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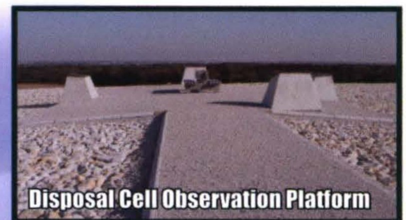
Weldon Spring Site Environmental Report for Calendar Year 2002

DOE/GJ/79491-931
Contract No. DE-AC13-02GJ79491
May 2003
Rev. 0

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


Seeding of Howell's Prairie


Disposal Cell Observation Platform


Weldon Spring Interpretive Center


May 2003


Interpretive Center Interior

Weldon Spring Site Remedial Action Project
Department of Energy
VPP
Star Site

DOE/GJ/79491-931
CONTRACT NO. DE-AC13-02GJ79491

WELDON SPRING SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 2002

WELDON SPRING SITE REMEDIAL ACTION PROJECT
WELDON SPRING, MISSOURI

MAY 2003 **REV. 0**

U.S. Department of Energy
Grand Junction Office
Weldon Spring Site Remedial Action Project

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APPROVALS

Melvin H. Lutz ___________________________ 5/19/03
Environmental Safety and Health Department Manager — Date

___________________________ 5-27-03
Project Quality Manager — Date

___________________________ 5-27-03
Project Director — Date

DOE/GJ/79491-931

Weldon Spring Site Remedial Action Project

EXECUTIVE SUMMARY

Weldon Spring Site Environmental Report for Calendar Year 2002

Revision 0

May 2003

Prepared by

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U.S. DEPARTMENT OF ENERGY
Grand Junction Office
Under Contract DE-AC13-02GJ79491

EXECUTIVE SUMMARY

This *Weldon Spring Site Environmental Report for Calendar Year 2002* has been prepared as required by DOE Order 232.1 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 former Weldon Spring Chemical Plant and Raffinate Pits area and the Weldon Spring Quarry. The chemical plant and raffinate pits area and the 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 presents environmental monitoring data from routine radiological and nonradiological sampling activities. These data include estimates of dose to the public from activities at 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 2002 to support environmental protection programs are discussed.

Historical water quality and water level data for existing wells can be found on the Grand Junction Long-Term Surveillance and Maintenance Program website: www.gjo.doe.gov/programs/ltsm/. This data can be graphed or presented in a table format for selected analytes. Photographs, maps, and physical features can also be viewed on this web page.

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). Throughout the remediation, the ALARA principle has driven the work activities conducted 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 CERCLA, 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), 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 2002:

- Final grading and seeding were completed at the chemical plant.
- A pilot scale in-situ chemical oxidation treatment of TCE in the groundwater was conducted.
- Backfilling, final grading, and seeding were completed at the Quarry.
- The Quarry Interceptor Field Study was completed.

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. Release estimates for total uranium in water (which include storm water and water from the treatment plants) decreased from the 2001 release estimate of 3.34 kg/yr (7.35 lb/yr) to 2.39 kg/yr (5.26 lb/yr) in 2002. As can be seen in the following figure, the annual release of total uranium for 2002 was a 99% reduction from the 1987 annual estimate. Effluent releases were well 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. Taking into account all applicable exposure pathways, the total effective dose equivalent to a hypothetical maximally exposed individual was from consumption of water at Spring 5303, located in the SE Drainage, and was 0.16 mrem (1.6E-3 mSv). This estimate is well below the DOE guideline of 100 mrem (1 mSv). 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).

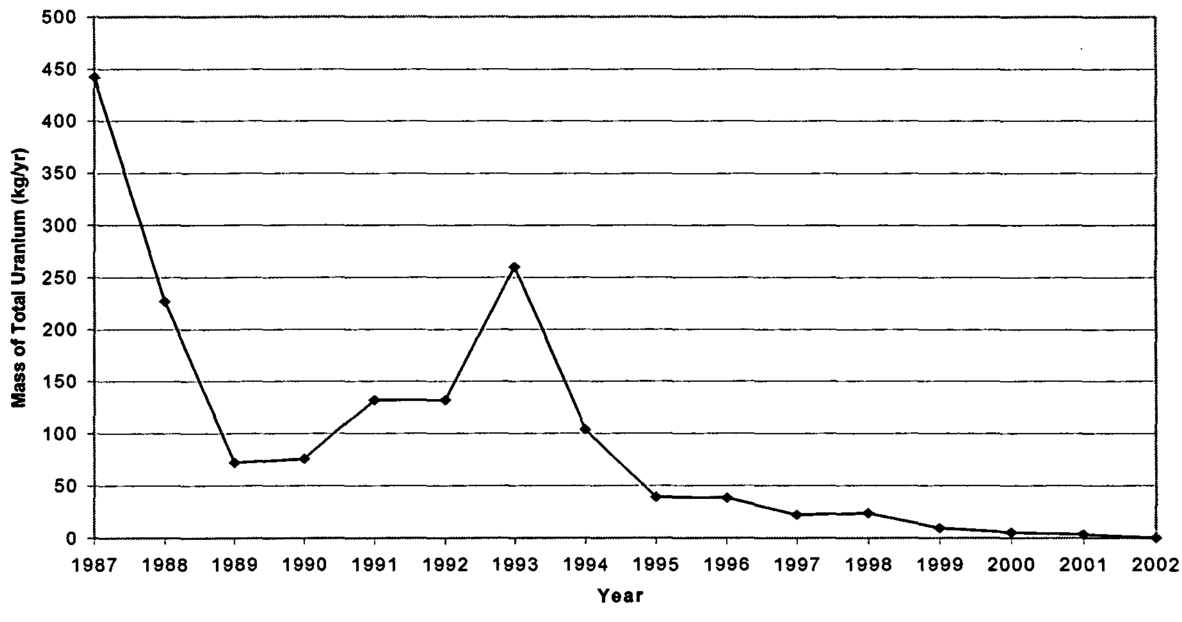
NPDES Monitoring

In 2002, surface water runoff at the chemical plant transported uranium from the site through seven major discharge routes that are identified in Section 6 of this report. The total mass of uranium migrating off-site in storm water and treated effluent was 2.39 kg/yr (5.26 lb/yr). Based on natural uranium activity ratios, this is equivalent to an activity of 0.0024 Ci/yr (8.88E7 Bq/yr). The total mass of uranium was less than the CY 2001 mass of 3.34 kg/yr (7.35 lb/yr). 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 as the site vegetation becomes more dense.

Annual average uranium concentrations at the NPDES outfalls were all well below the derived concentration guideline of 600 pCi/l. With respect to 2001 levels, average uranium concentrations have decreased or remained substantially the same at the stormwater outfalls. Historical uranium trends for the three major NPDES outfalls (i.e., NP-0002, NP-0003, and NP-0005) are discussed in Section 6.

Radiological parameters at the outfalls were in compliance with NPDES permit requirements during 2002. Other parameters were also in compliance with the exception of thirteen storm water settleable solids results.

Total Annual Uranium Discharged at NPDES Outfalls



Surface Water Monitoring

Surface water monitoring in 2002 indicated that contaminant concentrations were within historic ranges. Average uranium levels at the off-site surface water locations were similar to those averages reported in 2001.

Groundwater Monitoring

The groundwater monitoring programs included extensive monitoring for radiological and chemical compounds, as discussed in Section 7. 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.

Chemical plant area monitoring continued to show elevated concentrations of nitroaromatic compounds in the former Frog Pond area. A contaminant investigation has been performed in response to these increases. Other contaminants (nitrate, uranium, and TCE) remained within historical levels. Monitoring at Burgermeister Spring has shown a decrease in uranium and nitrate concentrations over time.

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 variations in the existing groundwater contamination underlying the site.

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Weldon Spring Site Remedial Action Project

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ABSTRACT

This *Site Environmental Report for Calendar Year 2002* 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.

The total effective dose equivalent (TEDE) to a hypothetical maximally-exposed individual who frequented the Weldon Spring Vicinity Properties during 2002 was 0.16 mrem (1.6E-3 mSv). This estimate is well below the U.S. Department of Energy (DOE) requirement of 100 mrem (1 mSv) annual TEDE for all exposure pathways.

Concentration limits are specified for liquid effluent pollutants in the National Pollutant Discharge Elimination System (NPDES) permits. Parameters were in compliance with the permit limits except for thirteen samples which exceeded the 1.0 ml/l/hr settleable solids limit for storm water. The total mass of uranium migrating off-site in storm water and treated effluent during 2002 was 2.39 kg (5.26 lb).

Extensive groundwater monitoring at the WSSRAP showed that there was no radiological impact to any drinking water sources. Several field studies were conducted to assess the technological feasibility of removing groundwater contaminants at both the quarry and the chemical plant/raffinate pits area.

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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 2002* summarizes the environmental monitoring results obtained in 2002 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 231.1, *Environment, Safety and Health Reporting;* 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 2002, 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 2002* include:

- Providing general information on the WSSRAP and the current status of remedial activities.
- Presenting summary data and interpretations for the 2002 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

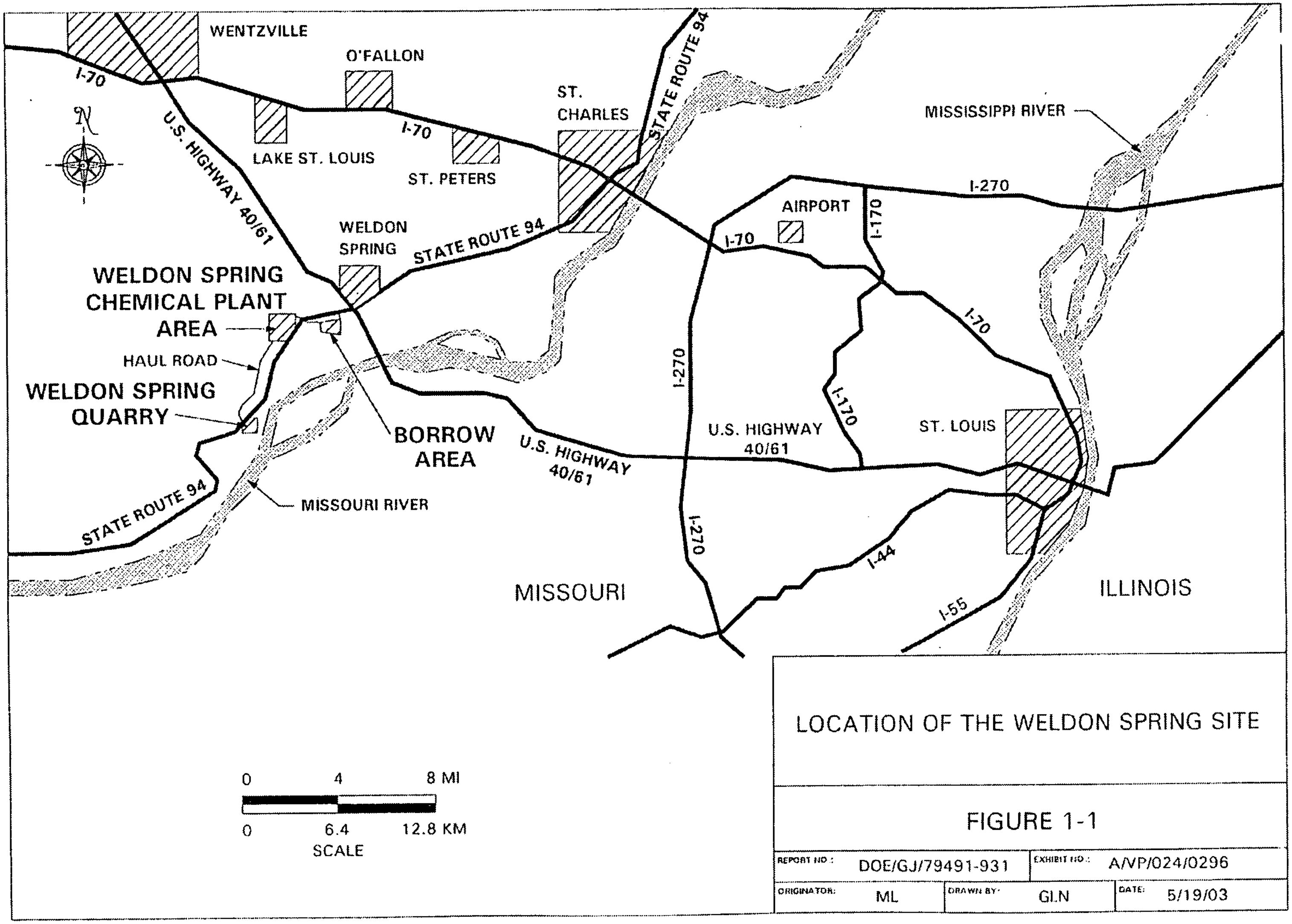
The Weldon Spring site is in southern St. Charles County, Missouri, approximately 48 km (30 mi) west of St. Louis, as shown in Figure 1-1. The site consists of two main areas, the former Weldon Spring Chemical Plant and Raffinate Pits area and the Weldon Spring Quarry, both located along Missouri State Route 94.

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 (see Figure 1-2). 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. These contaminated soils have all been remediated. The Raffinate Pits on the chemical plant site consisted of four settling basins that covered approximately 10.5 ha (26 acres). 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). During 1999 and 2000, the four raffinate pits were remediated and backfilled. The disposal cell was completed in 2001.

The Weldon Spring Quarry is a former 3.6 ha (9 acre) limestone quarry south-southwest of the chemical plant area (Figure 1-3). 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. The quarry water treatment plant was dismantled in 2001, and backfilling of the quarry was completed in 2002.

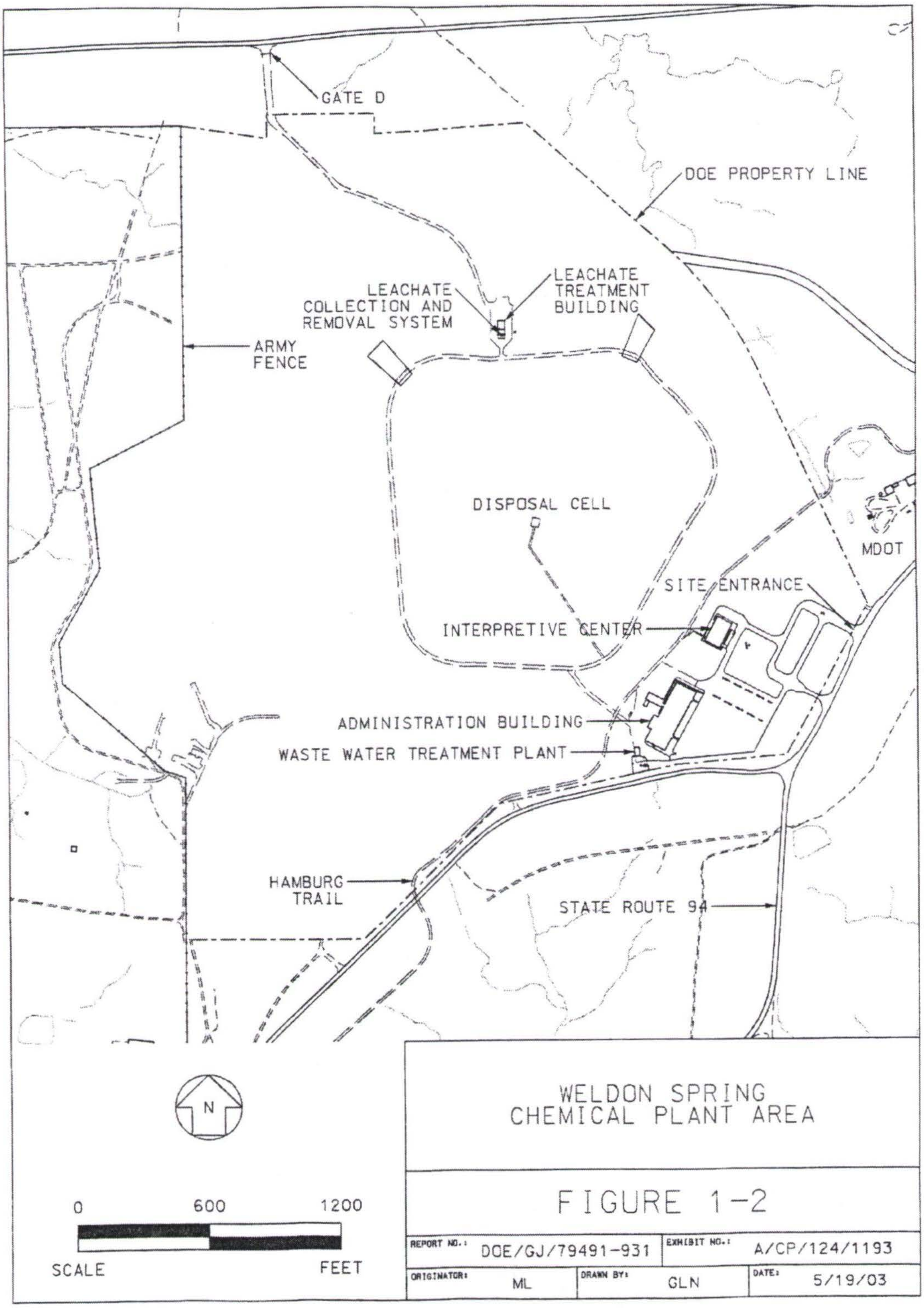
1.2 Site History

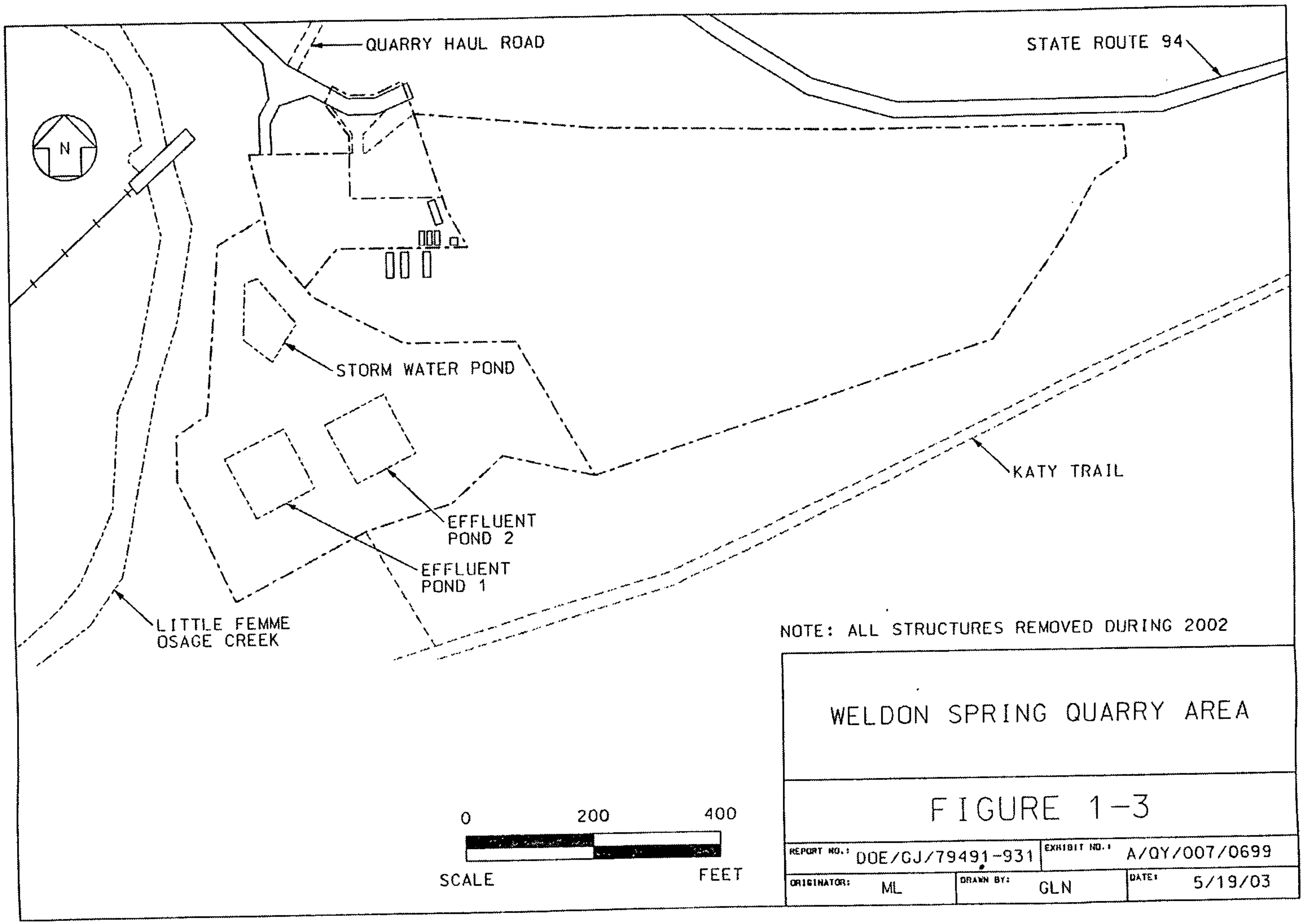
From 1941 to 1945, the U.S. Department of the Army produced trinitrotoluene (TNT) and dinitrotoluene (DNT) at the Weldon Spring Ordnance Works, which covered 6,974 ha (17,233 acres) of land that now includes the Weldon Spring site. By 1949, all but about 809 ha (2,000 acres) had been transferred to the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


GATE D
DOE PROPERTY LINE
LEACHATE COLLECTION AND REMOVAL SYSTEM
LEACHATE TREATMENT BUILDING
ARMY FENCE
DISPOSAL CELL
MDOT
SITE ENTRANCE
INTERPRETIVE CENTER
ADMINISTRATION BUILDING
WASTE WATER TREATMENT PLANT
HAMBURG TRAIL
STATE ROUTE 94
N
0
600
1200
SCALE
FEET
WELDON SPRING CHEMICAL PLANT AREA
FIGURE 1-2
REPORT NO.: DOE/GJ/79491-931
EXHIBIT NO.: A/CP/124/1193
ORIGINATOR: ML
DRAWN BY: GLN
DATE: 5/19/03


QUARRY HAUL ROAD
STATE ROUTE 94
N
STORM WATER POND
KATY TRAIL
EFFLUENT POND 2
EFFLUENT POND 1
LITTLE FEMME OSAGE CREEK
NOTE: ALL STRUCTURES REMOVED DURING 2002
0
200
400
SCALE
FEET
WELDON SPRING QUARRY AREA
FIGURE 1-3
REPORT NO.: DOE/GJ/79491-931
EXHIBIT NO.: A/QY/007/0699
ORIGINATOR: ML
DRAWN BY: GLN
DATE: 5/19/03

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, which consisted of 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.

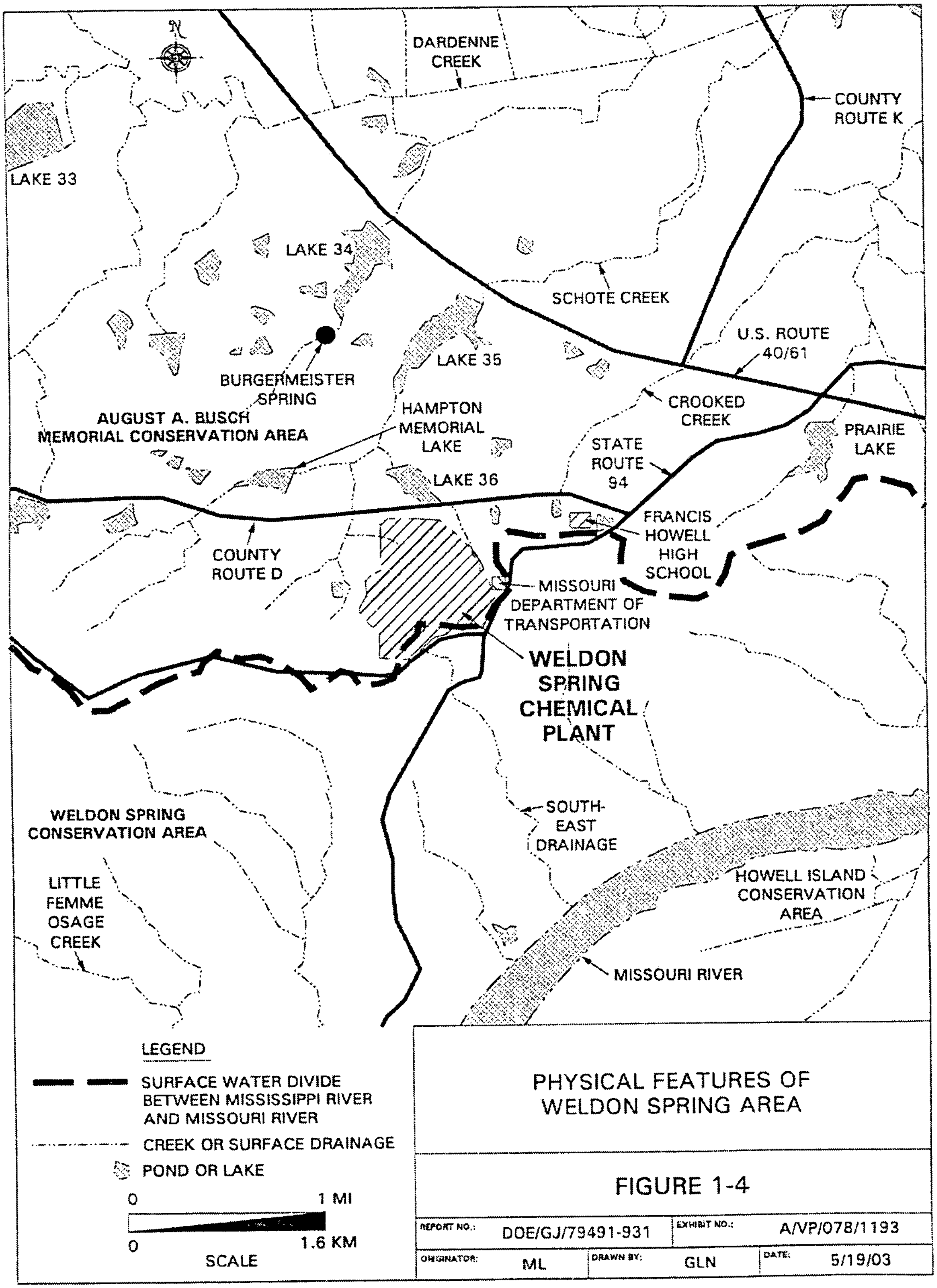
There are three bedrock aquifers underlying St. Charles County. The shallow aquifer consists of Mississippian Limestones, and the middle aquifer consists of the Ordovician Kimmswick Limestone. The deep aquifer includes formations from the top of the Ordovician St. Peter Sandstone to the base of the Cambrian 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 areas are 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 203 m (665 ft) above msl near the southern edge. (The cell is not included in these elevation measurements.) The natural 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 (or 5300 Drainageway - based on the site's nomenclature) that flows to the Missouri River.



PHYSICAL FEATURES OF WELDON SPRING AREA

FIGURE 1-4

The northern and western portions of the chemical plant site drain to tributaries of the Busch Lakes and Schote Creek, which in turn enter Dardenne Creek, which ultimately drains to the Mississippi River. The manmade 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 water from the lakes or creeks is used for irrigation or for public drinking water supplies.

Before remediation of the chemical plant and raffinate pits area began, there were six surface water bodies on the site: the four raffinate pits, Frog Pond, and Ash Pond. The water in the raffinate pits was treated prior to release, and the pits were remediated and confirmed clean. Frog Pond and Ash Pond were flow-through ponds that were monitored prior to being remediated and confirmed clean. Throughout the project, retention basins and sedimentation basins were constructed and used to manage potentially contaminated surface water. During 2001, the four sedimentation basins that remained were remediated, and the entire site was brought to final grade and seeded with temporary vegetation. Final seeding was conducted during 2002.

The Weldon Spring Quarry is situated on a bluff of the Missouri River valley about 1.6 k (1 mi) northwest of the Missouri River at approximately River Mile 49. Because of the topography of the area, no direct surface water entered or exited the quarry before it was remediated. A 0.07 ha (0.2-acre) pond within the quarry proper acted as a sump that accumulated direct rainfall within the quarry. Past dewatering activities in the quarry suggested that the sump interacted directly with the local ground water. All water pumped from the quarry before remediation was treated before it was released. Bulk waste removal, which included removal of some sediment from the sump area, was completed during 1995. The quarry was backfilled, graded, and seeded during 2002.

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 experimental farms (Ref. 4). The slough is essentially land-locked and is currently used for recreational fishing. The slough is not used for drinking water or irrigation.

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.).

The on-site meteorological station was dismantled in May 2002, to facilitate final site restoration activities. For the four months it was operational, the on-site meteorological data recovery exceeded 99% in 2002. Precipitation, temperature, wind speed, and wind direction results are in Table 1-1. Precipitation, average temperature, wind speed, and wind direction were all within historical ranges for the St. Louis area.

Table 1-1 Monthly Meteorological Monitoring Results for 2002

MONTH	TOTAL PRECIP (CM)	AVERAGE TEMP (DEGREES C)	AVERAGE WIND SPEED (M/SEC)	PREDOMINANT WIND DIRECTION
January	9.4	2.7	3.1	SSW – 26.8%
February	2.6	3.3	3.8	S – 11.8%
March	9.1	5.2	3.5	SSW – 13.2%
April	13.7	14.6	3.3	SSW – 15.3%
May*	19.8	17.6	4.0	NA
June*	13.4	25.6	3.5	NA
July*	3.7	28.2	3.2	NA
August*	10.5	26.7	3.5	NA
September*	6.2	23.0	2.9	NA
October*	12.1	12.9	3.3	NA
November*	2.9	6.7	4.0	NA
December*	5.1	3.1	4.1	NA

* Data obtained from the National Weather Service.
NA Not available.

1.7 Land Use and Demography

The population of St. Charles County is about 300,000. Twenty percent of the population lives in the city of St. Charles, approximately 22 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 is about 5,000. 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 (Ref. 7).

Francis Howell High School (FHHS) is about 1 km (0.6 mi) northeast of the site along Missouri State Route 94 (Figure 1-4). The school employs approximately 150 faculty and staff, and about 1,600 students attend school there. In addition, approximately 50 full-time employees work at the high school annex, and about 50 bus drivers park their school buses in the adjacent parking lot.

The Missouri Department of Transportation Weldon Spring Maintenance facility, located adjacent to the north side of the chemical plant, employs about 10 workers. 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 (Ref. 7). 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 50 people.

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 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.

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 included 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

At the WSSRAP, environmental monitoring is conducted 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 complies with DOE Order 5400.5 requirements for preparation and maintenance of an *Environmental Monitoring Plan* (EMP) (Ref. 8). The EMP details the schedule and analyses required 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. 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) and/or Ra-226, Ra-228, Th-228, Th-230, and Th-232. These parameters are the primary radiological contaminants of concern at the Weldon Spring site. Radiological monitoring is conducted on National Pollutant Discharge Elimination System (NPDES) discharges, streams, lakes, ponds, groundwater, and springs. Radiological air monitoring was discontinued at the end of 2000 because radioactive waste handling activities were essentially complete and no critical receptor air monitoring data had ever demonstrated an effective dose equivalent to the public greater than 10% of the 10 mrem standard (Ref. 7).

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 2002 monitoring program are metals, inorganic ions (nitrate and sulfate), TCE, and nitroaromatic compounds.

2.4 Project Accomplishments in 2002

The majority of remedial action activities were completed prior to 2002 under the overall plan for remediation of the site. The remaining accomplishments from 2002 for the operable units are detailed below.

2.4.1 Weldon Spring Chemical Plant Operable Unit

The disposal cell was completed in 2001 with additional final grading and seeding being conducted in 2002.

The EPA conducted the Chemical Plant Operable Unit remedial action inspection on August 29, 2002, with MDNR participation.

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 Quarry Residuals Operable Unit (QROU) addresses contamination remaining in the quarry after the water and bulk wastes were removed. The following activities were completed:

- Removal of effluent ponds.
- Initiation of the Quarry Residuals Long-Term Monitoring Plan.
- Completion of the Quarry Interceptor Trench Field Study.
- Demolition of the Quarry Interceptor Trench System (QITS).
- Completion of the final Quarry backfill.
- Stabilization and off-site disposal of sediment from effluent pond 2.

EPA conducted the Quarry Residuals Operable Unit remedial action inspection on December 6, 2002, with MDNR participation.

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.

A subcontract to perform pilot scale treatment and prepare of a full-scale design for in-situ chemical oxidation of TCE in the groundwater was awarded on December 26, 2001. Injection wells and monitoring well installations and development were performed from January 30, 2002, through March 1, 2002. Baseline groundwater sampling was performed from March 26 through March 28, 2002. Performance monitoring was conducted by both the subcontractor and the PMC throughout the pilot scale project. A summary has been provided in Section 10 of this report.

2.5 Incident Reporting - Environmental Occurrences in 2002

In accordance with DOE Order 231.1, 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 2002, four 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, which are discussed in the following paragraphs. Each of the occurrence reports included more than one occurrence. The reports were each reissued as roll-up reports in accordance with the DOE Order to include the subsequent occurrences.

Table 2-1 Environmental Occurrences Calendar Year 2002

OCCURRENCE REPORT NUMBER	INITIAL OCCURRENCE DATE	SUBJECT OF OCCURRENCES
2002-0002	01/31/2002	Two NPDES permit exceedances.
2002-0004	05/09/2002	Two NPDES permit exceedances.
2002-0005	08/13/2002	Six NPDES permit exceedances.
2002-0006	10/29/2002	Three NPDES permit exceedances.

The environmental occurrences, which were reported in 2002, involved exceedances of the NPDES permit total settleable solids limits at different storm water outfalls around the site. The limit is set at 1.0 ml/l/hr. Settleable solids permit exceedances have occurred periodically during remediation generally caused by the fact the site has been undergoing extensive remediation, construction, excavation, grading, and restoration. The exceedances were required to be reported to the Missouri Department of Natural Resources in accordance with the standard conditions of the NPDES permits.

The exceedances have only occurred at times of extremely heavy rainfall. The project has maintained an active erosion protection program and has continually strived to prevent the NPDES exceedances. Final grading and seeding was completed during 2002, and with the ongoing establishment of good vegetation, the exceedances should be prevented in the future.

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 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 *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

The meteorological station was dismantled during April 2002, to allow for final site restoration. After this time, local metropolitan area data available from the National Weather Service has been used to support any remaining environmental programs.

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 procedure 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. 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, 2002, the WSSRAP was in full compliance with all applicable sections of 10 CFR 835.

2.6.5 Waste Management Program

The waste management program for the Weldon Spring site has encompassed all waste-related activities (both interim and long term) including characterization, treatment, storage, transportation, minimization, and disposal. Hazardous, radioactive, toxic, mixed, special, and uncontaminated waste produced as a direct result of project cleanup activities have been within the scope of this program. Garbage and refuse generated as a result of project administration were excluded. The majority of waste management activities at the site have been completed.

Waste management activities for 2002 included:

- Management and planning for wastes generated after cell closure.
- Carbon adsorption treatment of TCE-tainted monitoring well purge water.
- Stabilization and neutralization of small quantities of miscellaneous waste.
- Collection and inventory of remaining chemical and laboratory wastes.
- Shipment of remaining site debris, soil and stabilized sediment from effluent pond 2 to Environsafe in Grandview, Idaho.
- Shipment of 24 drums of stabilized ion exchange resin and small amounts of debris to Envirocare in Clive, Utah.
- Shipment of light bulbs, batteries, and computer parts 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 that have been 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 list of items recycled during 2002: batteries, paper, cardboard, newspaper, aluminum cans, circuit boards, toner cartridges and light bulbs.

3. COMPLIANCE SUMMARY

3.1 Compliance Status for 2002

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. With near completion of the project, the applicability of certain ARARs has been reduced or eliminated.

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.

Resource Conservation and Recovery Act

Hazardous wastes at the Weldon Spring site have been managed as required by RCRA as substantive, applicable, or relevant and appropriate requirements (ARARs). This has included 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 were generated during remedial activities. The majority of the hazardous waste activities at the site have been completed.

A RCRA treatment, storage, and disposal permit was not required at the site since the remediation has been 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.

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 includes meeting parameter limits and permit conditions specified in five National Pollutant Discharge Elimination System (NPDES) permits. Under these permits, both effluent and erosion-control monitoring are performed. Section 6 provides additional details on the NPDES program.

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.

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 2002 *Emergency Planning and Community Right-to-Know Act* (EPCRA) Tier II report was completed and submitted on February 28, 2003, to the local emergency planning committee, the Missouri State Emergency Response Commission, and Cottleville Fire Protection District.

The Toxic Release Inventory (TRI) report for 2002 is due on July 1, 2003. Based on the chemical usage in 2002, the WSSRAP is not required to submit a TRI report.

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 hypothetical maximally exposed individual was due to consumption of water from Burgermeister Spring. This dose was calculated to be 0.38 mrem, which is well below the 100 mrem (1 mSv) guideline for all potential exposure pathways.

The annual average uranium concentrations at all NPDES outfalls were well 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 during 2002 are maintained in accordance with the requirements of this Order. All reports and records generated at the WSSRAP during 2002, pursuant to DOE Order requirements, presented data in the units specified by the applicable regulation or Order.

The WSSRAP transmitted for approval an application for authorized limits for off-site waste disposal, dated February 6, 2002. The purpose of this request was to receive authorized limits approval in accordance with DOE Order 5400.5 to dispose of the low-level radioactively contaminated debris, soil and sediments at Envirosafe in Grandview, Idaho. The authorized limits request was approved by the Manager of the Oak Ridge Operations Office on March 29, 2002.

3.1.2.2 DOE Order 5400.1, General Environmental Protection Program

DOE Order 5400.1 establishes environmental protection program requirements, authorities, and responsibilities for DOE operations to ensure compliance with applicable federal, state, and local environmental protection laws and regulations, EOs, and DOE policies.

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.

3.1.2.3 DOE Order 231.1, Environmental, Safety, and Health Reporting

DOE Order 231.1 ensures collection and reporting of information on environment, safety and health that is required by law or regulation.

3.2 Summary of Permits for 2002

Table 3-1 provides a summary of all NPDES permits. Five active NPDES operating permits covered storm and treated water discharges from the site (MO-0107701); storm and treated water discharges from the quarry (MO-0108987); storm water discharges from the Borrow Area (MO-R100B69); hydrostatic test water discharges from the site (MO-G670203); and storm water discharges from the quarry borrow area (MO-R104031).

Table 3-1 Summary of WSSRAP NPDES Operating and Construction Permits

PERMIT NO.	(a)	DATE ISSUED	EXPIRATION DATE	(b)	DATE RENEWAL OR EXTENSION REQUEST DUE	SCOPE AND COMMENTS
MO-0107701	O	07/14/00	07/13/05	N	01/13/05	Covers storm water, sanitary, and SWTP discharges.
MO-0108987	O	07/17/98	07/16/03	N	01/16/03	Covers QWTP discharge and storm water.
MO-R100B69	O	05/03/02*	02/02/07	N	Termination request submitted on 09/13/02.	Storm water discharges from Borrow Area and haul road operations.
MO-G670203	O	12/05/97	10/23/02	N	Terminated on 01/28/03.	Covers hydrostatic test water at site.
MO-R104031	O	05/03/02*	02/07/07	N	Termination request submitted on 07/18/02.	Covers quarry borrow area storm water land disturbance.
CP-22-5186	C	01/08/97	01/07/02	N	Permit closed.	Covered construction of cell leachate collection system.

(a) Permit type, O = Operating, C = Construction
(b) Permit renewal application submitted N = No, Y = Yes.
QWTP Quarry water treatment plant
SWTP Site water treatment plant.
* Existing permits reissued during 2002.

3.3 Site Mitigation Action Plan

Progress of mitigative actions for remediation of the Weldon Spring site is reported annually in this document, 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. Mitigative actions for 2002 are described in the following paragraphs.

Construction activities at the Weldon Spring site have been managed by using good engineering practices for control of surface water runoff at, and from, the site. Surface water protection during 2002 included erosion prevention and sediment control and monitoring. Monitoring was conducted at six outfall locations at the chemical plant and one at the quarry. The requirements of NPDES permits and the *Missouri Clean Water Act* were met during 2002. Further information on NPDES compliance issues is provided in Section 6.

The Borrow Area operations were completed and the Borrow Area Facility was turned over to the Missouri Department of Conservation.

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.

The construction activities and other related activities which were the subject of the MAP have been completed, therefore the requirements of the MAP are considered complete and final.

4. AIR MONITORING PROGRAMS

In the past, the Weldon Spring Site Remedial Action Project (WSSRAP) operated an extensive environmental airborne monitoring and surveillance program in accordance with U.S. Department of Energy (DOE) Orders, U.S. Environmental Protection Agency (EPA), National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations, and the WSSRAP *Environmental Monitoring Plan* (Ref. 8). Throughout the remediation of contaminated soils and materials, the potential for airborne releases and atmospheric migration of radioactive contaminants was closely monitored by measuring concentrations of radon, gamma exposure, airborne radioactive particulates, airborne asbestos, and fine particulate matter at various site perimeter and off-site locations. With the final disposition of contaminated materials in the permanent disposal cell, the potential for airborne release of radionuclides has been eliminated. The environmental air monitoring program for 2001 consisted only of ambient dust monitoring. With the completion of most site activities, no ambient dust monitoring was conducted during 2002.

5. RADIATION DOSE ANALYSIS

This section evaluates the potential effects of surface water and groundwater discharges of radiological contaminants from the Weldon Spring Site Remedial Action Project (WSSRAP) in 2002. Effective dose equivalent has been calculated for 2002 based on the applicable exposure pathway. Doses resulting from airborne emissions are no longer calculated since the potential for airborne release of radiological contaminants has been eliminated and, therefore, 40 CFR 61, Subpart H *(National Emission Standards for Emissions of Radionuclides other than Radon From Department of Energy Facilities)* regulations are no longer relevant. Similarly, doses resulting from external gamma radiation are no longer calculated since the radon sources have been remediated and are contained within the permanent disposal cell. The cell cover effectively mitigates radon releases to levels comparable to background locations.

For this report, the exposure scenario and dose calculation for a hypothetical maximally exposed individual are presented. The estimated total effective dose equivalent (TEDE) to the hypothetical maximally exposed individual due to consumption of water from Spring 5303, which is located in the SE Drainage, is 0.16 mrem (1.6 E-3 mSv). This result is compared to U.S. Department of Energy (DOE) limits contained in DOE Order 5400.5 to demonstrate compliance with regulatory requirements.

The dose for a collective population would be similar to that calculated and presented in the *2001 Site Environmental Report* (Ref. 25) where the collective dose was reported to be 0.103 person-rem (1.03E-3 person-Sv).

5.1 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 evaluated to determine which pathways are complete. This pathway analysis is detailed in the site *Environmental Monitoring Plan* (Ref. 8). 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. If a link exists between one or more contaminant sources, or between one or more environmental transport processes and an exposure point where human or ecological receptors are present, a pathway exist and is used to assess radiological and nonradiological exposures.

Consumption of contaminated groundwater is not a relevant pathway as concentrations of radioactive contaminants in the production wells near the Weldon Spring Quarry are comparable to background concentrations (see Section 7.5). In addition, no drinking water wells are located in the vicinity of the contaminated groundwater in the chemical plant and raffinate pits area.

The inhalation of airborne particulates, radon gas and external gamma irradiation pathways are also not applicable to the 2002 dose estimate since the contaminated soils and water have been remediated and placed in the on-site cell.

DOE Order 5400.5 contains the radiological public dose guideline that is applicable for the WSSRAP. This guideline provides for an annual limit of 100 mrem (1 mSv) total effective dose equivalent accounting for all exposure pathways (excluding background).

5.2 Radiological Release Estimates

During 2002, intermittent surface water runoff transported isotopes of uranium from the site through seven storm water outfalls. The outfalls were monitored monthly in accordance with National Pollutant Discharge Elimination System (NPDES) requirements. Total 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. Table 5-1 shows the estimated activity release of radionuclides to the environment, the corresponding mass released, and the half-life for each uranium isotope present at the Weldon Spring site.

Table 5-1 Radionuclide Releases to the Environment

RADIONUCLIDE	ACTIVITY OF RADIONUCLIDES RELEASED TO WATER (Ci)	MASS OF RADIONUCLIDE RELEASED (grams)	HALF-LIFE (Yrs)
U-238	1.183E-3	3.59E+3	4.47E+09
U-235	0.055E-3	2.5E+1	7.04E+08
U-234	1.171E-3	1.89E-1	2.46E+05
Total	2.409E-3	3.62E+3	NA

NA Not applicable.
Note: Multiply by 3.7E10 to convert Ci to Bq.

5.3 Exposure Scenarios

Dose calculations were performed for a hypothetical maximally exposed individual to assess dose due to radiological releases from the Weldon Spring site. A dose calculation for a population within 80 km (49.6 mi) of the site is not estimated since airborne release of radioactive contaminants is not a factor.

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.

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).

5.4 Dose Equivalent Estimates

Total effective dose equivalent (TEDE) estimate for the exposure scenario was calculated using 2002 environmental monitoring data. The dose is well below the standards set by the DOE for annual public exposure.

This section discusses the estimated total effective dose equivalent to a hypothetical individual assumed to frequent the SE Drainage (SP-5303) of the Weldon Spring Conservation Area. No private residences are adjacent to the SE Drainage, which is situated on land currently managed by the Missouri Department of Conservation (MDC). Therefore, the calculation of dose equivalent is based on a recreational user of the Conservation Area who drank from Spring 5303 twenty times per year during 2002.

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

- The maximally exposed individual drank one cup (0.2 l) of water from the Spring twenty times per year (equivalent to 1.05 gal (4.0) of water for the year).
- Maximum uranium concentration in water samples taken from SP-5303 during 2002 (145 pCi/l) were assumed to be present in all of the water ingested by the maximally exposed individual. For comparison, the maximum uranium concentration at Burgermeister Spring during 2002 was 100 pCi/l.
- The total uranium dose conversion factor (DCFs) for ingestion (Ref. 28) is 2.69E-4 mrem/pCi (soluble). (The DCF for total soluble uranium was calculated using isotopic dose conversion factors for ingestion and the natural uranium activity ratios listed in Section 5.2.)

The total effective dose equivalent (TEDE) is calculated as shown below:

TEDE (ingestion of contaminated water for a given radionuclide) = Concentration (pCi/l) x Volume of Water Ingested (l) x Dose Conversion Factor (mrem/pCi)

TEDE (total uranium) = 145 pCi/l x 4.0 x 2.69E-4 mrem/pCi = 0.16 mrem (1.6E-3mSv)

This value represents less than 0.16% of the DOE standard of 100 mrem (1 mSv) TEDE above background. 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. 36).

6. SURFACE WATER PROTECTION

6.1 Highlights of the Surface Water Program

During 2002, final grading was completed at the chemical plant and quarry sites. These items, and others, are discussed in detail in this chapter.

- The mass of uranium migrating off site in storm water and treated effluent, 2.39 kg/yr (5.26 lb/yr), was a 30.2% reduction from the 2001 mass of 3.34 kg/yr (7.35 lb/yr) and a 99% reduction from the 1987 mass of 442 kg. This demonstrates the effectiveness of remediation.

- Four samples of treatment plant effluent were collected at the quarry during 2002. All parameters monitored in treatment plant effluent were in compliance with National Pollutant Discharge Elimination System (NPDES) permit limits and conditions.

- The annual average concentration of uranium in storm water was reduced to less than 6.6 pCi/l at all outfalls.

- The overall results of the whole effluent toxicity (WET) tests indicated that the quarry water treatment plant effluent was not toxic to test organisms during 2002.

- Surface water bodies downstream of the chemical plant site continue to show declining uranium levels.

- Surface water bodies downstream of the quarry continue to show declining uranium levels.

6.2 Program Overview

The environmental monitoring and protection program for surface waters at the Weldon Spring Site Remedial Action Project (WSSRAP) is described in the *Environmental Monitoring Plan* (Ref. 8) and includes 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, site and quarry borrow areas and hydrostatic test discharges. 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 addition, the surface water monitoring program monitors off-site water bodies for uranium levels 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.

6.3 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 2002 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 6-1 and 6-2. 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 required.

Permit MO-G670203 was issued on December 5, 1997, for discharge of hydrostatic test water from the chemical plant site. Hydrostatic test water is potable 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 6.6.1.2.4.

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 7-1.

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 6-1 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[(a)] NP-1005	NP-0006
Sampling Frequency	once/month	Once/quarter
Flow	GPD (monitor only)	GPD (monitor only)[(b)]
Settleable Solids	1.0 ml/l/hr	NA
Total Suspended Solids	mg/l (monitor only)[(c)]	30/45 mg/l[(d)]
Nitrate and Nitrite as N**	mg/l (monitor only)	NA
Uranium, total	mg/l (monitor only)*	NA
Gross alpha, beta	pCi/l (monitor only)	NA
PH	6 - 9 standard units	6 - 9 standard units
Fecal coliform	NA	400/1000 colonies/ 100 ml[(e)]
Biochemical Oxygen Demand	NA	30/45 mg/l[(d)]
Total Residual Chlorine	NA	1.0 mg/l

NOTE: Refer to Figures 6-1 and 6-2 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 area.
(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.
NA Not Applicable.

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

NOTE: Refer to Figures 6-1 and 6-2 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 0.5 μg/l.
(e) Daily maximum (monthly average).
(f) Priority pollutants are listed in 40 CFR 122.21 Appendix D, Tables II and III.
(g) Limit applies to chemical plant; monitoring only at quarry.
(h) Annual monitoring.
(i) Quarterly monitoring.
(j) "No statistical difference between effluent and upstream results at 95% confidence level."

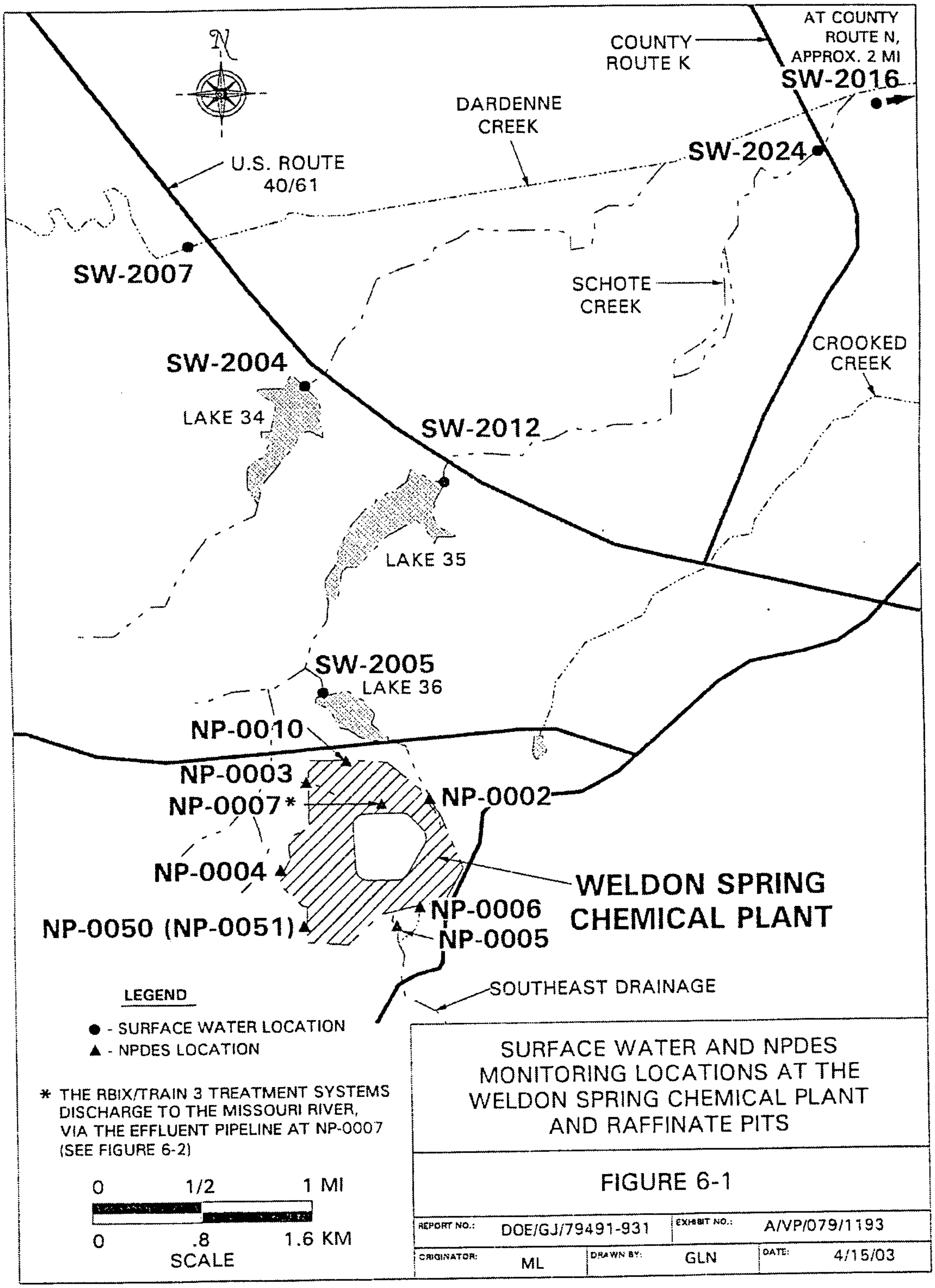
6.4 Hydrology Description of the Site and Quarry

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.

6.4.1 Weldon Spring Chemical Plant and Raffinate Pits

The chemical plant area is located on the Missouri-Mississippi River surface drainage divide (Figure 1-4). 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 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 6-1). During 2002 the area received final seeding. Runoff from part of the disposal cell discharges in this watershed.

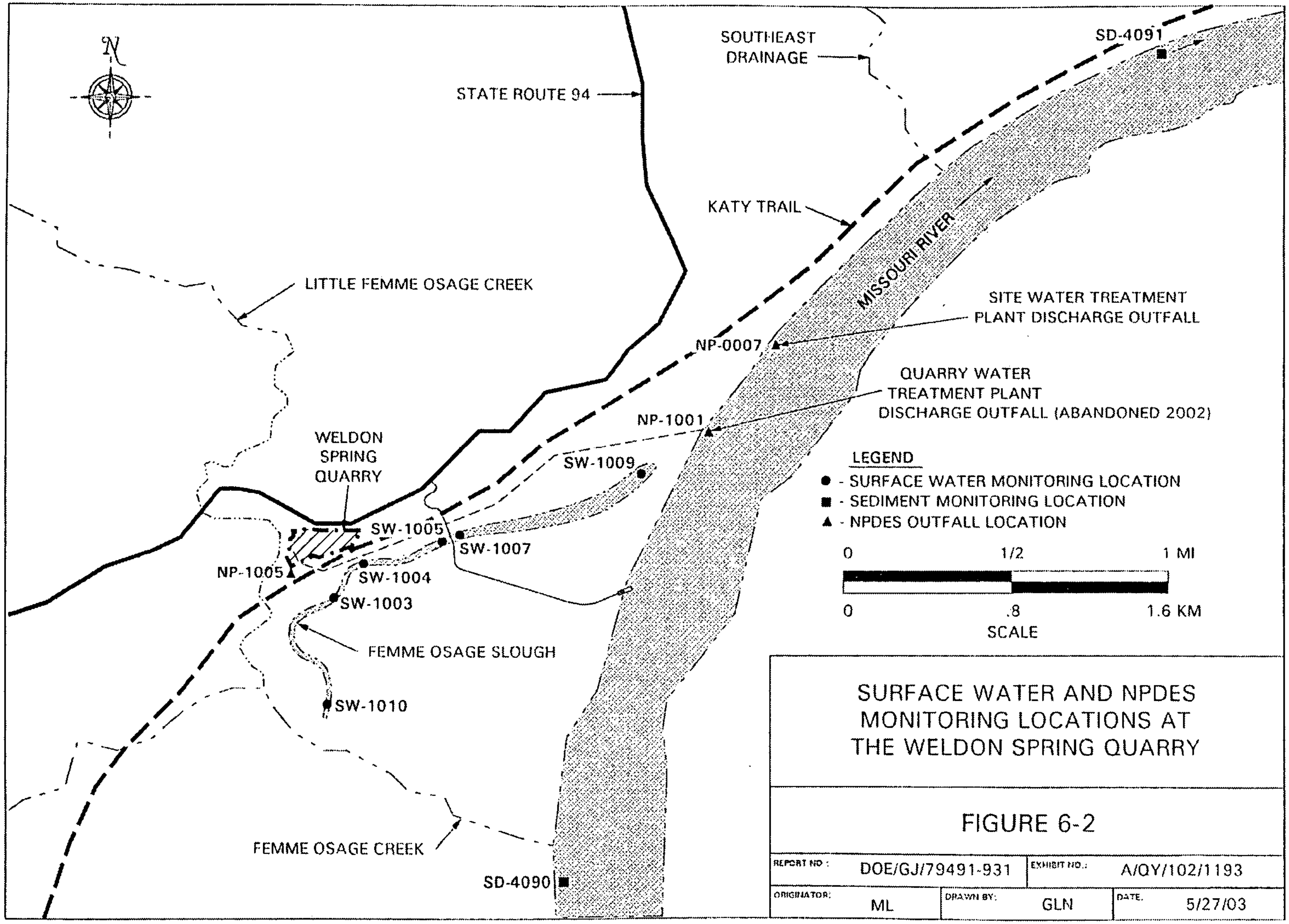
Surface water drainage from the northeast section of the chemical plant site discharges to Dardenne Creek from Schote Creek after first flowing through Busch Lakes 36 and 35 (Figure 6-1). Runoff from the southern portion of the chemical plant site (Figure 6-1) flows southeast to the Missouri River via the Southeast Drainage (Valley 5300). During 2002, the area received final seeding.



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

FIGURE 6-1

REPORT NO.: DOE/GJ/79491-931 EXHIBIT NO.: A/VP/079/1193
ORIGINATOR: ML DRAWN BY: GLN DATE: 4/15/03



SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 6-2

REPORT NO.:	DOE/GJ/79491-931	EXHIBIT NO.:	A/QY/102/1193
ORIGINATOR: ML	DRAWN BY: GLN	DATE:	5/27/03

6.4.2 Weldon Spring Quarry

The Femme Osage Slough is directly south of the quarry and is known to receive contaminated groundwater from the quarry through subsurface recharge (Figure 6-2). There is no natural surface flow from the slough; it is essentially land locked. The Femme Osage Slough is monitored to detect changes in the system.

6.5 Monitoring Requirements

Sections 6.5.1 and 6.5.2 discuss monitoring requirements at NPDES outfalls and surface water locations at the chemical plant site and the quarry.

6.5.1 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 6-1 and 6-2, 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.

6.5.2 Surface Water Monitoring

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

6.5.2.1 Weldon Spring Chemical Plant and Raffinate Pits

In accordance with the surface water monitoring program, Schote Creek, Dardenne Creek, and Busch Lakes 34, 35, and 36 were sampled quarterly, at five locations (Figure 6-1) for total uranium. This monitoring was conducted to measure the effects of surface water discharges from the site on the quality of downstream surface water.

6.5.2.2 Weldon Spring Quarry

Six locations within the Femme Osage Slough were monitored to determine the impact of groundwater migration from the quarry. These locations, which are shown on Figure 6-2, were monitored quarterly for total uranium.

6.6 Monitoring Results

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

6.6.1 National Pollutant Discharge Elimination System Program Monitoring Results

Radiochemical, chemical, and physical analytical results for NPDES outfalls are presented in subsections 6.6.1.1 and 6.6.1.2.

6.6.1.1 Radiochemical Analysis

For 2002, the annual average uranium concentrations at the storm water discharge points ranged from 0.9 pCi/l (0.03 Bq/l) at NP-0004 to 6.6 pCi/l (0.24 Bq/l) at NP-0010, which are 0.2% and 0.9%, respectively, of the DCG for natural uranium. Average annual gross alpha concentrations ranged from 10.3 pCi/l (0.38 Bq/l) at NP-0004 to 40.6 pCi/l (1.50 Bq/l) at NP-0002. The year 2002 annual average radionuclide concentrations for all the permitted storm water outfalls are shown in Table 6-3.

Uranium concentration averages were calculated on a flow weighted basis for storm water Outfalls NP-0002, NP-0003, NP-0004, NP-0005, and NP-0010. Flow was measured at these outfalls by 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 2002. 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 outfalls NP-0050 (and NP-0051) and NP-1005 because the areas are relatively flat and the flow is diffuse, so it was difficult to get total flow measurements accurate enough for averaging.

Four batches were discharged from the quarry plant. One of the discharges for 2002 was a batch discharge and three were continuous discharges. A batch discharge is treated water that is stored, sampled, and then discharged after compliance is demonstrated. A continuous discharge is treated water that is sampled and discharged prior to receipt of the analytical results. Continuous discharges were used after the final effluent pond had been remediated. No daily maximum or monthly average limits are established for uranium in treated water; however, the design of the treatment plant is based on achieving an average of 30 pCi/l (1.11 Bq/l) uranium, with a maximum never to exceed 100 pCi/l (3.7 Bq/l). The average uranium concentration for the quarry water treatment plant was well below this level at 12.5 pCi/l (0.46 Bq/l) (Table 6-5). In addition, the quarry water treatment plant averaged 18.9 pCi/l (0.70 Bq/l) for gross alpha and 10.2 pCi/l (0.38 Bq/l) for gross beta (Table 6-4).

Table 6-3 2002 Annual Average NPDES Results for the Weldon Spring Chemical Plant and Quarry Storm Water Outfalls[(c)]

	LOCATIONS						
	CHEMICAL PLANT						QUARRY
PARAMETER	NP-0002	NP-0003	NP-0004	NP-0005	NP-0010	NP-0050, 51	NP-1005
Number of sample events	12	12	11	11	9	11	10
pH range	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Nitrate as N (mg/l)	0.77	0.6	3.7	0.1	0.2	0.1	NS
Total suspended solids (mg/l)	1416	1190	342	524	2211	417	651
Settleable solids (ml/l/hr)	12/2[(b)]	12/3[(b)]	11/1[(b)]	11/1[(b)]	9/3[(b)]	11/1[(b)]	10/2[(b)]
Arsenic (mg/l)	<0.001(1)	0.034(4)	0.007(1)	0.004(2)	NS	NS	0.019(2)
Chromium (mg/l)	<0.007(1)	0.094(4)	0.017(1)	0.005(2)	NS	NS	0.038(2)
Lead (mg/l)	0.010(1)	0.046(4)	0.010(1)	0.004(2)	NS	NS	0.028(2)
Thallium (mg/l)	0.002(1)	0.013(4)	0.009(1)	0.006(2)	NS	NS	0.014(2)
Total uranium (pCi/l)	3.8*	3.1*	0.9*	4.0*	6.6*	3.5	1.3
Gross alpha (pCi/l)	40.6	20.4	10.3	14.8	56.5	15.6	28.6
Gross beta (pCi/l)	38.3	22.8	12.6	17.6	48.6	16.1	40.4
Radium-226 (pCi/l)	0.8(1)	2.58(1)	NS	0.46(3)	NS	NS	NS
Radium-228 (pCi/l)	0.7(1)	<0.47(1)	NS	1.57(3)	NS	NS	NS
Thorium-228 pCi/l)	<0.1(1)	0.23(1)	NS	0.16(3)	NS	NS	NS
Thorium-230 pCi/l)	0.2(1)	<0.65(1)	NS	0.14(3)	NS	NS	NS
Thorium-232 pCi/l)	0.1(1)	0.30(1)	NS	0.08(3)	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.
NS Not Sampled.
Note: 1 pCi/l = 0.037 Bq/l.

Radium and thorium were monitored once per month, as required by the permit, in the quarry water treatment plant batches. Annual averages for radium and thorium at the plant are shown in Table 6-4. Radium and thorium levels were all well below the DCGs, at annual averages at or less than 1.0 pCi/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 6-2). The one-time sampling results were 2.03 pCi/g (0.08 Bq/g) at SD-4090 and 1.20 pCi/g (0.04 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 6-4 Quarry Water Treatment Plant Annual Averages for Radium and Thorium (pCi/l)

PARAMETER	QUARRY WTP (NP-1001)*
Ra-226	0.19 (4/4)
Ra-228	1.0 (1/4)
Th-228	0.08 (4/4)
Th-230	0.16 (4/4)
Th-232	0.10 (2/4)
Gross alpha	18.9 (0/4)
Gross beta	10.2 (0/4)

* Number in parentheses represents the number of results below detection limit (including uncensored values)/total number of samples. When all results are below the detection limit, the value reported is an average detection limit.

Note: 1 pCi/l = 0.037 Bq/l

Estimated quantities of total natural uranium released off site through surface water runoff and treatment plant discharges are in Table 6-5. 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 2002 was 2.39 kg (5.26 lb) and was calculated by multiplying the total runoff volume by the average uranium concentration. This is a decrease from the estimated amount released during 2001, which was 3.34 kg (7.35 lb). Table 6-6 shows the annual average uranium concentrations at NPDES outfalls from 1987 to 2002. Average uranium concentrations at storm water outfalls for 2002, in comparison to levels for 2001, have decreased or remained the same at all outfalls except NP-0010. Radium and thorium were measured at Outfalls NP-0002, NP-0003, and NP-0005 periodically throughout the year to monitor the effects and effectiveness of remediation.

Descriptions of each outfall are provided in the following paragraphs. 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 values are in Table E-4, Appendix E, of the EMP (Ref. 8). All levels were well below the DCGs.

Table 6-5 2002 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	30.6 (75.7)	60	3.8*	318.58 (84.17)	191.15 (50.50)	0.726E-3	1.068
NP-0003	27.8 (68.6)	50	3.1*	288.70 (76.28)	144.35 (38.14)	0.447E-3	0.658
NP-0004	11.3 (28)	30	0.9*	117.84 (31.13)	35.35 (9.34)	0.318E-3	0.047
NP-0005	9.1 (22.4)	30	4.0*	94.27 (24.91)	28.28 (7.47)	0.113E-3	0.166
NP-0010	5.7 (14)	30	6.6*	58.92 (15.57)	17.68 (4.67)	0.117E-3	0.172
NP-0050, 51[b]	5 (12.4)	30	3.5	52.61 (13.90)	15.78 (4.17)	0.552E-3	0.081
NP-1005	6.0 (15)	50	1.3	63.13 (16.68)	31.56 (8.33)	0.041E-3	0.060
NP-1001	NA	NA	12.5	NA	7.36 (1.94)	0.092E-3	0.135
TOTAL	NA	NA	NA	994.05 (262.64)	471.51 (124.56)	2.41E-3	2.39

* 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.

NA Not Applicable.

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

Table 6-6 Fifteen-Year Annual Average Uranium Concentrations (pCi/l) at NPDES Outfalls Since 1987

	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(d)
2000	(a)	5.6*	15.6*	6.0*	6.9*	6.1*	2.7	0.8	1.0*	8.4
2001	(a)	5.7*	4.7*	1.8*	7.2*	3.2*	2.2	6.4	3.5	7.6
2002	(a)	3.8*	3.1*	0.9*	4.0*	6.6*	---	12.5	1.3	3.5

* 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 an abandoned process sewer line. This outfall was physically removed in May 1994 and was officially eliminated from the permit on August 4, 1995.

Outfall NP-0002 is along the northeast perimeter of the site. The average uranium concentration for Outfall NP-0002 in 2002 was 3.8 pCi/l (0.14 Bq/l), lower than the 2001 average of 5.7 pCi/l (0.21 Bq/l). Annual average NPDES results for Outfall NP-0002 are in Table 6-3.

Outfall NP-0003 is along the western perimeter. The average uranium concentration for Outfall NP-0003 was 3.1 pCi/l (0.11 Bq/l), which is lower than the 2001 average of 4.7 pCi/l (0.17 Bq/l). One radium-226 level was above the baseline level. Annual average values are shown in Table 6-3.

Outfall NP-0004 is along the western perimeter. Outfall NP-0004 was eliminated from NPDES permit MO-0107701 on March 4, 1994, but was repermitted on May 22, 1998. The annual average for uranium at NP-0004 was 0.9 pCi/l (0.03 Bq/l), which was lower than the 2001 annual average of 1.8 pCi/l (0.07 Bq/l).

Outfall NP-0005 is along the southern perimeter at the head of the southeast drainage. The annual average uranium concentration at Outfall NP-0005 for 2002 was 4.0 pCi/l (0.15 Bq/l), which was less than the 2001 average of 7.2 pCi/l (0.27 Bq/l). Annual average NPDES results are in Table 6-3.

Outfall NP-0010 is along the northern perimeter. The annual average uranium concentration for 2002 was 5.5 pCi/l (0.20 Bq/l), well below the DCG of 600 pCi/l (22.2 Bq/l) and slightly above the 2001 average of 3.2 pCi/l (0.12 Bq/l). The slight increase is likely the result of elevated solids in the effluent. The annual average NPDES results are in Table 6-3.

Outfall NP-1005 is the storm water outfall at the quarry. This outfall discharges water from the quarry area. The annual average uranium concentration for 2002 was 1.3 pCi/l (0.05 Bq/l), a decrease from the 2001 average of 3.5 pCi/l (0.13 Bq/l). The annual average NPDES results are reported in Table 6-3.

Outfall NP-0051 is along the western side of the site. Before the area was remediated, this outfall was actually two separate outfalls (NP-0050 and NP-0051). 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 2002 was 3.5 pCi/l (0.13 Bq/l), well below the DCG of 600 pCi/l (22.2 Bq/l) and lower than the 2001 average of 7.6 pCi/l (0.28 Bq/l). The annual average NPDES results are in Table 6-3.

6.6.1.2 Physical and Chemical Results

Analytical results for physical and chemical parameters at NPDES outfalls and other sample locations are discussed in Subsections 6.6.1.2.1 through 6.6.1.2.4.

6.6.1.2.1 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 6-3. There were thirteen samples where settleable solids were above the 1.0 ml/l/hr limit. Additional details can be found in Section 2.5 Incident Reporting – Environmental Occurrences in 2002. In addition to the permitted parameters; arsenic, chromium, lead, and thallium were periodically monitored at some outfalls. There was one instance at outfall NP-0003 of a metal (Chromium) that does not have permit limits having a concentration above the 100 μg/l reporting levels for toxic pollutants. This elevated level was suspected of being caused by elevated solids levels in the sample.

6.6.1.2.2 Administration Building Sewage Treatment Plant

Monitoring results for the sewage treatment plant, Outfall NP-0006, are in Table 6-7. All parameters were in compliance for the year. The fecal coliform result for July (700 colonies/100 ml) was above the monthly average limit, but below the daily maximum limit. A second sample for fecal coliform was collected later in July and was non-detect. The two sample results averaged 350 colonies/100 ml, which is below the 400 colonies/100 ml monthly average limit. Therefore, fecal coliform was in compliance for July.

6.6.1.2.3 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 quarry. Therefore, the parameter levels are not summarized here.

During 2002, whole effluent toxicity (WET) tests were required quarterly for effluent from the quarry water treatment plant. Because the quarry plant was only in operation during the first two quarters, there are only two sample results. The WET test is a measure of toxicity without quantifying or identifying the toxic constituents. Tests were conducted on both Ceriodaphnia dubia (water flea) and Pimephales promelas (fathead minnow). The tests were conducted in effluents and in test controls of upstream river water and laboratory control water. No samples failed the WET tests during 2002, indicating that the quarry water treatment plant effluents did not cause the receiving stream to be toxic to test organisms (see Table 6-2). WET test results are summarized in Table 6-8.

Table 6-7 NP-0006, Sewage Treatment Plant Outfall, Sample Test Results for Permitted Parameters

	PARAMETER [(a)] (PERMIT LIMITS)				
MONTH (QUARTER)	TSS (30/45 mg/l)*	BOD (30/45 mg/l)*	FC [(b)] (400/1000 col/100 ml)**	pH (6.0 – 9.0 SU)	TOTAL RESIDUAL CHLORINE (1.0/1.0 mg/l)**
January (1)	10	23	< 4	7.11	0.37
April (2)	< 5	8	<4	6.91	0.74
July (3)	8	8	700***	6.62	0.12
July (3)	N.S.	N.S.	<4***	N.S.	N.S.
October (4)	11	<5	8	6.65	0.35

(a) One sample analysis required for each calendar quarter.
(b) FC – Fecal Coliform.
* Monthly average/Weekly average.
** Monthly average/daily maximum.
*** Monthly average = 351.

Table 6-8 2002 Whole Effluent Toxicity Test Results for the Quarry Water Treatment Plant

BATCH	DATE	DAPHNIA (D) % MORTALITY	PIMEPHALES (P) % MORTALITY	RIVER CONTROL D,P % MORTALITY	LAB CONTROL D,P % MORTALITY
Q077	03/25/02	0	0	0,0	0,0
Q078	05/22/02	0	0	0,0	0,0

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

6.6.1.2.4 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.

There were no hydrostatic test water discharges during calendar year 2002. This permit was terminated in January 2003.

6.6.1.2.5 Borrow Area Land Disturbance Results

NPDES permit MO-R100B69 was reissued on May 29, 1998, for storm water at the borrow area and has no specified monitoring or reporting requirements. The *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 6-9. Settleable solids were all less than 0.2 ml/l/hr.

Oil and grease were monitored four times at the NP-0040 outfall, which is the outfall from the vehicle maintenance area sedimentation basin. All results were below the 10 mg/l water quality standard for oil and grease.

The entire area was seeded and mulched and vegetation became established during 2002. On September 12, 2002, a request was sent to the Missouri Department of Natural Resources to terminate the permit.

Table 6-9 Borrow Area Settleable Solids (ml/l/hr) and Oil and Grease (mg/l)

DATE	LOCATIONS		
	NP-0040*		NP-0046**
	SETTLEABLE SOLIDS	OIL AND GREASE	SETTLEABLE SOLIDS
01/30/02	<0.1	2.3	0.1
04/08/02	<0.1	5.0	<0.1
08/23/02	0.1	2.8	NS
10/25/02	<0.1	1.9	<0.1

NS Not sampled (no discharge).
* North Borrow Area sedimentation basin.
** East Borrow Area sedimentation basin.

6.6.2 Surface Water Monitoring Results

Analytical results for surface water monitoring locations at the chemical plant site and quarry are in Subsections 6.6.2.1 and 6.6.2.2, respectively.

6.6.2.1 Weldon Spring Chemical Plant

Average uranium levels at the off-site surface water locations for 2002 were similar to 2001 averages, being slightly lower at three locations and slightly higher at two locations. This reflects the lower levels seen at the NPDES outfalls. The slightly higher values are in Schote and Dardenne Creeks and are attributed to natural variations. Average annual uranium concentrations for surface water are in Table 6-10 along with the recent 3 year high for each location for comparison. Historic annual averages for these locations are plotted in Figure 6-3. 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.

Table 6-10 2002 Annual Averages for Total Uranium (pCi/l) Concentrations at Weldon Spring Chemical Plant Area Surface Water Locations

LOCATION	ANNUAL AVERAGE	MAXIMUM CONCENTRATION	MINIMUM CONCENTRATION	RECENT 3 YEAR HIGH
SW-2004	4.3	6.7	2.6	11.5
SW-2005	3.1	4.1	2.5	8.0
SW-2012	2.4	4.5	1.0	7.5
SW-2016	0.9	1.4	0.3	3.1
SW-2024	1.9	2.8	0.8	2.8
SW-2007	1.2	8.2	0.1	---

Note 1: 1 pCi/l = 0.037 Bq/l.
Note 2: SW-2007 represents the historical background location.

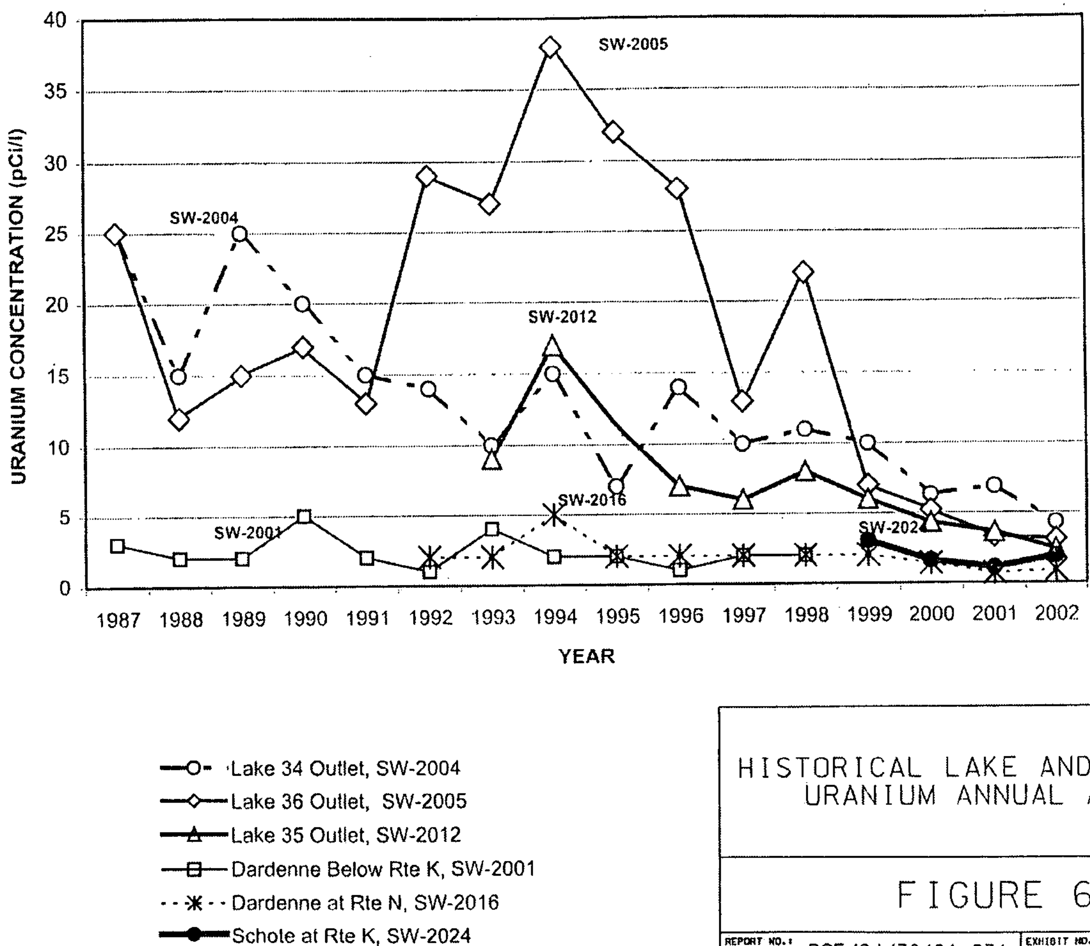
6.6.2.2 Weldon Spring Quarry

The annual averages for the surface water locations are summarized in Table 6-11. 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 2002. Historic annual average concentrations for uranium in the Femme Osage Slough are presented in Figure 6-4.

Table 6-11 2002 Annual Averages for Total Uranium (pCi/l) at Weldon Spring Quarry Surface Water Locations

LOCATION	ANNUAL AVERAGE	MAXIMUM CONCENTRATION	MINIMUM CONCENTRATION	RECENT 3 YEAR HIGH
SW-1003	14.8	17.7	11.3	25.5
SW-1004	16.4	17.4	14.4	24.6
SW-1005	11.1	12.1	10.2	21.0
SW-1007	7.2	9.3	6.3	19.8
SW-1009	6.3	8.6	4.9	20.4
SW-1010	15.0	19.3	12.3	27.5

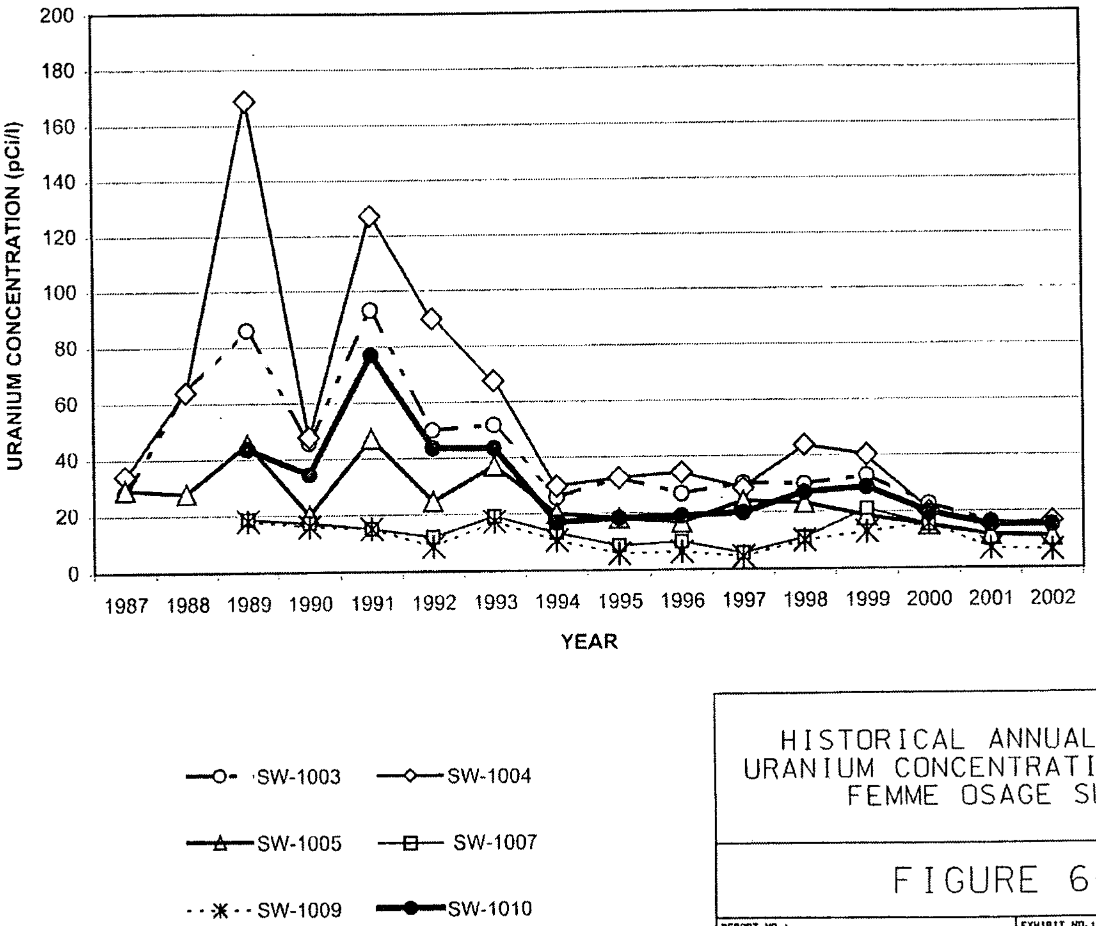
Note 1: 1 pCi/l = 0.037 Bq/l



HISTORICAL LAKE AND DOWNSTREAM URANIUM ANNUAL AVERAGES

FIGURE 6-3

REPORT NO.: DOE/GJ/79491-931		EXHIBIT NO.: A/PI/006/0702	
ORIGINATOR: TW	DRAWN BY: GLN	DATE: 4/15/03	



HISTORICAL ANNUAL AVERAGE URANIUM CONCENTRATIONS AT THE FEMME OSAGE SLOUGH

FIGURE 6-4

REPORT NO.: DOE/GJ/79491-931		EXHIBIT NO.: A/PI/062/0702
ORIGINATOR: TW	DRAWN BY: GLN	DATE: 4/15/03

7. GROUNDWATER MONITORING

7.1 Highlights of the Groundwater Monitoring Program

The following are highlights of the 2002 groundwater monitoring program. These items, and others, are discussed in detail in this chapter.

- Uranium, nitrate, and TCE concentrations generally remained within historic ranges at all chemical plant groundwater monitoring locations.
- High concentrations of nitroaromatic compounds reported in groundwater monitoring locations in the vicinity of Frog Pond which were initially detected in 1999, continued to be monitored during 2002.
- Volatile organic compounds (VOC) trichloroethene (TCE) and 1,2-dichloroethene (DCE), which were detected in groundwater in 1996 at the chemical plant, continued to be monitored during 2002.
- Groundwater detection monitoring for the disposal cell, which was initiated in June 1998, continued in 2002.
- Monitoring results for Burgermeister Spring were within historical ranges. No new highs or lows were recorded, although average annual concentrations of contaminants are decreasing.
- Contaminant levels generally remained within historic ranges at all quarry groundwater monitoring locations.
- Uranium concentrations were within background ranges, and no detectable concentrations of nitroaromatic compounds were observed south of the Femme Osage Slough.

7.2 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 7-1, and hydrogeologic descriptions of lithologies monitored for the program are in Sections 7.4 and 7.5.

7.3 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 7-1 identifies EPA water quality standards and Missouri Drinking Water Standards for contaminants that are routinely monitored in the groundwater program. Maximum contaminant levels (MCLs) and other drinking water standards are used only as references by the WSSRAP since the affected groundwater aquifer underlying the chemical plant is presently not a public drinking water source as defined in 40 CFR, Part 141, Subpart A – General; however it has been classified as a potential drinking water source.

Table 7-1 Referenced Federal and State Water Standards

PARAMETER		LEVEL	REFERENCE STANDARD	
Radiochemical	Uranium, total	30 μg/l (20 pCi/l)	Primary MCL:	EPA - 40 CFR 141.66[a]
Organics	2,4-DNT	0.11 μg/l	Criteria for use:	MGWQS - 10 CSR 20-7
	TCE	5 μg/l	Primary MCL:	EPA - 40 CFR 141.61
Anions	NO_3(asN)	10 mg/l	Primary MCL: Primary MCL:	MDWS - 10 CSR 60-4 EPA - 40 CFR 141.62

(a) EPA promulgated a drinking water MCL of 30 μg/l (20 pCi/l) December 7, 2000. The new regulation, 40 CFR 141.66, will take effect December 8, 2003.
EPA U. S. Environmental Protection Agency
MCL Maximum Contaminant Level
MDWS Missouri Drinking Water Standard
MGWQS Missouri Ground Water Quality Standard

Impacted groundwater at the quarry has been determined to be unusable due to low yields but groundwater south of the slough, which has not been impacted, is a drinking water source for St. Charles County.

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

(1) THICKNESS DATA SOURCES VARY. QUATERNARY UNIT THICKNESS BASED ON ON-SITE DRILLING AND TRENCHING. BURLINGTON AND KEOKUK THROUGH JOACHIM DOLOMITE BASED ON USGS WELLS MW-GS02 AND GS05. ST. PETER SANDSTONE AND BELOW FROM KLEESCHULTE AND EMMETT (REF 3). WARSAW AND SALEM FORMATIONS FROM MISSOURI DNR-DGLS GEOLOGIC MAP OFM-89-252-GI.

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

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

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

(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 7-1

REPORT NO.	EXHIBIT NO.	
DOE/GJ/79491-931	A/PI/047/0391	
ORIGINATOR ML	DRAWN BY GLN	DATE 3/12/03

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 7-2). 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 7-2 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.

7.4 Weldon Spring Chemical Plant

Since remediation activities began in 1987, more than 100 monitoring locations have been used for groundwater observations and sampling. Each year, wells are installed and/or abandoned as necessary to support the changing needs of the project. During 2002, no wells were abandoned. Eight new wells were installed during 2002 to support the pilot scale insitu chemical oxidation project, however they are not routinely monitored. A total of 68 wells and 5 springs were routinely sampled to monitor the groundwater impacts of historical chemical plant operations, recent remedial activities, and ongoing field studies.

7.4.1 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 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).

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.

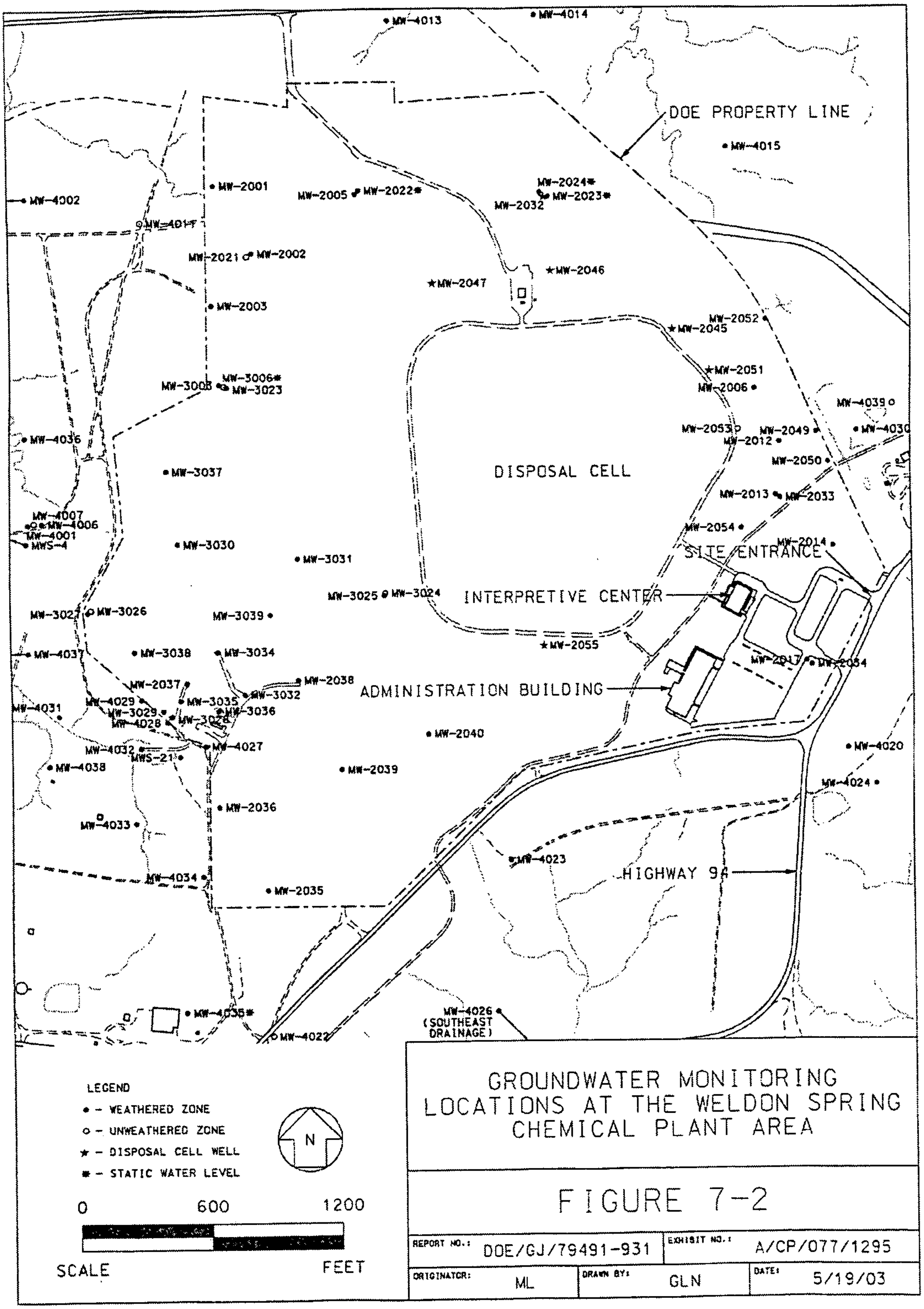
Potential groundwater impacts are assessed by monitoring groundwater from the monitoring well network at the site. The aquifer of concern beneath the chemical plant, raffinate pits, and vicinity properties is the shallow bedrock aquifer comprised of Mississippian-age Burlington-Keokuk Limestone (the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

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 7-2).

Upgradient-downgradient water quality comparisons are not practical for the chemical plant site because it is situated on the regional groundwater divide. Site-specific background levels established in the Groundwater Operable Unit (GWOU) *Remedial Investigation* are used as reference levels in lieu of these comparisons (Ref. 30).

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 7-3, have been historically influenced by chemical plant discharge water and/or groundwater 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. 30) indicated that a discrete and rapid subsurface hydraulic connection exists between the northern portion of the chemical plant and Burgermeister Spring.


DOE PROPERTY LINE
DISPOSAL CELL
SITE ENTRANCE
INTERPRETIVE CENTER
ADMINISTRATION BUILDING
HIGHWAY 94
MW-4013
MW-4014
MW-4015
MW-4002
MW-2001
MW-2005
MW-2022
MW-2024
MW-2023
MW-2032
MW-4011
MW-2021
MW-2002
MW-2046
MW-2047
MW-2003
MW-2052
MW-2045
MW-2051
MW-2006
MW-3006
MW-3003
MW-3023
MW-4039
MW-4030
MW-2053
MW-2049
MW-2012
MW-4036
MW-3037
MW-2050
MW-2013
MW-2033
MW-4007
MW-4006
MW-4001
MWS-4
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MW-2034
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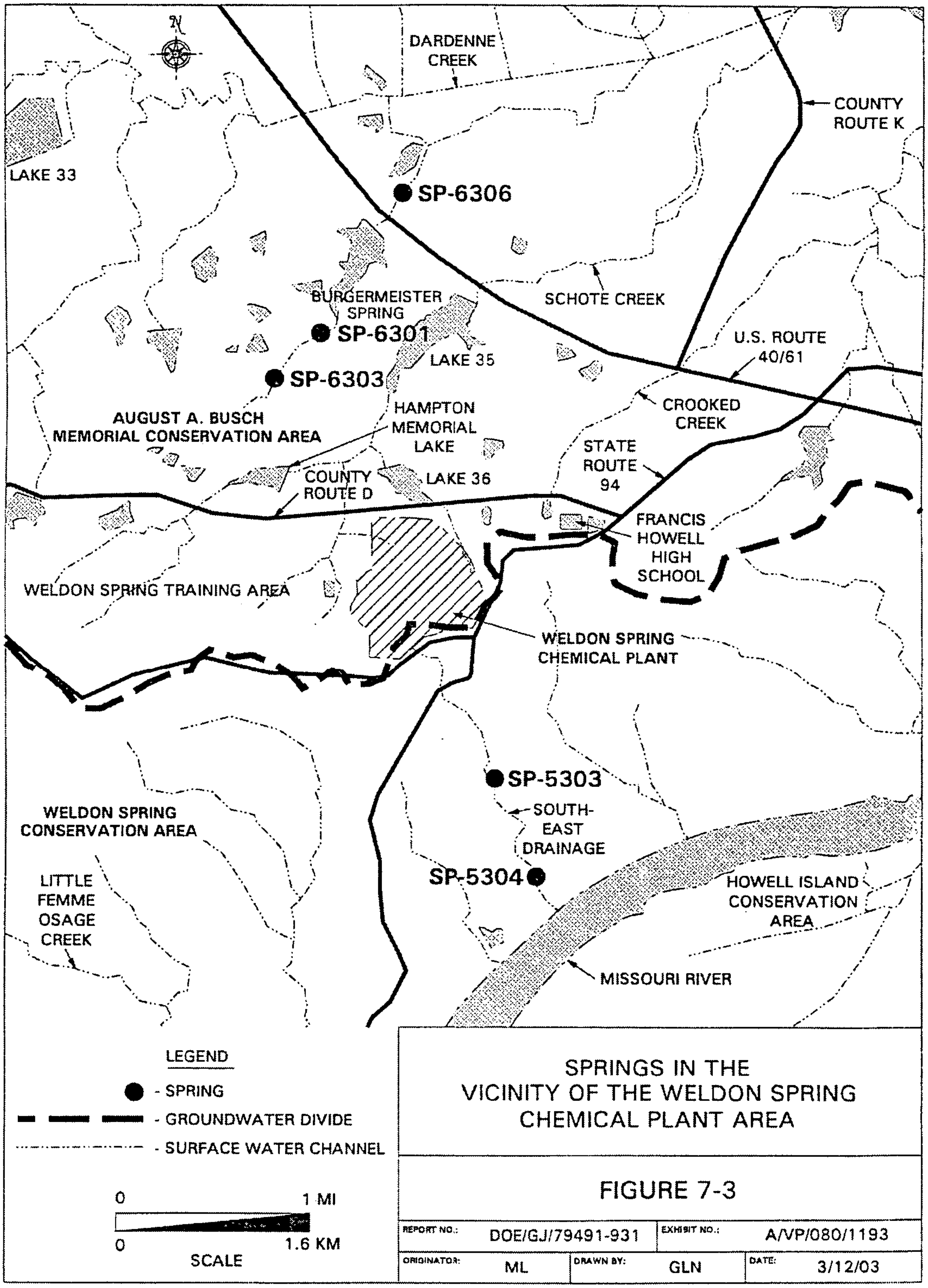
MW-3035
MW-3029
MW-3036
MW-4028
MW-3028
MW-2040
MW-4032
MW-4027
MWS-21
MW-4020
MW-4038
MW-2039
MW-4024
MW-2036
MW-4033
MW-4023
MW-4034
MW-2035
MW-4035
MW-4026
(SOUTHEAST DRAINAGE)
MW-4022
LEGEND
• - WEATHERED ZONE
○ - UNWEATHERED ZONE
★ - DISPOSAL CELL WELL
✱ - STATIC WATER LEVEL
N
0 600 1200
SCALE FEET
GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT AREA
FIGURE 7-2
REPORT NO.: DOE/GJ/79491-931
EXHIBIT NO.: A/CP/077/1295
ORIGINATOR: ML
DRAWN BY: GLN
DATE: 5/19/03



SPRINGS IN THE VICINITY OF THE WELDON SPRING CHEMICAL PLANT AREA

FIGURE 7-3

7.4.2 Monitoring Program

The 2002 groundwater monitoring program at the former chemical plant and raffinate pits area focused on monitoring known contaminants and assessing any groundwater impacts or improvements 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 were based on recent concentrations of contaminants in the groundwater at each location and on the likelihood of changes in contaminant concentrations due to remedial activities. Analytical results for all monitored parameters are summarized and discussed in Section 7.4.3.

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). The first four nitroaromatic production lines were located within the boundaries of the former chemical plant and raffinate pits area. Wastes generated from the initial operation of these early production lines were disposed of in open earthen pits which released contaminated seepage to groundwater. One such pit, Lagoon 1, was located along the northeast boundary of the chemical plant. Wastewater containing nitroaromatic compounds was initially discharged to surface drainages and then later transported through wooden pipe networks. Groundwater in the former areas known as Frog Pond, Ash Pond, and Raffinate Pit 4, was sampled for nitroaromatic compounds in 2002. These 3 areas coincide with the location of former TNT production lines.

Groundwater in the vicinity of the former raffinate pits has been impacted with elevated nitrate and uranium. The pits contained ore-refining wastes from uranium ore concentrates that were digested with nitric acid during the original chemical plant operations. During 2002, groundwater samples from selected locations near the former raffinate pits were analyzed for nitrate and total uranium.

Trichloroethene (TCE) was detected in groundwater southeast of the former Raffinate Pit 4 during 1996. VOC monitoring was conducted quarterly at selected wells during 2002 to monitor trends in the area of TCE impact, and evaluate the effect of remediation activities on VOC contamination levels.

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

Groundwater moves under the chemical plant by both diffuse and discrete flow components. In order to monitor the discrete flow component, five springs were monitored during 2002 for total uranium, nitrate, nitroaromatic compounds, and VOCs. The springs were sampled during high- and base-flow conditions to monitor the potential impacts from surface water runoff in the vicinity of the chemical plant.

7.4.3 Chemical Plant Monitoring Results

7.4.3.1 Groundwater Monitoring Wells

Analytical data for contaminants monitored during 2002 (e.g., uranium, nitrate, volatile organic compounds, and nitroaromatics) are summarized and compared with background levels and/or water quality standards. 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. 30).

Uranium. Total uranium, which is measured at all active monitoring wells, continues to be present in the groundwater near the former raffinate pits. In 2002, groundwater from 31 monitoring well locations exceeded the average background level of 0.93 pCi/l (0.03 Bq/l) established during the GWOU remedial investigation (Ref. 30). Only two wells (MW-3024 and MW-3030) exceeded the groundwater standard of 30 µg/l (20 pCi/l) (40 CFR 141). Average measured values from wells exceeding background are shown in Table 7-3.

Nitrate. In 2002, nitrate was monitored at 68 monitoring wells in the chemical plant area. Nitrate levels exceeded the Missouri drinking water primary MCL (10 mg/l) at 36 of those locations (see Table 7-4).

Table 7-3 Annual Averages for Total Uranium Above Background at the Weldon Spring Chemical Plant

LOCATION	AVERAGE (pCi/l)	NUMBER OF SAMPLES
MW-2003	2.7	2
MW-2017	5.2	2
MW-2032	1.8	2
MW-2034	2.3	2
MW-2038	1.5	4
MW-2039	3.2	2
MW-2040	3.0	2
MW-2047	0.97	2
MW-2049	6.0	2
MW-2053	3.7	1
MW-2054	1.0	1
MW-2055	3.0	5
MW-3003	14	2
MW-3023	10	2
MW-3024*	53	4
MW-3025	2.2	4
MW-3026	1.8	2
MW-3030*	54	7
MW-3031	2.3	2
MW-3034	1.6	6
MW-3038	1.2	5
MW-4013	1.6	3
MW-4020	7.2	2
MW-4022	4.5	2
MW-4023	1.7	2
MW-4024	3.9	2
MW-4030	1.1	2
MW-4037	9.5	3
MW-4038	2.2	3
MW-4039	2.6	1
MW-S021	1.0	6

* Concentration exceeds the groundwater standard of 30 µg/l (20 pCi/l).
Note 1: Background uranium concentration equals 0.93 pCi/l.
Note 2: 1 pCi/l = 0.037 Bq/l.

Table 7-4 Annual Nitrate Averages at the Weldon Spring Chemical Plant

LOCATION	AVERAGE (mg/l)	NUMBERS OF SAMPLES
MW-2001*	184	4
MW-2002*	214	4
MW-2003*	206	4
MW-2005*	168	4
MW-2021	<0.05	1
MW-2032	3.1	2
MW-2035	0.43	1
MW-2036	1.51	3
MW-2037*	22.8	7
MW-2038*	634	6
MW-2039*	81.1	4
MW-2040*	139	4
MW-2045	1.40	2
MW-2046	1.45	2
MW-2047*	42.4	2
MW-2051	2.02	2
MW-2055	0.66	5
MW-3003*	286	4
MW-3023*	238	4
MW-3024*	225	4
MW-3025*	307	6
MW-3026*	196	4
MW-3027*	36.5	6
MW-3028*	174	5
MW-3029*	245	6
MW-3030*	287	7
MW-3031*	102	4
MW-3032	1.60	7
MW-3034*	556	7
MW-3035*	54.7	7
MW-3036*	74.3	7
MW-3038*	24.0	5
MW-3039*	617	3
MW-4001*	56.9	6
MW-4002	1.80	1
MW-4006	9.65	2
MW-4007	0.15	1
MW-4011*	94.2	4
MW-4013*	67.1	1
MW-4014	5.70	1
MW-4027*	31.4	7
MW-4028*	202	7
MW-4029*	473	7
MW-4031*	246	7
MW-4032*	199	7
MW-4033*	11.2	2
MW-4034	0.09	1
MW-4037*	86.0	3
MW-4038*	144	3
MW-4039	0.50	1

Table 7-4 Annual Nitrate Averages at the Weldon Spring Chemical Plant (Continued)

LOCATION	AVERAGE (mg/l)	NUMBER OF SAMPLES
MW-S004	3.85	2
MW-S021*	156	7

* Exceed the Missouri Drinking Water Standard for nitrate of 10 mg/l.

Nitroaromatic Compounds Nitroaromatic compounds, which are not naturally occurring, were detected in 47 monitoring wells (Table 7-5). New historic highs were reported during 2002 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 by the DOE and Army in this area. Additional wells were installed in the vicinity of Frog Pond in 2000 and 2001 to further define the extent of contamination in this area; however, MW-2012 continues to demonstrate the highest concentrations of nitroaromatic compounds.

The Missouri drinking water quality standard for 2,4-DNT of 0.11 µg/l was equaled or exceeded in 15 locations at the chemical plant (see Table 7-5).

Table 7-5 Annual Averages for Nitroaromatic Compounds (µg/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
2001	0.17	<0.09	<0.08	<0.06	<0.10	<0.08
2002	0.04	<0.09	<0.08	<0.06	0.26	<0.08
2003	<0.04	<0.09	<0.08	0.08	0.44	<0.08
2005	0.38	0.10	<0.08	<0.06	0.13	<0.08
2006	5.5	0.10	0.24	0.07	0.98	0.30
2012*	223	0.90	242	1300	1070	12
2013	1.8	0.07	0.19	0.08	0.87	<0.08
2014*	2.5	<0.09	0.08	0.13	0.48	0.21
2021	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08
2033	2.0	<0.09	0.40	0.05	0.91	<0.08
2035	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08
2036	<0.04	<0.09	<0.08	<0.03	<0.10	<0.08
2037	<0.04	<0.09	<0.08	0.04	<0.10	<0.08
2038*	0.04	<0.09	<0.08	0.22	<0.10	<0.08
2039	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08
2040	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08
2045	0.09	0.07	0.08	0.07	0.65	<0.08
2046*	3.0	<0.09	4.6	0.14	1.6	<0.08
2047	0.08	<0.09	<0.08	0.10	0.23	<0.08
2049*	0.27	0.05	0.42	18	64	0.48
2050*	5.5	0.18	0.15	32	5.9	0.09
2051	0.10	0.07	0.10	0.04	0.27	0.03
2052	2.8	0.05	0.46	0.09	0.23	0.05
2053*	7.7	0.09	6.3	0.16	6.1	0.37
2054*	0.12	<0.09	<0.08	2.3	4.4	0.11
2055	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08
3003	<0.04	<0.09	<0.08	0.08	0.17	<0.08
3023	<0.04	<0.09	<0.08	0.10	0.93	<0.08
3024	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08
3025	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08
3026	<0.04	<0.09	<0.08	0.05	<0.10	<0.08
3027	0.10	<0.09	<0.08	<0.06	<0.10	<0.08
3028	0.22	0.07	<0.08	0.09	<0.10	<0.08
3029	0.27	<0.09	<0.08	0.07	<0.10	<0.08
3030*	<0.04	<0.09	<0.08	1.1	0.38	<0.08
3031	<0.03	<0.09	<0.08	<0.06	<0.10	<0.08
3032	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08
3034*	0.05	0.05	<0.08	0.26	0.15	0.09
3035	<0.04	<0.09	<0.08	0.04	<0.10	<0.08
3036*	0.11	<0.09	<0.08	0.13	<0.10	<0.08
3038	0.08	<0.09	<0.08	<0.06	<0.10	<0.08
3039*	0.23	<0.09	<0.08	1.2	0.11	<0.08
4001	36	0.10	1.7	0.08	1.5	<0.08
4006	20	<0.09	<0.08	0.10	2.8	<0.08
4007	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08
4011	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08
4013	19	<0.09	<0.08	<0.06	0.58	<0.08
4014	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08
4015	3.8	<0.09	0.06	0.06	0.77	0.13
4026	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08
4027	0.04	<0.09	<0.08	0.04	<0.10	<0.08

Table 7-5 Annual Averages for Nitroaromatic Compounds (µg/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
4028*	0.28	0.06	<0.08	0.12	0.13	<0.08
4029*	0.88	0.09	<0.08	0.11	0.34	<0.08
4030*	4.4	<0.09	1.6	0.14	0.49	<0.08
4031	3.3	<0.09	0.81	0.06	0.21	<0.08
4032	1.1	0.07	<0.08	0.08	0.14	<0.08
4033	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08
4037	1.6	<0.09	1.9	<0.06	0.24	<0.08
4038	0.12	0.05	<0.08	<0.06	<0.10	<0.08
4039	<0.04	<0.09	0.05	0.07	0.09	<0.08
S004	7.2	<0.09	0.48	<0.06	0.68	<0.08
S021	0.08	<0.09	<0.08	0.15	<0.10	<0.08

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

Volatile Organic Compounds. VOC monitoring continued through 2002 to monitor the extent of contamination and changes in concentration that may have resulted from remedial activities and groundwater field studies. Twenty-five wells demonstrated detectable levels of at least one VOC. The analytical results for all wells with detectable levels of either 1,2-DCE, PCE, TCE or vinyl chloride are summarized in Table 7-6. Vinyl chloride was monitored at some locations in the vicinity of the in-situ chemical oxidation pilot study. Seventeen of these wells exceeded the MCL of 5 µg/l for TCE.

Table 7-6 Annual Average VOC Concentrations at the Weldon Spring Chemical Plant

LOCATION	1,2-DCE (µg/l)	PCE (µg/l)	TCE (µg/l)	Vinyl Chloride (µg/l)	Number of Samples
MW-2013	1.2	<1	0.42	<1	2
MW-2036	<2	<1	<1	<1	2
MW-2037*	0.97	0.75	41	<1	7
MW-2038*	0.78	<1	22	<1	6
MW-2039	<2	<1	<1	<1	1
MW-2055	<2	<1	<1	<1	4
MW-3003	<2	<1	<1	NS	1
MW-3023	<2	<1	(0.4)	<1	1
MW-3024	<2	<1	2.6	<1	2
MW-3025	0.92	<1	4.2	<1	6
MW-3026	<2	<1	<1	<1	1
MW-3027	<2	<1	(0.8)	<1	3
MW-3028*	4.7	<10	146	<10	5
MW-3029*	8.1	<20	225	<20	5
MW-3030*	14	<20	273	<20	7
MW-3031	<2	<1	<1	NS	1
MW-3032	<2	<1	<1	<1	6
MW-3034*	4.8	<25	153	<25	7
MW-3035*	1.6	<10	62	<5	7
MW-3036*	<2	<1	7.1	<1	7

Table 7-6 Annual Average VOC Concentrations at the Weldon Spring Chemical Plant (Continued)

LOCATION	1,2-DCE (µg/l)	PCE (µg/l)	TCE (µg/l)	Vinyl Chloride (µg/l)	Number of Samples
MW-3037	<2	1.2	<1	NS	2
MW-3038	<2	1.2	<1	<1	7
MW-3039*	5.8	12	108	<100	5
MW-4001*	<2	<1	6.5	<1	6
MW-4007	<2	<1	<1	<1	1
MW-4027	<1	2.8	1.1	<1	6
MW-4028*	3.3	10	96	<10	7
MW-4029*	17	8.3	488	<25	7
MW-4031*	9.5	<25	157	<25	7
MW-4032*	2.1	<5	67	<2.5	7
MW-4033	<2	<1	<1	<1	1
MW-4036	<2	<1	<1	NS	2
MW-4037*	<4	<2	16	<1	5
MW-4038*	<2	0.42	25	<1	5
MW-S004	<2	<1	<1	<1	1
MW-S021*	2.1	<5	72	<2.5	7

<DL All samples less than highest detection limit.
(#) Value reported is less than the detection limit.
* Concentration exceeds the Missouri water quality standard of 5 µg/l for TCE.
NS Not sampled.

Groundwater Overview. Uranium, nitrate, and TCE concentrations generally remained within recent historical ranges at the monitoring wells sampled under the environmental monitoring program during 2002; however, decreased concentrations at source areas have been observed. Nitroaromatic compounds at the site indicated upward trends and new historical highs at some locations.

7.4.3.2 Springs

Burgermeister Spring (SP-6301) is a perennial spring that represents a primary localized emergence of groundwater impacted by a recognizable contribution of contaminants from the chemical plant throughout the year. The highest contaminant concentrations occur 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.

Annual average concentrations for nitrate, uranium, and nitroaromatic compounds are presented in Table 7-7. Compared to concentrations reported for Burgermeister Spring in 2001, these concentrations were in the same general range, with uranium being slightly lower during base flow and slightly higher during high flow. Of the nitroaromatic compounds analyzed, only 2,6-DNT was reported above detection limits. No VOCs were reported above detection limits at this spring.

Table 7-7 2002 Monitoring Data for Burgermeister Spring

PARAMETER	HIGH FLOW			LOW (BASE) FLOW		
	MIN	MAX	AVG	MIN	MAX	AVG
Nitrate (mg/l)	0.94	1.1	1.0	0.97	10.9	5.1
U-total (pCi/l)	8.6	9.7	9.2	11.4	100	51.0
2,6-DNT (µg/l)	<0.1	<0.1	<0.1	<0.1	0.17	0.12

< All samples less than the highest detection limit.

A total of four other springs, two of which are located in the Southeast Drainage (SP-5303 and SP-5304) and 2 located in the Burgermeister Spring Branch (SP-6303 and SP-6306), were monitored during 2002 to assess the emergence of contaminated groundwater at possible exposure points. Spring water in the Southeast Drainage is impacted by residual contamination deposited in the fractures in the bedrock. The source of this residual material was historical process sewer discharges from the chemical plant site. These locations were sampled during base flow for VOCs, uranium, and nitroaromatic compounds, and at high flow for uranium and nitroaromatic compounds. Annual average concentrations of parameters for which detection limits were exceeded are presented in Table 7-8. No VOCs or the nitroaromatic compounds 1,3-DNB or 2,4-DNT were reported above detection limits at any of the springs.

Table 7-8 2002 Annual Average Monitoring Data for Springs

PARAMETER	HIGH FLOW				LOW (BASE) FLOW			
	SP-5303	SP-5304	SP-6303	SP-6306	SP-5303	SP-5304	SP-6303	SP-6306
U-total (pCi/l)	34.6	29.6	0.97	0.26	82.8	65.2	1.2	0.34
1,3,5-TNB (µg/l)	<0.04	<0.04	0.11	<0.04	0.34	<0.04	0.22	<0.04
2,4,6-TNT (µg/l)	2.0	0.10	0.10	<0.08	42.6	0.10	0.09	<0.08
2,4-DNT ((µg/l)	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	0.06	<0.06
2,6-DNT (µg/l)	<0.10	<0.10	0.17	<0.10	0.17	<0.10	0.30	<0.10

< All samples less than the highest detection limit.

7.4.4 Trend Analysis

The computer program TREND, developed at Pacific Northwest Laboratory, was used to perform the formal groundwater trend testing. The trend method employed was the nonparametric Mann-Kendall test. 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.

7.4.4.1 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 based on the mean and variance of the data set. A positive value of Z indicates that the data are skewed in an upward direction, and a negative value of Z indicates that the data are skewed in a downward direction. The alpha value (or error limit) used to identify a significant trend 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, which is calculated independently of the trend, was estimated for all data sets. 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 line was based. The direction and magnitude of the slope, 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.

No statistical tests were conducted for suspect outliers. Data that were suspect were flagged and rechecked for potential data transcription errors. Outliers were included in the analysis since the TREND program corrects for these.

7.4.4.2 Chemical Plant Trend Results

Selected wells from the chemical plant and nearby springs were trended for uranium, nitrate, nitroaromatic compounds, or TCE. The cumulative results for the time period 1999 through 2002 were evaluated using the TREND program and are summarized below.

Nitrate

Fifteen locations at the chemical plant and Burgermeister Spring, at both high flow and low flow, were selected for nitrate trend analyses. The well locations consisted of both weathered and unweathered bedrock wells in the Raffinate Pit and Ash Pond areas, where nitrate is the primary contaminant of concern.

Nitrate trends for 1999-2002 groundwater data are stationary at 9 locations, downward at three locations, and upward at three locations as shown in Table 7-9. Two of the trend directions changed from last year's analyses. The trend direction for MW-2003 changed from a stationary to a downward trend. The trend direction changed from a downward to a stationary trend for MW-4011. Ten of the 15 locations were not trended for nitrate in last year's analyses, thus no comparison to past trend results can be made. Burgermeister Spring trending results showed a downward trend during high flow and a stationary trend during low (base) flow.

Seven of the 17 locations that were evaluated for the 1999-2002 time frame have a reported concentration in 2002 that exceed all past 1999, 2000, and 2001 data for the specific sampling location. These nitrate levels are 314 mg/l at MW-2001, 297 mg/l at MW-2002, 95.80 mg/l at MW-2039, 450 mg/l at MW-3003, 341 mg/l at MW-3023, 502 mg/l at MW-3025, and 247 mg/l at MW-3026. The new four year highs are within the historical range for all of these locations, except MW-2001. This location exhibited a new historical high during 2002, however it is within the expected migration pathway on-site.

Nitroaromatic Compounds

Ten locations at the chemical plant were selected for trend analyses of nitroaromatic compounds. All of these locations are weathered bedrock wells in the former Frog Pond area. With the exception of MW-4015, these locations were also included in last year's trending effort.

The results of the nitroaromatic compound analyses for the monitoring wells near the chemical plant are presented in Table 7-10. Each of these locations were trended for the following nitroaromatic compounds: 2,4-dinitrotoluene (2,4-DNT), 2,6-dinitrotoluene (2,6-DNT), 1,3,5-trinitrobenzene (1,3,5-TNB), and 2,4,6-trinitrotoluene (2,4,6-TNT). A total of 37 trend analyses were performed on the nitroaromatic compounds at the ten groundwater monitoring well locations. Trending was not performed on 2,4,6-TNT at MW-2014, MW-2050, and MW-4015 because fewer than three detected concentrations were reported for the time period between 1999 and 2002.

Four locations, MW-2006, MW-2012, MW-2050 and MW-4030, have upward trends indicated for at least one nitroaromatic compound. At the well location MW-2006, the upward trend direction indicated for 2,4,6-TNT could not be compared to last year's analyses because fewer than three detected concentrations were reported for the time period 1998-2001. One location, MW-2012, has upward trends indicated for all four of the nitroaromatic compounds. This is consistent with last year's trends for 2,4-DNT and 1,3,5-TNB, but is a change from the analyses of 2,6-DNT and 2,4,6-TNT which previously indicated a stationary trend. The upward trends indicated for 2,4-DNT, 2,6-DNT, and 1,3,5-TNB at MW-2050 and 1,3,5-TNB and 2,4,6-TNT at MW-4030 is a change from the previously indicated stationary trends.

All other results of the trend analyses indicate stationary trends. This is consistent with prior analyses with the exception of 2,6-DNT at MW-2006, 1,3,5-TNB and 2,4,6-TNT at MW-2013, 2,4-DNT and 1,3,5-TNB at MW-2014, and 2,6-DNT at MW-2033 which all previously indicated downward trends.

As shown in Table 7-10, all four nitroaromatic compounds at MW-2012 and MW-2050 have reported concentrations in 2002 that exceed all past 1999, 2000, and 2001 data for their respective sampling locations. The new highs for MW-2012 are the following: 1,600 µg/l for 2,4-DNT, 1,300 µg/l for 2,6-DNT, 280 µg/l for 1,3,5-TNB, and 290 µg/l for 2,4,6-TNT. The new highs for MW-2050 are the following: 45 µg/l for 2,4-DNT, 11 µg/l for 2,6-DNT, 7.9 µg/l for 1,3,5-TNB, and 0.73 µg/l for 2,4,6-TNT. The following individual nitroaromatic compounds also had reported new high concentrations: 0.25 µg/L for 2,4,6-TNT at MW-2014, 0.11 µg/l for 2,4,6-TNT at MW-4015, 7.10 µg/l for 1,3,5-TNB at MW-4030, and 2.30 µg/l for 2,4,6-TNT at MW-4030.

Uranium

Four locations at the chemical plant and two springs, at both high flow and low flow, were selected for trend analyses of uranium. The well locations consisted of 3 weathered bedrock wells and 1 unweathered bedrock well near the former Raffinate Pits where uranium is a contaminant of concern. Burgermeister Spring and SP-5304 in the Southeast Drainage were the springs chosen for trending.

Total uranium trends for 1999-2002 data were stationary at three of the well locations and upward at one well location as shown in Table 7-11. Of the 6 locations selected for trend analysis in 2001 and this year, only the bedrock well MW-3023 changed from a stationary to an upward trend.

Of the two spring locations not selected for trend analyses last year, there were both stationary and downward trends depending upon flow conditions. SP-5304H and SP-6301L showed downward trends, while SP-5304L and SP-6301H showed stationary trends.

Two of the locations that were evaluated for the 1999-2002 time frame have reported uranium concentrations in 2002 that exceed all past 1999 through 2001 data for the specific sampling location. These uranium levels are 103 pCi/l at SP-5304L, and 100 pCi/l at SP-6301L. These values do not represent historical highs.

TCE

Five locations at the chemical plant were selected for trend analyses of TCE data. The well locations consisted of weathered bedrock wells in the vicinity of the former Raffinate Pits where TCE is a primary contaminant of concern. These wells were selected because they have shown no external influence from the pilot scale ICO project or other field studies performed in the area.

Trichloroethene trends for 1999-2002 data are stationary at one location, downward at two locations, and upward at two locations as shown in Table 7-12. Trending for trichloroethene was not included in last year's analyses. However, the downward trend identified at MW-2038 and the stationary trend identified at MW-4029 remain unchanged from the previous analyses conducted using the 1997 through 2000 data. The other three locations were not previously trended for trichloroethene.

Two of the five locations evaluated for the 1999-2002 time frame have reported concentrations in 2002 that exceed all past 1999, 2000, and 2001 data for the specific sampling location. The trichloroethene levels are 330 µg/l at MW-3030 and 7.2 µg/l at MW-4001. Both of these high concentrations are new historical highs and both locations exhibit upward trends; however higher concentrations are present upgradient. These increases are expected since both wells are along the migration pathway on-site.

Table 7-9 Chemical Plant Groundwater Wells Nitrate Trend Analysis Summary For 1999 To 2002

Well ID	Location	No. of Samples 1999-2002	No. of Non-Detect Data 1999-2002	Trend Direction (Alpha = 0.05) 1999-2002	Slope (mg/l/yr) 1999-2002	95% Upper & Lower Confidence Intervals On Slope (mg/l/yr) 1999-2002	2002 New High Concentration (mg/l) 1999 to Date
MW-2001	Weathered bedrock, west of Ash Pond	13	0	U	17.000	9.747, 27.292	314
MW-2002	Weathered bedrock, west of Ash Pond	13	0	S	-1.000	-20.896, 31.943	297
MW-2003	Weathered bedrock, west of Ash Pond	13	0	D	-60.083	-101.251, -15.968	No
MW-2005	Weathered bedrock, north of Ash Pond	13	0	S	24.250	-4.772, 31.772	No
MW-2038	Weathered bedrock, south of disposal cell	48	0	D	-110.000	-204.029, -26.255	No
MW-2039[1]	Weathered bedrock, south of disposal cell	12	0	S	5.267	-3.930, 8.582	96
MW-2040	Weathered bedrock, south of disposal cell	16	0	S	-3.750	-11.300, 9.000	No
MW-3003	Weathered bedrock, west of disposal cell	31	0	S	-21.750	-41.000, -2.143	450
MW-3023	Weathered bedrock, west of disposal cell	18	0	S	20.167	-2.407, 51.407	341
MW-3024	Unweathered bedrock, south of disposal cell	16	0	D	-41.333	-63.143, -15.924	No
MW-3025	Weathered bedrock, south of disposal cell	30	0	S	17.000	1.719, 35.710	502
MW-3026	Unweathered bedrock, southwest of disposal cell	18	0	S	7.000	-10.000, 21.946	247
MW-3027	Weathered bedrock, southwest of disposal cell	33	0	U	3.350	1.264, 5.724	No
MW-4001	Weathered bedrock, west of site	33	0	U	4.150	1.254, 6.373	No
MW-4011	Unweathered bedrock, west of site	14	0	S	-16.000	-33.319, 0.377	No

Table 7-9 Chemical Plant Groundwater Wells Nitrate Trend Analysis Summary For 1999 To 2002 (Continued)

Well ID	Location	No. of Samples 1999-2002	No. of Non-Detect Data 1999-2002	Trend Direction (Alpha = 0.05) 1999-2002	Slope (mg/l/yr) 1999-2002	95% Upper & Lower Confidence Intervals on Slope (mg/l/yr) 1999-2002	2002 New High Concentration (mg/l) 1999 to Date
SP-6301H	Burgermeister spring – high flow	14	0	D	-2.045	-4.954, -0.600	No
SP-6301L	Burgermeister spring – low flow	31	0	S	-1.800	-3.802, -0.097	No

D = Downward
S = Stationary
U = Upward

[1]Data from 2001 are not available for well MW-2039.

Table 7-10 Chemical Plant Groundwater Nitroaromatics Trend Analysis Summary for 1999 to 2002

Well ID	Location	Compound	No. of Samples 1999-2002	No. of Non-Detect Data 1999-2002	Trend Direction (Alpha = 0.05) 1999-2002	Slope (µg/l/yr) 1999-2002	95% Upper & Lower Confidence Intervals on Slope (µg/l/yr) 1999-2002	2002 New High Concentration (µg/l) 1999 to Date
MW-2006	Weathered bedrock – Former frog pond	2,4-DNT	18	8	S	-0.010	-0.055, 0.010	No
		2,6-DNT	18	3	S	-0.017	-0.328, 0.100	No
		1,3,5-TNB	18	1	S	-0.183	-0.700, 1.200	No
		2,4,6-TNT	18	15	U	0.012	0.000, 0.025	No
MW-2012	Weathered bedrock - Former frog pond	2,4-DNT	20	0	U	250.000	139.854, 342.350	1600
		2,6-DNT	20	0	U	130.000	76.815, 228.790	1300
		1,3,5-TNB	20	0	U	51.000	26.000, 73.000	280
		2,4,6-TNT	20	0	U	25.000	10.000, 40.000	290
MW-2013	Weathered bedrock - Southeast of former frog pond	2,4-DNT	17	3	S	-0.034	-0.061, 0.006	No
		2,6-DNT	17	0	S	-0.305	-0.705, 0.033	No
		1,3,5-TNB	17	0	S	-1.075	-2.004, 0.100	No
		2,4,6-TNT	17	5	S	-0.085	-0.140, -0.010	No
MW-2014	Weathered bedrock - Southeast of disposal Cell	2,4-DNT	17	1	S	-0.010	-0.035, 0.010	No
		2,6-DNT	17	1	S	0.012	-0.080, 0.115	No
		1,3,5-TNB	17	0	S	-0.275	-0.600, 0.200	No
		2,4,6-TNT	17	16	(a)	(a)	(a)	0.25
MW-2032	Weathered bedrock - North of disposal cell	2,4-DNT	11	5	S	-0.014	-0.019, 0.002	No
		2,6-DNT	11	5	S	-0.022	-0.039, 0.001	No
		1,3,5-TNB	11	6	S	-0.007	-0.020, 0.001	No
		2,4,6-TNT	11	5	S	-0.023	-0.030, 0.005	No
MW-2033	Weathered bedrock - South of former frog Pond	2,4-DNT	17	8	S	-0.035	-0.057, 0.004	No
		2,6-DNT	17	1	S	-0.123	-0.355, 0.150	No
		1,3,5-TNB	17	0	S	-0.550	-1.000, 0.100	No
		2,4,6-TNT	17	2	S	-0.025	-0.120, 0.035	No
MW-2049[1]	Weathered bedrock - former frog pond area	2,4-DNT	14	1	S	-3.000	-23.788, 9.233	No
		2,6-DNT	14	0	S	-19.000	-54.408, 11.772	No
		1,3,5-TNB	14	3	S	-0.040	-0.220, 0.125	No
		2,4,6-TNT	14	10	S	0	-0.560, 0.361	No

Table 7-10 Chemical Plant Groundwater Nitroaromatics Trend Analysis Summary for 1999 to 2002 (Continued)

Well ID	Location	Compound	No. of Samples 1999-2002	No. of Non-Detect Data 1999-2002	Trend Direction (Alpha = 0.05) 1999-2002	Slope (µg/l/yr) 1999-2002	95% Upper & Lower Confidence Intervals on Slope (µg/l/yr) 1999-2002	2002 New High Concentration (µg/l) 1999 to Date
MW-2050[1]	Weathered bedrock - Former frog pond area	2,4-DNT	14	0	U	19.260	8.392, 28.490	45
		2,6-DNT	14	0	U	2.300	0.611, 3.751	11
		1,3,5-TNB	14	1	U	2.500	1.888, 3.787	7.90
		2,4,6-TNT	14	12	(a)	(a)	(a)	0.73
MW-4015	Weathered bedrock - North of chemical plant	2,4-DNT	8	2	S	-0.001	-0.021, 0.008	No
		2,6-DNT	8	0	S	0.000	-0.088, 0.147	No
		1,3,5-TNB	8	0	S	-0.250	-1.402, 0.795	No
		2,4,6-TNT	8	7	(a)	(a)	(a)	0.11
MW-4030[1]	Weathered bedrock - lagoon area	2,4-DNT	13	1	S	0.010	-0.037, 0.043	No
		2,6-DNT	13	1	S	0.180	0.007, 0.310	No
		1,3,5-TNB	13	0	U	2.400	1.302, 3.422	7.10
		2,4,6-TNT	13	0	U	0.670	0.148, 0.933	2.30

S = Stationary
U = Upward

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

(a) Fewer than three detected concentrations were reported for the time period; therefore, no trending was performed.

[1]Data from 1999 are not available for wells MW-2049, MW-2050, and MW-4030.

Table 7-11 Chemical Plant Groundwater Uranium Trend Analysis Summary for 1999 to 2002

Well ID	Location	No. of Samples 1999-2002	No. of Non-Detect Data 1999-2002	Trend Direction (Alpha = 0.05) 1999-2002	Slope (pCi/l/yr) 1999-2002	95% Upper & Lower Confidence Intervals On Slope (pCi/l/yr) 1999-2002	2002 New High Concentration (pCi/l) 1999 to Date
MW-3003	Weathered bedrock, west of disposal cell	28	0	S	-0.300	-0.661, 0.200	No
MW-3023	Weathered bedrock, west of disposal cell	14	0	U	0.862	0.315, 1.497	No
MW-3024	Unweathered bedrock, south of disposal cell	16	0	S	-1.300	-4.408, 1.669	No
MW-3030[2]	Weathered bedrock, west of disposal cell	23	0	S	1.000	-0.555, 2.900	No
SP-5304H[2]	Southeast drainage spring – high flow	11	0	D	-44.150	-72.048, -21.714	No
SP-5304L[2]	Southeast drainage spring – low flow	15	0	S	-17.350	-37.492, 6.096	103
SP-6301H	Burgermeister spring – high flow	15	0	S	-6.200	-16.066, 0.702	No
SP-6301L	Burgermeister spring – low flow	31	0	D	-8.500	-16.158, -1.571	100

D = Downward
S = Stationary
U = Upward
[1]Data from 1999 are not available for wells MW-1051 and MW-1052.
[2]Data from 1999 and 2000 are not available for MW-3030, SP-5304H, and SP-5304L.

Table 7-12 Chemical Plant Groundwater TCE Trend Analysis Summary for 1999 to 2002

Well ID	Location	No. of Samples	No. of Non-Detect Data	Trend Direction	Slope (µg/l/yr)	95% Upper & Lower Confidence Intervals on Slope (µg/l/yr) 1999-2002	2002 New High Concentration (µg/l) 1999 to Date
		1999-2002	1999-2002	(Alpha = 0.5) 1999-2002	1999-2002		
MW-2038	Weathered bedrock, south of disposal cell	49	0	D	-23.775	-32.100, -16.000	No
MW-3030[1]	Weathered bedrock, west of disposal cell	23	0	U	60.000	20.000, 100.000	330
MW-4001	Weathered bedrock, west of site	35	0	U	0.500	0.367, 0.600	7.2
MW-4029	Weathered bedrock, west of site	49	0	S	-35.000	-66.000, 0.000	No
MW-4031[1]	Weathered bedrock, west of site	24	0	D	-20.000	-40.000, -10.000	No

D = Downward
S = Stationary
U = Upward

[1]Data from 1999 and 2000 are not available for wells MW-3030 and MW-4031.

7.5 Weldon Spring Quarry

7.5.1 Hydrogeologic Description

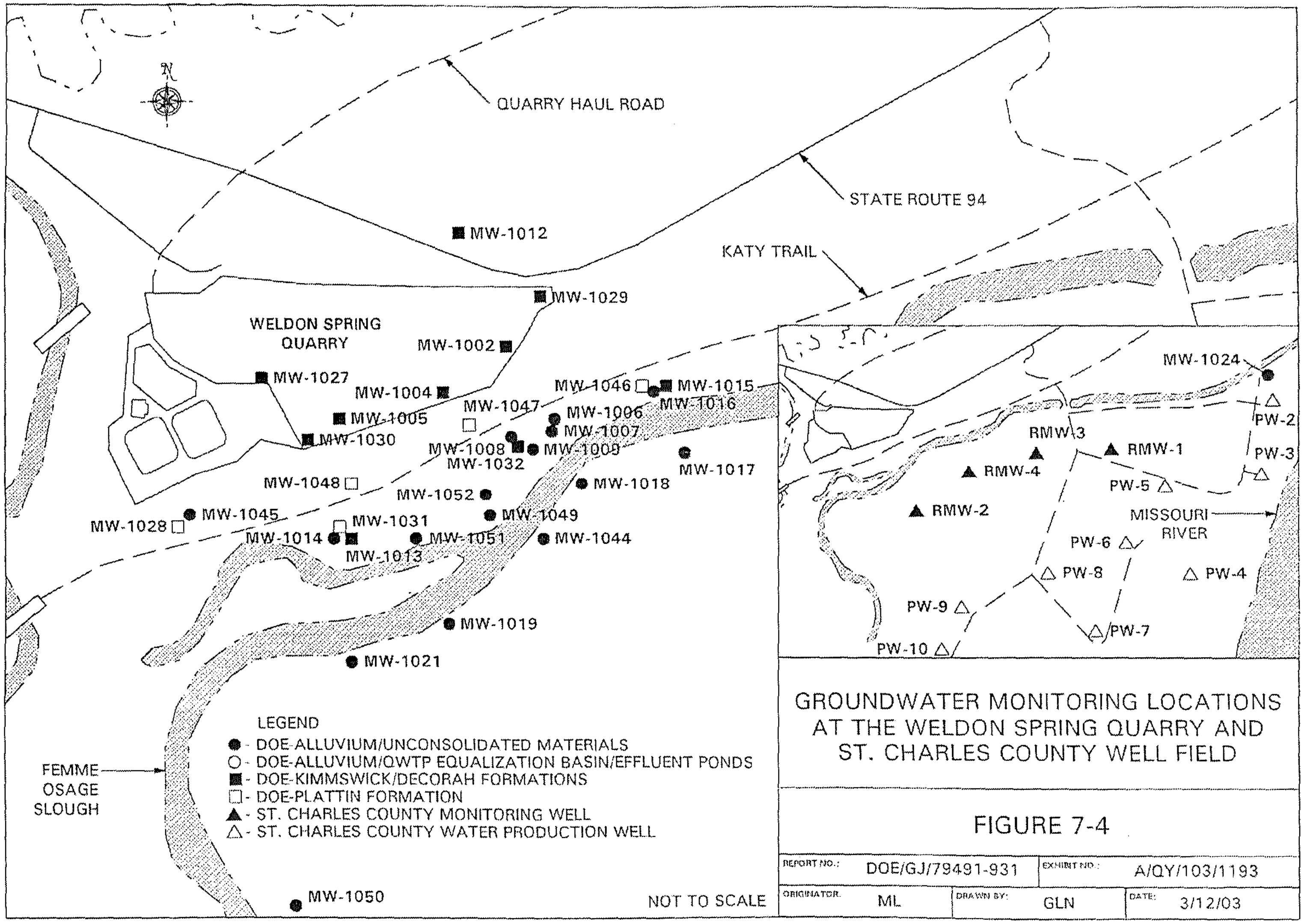
The geology of the quarry area is separated into three units; upland overburden, Missouri River alluvium, and bedrock. The unconsolidated upland material overlying bedrock consists of up to 9.2 m (30 ft) of silty clay soil and loess deposits and is not saturated (Ref. 1). Three Ord+ovician-age formations 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, 15 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 7-4). Ten of the 15 monitoring wells were installed to monitor contaminants within the Kimmswick-Decorah Formations comprising and surrounding the quarry. The remaining five monitoring wells are located south of the quarry within the Plattin Limestone to assess vertical contaminant migration.

There are 15 monitoring wells completed into the alluvium near the quarry and the Missouri River. 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, were designed to provide an early warning of contaminant migration toward the county production well field. The county production wells were monitored to verify the quality of the municipal well field water supply.



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

FIGURE 7-4

REPORT NO.: DOE/GJ/79491-931		EXHIBIT NO.: A/QY/103/1193	
ORIGINATOR: ML	DRAWN BY: GLN	DATE: 3/12/03	

Eight groundwater monitoring wells once 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 7-13 (Ref. 35).

Table 7-13 Average Background Values for Quarry Monitoring Locations

PARAMETER	ALLUVIUM [(a)]	KIMMSWICK/DECORAH[(b)]	PLATTIN [(c)]
Total Uranium (pCi/l)	2.77	3.41	12.30
Nitroaromatics (µg/l)	NA	NA	NA
Sulfate (mg/l)	44.20	95.90	165.00
Iron (µg/l)	8,405	1,177	9,272

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

7.5.2 Monitoring Program

Two separate programs were employed in 2002 to monitor groundwater near the quarry. The first program involved sampling the Department of Energy wells in the quarry area to continue monitoring the effects of quarry dewatering and bulk waste removal on groundwater quality. 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 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 quarry locations were sampled at least annually for uranium, 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.

As discussed in the EMP (Ref. 8), monitoring at the quarry as of the fourth quarter, was conducted in accordance with the *Remedial Design/Remedial Action Work Plan for the Quarry Residuals Operable Unit* (Ref. 13).

7.5.3 Weldon Spring Quarry Monitoring Results

7.5.3.1 Quarry

Uranium. 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 2002 annual averages for total uranium are summarized in Table 7-14. Eighteen locations exceeded their background, although no locations south of the Femme Osage Slough exceeded background.

Table 7-14 Annual Groundwater Averages for Total Uranium at the Weldon Spring Quarry

LOCATION	AVERAGE (pCi/l)	NUMBER OF SAMPLES
MW-1002[1]	3.70	4
MW-1004[1]	1142.50*	4
MW-1005[1]	1132.50*	4
MW-1006[2]	1116.0*	4
MW-1007[2]	11.34	4
MW-1008[2]	2927.50*	4
MW-1009[2]	0.94	4
MW-1012[1]	2.23	4
MW-1013[1]	472.30*	4
MW-1014[2]	741*	4
MW-1015[1]	161.20*	4
MW-1016[2]	82.40*	4
MW-1017[2]	<0.68	2
MW-1018[2]	<0.68	2
MW-1019[2]	0.19	2
MW-1021[2]	0.12	2
MW-1027[1]	236.25*	4
MW-1028[3]	1.83	2
MW-1029[1]	2.02	4
MW-1030[1]	12.28	4
MW-1031[3]	12.25	4
MW-1032[1]	1097.50*	4
MW-1044[2]	<0.68	2
MW-1045[2]	5.19	4
MW-1046[3]	4.21	4
MW-1047[3]	0.97	4
MW-1048[3]	367*	4
MW-1049[2]	<0.70	4
MW-1050[2]	<0.68	2
MW-1051[2]	766*	1
MW-1052[2]	37.30*	1

NOTE: 1 pCi/l = 0.037 Bq/l * Annual average exceeds groundwater standard of 30 μg/l (20 pCi/l).

Note 1: This will is completed in the Kimmswick/Decorah. Compare to the background concentration of 3.41 pCi/l as shown in Table 7-13.

Note 2: This well is completed in the alluvium. Compare to the background concentration of 2.77 pCi/l as shown in Table 7-13.

Note 3: This well is completed in the plattin. Compare to the background concentration of 12.30 pCi/l as shown in Table 7-13.

The groundwater standard of 30 µg/l (20 pCi/l) (40 CFR 141) 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 similar to 2001, with only a few exceptions. MW-1009 and MW-1031 no longer had averages greater than background. MW-1051 and MW-1052, which were added to the list as locations having average concentrations exceeding background, were installed as observation wells for the interceptor trench. After the study was completed, these locations were added to the routine long-term monitoring program.

Nitroaromatic Compounds. In 2002, 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 2001. No detectable concentrations were observed south of the Femme Osage Slough. A summary of the annual averages for all locations is provided in Table 7-16. The 2,4-DNT average concentration for location MW-1027 remained above the Missouri drinking water standard of 0.11 µg/l during 2001. Background comparisons are not discussed since nitroaromatics are not naturally occurring compounds.

Table 7-15 Annual Groundwater Averages for Nitroaromatic Compounds (µg/l) at the Weldon Spring Quarry

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB	NUMBER OF SAMPLES
MW-1002	4.23	<0.09	1.68	<0.06	2.20	<0.08	4
MW-1004	<0.04	<0.09	0.05	0.04	0.12	<0.08	4
MW-1005	<0.09	<0.27	<0.09	0.05	<0.18	<0.08	4
MW-1006	4.85	<0.09	0.58	0.08	0.30	<0.08	4
MW-1007	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1008	0.08	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1009	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1012	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1013	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1014	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1015	0.70	0.08	0.36	<0.06	<0.10	<0.08	4
MW-1016	0.08	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1017	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	2
MW-1018	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	2
MW-1019	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	2
MW-1021	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	2
MW-1027	<0.04	<0.09	0.19	1.63*	1.43	<0.08	4
MW-1028	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	2
MW-1029	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1030	<0.06	<0.18	<0.08	<0.08	<0.10	<0.08	4
MW-1031	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1032	<0.04	<0.09	<0.08	<0.06	<0.10	0.06	4
MW-1044	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	2
MW-1045	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1046	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1047	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1048	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1049	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	4
MW-1050	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	2
MW-1051	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	1
MW-1052	<0.04	<0.09	<0.08	<0.06	<0.10	<0.08	1

< All samples less than highest detection limit.
* Exceeds the Missouri Water Quality Standard of 0.11 µg/l for 2,4-DNT.

Sulfate. Groundwater analyses in 2002 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. Annual sulfate averages are summarized in Table 7-16. Overall, twelve monitoring wells had averages above background, which is similar to 2001.

Table 7-16 Annual Groundwater Averages for Sulfate at the Weldon Spring Quarry

LOCATION	ANNUAL AVERAGE (mg/l)	NUMBER OF SAMPLES
MW-1002[1]	102.58	4
MW-1004[1]	121.40	4
MW-1005[1]	299.50	4
MW-1006[2]	87.20	4
MW-1007[2]	8.49	4
MW-1008[2]	98.68	4
MW-1009[2]	36.03	4
MW-1012[1]	38.50	4
MW-1013[1]	113.50	4
MW-1014[2]	125.25	4
MW-1015[1]	101.13	4
MW-1016[2]	79.30	4
MW-1017[2]	0.31	2
MW-1018[2]	11.85	2
MW-1019[2]	<0.50	2
MW-1021[2]	<0.50	2
MW-1027[1]	68.75	4
MW-1028[3]	61.95	2
MW-1029[1]	88.90	4
MW-1030[1]	73.40	4
MW-1031[3]	30.88	4
MW-1032[1]	137.00	4
MW-1044[2]	<0.50	2
MW-1045[2]	54.65	4
MW-1046[3]	70.88	4
MW-1047[3]	98.68	4
MW-1048[3]	65.20	4
MW-1049[2]	0.31	4
MW-1050[2]	0.53	2
MW-1051[2]	67.50	1
MW-1052[2]	6.20	1

< All sample results less than the highest detection limit.

Note 1: This well is completed in the Kimmswick/Decorah. Compare to the background concentration of 95.90 mg/l as shown in Table 7-13.

Note 2: This well is completed in the alluvium. Compare to the background concentration of 44.20 mg/l as shown in Table 7-13.

Note 3: This well is completed in the plattin. Compare to the background concentrations of 165 mg/l as shown in Table 7-13.

Iron. Iron groundwater analyses was added during 2002 to begin preparation for long-term monitoring as detailed in the *Remedial Design/Remedial Action Work Plan for the Quarry Residual Operable Unit* (Ref. 13). Annual iron averages are summarized in Table 7-17.

Table 7-17 Annual Groundwater Averages for Iron at the Weldon Spring Quarry

LOCATION	ANNUAL AVERAGE (μg/l)	NUMBER OF SAMPLES
MW-1002	36.08	4
MW-1004	39.34	4
MW-1005	29.84	4
MW-1006	1,421	4
MW-1007	32,350	4
MW-1008	46.19	4
MW-1009	23,075	4
MW-1012	27.11	4
MW-1013	3,602	4
MW-1014	1,187	4
MW-1015	33.21	4
MW-1016	<68.70	4
MW-1017	28,700	2
MW-1018	25,950	2
MW-1019	16,950	2
MW-1021	15,350	2
MW-1027	45.19	4
MW-1028	3,580	2
MW-1029	28.41	4
MW-1030	23.94	4
MW-1031	31.39	4
MW-1032	55.34	4
MW-1044	19,150	2
MW-1045	26.61	4
MW-1046	1,356	4
MW-1047	112.60	4
MW-1048	563.75	4
MW-1049	43,575	4
MW-1050	20,050	2
MW-1051	144	1
MW-1052	29,500	1

Note 1: This well is completed in the Kimmswick/Decorah. Compare to the background concentration of 1,177 μg/l as shown in Table 7-13.
Note 2: This well is completed in the alluvium. Compare to the background concentration of 8,405 μg/l as shown in Table 7-13.
Note 3: This well is completed in the plattin. Compare to the background concentration of 9,272 μg/l as shown in Table 7-13.

7.5.3.2 St. Charles County Well Field

Uranium. The St. Charles County production wells, pretreated (MW-RAWW) and treated water (MW-FINW) from the St. Charles County water treatment plant and DOE well MW-1024, were sampled semiannually during 2002 for total uranium. The RMW-series monitoring wells were analyzed quarterly for total uranium. A summary of the uranium annual averages is provided in Table 7-18. The annual averages for total uranium in the well field remain at background. No production well exceeded the groundwater standard of 30 μg/l (20 pCi/l) as established in 40 CFR 141.66.

Table 7-18 Annual Groundwater Averages for Total Uranium in the St. Charles County Well Field

LOCATION	AVERAGE (pCi/l)	NUMBER OF SAMPLES
MW-1024	<0.70	4
MW-RMW1	0.77	4
MW-RMW2	3.94	4
MW-RMW3	<0.68	4
MW-RMW4	1.37	4
MW-PW02	<0.68	2
MW-PW03	<0.13	1
MW-PW04	<0.68	2
MW-PW05	<0.68	2
MW-PW06	<0.68	2
MW-PW07	<0.70	2
MW-PW08[a]	0.15	1
MW-PW09	<0.68	2
MW-PW10	<0.70	2
MW-RAWW	<0.68	2
MW-FINW	<0.68	2

Note 1: 1 pCi/l = 0.037 Bq/l.
(n) Sample population.
< All samples less than highest detection limit.
(a) PW08 was off-line during one sampling event, therefore no sample was collected.

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

Sulfate. The St. Charles County production wells were sampled semiannually and the RMW-series monitoring wells were sampled quarterly for sulfate. The 2002 annual averages for the well field are summarized in Table 7-19.

Table 7-19 Annual Groundwater Averages for Sulfate and Iron in the St. Charles County Well Field

LOCATION	SULFATE (mg/l)		IRON (µg/l)	
	AVERAGE	NUMBER OF SAMPLES	AVERAGE	NUMBER OF SAMPLES
MW-1024	12.80	4	19,275	4
MW-RMW1	26.10	4	6,685	4
MW-RMW2	15.58	4	7,010	4
MW-RMW3	35.90	4	13,825	4
MW-RMW4	30.58	4	2,046	4
MW-PW02	114.50	2	2,985	2
MW-PW03	118	1	1,730	1
MW-PW04	126.50	2	1,750	2
MW-PW05	99.65	2	2,944	2
MW-PW06	73.80	2	4,265	2
MW-PW07	29.45	2	5,635	2
MW-PW08	32.70	1	7,070	1
MW-PW09	35.10	2	5,915	2
MW-PW10	118.50	2	1,680	2
MW-RAWW	84.85	2	3,725	2
MW-FINW	94.55	2	<68.7	2

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

Iron. Iron was monitored during 2002 at the St. Charles County well field on a quarterly basis at the RMW-series monitoring wells and semiannually at the St. Charles County production wells. The 2002 annual averages for Iron are reported in Table 7-19.

7.5.4 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 1999 to 2002. 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 former bulk waste sources and in areas of possible impact south of the slough. Nitroaromatic compounds were analyzed for locations down-gradient of former bulk waste sources. Remedial actions that addressed contamination source areas in the quarry were completed in 1995.

The computer program, TREND, which is described in detail in Section 7.4.4, was used for this trend analysis. The method employed was the nonparametric Mann-Kendall test.

7.5.4.1 Quarry Trend Results

The cumulative results for the period 1999 through 2002 for each parameter that was evaluated using the TREND program are summarized below. The trending results for the quarry area during this period were compared to past trending results performed for the period 1998 through 2001. The results of these analyses are summarized below.

Total Uranium

Twenty-one locations near the quarry were selected for total uranium trend analyses. Of these, 12 were bedrock wells and seven were alluvial wells. These locations have been designated as long-term monitoring wells.

Total uranium trends for 1999 through 2002 are shown in Table 7-20. Trends were all stationary except at four locations. These four locations, bedrock wells MW-1004, MW-1013, MW-1031, and MW-1048 indicated downward trends. This represents a change in trend for the bedrock well MW-1004, which last year reported a stationary trend based on the 1998 through 2001 data.

As shown in Table 7-20, two of the 21 locations that were evaluated for the 1999 through 2002 time frame have reported uranium concentrations in 2002 that exceed all past 1999 through 2001 data for the specific sampling location. These uranium levels are 4,420 pCi/l at MW-1008 and 920 pCi/l at MW-1014. While both locations had new highs since 1999, these values do not represent historical highs.

Table 7-20 Quarry Groundwater Uranium Trend Analysis Summary for 1999 to 2002

Well ID	Location	No. of Samples 1999-2002	No. of Non-Detect Data 1999-2002	Trend Direction (Alpha = 0.05) 1999-2002	Slope (pCi/l/yr) 1999-2002	95% Upper & Lower Confidence Intervals On Slope (pCi/l/yr) 1999-2002	2002 New High Concentration (pCi/l) 1999 to Date
MW-1002	Bedrock – east rim	11	0	S	-0.243	-0.841, 0.197	No
MW-1004	Bedrock – rim	11	0	D	-273.333	-504.694, -73.435	No
MW-1005	Bedrock – south rim	10	0	S	-170.000	-302.616, -20.281	No
MW-1006	Alluvium – north of slough	11	0	S	-36.500	-375.900, 170.089	No
MW-1007	Alluvium - north of slough	11	0	S	-15.870	-81.890, 0.019	No
MW-1008	Alluvium – north of slough	26	0	S	-10.000	-247.615, 378.808	4420
MW-1009	Alluvium - north of slough	28	6	S	0.031	-0.109, 0.822	No
MW-1013	Bedrock – north of slough	28	0	D	-65.000	-124.591, -22.084	No
MW-1014	Alluvium - north of slough	28	0	S	-9.500	-86.726, 72.363	920
MW-1015	Bedrock – north of slough	11	0	S	-24.500	-47.270, 1.810	No
MW-1016	Alluvium - north of slough	11	0	S	-2.000	-8.832, 7.741	No
MW-1027	Bedrock – west of quarry	11	0	S	-70.000	-127.338, 16.620	No
MW-1028	Bedrock – north of slough	6	0	S	0.373	-0.499, 1.139	No
MW-1030	Bedrock – south rim	11	0	S	-2.850	-9.593, -1.619	No
MW-1031	Bedrock - north of slough	15	0	D	-13.550	-23.445, -9.200	No
MW-1032	Bedrock – north of slough	28	0	S	-30.000	-75.000, 24.607	No
MW-1045	Bedrock – north of slough	8	0	S	-1.227	-7.656, 1.746	No
MW-1046	Bedrock – north of slough	10	0	S	-1.840	-48.916, 0.061	No
MW-1048	Bedrock – north of slough	27	0	D	-70.167	-94.610, -43.000	No
MW-1051[1]	Alluvium - north of slough	21	0	S	95.500	-111.018, 411.255	No
MW-1052[1]	Alluvium - north of slough	21	0	S	-0.635	-29.529, 10.036	No

D = Downward S = Stationary U = Upward

[1]Data from 1999 are not available for wells MW-1051 and MW-1052.

[2]Data from 1999 and 2000 are not available for MW-3030, SP-5304H, and SP-5304L.

Nitroaromatic Compounds

Eight locations near the quarry were selected for trend analyses of 2,4-dinitrotoluene (2,4-DNT). Of these locations, seven are bedrock wells and one is an alluvial well. All eight of these locations were also included in last year's analyses.

The results of the 2,4-DNT analyses for the monitoring wells near the quarry are presented in Table 7-21. Based on the results of the analyses, one downward trend was identified at MW-1002, a trend that remains unchanged from last year's analyses. Trending was not performed at MW-1030 because fewer than three detected concentrations were reported for the time period between 1999 and 2002.

The other six locations have stationary trends. The stationary trend result is a change from the analyses results using the 1998 through 2001 data at location MW-1004 (previously indicated a downward trend) and at location MW-1027 (previously indicated an upward trend.) Trending was not performed last year at MW-1005 or MW-1032 since fewer than three detected concentrations were reported at each of these wells.

As shown in Table 7-21, two of the eight locations that were evaluated for the 1999-2002 time frame have reported concentrations in 2002 that exceed all past 1999, 2000, and 2001 data for their respective sampling locations. These concentrations are 0.21 µg/l at MW-1006 and 0.04 µg/l at MW-1030. Only the concentration at MW-1006 was actually detected. The concentration at MW-1030 is calculated using one-half the detection limit. Due to a change in detection limits from year to year, this computed value is higher than any previously detected concentration. These values do not represent historical highs for either location.

7.6 Disposal Cell Monitoring

Five groundwater monitoring wells and one spring were monitored during 2002 to detect contaminants in the uppermost water unit beneath the permanent disposal cell in order to meet the substantive requirements of 40 CFR 264, Subpart F; 10 CSR 25-7.264(2)(F); and 10 CSR 80-3.010(8). These locations are shown in Figure 7-2 and 7-3. The monitoring parameters were derived from previous evaluations documented in the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (Ref. 37) and the *Weldon Spring Site Cell Groundwater Monitoring Demonstration Report* (Ref. 10).

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).

Table 7-21 Quarry Groundwater Nitroaromatic Trend Analysis Summary for 1999 to 2002

Well ID	Location	Compound	No. of Samples 1999-2002	No. of Non-Detect Data 1999-2002	Trend Direction (Alpha = 0.05) 1999-2002	Slope (µg/l/yr) 1999-2002	95% Upper & Lower Confidence Intervals on Slope (µg/l/yr) 1999-2002	2002 New High Concentration (µg/l) 1999 to Date
MW-1002	Bedrock – east rim	2,4-DNT	10	6	D	-0.007	-0.013, -0.003	No
MW-1004	Bedrock – south rim	2,4-DNT	10	5	S	-0.017	-0.032, 0.008	No
MW-1005	Bedrock – south rim	2,4-DNT	9	6	S	0.005	-0.150, 0.019	No
MW-1006	Alluvium - north of slough	2,4-DNT	10	6	S	-0.002	-0.040, 0.028	0.21
MW-1015	Bedrock – north of slough	2,4-DNT	10	6	S	-0.002	-0.010, 0.006	No
MW-1027	Bedrock – rim	2,4-DNT	12	0	S	0.107	-0.783, 0.920	No
MW-1030	Bedrock – south rim	2,4-DNT	7	6	(a)	(a)	(a)	0.04[1]
MW-1032	Bedrock – north of slough	2,4-DNT	16	13	S	0.005	0.000, 0.007	No

D = Downward 2,4 DNT 2,4-Dinitrotoluene
S = Stationary
(a) Fewer than three detected concentrations were reported for the time period; therefore, no trending was performed.

[1]The value listed is computed from one-half the detection limit. Due to a change in detection limits from year to year, this computed value is higher than any previous detected concentration.

- 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 cell well network were compared with previously established baseline concentrations for each location. 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 cell liners, to confirm the integrity of the disposal cell.

7.6.1 Monitoring Program

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-2055), four downgradient wells (MW-2032, MW-2046, MW-2047, and MW-2051), and one downgradient spring (SP-6301). Wells MW-2051 and MW-2055 were installed in 2001 as replacement wells. Semi-annual detection monitoring began in mid-1998, after cell construction had begun and 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 yields samples representative of the quality of surface water hydraulically downgradient of the disposal cell.

7.6.1.1 Baseline Conditions

Prior to waste placement, the disposal cell monitoring wells MW-2032, MW-2046, and MW-2047 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. Monitoring wells MW-2051 and MW-2055 were installed in 2001 as replacements for MW-2045 and MW-2048, respectively. Baseline has been established using the data collected from each well during 2001 and 2002.

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 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 *Disposal Cell 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 7-22 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 7-22 represent a revision to baseline values used from 1998 until mid-2000, based on a re-interpretation of the applicable guidance (Ref. 10).

7.6.1.2 Monitoring Results

The detection monitoring program for the cell well network provides for semi-annual sampling at each location. The 2002 monitoring results are presented in Tables 7-23 and 7-24. 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 7-23, indicated that several parameters exceeded baseline. Upon resampling for those parameters, the following baseline exceedances were confirmed:

- MW-2045 chromium, cobalt, molybdenum, nickel, 1,3,5-TNB
- MW-2046 2,4,6-TNT

Results of the second semi-annual sampling event, as shown in Table 7-24, indicated that several parameters exceeded baseline. Upon resampling for those parameters, the following baseline exceedances were confirmed:

- MW-2045 chromium, molybdenum, nickel
- MW-2046 chloride, 2,4,6-TNT

Table 7-22 Baseline Values for the Disposal Cell Monitoring Locations

PARAMETER	MW-2032	MW-2045	MW-2046	MW-2047	MW-2051	MW-2055	SP-6301
Chloride (mg/l)	30.55	87.26	19.66	13.10	63.44	7.18	29.21
Fluoride (mg/l)	1.64	0.25	0.26	1.28	0.82	0.31	0.57
Nitrate (mg/l)	163.32	3.04	3.64	150.42	5.84	1.39	35.28
Sulfate (mg/l)	91.53	69.43	71.56	52.98	84.86	514.83	121.35
Aluminum (μg/l)	3546.22	342.84	472.97	858.76	3059.66	6143.45	1,711.84
Antimony (μg/l)	9.93	15.59	28.07	27.20	2.67	3.14	13.57
Arsenic (μg/l)	4.74	3.80	4.45	4.59	3.68	5.74	3.90
Barium (μg/l)	547.66	304.62	319.96	501.17	270.40	89.79	280.61
Chromium (μg/l)	11.91	61.34	9.56	12.54	4.81	27.48	10.96
Cobalt (μg/l)	2.79	14.14	2.71	2.46	3.63	10.19	13.12
Copper (μg/l)	28.89	42.22	18.01	48.56	32.05	27.49	8.64
Lead (μg/l)	15.70	1.78	4.27	4.43	3.86	10.21	4.27
Lithium (μg/l)	25.13	35.31	17.43	87.30	46.30	32.56	44.41
Magnesium (μg/l)	68,895	60,867	66,642	94,431	24,496	112,886	54,057
Molybdenum (μg/l)	7.05	10.75	7.65	23.06	21.51	6.94	8.49
Nickel (μg/l)	22.62	1161.79	22.10	56.41	77.56	63.48	19.40
Selenium (μg/l)	9.57	5.12	5.08	8.64	2.04	22.58	5.91
Silver (μg/l)	17.73	3.77	6.12	5.41	4.50	4.16	2.75
Vanadium (μg/l)	8.29	7.97	13.69	13.09	3.02	40.64	20.78
Zinc (μg/l)	61.07	30.24	45.86	40.25	48.66	64.75	53.03
C.O.D. (mg/l)	3.94	8.44	8.45	5.74	18.09	16.01	29.84
Cyanide (μg/l)	138.71	4.73	3.94	5.70	11.86	2.50	4.88
T.D.S (μg/l)	1,262	568	637	1,051	465	1,039	552
T.O.X (μg/l)	0.07	0.07	0.05	0.06	0.06	0.06	0.04
T.O.C.(mg/l)	49.55	56.35	109.75	102.94	2.99	15.69	46.32
1,3,5-TNB (μg/l)	7.80	0.03	4.74	<DL	0.41	<0.04	0.156
1,3-DNB (μg/l)	1.18	0.18	0.75	0.075	0.21	<0.09	0.10
2,4,6-TNT (μg/l)	12.94	<DL	3.93	<DL	0.23	<0.08	0.357
2,4-DNT (μg/l)	1.04	0.18	1.12	0.56	0.09	<0.06	0.151
2,6-DNT (μg/l)	7.08	1.12	129.23	1.25	0.64	<0.10	0.508
Radium-226 (pCi/l)	1.02	1.03	0.45	0.70	1.92	2.20	0.50
Radium-228 (pCi/l)	3.62	2.79	4.11	2.12	2.31	2.55	6.17
Thorium-228 (pCi/l)	0.38	0.87	0.21	0.27	0.27	0.46	1.13
Thorium-230 (pCi/l)	0.35	0.91	0.29	0.68	0.39	0.58	1.74
Thorium-232 (pCi/l)	0.15	0.36	0.19	0.19	0.33	0.35	0.74
Uranium, Total (pCi/l)	6.56	1.76	2.13	1.69	4.23	7.07	203.73
pH (Std. Units)	7.81	7.46	7.33	7.80	8.38	8.29	7.12
Specific Conductance (umhos/cm)	2,021	1,114	1,061	1,545	770	1199	543

Table 7-23 Summary of Detection Monitoring Data for Cell Well Network (June 2002)

	CONCENTRATION						
PARAMETER	MW-2032	MW-2045	MW-2046	MW-2047	MW-2051	MW-2055*	SP-6301
Chloride (mg/l)	9.8	68.7	18.3	6.7	30.2	NS	13.6
Fluoride (mg/l)	ND	0.12	ND	ND	ND	NS	ND
Nitrate-N (mg/l)	4.4	1.7	2.2	64.4	3.1	NS	3.8
Sulfate (mg/l)	51.9	24.7	NS	23.5	NS	NS	NS
Aluminum (µg/l)	43.5	20.1	119	123	43.3	NS	544
Antimony (µg/l)	ND	ND	ND	ND	ND	NS	ND
Arsenic	ND	ND	ND	ND	ND	NS	ND
Barium (µg/l)	200	155	155	395	152	NS	113
Chromium (µg/l)	5.1	544	2.7	7.1	2.6	NS	1.7
Cobalt (µg/l)	ND	22.3	ND	1.6	ND	NS	ND
Copper (µg/l)	ND	5.4	ND	2.2	ND	NS	ND
Cyanide, total	ND	ND	ND	5.2	ND	NS	ND
Lead	ND	ND	ND	ND	ND	NS	ND
Lithium (µg/l)	9.4	4.5	8.4	27.0	4.6	NS	7.7
Magnesium (µg/l)	27,700	47,800	35,700	82,800	16,300	NS	13,500
Molybdenum (µg/l)	ND	70.5	ND	2.1	7.8	NS	ND
Nickel (µg/l)	4.6	1210	10.5	8.3	9.1	NS	3.7
Selenium (µg/l)	ND	ND	2.6	3.5	ND	NS	ND
Silver	ND	ND	ND	ND	ND	NS	ND
Thallium	NS	NS	NS	NS	NS	NS	NS
Zinc (µg/l)	6.6	6.1	4.7	10.9	5.5	NS	10.6
Vanadium (µg/l)	ND	ND	ND	ND	ND	NS	ND
Chemical Oxygen Demand (mg/l)	ND	ND	ND	ND	ND	NS	ND
Total Dissolved Solids (mg/l)	450	525	571	833	370	NS	280
Total Organic Carbon (mg/l)	ND	ND	1.4	ND	ND	NS	1.8
TOX (mg/l)	ND	0.02	0.02	ND	0.02	NS	0.02
1,3,5-Trinitrobenzene (µg/l)	ND	0.06	2.9	ND	0.05	NS	ND
1,3-DNB	ND	ND	ND	ND	ND	NS	ND
2,4,6-Trinitrotoluene (µg/l)	ND	ND	4.7	ND	ND	NS	ND
2,4-Dinitrotoluene (µg/l)	ND	0.09	ND	0.09	ND	NS	ND
2,6-Dinitrotoluene (µg/l)	ND	0.74	2.0	0.21	0.35	NS	0.12
Nitrobenzene	ND	ND	ND	ND	ND	NS	ND
Radium-226 (pCi/l)	ND	ND	ND	0.62	0.43	NS	ND
Radium-228 (pCi/l)	ND	ND	ND	ND	1.04	NS	ND
Thorium-228	ND	0.03	ND	ND	0.04	NS	ND
Thorium-230 (pCi/l)	0.18	0.17	0.20	0.16	0.11	NS	0.13
Thorium-232 (pCi/l)	ND	ND	ND	0.02	0.02	NS	0.02
Uranium, Total (pCi/l)	1.85	ND	0.72	0.93	0.95	NS	28.6

ND Non-detect.
NS Not sampled.
* MW-2048 was irreparably damaged in 2001. A new upgradient well (MW-2055) installed and replaced MW-2048 as part of the cell well sampling network.

Table 7-24 Summary of Detection Monitoring Data for Cell Well Network (December 2002)

	CONCENTRATIONS						
PARAMETER	**MW-2032**	**MW-2045**	**MW-2046**	**MW-2047**	**MW-2051**	**MW-2055***	**SP-6301**
Chloride (mg/l)	7.2	60.8	20.8	7.5	43.9	5.3	36.6
Fluoride (mg/l)	0.2	ND	0.14	0.14	0.23	0.14	0.21
Nitrate-N (mg/l)	1.8	1.1	0.70	20.4	0.93	0.66	4.7
Sulfate (mg/l)	34.9	26.6	53.2	23.9	53.3	277	24.3
Aluminum (µg/l)	28.7	19.4	26.4	32.3	23.0	1220	125
Antimony (µg/l)	ND	3.5	ND	ND	ND	ND	2.3
Arsenic (µg/l)	ND	ND	ND	ND	ND	ND	ND
Barium (µg/l)	149	166	181	347	148	24.3	122
Chromium (µg/l)	3.1	237	1.6	2.0	1.2	9.7	1.5
Cobalt (µg/l)	ND	5.9	ND	ND	ND	2.5	1.6
Copper (µg/l)	ND	ND	ND	ND	ND	ND	ND
Cyanide, total	12.7	ND	ND	5.4	ND	ND	ND
Iron	95.1	2,750	145	327	114	1,560	146
Lead (µg/l)	ND	ND	ND	ND	ND	ND	ND
Lithium (µg/l)	8.5	6.4	11.6	21.1	22.5	17.3	14.6
Magnesium (µg/l)	28,100	42,400	38,100	82,400	18,000	83,000	20,500
Manganese	5.9	137	9.7	25.9	4.1	29.8	2.3
Molybdenum (µg/l)	ND	70.0	ND	ND	4.6	2.4	2.0
Nickel (µg/l)	5.5	2700	20.3	5.7	7.5	26.8	3.6
Selenium (µg/l)	ND	ND	2.9	1.8	ND	13.6	2.2
Silver (µg/l)	ND	ND	ND	ND	ND	ND	0.77
Thallium	3.9	4.0	5.2	4.2	3.9	3.5	6.6
Vanadium (µg/l)	ND	2.9	ND	ND	ND	3.3	1.1
Zinc (µg/l)	4.8	ND	ND	ND	2.1	9.6	7.4
Chemical Oxygen Demand (mg/l)	ND	ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/l)	383	513	580	700	407	791	402
Total Organic Carbon (mg/l)	ND	ND	1.2	ND	ND	1.01	ND
TOX (mg/l)	ND	ND	0.02	ND	0.01	0.01	0.01
1,3,5-Trinitrobenzene (µg/l)	ND	0.27	3.2	0.13	0.29	ND	ND
1,3-Dinitrobenzene (µg/l)	ND	ND	ND	ND	ND	ND	ND
2,4,6-Trinitrotoluene (µg/l)	ND	0.20	5.0	ND	0.14	ND	ND
2,4-Dinitrotoluene (µg/l)	ND	0.09	0.26	0.12	0.07	ND	ND
2,6-Dinitrotoluene (µg/l)	ND	0.80	1.3	0.25	0.40	ND	0.17
Nitrobenzene	ND	ND	ND	ND	ND	ND	ND
Ra-226	ND	ND	ND	ND	ND	ND	ND
Radium-228 (pCi/l)	ND	ND	ND	ND	ND	1.39	2.21
Thorium-228	ND	ND	ND	ND	0.16	ND	ND
Thorium-230 (pCi/l)	0.34	ND	ND	ND	ND	ND	ND
Thorium-232	ND	ND	ND	ND	0.13	0.13	ND
Uranium, Total (pCi/l)	1.74	ND	0.81	1.02	0.86	3.16	100

NS Parameter was not sampled.
ND Non-detect.
* MW-2048 was irreparably damaged in 2001. A new upgradient well (MW-2055) installed and replaced MW-2048 as part of the cell well sampling network.

- MW-2047 1,3,5-TNB
- SP-6301 chloride

The above baseline nitroaromatic compound data are the result of increases in the existing groundwater contamination in the former Frog Pond area just northeast of the disposal cell. A demonstration report regarding these exceedances will be prepared. The report will evaluate historical site-wide water quality, analyze disposal cell leachate data and flow rates, and review cell well hydraulic performance characteristics.

The above baseline data for MW-2045 can be attributed to leaching of metals from the stainless steel (Type 316) well materials. Leaching may be attributed to poor hydraulic performance that could result in conditions that may promote leaching. Also, this well is highly turbid and metals may bind to colloids in the samples. During 2001, a new well (MW-2051) was installed about 200 feet southeast of MW-2045. The new well was monitored bimonthly to establish "baseline" levels and was incorporated into the cell well monitoring network in 2002. MW-2045 will not be utilized in the cell monitoring program for 2003.

The above baseline chloride data is under investigation. Burgermeister Spring and MW-2046 were resampled to verify the elevated results. Blank contamination was reported by the contract laboratory that may have biased the natural chloride concentrations high.

8. BIOLOGICAL MONITORING PROGRAM

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 shown that the radiation dose to native aquatic organisms in water influenced by the Weldon Spring site has never exceeded 0.1 rad/day, which is well within the protective guidelines of <1 rad/day 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 since the WSSRAP has no remaining sources of airborne radiological emissions. Based upon this information, no further biological monitoring will be conducted.

9. ENVIRONMENTAL QUALITY ASSURANCE PROGRAM INFORMATION

9.1 Highlights of the Quality Assurance Program

- Average relative percent differences calculated for groundwater, surface water, National Pollutant Discharge Elimination System (NPDES) samples, and springs were generally within the 20% criterion recommended by the Contract Laboratory Program (CLP).
- The data validation program accepted 99.5% of the data selected for validation qualifying in 2002.

9.2 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.

9.2.1 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.

9.2.2 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.

9.2.3 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.

9.2.4 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).

9.2.5 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.*

9.2.6 Independent Assessments and Appraisals

The environmental programs and contract laboratories are assessed periodically 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. There were no laboratories assessed during 2002.

9.2.7 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.

9.3 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.

9.3.1 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. 23 and Ref. 16), 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. 17).

9.3.2 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. 16). Descriptions of the Quality Control samples collected at the WSSRAP are detailed in Table 9-1.

Table 9-1 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.
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.

9.3.3 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.

9.3.4 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.

9.4 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.

9.4.1 Duplicate Results Evaluation

Two kinds of duplicate analyses were evaluated in 2002, 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.

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. 16), 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 9-2 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 9-2 Summary of Calculated Relative Percent Differences

PARAMETER	NUMBER OF SAMPLES	AVG. RPD	MIN. RPD	MAX. RPD
Arsenic	11	21.1	0.33	39.0
Chromium	11	7.8	0.52	15.0
Gross Alpha	19	25.9	1.0	73.4
Gross Beta	19	12.8	0.5	58.5
Lead	11	31.9	0.3	73.0
Manganese	9	2.2	0.0	5.5
Nitrate-N	27	2.3	0.0	12.0
Selenium	9	20.3	0.7	49.0
Sulfate	19	3.5	0.0	22.0
Total Suspended Solids	17	9.2	0.0	46.0
Trichloroethene	10	3.5	0.4	8.5
Uranium, Total	42	5.1	0.0	29.0
2,4-DNT	30	11.7	0.41	57.0
2,6-DNT	30	12.7	0.8	58.0
1,3,5-TNB	22	7.6	0.0	32.0
2,4,6-TNT	29	10.8	0.7	52.0

The results in Table 9-2 demonstrate that most average relative percent differences (RPDs) calculated were within the 20% criterion as recommended in the CLP (Ref. 23 and Ref. 16). Chemical oxygen demand, lead and selenium exceeded the 20% criteria, but a majority of the RPDs were acceptable, and several outliers were present in the data sets. As a result, duplicate sample analyses in 2002 were of acceptable quality.

9.4.2 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 9.4.2.1 through 9.4.2.4 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_S	= error associated with the sample
Err_B	= error associated with the blank

9.4.2.1 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 2002, 19 trip blanks were analyzed for volatile organic compounds. Detections for acetone were found in one blank, methylene chloride in three blanks, and toluene in one blank.

All environmental samples associated with these five blank samples were evaluated. Three samples were potentially impacted where methylene chloride had been detected, one where acetone had been detected, and one where toluene 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 and are probably not associated with transportation or field contamination.

9.4.2.2 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. Three equipment blanks were collected in 2002 for surface water sampling and were analyzed for total uranium. Uranium was not detected in these blanks.

9.4.2.3 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.

In 2002, four water blanks were collected. Table 9-3 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 number of potentially impacted samples. In cases where there were no detects in any blank, the number 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 9-3 Summary of Distilled Water Blank Parameter Results

PARAMETER	NUMBER OF DETECTS/NUMBER OF BLANK ANALYSES	NUMBER OF POTENTIALLY IMPACTED SAMPLES
Aluminum	2 of 4 (50%)	0
Arsenic	0 of 4 (0%)	NA
Barium	0 of 4 (0%)	NA
Cadmium	1 of 4 (25%)	1
Calcium	0 of 4 (0%)	NA
Chloride	0 of 4 (0%)	NA
Chromium	0 of 4 (0%)	NA
Fluoride	0 of 4 (0%)	NA
Iron	1 of 4 (25%)	0
Lead	2 of 4 (50%)	1
Lithium	2 of 4 (50%)	1
Mercury	1 of 4 (25%)	0
Molybdenum	0 of 4 (0%)	NA
Nickel	3 of 4 (75%)	1
Nitrate as N	0 of 4 (0%)	NA
Selenium	0 of 4 (0%)	NA
Silver	2 of 4 (50%)	0
Sulfate	0 of 4 (0%)	NA
Thallium	3 of 4 (75%)	0
Uranium, Total	0 of 4 (0%)	NA
Zinc	4 of 4 (100%)	1
1,3,5-TNB	0 of 4 (0%)	NA
1,3-DNB	0 of 4 (0%)	NA
2,4,6-TNT	0 of 4 (0%)	NA
2,4-DNT	0 of 4 (0%)	NA
2,6-DNT	0 of 4 (0%)	NA
Nitrobenzene	1 of 4 (25%)	1
Volatiles	0 of 4 (0%)	NA

NA Not applicable.

9.5 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 9-4 identifies the number of quarterly and total data points that were selected for data validation in 2002, and indicates the percentage of those selected that were complete. Data points in this table include all sample types.

Table 9-4 WSSRAP Validation Summary for Calendar Year 2002

CALENDAR QUARTER	NO. OF DATA POINTS COLLECTED	NO. OF DATA POINTS SELECTED FOR VALIDATION	PERCENT SELECTED	NO. OF VALIDATED DATA POINTS REJECTED	COMPLETENESS[a]
Quarter 1	4,197	583	13.9%	0	100%
Quarter 2	2,550	267	10.5%	2	99.3%
Quarter 3	2,183	343	15.7%	0	100%
Quarter 4	2,431	244	10.0%	5	98%
2002 Total	11,361	1,437	12.6%	7	99.5%

(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 9-5 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. 16), the U.S. EPA Contract Laboratory Program *Statement of Work for Organic Analysis* (Ref. 23), and the *Laboratory Data Validation Guidelines for Evaluating Radionuclide Analysis* (Ref. 18). For calendar year 2002, 100% of data validation has been completed. Data points in this table include groundwater, surface water, spring and seep water, and NPDES samples.

Table 9-6 identifies the average accuracy and precision for anion, metals, nitroaromatic, radiochemical, volatiles, 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."

Table 9-5 WSSRAP Validation Qualifier Summary for Calendar Year 2002

	NUMBER OF DATA POINTS								
	ANIONS	METALS	MISC.	NITRO-AROMATICS	PESTICIDES /PCBs	RADIO-CHEMICAL	SEMI-VOLATILES	VOLATILES	TOTAL
Accepted	72	387	79	270	26	157	57	382	1,430
Rejected	2	5	0	0	0	0	0	0	7
Not Validatable	0	0	0	0	0	0	0	0	0
Total	74	392	79	270	26	157	57	382	1,437
	PERCENTAGES								
Accepted	97.3%	98.7%	100%	100%	100%	100%	100%	100%	99.5%
Rejected	2.7%	1.3%	0%	0%	0%	0%	0%	0%	0.5%
Not Validatable	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 9-6 Laboratory Accuracy and Precision Summary for Calendar Year 2002

PARAMETER	NUMBER OF ANALYSES	LABORATORY ACCURACY			LABORATORY PRECISION		
		AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM
ANIONS							
Chloride	2	98.0	93	103	3.1	2.8	3.3
Fluoride	2	96.0	93	99	3.4	1.6	5.1
Nitrate-N	7	96.9	94	109	1.1	0.0	4.1
Sulfate	3	94.0	87	98	0.7	0.56	0.81
METALS							
Aluminum	2	98.9	88	110	13.2	13.2	NA
Antimony	2	105.0	98	112	0.6	0.6	NA
Arsenic	4	106.1	101.4	109.1	0.3	0.2	0.5
Barium	3	100.3	91.9	102.6	2.0	0.2	8.2
Beryllium	1	108.0	108.0	NA	NA	NA	NA
Cadmium	3	101.3	100.8	106.6	0.6	0.4	1.3
Calcium	1	102.2	102.2	NA	NA	NA	NA
Chromium	4	96.7	92.6	98.4	0.5	0.3	1.2
Cobalt	2	96.7	92.8	100.6	0.4	0.4	NA
Copper	2	98.0	94.0	102.0	0.5	0.5	NA
Iron	2	100.9	98.8	102.9	2.5	1.9	3.1
Lead	4	101.3	96.3	108.5	1.1	0.2	1.5
Lithium	2	98.1	94.5	101.7	0.4	0.4	NA
Magnesium	2	100.2	99.5	100.9	12.2	12.2	NA
Manganese	4	96.6	92.2	100.9	0.6	0.3	1.2
Mercury	3	106.6	104.9	109	1.2	0.0	2.8
Molybdenum	2	99.9	95.1	104.6	0.7	0.7	NA
Nickel	2	98.5	94.4	102.5	0.3	0.3	NA
Potassium	1	100.5	100.5	NA	NA	NA	NA
Selenium	4	109.2	100.1	117.6	0.6	0.3	1.4
Silver	4	100.8	94.4	106.9	0.5	0.1	1.0
Sodium	1	99.3	99.3	NA	NA	NA	NA
Thallium	2	100.9	97.9	103.8	0.2	0.2	NA
Vanadium	2	97.2	92.8	101.6	0.5	0.5	NA
Zinc	2	102.5	98.5	106.4	0.7	0.7	NA

Table 9-6 Laboratory Accuracy and Precision Summary for Calendar Year 2002 (Continued)

		LABORATORY ACCURACY			LABORATORY PRECISION		
PARAMETER	**NUMBER OF ANALYSES**	**AVERAGE**	**MINIMUM**	**MAXIMUM**	**AVERAGE**	**MINIMUM**	**MAXIMUM**
MISC.							
Total suspended solids	6	94.7	90	107	NA	NA	NA
Chemical Oxygen Demand	2	96	94	98	NA	NA	NA
Total Dissolved Solids	2	101.5	101	102	1.8	1.8	NA
Total Organic Halides	1	90.9	90.9	NA	0.11	0.11	NA
Total Organic Carbon	2	98.5	98	99	0.2	0.1	0.41
Cyanide, total	1	103	103	NA	3.3	3.3	NA
Oil & Grease	1	86	86	NA	6.0	6.0	NA
Phosphorus, total	1	94	94	NA	3.0	3.0	NA
NITROAROMATICS							
2,4,6-Trinitrotoluene	8	73.2	64	84	6.0	0.0	23.3
2,4-Dinitrotoluene	8	76.1	62	85	0.6	0.0	1.6
1,3,5-Trinitrobenzene	8	81.1	62	88	4.0	0.0	19.1
1,3-Dinitrobenzene	8	79.2	64	86	3.9	0.0	10.2
2,6-Dinitrotoluene	8	74.2	57	82	5.0	0.0	16.1
Nitrobenzene	8	75.7	63	82	5.1	0.0	14.9
RADIOCHEMICAL							
Gross Alpha	4	102.4	83	124	12.4	3.9	31.3
Gross Beta	4	107.9	96.9	119	3.5	1.3	5.8
Radium-226	2	95.9	83.5	108.4	2.3	1.5	3.1
Radium-228	2	106.9	97.7	116	1.8	1.7	1.9
Thorium-228	2	100.3	94.0	106.5	10.6	3.9	17.3
Thorium-230	2	99.2	91.5	106.9	5.65	3.2	8.1
Thorium-232	2	97.1	92.2	102	6.3	2.9	9.7
Uranium, total	8	95.4	89.5	103	6.2	3.0	21.3
VOLATILES							
1,2-Dichloroethene	2	105.5	105	106	5.3	3.3	7.3
Tetrachloroethene	2	101	100	102	1.4	0.9	1.9
Trichloroethene	2	99	97	101	3.6	2.8	4.4
Vinyl Chloride	2	153.5	129	178	20.3	11.6	28.9

NA = Not Applicable

10. SPECIAL STUDIES

10.1 Quarry Interceptor Trench

The Quarry Residuals Operable Unit (QROU) is the second of two operable units established for the quarry area of the Weldon Spring site. The QROU addresses residual conditions at the quarry after bulk waste removal, primarily contaminated groundwater north of the Femme Osage Slough. The *Record of Decision for Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site* (ROD) (Ref. 34) was signed by the U.S. Environmental Protection Agency and the U.S. Department of Energy on September 30, 1998. This *Record of Decision* presents the selected remedial action for the QROU following the requirements for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The selected action stipulates long-term monitoring of groundwater to ensure continued protection of human health and the environment. Institutional controls are to be implemented, as necessary, to prevent groundwater usage inconsistent with recreational uses or uses that would adversely affect contaminant migration. Field studies were also required to collect data to verify the existing conceptual fate and transport model for the quarry area.

The conceptual model is that sorption of uranium onto the aquifer matrix and organics and precipitation of dissolved uranium from groundwater is responsible for the notable decrease of uranium (from 3,000 pCi/l to less than 1 pCi/l) over a short distance (100 to 300 ft) north of the slough. The sharp decrease in uranium levels indicates that dispersion and dilution, which typically generate more diffuse boundaries, are not the primary processes attenuating the uranium in groundwater.

The interceptor trench was constructed to support the action in the ROD. A field test was performed southeast of the quarry to quantify the mass of uranium that could be removed from the aquifer by pumping contaminated groundwater from the interceptor trench located between the quarry and the Femme Osage Slough (see Figure 10-1). The trench operated from April 27, 2000 through April 26, 2002. Sampling of groundwater from the trench and nearby monitoring wells was conducted according to the *Sampling Plan for the QROU Interceptor Trench Field Study* (Ref. 21).

Based on the two-year operational period, a total of 6,306,696 liters (1,666,234 gal) of water was pumped from the interceptor trench. Pumps were operational only during periods of flow from the respective sumps. Samples were collected daily from the operating pumps for onsite analysis of uranium, and weekly for off-site analysis of uranium and nitroaromatic compounds. Based on the analytical results, the total mass of uranium removed from the shallow aquifer during the two year study period was 14 kg. A summary of the groundwater production and resulting uranium mass removed from each sump is provided in Table 10-1.

Table 10-1 Quarry Interceptor Trench Groundwater Production and Uranium Mass Removal Summary

SUMP	PRODUCTION (1,000 LITERS)	PRODUCTION (1,000 GALLONS)	MASS REMOVED (KG)
3004	1.0	0.3	0.002
3104	413	109	1.4
3204	599	158	1.6
3304	5,302	1,399	11
Total	6,315	1,666	14

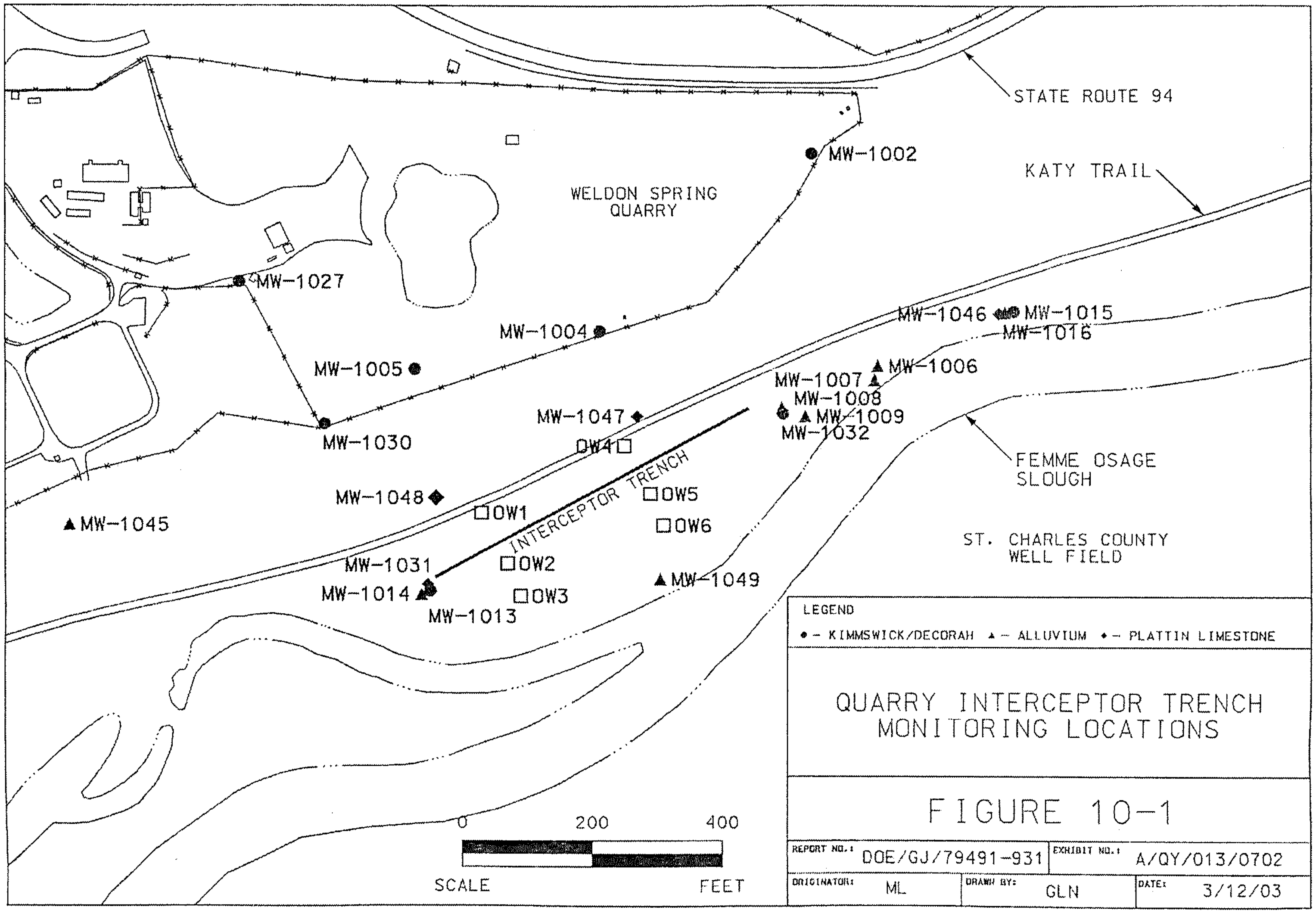
Nearby monitoring wells, which are shown on Figure 10-1, were sampled weekly for the first three months of the field study for uranium, nitroaromatic compounds, and geochemical parameters. After the first three months, the six OW-series monitoring wells were sampled biweekly for onsite analysis of uranium and monthly for off-site analysis of uranium, nitroaromatic compounds, and geochemical parameters. The remainder of the nearby monitoring wells were sampled monthly. A summary of the analytical data is provided in Table 10-2. Complete details are provided in the *Evaluation of the Performance of the Interceptor Trench Field Study* (Ref. 11).

Table 10-2 Summary of Uranium and Nitroaromatic Data for Quarry Monitoring Wells

LOCATION	URANIUM (PCI/L)			NITROAROMATIC COMPOUNDS (μG/L)
	AVERAGE	MAXIMUM	MINIMUM	
OW01	206	352	91	ND
OW02	197	511	45	ND
OW03	578	1,300	17	ND
OW04	2,263	3,220	1,490	ND
OW05	56	1,040	0.8	ND
OW06	142	784	0.75	ND
1008	2,468	4,490	960	ND
1009	8.6	101	<0.7	ND
1013	525	718	337	ND
1014	602	812	355	ND
1031	29	61	13	ND
1032	1,183	2,150	796	ND
1047	3.2	35	<0.7	ND
1048	450	672	347	ND
1049	1.6	12.4	<0.7	ND

ND Not detected

The evaluation indicates that 1,569 kg of uranium are present in the area of uranium impact (both dissolved phase and sorbed). Of this mass, 791 kg of uranium is within the capture zone of the interceptor trench. A total of 14.0 kg of uranium has been extracted using the interceptor trench. This accounts for 1.8% of the total mass available. The results of this field study indicate that the amount of uranium that can be removed using an interceptor trench is similar to or less than that predicted using analytical models. The mass removed constitutes only a small reduction of the total uranium contamination present and would not provide a measurable increase in the protection of the well field over the foreseeable future.



QUARRY INTERCEPTOR TRENCH MONITORING LOCATIONS

FIGURE 10-1

It can be concluded from the other hydrogeological and geochemical field studies that the natural system present in the area between the quarry and the Femme Osage Slough provides adequate protection of the St. Charles County well field. The results of these studies support that active remediation of the uranium impacted groundwater north of the slough is not necessary. The natural system has resulted in a significant reduction of dissolved uranium in groundwater through precipitation and adsorption and the groundwater quality south of the slough has not been impacted. Continued monitoring to demonstrate that the uranium concentrations north of the slough decrease over time as expected and that the groundwater quality south of the slough remains unchanged (selected remedy in the Record of Decision) will ensure that the groundwater in the well field is safe to use.

10.2 Geochemical Characterization at the Quarry

Geochemical characterization of the shallow aquifer between the quarry and the Femme Osage slough was performed to provide a better understanding of the impact the natural environment in the alluvial aquifer in this area on the fate of uranium contamination. The objectives of the study were to:

- Evaluate the geochemistry, emphasizing factors that influence the attenuation of uranium in groundwater.
- Estimate the uranium distribution coefficients (K_dS) for the aquifer materials.
- Characterize the oxidation state of the shallow aquifer and define the boundary of the reducing zone.
- Determine the distribution of precipitated uranium across the reducing front.

The results of the geochemical characterization provided a better understanding of the natural geochemistry of the alluvial aquifer north of the Femme Osage slough and its impact on the fate of uranium contamination in groundwater. This area contains a naturally occurring oxidation/reduction front, which acts as a barrier to the migration of dissolved uranium by inducing its precipitation. These results confirm that the geochemical parameters measured in the field and laboratory support observations and interpretations made during previous investigations. The physical and chemical parameters measured in groundwater samples were successfully correlated with the physical properties of the aquifer material and support the conceptual fate and transport model presented in the *Remedial Investigation* (Ref. 35).

A distinct contact was evident across the study area separating alluvial soils with characteristics indicative of oxidized conditions from those indicating reducing conditions. The oxidized/reduced zone contact is characterized as a change in the physical characteristics of the alluvial material with depth. The geochemical sampling program was designed to obtain soil and groundwater samples from discrete intervals from both the oxidized and reduced zones. Discrete groundwater samples were collected from wells that were screened to isolate zones above and below the redox front. Analytical results for redox parameters, including Eh, dissolved ferric/ferrous iron, manganese, sulfate/sulfide, and uranium were consistent with field observations distinguishing the oxidizing and reducing zones.

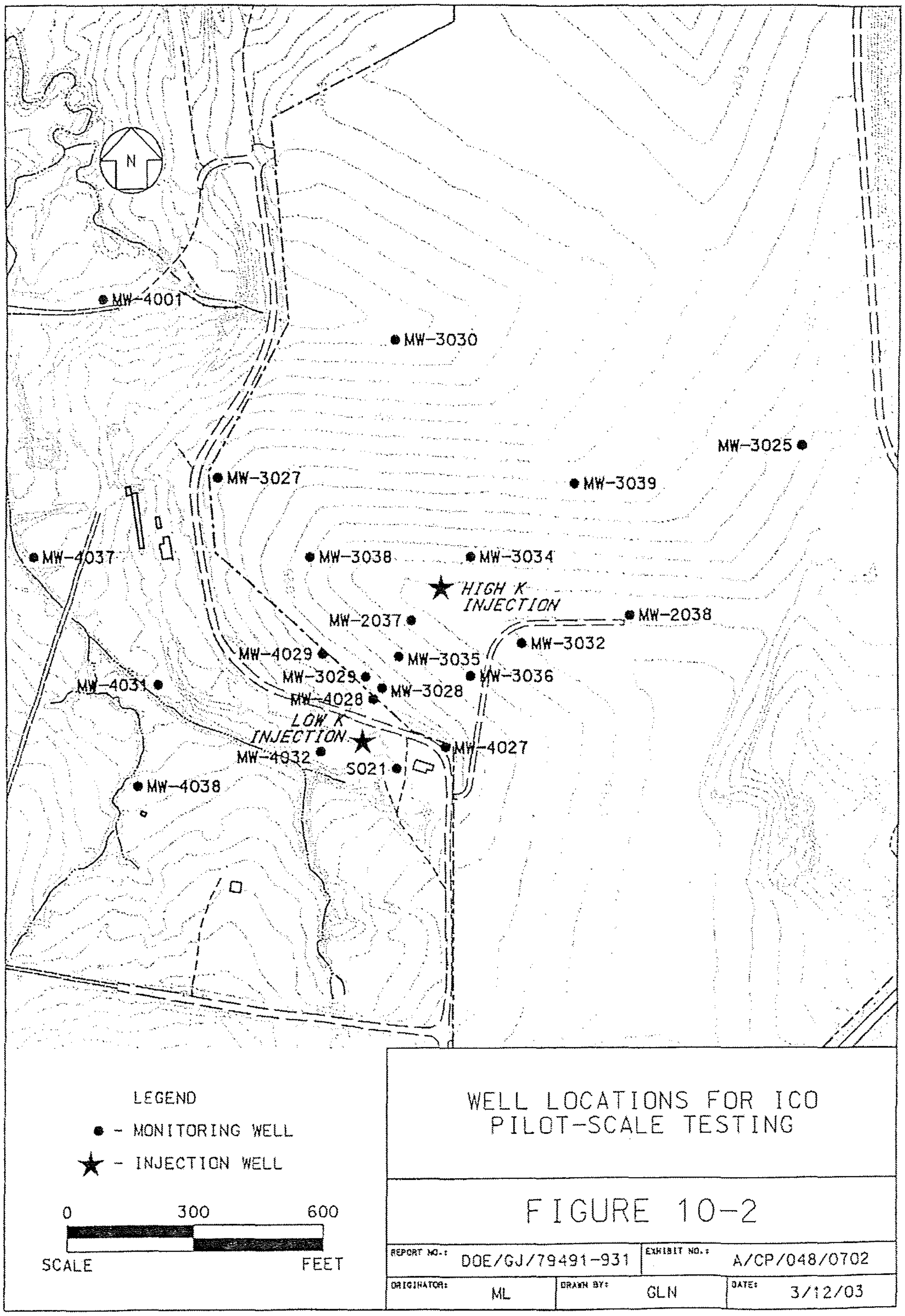
This study confirms that the primary mechanisms controlling the distribution of uranium in groundwater in the quarry area are precipitation due to the presence of an oxidation-reduction front and the sorption in the aquifer materials north of the slough. The distribution of dissolved uranium in groundwater reflects an environment where the chemically reducing portion of the alluvial aquifer exerts an immediate effect on the distribution by rapidly causing uranium to precipitate out of solution over a very short distance. The rapid change in uranium soil concentrations at the oxidation/reduction contact supports the dramatic decrease in uranium groundwater concentrations within a distance of less than 100 ft. Results from close-spaced soil samples showed a relatively high concentration of uranium in the interval immediately below the contact, decreasing to generally low concentrations with depth, all within the same material type. This suggests rapid precipitation in response to a change in the groundwater oxidation state across the oxidizing/reducing zone contact at this location. However, this does not preclude that some sorption of uranium occurs below the contact.

The attenuation mechanisms at work in the area north of the slough are reduction and adsorption. The capacity of the reduction zone should not be limited. As long as reducing conditions persist, dissolved uranium should precipitate out of solution. The capability of this area to remain reducing is largely a function of the amount of organic material in the saturated alluvium. Field observations have consistently shown abundant organic material in the reducing zone of the alluvium. The attenuation mechanism that does have a limited capacity is sorption of uranium onto the aquifer materials. As uranium is sorbed, sites on the aquifer material will be used up until it has reached capacity. Since both of these mechanisms are at work and reduction of uranium into insoluble forms is the predominant attenuation mechanism, the attenuation of uranium in this area should be unlimited.

10.3 Groundwater Operable Unit Insitu Chemical Oxidation Testing

The *Interim Record of Decision (IROD) for Remedial Action for the Groundwater Operable Unit (GWOU) at the Chemical Plant Area of the Weldon Spring Site* (Ref. 20) specifies the use of insitu chemical oxidation (ICO) to treat groundwater contaminated with trichloroethene (TCE) in the vicinity of the former raffinate pits. Bench-scale testing was conducted in the spring of 2001 to evaluate the effectiveness of several different oxidants in destroying TCE in groundwater samples collected from this area of the site. Tests by four different subcontractors demonstrated that, under laboratory conditions, oxidation chemistry was able to destroy TCE without significantly affecting the concentrations of other contaminants.

Following the successful bench-scale testing, technical specifications were prepared for field implementation of a pilot-scale treatment system. One subcontract was awarded in December 2001 to evaluate the effectiveness of ICO under actual field conditions and to assess the feasibility of implementing ICO on a full-scale basis. The pilot-scale injection was



WELL LOCATIONS FOR ICO PILOT-SCALE TESTING

FIGURE 10-2

performed in April and May 2002 at two specified locations within the area of TCE impact: one location with relatively high hydraulic conductivity (i.e., K ≈ 10^{-3} cm/sec) and one location with relatively low hydraulic conductivity (i.e., K ≈ 10^{-4} cm/sec). These locations, which are designated the "High K" and "Low K" injection points, are shown in Figure 10-2 along with the locations of monitoring wells in the TCE-impact area and their respective baseline TCE concentrations.

Design, installation, and operation of the ICO pilot-scale system was performed by a specialty subcontractor. Approximately 15,000 gallons of 0.1% sodium permanganate solution were introduced to the aquifer during the first injection. Groundwater sampling ten days after the injection indicated that a second treatment was necessary to achieve the 5-μg/l remediation goal specified in the IROD (Ref. 20). Thus, a second injection, consisting of approximately 25,000 gallons of additional permanganate solution, was performed.

Groundwater monitoring was conducted before, during, and after the pilot-scale treatment, as described in *Groundwater Sampling Plan for In Situ Chemical Oxidation Pilot-Scale Testing* (Ref. 22). Preliminary monitoring results have demonstrated that permanganate is able to destroy TCE up to 30 meters (100 feet) away from the injection points in both the High K and Low K areas. Continued groundwater monitoring at locations within and beyond the subcontractor's immediate test area will be used to determine the extent to which ICO affects any other physical or chemical characteristics of the aquifer. Monitoring results were compiled in a completion report by the subcontractor during the summer of 2002. This report and additional data collected by the project will be used to assess the technical feasibility of implementing ICO on a full-scale basis at the WSSRAP.

11. LONG-TERM STEWARDSHIP

The project transferred stewardship responsibility for the Weldon Spring Site Remedial Action Project from DOE-Oak Ridge Office to the DOE-Grand Junction Office (GJO) on October 1, 2002. The GJO office is responsible for the Long-term Surveillance and Maintenance (LTSM) Program at DOE facilities, providing long-term care for low-level radioactive material disposal sites.

During 2002, stewardship activities primarily focused on issuing the draft *Long-Term Stewardship Plan for the Weldon Spring, Missouri, Site* and obtaining input from the public and regulators. The following timeline highlights the long-term stewardship events during 2002 and first quarter 2003.

Stewardship Timeline

June 27, 2002	Conducted an educational Workshop on Long-Term Stewardship for the Weldon Spring Site.
August 9, 2002	Issued the first draft for the *Long-Term Stewardship Plan for the Weldon Spring, Missouri, Site.*
August 28, 2002	Workshop to discuss the Long-Term Stewardship Plan.
September 10, 2002	Comments due on draft Long-Term Stewardship Plan for the Weldon Spring Site.
October 10, 2002	Responses to comments posted on Internet at www.gjo.doe.gov/programs/ltsm/maps/mo-i.htm and mailed to requesters
October 23, 2002	Focus Area Work Session: Communication and Public Participation
December 5, 2002	Focus Area Work Session: Land Use and Institutional Controls and Homeland Security
January 30, 2003	New resources available on the Weldon Spring LTSM Program website:

- Availability of On-line viewing of all site documents listed in the Weldon Spring Long-Term Stewardship Plan and key documents contained in the completed Administrative Records
- Availability of On-line viewing of historical water-quality and water-level data for existing wells

February 5, 2003	Focus Area Work Session: Monitoring and Maintenance

The June educational workshop prepared participants to review and comment on the upcoming first draft of the *Long-Term Stewardship Plan for the Weldon Spring, Missouri, Site* (hereafter known as The Stewardship Plan). The workshop described typical long-term stewardship activities, the U.S. Department of Energy Grand Junction Office Long-Term Surveillance and Maintenance Program, and upcoming long-term stewardship planning activities pertaining to the Weldon Spring Site.

The first draft of The Stewardship Plan was issued to the regulators and the public on August 9, 2002, for a one month review and comment period. During this period, a second public workshop was held to answer questions and provide clarification concerning the Stewardship Plan. Responses to comments on the Stewardship Plan, were posted on the Internet at www.gjo.doe.gov/programs/ltsm/maps/mo-i.htm and also mailed to requesters on October 10, 2002.

The three focus Area Work Sessions were conducted between October 2002 and February 2003. The major issues for each session were identified from the comments received on the draft Stewardship Plan. The goals for focusing on these issues were to promote general understanding of concerns and to facilitate communication between the DOE and the public on common themes.

The first session focused on communication and public participation which identified five major issues: Weldon Spring stewardship organizations' roles and responsibilities; approval of changes to the Stewardship Plan; communication approaches to maintain awareness of site issues; emergency notifications and coordination for contingency planning; and public comments on process and considerations for the next work session. The second session focused on land use, institutional controls, and homeland security. The four major issues identified included: assess risks from residual contamination; define the institutional control areas and requirements and the institutional control process and implementation; stewardship activities for institutional controls; and site security. Monitoring and maintenance was the focus of the third session, which involved discussion of two major issues: monitoring/operations and annual site inspections/maintenance. There was also a demonstration of the on-line document retrieval and geographic information systems. Summaries of these focus sessions can be found on the www.gjo.doe.gov web-site.

The next draft of the The Stewardship Plan is expected to be issued during May 2003. This plan will reflect changes based upon written comments received on the first draft, input during the focus sessions, and any new information that has become available since the last draft.

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DOE ORDERS

232.1A, *Occurrence Reporting and Processing of Operations Information*
231.1, *Environmental, Safety, and Health Reporting*
5400.1, *General Environmental Protection Program*
5400.5, *Radiation Protection of the Public and the Environment*
414.1A, *Quality Assurance*

REGULATIONS

10 CFR 835, *Occupational Radiation Protection*
29 CFR 1926.59, *Hazard Communication*
40 CFR 61, Subpart H, *National Emission Standards for Hazardous Air Pollutants*
40 CFR 141, *National Primary Drinking Water Regulations*
40 CFR 264, Subpart F, *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*
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 60-4, *Public Drinking Water Program – Contaminant Levels and Monitoring*
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*

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