not Sampled  
 TNTC – Too Numerous to Count (>15,000 colonies/100 ml).

Table 7-8 2000 Whole Effluent Toxicity Test Results for the Site and Quarry Water Treatment Plants\*

BATCH	DATE	DAPHNIA (D) % MORTALITY	PIMEPHALES (P) % MORTALITY	RIVER CONTROL D,P % MORTALITY	LAB CONTROL D,P % MORTALITY
S179	1/10/00	0	2.5	0,2,5	0,2,5
S181	4/6/00	0	0	0,0	0,0
S187	8/7/00	0	5	0,2,5	0,2,5
Q064	3/16/00	0	0	0,0	0,2,5
Q065	6/28/00	0	0	0,0	0,0
Q071	11/28/00	0	0	0,0	0,0

S Site  
 Q Quarry  
 P Pimephales  
 D Daphnia (*Ceriodaphnia*)  
 \* Each test is on four replicates of 10 organisms. % 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. It also requires that flow, total petroleum hydrocarbons (TPH), total suspended solids (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. During calendar year 2000, there were three hydrostatic test water discharges from the Leachate Collection and Recovery System (LCRS) storage pipe. All parameters were in compliance

#### 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 2000 *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. Settleable solids and oil and grease results are shown in Table 7-9. Settleable solids were all less than 1.6 ml/l/hr. Oil and grease were monitored five times at the NP-0040 outfall, which is the outfall from the vehicle maintenance area sedimentation basin. Three results were above the 10 mg/l water quality standard for oil and grease. There was no noticeable sheen or odor when these samples were collected. When elevated values were detected, additional sorbent booms were placed downstream of the maintenance building. This resulted in decreased levels.

Table 7-9 Borrow Area Settleable Solids (ml/l/hr) and Oil and Grease (mg/l)

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

N.S. Not Sampled

\* North Borrow Area sedimentation basin.

\*\* East Borrow Area sedimentation basin.

\*\*\* Discharge to Missouri River watershed. Water was pumped only one time from the east side of the borrow area to NP-0052.

## 7.6.2 Surface Water Monitoring Results

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

### 7.6.2.1 Weldon Spring Chemical Plant and Raffinate Pits

Average uranium levels at the off-site surface water locations were lower than the 1999 annual averages at four of five locations, and slightly higher at one location. This reflects the lower levels seen at the NPDES outfalls. Average annual uranium concentrations for surface water are in Table 7-10, along with the 1999 figures and the historic high for each location for comparison. Surface water locations are shown in Figure 7-1. Historic annual averages for Lakes 34, 35, and 36 outlets, as well as locations in Schote Creek and Dardenne Creek, are plotted in Figure 7-4. Uranium levels at the Busch Lake outlets have shown an overall decline since remediation started. The Schote Creek and Dardenne Creek locations are downstream of the lakes and have always shown relatively low levels because the chemical plant portion of the watershed is much smaller than the total watershed area. Data points are shown from the date the samples were first collected. No samples were collected for SW-2012 during 1995 because there was no flow from the lake. The historic high of 326 pCi/l at location SW-2012, the outlet of Lake 35, is considered an outlier. An outlier is a sample result that does not fit the rest of the uranium results for the location. It does not necessarily mean that the result was not real, but that it is an anomaly and is suspect. This was an isolated same with no samples collected before or after (until 1993). This location is downstream of Lake 36, which showed no similar elevated levels. The second highest uranium concentration at SW-2012 was 17 pCi/l during 1994.

Table 7-10 Annual Averages for Total Uranium (pCi/l) Concentrations at Weldon Spring Chemical Plant Area Surface Water Locations\*

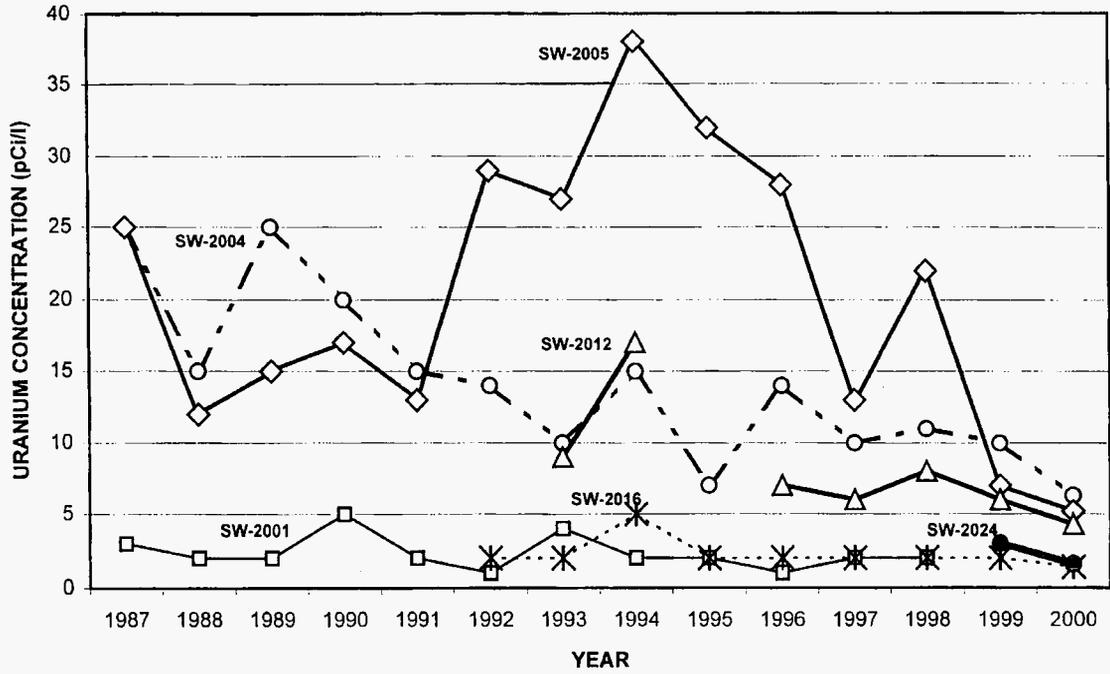
LOCATION	AVERAGE	MAXIMUM	MINIMUM	HISTORIC HIGH
SW-2004	6.3(9.3)	11.5(10.7)	<0.7(6.3)	39 (1989)
SW-2005	5.2(7.0)	8.0(7.7)	3.3(6.0)	53.7 (1996)
SW-2012	4.3(5.7)	7.5(8.5)	<0.7(3.7)	326 (1991)**
SW-2016	1.4(1.3)	3.1(2.2)	<0.7(0.6)	7.8 (1994)
SW-2024	1.6(2.8)	1.9(5.3)	0.9(1.1)	5.3(1999)

\* 1999 results are given in parentheses.

\*\* This historic high is considered an outlier.

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

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



- Lake 34 Outlet, SW-2004
- ◇ Lake 36 Outlet, SW-2005
- △ Lake 35 Outlet, SW-2012
- Dardenne Below Rte K, SW-2024
- \* Dardenne at Rte N, SW-2016
- Schote at Rte K, SW-2014

HISTORICAL LAKE AND DOWNSTREAM  
URANIUM ANNUAL AVERAGES

FIGURE 7-4

REPORT ID:	DOE/OR/21548-886	EXHIBIT NO.:	A/PI/009/0301
ORIGINATOR:	TW	DRAWN BY:	GLN
		DATE:	6/25/01

### 7.6.2.2 Weldon Spring Quarry

The annual averages for the surface water locations are summarized in Table 7-11. Uranium levels in the Femme Osage Slough remain within historical ranges. No new historic total uranium high concentrations were reported for quarry surface water during 2000.

Table 7-11 Annual Averages for Total Uranium (pCi/l) at Weldon Spring Quarry Surface Water Locations

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

Note 1: 1999 results given in parentheses

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

(a) A sample collected during 1993 flood conditions, which represented groundwater discharge to the surface had a result of 4,000 pCi/l. This sample is not reported as the historic high since it represents groundwater, not surface water.

## 8. GROUNDWATER MONITORING

### 8.1 Highlights of the Groundwater Monitoring Program

The following are highlights of the 2000 groundwater monitoring program. These items, and others, are discussed in detail in this chapter.

- Contaminant levels generally remained within historic ranges at all chemical plant and quarry groundwater monitoring locations.
- High concentrations of nitroaromatic compounds reported in groundwater monitoring locations in the vicinity of Frog Pond continued to be monitored during 2000. Three new monitoring wells were installed in this area at the end of 2000 to further define the extent of contamination.
- Volatile organic compounds (VOC) trichloroethene (TCE) and 1,2-dichloroethene (DCE) detected in groundwater in 1996 at the chemical plant continued to be under investigation during 2000. Several new monitoring wells have been installed in this area and will be monitored in 2001 to further define the extent of contamination. Treatment of the VOC-contaminated groundwater is scheduled to begin in 2001.
- Groundwater detection monitoring for the disposal cell that was initiated in June 1998 continued in 2000.
- Monitoring results for Burgermeister Spring were within historical ranges. No new highs or lows were recorded, although average annual concentrations of contaminants are decreasing.
- Quarry water treatment plant and temporary storage area waste facility monitoring programs were discontinued during 2000.

### 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 chemical plant and raffinate pits site, the quarry site, adjacent properties, and selected springs in the vicinity of the chemical plant site. The groundwater protection program is formally defined in the *Weldon Spring Site Remedial Action Project Groundwater Protection Management Program Plan* (Ref. 12). The groundwater monitoring portion of the program is detailed in the *Environmental Monitoring Plan (EMP)* (Ref. 8).

Due to lithologic differences, including geologic features that influence groundwater flow mechanics, and the geographical separation of the chemical plant and quarry areas, separate groundwater monitoring programs have been established for 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 Sections 8.4 and 8.5.

### 8.3 Referenced Standards

Two references used to develop the criteria for the groundwater monitoring program are: (1) the U.S. Environmental Protection Agency (EPA) *Quality Criteria for Water 1986* (Ref. 32), which is intended to protect public groundwater resources, and (2) the Missouri Drinking Water Standards (Ref. 33). 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

Table 8-1 Referenced Federal and State Water Standards

PARAMETER		LEVEL	REFERENCE STANDARD
Radiochemical	Uranium, total	30 pCi/l	Groundwater Standards for Remedial Actions at Inactive Uranium Processing Sites – 40 CFR 192
	Gross Alpha	15 pCi/l	MDWS - Primary Maximum Contaminant Level
	Radium <sup>(a)</sup>	5 pCi/l	MDWS - Primary Maximum Contaminant Level
Misc.	2,4-DNT	0.11 µg/l	MDNR - Water Quality Standard for Groundwater
	TCE	5 µg/l	MDNR - Water Quality Standard for Groundwater
Metals	As	50 µg/l	MDWS - Primary Maximum Contaminant Level
	Ba	2 mg/l	MDWS - Primary Maximum Contaminant Level
Anions	NO <sub>3</sub>	10 mg/l	MDWS - Primary Maximum Contaminant Level
	SO <sub>4</sub>	250 mg/l	MDWS - Secondary Maximum Contaminant Level

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

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

(1) THICKNESS DATA SOURCES VARY. QUATERNARY UNIT THICKNESS BASED ON ON-SITE DRILLING AND TRENCHING. BURLINGTON AND KEOKUK THROUGH JOACHIM DOLOMITE BASED ON USGS WELLS MW-G502 AND G505. ST. PETER SANDSTONE AND BELOW FROM KLEESCHULTE AND EMWELL (REF 54). WARSAW AND SALEM FORMATIONS FROM MISSOURI DNR-DGLS GEOLOGIC MAP OFM-89-252-G1 (REF 53).

(2) GLACIAL DRIFT UNIT SATURATED IN NORTHERN PORTION OF ORONANCE 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. DOE/OR/21548-886	EXHIBIT NO. A/PI/047/0391
ORIGINATOR MET	DATE 3/21/01
DRAWN BY SRS	

references by the WSSRAP since the affected groundwater aquifer underlying the site is not a public drinking water source as defined in 40 CFR, Part 141, Subpart A - General.

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-226	100 pCi/l
Ra-228	100 pCi/l
Th-230	300 pCi/l
Th-232	50 pCi/l

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

## 8.4 Weldon Spring Chemical Plant

### 8.4.1 Hydrogeologic Description

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

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

The chemical plant and raffinate 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.

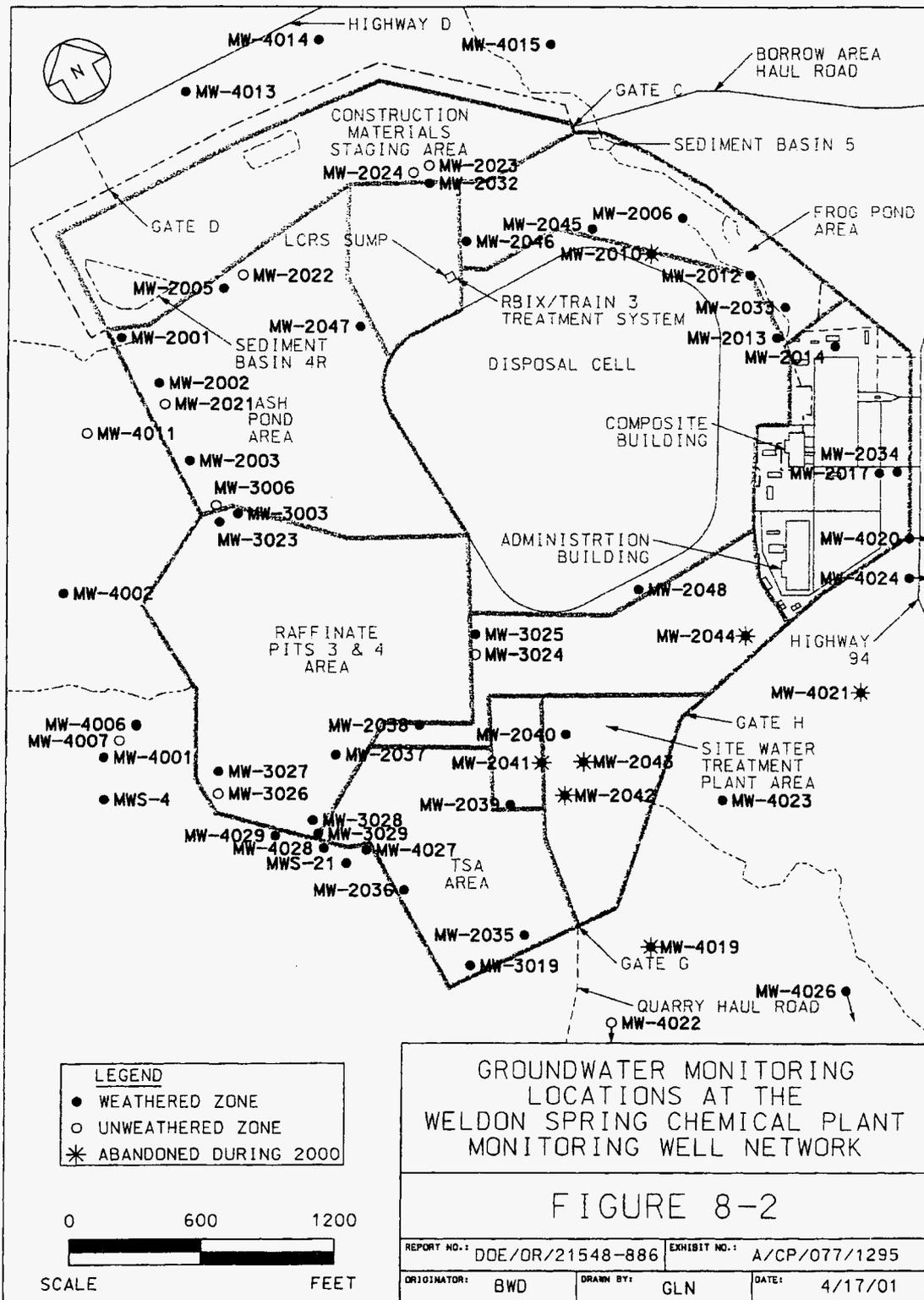
More than 100 monitoring wells have been used for groundwater observations and sampling since 1987. Many of these have been deactivated and abandoned. In 2000, seven wells were abandoned, and active monitoring was performed in 46.

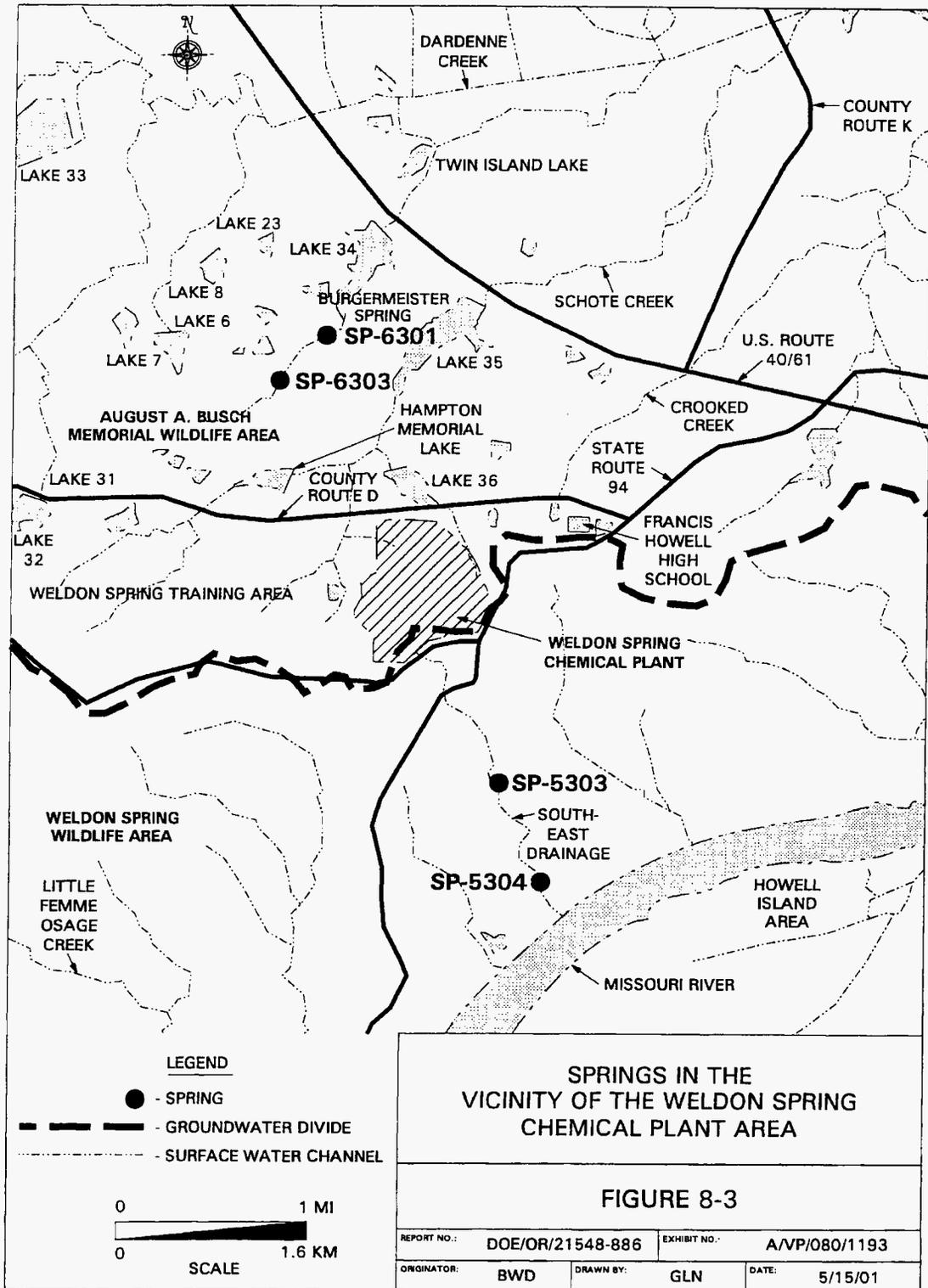
All monitoring wells are completed in the Burlington-Keokuk Limestone. Some wells that are screened in the unweathered zone of the Burlington-Keokuk Limestone are used to assess the vertical migration of contaminants. Most of the wells are completed in the weathered unit of the bedrock where groundwater has the greatest potential to be contaminated. Where possible, monitoring wells within the boundaries of the chemical plant area are located near potential contaminant sources to assess migration into the groundwater system. Additional wells are located outside the chemical plant boundary to detect and evaluate potential off-site migration of contaminants (Figure 8-2).

Upgradient-downgradient water quality comparisons are not practical for the chemical plant site because it straddles the regional groundwater divide. Background values developed by the U.S. Geological Survey (USGS) for uranium and sulfate in the shallow aquifer have previously been used as reference levels in lieu of these comparisons (Ref. 34). In this year's report, the site-specific background levels established in the Groundwater Operable Unit (GWOU) Remedial Investigation are used instead (Ref. 50).

Springs, a common feature in carbonate terrains, are present in the vicinity of the site. Four springs are monitored routinely as part of the EMP (Ref. 8). These springs, which are shown on Figure 8-3, have been historically influenced by chemical plant discharge water that contained one or more of the contaminants of concern.

The presence of elevated total uranium and nitrate levels at Burgermeister Spring (SP-6301), which is 1.9 km (1.2 mi) north of the site, indicates that discrete flow paths are present in the vicinity of the site. Groundwater tracer tests performed in 1995 (Ref. 50) indicated





that a discrete and rapid hydraulic connection exists between the northern portion of the chemical plant and Burgermeister Spring.

#### 8.4.2 Monitoring Program

The 2000 groundwater monitoring program at the chemical plant and raffinate pits area focused on monitoring known contaminants and determining any groundwater impacts which may have resulted from remedial action (e.g., soil excavation and sludge removal) at the site. A summary of monitoring locations and parameters may be found in the *Environmental Monitoring Plan* (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.

Total uranium, nitroaromatic compounds, VOCs, and nitrate were monitored at selected locations throughout the chemical plant area. The frequency and type of sampling performed at each location was based on recent concentrations of contaminants in the groundwater at each location and on the likelihood of nearby remedial activities causing mobilization of contaminants into the groundwater. Analytical results for all monitored parameters are summarized and discussed in Section 8.4.3.

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

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

Monitoring wells in the vicinity of Frog Pond, which began demonstrating elevated concentrations of nitroaromatic compounds in 1999, were sampled quarterly in 2000. In addition, three new wells were installed at the end of 2000 to further define the extent of nitroaromatic contamination in this area. Data from the new wells will be available in the 2001 site environmental report.

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

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

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

### 8.4.3 Chemical Plant Monitoring Results

#### 8.4.3.1 Groundwater Monitoring Wells

Analytical data for contaminants monitored during 2000 (e.g., uranium, radiological parameters, nitrate, sulfate, volatile organic compounds, and nitroaromatics) are summarized and compared with background levels and water quality standards in the following paragraphs. Comparisons to drinking water standards are for reference purposes only, and are not intended to imply that groundwater from WSSRAP monitoring wells must be in compliance with drinking water standards. Average annual concentrations are compared to background levels established during the GWOU remedial investigation (Ref. 50).

Uranium. Total uranium, which is measured at all monitoring wells, continues to be present in the groundwater near the raffinate pits. In 2000, groundwater from seventeen monitoring well locations exceeded the average background level of 0.93 pCi/l (0.03 Bq/l) established during the GWOU remedial investigation (Ref. 50). Only one well exceeded the groundwater standard of 30 pCi/l (40 CFR 192). Average measured values exceeding background are shown in Table 8-3. A new historic high for uranium in MW-3024 was recorded during 2000 (64.7 pCi/l [2.39 Bq/l]), although subsequent samples have indicated lower concentrations.

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

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

\* Concentration exceeds the groundwater standard of 30 pCi/l.

Note 1: Background uranium concentration equals 0.93 pCi/l.

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

**Radiological Parameters.** The other radiological parameters (Ra-226, Ra-228, and isotopic thorium) that were measured in the raffinate pit wells were within historic values. The annual averages are presented in Table 8-4 for all wells where at least one parameter was present above the detection limit. No wells in the chemical plant area exceeded the EPA drinking water MCL of 5 pCi/l for Ra-226 and Ra-228 combined.

**Nitrate and Sulfate.** In 2000, nitrate was measured at 27 monitoring wells in the chemical plant area that previously exceeded the reference levels. Nitrate levels exceeded the Missouri drinking water primary MCL (10 mg/l) at 20 of those locations (see Table 8-5).

Sulfate was measured at 10 monitoring wells in the chemical plant area. Average sulfate levels exceeded background (12 mg/l) as determined during the GWOU remedial investigation (Ref. 50) at eight locations. (See Table 8-6.) No well indicated sulfate concentrations above the Minimum Drinking Water Secondary MCL (250 mg/l).

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

LOCATION	AVERAGE CONCENTRATION (pCi/l)				
	Ra-226	Ra-228	Th-228	Th-230	Th-232
MW-2037	<0.15	<0.79	<0.07	0.05	<0.03
MW-2038	<0.14	1.11	<0.08	0.10	<0.05
MW-2040	1.09	<0.93	0.27	0.42	0.17
MW-3003	0.27	<0.81	<0.09	<0.05	0.04
MW-3023	<0.17	<0.79	<0.08	0.11	0.02
MW-3024	0.57	<0.68	<0.09	0.10	<0.03
MW-3025	0.40	<0.81	<0.05	0.09	0.05
MW-3026	0.68	<1.20	0.10	0.11	<0.03
MW-3027	0.50	<0.89	<0.07	0.06	<0.03

< All samples less than the highest detection limit.

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

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

Note : Missouri Drinking Water Standards designate the primary maximum contaminant level as 10 mg/l.

- (a) This value contains a historic high of 563 mg/l. When this value is disregarded, the average concentration is 119 mg/l.
- (b) This value contains a historic high of 189 mg/l. When this value is disregarded, the average concentration is 361 mg/l.

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

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

Note : Background sulfate concentration equals 12 mg/l.

Nitroaromatic Compounds Nitroaromatic compounds, which are not naturally occurring, were detected in 25 monitoring wells (Table 8-7). New historic highs were reported during 2000 at several wells in the vicinity of Frog Pond, most notably at MW-2012. Levels of nitroaromatics have increased at this well since 1997, most likely as a result of remedial activities in this area. Three additional wells were installed in the vicinity of MW-2012 at the end of 2000 to further define the extent of contamination in this area.

Table 8-7 Annual Averages for Monitoring Locations with at Least One Detectable Concentration of a Nitroaromatic Compound ( $\mu\text{g/l}$ ) 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	0.07	<0.09	<0.03	0.05	0.05	<0.03
MW-2002	<0.03	<0.09	<0.03	0.05	0.32	<0.03
MW-2003	<0.03	<0.09	<0.03	0.15*	1.00	<0.03
MW-2005	0.13	0.08	<0.03	0.06	0.17	<0.03
MW-2006	4.75	<0.20	0.22	1.27*	2.17	<0.20
MW-2012	86.3	<2.0	180	598*	635	<2.0
MW-2013	4.60	<0.20	0.34	0.19*	1.84	<0.20
MW-2014	3.15	<0.20	<0.20	0.17*	0.81	<0.20
MW-2033	2.36	<0.20	0.33	0.19*	1.49	<0.20
MW-2037	<0.03	<0.09	<0.03	0.10	0.03	<0.03
MW-2038	0.07	<0.09	<0.03	0.40*	0.07	0.03
MW-3003	<0.03	<0.09	<0.03	0.14*	0.19	<0.03
MW-3023	<0.03	<0.09	<0.03	0.09	0.45	<0.03
MW-3025	<0.03	<0.09	<0.03	0.74*	0.09	<0.03
MW-3026	0.12	<0.09	<0.03	0.07	0.05	<0.03
MW-3027	0.09	<0.09	<0.03	0.04	0.05	<0.03

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

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-4001	46	<0.09	2.05	0.11*	1.75	0.02
MW-4006	13.5	<0.09	<0.03	0.11*	2.35	<0.03
MW-4011	<0.03	<0.09	<0.03	<0.03	0.04	<0.03
MW-4015	3.70	<0.09	<0.03	0.07	0.69	<0.03
MW-4027	0.04	<0.09	<0.03	0.08	0.02	<0.03
MW-4028	0.56	0.093	<0.03	0.16*	0.18	<0.03
MW-4029	0.93	0.16	0.073	0.17*	0.52	0.03
MW-S004	9.10	0.08	0.68	0.09	0.65	<0.03
MW-S021	0.09	<0.09	0.05	0.27*	0.09	<0.03

< All samples less than the highest detection limit.

\* Equals or exceeds the Missouri water quality standard of 0.11  $\mu\text{g/l}$ .

The Missouri drinking water quality standard for 2,4-DNT of 0.11  $\mu\text{g/l}$  was equaled or exceeded in 14 locations at the chemical plant (see Table 8-7). Elevated nitroaromatics in groundwater underlying the site are attributable to wastewater impoundments and production lines used in the production of TNT and DNT during the 1940s.

Volatile Organic Compounds. TCE monitoring continued through 2000 to monitor the extent of contamination and changes in concentration that may have resulted from remedial activities. The analytical results for all wells with detectable levels of TCE are summarized in Table 8-8. Six wells exceeded the Missouri water quality standard of 5  $\mu\text{g/l}$ . Many new wells have been installed in this area to further define the extent of contamination. Data from these wells will be used to support remediation of the VOC-contaminated groundwater, scheduled to begin in 2001.

Metals. One location (MW-4006) was monitored for metals (TCLP metals) as part of the environmental monitoring program. This well did not exceed Missouri drinking water primary MCLs for any metals and will not be monitored for metals in 2001.

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

Table 8-8 Annual Average TCE ( $\mu\text{g/l}$ ) Analytical Results

LOCATION	TCE	
	AVERAGE	(N)
MW-2037	625 <sup>(a)*</sup>	6
MW-2038	207 <sup>(b)*</sup>	6
MW-3024	2.0	5
MW-3025	4.7	5
MW-4001	5.5*	6
MW-4027	4.4	6
MW-4028	447*	6
MW-4029	647*	6
MW-S021	122*	6

(N) Sample population

\* Concentration exceeds the Missouri water quality standard of 5  $\mu\text{g/l}$ .

(a) This value includes a historic low of 66  $\mu\text{g/l}$ , which is 10 times lower than other data collected in 2000. When this value is disregarded, the average concentration is 736  $\mu\text{g/l}$ .

(b) This value includes a historic high of 960  $\mu\text{g/l}$ , which is 10 times higher than other data collected in 2000. When this value is disregarded, the average concentration is 55.8  $\mu\text{g/l}$ .

Select chemical plant locations were trended and are discussed in Section 8.4.4. Uranium, sulfate, and nitrate contamination continues to be concentrated in the area of the raffinate pits, with a small area of elevated uranium near the eastern boundary of the site. Discrete areas of nitroaromatic-contaminated groundwater continue to be present in the vicinity of Frog Pond, along the northern perimeter of the site, near Raffinate Pit 4, and west of the raffinate pits on the former Weldon Spring Ordnance Works property. The VOC contamination southeast of Raffinate Pit 4 remains under investigation.

#### 8.4.3.2 Springs

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

Uranium, nitrate, sulfate, and nitroaromatic data for Burgermeister Spring were all lower than data collected in 1999. Sampling results for these parameters are presented in Table 8-9. Nitroaromatic compounds were analyzed in samples from base stage flow only, and the compounds 2,4,6-TNT and 2,6-DNT were reported above detection limits. These results are presented in Table 8-9 also.

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 have impacted the local groundwater quality.

Table 8-9 2000 Monitoring Data for Burgermeister Spring

PARAMETER	HIGH FLOW				LOW (BASE) FLOW			
	MIN	MAX	AVG	(n)	MIN	MAX	AVG	(n)
Nitrate (mg/l)	5.19	7.3	6.25	2	0.82	13.8	7.40	6
Sulfate (mg/l)	24.2	26.3	25.25	2	22.6	48.6	33.78	6
U-Total (pCi/l)	1.02	20.2	13.17	3	14.1	81.1	47.74	7
2,4,6-TNT (µg/l)	NS	NS	NS	0	<0.03	0.05	0.01	4
2,6-DNT (µg/l)	NS	NS	NS	0	0.11	0.15	0.13	4

(n) Sample population  
 NS Not sampled.

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

#### 8.4.4 Trend Analysis

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

##### 8.4.4.1 Statistical Methods

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

program was also used in past analyses of 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, and 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. In other words, the absolute value of the TREND output statistic,  $Z$  was compared to the table  $Z_{.975}$  value of 1.96. If the absolute value of the  $Z$  output statistic was greater than 1.96, then a significant trend was reported.

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

One-half the specified quantitation limit (on the date of analysis) was used in the trend analysis for all data reported as below the detection limit. The purpose of using one-half the quantitation limit 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.

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

Graphs presenting the contaminant concentration versus time for each contaminant per trending location were developed. These graphs were used to identify suspect data outliers only for each trending analysis and are not presented in this report. No statistical tests were conducted for suspect outliers. Data that were suspect were flagged and rechecked for potential

data transcription errors. No obvious errors were identified. Outliers were included in the analysis since the TREND program corrects for these.

#### **8.4.4.2 Chemical Plant Trend Results**

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

##### Nitrate

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

Nitrate trends for 1997 through 2000 data were stationary at seven locations as shown in Table 8-10. Two of these locations, MW-2003 and MW-4029, were not previously trended for nitrate. The stationary trend was a change from the analyses using the 1995 through 1999 data where two locations, MW-2037 and MW-2038, previously indicated an upward trend, and MW-3024 previously indicated a downward trend.

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

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

Five of the 15 locations that were evaluated for the 1997 through 2000 period had concentrations in 2000 that exceeded all past 1997, 1998, and 1999 data for their respective sampling locations. The 2000 new high concentrations for these locations are in the far right column of Table 8-10.

### Trichloroethene

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

Trichloroethene trends for 1997 through 2000 data were stationary at one location and downward at the remaining five as shown in Table 8-11. The wells with the downward trends were MW-2037, MW-2038, MW-3025, MW-4028, and MW-S021. MW-4028 and MW-4029 were not previously trended for trichloroethene. The results of the recent analyses for the four other locations were the same as in the previous tests conducted using the 1995 through 1999 data.

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

Table 8-10 Chemical Plant Groundwater Wells Nitrate Trend Analysis Summary for 1997 to 2000

Well ID	Location	No. of Observations	No. of Non-Detect Data	Trend Direction (Alpha = 0.05)	Slope (mg/l/yr)	95% Upper & Lower Confidence Intervals on Slope (mg/l/yr)	2000 New High Concentration (mg/l)
MW2001	Weathered bedrock, west of Ash Pond	7	0	U	12.300	8.964, 18.383	115
MW2002	Weathered bedrock, west of Ash Pond	7	0	U	63.400	35.712, 81.884	252
MW2003	Weathered bedrock, west of Ash Pond	7	0	S	15.000	-24.706, 56.836	414
MW2037	Weathered bedrock, RAF	25	0	S	2.583	-6.509, 15.000	No
MW2038	Weathered bedrock, RAF	25	0	S	10.000	-40.115, 49.000	No
MW3003	Weathered bedrock, RAF	22	0	S	-1.167	-10.944, 5.000	No
MW3023	Weathered bedrock, RAF	22	0	S	5.667	-4.000, 15.000	No
MW3024	Weathered bedrock, RAF	16	0	S	-11.000	-28.015, 11.733	493
MW3025	Unweathered bedrock, RAF	19	0	D	-71.667	-86.465, -55.535	No
MW3026	Weathered bedrock, RAF	12	0	D	-8.000	-11.380, -4.000	No
MW3027	Unweathered bedrock, RAF	21	0	D	-6.825	-8.770, -4.600	No
MW4006 <sup>1</sup>	Weathered bedrock, west of chemical plant	17	0	D	-3.500	-4.576, -2.000	No
MW4011	Unweathered bedrock, west of chemical plant	8	0	D	-32.000	-89.457, -18.484	No
MW4028 <sup>2</sup>	Weathered bedrock, RAF	10	0	D	-63.000	-95.431, -18.853	No
MW4029 <sup>2</sup>	Weathered bedrock, RAF	5	0	S	-17.500	n too small, n too small	573

D = Downward    S = Stationary    U = Upward

<sup>1</sup>Data from 1998 are not available for well MW4006.

<sup>2</sup>Data from 1997 and 1998 are not available for wells MW4028 and MW4029.

Table 8-11 Chemical Plant Groundwater Wells Trichloroethene Trend Analysis Summary for 1997 to 2000

Well ID	Location	No. of Observations	No. of Non-Detect Data	Trend Direction (Alpha = 0.05)	Slope ( $\mu\text{g/l/yr}$ )	95% Upper & Lower Confidence Intervals on Slope ( $\mu\text{g/l/yr}$ )	2000 New High Concentration ( $\mu\text{g/l}$ )
MW2037	Weathered bedrock, RAF	30	0	D	-209.250	-261.608, -170.000	No
MW2038	Weathered bedrock, RAF	29	0	D	-205.833	-265.000, -155.090	No
MW3025	Unweathered bedrock, RAF	28	0	D	-12.310	-15.000, -10.772	No
MW4028 <sup>1</sup>	Weathered bedrock, RAF	12	0	D	-130.000	-205.092, -57.270	No
MW4029 <sup>2</sup>	Weathered bedrock, RAF	13	0	S	100.000	20.208, 150.000	No
MWS021	Weathered bedrock, RAF	30	0	D	-180.000	-231.262, -139.475	No

D = Downward

S = Stationary

<sup>1</sup>Data for 1997 and 1998 are not available for well MW4028.<sup>2</sup>Data for 1997 are not available for well MW4029.

### Nitroaromatic Compounds

Seven locations near the chemical plant were selected for trend analyses of nitroaromatic compounds. All seven of these locations are weathered bedrock wells. The results of these analyses are in Table 8-12. Each of these locations was trended for the following nitroaromatic compounds: 2,4-DNT, 2,6-dinitrotoluene (2,6-DNT), 2,4,6-trinitrotoluene (2,4,6-TNT), and 1,3,5-trinitrobenzene (1,3,5-TNB). A total of 26 trend analyses were performed on the nitroaromatic compounds at the seven groundwater monitoring well locations. Trending was not performed on 2,4,6-TNT at MW-2006 and MW-2014 because either none or only one detectable concentration was reported for the time period between 1997 and 2000.

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

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

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

As shown in Table 8-12, all four nitroaromatic compounds at MW-2006 and MW-2012 reported concentrations in 2000 that exceeded all past 1997, 1998, and 1999 data for their respective sampling locations. New highs were also observed at MW-2013, MW-2014, and MW-2033 for at least one of the four nitroaromatic compounds. The 2000 new high values for these locations are in the far right column of Table 8-12.

Table 8-12 Chemical Plant Groundwater Wells Nitroaromatics Trend Analysis Summary for 1997 to 2000

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

D = Downward      2,4-DNT      2,4-Dinitrotoluene  
S = Stationary    2,6-DNT      2,6-Dinitrotoluene

U = Upward      2,4,6-TNT      2,4,6-Trinitrotoluene  
                    1,3,5-TNB      1,3,5-Trinitrobenzene

(a) Either none or only one detectable concentration reported for time period; therefore, no trending performed.

## 8.5 Weldon Spring Quarry

### 8.5.1 Hydrogeologic Description

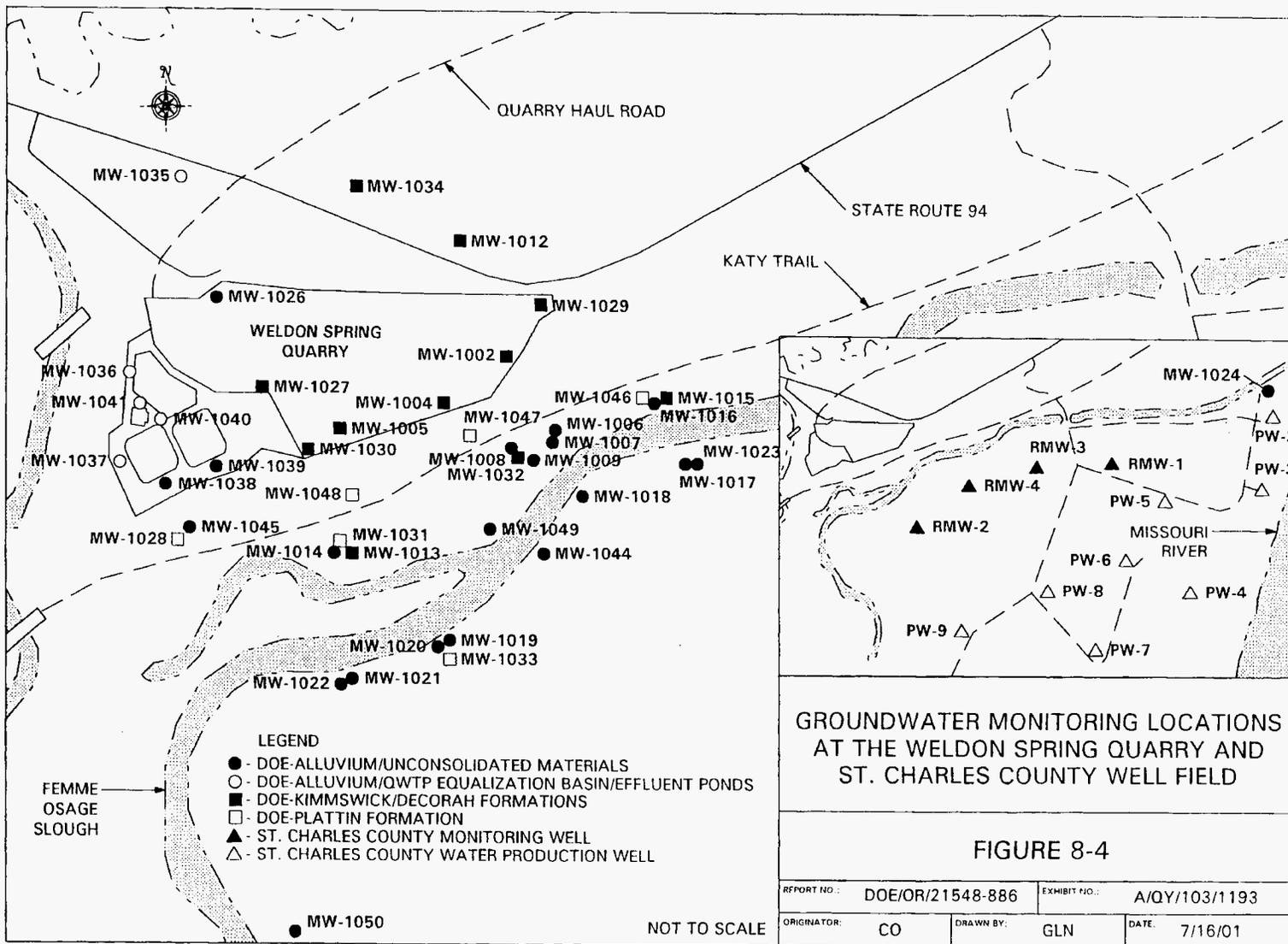
The geology of the quarry area is separated into three units; upland overburden, Missouri River alluvium, and bedrock. The unconsolidated upland material overlying bedrock consists of up to 9.2 m (30 ft) of silty clay soil and loess deposits and is not saturated (Ref. 1). Three Ordovician-age formations comprise the bedrock: 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 intermixed and interlayered clays, silts, and sands. Organic materials are intermixed throughout the sediments.

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). Eleven of the 17 monitoring wells were installed to monitor contaminants within the Kimmswick-Decorah Formations comprising and surrounding the quarry. The remaining six monitoring wells are located south of the quarry within the Plattin Limestone to assess vertical contaminant migration.

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

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 were utilized to study the upgradient characteristics of the Missouri River alluvium in the vicinity of the quarry. These wells provided



a reference for background values in the well field area and have been sampled by both the USGS (1992) and the DOE (1994). These wells have since been abandoned.

A summary of background values used at the quarry is provided in Table 8-13 (Ref. 51).

### 8.5.2 Monitoring Program

Three separate monitoring programs were employed in 2000. 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. These activities began in mid-1993 and were completed in late-1995.

The frequency of sampling for each location was based on the distance of the well from the source or migration pathway. Monitoring wells on the quarry rim were sampled quarterly for total uranium, 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, nitroaromatic compounds, and sulfate.

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

Table 8-13 Average Background Values (pCi/l) for Quarry Monitoring Locations

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

(a) Darst Bottom Wells (USGS and DOE)

(b) MW-1034 and MW-1043 (DOE)

(c) MW-1042 (DOE)

NA Not analyzed

The third program monitors the equalization basin at the quarry water treatment plant (Section 8.6). Monitoring wells MW-1035 through MW-1037, MW-1040, and MW-1041 were sampled quarterly and annually for selected parameters. The monitoring program was initially developed to meet the substantive requirements of 40 CFR Part 264, Subpart F, and 10 CSR Part 25.7, which require monitoring of contaminants of concern in groundwater beneath storage facilities. The contaminants of concern were derived from *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 35) and *Baseline Risk Evaluation for Exposure to Bulk Waste at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 36).

### 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, and isotopic thorium. 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. The 2000 annual averages for the locations that exceed background are summarized in Table 8-14.

Table 8-14 Annual Averages for Total Uranium (pCi/l) Above Background at the Weldon Spring Quarry

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

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

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

Ra-226, Ra-228, and isotopic thorium (Th-228, Th-230, and Th-232) were analyzed at all groundwater monitoring locations at the quarry. The 2000 annual averages for the locations that exceeded background are summarized in Table 8-15. Only 10 locations during 2000 had values exceeding background compared with 20 identified during 1999.

Table 8-15 Annual Averages for Isotopic Radionuclides (pCi/l) Above Average Background at the Weldon Spring Quarry

LOCATION	Ra-226	(n)	Ra-228	(n)	Th-228	(n)	Th-230	(n)	Th-232	(n)
MW-1002	-	-	-	-	-	-	1.11	1	-	-
MW-1004	-	-	-	-	-	-	-	-	0.59	1
MW-1013	0.75	1	-	-	-	-	-	-	-	-
MW-1017	1.25	2	-	-	0.46	2	-	-	-	-
MW-1023	2.25	1	-	-	1.49	1	-	-	1.07	1
MW-1027	-	-	2.26	1	-	-	-	-	-	-
MW-1030	0.69	1	-	-	0.64	1	-	-	0.61	1
MW-1032	-	-	1.1	1	-	-	-	-	-	-
MW-1038	1.56	1	-	-	0.37	1	-	-	-	-
MW-1044	-	-	-	-	-	-	-	-	0.29	1

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

(n) Sample population.

- Did not exceed average background.

Background values are presented in Table 8-13.

Nitroaromatic Compounds. In 2000, samples from quarry monitoring wells were analyzed for nitroaromatic compounds. The monitoring wells, which have historically been impacted with nitroaromatics, are situated in the alluvial materials or bedrock downgradient of the quarry and north of the Femme Osage Slough. Results were similar to those reported in 1999. No detectable concentrations were observed south of the Femme Osage Slough. A summary of the annual averages for all locations where at least one nitroaromatic compound was measured above the detection limit is provided in Table 8-16. One location, MW-1027, had average concentration which exceeded the Missouri drinking water standard of 0.11 µg/l for 2,4-DNT during 2000.

Table 8-16 Annual Averages for Monitoring Locations with at Least One Detectable Concentration of a Nitroaromatic Compound ( $\mu\text{g/l}$ ) at the Weldon Spring Quarry

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

< All samples less than highest detection limit.

(n) Sample population.

\* Exceeds the Missouri Water Quality Standard of 0.11  $\mu\text{g/l}$ .

**Sulfate.** Groundwater analyses in 2000 continued to indicate elevated sulfate levels in the monitoring wells in the bedrock of the quarry rim and in the alluvial materials north of the Femme Osage Slough. Those wells with annual averages above background are summarized in Table 8-17. One location, MW-1005, had an annual average which exceeded the secondary MCL of 250 mg/l in 2000. Overall only 11 monitoring wells had averages above background, which is less than the 16 monitoring wells from 1999.

Table 8-17 Annual Averages for Sulfate (mg/l) Above Background at the Weldon Spring Quarry

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

\* Exceeds secondary MCL of 250 mg/l.

(n) Sample population

### 8.5.3.2 St. Charles County Well Field

Radiochemical Parameters. The St. Charles County production wells, the RMW-series monitoring wells, and DOE well MW-1024, were sampled semiannually during 2000 for the radiochemical parameters Ra-226, Ra-228, and isotopic thorium. Gross alpha, gross beta, and total uranium were analyzed quarterly. A summary of the radiochemical annual averages is provided in Table 8-18. The annual averages for total uranium in the well field remain at background. No production well exceeded the groundwater standard of 30 pCi/l as established in 40 CFR 192.

The St. Charles County production wells, the RMW-series wells, and pretreated (MW-RAWW) and treated water (MW-FINW) from the St. Charles County water treatment plant were sampled quarterly for gross alpha and gross beta. The annual averages for these locations are within the statistical variation of background ranges for groundwater in the Missouri River alluvium. The Missouri Drinking Water Standard of 15 pCi/l (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 six nitroaromatic compounds. No detectable concentrations were observed at any of these locations.

Table 8-18 Summary of Annual Averages of Radiochemical Parameters (pCi/l) for the St. Charles County Well Field

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

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

(n) Sample population.

< All samples less than highest detection limit.

**Sulfate.** The St. Charles County production wells were sampled semiannually and the RMW-series monitoring wells were sampled quarterly for sulfate. The 2000 annual averages for the well field are summarized in Table 8-19. The secondary MCL for sulfate of 250 mg/l was not exceeded at any location in the well field.

**Metals.** Arsenic and barium were monitored during 2000 at the St. Charles County well field. The primary MCL for arsenic (50 µg/l) was exceeded at locations RMW-2 and RMW-4. The MCL for barium (2,000 µg/l) was not exceeded at any location. None of the values for either metal exceeded their respective MCLs in samples from the public water supply wells or from the St. Charles County water treatment plant (see Table 8-19). The 2000 results were similar to those reported for 1999.

### 8.5.4 Trend Analysis

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

The computer program, TREND, which is described in detail in Section 8.4.4, was used for this trend testing. The method employed was the nonparametric Mann-Kendall test.

#### 8.5.4.1 Quarry Trend Results

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

Table 8-19 Annual Averages for Sulfate (mg/l), Arsenic ( $\mu\text{g/l}$ ), and Barium ( $\mu\text{g/l}$ ) in the St. Charles County Well Field

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

(n) Sample population.

&lt; All samples less than highest detection limit.

### Total Uranium

Sixteen locations near the quarry were selected for total uranium trend analyses. Of these, 10 were bedrock wells and six were alluvial wells. Total uranium trends for 1997-2000 data were stationary except for two locations as shown in Table 8-20.

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

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

Table 8-20 Quarry Groundwater Wells Uranium Trend Analysis Summary for 1997 to 2000

Well ID	Location	No. of Observations	No. of Non-Detect Data	Trend Direction (Alpha = 0.05)	Slope (pCi/l/yr)	95% Upper & Lower Confidence Intervals on Slope (pCi/l/yr)	2000 New High Concentration (pCi/l)
MW1002	Bedrock – east rim	7	0	S	-0.020	-5.686, 0.611	No
MW1004	Bedrock – rim	7	0	D	-246.667	-330.000, -99.186	No
MW1006	Alluvium – north of slough	7	0	S	-497.000	-1038.458, 222.953	No
MW1007	Alluvium - north of slough	7	0	S	34.500	-12.215, 91.507	No
MW1008	Alluvium – north of slough	6	0	S	-130.000	-809.282, 291.489	No
MW1009	Alluvium - north of slough	6	0	S	-0.330	-4.260, 5.297	No
MW1013	Bedrock – north of slough	5	0	S	-56.000	-251.744, 7.200	No
MW1014	Alluvium - north of slough	6	0	S	-96.000	-222.703, 20.064	No
MW1015	Bedrock – north of slough	6	0	S	-18.500	-56.441, 33.694	No
MW1016	Alluvium - north of slough	6	0	D	-34.000	-43.187, -24.145	No
MW1027	Bedrock – west of quarry	6	0	S	68.000	-18.577, 192.150	No
MW1030	Bedrock – south rim	6	0	S	-2.700	-5.258, 0.018	No
MW1031	Bedrock - north of slough	6	0	S	-28.100	-63.885, 27.590	No
MW1032	Bedrock – north of slough	6	0	S	-30.000	-600.648, 634.793	No
MW1036	Bedrock – north of slough	16	0	S	0.823	-0.329, 2.242	No
MW1048 <sup>1</sup>	Bedrock – north of slough	4	0	S	-82.500	n to small, -6.901	No

D = Downward

S = Stationary

U = Upward

<sup>1</sup>Data from 1997 are not available for well MW1048.

Table 8-21 Quarry Groundwater Wells Nitroaromatic Trend Analysis Summary for 1997 to 2000

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

D = Downward  
S = Stationary

2,4-DNT

2,4-Dinitrotoluene

## Nitroaromatic Compounds

Four locations near the quarry were selected for trend analyses of 2,4-DNT. Of these locations, three were bedrock wells and one was an alluvial well. The results of the 2,4-DNT analyses are presented in Table 8-21. Based on the results of the analyses, no upward trends were identified in groundwater from the bedrock wells or the alluvial well that were analyzed from the 1997 to 2000 period. The most recent analyses of MW-1004 indicated a change from a downward to a stationary trend. The most recent analyses of MW-1006 indicated a change from a stationary to a downward trend. MW-1027 was not included in last year's scope of work; therefore, no comparison can be made.

As shown in Table 8-21, one of the four locations that were evaluated for the 1997 through 2000 period reported concentrations in 2000 that exceeded all past 1997, 1998, and 1999 data for the specific sampling location. This concentration was 0.14  $\mu\text{g/l}$  at MW-1004. Consistent with last years trending, all trends were downward or stationary.

## **8.6 Waste Treatment Facilities**

### **8.6.1 Monitoring Program**

Groundwater monitoring wells were used to monitor three waste management units during 2000: the temporary storage area, the quarry water treatment plant, and the disposal cell (see Figures 8-2 and 8-4). These wells were installed to detect contaminants in the uppermost water units beneath these facilities in order to meet the substantive requirements of 40 CFR 264, Subpart F, and 10 CSR 264, Subpart F. The monitoring parameters were derived from previous evaluations performed and documented in *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 35), *Baseline Risk Evaluation for Exposure to Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 36), and *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (Ref. 37).

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

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

and annual sampling for the following parameters:

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

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

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

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

### **8.6.2 Temporary Storage Area Monitoring Results**

Collection of baseline data for the wells surrounding the temporary storage area (TSA) was completed in December 1994. The baseline dataset for each well was established with a minimum of eight samples collected on a quarterly basis. A summary of baseline data for wells MW-2035 through MW-2039 may be found in Table 8-22. Monitoring data collected during 2000 were compared to the baseline values to identify significant changes in groundwater quality potentially attributable to operation of these facilities.

Once the TSA was removed and subsequent confirmation that the underlying soil met cleanup criteria, detection monitoring of these wells was discontinued in June 2000 in accordance with the *RCRA Closure Document* (Ref. 7). Annual average concentrations based on data collected during the first two quarters of 2000 are listed in Table 8-23. The only exceedance of baseline at the TSA was barium in MW-2039 during the first quarter of 2000. The reported concentration, however, was well below the EPA MCL of 2,000 µg/l.

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

A summary of baseline data for these wells is in Table 8-24. Annual average concentrations are in Table 8-25. Monitoring data collected during 2000 were compared to the baseline values to identify significant changes in groundwater quality potentially attributable to operation of these facilities. All metals, PAHs, PCBs, and pesticides were below baseline. Exceedances of baseline were as follows:

- Anions exceeded baseline at each well, including the upgradient well, during all four quarters.
- Total uranium exceeded baseline during two quarters at MW-1036.
- Radium-226 exceeded baseline during one quarter at MW-1036.
- Thorium-230 and 232 exceeded baseline during one quarter at MW-1037.

While ions were elevated above baseline concentrations, these values are not believed to be attributable to operation of the waste facility as they are similar to past results. Ion values are similarly increasing at the upgradient monitoring location. The Radium-226 and Thorium-230/232 exceedances were each slightly above baseline (less than 0.05 pCi/l over baseline in all three cases) and within two times background for the quarry area (Ref. 51).

Table 8-22 Baseline for the Detection Monitoring System at the Temporary Storage Area

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

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

(a) Value represents the detection limit.

Table 8-23 Summary of the 2000 Detection Monitoring Data for the Weldon Spring Site Temporary Storage Area Groundwater Wells

PARAMETER	MW-2035		MW-2036		MW-2037		MW-2038		MW-2039	
	AVERAGE	(n)								
Arsenic ( $\mu\text{g/l}$ )	<2.20	2	<2.20	2	<2.20	2	<2.20	2	2.30	1
Barium ( $\mu\text{g/l}$ )	101.20	2	269.5	2	96.55	2	380	2	538	1
Cadmium ( $\mu\text{g/l}$ )	<0.80	2	<0.80	2	<0.80	2	<0.80	2	<0.23	1
Chromium ( $\mu\text{g/l}$ )	2.65	2	1.90	2	<1.10	2	<1.10	2	8.90	1
Lead ( $\mu\text{g/l}$ )	<2.80	2	<2.80	2	<2.80	2	<2.80	2	<1.10	1
Mercury ( $\mu\text{g/l}$ )	<0.10	2	<0.10	2	<0.10	2	<0.10	2	<0.04	1
Selenium ( $\mu\text{g/l}$ )	1.30	2	1.50	2	1.65	2	12.25	2	5.80	1
Silver ( $\mu\text{g/l}$ )	<1.00	2	<1.00	2	0.95	2	0.80	2	<1.10	1
Total Uranium (pCi/L)	<0.68	2	<0.68	2	0.98	2	1.74	2	3.31	1
Nitrate (mg/l)	0.61	2	1.33	2	279	2	877	2	74.6	1
Sulfate (mg/l)	1.95	2	3.85	2	87.6	2	34.4	2	25.0	1
1,3,5-TNB ( $\mu\text{g/l}$ )	<0.03	2	<0.03	2	<0.03	2	0.07	2	<0.03	1
2,4,6-TNT ( $\mu\text{g/l}$ )	<0.03	2	<0.03	2	<0.03	2	<0.03	2	<0.03	1
2,4-DNT ( $\mu\text{g/l}$ )	<0.03	2	<0.03	2	0.20	2	0.52	2	<0.03	1
2,6-DNT ( $\mu\text{g/l}$ )	<0.01	2	<0.01	2	0.05	2	0.09	2	<0.01	1

NOTE: 1 pCi/l = 0.037 Bq/l

(n) Sample population.

&lt; All samples less than highest detection limit.

Table 8-24 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)	0.28	0.18	0.71	0.12	0.26
Nitrate (mg/l)	0.37	0.32	0.82	0.28	0.32
Sulfate (mg/l)	70.0	82.0	55.5	186	52.8
Arsenic ( $\mu\text{g/l}$ )	6.09	4.71	5.50	9.83	6.64
Barium ( $\mu\text{g/l}$ )	315	351	752	330	553
Cadmium ( $\mu\text{g/l}$ )	3.18	3.61	3.44	3.96	3.67
Chromium ( $\mu\text{g/l}$ )	4.81	7.57	7.57	19.6	15.5
Lead ( $\mu\text{g/l}$ )	1.59	2.06	2.06	2.72	5.84
Mercury ( $\mu\text{g/l}$ )	0.18	0.20	0.17	0.42	0.58
Selenium ( $\mu\text{g/l}$ )	7.81	3.63	5.09	5.63	5.28
Silver ( $\mu\text{g/l}$ )	4.99	4.78	4.78	5.69	8.45

(a) No data available for determination of baseline.

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

Table 8-25 Summary of the 2000 Detection Monitoring Data for the Weldon Spring Quarry Water Treatment Plant

PARAMETER	MW-1035		MW-1036		MW-1037		MW-1040		MW-1041	
	AVERAGE	(n)								
Uranium, Total (pCi/l)	0.41	4	9.09	4	1.00	4	3.98	4	5.47	4
U-234 (pCi/l)	0.24	1	3.27	1	0.70	1	3.34	2	3.58	1
U-235 (pCi/l)	0.05	1	0.15	1	0.02	1	0.24	2	0.13	1
U-238 (pCi/l)	0.16	1	2.80	1	0.38	1	2.89	2	2.85	1
Ra-226 (pCi/l)	0.26	1	0.29	1	<0.14	1	0.37	1	0.38	1
Ra-228 (pCi/l)	0.31	1	0.19	1	0.87	1	<0.83	1	0.43	1
Th-230 (pCi/l)	0.11	1	0.06	1	0.50	1	0.03	1	0.04	1
Th-232 (pCi/l)	0.075	1	0.016	1	0.44	1	<0.02	1	0.01	1
Chloride (mg/l)	30	4	102	4	4.06	4	17.03	1	10.15	4
Fluoride (mg/l)	0.23	4	0.25	4	0.46	4	0.19	4	0.14	4
Nitrate (mg/l)	0.20	4	0.18	4	0.49	4	0.08	4	0.07	4
Sulfate (mg/l)	59	4	81	4	342	4	139	4	61	4
Arsenic (µg/l)	<2.20	4	1.24	4	1.56	4	1.64	4	<2.20	4
Barium (µg/l)	254	4	223	4	44	4	197	4	405	4
Cadmium (µg/l)	<0.80	4	<0.80	4	<0.80	4	<0.80	4	<0.80	4
Chromium (µg/l)	<4.80	4	<2.00	4	<3.50	4	<1.10	4	<1.10	4
Lead (µg/l)	<2.80	4	<2.80	4	<2.80	4	<2.80	4	<2.80	4
Mercury (µg/l)	<0.10	4	<0.10	4	<0.10	4	<0.10	4	<0.10	4
Selenium (µg/l)	<2.40	4	1.51	4	<2.40	4	<2.40	4	<2.40	4
Silver (µg/l)	0.98	4	<1.40	4	1.03	4	1.41	4	<1.40	4

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

(n) Sample population.

< All samples less than highest detection limit.

The detection monitoring program for the quarry water treatment plant facility was discontinued in December 2000 following remediation. The equalization basin was confirmed during November 2000 and all results were less than the cleanup criteria. Once confirmation was complete, the requirements for a detection monitoring program were no longer applicable as outlined in the *RCRA Closure Document* (Ref. 7). Evaluation of historical analytical data from these wells shows no discernible impact on groundwater quality due to the quarry water treatment plant. The evaluation involved comparison of the data to respective monitoring well baselines, to background values for the quarry alluvium north of the Femme Osage Slough (presented in the report on Quarry Residuals Operable Unit remedial investigation [Ref. 51]), and to the process water data.

#### **8.6.4 Disposal Cell Groundwater Monitoring**

In the *Record of Decision for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 9), substantive requirements of Federal and State hazardous and/or solid waste regulations are identified as applicable or relevant and appropriate requirements (ARARs) for the selected remedy. 40 CFR 264, Subpart F, 10 CSR 25-7.264(2)(F), and 10 CSR 80-3.010(8) are identified as relevant and appropriate requirements for the disposal cell.

Groundwater monitoring requirements under the *Resource Conservation and Recovery Act* (RCRA) (40 CFR 264) specify that a monitoring system must consist of a sufficient number of wells installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that represent the quality of background water and provide detection of contamination. No set number of wells is required under the RCRA, but the Missouri Sanitary Landfill regulations (10 CSR 80.3) specify a minimum of one upgradient and three downgradient wells.

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

##### **8.6.4.1 Baseline Conditions**

Prior to waste placement, the disposal cell monitoring wells and SP-6301 were sampled on a quarterly basis for 1 year in order to establish baseline water quality conditions. A comprehensive list of parameters was analyzed at this time. Baseline conditions for each location

were determined by generating an upper bound value for each parameter based on a 95% tolerance interval calculated for each data set.

The *Disposal Cell Groundwater Monitoring Plan* (Ref. 37) indicates that the analysis of variance (ANOVA) procedure was the preferred method for data comparisons between the upgradient well and the compliance wells. However, subsequent monitoring data results have shown that, due to the presence of preexisting groundwater contamination, such inter-well comparisons cannot provide conclusive results. Instead, an intra-well comparison of baseline conditions with detection monitoring results is performed using the tolerance interval approach. This method is an accepted alternative procedure, as discussed in the *Groundwater Monitoring Plan* (Ref. 37) and recommended in the *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance* (Ref. 38).

Table 8-26 presents the baseline values for each monitoring well in the cell well network and SP-6301. No baseline values are presented for volatiles, PCBs, PAHs, and nitrobenzene, as these parameters were not detected during baseline sampling. The baseline values in Table 8-26 represent a revision to baseline values used in previous years, based on a re-interpretation of the applicable guidance (Ref. 38).

#### 8.6.4.2 Monitoring Results

The detection monitoring program for the cell well network provides for semi-annual sampling at each location. The 2000 monitoring results are presented in Tables 8-27 and 8-28. Results are reported for all parameters that exceeded the detection limit in at least one location.

Results of the first semi-annual sampling event, as shown in Table 8-27, indicated that the following parameters exceeded baseline:

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

Results of the second semi-annual sampling event, as shown in Table 8-28, indicated the following parameters exceeded baseline:

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

It is believed that these above-baseline data are a result of natural variations in the existing groundwater contamination underlying the site. Evaluation of the disposal cell leachate water quality and volume confirm that the elevated groundwater data are not the result of adverse

impacts from the disposal cell. A demonstration report was prepared in November 2000 to identify the contributing factors to recurring above-baseline conditions. The report discusses results of resampling the wells, evaluation of historical site-wide water quality, analysis of disposal cell leachate data and flow rates, and review of cell well hydraulic performance (Ref. 10).

Table 8-26 Baseline Values for the Disposal Cell Compliance Wells

PARAMETER	MW-2032	MW-2045	MW-2046	MW-2047	MW-2048	SP-6301
Chloride (mg/l)	30.55	87.26	19.66	13.10	16.09	29.21
Fluoride (mg/l)	1.64	0.25	0.26	1.28	0.49	0.57
Nitrate (mg/l)	163.32	3.04	3.64	150.42	2.11	35.28
Sulfate (mg/l)	91.53	69.43	71.56	52.98	270.88	121.35
Aluminum (µg/l)	3546.22	342.84	472.97	858.76	129.15	1,711.84
Antimony (µg/l)	9.93	15.59	28.07	27.20	13.47	13.57
Arsenic (µg/l)	4.74	3.80	4.45	4.59	3.80	3.90
Barium (µg/l)	547.66	304.62	319.96	501.17	59.20	280.61
Chromium (µg/l)	11.91	61.34	9.56	12.54	2.38	10.96
Cobalt (µg/l)	2.79	14.14	2.71	2.46	2.73	13.12
Copper (µg/l)	28.89	42.22	18.01	48.56	10.34	8.64
Lead (µg/l)	15.70	1.78	4.27	4.43	2.02	4.27
Lithium (µg/l)	25.13	35.31	17.43	87.30	14.56	44.41
Magnesium (µg/l)	68,895	60,867	66,642	94,431	47,493	54,057
Molybdenum (µg/l)	7.05	10.75	7.65	23.06	8.13	8.49
Nickel (µg/l)	22.62	1161.79	22.10	56.41	3.33	19.40
Selenium (µg/l)	9.57	5.12	5.08	8.64	17.74	5.91
Silver (µg/l)	17.73	3.77	6.12	5.41	4.87	2.75
Vanadium (µg/l)	8.29	7.97	13.69	13.09	2.73	20.78
Zinc (µg/l)	61.07	30.24	45.86	40.25	53.49	53.03
C.O.D. (mg/l)	3.94	8.44	8.45	5.74	10.54	29.84
Cyanide (µg/l)	138.71	4.73	3.94	5.70	5.53	4.88
T.D.S (µg/l)	1,262	568	637	1,051	913	552
T.O.X (µg/l)	0.07	0.07	0.05	0.06	0.82	0.04
T.O.C.(mg/l)	49.55	56.35	109.75	102.94	57.51	46.32
1,3,5-TNB (µg/l)	7.80	0.03	4.74	<DL	<DL	0.156
1,3-DNB (µg/l)	1.18	0.18	0.75	0.075	<DL	0.10
2,4,6-TNT (µg/l)	12.94	<DL	3.93	<DL	<DL	0.357
2,4-DNT (µg/l)	1.04	0.18	1.12	0.56	<DL	0.151
2,6-DNT (µg/l)	7.08	1.12	129.23	1.25	<DL	0.508
Radium-226 (pCi/l)	1.02	1.03	0.45	0.70	1.11	0.50
Radium-228 (pCi/l)	3.62	2.79	4.11	2.12	7.20	6.17
Thorium-228 (pCi/l)	0.38	0.87	0.21	0.27	0.22	1.13
Thorium-230 (pCi/l)	0.35	0.91	0.29	0.68	0.60	1.74
Thorium-232 (pCi/l)	0.15	0.36	0.19	0.19	0.22	0.74
Uranium, Total (pCi/l)	6.56	1.76	2.13	1.69	2.39	203.73
pH (Std. Units)	7.81	7.46	7.33	7.80	7.36	7.12
Specific Conductance (umhos/cm)	2,021	1,114	1,061	1,545	1,122	543

Table 8-27 Summary of Detection Monitoring Data for Cell Well Network (June 2000)

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

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

<DL Average concentration was less than highest detection limit.

Table 8-28 Summary of Detection Monitoring Data for Cell Well Network (December 2000)

PARAMETER	CONCENTRATION					
	MW-2032	MW-2045	MW-2046	MW-2047	MW-2048	SP-6301
Chloride (mg/l)	2.8	97.4	14.2	7.3	6.7	11.7
Fluoride (mg/l)	0.21	0.13	0.14	0.15	0.26	0.21
Nitrate-N (mg/l)	5.02	1.72	4.05	82.4	14.2	6.6
Sulfate (mg/l)	19.2	40	42.9	25.8	286	26.2
Aluminum (µg/l)	<DL	134	62.5	<DL	<DL	529
Barium (µg/l)	191	194	213	452	42.1	122
Chromium (µg/l)	4.9	108	2	3.9	2.8	<DL
Cobalt (µg/l)	<DL	3.1	<DL	<DL	<DL	<DL
Cyanide, total (µg/l)	<DL	<DL	5.1	30.6	280	<DL
Lead (µg/l)	<DL	<DL	6.0	<DL	<DL	<DL
Lithium (µg/l)	<DL	<DL	<DL	40.3	<DL	NS
Magnesium (µg/l)	34,400	48,200	35,600	92,600	55,100	13,500
Molybdenum (µg/l)	1.5	29.3	<DL	1.9	1.6	NS
Nickel (µg/l)	9.4	743	13.6	7.1	<DL	NS
Selenium (µg/l)	<DL	<DL	<DL	5.5	16.5	<DL
Silver (µg/l)	1.2	<DL	<DL	<DL	1.1	<DL
Zinc (µg/l)	<DL	<DL	22.2	<DL	<DL	<DL
Chemical Oxygen Demand (mg/l)	<DL	<DL	<DL	<DL	<DL	24
Total Dissolved Solids (mg/l)	270	428	500	672	726	335
Total Organic Carbon (mg/l)	<DL	<DL	1.0	<DL	1.2	1.6
TOX (mg/l)	<DL	0.012	0.01	<DL	0.006	<DL
1,3,5-Trinitrobenzene (µg/l)	<DL	<DL	2.3	<DL	<DL	<DL
1,3-Dinitrobenzene (µg/l)	<DL	0.16	<DL	<DL	<DL	<DL
2,4,6-Trinitrotoluene (µg/l)	<DL	<DL	1.7	<DL	<DL	0.5
2,4-Dinitrotoluene (µg/l)	<DL	0.081	0.17	0.21	<DL	<DL
2,6-Dinitrotoluene (µg/l)	<DL	0.62	1.00	0.38	<DL	0.15
Thorium-228 (pCi/l)	<DL	0.03	<DL	<DL	<DL	0.42
Thorium-230 (pCi/l)	0.125	0.10	0.11	0.17	0.27	0.09
Thorium-232 (pCi/l)	<DL	<DL	<DL	0.05	<DL	<DL
Uranium, Total (pCi/l)	1.94	<DL	<DL	1.32	1.7	31.4

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

NS Parameter was not sampled.

<DL Average concentration was less than highest detection limit.

## 9. BIOLOGICAL MONITORING PROGRAM

### 9.1 Biological Program Highlights

DOE Order 5400.1, 5400.5, and the *Regulatory Guide* (Ref. 24) have requirements for monitoring contaminant levels in terrestrial foodstuffs as well as in aquatic biota in the water column and sediments of affected surface waters. Past monitoring focused primarily on properties that received effluent from the site such as Busch Lakes 34, 35, and 36; Femme Osage Slough, and associated drainages.

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

### 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 by 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) required that sunfish samples from Busch Lake 35 to be collected if the average annual uranium concentration in the lake was found to be statistically higher than the average concentration found in previous years. Surface water samples collected in 1999 demonstrated that annual average uranium concentrations in the lake waters were no higher than in previous years; therefore, no fish samples were collected during 2000.

### 9.5 Terrestrial Monitoring

The *Environmental Monitoring Plan* (Ref. 8) stipulated that monitoring of terrestrial foodstuffs should be conducted only if annual average air monitoring results indicate above background concentrations of radionuclides at critical receptor sites. Since annual air monitoring results did not show above background air monitoring results at these sites during 1999, foodstuff sampling did not take place in 2000.

## 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 99.4% of the data selected for validation qualifying in 2000.

### 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. 39) establishes the quality assurance program for activities performed by the Project Management Contractor (PMC). The QAP requires compliance with the criteria of DOE Order 414.1A.

#### 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. 40). The EQAPjP outlines the appropriate requirements of U.S. Environmental Protection Agency (EPA) QA/R-5 (Ref. 41) 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 the EQAPjP is to specify the quality assurance requirements for environmental data operations of the WSSRAP. The document is also supported by standard operating procedures (SOPs), the *Sample Management Guide* (Ref. 42), the *Environmental Safety and Health Department Plan* (Ref. 43), 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* summarizes the data quality requirements for collecting and analyzing environmental data. The guide 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 guide 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 QAP (Ref. 39).

### **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 of annual averages where available. Uncensored data are data that do not represent an 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), as specified in Procedure ES&H 1.1.7, *Environmental Data Review and Above Normal Reporting*.

### **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 use EPA 600 (drinking water), or methods that are reviewed and approved by the Project Management Contractor (PMC) prior to analysis. Each of the subcontracted off-site laboratories has submitted to the WSSRAP a site-specific Quality Assurance Project Plan (QAPjP) and controlled copies of their SOPs. 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) (Ref. 44 and Ref. 46), 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 Methods for the Examination of Water and Wastewater* (Ref. 45).

### **10.3.2 Quality Control Samples**

Quality control samples for environmental monitoring are collected in accordance with the required sampling plan, which specifies the frequency of quality control sample collection. Quality control samples are normally collected in accordance with guidelines in the EPA CLP (Ref. 46).

Descriptions of the Quality Control 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 414.1A. 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 2000, 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 that is split by the WSSRAP, placed in 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 Quality Control 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 as samples are collected.
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 are 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 routine samples taken in the field and given altered identification codes to conceal each sample's 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)	Assesses 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, (RPD) as specified in the *USEPA Contract Laboratory Program, Inorganic Scope of Work*, (Ref. 46), was:

$$RPD = |S-D| / ((S+D) / 2) \times 100\%$$

where S = concentration in the normal sample  
D = concentration in the duplicate analysis

The RPD was calculated only for samples whose analytical results exceeded five times the detection limit.

Table 10-2 summarizes the data of calculated RPD 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	AVG. RPD	MIN. RPD	MAX. RPD
Aluminum	9	9.20	0.22	31
Arsenic	27	17.93	0.73	88
Barium	21	8.45	0.00	53
Chemical Oxygen Demand	10	15.07	3.08	40
Chloride	19	7.89	0.00	85
Chromium	20	19.82	0.00	107
Fluoride	17	7.24	0.00	42
Gross Alpha	32	17.85	0.00	56
Gross Beta	32	16.9	1.8	50
Lead	11	14.5	1.5	58
Manganese	12	2.49	0.49	3.7
Nitrate-N	40	6.28	0.00	75
Selenium	10	13.23	0.00	36
Sulfate	39	5.03	0.00	30
Total Suspended Solids	24	4.23	0.00	29
Trichloroethene	7	9.57	0.00	17.28
Uranium, Total	60	8.50	0.00	39

N = 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. 44 and Ref. 46). As a result, duplicate sample analyses in 2000 were of acceptable quality.

## 10.4.2 Blank Sample Results Evaluation

Various types of blanks are collected to assess the conditions and/or contaminants that may be introduced during sample collection and transportation. These conditions and contaminants are monitored by collecting blank samples to ensure that environmental 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 evaluate 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 were considered to be potentially contaminated. For all parameters except radiochemical, the sample concentration had to be above the detection limit and 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. The NAD was calculated as follows:

$$NAD = \frac{|S - B|}{\sqrt{Err_S^2 + Err_B^2}}$$

where:

- S = concentration of the sample
- B = concentration of the blank
- Err<sub>s</sub> = error associated with the sample

$Err_B$  = 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 2000, 31 trip blanks were analyzed for volatile organic compounds. Detections for acetone were found in nine blanks, methylene chloride in four blanks, 1,2-dichloroethene in one blank, and 2-butanone in three blanks. All environmental samples associated with these 12 blank samples were evaluated. Twenty-six samples were potentially impacted, 10 where methylene chloride had been detected, 10 where acetone had been detected, and seven where 2-butanone had been detected. None of the other samples evaluated exceeded the recommended CLP criterion. All of the parameters found in the trip blanks were associated with common laboratory solvents except 1,2-dichloroethene. No environmental samples were impacted by the one detection of 1,2-dichloroethene.

#### 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 ambient conditions at the sample locations and are generally for the parameters of concern, such as uranium, anions, metals, and nitroaromatics.

In 2000, two 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 2 (0%)	N/A
Barium	1 of 2 (50%)	0 of 12 (0%)
Cadmium	0 of 1 (0%)	N/A
Chloride	1 of 1 (100%)	2 of 6 (33%)
Chromium	1 of 1 (100%)	6 of 12 (50%)
Fluoride	0 of 1 (0%)	N/A
Gross Alpha	0 of 1 (0%)	N/A

Table 10-3 Summary of Field Blank Parameter Results (Continued)

PARAMETER	NUMBER OF DETECTS/NUMBER OF BLANK ANALYSES	NUMBER OF POTENTIALLY IMPACTED SAMPLES
Gross Beta	0 of 1 (0%)	N/A
Lead	1 of 1 (100%)	7 of 22 (32%)
Mercury	0 of 1 (0%)	N/A
Nitrate as N	1 of 1 (100%)	5 of 10 (50%)
Nitroaromatics	0 of 2 (0%)	N/A
Radium-226	0 of 1 (0%)	N/A
Radium-228	0 of 1 (0%)	N/A
Selenium	1 of 1 (100%)	2 of 12 (17%)
Silver	0 of 1 (0%)	N/A
Sulfate	1 of 2 (50%)	0 of 10 (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	0 of 2 (0%)	N/A
Volatiles	0 of 1 (0%)	N/A
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. No equipment blanks were collected in 2000 for non-soil sampling.

#### 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 2000, two 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 no

samples were 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	0 of 2 (0%)	N/A
Barium	0 of 2 (0%)	N/A
Cadmium	0 of 2 (0%)	N/A
Chloride	0 of 2 (0%)	N/A
Chromium	0 of 2 (0%)	N/A
Fluoride	0 of 2 (0%)	N/A
Lead	0 of 2 (0%)	N/A
Mercury	0 of 2 (0%)	N/A
Nitrate as N	2 of 2 (100%)	1 of 1 (100%)
Nitroaromatics	0 of 2 (0%)	N/A
PAHs	0 of 2 (0%)	N/A
PCBs	0 of 2 (0%)	N/A
Radium-226	1 of 2 (50%)	0
Radium-228	0 of 2 (0%)	N/A
Selenium	0 of 2 (0%)	N/A
Silver	0 of 2 (0%)	N/A
Sulfate	0 of 2 (0%)	N/A
Thorium-228	0 of 2 (0%)	N/A
Thorium-230	1 of 2 (50%)	0 of 1 (0%)
Thorium-232	0 of 2 (0%)	N/A
Uranium, Total	1 of 2 (50%)	0
Volatiles	0 of 1 (0%)	N/A

N/A Not Applicable

### 10.5 2000 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 in this table include all sample types.

Table 10-5 WSSRAP Validation Summary for Calendar Year 2000

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	6,847	750	10.9%	4	99.5%
Quarter 2	14,513	1,535	10.6%	4	99.7%
Quarter 3	10,284	1,194	11.6%	14	98.8%
Quarter 4	4,428	471	10.6%	0	100%
2000 Total	36,072	3,950	11.0%	22	99.4%

(a) Completeness is a measure of acceptable data. The value is given by:

$$\text{Completeness} = \frac{(\# \text{ validated} - \# \text{ rejected})}{\# \text{ validated}}$$

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. 46), the U.S. EPA *Contract Laboratory Program Statement of Work for Organic Analysis* (Ref. 44), and the *Laboratory Data Validation Guidelines for Evaluating Radionuclide Analysis* (Ref. 47). For calendar year 2000, 100% of data validation has been completed. Data points in this table include groundwater, surface water, spring and seep water, NPDES, and NESHAP samples only.

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 water, and NPDES samples only.

Table 10-6 WSSRAP Validation Qualifier Summary for Calendar Year 2000

<b>NO. OF DATA POINTS</b>									
	<b>ANIONS</b>	<b>METALS</b>	<b>MISC.</b>	<b>NITRO- AROMATICS</b>	<b>PESTICIDES /PCBs</b>	<b>RADIO- CHEMICAL</b>	<b>SEMI- VOLATILES</b>	<b>VOLATILES</b>	<b>TOTAL</b>
Accepted	22	214	6	72	0	19	0	0	333
Rejected	0	0	0	0	0	0	0	0	0
Not Validatable	12	0	0	0	0	0	0	0	12
Total	34	214	6	72	0	19	0	0	345
<b>PERCENTAGES</b>									
Accepted	64.7%	100.0%	100.0%	100.0%	0	100.0%	0	0	96.5%
Rejected	0.0%	0.0%	0.0%	0.0%	0	0.0%	0	0	0
Not Validatable	35.3%	0.0%	0.0%	0.0%	0	0.0%	0	0	3.5%
Total	100.0%	100.0%	100.0%	100.0%	0	100.0%	0	0	100.0%

Table 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 2000

PARAMETER	N	LABORATORY ACCURACY			LABORATORY PRECISION		
		AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM
<b>IONS</b>							
Chloride	1	93.5	0	93.5	3.6	0	3.6
Fluoride	1	92.2	0	92.2	1.97	0	1.97
Nitrate	1	97.9	0	97.9	0.61	0	0.61
Sulfate	1	94.4	0	94.4	0	0	0
<b>METALS</b>							
Arsenic	1	109.8	0	109.8	1.2	0	1.2
Barium	1	106.7	0	106.7	1.9	0	1.9
Cadmium	1	106.1	0	106.1	1.74	0	1.74
Chromium	1	104.1	0	104.1	1.76	0	1.76
Lead	2	102.6	101.7	103.5	1.61	1.35	1.86
Mercury	1	90.8	0	90.8	0.77	0	0.77
Selenium	1	112.8	0	112.8	1.64	0	1.64
Silver	1	96.8	0	96.8	1.98	0	1.98
<b>MISC.</b>							
Oil & Grease	1	90.7	0	90.7	6.3	0	6.3
Solids	1	97.0	0	97.0	5.03	0	5.03
<b>RADIOCHEMICAL</b>							
Uranium, Total	1	111.0	0	111.0	6.0	0	6.0
Radium-226	1	90.2	0	90.2	8.2	0	8.2
Radium-228	1	85.0	0	85.0	17.2	0	17.2
Thorium-228	1	95.9	0	95.9	7.6	0	7.6
Thorium-230	1	96.4	0	96.4	7.9	0	7.9
Thorium-232	1	81.7	0	81.7	23.2	0	23.3

N = Data population.

## 11. SPECIAL STUDIES

This section highlights significant activities and efforts at the Weldon Spring Site Remedial Action Project (WSSRAP) that support implementation of environmental protection policies. In addition, short term environmental studies are described that support implementation of regulatory requirements not specifically covered 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 and annual rainfall 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) annual mass migrating from each outfall is plotted with annual precipitation. The mass per inch of precipitation for each outfall is also plotted with precipitation. The uranium data for the years 1987 through 1994 were reviewed previously and corrected for several factors, as required, to normalize the data. The corrections were for precipitation, watershed areas, and runoff coefficients and are outlined in the *Weldon Spring Site Environmental Report for Calendar Year 1994* (Ref. 48).

These data have been updated with the inclusion of data for 1995 through 2000. The recent data did not require correction. The annual mass, annual precipitation, and mass per inch of precipitation are in Table 11-1. The annual precipitation and total annual mass discharged off site through 2000 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 2000 for all three outfalls in Figure 11-4.

Table 11-1 Mass of Uranium Discharged from NPDES Storm Water Outfalls<sup>(a)</sup>

YEAR	PPT (Inches)	OUTFALL						TOTAL MASS/YEAR (kg) (a)
		NP-0002		NP-0003		NP-0005		
		MASS (kg)	MASS/INCH OF PPT (kg/Inch)	MASS (kg)	MASS/INCH OF PPT (kg/Inch)	MASS (kg)	MASS/INCH OF PPT (kg/Inch)	
1987	35.8	42	1.17	362	10.11	38	1.06	442
1988	33.9	25	0.74	176	5.19	26	0.77	227
1989	28.5	22	0.77	35	1.23	15	0.53	72
1990	45.1	33	0.73	17.7	0.39	25	0.55	75.7
1991	36.9	32	0.87	73	1.98	27	0.73	132
1992	33.4	41	1.23	75	2.25	16	0.48	132
1993	54.7	66	1.21	163	2.98	31	0.57	260
1994	34.7	36	1.03	49	1.41	12	0.34	97
1995	39.3	20.6	0.52	12.6	0.32	5	0.13	38.2
1996	43.9	14.3	0.33	19.1	0.44	4	0.09	37.4
1997	31.5	2.3	0.07	19.2	0.61	0.5	0.02	22.0

Table 11-1 Mass of Uranium Discharged from NPDES Storm Water Outfalls <sup>(a)</sup> (Continued)

YEAR	PPT (Inches)	OUTFALL						TOTAL MASS/YEAR (kg) (a)
		NP-0002		NP-0003		NP-0005		
		MASS (kg)	MASS/INCH OF PPT (kg/Inch)	MASS (kg)	MASS/INCH OF PPT (kg/Inch)	MASS (kg)	MASS/INCH OF PPT (kg/Inch)	
1998	49.6	8.4	0.17	13.3	0.27	0.57	0.01	22.3
1999	34.1	0.83	0.02	3.9	0.11	0.67	0.02	5.4
2000	41	1.6	0.04	2.3	0.06	0.5	0.01	4.4

(a) Includes Outfalls NP-0002, NP-0003, and NP-0005. Other outfalls have historically contributed negligible amounts.

PPT Precipitation

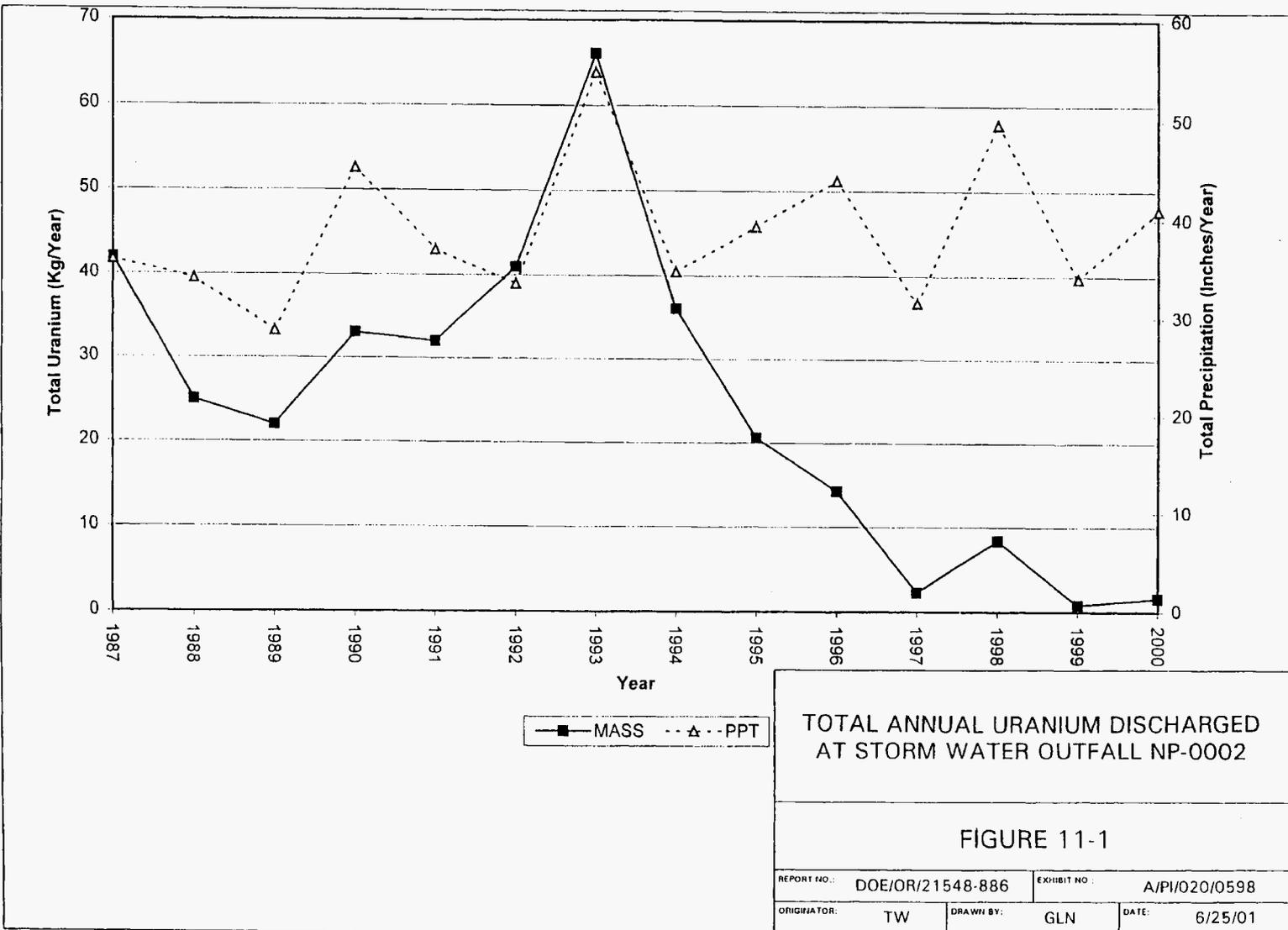
### 11.1.1 Storm Water Outfall NP-0002

Outfall NP-0002 is downstream of the Frog Pond area and receives runoff from the eastern section of the chemical plant area. Figure 11-1 indicates that before remediation started, uranium migrating off site initially decreased or increased in relative proportion to annual precipitation. Building dismantlement in 1992 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 the pond was removed in mid 1998. Total mass at Outfall NP-0002 increased slightly in 1998. An increase in precipitation during 1998 is suspected to be the cause.

The mass for 1999 was much reduced, as was the mass per inch of precipitation. This reduction is attributed to the NP-0002 watershed being almost completely remediated, and a significant reduction from 1998 precipitation. Precipitation in 1999 was not only less than in 1998, but there were few major storm events, which reduced runoff from the site.

There was a slight increase in total mass at outfall NP-0002 during 2000. Although the area was completely remediated, there was a large area of unvegetated soil which increased the runoff. In addition, precipitation was greater in 2000 than in 1999. The cell and parking areas have high runoff coefficients which also added to the increase in runoff and subsequently, mass.



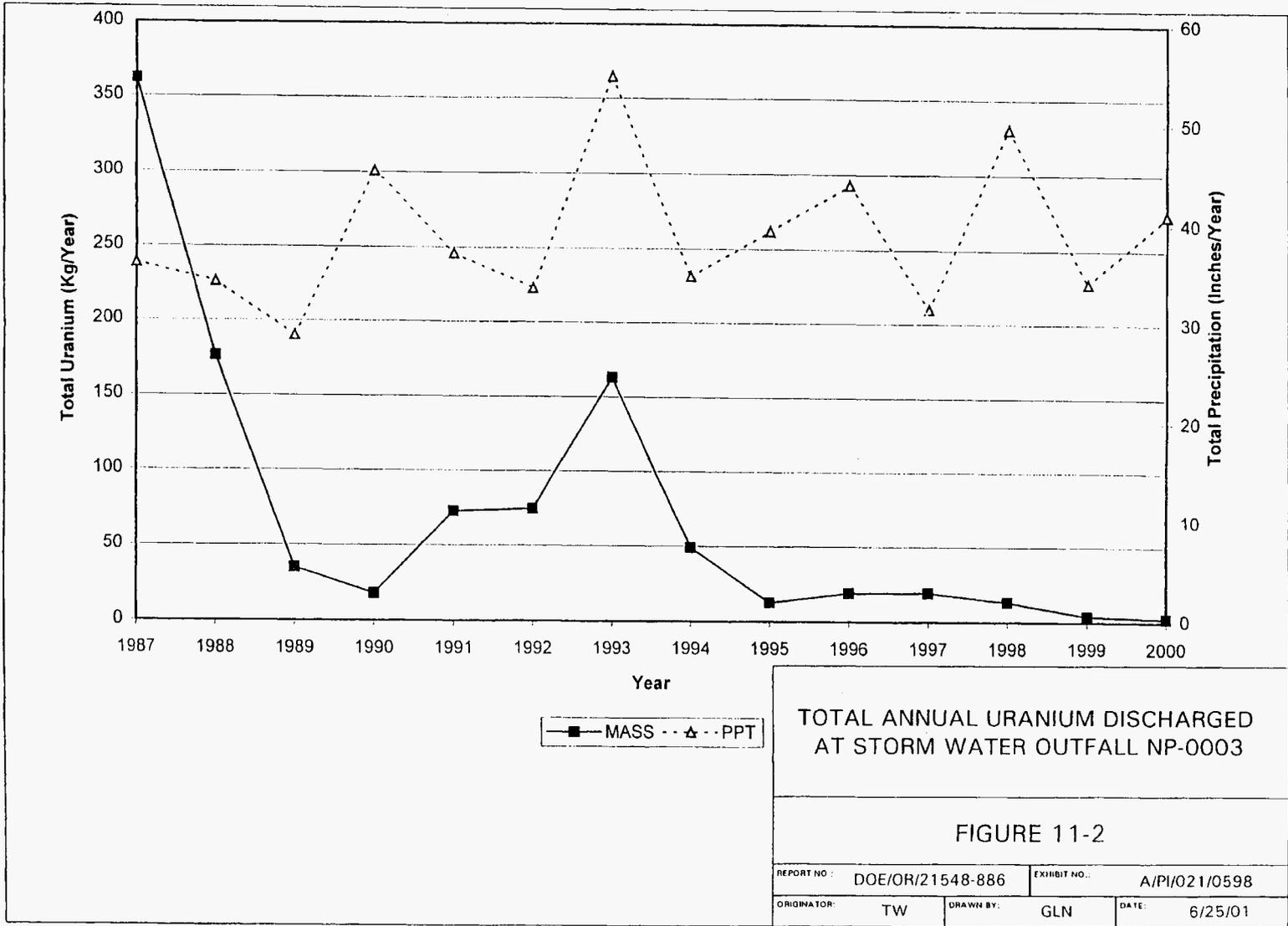
### 11.1.2 Storm Water Outfall NP-0003

Figure 11-2 indicates that uranium migrating off site sharply decreased from 1987 through 1989 at Outfall NP-0003. The reduction for 1988 is assumed to be due to precipitation patterns since there was no other activity in the watershed. The reduction in 1989 was due to construction of the Ash Pond diversion channel, which began in November of 1988 and was completed in April of 1989, along with lower precipitation in 1989. Prior to construction of the diversion channel, most of the water in the watershed flowed through Ash Pond, which was a highly contaminated area. Following construction of the diversion channel, the only water that flowed from Ash Pond was precipitation that fell directly on the pond area.

Construction of the diversion channel made the fluctuations in annual uranium mass at Outfall NP-0003 highly dependent on the flow from Ash Pond. During the summer and other dry periods, there was little or no flow from the pond. As a result, the diversion channel flow (from a much less contaminated area of the site) made up the bulk of the flow. This caused overall lower uranium levels at the outfall during periods of normal precipitation. During winter, when the Ash Pond soils may have become saturated and precipitation amounts generally have been higher and evaporation lower, flow from Ash Pond increased and concentrations at the outfall trended higher.

The mass in 1990 was again reduced over the previous year, although precipitation was much higher. This may have been a result of precipitation patterns and/or the times the samples were taken (i.e., no flow from Ash Pond). 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 was 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 construction during 1995 of a sedimentation basin immediately upstream of Outfall NP-0003. Mass increased slightly in 1996 due to increased precipitation and the storage of contaminated soil and debris in Ash Pond. With this storage, the water was managed and was not discharged to the sedimentation basin unless it was less than the 600 pCi/l (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 was expected to be highly dependent on precipitation and water discharged from the pond. The mass of uranium discharged during 1997 was slightly higher than that discharged during 1996, even though precipitation was much less. This was likely the result of the storage of contaminated materials in the pond area. During 1998, total mass at Outfall NP-0003 was less than during 1997, even though precipitation was



TOTAL ANNUAL URANIUM DISCHARGED AT STORM WATER OUTFALL NP-0003			
FIGURE 11-2			
REPORT NO.:	DOE/OR/21548-886	EXHIBIT NO.:	A/PI/021/0598
ORIGINATOR:	TW	DRAWN BY:	GLN
		DATE:	6/25/01

much higher. The decrease is assumed to be the result of management of the pond water and the removal of contaminated materials from the pond during 1998.

The 1999 mass of uranium migrating off site at Outfall NP-0003 was less than the 1998 mass. This reduction is attributed to a reduction in precipitation and remediation efforts in the Ash Pond area. The entire Ash Pond area and the chipped wood storage area were remediated and confirmed clean during 1999.

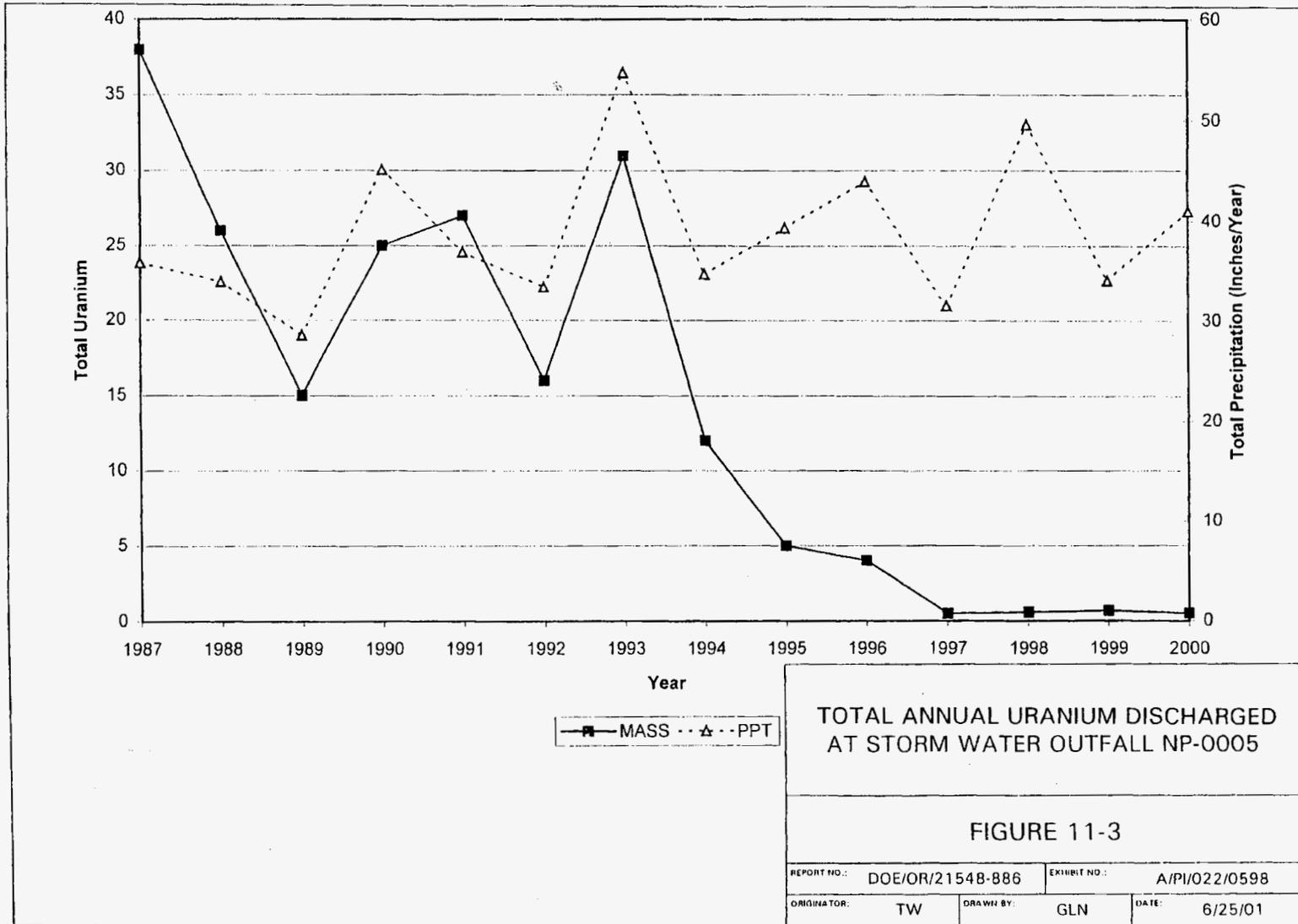
During 2000 the NP-0003 watershed was largely vegetated, and uranium mass migration was slightly decreased compared to 1999 levels even though there was an increase in precipitation. With remediation and soil stabilization, uranium discharges are expected to stabilize at a low level.

### 11.1.3 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 through 1994. Construction of the site water treatment plant, which began in 1992, appeared to have had little effect on the outfall, even though it involved substantial earth disturbance for construction of the effluent and equalization basins. A siltation basin was constructed to settle sediments from the water flowing off the treatment plant area and storm water from the siltation basin has historically contained less than 10 pCi/l (0.37 Bq/l) uranium. The other major source for the Outfall (until it was remediated in 1996) was a watershed that drained the highly contaminated Building 301 area. This area was partially capped 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 was 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. The mass of uranium migrating off site at Outfall NP-0005 for 1997 was much reduced compared to 1996 most likely due to the near complete remediation of the watershed. Because of the remediation uranium mass was expected to remain near background levels at Outfall NP-0005. The total mass at the outfall remained low for 1998, despite the increased precipitation. There was very little soil disturbance in the watershed during 1998.

There was a slight increase in mass at Outfall NP-0005 in 1999 although the total mass remained low. This increase is attributed to a collection sump near the chemical stabilization and solidification (CSS) area that prevented water from flowing to the NP-0003 watershed. The



water was collected to allow construction of the cell berm. The water was then pumped to Outfall NP-0005. The water that collected in the sump was from an area that was only partially remediated and slightly higher in uranium than other NP-0005 waters, thus causing the slight increase.

Mass at Outfall NP-0005 for 2000 decreased from 1999 levels despite an increase in precipitation and earth disturbance caused by the removal of the site water treatment plant and ponds. Complete remediation of the watershed contributed to the reduction.

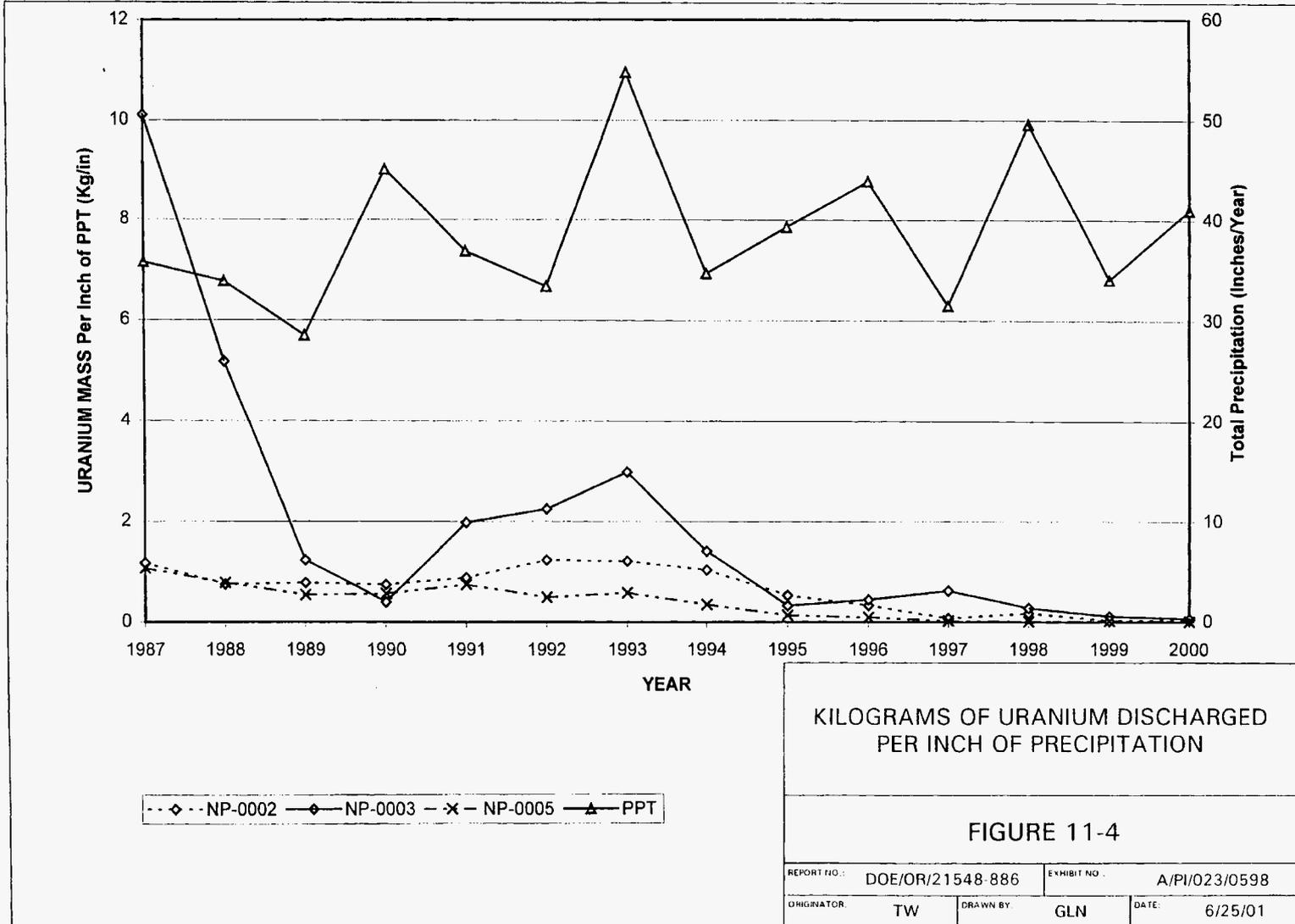
#### **11.1.4 Mass of Uranium Per Inch of Precipitation**

Figure 11-4 and Table 11-1 indicate that the 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 contained Ash Pond, which was a highly contaminated area.

Variations may be due to precipitation patterns, soil disturbance, or remediation, and in the case of Outfall NP-0003, the storage of contaminated materials in Ash Pond. Outfalls NP-0002 and NP-0005 have trended downward as a result of remediation in the watershed. Outfall NP-0003 increased slightly for 1997 because of the storage of contaminated materials in Ash Pond, but decreased during 1998 despite the increase in precipitation. With remediation of the Ash Pond area in 1999, the mass per inch of precipitation was reduced at Outfall NP-0003. The mass per inch of precipitation continued to trend downward during 2000 at outfalls NP-0003 and NP-0005 but increased at NP-0002. When the NP-0002 watershed is stabilized and vegetation established, this level is expected to be reduced to the same ranges seen at the other two outfalls.

#### **11.1.5 Annual Migration of Uranium Mass from the Chemical Plant Site**

The mass of uranium that migrated off site from the three major outfalls in 1987, before any remedial actions were taken, was 442 kg (972 lb). During 2000, 4.4 kg (9.68 lb) of uranium migrated off site, a 99% 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 may be attributed to increased precipitation. The 2000 mass was at a historical low, which was the expected result of extensive site remediation and soil stabilization.



The total annual uranium discharged from NPDES outfalls during 1987 through 2000 is shown in Figure 11-5. These values include uranium discharged at the three major outfalls discussed above, as well as at other minor storm water outfalls and in the water treatment plant effluents. As shown on the graph, total uranium migrating off site in surface water has steadily decreased since 1987, and is expected to decrease further still when the site is vegetated and stabilized.

## 11.2 Radon Flux Monitoring Results for the WSSRAP Disposal Facility

This section summarizes the results of Radon-222 (radon) flux monitoring performed on the top of the radon barrier proper of the WSSRAP disposal cell. Additional information can be found in the *Completion Report for Radon Flux Monitoring of the WSSRAP Disposal Facility* (Ref. 11).

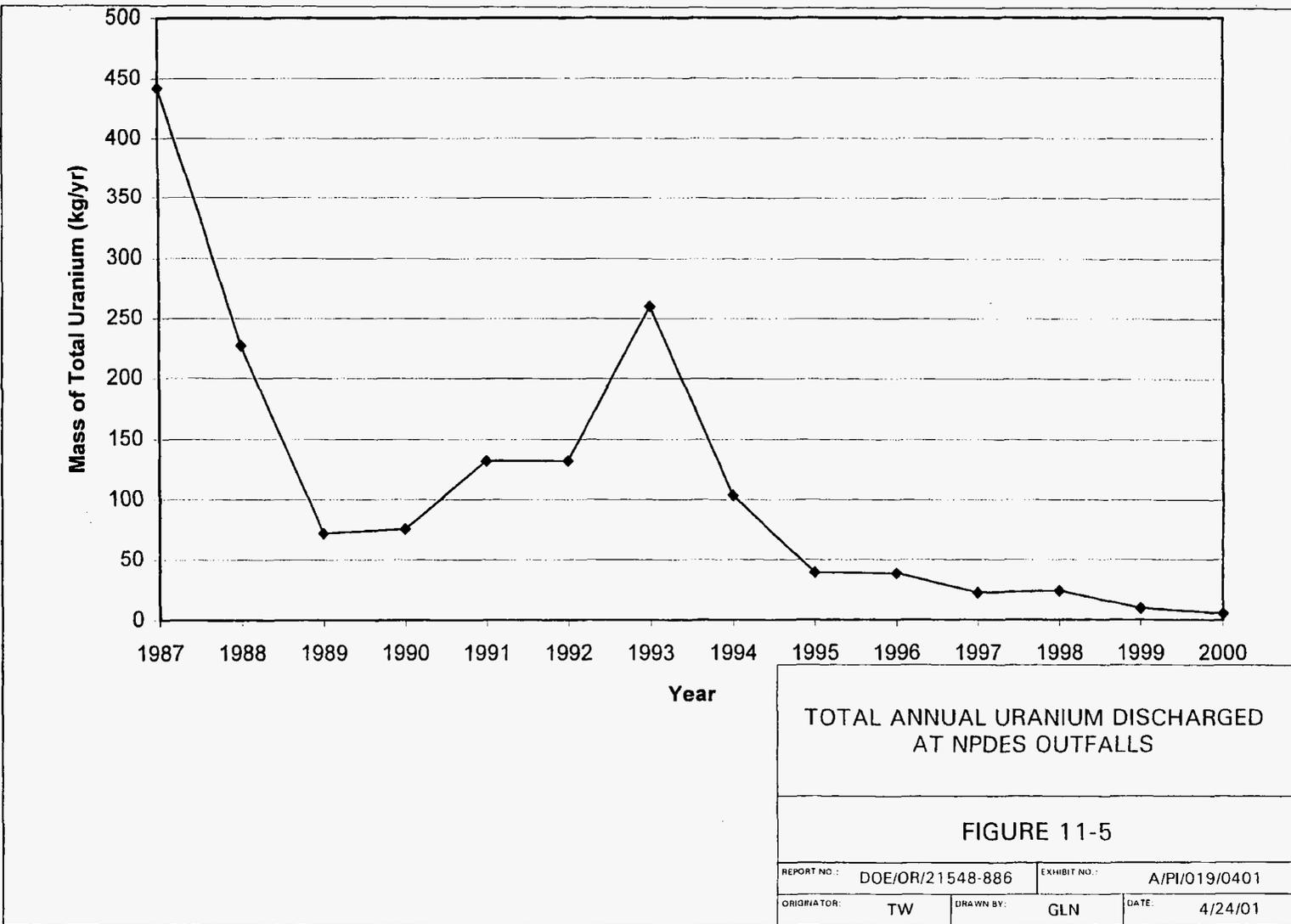
The *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 9) states that radon flux standards in 40 CFR 61, Subparts Q and T, and 40 CFR 192.32(b)(1)(ii) are applicable and/or relevant and appropriate. These standards require that Radon-222 (radon) flux from the disposal cell will not exceed an average of 20 pCi/m<sup>2</sup>/sec.

The primary method approved by the U.S. Environmental Protection Agency (EPA) for measuring radon flux is found in 40 CFR 61, Appendix B, Method 115. This method consists of deploying large-area activated charcoal collectors on the radon barrier proper for a 24-hr period during which time the radon emanating from the surface is adsorbed on the activated charcoal. The collectors are then returned to the vendor laboratory where they are analyzed by gamma spectroscopy to determine the amount of radon adsorbed. This was the monitoring method used to determine average radon flux from the WSSRAP disposal cell.

Originally, monitoring was going to be conducted in two phases, Phase 1 covering approximately 70% and Phase 2 covering that portion not included in Phase 1. However, due to favorable changes in construction sequencing, a 1-ft radon barrier surface was available over the entire cell by September 2000. Therefore, Phase 1 was conducted as detailed above and Phase 2 was rescheduled as a one-time monitoring effort covering the entire radon barrier area. The results are discussed below.

Phase 1 monitoring was conducted August 1-2, 2000, at 70 separate locations on top of the disposal cell. These locations included about two-thirds of the radon barrier area (i.e., all radon barrier area available at that time).

The requirements of both EPA Method 115 (40 CFR 61, Appendix B) and the *Radon Flux Monitoring Plan for the WSSRAP Disposal Facility* (Ref. 17) were met during Phase 1 monitoring. The average measured radon flux on the disposal cell was 0.10 pCi/m<sup>2</sup>/sec (standard deviation of 0.15 pCi/m<sup>2</sup>/sec, maximum value was 1.255 pCi/m<sup>2</sup>/sec). The average was well



below the regulatory requirement of 20 pCi/m<sup>2</sup>/sec. The individual measurements compared favorably to background radon flux levels, which can range from 0.005 to 1.4 pCi/m<sup>2</sup>/sec, with an average value of approximately 0.43 pCi/m<sup>2</sup>/sec. In fact, none of the individual measurements exceeded this background range.

Phase 2 monitoring was conducted October 11-12, 2000, at 100 separate locations on top of the disposal cell. These locations included all of the radon barrier area except the "deep dimple," the approximately 0.7 acre (at current grade) area reserved for the remaining contaminated waste. At the time of sampling, the dimple had at its deepest point approximately 9.5 ft of clean fill above the cell waste. Two monitoring locations, WSSRAP IDs 10 and 23, were to have been placed directly above the dimple. However they were repositioned 28 ft southeast to avoid the possibility of biased low measurements.

The requirements of both EPA Method 115 (40 CFR 61 Appendix B) and the *Radon Flux Monitoring Plan for the WSSRAP Disposal Facility* (Ref. 17) were met during Phase 2 monitoring. The average measured radon flux on the disposal cell was 0.55 pCi/m<sup>2</sup>/sec (standard deviation of 2.64 pCi/m<sup>2</sup>/sec, maximum value was 26.4 pCi/m<sup>2</sup>/sec). The average was well below the regulatory requirement of 20 pCi/m<sup>2</sup>/sec. Only three of the 100 individual measurements exceeded the background range of 0.005 to 1.4 pCi/m<sup>2</sup>/sec, (Section 2.1.2).

Additional monitoring was performed October 26-27, 2000, to confirm the 26.4 pCi/m<sup>2</sup>/sec maximum flux measurement. This included four additional measurements: one at the original location (WSSRAP ID 56), the others within 3 ft of this location. Additional monitoring results were 0.2795, 0.5629, 6.9934, and 13.2819 pCi/m<sup>2</sup>/sec. This was interpreted as confirmation of the original results. These additional results were not included in the calculated average since they were not part of the monitoring plan. However, they would have changed the average only slightly (from 0.55 to 0.74 pCi/m<sup>2</sup>/sec).

In summary, the average measured radon flux during Phase 1 and Phase 2 were both less than 5% of the regulatory requirement of 20 pCi/m<sup>2</sup>/sec.

## 12. REFERENCES

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**DOE ORDERS**

232.1A, *Occurrence Reporting and Processing of Operations 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*  
414.1A, *Quality Assurance*

**REGULATIONS**

10 CFR 830.120, *Quality Assurance*  
10 CFR 1022, *Department of Energy, Compliance With Floodplain/Wetlands Environmental Review Requirements*  
10 CFR 835, *Occupational Radiation Protection*  
36 CFR 800.5, *Protection of Historic and Cultural Properties*  
40 CFR 61, *National Emission Standards for Hazardous Air Pollutants*  
40 CFR 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*  
10 CSR 80-3, *Solid Waste Management – Sanitary Landfill*

**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

# TELECON

DATE AND TIME 4/3/01

PERSON RECEIVING THE CALL Susan Meyer

CALLER Master Sgt John Rogers

ADDRESS Weldon Spring Training Area - Dept of Army

PHONE NUMBER 636-441-8681

CONCERN OR QUESTION

Training Year (Calendar Year) 2000

Military Personnel Training = 3335 man days

Civilian Personnel Training (FBI, Police, etc) = 2760 man day.

HOW IT WAS ADDRESSED

FOLLOW-UP NEEDED

SIGNED

# TELECON

DATE AND TIME 3/26/01

PERSON RECEIVING THE CALL Susan Myers

CALLER \_\_\_\_\_

ADDRESS \_\_\_\_\_

PHONE NUMBER \_\_\_\_\_

CONCERN OR QUESTION Year 2000

St. Charles County population = 283,883  
Cottleville Population = approx. 3000-4000  
Weldon Spring population = 5270  
Weldon Spring Heights population = 79

HOW IT WAS ADDRESSED Population data taken from  
Wentzville Journal 3/21/01 and St. Louis Post  
Dispatch 3/16/01 issue. Verified numbers  
with individual municipalities. Cottleville's  
census was incorrect and is in the process  
of being redone.

FOLLOW-UP NEEDED \_\_\_\_\_

SIGNED \_\_\_\_\_

# TELECON

DATE AND TIME 3/26/01

PERSON RECEIVING THE CALL Susan Myers

CALLER Denise Lehmann

ADDRESS Busch Wildlife Area

PHONE NUMBER 636-441-4554 ext 223

CONCERN OR QUESTION

Year 2000

# of employees = 48

# of weeks worked = 52

# of visitors to site = approx. 300,000 - 600,000

# of people at residence = 2

Residence located across from new entrance

HOW IT WAS ADDRESSED

FOLLOW-UP NEEDED

SIGNED

# TELECON

DATE AND TIME 3/26/01

PERSON RECEIVING THE CALL Susan Myers

CALLER \_\_\_\_\_

ADDRESS First Student Bus for Francis Howell

PHONE NUMBER 636-441-7654

CONCERN OR QUESTION \_\_\_\_\_

Year 2000 -

# of employees from bus company located  
at Francis Howell annex =

≈ 50 bus drivers there

× 3 hrs/day for

52 weeks/yr.

HOW IT WAS ADDRESSED \_\_\_\_\_

FOLLOW-UP NEEDED \_\_\_\_\_

SIGNED \_\_\_\_\_

# TELECON

DATE AND TIME 3/26/01

PERSON RECEIVING THE CALL Susan Myers

CALLER Ms. Platte

ADDRESS Francis Howell High School Annex

PHONE NUMBER 636-441-0088

CONCERN OR QUESTION

Year 2000

# of employees at annex = 53

# of weeks worked = 52

HOW IT WAS ADDRESSED

FOLLOW-UP NEEDED

SIGNED

# TELECON

DATE AND TIME 3/26/01

PERSON RECEIVING THE CALL Susan Myers

CALLER Dan Kline

ADDRESS St. Charles County Planning & Zoning

PHONE NUMBER 636-949-7335

CONCERN OR QUESTION \_\_\_\_\_

Average number of people per household  
(based on latest census which was 1990) =  
2.83

HOW IT WAS ADDRESSED \_\_\_\_\_

FOLLOW-UP NEEDED \_\_\_\_\_

SIGNED \_\_\_\_\_

# TELECON

DATE AND TIME 3/28/01

PERSON RECEIVING THE CALL Susan Myers

CALLER Mike Watawa

ADDRESS Francis Howell High School

PHONE NUMBER 636-926-8773

CONCERN OR QUESTION Year 2000

# of employees = 150

# of students = 1450

# of weeks in school = approx. 36

7 employees work 52 weeks/year

HOW IT WAS ADDRESSED \_\_\_\_\_

FOLLOW-UP NEEDED \_\_\_\_\_

SIGNED \_\_\_\_\_

# TELECON

DATE AND TIME 3/26/01

PERSON RECEIVING THE CALL Susan Myers

CALLER Master Sgt. John Rogers

ADDRESS Weldon Spring Training Area - Dept of Army

PHONE NUMBER 636-441-8681

CONCERN OR QUESTION Year 2000

# of employees = 1

# of weeks worked = approx. 2 days/week  
for 52 weeks/year

# of subcontractors (information received  
from Ray Allison, Army Corp of Engineers)  
10 people for 8 months, 8 hrs/day

Maintenance = 1 person 40 hrs/week from  
April 1<sup>st</sup> thru October 1<sup>st</sup>

HOW IT WAS ADDRESSED

FOLLOW-UP NEEDED

SIGNED

# TELECON

DATE AND TIME 3/26/01

PERSON RECEIVING THE CALL Susan Myers

CALLER John Ronchetto

ADDRESS MO State Highway Department - Weldon Spring

PHONE NUMBER 636-441-8471

CONCERN OR QUESTION \_\_\_\_\_

Year 2000

# of employees = 11

# of weeks worked = 52

HOW IT WAS ADDRESSED \_\_\_\_\_

FOLLOW-UP NEEDED \_\_\_\_\_

SIGNED \_\_\_\_\_

**APPENDIX B**  
**Assumptions and Scenarios for Dose Calculations**

### A. Dose from the Chemical Plant and Raffinate Pits to a Maximally Exposed Individual

Because monitoring results at the critical receptor station representing the Missouri Highway and Transportation Department (MHTD) maintenance facility (AP-2001 – radioactive air particulate, RD-2004 – radon and thoron gas, and TD-2004 – direct gamma exposure) did not exceed background levels in 2000, and ingestion pathways are nonexistent (no bodies of water exist at the MHTD), no dose assessment is necessary for an individual located there.

### B. Dose from the Weldon Spring Quarry to a Maximally Exposed Individual

Because air monitoring results at the quarry did not exceed background levels in 2000, 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, in the Busch Memorial Conservation Area, exhibits elevated concentrations of radium, thorium, and uranium. It is assumed that an individual walked past Burgermeister Spring once a week during 2000, stopping during each visit to drink one cup (0.237 l) of water from the spring. Therefore, the individual ingests (52 x 0.237) liters of water, or 12.3 liters (3.24 gal). No radiological exposure was calculated for the individual for inhalation or external exposure because environmental monitoring results indicated radioactive air particulate, gamma exposure, and radon levels to be no greater than background at this location.

The maximum concentrations recorded in 2000 for the radionuclides detected in Burgermeister Spring and their corresponding dose conversion factors (DCFs) for ingestion are:

<b>RADIONUCLIDE</b>	<b>2000 MAXIMUM RECORDED CONCENTRATION (pCi/l)<sup>(a)</sup></b>	<b>DOSE CONVERSION FACTOR FOR INGESTION (mrem/pCi)</b>
Total Uranium (soluble)	81.1	2.69E-4 (Soluble)
Ra-226	0.13	1.33E-3
Ra-228	1.25	1.44E-3
Th-228	0.88	3.96E-4
Th-230	3.91	5.48E-4
Th-232	0.58	2.73E-3
Ra-224	0.88	3.66E-4
Pb-212	0.88	4.56E-5

(a) Ra-224 and Pb-212 concentrations derived from measured Th-228 concentration, based on assumption of secular equilibrium.

The above DCFs are obtained from EPA's Federal Guidance Report No. 11 (Ref. 28). The DCF for total soluble uranium is calculated using the isotopic DCFs and the natural uranium isotopic activity ratios given in Section 5.3.2.

The total effective dose equivalent (TEDE) is calculated by summing the doses contributed by each radionuclide in the water, as shown below:

$$\begin{aligned} \text{TEDE (ingestion of contaminated water)} = & \text{TEDE (total uranium)} + \text{TEDE (Ra-226)} + \\ & \text{TEDE (Ra-228)} + \text{TEDE (Th-228)} + \\ & \text{TEDE (Th-230)} + \text{TEDE (Th-232)} + \\ & \text{TEDE (Ra-224)} + \text{TEDE (Pb-212)} \end{aligned}$$

where:

$$\text{TEDE (ingestion of contaminated water for a given radionuclide)} = \text{Concentration (pCi/l)} \times \text{Volume of Water Ingested (L)} \times \text{Dose Conversion Factor (mrem/pCi)}$$

$$\text{TEDE (total uranium)} = 81.1 \text{ pCi/l} \times 12.3 \text{ l} \times 2.69\text{E-}4 \text{ mrem/pCi}$$

$$= 0.27 \text{ mrem}$$

$$\text{TEDE (Ra-226)} = 0.13 \text{ pCi/l} \times 12.3 \text{ l} \times 1.33\text{E-}3 \text{ mrem/pCi}$$

$$= 0.002 \text{ mrem}$$

$$\text{TEDE (Ra-228)} = 1.25 \text{ pCi/l} \times 12.3 \text{ l} \times 1.44\text{E-}3 \text{ mrem/pCi}$$

$$= 0.022 \text{ mrem}$$

$$\text{TEDE (Th-228)} = 0.88 \text{ pCi/l} \times 12.3 \text{ l} \times 3.96\text{E-}4 \text{ mrem/pCi}$$

$$= 0.004 \text{ mrem}$$

$$\text{TEDE (Th-230)} = 3.91 \text{ pCi/l} \times 12.3 \text{ l} \times 5.48\text{E-}4 \text{ mrem/pCi}$$

$$= 0.026 \text{ mrem}$$

$$\text{TEDE (Th-232)} = 0.58 \text{ pCi/l} \times 12.3 \text{ l} \times 2.73\text{E-}3 \text{ mrem/pCi}$$

$$= 0.019 \text{ mrem}$$

$$\text{TEDE (Ra-224)} = 0.88 \text{ pCi/l} \times 12.3 \text{ l} \times 3.66\text{E-}4 \text{ mrem/pCi}$$

$$= 0.004 \text{ mrem}$$

$$\text{TEDE (Pb-212)} = 0.88 \text{ pCi/l} \times 12.3 \text{ l} \times 4.56\text{E-}5 \text{ mrem/pCi}$$

$$= 0.0005 \text{ mrem}$$

Thus, the TEDE for all radionuclides combined is  $(0.27 + 0.002 + 0.022 + 0.004 + 0.026 + 0.019 + 0.004 + 0.0005)$  mrem, or 0.35 mrem ( $3.5\text{E-}3$  mSv).

#### D. Collective Population Effective Dose Equivalent (CPEDE)

Exposure points are locations near the WSSRAP where members of the public have the potential for exposure 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 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 2000, a statistical analysis of low volume monitoring results indicated that, at the 95% confidence level, one chemical plant perimeter location (AP-2025) had an ambient gross alpha concentration greater than the 52-week background average. Station AP-2025 is located on the northern site perimeter, in an area that is not expected to be frequented on a regular basis by members of the public. Therefore, inhalation of airborne radionuclide particulates is not included in the CPEDE estimate for 2000.

## 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. In addition, the only elevated result occurred at Station RD-CE07, located on top of the disposal cell, in an area that was not accessible to members of the public. Therefore, inhalation of radon and thoron gas is not included in the CPEDE estimate for 2000.

## 3. External Gamma Pathway

Statistical analysis of gamma monitoring locations indicated that at the 95% confidence level none of the results were distinguishable above background. Therefore, external gamma exposure is not included in the CPEDE estimate for 2000.

## 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. In 1991 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. 29). Because this study is 10 years old, and the population of St. Charles County has increased significantly during the past decade, the numbers in the study have been increased by 25% for purposes of this dose assessment.

Fishing at the Busch Conservation Area is assumed to have averaged 2.5 hours per visit for the approximately 200,000 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 100,000 fish). Assuming that each person keeps one fish, the population of concern would be 100,000 persons. For the water ingestion scenario, boating is the activity assumed to provide the potential for incidental water ingestion. An estimated 7,480 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 7,480 persons. Each of these ingestion scenarios is further addressed in the calculations below.

a. Collective dose estimate due to ingestion of fish obtained at the Busch Memorial Conservation Area is based on the following assumptions:

- Each person of the 100,000 population is assumed to consume one fish.

- The edible portion of a fish is assumed to have a mass of 200 g. Over a 1-year (365 days) period, the average consumption rate specific to the affected population is 200 g/365 days, or 0.55 g/person/day.
- Fish samples were last 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)

$$\begin{aligned}
 &= \text{consumption rate} \times \text{total uranium concentration in fish} \times \text{exposure time} \times \text{total} \\
 &\quad \text{soluble uranium dose conversion factor} \times \text{persons} \\
 &= 0.55 \text{ g/day} \times 0.019 \text{ pCi/g} \times 365 \text{ day} \times 2.69 \text{ E-4 mrem/pCi} \times 100,000 \text{ persons} \times \\
 &\quad 1 \text{ rem/1,000 mrem} \\
 &= 0.103 \text{ person-rem (1.03 E-3 person-Sv)}
 \end{aligned}$$

- b. Collective dose estimate due to incidental ingestion of water at the Busch Conservation lakes is based on the following assumptions:

- Each person of the 7,480 population makes one boating visit on an annual basis, and 5% of the visit is spent swimming (0.285 hours/visit).
- Maximum total uranium surface water content is 7.45 pCi/l (obtained from Lake 35 in 2000, Table 7-10), and ingestion rate is 0.05 l/hour (Ref. 29).

Population Dose Equivalent (water ingestion)

$$\begin{aligned}
 &= \text{ingestion rate} \times \text{average total uranium concentration in Lake 35 water} \times \\
 &\quad \text{exposure time} \times \text{total soluble uranium dose conversion factor} \times \text{number of} \\
 &\quad \text{individuals} \\
 &= 0.05 \text{ l/hr} \times 7.45 \text{ pCi/l} \times 0.285 \text{ hr} \times 2.69\text{E-4 mrem/pCi} \times 7,480 \text{ persons} \times \\
 &\quad 1 \text{ rem/1,000 mrem} \\
 &= 0.0002 \text{ person-rem (2.1E-6 person-Sv)}
 \end{aligned}$$

Therefore, the CPEDE obtained from ingestion of food or water at the Busch Memorial Conservation Area is:

Dose (fish ingestion) + Dose (water ingestion)

$$= 0.103 + 0.0002 \text{ person-rem}$$

$$= 0.103 \text{ person-rem (1.03E-3 person-Sv)}$$

The 2000 total collective population effective dose equivalent (CPEDE) for all applicable pathways addressed in this section is:

CPEDE (airborne particulates) + CPEDE (gamma exposure) + CPEDE (ingested food and water)

$$= 0 + 0 + 0.103 \text{ person-rem}$$

$$= 0.103 \text{ person-rem (0.00103 person-Sv)}$$

#### E. Airborne Radioactive Release Estimates

During 2000, one low volume monitoring station at the chemical plant perimeter indicated an annual average concentration that was statistically greater than the 52-week average background concentration. This station was AP-2025. The net annual average gross alpha concentration at this station was incorporated into a box model to estimate the total radioactive airborne particulate release from the site for 2000. Table B-1 summarizes the approximate activity ratios for the radionuclides contained in the waste common to the area of the site where the elevated annual average concentration was documented (see Section 4). The table also identifies the source believed to be responsible for the 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.

Table B-1 Sources and Activity Ratios Corresponding to Elevated Gross Alpha Concentrations at Perimeter Low Volume Monitoring Stations

STATION ID	Net Alpha Concentration Above Background (Ci/m <sup>3</sup> )	WSSRAP Source Contributing to Elevated Concentrations	Activity Ratios					
			U-234	U-235	U-238	Th-228	Th-230	Th-232
AP-2025	1.70E-16	Disposal Cell	0.074	0.003	0.073	0.080	0.680	0.090

(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:

$$\text{Release Rate (Ci/y)} = \sum_i \sum_j [\text{Box Length (m)} \times \text{Release Height (m)} \times \text{Wind Speed (m/s)} \times \text{Net Annual Gross Alpha Concentration (Ci/m}^3) \times 3.1536 \text{ E7 sec/y} \times \text{Directional Frequency}]$$

where:

- i = monitoring station
- j = radionuclide

For Station AP-2025, the total release rate was determined as follows:

$$\begin{aligned} \text{Total Radioactive Airborne Particulate Release Rate (AP-2025)} &= 252 \text{ m} \times 3 \text{ m} \times 2.77 \text{ m/s} \times 1.70 \text{ E-16 Ci/m}^3 \times 3.1536 \text{ E7 sec/y} \times 0.249 \\ &= 2.80 \text{ E-6 Ci/y} \end{aligned}$$

The radionuclide-specific airborne particulate release rates based on annual results from Station AP-2025 were subsequently determined by multiplying the total AP-2025 release rate by each activity ratio listed in Table B-1 for the contributing source. Table B-3 provides radionuclide-specific activity releases calculated for all monitoring stations that were determined to have concentrations that were statistically greater than the 52-week average background concentration. The total activity for each radionuclide released from the chemical plant area was found by summing the results in each column of the table.

Table B-2 Parameters and Assumptions Used in Box Modeling to Determine Radioactive Airborne Particulate Release Rate from the WSSRAP for 2000

Box Model	Station ID	Range of Wind Directions (Wind Blowing From)	Average Wind Speed for Range (m/s)	Directional Frequency	Box Length (m)	Release Height (m)
1	AP-2025	191.25° - 258.75° (SSW, SW, WSW)	2.77	0.249	252	3

Table B-3 Radionuclide-Specific Activity Release Rates Corresponding to Monitoring Stations with Gross Alpha Results Greater Than Background for 2000

Station	Net Concentration	Release Rates (Ci/y)					
		U-234	U-235	U-238	Th-228	Th-230	Th-232
AP-2025	2.80E-6	2.07E-7	8.39E-9	2.04E-7	2.24E-7	1.90-6	2.52E-7
<b>Total Release Rates</b>		2.07E-7	8.39E-9	2.04E-7	2.24E-7	1.90-6	2.52E-7

#### F. Radon-220 and Radon-222 Release Estimates

All annual average Rn-222 and Rn-220 concentrations measured at critical receptor and perimeter locations were statistically indistinguishable from background levels. Therefore, it is assumed that no Rn-222 or Rn-220 gas above background levels was released from either the chemical plant or the quarry areas in 2000.

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