DOE–LM/1486–2007

Weldon Spring Site Environmental Report for Calendar Year 2006

August 2007

Work Performed Under DOE Contract No. DE–AC01–02GJ79491
for the U.S. Department of Energy Office of Legacy Management.
Approved for public release; distribution is unlimited.

This page intentionally left blank

DOE-LM-1486-2007

U.S. Department of Energy
Office of Legacy Management

Weldon Spring Site Environmental Report for Calendar Year 2006

August 2007

Work Performed by S.M. Stoller Corporation under DOE Contract No. DE–AC01–02GJ79491
for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado

This page intentionally left blank

Contents

Figures

Tables

End of current text

Acronyms

AEC	Atomic Energy Commission
ARAR	applicable or relevant and appropriate requirement
BTLs	baseline tolerance limits
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	contaminant of concern
COD	Chemical Oxygen Demand
CWA	Clean Water Act
DA	Department of the Army
DCF	dose conversion factor
DNB	dinitrobenzene
DNT	Dinitrotoluene
DOE	U.S. Department of Energy
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Difference
FFA	Federal Facility Agreement
ft	feet
ft/mi	feet per mile
GPS	global positioning system
GWOU	Groundwater Operable Unit
ha	hectare(s)
IC	Institutional Control
ICO	in-situ chemical oxidation
IRA	Interim Response Action
kg	kilogram(s)
km	kilometer(s)
L	liter
LCRS	Leachate Collection and Removal System
LTS&M	Long-Term Surveillance and Maintenance
m	meter(s)
MCL	maximum contaminant level
MDC	Missouri Department of Conservation
MDNR	Missouri Department of Natural Resources
mg/L	milligram(s) per liter
m/km	meters per kilometer
MoDOT	Missouri Department of Transportation
MNA	monitored natural attenuation
MOU	Memorandum of Understanding
mrem	millirem
MSD	Metropolitan St. Louis Sewer District
msl	mean sea level
mSv	millisievert
MW	Monitoring Well
µg	microgram(s)
µg/L	microgram(s) per liter
N	nitrate

NB	nitrobenzene
ND	Non-Detect
NHPA	National Historic Preservation Act
NPL	National Priorities List
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
ORP	oxidation reduction potential
OU	Operable Unit
PAHs	Polyaromatic hydrocarbons
PCB	polychlorinated biphenyl
pCi	picocurie(s)
pCi/L	picocurie(s) per liter
Ra	Radium
RCRA	Resource Conservation and Recovery Act
RME	Reasonable Maximally Exposed
ROD	Record of Decision
RPD	Relative Percent Difference
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SP	Spring
SWTP	Site Water Treatment Plant
TCE	Trichloroethylene
TDS	Total Dissolved Solids
TEDE	Total Effective Dose Equivalent
Th	Thorium
TNB	trinitrobenzene
TNT	Trinitrotoluene
TOC	Total Organic Carbon
TRI	Toxic Release Inventory
U-234	uranium-234
U-238	uranium-238
USGS	United States Geological Survey
WSSRAP	Weldon Spring Site Remedial Action Project
yr	year

Executive Summary

This *Weldon Spring Site Environmental Report for Calendar Year 2006* has been prepared as required by U.S. Department of Energy (DOE) Order 231.1A, *Environmental, Safety, and Health Reporting*, to provide information about the environmental and health protection programs conducted at the Weldon Spring Site. The Weldon Spring Site is in southern St. Charles County, Missouri, approximately 48 kilometers (km) (30 miles) west of St. Louis. The Site consists of two main areas, the former Weldon Spring Chemical Plant and the Weldon Spring Quarry, 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 in 2006 to assess their impacts on the public and environment. Since the Site has reached physical completion the long-term surveillance and maintenance (LTS&M) activities have become the main focus of the project. Therefore this report has been restructured and revised to reflect the reduction in physical activities and includes more emphasis on LTS&M activities.

Compliance Summary

The Weldon Spring Site is listed on the National Priorities List and is governed by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Under CERCLA, the Weldon Spring Site has been subject to meeting or exceeding applicable or relevant and appropriate requirements of federal, state, and local laws. Primary regulations have included the Resource Conservation and Recovery Act, Clean Water Act, and because DOE is the lead agency for the Site, the National Environmental Policy Act (NEPA) values are incorporated into CERCLA documents as outlined in the Secretarial Policy statement on NEPA. Many of these regulations are no longer applicable due to the reduction in physical activities and waste handling at the Site.

The Site has reached construction completion under CERCLA, which was documented in a Preliminary Closeout Report which was issued by the U.S. Environmental Protection Agency (EPA) on August 22, 2005.

Because contamination remains at some of the areas of the Site at levels above those that allow unlimited use and unrestricted exposure, CERCLA requires that the remedial actions be reviewed at least every 5 years. These reviews are commonly called Five-Year Reviews. DOE issued the third Five-Year Review for the Site in September 2006. The next Five-Year Review will be completed in 2011.

A new Federal Facility Agreement (FFA) between EPA, DOE, and the Missouri Department of Natural Resources (MDNR) was signed by all parties with the final signature by EPA on March 31, 2006. The focus of the new FFA is LTS&M activities.

Environmental Monitoring Summary

Historical water quality and water level data for existing wells can be found on the DOE Office of Legacy Management website: www.gjo.doe.gov/LM/. Photographs, maps, and physical features can also be viewed on this web page.

Groundwater monitoring at the Chemical Plant was focused on the selected remedy of monitored natural attenuation (MNA) for the Groundwater Operable Unit (GWOU). Total uranium, nitroaromatic compounds, TCE, and nitrate have been monitored at selected locations throughout the Chemical Plant area and offsite. The sampling locations target areas of highest impact in the shallow aquifer and migration pathways associated with paleochannels in the weathered unit of the Burlington-Keokuk Limestone.

The performance of the MNA remedy is assessed through the sampling of the Objective 2 monitoring wells, which are located within the areas of impact. These wells are monitored to verify contaminant concentrations are declining as expected and that cleanup standards will be met within a reasonable timeframe. The different objectives are described in Section 3.1.1.2. The following is a summary of the results for the MNA performance monitoring:

- Uranium levels in the weathered unit are generally stable or declining. Uranium continues to exceed the MCL of 20 picocuries per liter (pCi/L), except in well MW-3003.
- Uranium levels are higher in the unweathered unit. Uranium levels in the unweathered unit are variable. Well MW-4040 has an upward trend. Monitoring in the unweathered will continue to be performed more frequently in order to evaluate baseline levels in this area.
- Nitrate (as N) concentrations in the weathered and unweathered units are generally stable or declining. Nitrate concentrations are higher in the weathered unit. Nitrate continues to exceed the MCL of 10 milligrams per liter (mg/L) for nitrate as N.
- TCE concentrations are stable. An upward trend was identified in well MW-3034; however, this well was significantly impacted by field studies performed in the TCE impact area and the increase is a result of rebound. TCE impact occurs only in the weathered unit. TCE continues to exceed the MCL of 5 micrograms per liter (μg/L).
- Nitroaromatic compound concentrations are generally stable across the Site. Nitroaromatic compound impact occurs only in the weathered unit. Nitroaromatic compounds continue to exceed their respective cleanup standards, except for nitrobenzene, which was not detected in 2006.
- Upward trends have been identified for 2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene (DNT), and 2,6-DNT in 3 wells in the Frog Pond area.
- Concentrations of 2,4-DNT have decreased in wells in the Raffinate Pit area.

Detection monitoring is performed to ensure that lateral and vertical migration remains confined to the current area of impact and that expected lateral downgradient migration within the paleochannels is minimal or non-existent. Detection monitoring is performed by sampling the Objective 3 and 4 wells and Objective 5 springs and surface water locations. The following is a summary of the results for the MNA detection monitoring:

- Concentrations of the contaminants of concern (COCs) from the detection monitoring locations indicate that the movement of the areas of groundwater impact is behaving as expected. No increases were observed in either the weathered (Objective 3) or unweathered (Objective 4) wells. None of the detection monitoring well locations exceeded the MCL or cleanup standards for the COCs.

- Uranium levels in the springs (Objective 5) are generally stable. An upward trend was identified for Burgermeister Spring (SP-6301); however the levels of uranium are significantly less than historical highs. Levels of uranium exceed the MCL of 20 pCi/L in all of the springs, except SP-6303.
- Nitrate concentrations in Burgermeister Spring and SP-6303 are generally decreasing. Both of the springs have concentrations of nitrate (as N) that are less than the MCL of 10 mg/L.
- No detectable concentrations of TCE were reported for Burgermeister Spring. An estimated value (less than the detection limit) was reported for SP-6303 and is less than the MCL of 5 µg/L.
- No detectable concentrations of nitroaromatic compounds were reported for Burgermeister Spring. Detectable concentrations of 2,4-DNT and 2,6-DNT were reported for SP-6303 and are less than their respective cleanup standards.

Groundwater monitoring at the Quarry was focused on the selected remedy of long-term groundwater monitoring for the Quarry Residuals Operable Unit (QROU). Total uranium, nitroaromatic compounds, and geochemical parameters have been monitored in the area of impact and in the Missouri River Alluvium. Groundwater is sampled under two programs that focus on the area of impact in the quarry proper and north of the Femme Osage Slough and the Missouri River Alluvium located south of the Femme Osage Slough.

Uranium and 2,4-DNT are monitored in the area of groundwater impact to determine whether a target level of 300 pCi/L for total uranium and 0.11 µg/L for 2,4-DNT has been attained. These levels have been identified as having negligible impact on the groundwater south of the slough. The following is a summary of the results for monitoring performed within the area of impact:

- Uranium levels in the area of impact are generally stable. Some downward trends have been identified, primarily along the quarry rim. These decreases are the result of bulk waste removal and restoration activities that have reduced infiltration of precipitation and stormwater in the quarry proper.
- The attainment objective for the long-term monitoring of uranium in groundwater north of the slough is that the 90^{th} percentile of the data within a monitoring year is below the target level of 300 pCi/L. Nine wells exceeded the target level during 2006. The 90^{th} percentile associated with the data was 830 pCi/L and is a decrease from previous years.
- Detectable concentrations of 2,4-DNT were reported for only one well, MW-1027, during 2006 which exceeds the cleanup standard of 0.11 µg/L. This location has had an upward trend in concentrations over time.
- The attainment objective for the long-term monitoring for 2,4-DNT in groundwater north of the slough is that the 90^{th} percentile of the data within a monitoring year is below the target level of 0.11 µg/L. Eight monitoring wells have been selected for continued monitoring of 2,4-DNT. The 90^{th} percentile associated with the data from these eight wells was 0.11 µg/L. This value is higher than the previous year, which is the result of using a smaller dataset.

Uranium and 2,4-DNT are monitored in the Missouri River Alluvium south of the Femme Osage Slough to verify there has been no impact from contaminated groundwater north of the slough. To date, no measurable impact has occurred in the Missouri River Alluvium. The following is a summary of the results for monitoring performed within the Missouri River Alluvium:

- Results from the six wells located immediately south of the slough and the wells located within the productive portions of the alluvial aquifer indicate that uranium levels fall within the range used to calculate background for uranium. One well, RMW-2, exceeded the statistical background value in the alluvium; however, the value was well within the background range. This data was consistent with data from previous years. None of the locations exceed the MCL of 20 pCi/L for uranium.
- No detectable concentrations of nitroaromatic compounds were reported for the wells located in the Missouri River Alluvium.

The geochemistry of the aquifer is monitored to verify the presence of the reduction zone and to confirm that the reduction zone is capable of ongoing attenuation of uranium in the groundwater. The following is a summary of the results for geochemical monitoring:

- Review of the geochemical data within the area of impact indicates that reducing conditions are prevalent along the southern margin of the area of impact. This is consistent with the uranium data that indicates low uranium levels in wells that have more reducing characteristics. The location of the reducing area is consistent with previous years and the attenuation of uranium in this area continues.
- Geochemical data from the Missouri River Alluvium indicates that a strong reducing environment is prevalent in the groundwater immediately south of the slough. This type of environment is not favorable for the migration of uranium, if it were to pass beyond the reducing zone north of the slough.

Groundwater, spring, and leachate samples are collected as part of the detection monitoring program for the disposal cell. Under the monitoring program, signature parameter (barium, iron, manganese, and uranium) data from each location are compared to baseline tolerance limits (BTLs) to track general changes in groundwater quality and determine whether statistically significant evidence of contamination due to cell leakage exists. The data from the remainder of the parameters are reviewed to evaluate the general groundwater quality in the vicinity of the disposal cell and to determine if changes are occurring in the groundwater system. Leachate is sampled to verify the composition of the leachate. The following is a summary of the detection monitoring for the disposal cell:

- The results from the 5 monitoring wells and spring indicate that the concentrations of the signature parameters were less than their respective BTLs at each location. This indicates no evidence of leakage is evident in the groundwater beneath the disposal cell.
- The general groundwater quality in the detection monitoring wells and spring was similar to that measured in previous years.
- The composition of the leachate is similar to that measured in previous year. The four signature parameters remain at concentrations higher than those measured in groundwater beneath the disposal cell.

Surface water monitoring in the vicinity of the Chemical Plant was conducted to measure the effects of groundwater and surface water discharge from the Site on the quality of downstream surface water. The following is a summary of the surface water monitoring results:

- Uranium levels at the Busch Conservation Lakes were similar to previous years. The uranium levels at Lake 34 continue to be elevated compared to the remainder of the locations; however, uranium levels have declined in all of the lakes since remediation at the Chemical Plant started.
- The Schote Creek and Dardenne Creek locations showed relatively low levels of uranium and were consistent with data from previous years.

Surface water monitoring in the vicinity of the quarry was conducted to assess the water quality in the slough and potential impact of groundwater from the area of impact north of the slough. The following is a summary of the surface water monitoring results:

- Uranium levels over time in the slough have generally been stable.
- Samples were not collected during the second half of the year except at SW-1004 because the slough did not contain water.
- An elevated level of uranium (135 pCi/L) was reported at location SW-1004 for the second semiannual sample. This sample was collected from an area that has occasionally had elevated uranium levels due to discharge of impacted groundwater into the slough. This sample was collected from a small pool of water in an otherwise dry bed, and it is concluded that this sample did not represent the actual surface water quality had the slough not been dry. It is assumed that the elevated uranium was the result of uranium bound to colloids and during preservation of the sample, the uranium was stripped from the colloids and became part of the dissolved phase, leading to the elevated reading for this sampling event.

<u>Long-Term Surveillance and Maintenance Activity Summary</u>

The Weldon Spring Site Interpretive Center is part of DOE's LTS&M activities at the Site. Attendance for calendar year 2006 totaled 16,772.

The third annual public meeting required by the LTS&M plan was held on April 11, 2006. This meeting was held to discuss the 2005 second annual inspection which took place in November 2005. Also discussed were changes to the LTS&M Plan, a summary of environmental data, five-year review, MNA report, Institutional Control (IC) status, and the interpretive center/prairie activities.

The 2006 annual inspection took place on December 5, 6, and 15, 2006. The main inspection took place on December 5 and 6, but due to ice and snow conditions, inspection of the disposal cell transects and rock plots was postponed until December 15. The main areas inspected were the disposal cell, the Quarry, the LCRS, and monitoring wells. Areas where future ICs will be established were also inspected to verify that no groundwater or resource use that is incompatible with the necessary restrictions was occurring. The fourth annual LTS&M public meeting was held on April 22, 2007.

End of current text

1.0 Introduction

This *Weldon Spring Site Environmental Report for Calendar Year 2006* summarizes the environmental monitoring results obtained in 2006 and presents the status of federal and state compliance activities.

In 2006, environmental monitoring activities were conducted to support remedial action under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the National Environmental Policy Act (NEPA), the Clean Water Act (CWA), and other applicable regulatory requirements. The monitoring program at the Weldon Spring Site 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 2006* include:

- Providing general information on the Weldon Spring Site and the current status of remedial activities and long-term surveillance and maintenance (LTS&M) activities.
- Presenting summary data and interpretations for the environmental monitoring program.
- Reporting compliance with federal, state, and local requirements and DOE standards.
- Providing dose estimates for public exposure to radiological compounds due to activities at the Weldon Spring Site.
- 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 located in St. Charles County, Missouri, about 30 miles (48 kilometers [km]) west of St. Louis (Figure 1–1). The Site comprises two geographically distinct DOE-owned properties: the Weldon Spring Chemical Plant and Raffinate Pit Sites (Chemical Plant) and the Weldon Spring Quarry (Quarry). The Chemical Plant is located about 2 miles (2.3 km) southwest of the junction of Missouri State Route 94 and U.S. Highway 40/61. The Quarry is about 4 miles southwest of the Chemical Plant. Both sites are accessible from Missouri State Route 94.

During the early 1940s, the Department of the Army (DA) acquired 17,232 acres (6,974 hectares [ha]) of private land in St. Charles County for construction of the Weldon Spring Ordnance Works facility. The former ordnance works site has since been divided into several contiguous areas under different ownership as depicted in Figure 1–2. Current land use of the former ordnance works area includes the Chemical Plant and Quarry, the U.S. Army Reserve Weldon Spring Training area, Missouri Department of Conservation (MDC) and Missouri Department Natural Resources-Division of State Parks managed lands, the Francis Howell High School, a Missouri Department of Transportation (MoDOT) maintenance facility, the St. Charles County water treatment facility and law enforcement training center, the village of Weldon Spring Heights, and a University of Missouri research park.

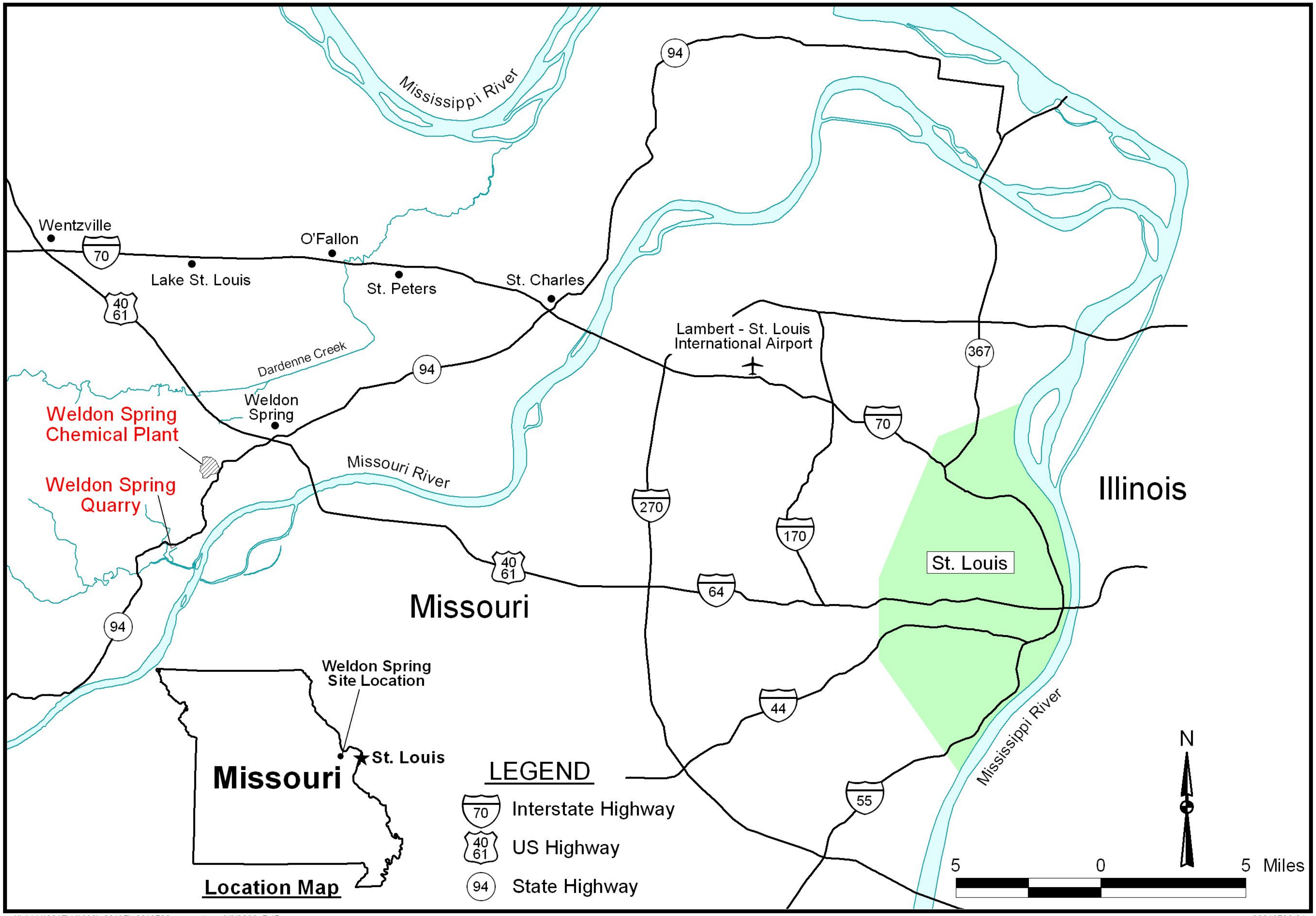

Figure 1–1. Location of the Weldon Spring, Missouri, Site

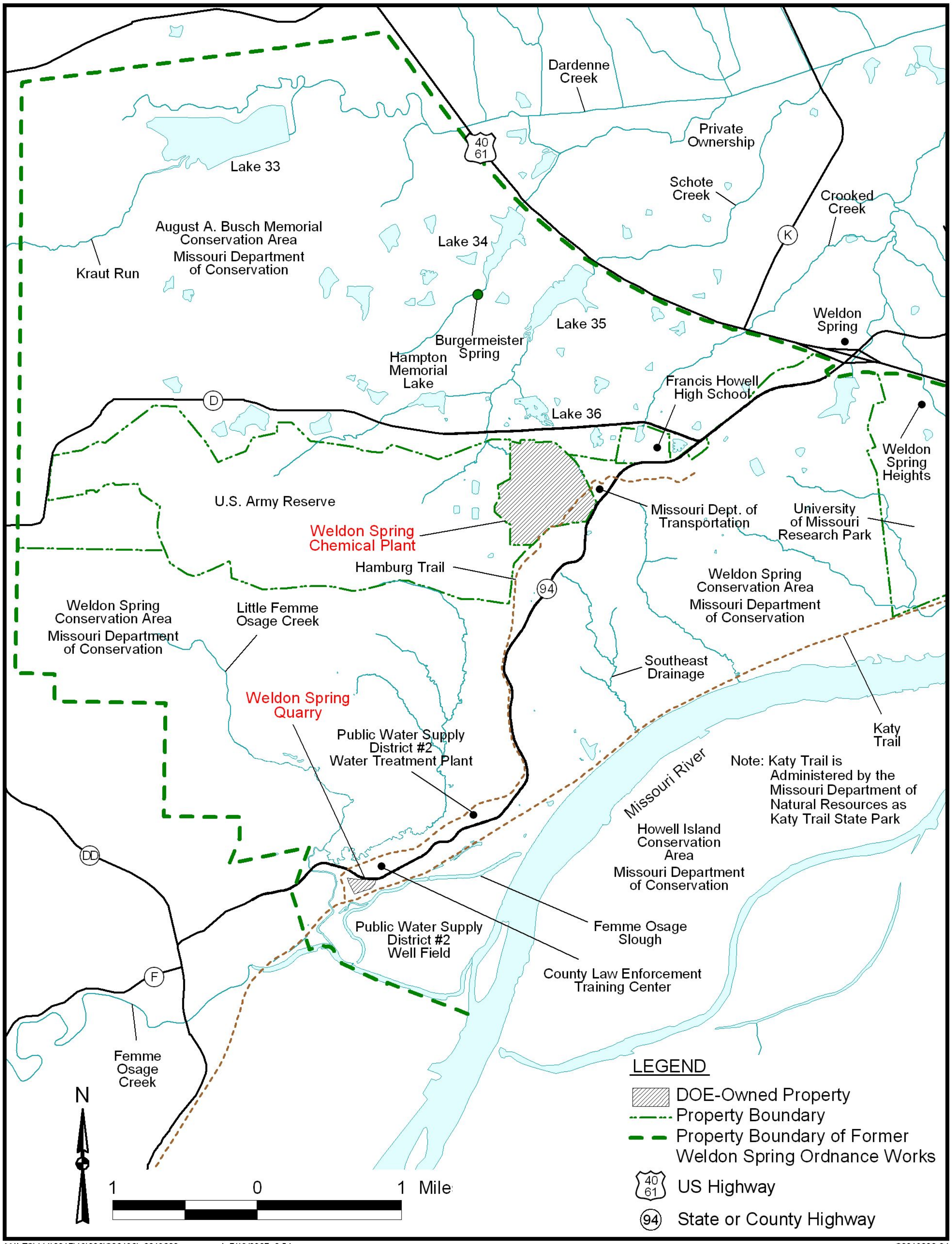

Figure 1–2. Vicinity Map of the Weldon Spring, Missouri, Site

The Chemical Plant and Quarry areas total 228.16 acres (92.33 ha). The Chemical Plant property is located on 219.50 acres (88.83 ha); and the Quarry occupies 8.66 acres (3.50 ha).

1.2 Site History

1.2.1 Operations History

In 1941, the U.S. Government acquired 17,232 acres (6,974 ha) of rural land in St. Charles County to establish the Weldon Spring Ordnance Works. In the process, the towns of Hamburg, Howell, and Toonerville and 576 citizens of the area were displaced (DA undated). From 1941 to 1945, the DA manufactured trinitrotoluene (TNT) and dinitrotoluene (DNT) at the Ordnance Works site. Four TNT production lines were situated on what was to be the Chemical Plant. These operations resulted in nitroaromatic contamination of soil, sediments, and some off-site springs.

Following a considerable amount of explosives decontamination of the facility by the Army and the Atlas Powder Company, 205 acres (83.0 ha) of the former ordnance works property were transferred to the U.S. Atomic Energy Commission (AEC) in 1956 for construction of the Weldon Spring Uranium Feed Materials Plant, now referred to as the Weldon Spring Chemical Plant. An additional 14.88 acres (6.02 ha) were transferred to AEC in 1964. The plant 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 four raffinate pits located on the plant property. Uranium processing operations resulted in radiological contamination of the same locations previously contaminated by former Army operations.

The Quarry was mined for limestone aggregate used in construction of the ordnance works. The Army also used the Quarry for burning wastes from explosives manufacturing and disposal of TNT-contaminated rubble during operation of the ordnance works. These activities resulted in nitroaromatic contamination of the soil and groundwater at the Quarry.

In 1960, the Army transferred the Quarry to AEC, who used it from 1963 to 1969 as a disposal area for uranium and thorium residues from the Chemical Plant (both drummed and uncontained) and for disposal of contaminated building rubble, process equipment, and soils from demolition of a uranium processing facility in St. Louis. Radiological contamination occurred in the same locations as the nitroaromatic contamination.

Uranium processing operations ceased in 1966, and on December 31, 1967, AEC returned the facility to the Army for use as a defoliant production plant. In preparation for the defoliant process, the Army removed equipment and materials from some of the buildings and disposed of them principally in Raffinate Pit 4. The defoliant project was canceled before any process equipment was installed, and the Army transferred 50.65 acres (20.50 ha) of land encompassing the raffinate pits back to AEC while retaining the Chemical Plant. AEC and subsequently DOE managed the Site, including the Army-owned Chemical Plant, under caretaker status from 1968 through 1985. Caretaker activities included Site security oversight, fence maintenance, grass cutting, and other incidental maintenance. In 1984, the Army repaired several of the buildings at the Chemical Plant, decontaminated some of the floors, walls, and ceilings, and isolated some equipment. In 1985, the Army transferred full custody of the Chemical Plant to DOE, at which time DOE designated control and decontamination of the Chemical Plant, raffinate pits, and Quarry as a major project.

1.2.2 Remedial Action History

The U.S. Environmental Protection Agency (EPA) placed the Quarry and Chemical Plant areas on the National Priorities List (NPL) in 1987 and 1989, respectively. Initial remedial activities at the Chemical Plant, a series of Interim Response Actions (IRAs) authorized through the use of Engineering Evaluation/Cost Analysis (EE/CA) reports, included:

- Removal of electrical transformers, electrical poles and lines, and overhead piping and asbestos that presented an immediate threat to workers and the environment.
- Construction of an isolation dike to divert runoff around the Ash Pond area to reduce the concentration of contaminants going off site in surface water.
- Detailed characterization of on-site debris, separation of radiological and nonradiological debris, and transport of materials to designated staging areas for interim storage.
- Dismantling of 44 Chemical Plant buildings under four separate IRAs.
- Treatment of contaminated water at the Chemical Plant and the Quarry.

Remediation of the Weldon Spring Site was administratively divided into four Operable Units (OUs): Quarry Bulk Waste OU, Quarry Residuals OU, Chemical Plant OU, and Groundwater OU (GWOU). The Southeast Drainage was remediated as a separate action through an EE/CA report (DOE 1996). The selected remedies are described in the following sections.

1.2.2.1 Chemical Plant OU

In the *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (DOE 1993), DOE established the remedy for controlling contaminant sources at the Chemical Plant (except groundwater) and disposing of contaminated materials in an on-site disposal cell.

The selected remedy included:

- Removal of contaminated soils, sludge, and sediment.
- Treatment of wastes, as appropriate, by chemical stabilization/solidification.
- Disposal of wastes removed from the Chemical Plant and stored Quarry bulk wastes in an engineered on-site disposal facility.

The remedy included remediation of 17 off-site vicinity properties affected by Chemical Plant operations. The vicinity properties were remediated in accordance with Chemical Plant Record of Decision (ROD) cleanup criteria.

The *Chemical Plant Operable Unit Remedial Action Report* (DOE 2004a) was finalized in January 2004.

1.2.2.2 Quarry Bulk Waste OU

DOE implemented remedial activities for the Quarry Bulk Waste OU set forth in the *Record of Decision for Management of Bulk Wastes at the Weldon Spring Quarry* (DOE 1990b).

The selected remedy included:

- Excavation and removal of bulk waste (i.e., structural debris, drummed and unconfined waste, process equipment, sludge, and soil).
- Transportation of the waste along a dedicated haul road to a temporary storage area located at the Chemical Plant.
- Staging of bulk wastes at the temporary storage area.

1.2.2.3 Quarry Residuals OU

The Quarry Residuals OU remedy was described in the *Record of Decision for the Quarry Residuals Operable Unit at the Weldon Spring Site, Weldon Spring, Missouri* (DOE 1998b). The Quarry Residuals OU addressed residual soil contamination in the Quarry proper, surface water and sediments in the Femme Osage slough and nearby creeks, and contaminated groundwater.

The selected remedy included:

- Long-term monitoring and institutional controls (ICs) to prevent exposure to contaminated groundwater north of the Femme Osage slough.
- Long-term monitoring and ICs to protect the quality of the public water supply in the Missouri River alluvium and implementing a well field contingency plan.
- Confirming the model assumptions regarding extraction of contaminated groundwater and establishing controls to protect naturally occurring attenuation processes.
- Restoring the Quarry and establishing ICs.

The *Quarry Residual Operable Unit Remedial Action Report* (DOE 2003b) was finalized in January 2004.

1.2.2.4 Groundwater OU

DOE implemented an interim ROD, which was approved on September 29, 2000, to investigate the practicability of remediating trichloroethene (TCE) contamination in Chemical Plant groundwater, using in situ chemical oxidation (ICO) (DOE 2000b). It was determined based on extensive monitoring that the ICO did not perform adequately under field conditions; therefore, the remediation of TCE was reevaluated with the remaining contaminants of concern.

DOE issued a final ROD (DOE 2004f) in January 2004, which was signed by EPA in February 2004. The GWOU ROD selected a remedy of monitored natural attenuation (MNA) with ICs to limit groundwater use during the period of remediation. MNA involves the collection of monitoring data to verify the effectiveness of naturally occurring processes to reduce contaminant concentrations over time. The ROD establishes remedial goals and performance standards for MNA. Activities regarding the GWOU are further discussed in Section 3.1.

1.2.2.5 Southeast Drainage

Remedial action for the Southeast Drainage was addressed as a separate action under CERCLA. The *Engineering Evaluation/Cost Analysis for the Proposed Removal Action at the Southeast Drainage near the Weldon Spring Site, Weldon Spring, Missouri* (DOE 1996) was prepared in August 1996 to evaluate the human and ecological health risks within the drainage. The EE/CA recommended that selected sediment in accessible areas of the drainage should be removed with track-mounted equipment and transported by off-road haul trucks to the Chemical Plant. The excavated materials would be stored temporarily at an on-site storage area until final disposal in the disposal cell. Soil removal was in two phases: 1997-1998 and again in 1999. Post-remediation soil sampling was conducted. More details are included in the *Southeast Drainage Closeout Report Vicinity Properties DA-4 and MDC-7* (DOE 1999b).

1.3 Final Site Conditions

Contamination remains at the Weldon Spring Site at the following locations:

- An on-site disposal cell contains approximately 1.48 million cubic yards of contaminated material.
- Residual groundwater contamination remains in the shallow aquifer beneath the Chemical Plant, at the Quarry, and at some surrounding areas.
- Several springs near the Chemical Plant discharge contaminated groundwater.
- Residual soil and sediment contamination remain in the Southeast Drainage.
- Contamination remains at two culvert locations along Missouri State Route 94 and Highway D.
- Residual soil contamination remains at inaccessible locations within the Quarry.

1.4 Geology and Hydrogeology

Due to lithologic differences, including geologic features that influence groundwater flow, 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 1.4. A generalized stratigraphic column for reference is provided in Figure 1–3. Hydrogeologic descriptions of lithologies monitored for each program are discussed in Sections 3.1.1.1 and 3.1.2.1. The appropriate cleanup standards for groundwater in each area of the Weldon Spring Site are summarized in Section 2.1.1.5.

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 (Kleeschulte et al. 1986).

System	Series	Stratigraphic Unit	Typical Thickness (feet)[a]	Physical Characteristics	Hydrostratigraphic Unit
Quaternary	Holocene	Alluvium	0–120	Gravelly, silty loam	Alluvial aquifer
	Pleistocene	Loess and glacial drift[b]	10–60	Silty clay, gravelly clay, silty loam, or loam over residuum from weathered bedrock	Locally a leaky confining unit[c]
Mississippian	Meramecian	Salem Formation[c]	0–15	Limestone, limey dolomite, finely to coarsely crystalline, massively bedded, and thin bedded shale	
		Warsaw Formation[c]	0–80	Shale and thin to medium bedded finely crystalline limestone with interbedded chert	
	Osagean	Burlington-Keokuk Limestone	100–200	Cherty limestone, very fine to very coarsely crystalline, fossiliferous, thickly bedded to massive	Shallow aquifer system
		Fern Glen Limestone	45–70	Cherty limestone, dolomitic in part, very fine to very coarsely crystalline, medium to thickly bedded	
	Kinderhookian	Chouteau Limestone	20–50	Dolomitic argillaceous limestone, finely crystalline, thin to medium bedded	Upper leaky confining unit
Devonian	Upper	Sulphur Springs Group Bushberg Sandstone[d]	40–55	Quartz arenite, fine to medium grained, friable	
		Lower part of Sulphur Springs Group undifferentiated		Calcareous siltstone, sandstone, oolitic limestone, and hard carbonaceous shale	
Ordovician	Cincinnatian	Maquoketa Shale[e]	0–30	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 crystalline 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 crystalline, minor chert and shale	
		Cotter Dolomite	200–250	Argillaceous, cherty dolomite, fine to medium crystalline, interbedded with shale	
		Jefferson City Dolomite	160–180	Dolomite, fine to medium crystalline	
		Roubidoux Formation	150–170	Dolomitic sandstone	
		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	

[a]Thickness estimates vary depending on data source.
[b]Glacial drift unit includes the Ferrelview Formation and is saturated in the northern portion of the Ordnance Works where this unit behaves locally as a leaky confining unit.
[c]The Warsaw and Salem Formations are not present in the Weldon Spring area.
[d]The Sulphur Springs Group also includes the Bachelor Sandstone and the Glen Park Limestone.
[e]The Maquoketa Shale is not present in the Weldon Spring Area.

Figure 1–3. Generalized Stratigraphy and Hydrostratigraphy of the Weldon Spring, Missouri, Site

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 meters per kilometer (m/km) to 15 m/km (58 feet [ft] per mile (ft/mi) to 79 ft/mi) (DOE 1990a). Massive Quaternary deposits of Missouri River alluvium cover the bedrock to the south and east of the Quarry.

1.5 Surface Water System and Use

The Chemical Plant and raffinate pits areas are on the Missouri−Mississippi River surface drainage divide. Elevations on the Site range from approximately 185 meters (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 (Kleeschulte et al. 1986).

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.

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. The Frog Pond and the 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 km (1 mile) 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 groundwater. 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 mile) 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 (DOE 1990a). The slough is essentially land-locked and is currently used for recreational fishing. The slough is not used for drinking water or irrigation.

1.6 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 acres) 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 1–2).

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 (DOE 1992b). 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 (DOE 1990a).

1.7 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 (Ruffner and Bair).

The National Oceanic and Atmospheric Administration has published the following information on its website based on analysis of long-term meteorological records for the St. Louis area. The information is titled *The Climatology of St. Louis and the Bi-State Area* and states the following:

> St. Louis is located at the confluence of the Mississippi and Missouri Rivers, and near the geographical center of the US. Its position in the middle latitudes allows the area to be affected by warm moist air that originates in the Gulf of Mexico, as well as cold air masses that originate in Canada. The alternate invasion of these air masses produces a wide variety of weather conditions, and allows the region to enjoy a true four-season climate.
>
> During the summer months, air originating from the Gulf of Mexico tends to dominate the area, producing warm and humid conditions. Since 1870, records indicate that temperature of 90 degrees or higher occur on about 35-40 days per year. Extremely hot days (100 degrees or more) are expected on no more than 5 days per year.
>
> Winters are brisk and stimulating, but prolonged periods of extremely cold weather are rare. Records show that temperatures drop to zero or below an average of 2 or 3 days per year, and temperatures as cold as 32 degrees or lower occur less than 25 days in most years. Snowfall has averaged a little over 18 inches per winter season, and snowfall of an inch or less is received on 5 to 10 days in most years.
>
> Normal annual precipitation for the St. Louis is a little less than 34 inches. The three winter months are the driest, with an average total of about 6 inches of precipitation. The spring months of March through May are normally the wettest with normal total rainfall of just under 10.5 inches. It is not unusual to have extended dry periods of one to two weeks during the growing season.
>
> Thunderstorms normally occur on between 40 and 50 days per year. During any year, there are usually a few of these thunderstorms that are severe, and produce large hail and damaging winds.

The on-site meteorological station was dismantled in May 2002 to facilitate final Site restoration activities. The precipitation and temperature results in Table 1–1 are from the National Weather Service. Precipitation and average temperature were all within historical ranges for the St. Louis area.

Table 1–1. Monthly Meteorological Monitoring Results for 2006

Month	Total Precipitation (cm)[a]	Average Temp (°C)
January	4.14	5.72
February	1.17	1.83
March	8.28	8.11
April	5.33	16.72
May	7.32	19.00
June	6.02	24.55
July	6.93	28.11
August	5.77	26.72
September	3.25	19.72
October	9.30	12.94
November	13.36	8.27
December	5.18	13.67

[a]cm = centimeters

1.8 Land Use and Demography

The population of St. Charles County was estimated by the census in 2005 to be about 329,940. This has been a 16.2 percent increase from the 2000 census and about a 30 percent increase over the past 10 years. The three largest communities in St. Charles County are O'Fallon (pop: 67,009), St. Charles (pop: 61,411), and St. Peters (pop: 53, 907) (Figure 1–1). The two communities closest to the Site are Weldon Spring and Weldon Spring Heights, about 3.2 km (2 miles) 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 percent of county land, and nonurban areas occupy 90 percent; the remaining 4 percent is dedicated to transportation and water uses.

Francis Howell High School is about 1 km (0.6 mile) northeast of the Site along Missouri State Route 94 (Figure 1–2). The school employs approximately 150 faculty and staff, and about 1,760 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 MoDOT 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 Chemical Plant and in the past was periodically visited by DA trainees and law enforcement personnel. Presently, there are about 40 full-time personnel working on military equipment at the DA site. During 2005, the training site had 18,000 man-days of usage by all branches of the military and law enforcement. 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 Chemical Plant are operated by MDC and employ about 50 people.

2.0 Compliance Summary

2.1 Compliance Status for 2006

The Weldon Spring Site is listed on the NPL, and therefore, has been and is governed by the CERCLA process. Under CERCLA, the Weldon Spring Site Remedial Action Project (WSSRAP) was subject to meeting or exceeding the applicable or relevant and appropriate requirement (ARARs) of federal, state, and local laws and statutes, such as the Resource Conservation and Recovery Act (RCRA), CWA, Clean Air Act, 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, NEPA values must be incorporated. The requirements of DOE Orders must also be met. Section 2.1.1 is a summary of compliance with applicable federal and state regulations, Section 2.1.2 is a summary of compliance with major DOE orders, and Section 2.1.3 is a discussion of compliance agreements and permits. With physical completion of the project, the applicability of certain ARARs has been reduced or eliminated.

2.1.1 Federal and State Regulatory Compliance

2.1.1.1 Comprehensive Environmental Response, Compensation and Liability Act

The Weldon Spring Site has integrated the procedural and documentation requirements of CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA), and NEPA. The remedial actions conducted under CERCLA are discussed in Section 1.2.2.

The Site has reached construction completion under CERCLA, which was documented in a Preliminary Closeout Report, which was issued by EPA on August 22, 2005.

Because contamination remains at some of the areas of the Site at levels above those that allow unlimited use and unrestricted exposure, CERCLA requires that the remedial actions be reviewed at least every 5 years. These reviews are commonly called 5-year reviews. DOE completed the third 5-Year Review Report for the Site in September 2006.

2.1.1.2 Resource Conservation and Recovery Act

Hazardous wastes at the Weldon Spring Site have been managed as required by RCRA as substantive 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 and wastes that were generated during remedial activities.

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.

The Weldon Spring Site no longer generates any hazardous waste and has deactivated its generator identification number.

The disposal cell contents are not regulated under RCRA, but RCRA post-closure disposal cell monitoring and maintenance requirements are ARARs. The RCRA groundwater protection standard (40 CFR 264 Subpart F) sets forth the general groundwater monitoring requirements for the disposal cell. Generally, the disposal cell groundwater monitoring program must provide representative samples of background groundwater quality, as well as groundwater passing the point of compliance. For a more complete description, see the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (DOE 2004b) which was developed to address these requirements. Additional post-closure requirements for the cell are identified in 40 CFR 264 Subpart N and include action leakage rate and leachate collection and removal requirements. These requirements are addressed in the LTS&M Plan (DOE 2005a). Subpart N also includes requirements to maintain the integrity of the final cover, including making repairs as necessary.

2.1.1.3 Clean Water Act

Effluents discharged to waters of the United States are regulated under the 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 Site has included meeting parameter limits and permit conditions specified in the National Pollutant Discharge Elimination System (NPDES) permits. Under these permits, both effluent and erosion-control monitoring have been performed. The majority of these remaining permits were terminated in 2003 and the Site has no discharges off-site at this time. See Section 2.1.3 for additional discussion regarding the remaining permit.

2.1.1.4 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. The principal ARARs for the impacted groundwater at the Chemical Plant are the MCLs and Missouri water quality standards, which were established in the GWOU ROD, and are shown in Table 2–1.

Table 2–1. Federal and State Water Quality Standards for the Chemical Plant Groundwater OU

Constituent	Standard	Citation
Nitrate (as N)	10 mg/L	40 CFR 141.62
Total Uranium	20 pCi/L	40 CFR 141
1,3-DNB	1.0 µg/L	10 CSR 20-7[a]
2,4-DNT	0.11 µg/L	10 CSR 20-7[a]
NB	17 µg/L	10 CSR 10-7[a]
TCE	5 µg/L	40 CFR 141.61
2,6-DNT	1.3 µg/L	Risk Based[b]
2,4,6-TNT	2.8 µg/L	Risk Based[c]

[a]Missouri Groundwater Quality Standard.
[b]Risk-based concentration equivalent to 10^{-5} for a resident scenario.
[c]Risk-based concentration equivalent to 10^{-6} for a resident scenario.
Key: DNB = dinitrobenzene; NB = Nitrobenzene; DNT = dinitrotoluene; mg/L = milligram(s) per liter; pCi/L = picocurie per liter; µg/L = microgram(s) per liter

Long-term groundwater monitoring for the Quarry Residuals OU consists of two separate programs. Groundwater monitoring is necessary to continue to ensure that uranium-contaminated groundwater has a negligible potential to affect the former St. Charles County (now owned by Public Water District #2) well field. The first program details the monitoring of uranium and 2,4-DNT south of the slough to ensure that levels remain protective of human health and the environment. The second program consists of monitoring groundwater contaminant levels within the area north of the slough until they attain a predetermined target level indicating negligible potential to affect groundwater south of the slough.

The objective for monitoring groundwater south of the slough is to verify that the groundwater is not impacted. Uranium concentrations south of the slough and in the area of production wells at the well field remain within the observed natural variation within the aquifer; therefore the MCL for uranium of 20 picocuries per liter (pCi/L) has been established as a trigger level only in this area. If concentrations in groundwater south of the slough exceed the MCL of 20 pCi/L, DOE will evaluate risk and take appropriate action.

Under current conditions, groundwater north of the slough poses no imminent risk to human health from water obtained from the well field. A target level of 300 pCi/L for uranium (10 percent of the 1999 maximum) was established to represent a significant reduction in the contaminant levels north of the slough. The target level for 2,4-DNT has been set at 0.11 micrograms per liter (µg/L), the Missouri Water Quality standard.

2.1.1.5 Emergency Planning and Community Right-to-Know Act

The Site no longer stores large quantities of chemicals and none above a threshold level, therefore the Site is not required to submit a 2006 *Emergency Planning and Community Right-to-Know Act* Tier II report.

The Toxic Release Inventory (TRI) report for 2006 is due on July 1, 2007. Based on the chemical usage in 2006, the Weldon Spring Site is not required to submit a TRI report.

2.1.2 DOE Order Compliance

2.1.2.1 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. 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 0.17 millirem (mrem), which is well below the 100 mrem (1 millisievert [mSv]) guideline for all potential exposure pathways.

2.1.2.2 DOE Order 231.1A, Environmental, Safety, and Health Reporting

DOE Order 231.1A and DOE Manual 231.1-1A ensures collection and reporting of information on environment, safety, and health that is required by law or regulation. This site environmental report fulfills the requirement of the order to summarize the environmental data annually. These directives also include requirements for occurrence reporting. There were no occurrences as defined by these directives at the Site during 2006.

2.1.3 Permit and Agreement Compliance

2.1.3.1 NPDES Permits

The Weldon Spring Site has no off-site discharges at this time and has one NPDES permit (MO-0107701). The permit only covers the former Site Water Treatment Plant (SWTP) discharge line. The SWTP discharge line will only be used if the Site ever operates Train 3 at the leachate collection and removal system (LCRS) as a contingency to current disposal methods (see Section 2.1.3.3). This permit's expiration date was in July 2005. DOE submitted a renewal application to the Missouri Department of Natural Resources (MDNR) in January 2005, but has not received a renewed permit to date. The Site currently operates under the existing permit until MDNR issues a renewed permit.

2.1.3.2 Federal Facility Agreement

A Federal Facility Agreement (FFA) was signed by EPA and DOE in 1986, and it was amended in 1992. The main purpose of the FFA is to establish a procedural framework and schedule for developing, implementing and monitoring appropriate response actions at the Site in accordance with CERCLA. An FFA Quarterly report was issued to EPA and MDNR each quarter which documented compliance with the FFA and reported on activities at the Site.

A new FFA between EPA, DOE, and MDNR was signed by all parties with the final signature by EPA on March 31, 2006. The focus of the new FFA is long-term surveillance and maintenance activities. A quarterly report is no longer required by the new version of the FFA.

2.1.3.3 Metropolitan St. Louis Sewer District (MSD) Agreement

The Weldon Spring Site has approval from the Metropolitan St. Louis Sewer District (MSD) to haul disposal cell leachate and purge water to their Bissell Point Plant. The DOE received notification in April 2004 that the leachate must meet the radiological drinking water standard of 30 µg/L (20 pCi/L) prior to acceptance. The disposal cell leachate was very close to this limit in 2004, therefore, DOE exercised a pretreatment contingency process and began treating the leachate through a system of cartridge filters and ion exchange media that is selective for uranium. The leachate was sampled after treatment and found to be significantly below the 30 µg/L limit for uranium. The pretreated levels continued to be close to the 30 µg/L limit during 2006, so the leachate continued to be treated by the same process with the same results of the levels being significantly lower than the 30 µg/L limit. DOE received a 5-year extension letter from MSD on November 3, 2006, which extended the agreement to December 21, 2011. Further information regarding the leachate is discussed in Section 3.3.

End of current text

3.0 Environmental Monitoring Summary

3.1 Groundwater Monitoring

The groundwater monitoring program at the Weldon Spring Site includes sampling and analysis of water collected from wells at the Chemical Plant, the Quarry, adjacent properties, and selected springs in the vicinity of the Chemical Plant. The groundwater monitoring program is formally defined in the LTS&M Plan (DOE 2005a).

3.1.1 Chemical Plant Groundwater

The *Record of Decision for the Final Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site* (GWOU ROD) (DOE 2004f) was signed by EPA on February 20, 2004. The final GWOU ROD specified a remedy of MNA with ICs to limit groundwater use during the period of remediation. MNA relies on the effectiveness of naturally occurring processes to reduce contaminant concentrations over time. The GWOU ROD establishes remedial goals and performance standards for MNA.

In July 2004, DOE initiated monitoring for MNA as outlined in the *Remedial Design/Remedial Action Work Plan for the Final Remedial Action for the Groundwater Operable Unit at the Weldon Spring Site* (DOE 2004c). This network has since been modified as presented in the *Interim Remedial Action Report for the Groundwater Operable Unit of the Weldon Spring Site* (DOE 2005d).

3.1.1.1 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. Subsurface flow and transport in the Chemical Plant area occurs primarily in the carbonate bedrock. The unconsolidated surficial materials are clay-rich, mostly glacially derived units, which are generally unsaturated beneath the Site. These materials become saturated to the north and influence groundwater flow. Thicknesses of the unconsolidated materials range from 6.1 m to 15.3 m (20 ft to 50 ft) (DOE 1992a).

A groundwater divide is located along the southern boundary of the Site. Groundwater north of the divide flows north toward Dardenne Creek and ultimately to the Mississippi River, and groundwater south of the divide flows south to the Missouri River. Localized flow is controlled largely by topographic highs, streams and drainages. Groundwater movement is by generally diffuse flow with localized zones of discrete fracture-controlled flow.

Areas of groundwater impact are assessed by using data collected from the monitoring well network at the Site. The aquifer of concern beneath the Chemical Plant is the shallow bedrock aquifer comprised of Mississippian-age Burlington-Keokuk Limestone (the uppermost bedrock unit). The Burlington-Keokuk Limestone is described as having two different lithologic zones, a shallow weathered zone and an underlying 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, particularly in the vicinity of buried preglacial stream channels. 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-overburden interface.

All monitoring wells at the Chemical Plant are completed in the Burlington-Keokuk Limestone. Most of the wells are completed in the weathered zone of the bedrock where groundwater has the greatest potential to be contaminated. Some wells screened in the unweathered zone of the Burlington-Keokuk Limestone are used to assess the vertical migration of contaminants. Where possible, monitoring wells within the boundaries of the Chemical Plant are located near historical contaminant sources and preferential flow pathways (paleochannels) to assess the movement of contaminated groundwater in the shallow aquifer. Additional wells are located outside the Chemical Plant boundary to detect and evaluate potential off-site migration of contaminants (Figure 3–1).

Numerous springs, a common feature in carbonate terrains, are present in the vicinity of the Site. Four springs are monitored routinely. These springs, shown on Figure 3–2, 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 miles) north of the Site, indicates that discrete subsurface flow paths are present in the vicinity of the Site. Groundwater tracer tests performed in 1995 (DOE 1997) indicated that a discrete and rapid subsurface hydraulic connection exists between the northern portion of the Chemical Plant and Burgermeister Spring. These flow paths are associated with the preglacial stream channels present beneath the Site.

3.1.1.2 Chemical Plant (GWOU) Monitoring Program

Monitoring at the Chemical Plant was changed in July 2004 to focus on the selected remedy of MNA. Under the new monitoring program, total uranium, nitroaromatic compounds, TCE, and nitrate (as N) have been monitored at selected locations throughout the Chemical Plant area (Table 3–1). The sampling locations target areas of highest impact in the shallow aquifer and migration pathways associated with paleochannels in the weathered unit of the Burlington-Keokuk Limestone. Wells in the underlying unweathered unit are sampled to assess vertical movement. Analytical results for 2006 are discussed in Section 3.1.1.3.

The objectives specified in the GWOU ROD (DOE 2004f) for the MNA monitoring network (Table 3–2) are:

- Objective 1 is to monitor the unimpacted water quality at upgradient locations in order to maintain a baseline of naturally occurring constituents from which to evaluate changes in downgradient locations. This objective will be met by using wells located upgradient of the contaminant plumes.

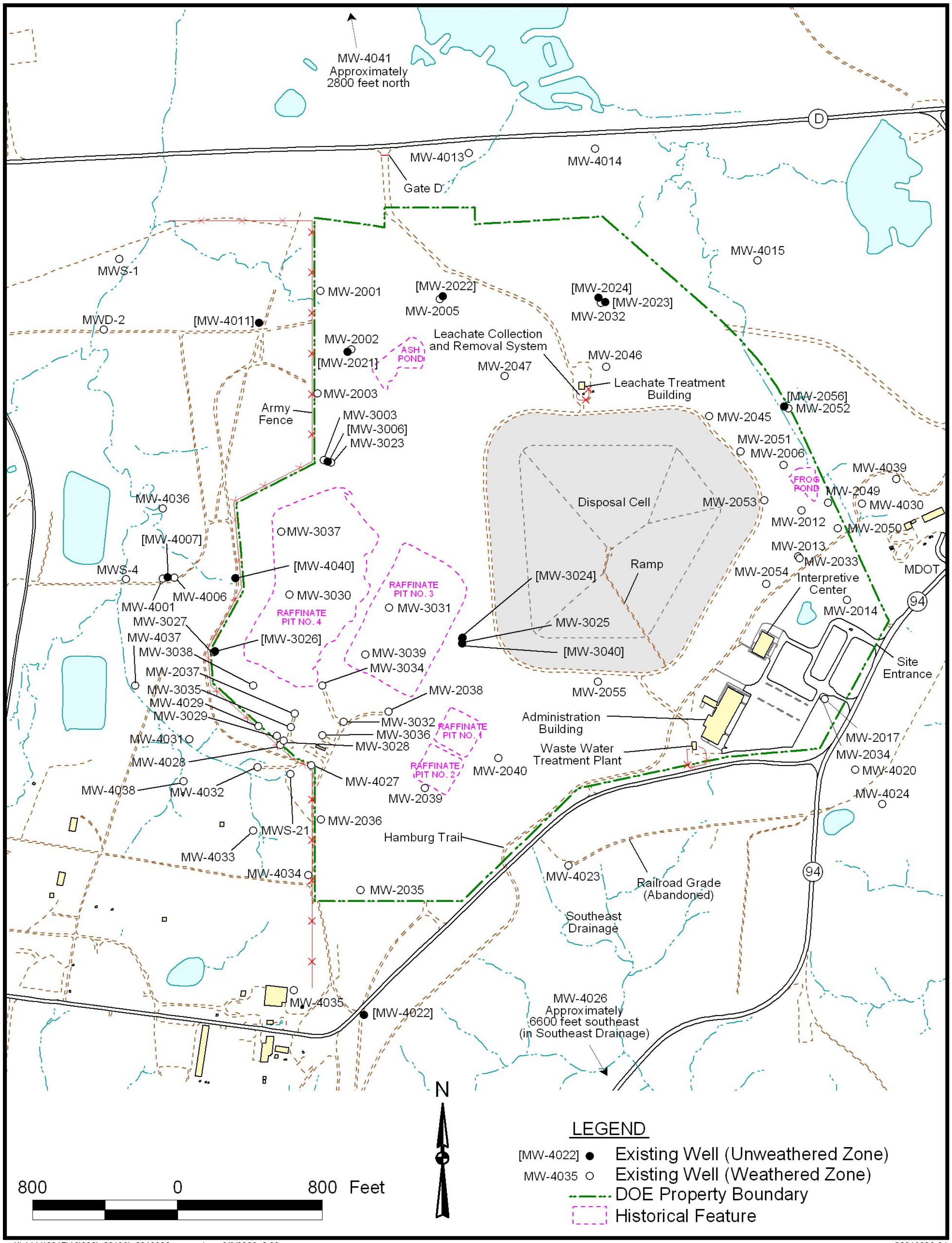

Figure 3–1. Existing Monitoring Well Network

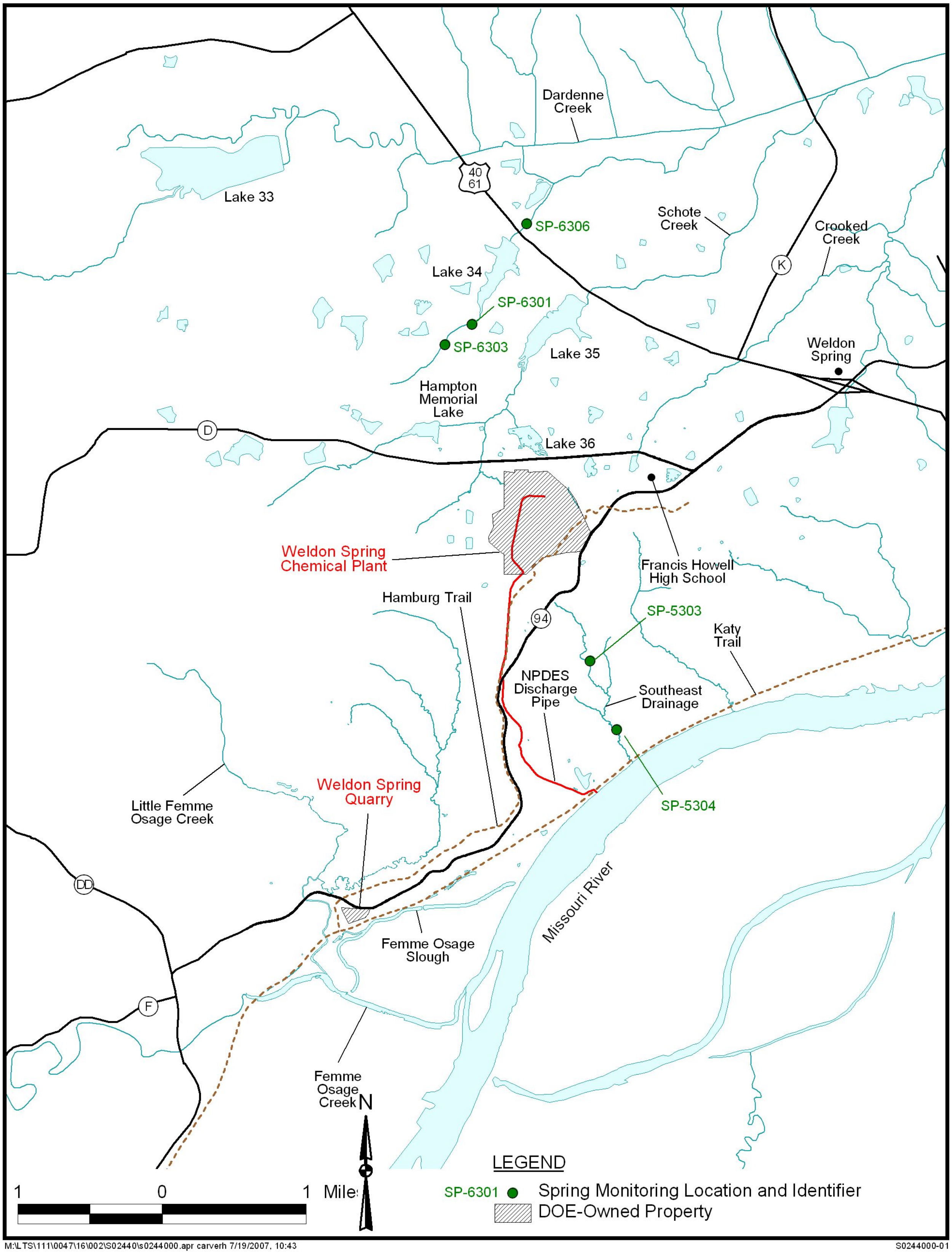

Figure 3–2. Spring Monitoring Locations at the Chemical Plant Area of the Weldon Spring, Missouri, Site

Table 3–1. Monitoring Parameters for MNA Locations

Location	Sampling Frequency[a]	Monitoring Parameters							
		TCE	Nitrate (as N)	Uranium	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-2012	S				✔	✔	✔	✔	✔
MW-2014	S						✔	✔	
MW-2017	S				✔	✔	✔	✔	✔
MW-2021	S		✔						
MW-2022	Q		✔		✔	✔			
MW-2023	Q				✔	✔	✔	✔	✔
MW-2032	S				✔	✔	✔	✔	✔
MW-2035	S	✔	✔	✔			✔		
MW-2038	S		✔				✔		
MW-2040	S		✔			✔			
MW-2046	S					✔			
MW-2050	S						✔	✔	
MW-2051	S				✔	✔	✔	✔	✔
MW-2052	S						✔	✔	
MW-2053	S					✔	✔	✔	
MW-2054	S						✔	✔	
MW-2056	Q				✔	✔	✔	✔	✔
MW-3003	S		✔	✔					
MW-3006	S	✔	✔	✔			✔		
MW-3024	S			✔					
MW-3030	S	✔		✔			✔		
MW-3031	S	✔		✔					
MW-3034	S	✔	✔				✔		
MW-3037	S	✔		✔			✔		
MW-3039	S						✔		
MW-3040	Q	✔	✔	✔					
MW-4007	S	✔	✔						
MW-4013	S		✔				✔	✔	✔
MW-4014	S		✔		✔	✔	✔	✔	✔
MW-4015	S						✔	✔	✔
MW-4022	S		✔	✔					
MW-4023	S		✔	✔					
MW-4026	S			✔					
MW-4029	S	✔	✔						
MW-4031	S		✔						
MW-4036	S	✔	✔	✔			✔		
MW-4039	S				✔	✔	✔	✔	✔
MW-4040	Q	✔	✔	✔			✔		
MW-4041	Q	✔	✔	✔	✔	✔	✔	✔	✔
MWS-1	Q	✔	✔	✔			✔		
MWS-4	Q	✔	✔	✔					
MWD-2	Q		✔	✔					
SP-5303	S			✔					
SP-5304	S			✔					
SP-6301	S	✔	✔	✔	✔	✔	✔	✔	✔
SP-6303	S	✔	✔	✔	✔	✔	✔	✔	✔
SW-2007	Q			✔					

[a]Monitoring frequencies may be decreased to annual or biennial on the basis of trends in at least the first 2 years of data.
S = semiannual Q = quarterly

Table 3–2. MNA Monitoring Locations for the GWOU

Objective 1	Objective 2	Objective 3	Objective 4	Objective 5	Objective 6
MW-2017 MW-2035 MW-4022 MW-4023	MW-2012 MW-2014 MW-2038 MW-2040 MW-2046 MW-2050 MW-2052 MW-2053 MW-2054 MW-3003 MW-3024 MW-3030 MW-3034 MW-3039 MW-3040 MW-4013[a] MW-4029 MW-4031 MW-4036[a] MW-4040	MW-2032 MW-2051 MW-3031 MW-3037 MW-4013 MW-4014 MW-4015 MW-4026 MW-4036 MW-4039 MW-4041 MWS-1 MWS-4	MW-2021 MW-2022 MW-2023 MW-2056 MW-3006 MW-4007 MWD-2	SP5303 SP5304 SP6301 SP6303 SW-2007[b]	MW-2005 MW-2055 MW-3025 MW-3038 MW-4001 MW-4011 MW-4020 MW-4037

[a]Location is also an Objective 3 location.
[b]Location is on Dardenne Creek immediately upstream of Highway 40/61, approximately 2.1 miles north of the Site.

- Objective 2 is to verify contaminant concentrations are declining with time at a rate and in a manner that cleanup standards will be met in approximately 100 years as established by predictive modeling. This objective will be met using wells at or near the locations with the highest concentrations of contaminants, both near the former source areas and along expected migration pathways. The objective will be to evaluate the most contaminated zones. Long-term trend analysis will be performed to confirm downward trends in contaminant concentration over time. Performance will be gauged against long-term trends. It is anticipated that some locations could show temporary upward trends due to the recent source control remediation, ongoing dispersion, seasonal fluctuations, analytical variability, or other factors. However, concentrations are not expected to exceed historical maximums.
- Objective 3 is to ensure that lateral migration remains confined to the current area of impact. Contaminants are expected to continue to disperse within known preferential flow paths associated with bedrock lows (paleochannels) in the upper Burlington-Keokuk Limestone and become more dilute over time as rain events continue to recharge the area. This objective will be met by monitoring various downgradient fringe locations that are either not impacted or minimally impacted. Contaminant impacts in these locations are expected to remain minimal or non-existent.
- Objective 4 is to monitor locations underlying the impacted groundwater system to confirm that there is no significant vertical migration of contaminants. This will be evaluated using deeper wells screened in and influenced by the unweathered zone. No significant impacts at these locations should be observed.
- Objective 5 is to monitor contaminant levels at the impacted springs that are the only potential points of exposure under current land use conditions. The springs discharge groundwater that includes contaminated groundwater originating at the Chemical Plant area. Presently, contaminant concentrations at these locations are protective of human

health and the environment under current recreational land uses. Continued improvement of the water quality in the affected springs should be observed.

- Objective 6 is to monitor for hydrologic conditions at the Site over time in order to identify any changes in groundwater flow that might affect the protectiveness of the selected remedy. The static groundwater elevation of the monitoring network will be measured to establish that groundwater flow is not changing significantly and resulting in changes in contaminant migration.

The monitoring network is designed to collect data to show that either natural attenuation processes are acting as predicted or to trigger the implementation of contingencies when these processes are not acting as predicted (i.e., unexpected expansion of the plume or sustained increases in concentrations within the area of impact). The data analysis and interpretation will satisfy the following:

- Baseline conditions (Objective 1) have remained unchanged.
- Performance monitoring locations (Objective 2) indicate that concentrations within the area of impact are decreasing as expected.
- Detection monitoring locations (Objective 3, 4, and 5) indicate when a trigger has been exceeded.

The monitoring network consists of 50 wells, 4 springs, and 1 surface water location.
The locations and the objectives they satisfy are summarized in Table 3–2 and are depicted on Figure 3–1 and Figure 3–2.

3.1.1.3 Baseline Monitoring Results for the GWOU

Baseline conditions are monitored in four upgradient wells to determine if possible changes in downgradient areas of impact are the result of upgradient conditions. The objective of this monitoring is to determine if baseline conditions have remain unchanged. Each of these wells was sampled twice during 2006. The annual average concentration for each parameter is presented in Table 3–3. The average concentrations measured in 2006 are similar to those from 2005.

Table 3–3. Summary of Baseline Monitoring Locations for the GWOU MNA Remedy

Location	MW-2017	MW-2035	MW-4022	MW-4023
Zone	Weathered	Weathered	Unweathered	Weathered
Number of Samples	2	2	2	2
Parameters				
Uranium (pCi/L)	NA	0.46	3.35	1.85
Nitrate (as N) (mg/L)	NA	0.52	0.22	0.95
TCE (μg/L)	NA	ND	NA	NA
1,3-DNB (μg/L)	ND	ND	NA	NA
2,4,6-TNT (μg/L)	ND	ND	NA	NA
2,4-DNT (μg/L)	ND	ND	NA	NA
2,6-DNT (μg/L)	ND	ND	NA	NA
Nitrobenzene (μg/L)	ND	ND	NA	NA

ND = Analyte not detected above method detection limit
NA = Analyte not analyzed

3.1.1.4 Performance Monitoring Results for the GWOU

The performance of the MNA remedy is assessed through the sampling of the Objective 2 monitoring wells. Objective 2 wells are located within the areas of impact and monitor both the weathered and unweathered units of the Burlington-Keokuk Limestone. Objective 2 of the MNA strategy is to verify contaminant concentrations are declining as expected and that cleanup standards will be met in a reasonable timeframe.

Contaminant concentrations are monitored using 20 wells (Figure 3–1) situated within the areas of highest impact of each contaminant plume at the Site. These wells were sampled at least semiannually during 2006. The data is discussed in the following sections.

<u>Uranium</u>

The area of uranium impact is located in the former Raffinate Pit area. Uranium levels exceed the MCL of 20 pCi/L in both the weathered and unweathered units of the Burlington-Keokuk Limestone. A summary of the uranium data for 2006 is presented in Table 3–4.

Table 3–4. 2006 Uranium Data from Objective 2 Wells

Location	Uranium Activity (pCi/L)			
	S1		S2	Average
Weathered Unit				
MW-3003	6.8		3.9	5.3
MW-3024	76.5		67.0	71.8
MW-3030	39.3		41.3	40.3
Unweathered Unit				
MW-3040	86.7	90	104	93.6
MW-4040	249	280	236	255

S1 = First sampling event
S2 = Second sampling event

The highest uranium impact in the weathered unit is measured in MW-3024. This well has shown variable uranium levels over time (Figure 3–3). The remaining Objective 2 wells show gradually decreasing uranium levels over time. This is supported by the trending analysis (Section 3.1.1.6). The levels in MW-3003 have consistently been less than the MCL since 2000. The levels measured in these wells are similar to those measured in 2005.

Uranium impact is greatest in the two unweathered wells that were installed beneath and immediately downgradient of the former Raffinate Pits. These wells were initially installed to be Objective 4 wells; however, uranium levels greater than the MCL were identified. The uranium levels in both of these wells have not stabilized since installation in 2004 (Figure 3–4). The level in MW-4040, which is located downgradient of the area of impact in the weathered unit, has shown an upward trend in uranium levels since installation, as supported by trending analysis. These wells will continue to be monitored more frequently during 2007 to establish a better baseline.

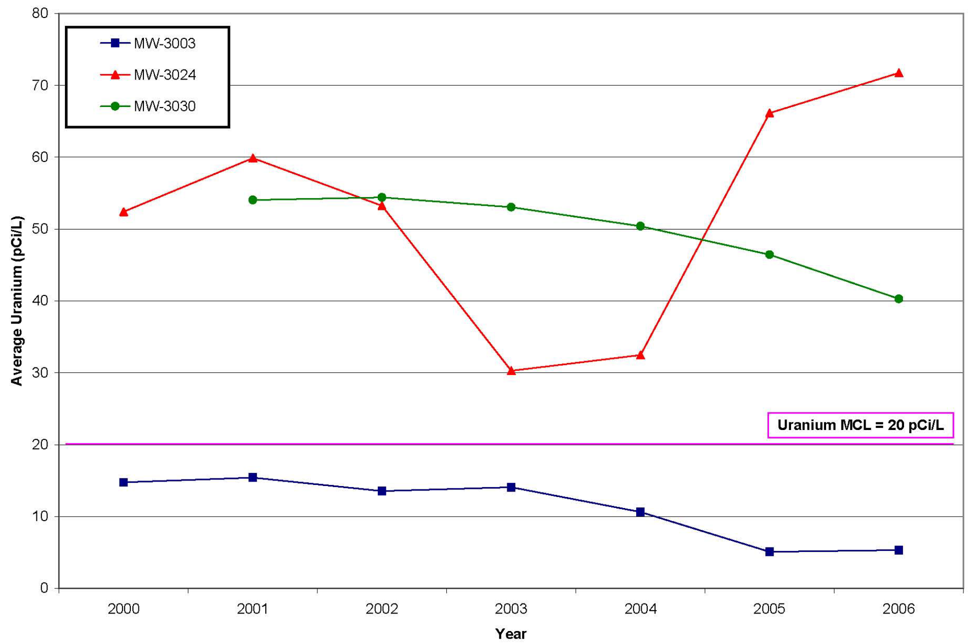

Figure 3–3. Annual Average Uranium Levels in Objective 2 Wells Screened in the Weathered Unit (2000−2006)

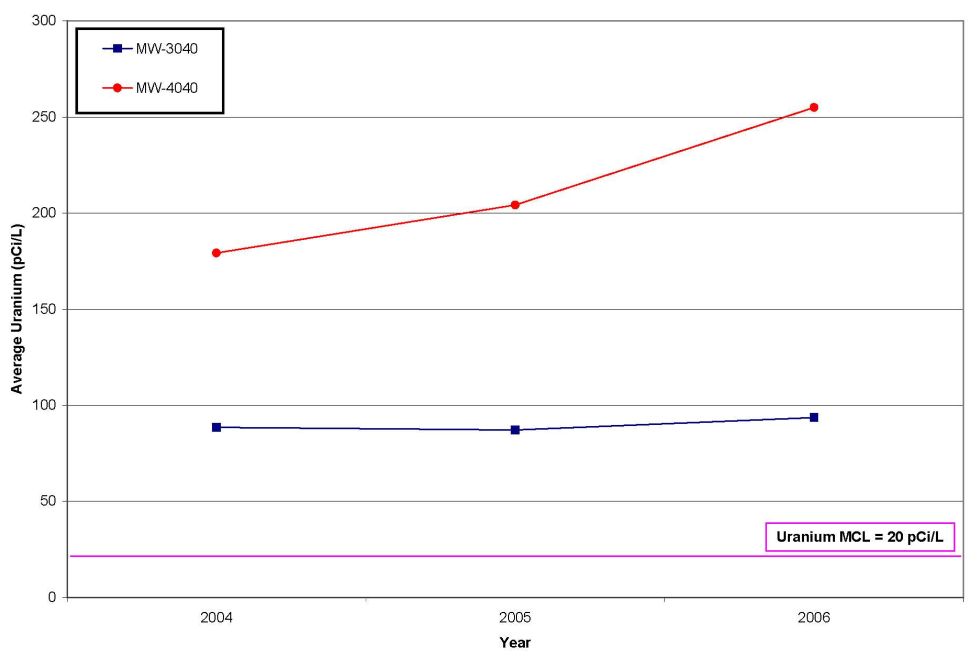

Figure 3–4. Annual Average Uranium Levels in Objective 2 Wells Screened in the Unweathered Unit (2004−2006)

Nitrate (as N)

The highest concentrations of nitrate have typically been measured in the vicinities of the Raffinate Pits and Ash Pond, which are the historical sources of this contaminant. The higher mobility of nitrate as compared to other contaminants at the Site has resulted in a larger distribution in the shallow aquifer. Nitrate levels exceed the MCL of 10 milligrams per liter (mg/L) (for nitrate as N) in both the weathered and unweathered units of the Burlington-Keokuk Limestone. A summary of the nitrate data for 2006 is presented in Table 3–5.

Table 3–5. Nitrate Data from Objective 2 Wells

Location	Nitrate Concentration (mg/L)			
	S1		S2	Average
Weathered Unit				
MW-2038	505		(a)	505
MW-2040	90.3		96.9	93.6
MW-3003	516		239	378
MW-3034	473		(a)	473
MW-4013	88		(a)	88
MW-4029	515		588	552
MW-4031	162		148	155
MW-4036	9.16		(a)	9.16
Unweathered Unit				
MW-3040	187	204	192	194
MW-4040	144	124	65.1	111

(a) Data reported for the second semiannual sampling was not used in this report. The values were reported as less than the detection limit and were not considered representative of actual groundwater quality.
S1 = First sampling event
S2 = Second sampling event

Nitrate concentrations are highest in the weathered unit of the Burlington-Keokuk Limestone. The highest concentrations in the weathered unit are measured in wells that are located in the former Raffinate Pit area (MW-2038, MW-3034, and MW-4029). Wells MW-2038, MW-2040, and MW-3034 appear to be declining over time (Figure 3–5); however, trend analysis supports a decline only in MW-2040. Well MW-4029 has slightly increased over time; however, this well is situated along a preferential flow pathway immediately downgradient of the Raffinate Pits. The remainder of the wells have lower nitrate impact. Wells MW-2040 and MW-4036 have shown a slight decrease where the remaining locations fluctuate over time. Well MW-4036, downgradient of former Raffinate Pit 4, decreased below the MCL in 2006.

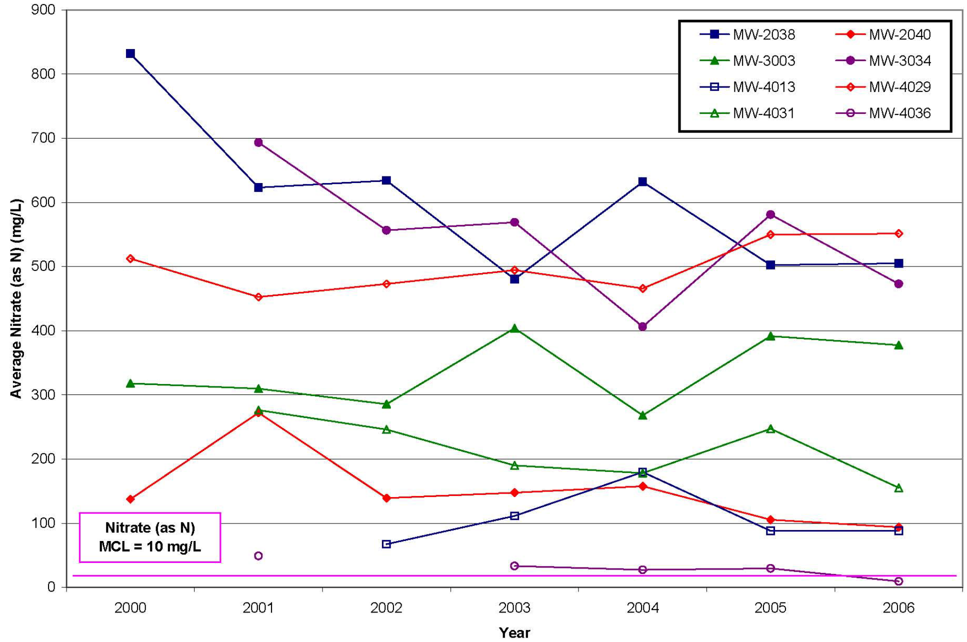

Figure 3–5. Annual Average Nitrate Concentrations in Objective 2 Wells Screened in the Weathered Unit (2000−2006)

Nitrate exceeds the MCL in the two unweathered wells located in the Raffinate Pit area. The nitrate concentrations in MW-3040 has decreased since installation (as supported by trend analysis) and has remained stable in MW-4040 (Figure 3–6). These wells will continue to be monitored more frequently during 2007 to better establish baseline.

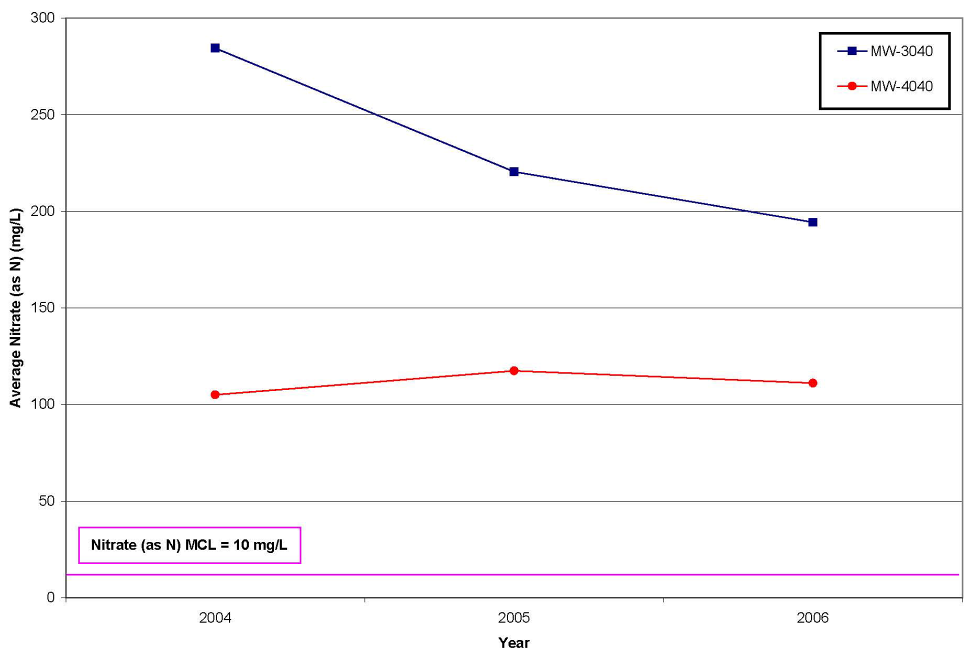

Figure 3–6. Annual Average Nitrate Concentrations in Objective 2 Wells Screened in the Unweathered Unit (2004−2006)

Trichloroethylene

TCE contamination in the shallow groundwater is located in the vicinity of Raffinate Pit 4, where drums containing TCE are suspected to have been discarded. TCE impact is detected in only the weathered unit of the Burlington-Keokuk Limestone. TCE levels exceed the MCL of 5 μg/L in the groundwater. A summary of the TCE data for 2006 is presented in Table 3–6.

Table 3–6. TCE Data from Objective 2 Wells

Location	TCE Concentration (μg/L)		
	S1	S2	Average
MW-3030	410	380	395
MW-3034	430	430	430
MW-4029	640	560	600

S1 = First sampling event
S2 = Second sampling event

TCE impact is highest in MW-4029 located along a preferential flow pathway in the area. Concentrations have remained relatively stable over time at this location. The TCE concentrations in MW-3030 and MW-3034 appear to have shown an increase (Figure 3–7); however, this increase is a result of rebound from field studies performed in 2001 and 2002. Recent concentrations (2005 and 2006) appear to have stabilized. Trend analysis supports an upward trend in MW-3030 based on data from the last 5 years.

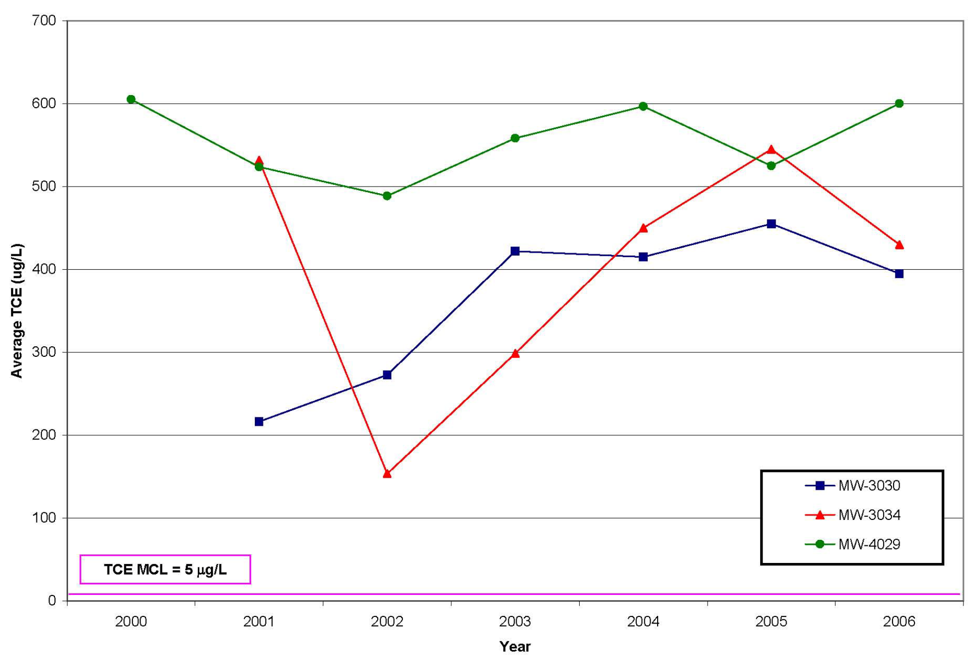

Figure 3–7. Annual Average TCE Concentrations in Objective 2 Wells (2000−2006)

1,3-Dinitrobenzene

Groundwater impacted with 1,3-dinitrobenzene (DNB) that exceeds the cleanup standard 1.0 µg/L is located in a discrete portion of the Frog Pond area, where a TNT production line was located. Nitroaromatic compound impact is isolated to the weathered unit of the Burlington-Keokuk Limestone. A summary of the 1,3-DNB data for 2006 is presented in Table 3–7.

Table 3–7. 1,3-DNB Data from Objective 2 Wells

Location	1,3-DNB Concentration (µg/L)			
	S1		S2	Average
MW-2012	ND	0.13	(a)	0.092

(a) Data was rejected during the validation process.
ND = non-detect
S1 = First sampling event
S2 = Second sampling event

Impact from 1,3-DNB is highest in well MW-2012. This well is located adjacent to the production houses for TNT Line #1. Concentrations of 1,3-DNB have fluctuated in this well over time (Figure 3–8). Presently the average concentration has decreased below the cleanup standard of 1.0 µg/L. It is suspected that the recent decreases (since 2004) observed in nitroaromatic compounds at this location (and others) are the result of surface infiltration.

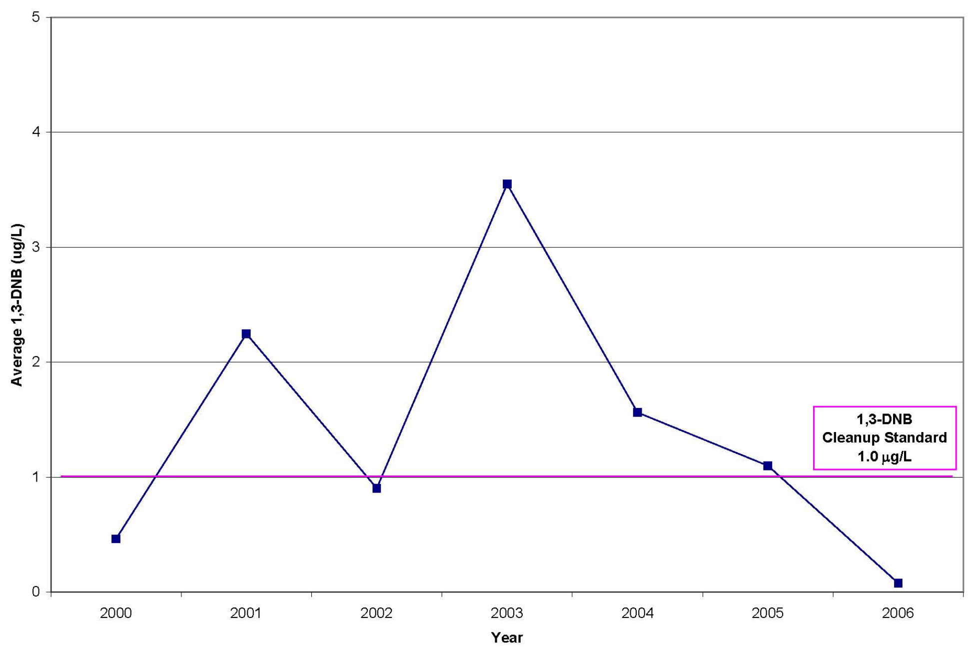

Figure 3–8. Annual Average 1,3-DNB Concentrations in Objective 2 Well MW-2012 (2000−2006)

In 2004, a subsidence feature associated with historical trenching activities formed near MW-2012. During that time, the concentrations of nitroaromatic compounds decreased dramatically. Surface runoff infiltrated into the subsurface through this subsidence feature resulting in dilution of contaminated groundwater in the vicinity of MW-2012 and other downgradient locations. Data collected subsequent to repair of the feature in early 2006 have shown a rebound in nitroaromatic compound concentrations. Downward trends associated with MW-2012 are not considered to be the result of attenuation processes, and subsequent data may return to near historical levels.

2,4,6-Trinitrotoluene

Groundwater impacted with 2,4,6-TNT that exceeds the cleanup standard of 2.8 μg/L is located in two discrete portions of the Frog Pond area. Nitroaromatic compound impact is isolated to the weathered unit of the Burlington-Keokuk Limestone. A summary of the 2,4,6-TNT data for 2006 is presented in Table 3–8.

Table 3–8. 2,4,6-TNT Data from Objective 2 Wells

Location	2,4,6-TNT Concentration (μg/L)			
	S1		S2	Average
MW-2012	22	3.4	(a)	12.7
MW-2046	1.1		4.8	2.95
MW-2053	ND		(a)	ND

(a) Data was rejected during the validation process.
ND = non-detect
S1 = First sampling event
S2 = Second sampling event

The highest 2,4,6-TNT concentrations are associated with MW-2012. Data collected since 2004 has indicated a substantial decrease (Figure 3–9), which is suspected to be associated with surface infiltration. It appears that this surface infiltration may have also affected concentrations in well MW-2053 based on the similar behavior of contaminant concentrations since 2004. The concentrations in MW-2046 also decreased during 2005. This well is located some distance from the subsidence feature and it is not expected that there was an influence at this location. Concentrations of 2,4,6-TNT increased at this location in 2006.

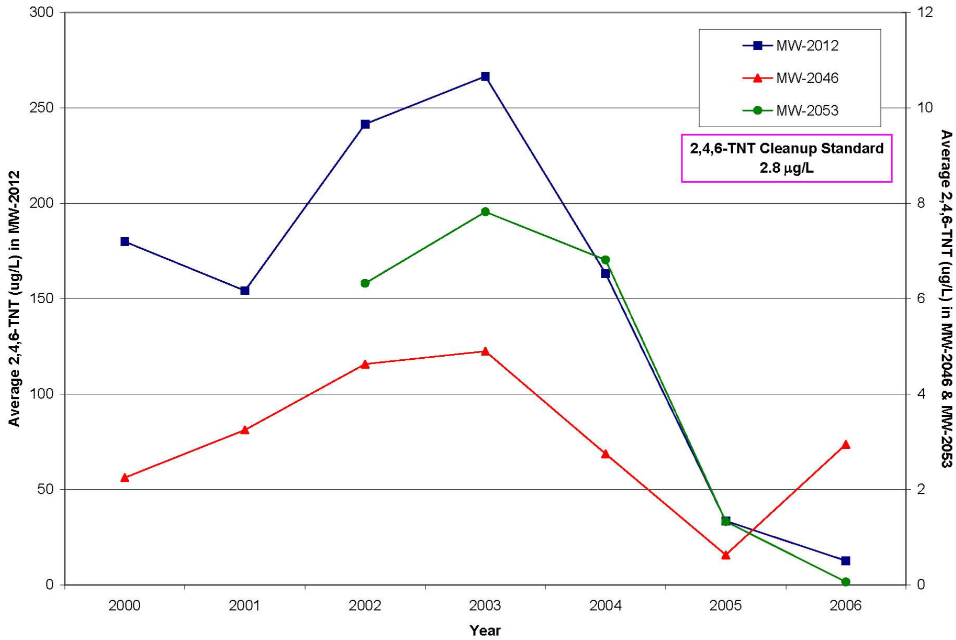

Figure 3–9. Annual Average 2,4,6-TNT Concentrations in Objective 2 Wells (2000−2006)

2,4-Dinitrotoluene

Groundwater impacted with 2,4-DNT that exceeds the cleanup standard of 0.11 µg/L is located in the Frog Pond and Raffinate Pit areas of the Chemical Plant. TNT production lines were located in both of these areas. Nitroaromatic compound impact is isolated to the weathered unit of the Burlington-Keokuk Limestone. A summary of the 2,4-DNT data for 2006 is presented in Table 3–9.

The highest 2,4-DNT impact has been associated with MW-2012. Data from recent years has likely been affected by surface infiltration as previously discussed and has resulted in decreased 2,4-DNT concentrations at this location (Figure 3–10). Levels at this location still exceed the cleanup standard of 0.11 µg/L.

Table 3–9. 2,4-DNT Data from Objective 2 Wells

Location	2,4-DNT Concentration (µg/L)		
	S1	**S2**	**Average**
Frog Pond Area			
MW-2012	50 1	420	157
MW-2014	0.12	0.17	0.15
MW-2050	44	41	42
MW-2052	ND	0.073	0.052
MW-2053	0.31	(a)	0.31
MW-2054	ND	1.6	0.82
Raffinate Pit Area			
MW-2038	0.21	0.28	0.25
MW-3030	0.93	0.93	0.93
MW-3034	0.20	0.20	0.20
MW-3039	0.42	0.38	0.40

(a) Data was rejected during the validation process.
ND = non-detect
S1 = First sampling event
S2 = Second sampling event

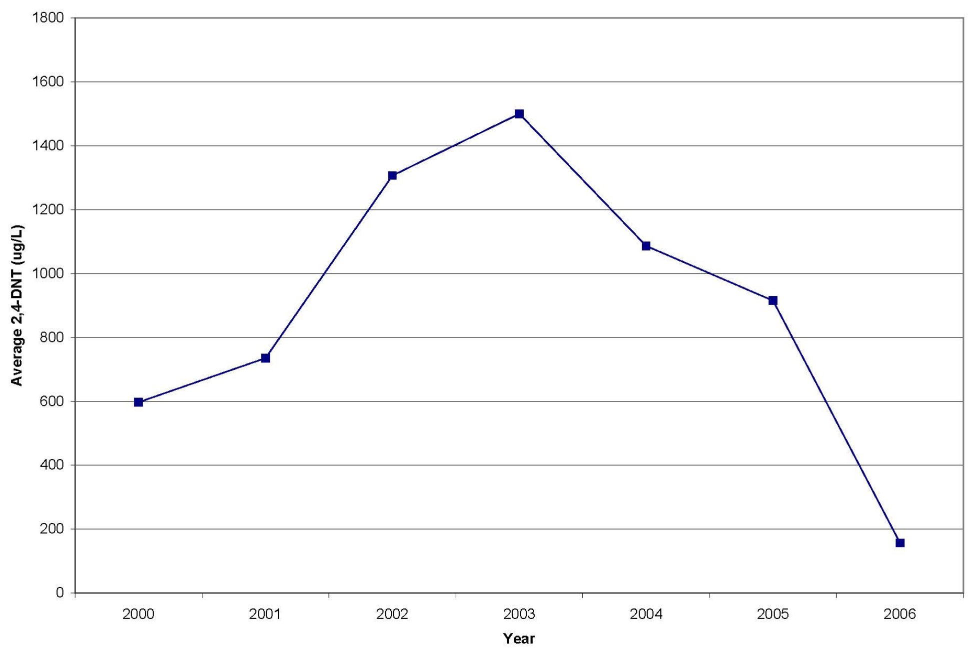

Figure 3–10. Annual Average 2,4-DNT Concentrations in Objective 2 Well MW-2012 (2000−2006)

Concentrations in MW-2050 indicate an increase in 2,4-DNT concentrations over time (Figure 3–11); although data from the last few years indicates that these concentrations may be stabilizing. Concentrations in MW-2053 also seem to have increased slightly over the last few years. The substantial decrease in MW-2054 could not be explained. This well is located upgradient of the subsidence feature near MW-2012. Data from 2006 indicates that concentrations are increased from those measured in 2005. The remainder of the monitoring locations have stable concentrations over time.

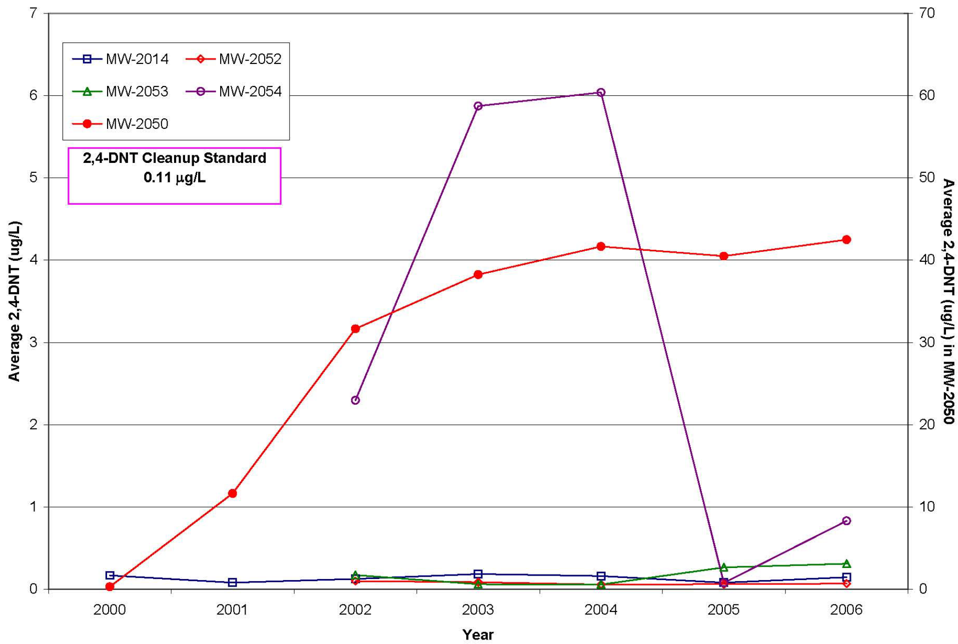

Figure 3–11. Annual Average 2,4-DNT Concentrations in Objective 2 Wells in the Frog Pond Area (2000−2006)

Elevated concentrations of 2,4-DNT are also present in the former Raffinate Pit area (Figure 3–12). Production Lines #3 and #4 were located in this area of the Site, although Production Line #4 was primarily on the neighboring Army property. Concentrations of 2,4-DNT continue to exceed the cleanup standard of 0.11 µg/L in this area. Concentrations over time have been relatively stable. A decrease is indicated in MW-3039, as supported by trend analysis.

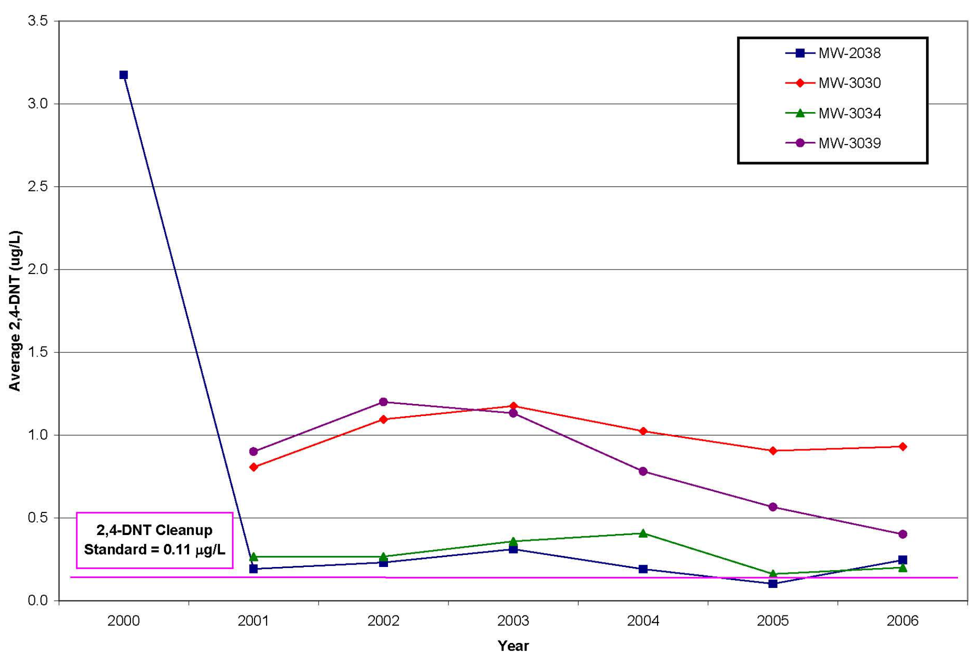

Figure 3–12. Annual Average 2,4-DNT Concentrations in Objective 2 Wells in the Raffinate Pit Area (2000−2006)

2,6-Dinitrotoluene

Groundwater impacted with 2,6-DNT that exceeds the cleanup standard of 1.3 µg/L is located in a discrete portion of the Frog Pond area. Nitroaromatic compound impact is isolated to the weathered unit of the Burlington-Keokuk Limestone. A summary of the 2,6-DNT data for 2006 is presented in Table 3–10.

Table 3–10. 2,6-DNT Data from Objective 2 Wells

Location	2,6-DNT Concentration (µg/L)			
	S1		S2	Average
MW-2012	120	13	370	168
MW-2014	0.46		0.60	0.53
MW-2050	49		48	48
MW-2052	ND		0.23	0.14
MW-2053	5.1		4.9	5.0
MW-2054	ND		26	13.0

ND = non-detect
S1 = First sampling event
S2 = Second sampling event

Concentration of 2,6-DNT have been the highest in MW-2012, but have shown a substantial decrease since 2004 (Figure 3–13). The behavior of the concentrations over time for 2,6-DNT in this well and others are similar to those for 2,4-DNT and are suspected to be affected by surface infiltration since 2004 . Increases in concentrations are indicated in MW-2050, MW-2053, and MW-2054 (Figure 3–14). The increases observed during the second sampling period may be a result of repairing the subsidence feature during 2006. Concentrations in MW-2014 and MW-2052 are relatively stable.

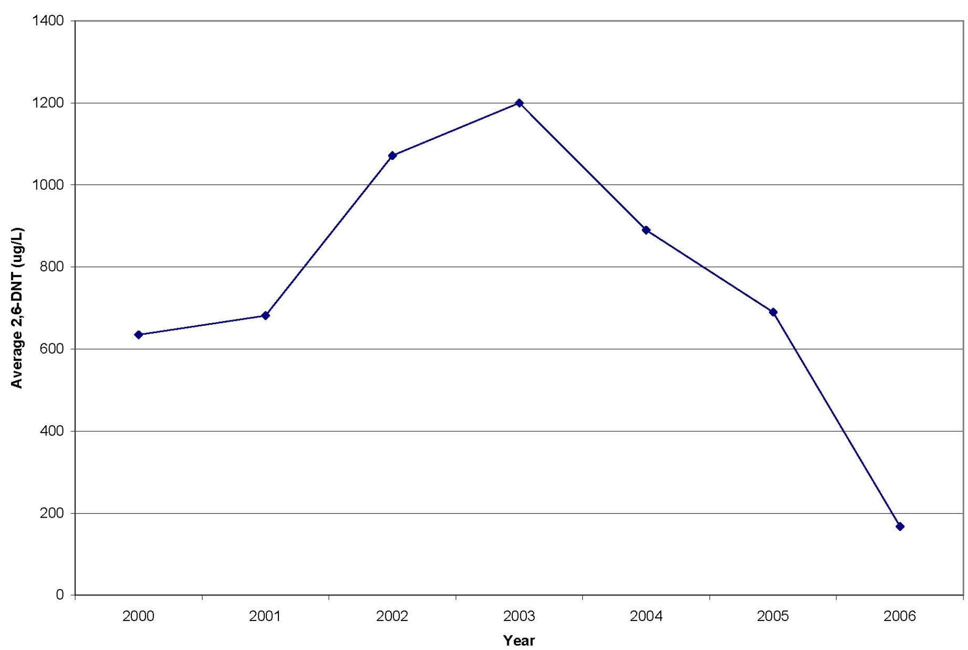

Figure 3–13. Annual Average 2,6-DNT Concentrations in Objective 2 Well MW-2012 (2000−2006)

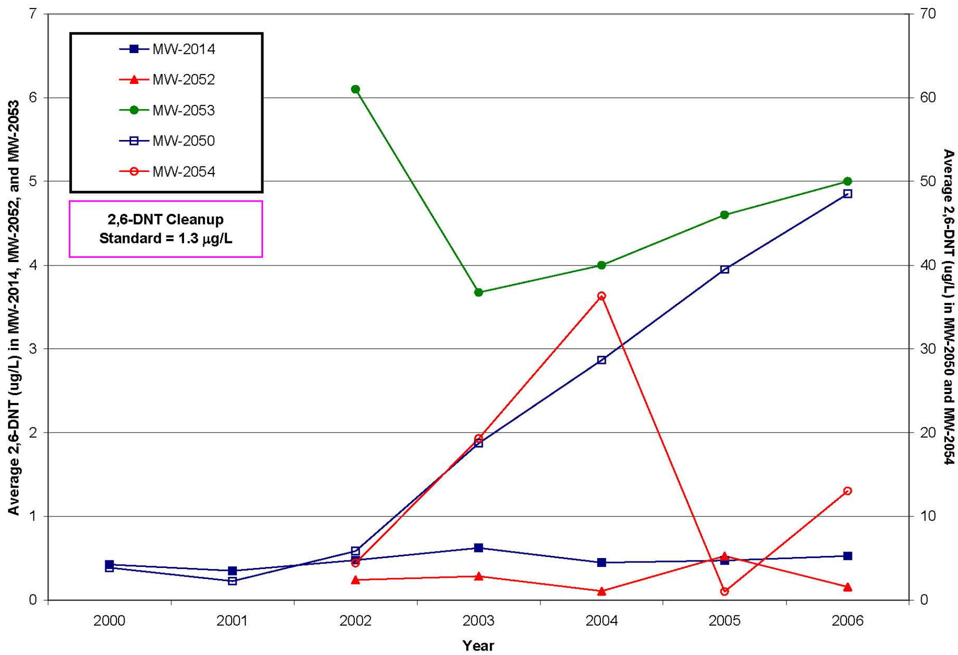

Figure 3–14. Annual Average 2,6-DNT Concentrations in Objective 2 Wells (2000−2006)

Nitrobenzene

Groundwater impacted with nitrobenzene (NB) that exceeds the cleanup standard of 17 µg/L is located in a discrete portion of the Frog Pond area. Nitroaromatic compound impact is isolated to the weathered unit of the Burlington-Keokuk Limestone. A summary of the NB that data for 2006 is presented in Table 3–11. NB has not been detected at this location since 2002 when a one time detect of 69 µg/L was measured.

Table 3–11. NB Data from Objective 2 Wells

Location	NB Concentration (µg/L)		
	S1	S2	Average
MW-2012	ND	ND	< 0.068

ND = non-detect

3.1.1.5 Detection Monitoring Results for the GWOU

Detection monitoring consists of sampling to fulfill Objectives 3, 4, and 5 of the MNA strategy. Wells along the fringes and downgradient (both laterally and vertically) of the areas of impact are monitored to ensure that lateral and vertical migration remains confined to the current area of impact and that expected lateral downgradient migration within the paleochannels is minimal or non-existent. Springs and a surface water location on Dardenne Creek are also monitored as part of this program, as these are the closest groundwater discharge points for the shallow aquifer in the vicinity of the Chemical Plant. These locations are monitored to ensure that concentrations remain protective of human health and the environment and that improvement of the water quality continues.

Contaminant concentrations are monitored using 21 wells, 4 springs, and 1 surface water location situated along the fringes or downgradient of the areas of highest impact of the different contaminant plumes at the Site. These locations were sampled at least semiannually during 2006. The data is discussed in the following sections.

Uranium

Uranium levels in the detection monitoring network indicate that the migration of the area of uranium impact is behaving as expected. The average uranium level in MW-4036 (23.2 pCi/L) does exceed the MCL of 20 pCi/L. The maximum level measured at this location during 2006 was 45 pCi/L, which is less than the trigger of 50 pCi/L for the closer Objective 3 wells. This well is screened in the weathered unit and is located immediately downgradient of the highest uranium impact in the weathered unit. While this level is high, it is not unexpected that increases would occur at this downgradient location. No increases were identified in the wells screened in the unweathered unit. A summary of the uranium data is presented in Table 3–12.

Table 3–12. Uranium Data for Objective 3, 4, and 5 Locations

Sample ID	Unit/Location	Average (pCi/L)	Number of Samples
Weathered Unit			
MW-3031	Fringe	2.5	2
MW-3037	Fringe	1.5	2
MW-4026	Southeast Drainage (alluvium)	ND	2
MW-4036	Downgradient	23.2	2
MW-4041	Downgradient	1.6	3
MWS-1	Downgradient	0.79	3
MWS-4	Downgradient	0.37	3
Unweathered Unit			
MW-3006	Fringe	3.4	2
MWD-2	Downgradient	0.23	3
Springs and Surface Water			
SP-5303	Southeast Drainage	64.4	2
SP-5304	Southeast Drainage	61.4	2
SP-6301	Burgermeister Spring Branch	55.9	2
SP-6303	Burgermeister Spring Branch	0.78	
SW-2007	Dardenne Creek	0.77	3

Uranium levels in Burgermeister Spring (SP-6301) have increased since 2004 (Figure 3–15); however, these levels are significantly less than historical highs. The levels in Burgermeister Spring exceed the MCL, but are less than the trigger levels established for the springs. The results of the trend analysis indicate an upward trend at Burgermeister Spring based on data from the last 5 years. Uranium levels in SP-6303 remain stable and below the MCL.

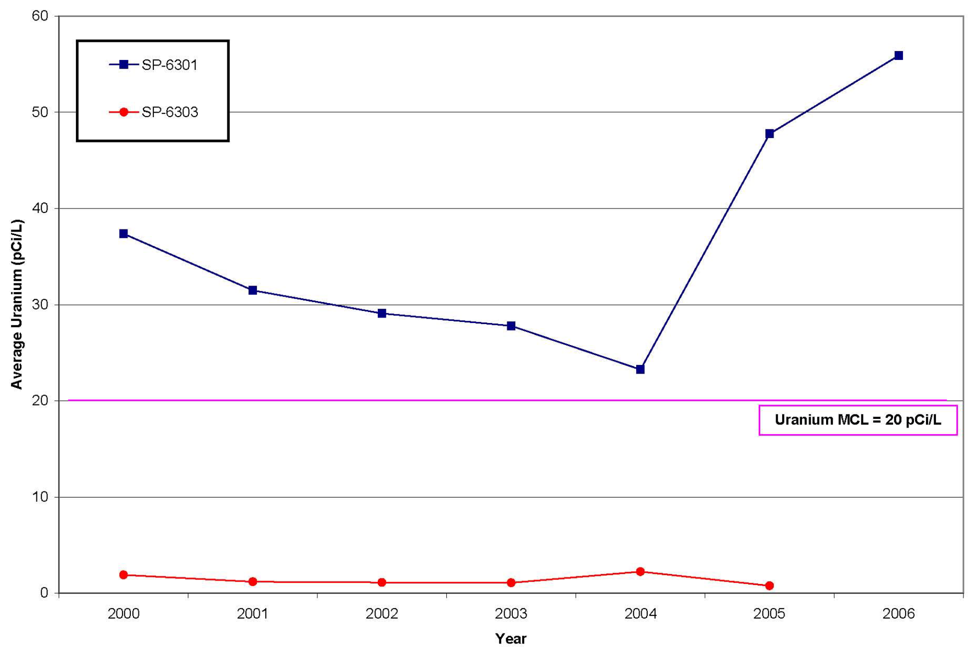

Figure 3–15. Annual Average Uranium Levels in Burgermeister Spring and SP-6303 (2000−2006)

The uranium levels in the two Southeast Drainage springs monitored under this program have fluctuated over time (Figure 3–16) and the behavior is similar in both springs. The levels in 2006 are less than those observed in 2005. Uranium levels in both wells exceed the MCL, but are less than the trigger levels established for the springs.

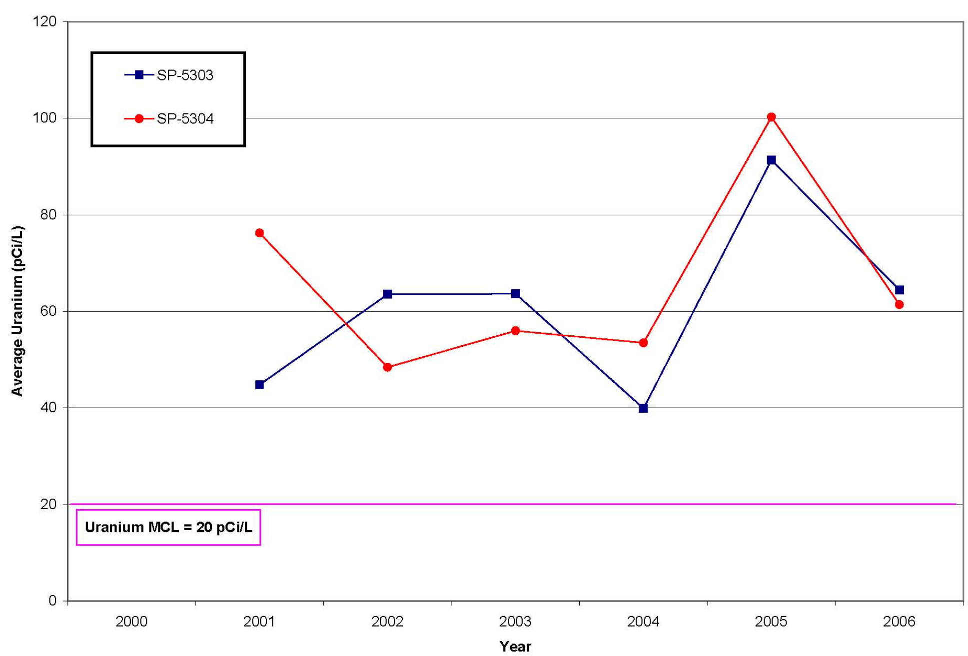

Figure 3–16. Annual Average Uranium Levels in Southeast Drainage Springs (2000−2006)

The uranium levels in Dardenne Creek measured at location SW-2007 are less than the MCL. The levels measured during 2006 are similar to those measured during 2005.

Nitrate (as N)

The nitrate concentrations in the detection monitoring wells indicate that the movement of the nitrate area of impact is behaving as expected. No increases were observed in either the weathered or unweathered unit wells. None of these locations exceed the MCL for nitrate (as N) or the trigger levels set for these locations. An estimated value (less than the detection limit of 1.0 µg/L) was reported for SP-6303. This is consistent with historical data. A summary of the data is presented in Table 3–13.

Table 3–13. Nitrate (as N) Data for Objective 3, 4, and 5 Locations

Sample ID	Location	Average (mg/L)	Number of Samples
Weathered Unit			
MW-4014	Fringe	4.4	2
MW-4041	Downgradient	0.17	3
MWS-1	Downgradient	9.4	3
MWS-4	Downgradient	2.2	3
Unweathered Unit			
MW-2021	Vertical Extent	ND	2
MW-2022	Vertical Extent	ND	2
MW-3006	Fringe	ND	2
MW-4007	Downgradient	ND	2
MWD-2	Downgradient	ND	3
Springs			
SP-6301	Burgermeister Spring Branch	2.7	2
SP-6303	Burgermeister Spring Branch	0.30	2

ND = non-detect

The nitrate concentrations in Burgermeister Spring and SP-6303 are less than the MCL of 10 mg/L. The overall trend of nitrate at these locations has been downward (Figure 3–17). The concentrations measured during 2006 are lower than those measured in 2005.

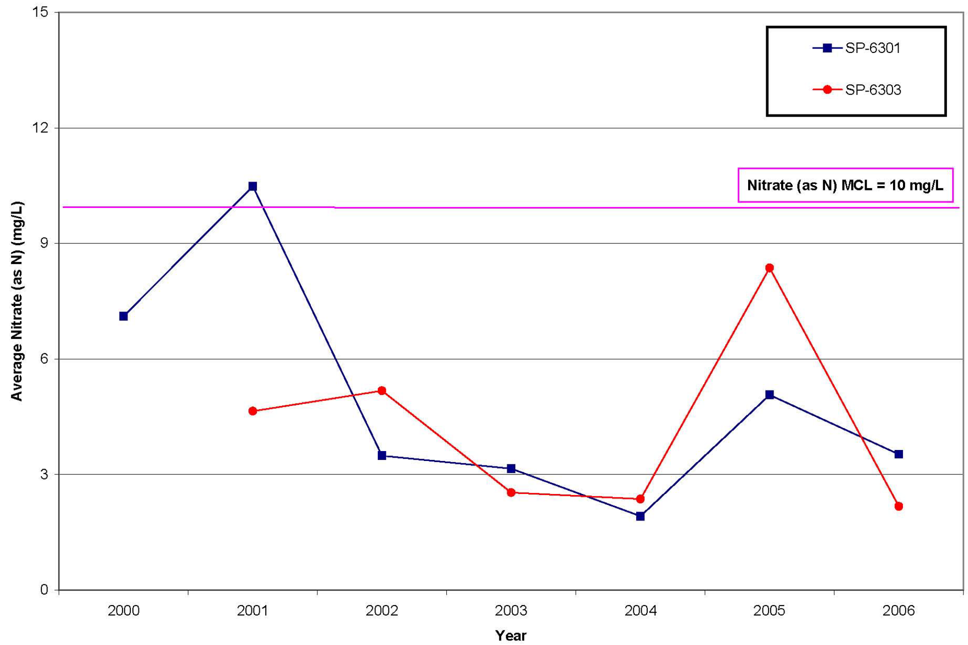

Figure 3–17. Annual Average Nitrate Concentrations in Burgermeister Spring and SP-6303 (2000−2006)

Trichloroethylene

No detectable concentrations of TCE have been reported for the detection monitoring wells. This indicates that the area of TCE impact has not expanded either laterally or vertically. A summary of the data is presented in Table 3–14.

Table 3–14. TCE Data for Objective 3, 4, and 5 Locations

Sample ID	Location	Average (µg/L)	Number of Samples
Weathered Unit			
MW-3031	Fringe	ND	2
MW-3037	Fringe	ND	2
MW-4036	Downgradient	ND	2
MW-4041	Downgradient	ND	3
MWS-1	Downgradient	ND	3
MWS-4	Downgradient	ND	3
Unweathered Unit			
MW-3006	Fringe	ND	2
MW-4007	Downgradient	ND	2
MW-4040	Vertical Extent	ND	3
Springs			
SP-6301	Burgermeister Spring Branch	ND	ND
SP-6303	Burgermeister Spring Branch	0.59*	0.59*

ND = non-detect
*estimated value

Nitroaromatic Compounds

The nitroaromatic compound concentrations in the detection monitoring wells indicate that the movement of the discrete areas of impact is behaving as expected. No increases were observed downgradient or laterally from either of the areas of impact in the weathered unit. The data for the unweathered unit wells were all reported as not detected. None of these locations exceed the cleanup standards for the five compounds or the trigger levels set for these locations. A summary of the data is presented in Table 3–15.

Table 3–15. Nitroaromatic Compound Data for Objective 3, 4, and 5 Locations

Sample ID	Location	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB	Number of Samples
Weathered Unit							
MW-2032	Fringe	ND	ND	ND	ND	ND	2
MW-2051	Fringe	0.08	0.11	0.05	0.07	ND	2
MW-3037	Fringe	---	---	ND	---	---	2
MW-4013	Downgradient	---	---	ND	0.61	ND	2
MW-4014	Downgradient	ND	ND	ND	ND	ND	2
MW-4015	Downgradient	---	---	0.06	0.80	ND	2
MW-4036	Downgradient	---	---	ND	---	---	2
MW-4039	Fringe	ND	ND	ND	ND	ND	2
MW-4041	Downgradient	ND	ND	ND	ND	ND	2
MWS-1	Downgradient	---	---	ND	---	---	2
Unweathered Unit							
MW-2022	Fringe	ND	ND	---	---	---	3
MW-2023	Vertical Extent	ND	ND	ND	ND	ND	3
MW-2056	Vertical Extent	ND	ND	ND	ND	ND	3
MW-3006	Fringe	---	---	ND	---	---	2
MW-4040	Vertical Extent	---	---	ND	---	---	3
Springs							
SP-6301	Burgermeister Spring Branch	ND	ND	ND	ND	ND	
SP-6303	Burgermeister Spring Branch	ND	ND	0.13	0.15	ND	

ND = non-detect
--- = These contaminants are not monitored at these locations.

3.1.1.6 Trend Analysis

Concentrations of contaminants of concern are expected to decrease to cleanup standards within a reasonable timeframe (i.e., approximately 100 years). Long-term trend analysis is performed to confirm downward trends in contaminant concentrations over time. Performance of the remedy will be gauged against long-term trends of the Objective 2 wells for each contaminant of concern. It is anticipated that some locations may show temporary upward trends as a result of recent source removal and ongoing dispersion.

As outlined in the *Remedial Design/Remedial Action Work Plan for the Final Remedial Action for the Groundwater Operable Unit at the Weldon Spring Site* (DOE 2004c), a trend method using the nonparametric Mann-Kendall test is used. The Mann-Kendall test is used for temporal trend identification because it can easily facilitate missing data and does not require the data to conform to a particular distribution (such as a normal or log-normal distribution). The nonparametric method is valid for scenarios where there are a high number of nondetect 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 detection limit). This approach is valid because only the relative magnitudes of the data, rather than their measured values, are used in the method. A possible consequence of this approach is that the test can produce biased results if a large fraction of data within a given time series are nondetect and detection limits change between sampling events. One-half the specified detection limit (on the date of analysis) was used in place of all concentrations reported at or below the detection limit.

The two-tailed version of the Mann-Kendall test was employed to detect either an upward or downward trend for each data set. As part of this approach, a test statistic, Z, was calculated. A positive value of Z indicated that the data were skewed in an upward direction, and a negative value of Z indicated that the data were skewed in a downward direction. The alpha value (or error limit) used to identify a significant trend was 0.05. 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 output statistic, Z was compared to the tabular $Z_{0.975}$ value of 1.96. If the absolute value of the Z output statistic was greater than 1.96, then a significant trend was reported.

A non-parametric estimate of the slope, which is calculated independently of the trend, was determined for each data set. In addition, a 95 percent (1-α) two-sided confidence interval about the true slope was obtained. The direction and magnitude of the slope, along with associated upper and lower 95 percent confidence limit estimates, are included in test results presented in the following section.

Testing for temporal trends was performed for the contaminants of concern for the GWOU using data collected between 2002 and 2006. Results for the trending analysis are reported for the Objective 2 wells and the Objective 5 springs, as these locations monitor the area of groundwater impact and the discharge points.

Results for trend analyses for uranium (Table 3–16) indicate the levels are either stable or decreasing in all of the Objective 2 wells except for MW-4040. The stabilization of the uranium levels is the result of source removal in the Raffinate Pit area; however, flushing of the system is slow due to the low amount of recharge through the system. The increases in MW-4040 will continue to be evaluated.

Table 3–16. Trending Analysis for Uranium in Objective 2 MNA Wells

Location	No. of Samples	Trend	Slope (pCi/L/yr)	Confidence Intervals	
				Lower	Lower
MW-3003	12	Down	-2.268	-3.465	-0.788
MW-3024	15	None	4.633	-5.792	14.444
MW-3030	18	Down	-2.609	-3.442	-1.301
MW-3040	11	None	4.133	-5.340	12.710
MW-4040	11	Up	44.724	-3.663	76.256

The concentrations of nitrate have stabilized over the past 5 years and some decreases have been indicated based on the results of the trending analyses (Table 3–17). No upward trends were calculated. Again, the stabilization of the concentrations is the result of source removal in the Raffinate Pit and Ash Pond areas.

Table 3–17. Trending Analysis for Nitrate (as N) in Objective 2 MNA Wells

Location	No. of Samples	Trend	Slope (mg/L/yr)	Confidence Intervals	
				Lower	Lower
MW-2038	14	None	-51.896	-106.164	48.496
MW-2040	12	Down	-7.335	-28.711	2.698
MW-3003	13	None	13.259	-39.243	74.141
MW-3034	14	None	0.921	-61.362	94.288
MW-3040	11	Down	-32.401	-59.513	-22.272
MW-4013	8	None	3.910	-26.266	16.828
MW-4029	15	None	12.481	-17.237	45.85
MW-4031	15	Down	-22.455	-44.438	-8.408
MW-4036	7	None	-7.520	-12.447	6.280
MW-4040	11	None	12.986	-22.956	37.920

Results of the trend analysis for the Objective 2 wells indicate that TCE in groundwater is stable (Table 3–18). An upward trend was determined for MW-3030; however, this location showed the greatest effects of the additional groundwater field studies and the in-situ chemical oxidation (ICO) pilot scale study performed in 2001. This well is still rebounding from these studies.

Table 3–18. Trending Analysis for TCE in Objective 2 MNA Wells

Location	No. of Samples	Trend	Slope (µg/L/yr)	Confidence Intervals	
				Lower	Lower
MW-3030	16	Up	49.903	23.090	109.226
MW-3034	18	None	-42.372	-4570.54	59.156
MW-4029	18	None	22.190	-8.130	61.987

Results of the trend analyses for the nitroaromatic compounds (Table 3–19 through Table 3–22) indicated upward trends in the Frog Pond area for 2,4,6-TNT, 2,4-DNT, and 2,6-DNT. Wells MW-2050, MW-2052, and MW-2053 showed upward trends for one or more of these nitroaromatic compounds. Decreasing trends in 2,4-DNT were determined for MW-3030 and MW-3039 in the Raffinate Pit area.

Table 3–19. Trending Analysis for 2,4-DNT in Objective 2 MNA Wells

Location	No. of Samples	Trend	Slope (µg/L/yr)	Confidence Intervals	
				Lower	Lower
MW-2012	19	Down	-236.021	-330.576	-138.092
MW-2014	16	None	0.008	-0.007	0.035
MW-2038	15	None	-0.002	-0.050	0.067
MW-2046	10	None	182.621	-5856.33	182.621
MW-2050	17	None	1.661	-1.400	5.277
MW-2052	18	Up	182.621	0.014	5375.88
MW-2053	18	None	182.621	-0.020	182.621
MW-2054	18	None	0.414	-1.230	5.721
MW-3030	18	Down	-0.041	-0.078	0.0
MW-3034	18	None	0.010	-0.040	0.076
MW-3039	14	Down	-0.193	-0.379	0.0

Table 3–20. Trending Analysis for 2,6-DNT in Objective 2 MNA Wells

Location	No. of Samples	Trend	Slope (µg/L/yr)	Confidence Intervals	
				Lower	Lower
MW-2012	19	Down	-189.385	-267.798	-103.084
MW-2014	16	None	0.014	-0.040	0.091
MW-2050	17	Up	10.324	8.909	11.562
MW-2052	18	Up	182.621	0.027	5088.54
MW-2053	18	None	0.077	-0.639	0.779
MW-2054	18	None	0.0	-12.567	15.385

Table 3–21. Trending Analysis for 2,4,6-TNT in Objective 2 MNA Wells

Location	No. of Samples	Trend	Slope (µg/L/yr)	Confidence Intervals	
				Lower	Lower
MW-2012	19	Down	-53.113	-77.311	-17.676
MW-2046	11	None	-0.050	-1.216	0.652
MW-2053	18	Up	1.548	0.194	9.772

Table 3–22. Trending Analysis for 1,3-DNB in Objective 2 MNA Wells

Location	No. of Samples	Trend	Slope (µg/L/yr)	Confidence Intervals	
				Lower	Lower
MW-2012	19	None	-0.031	-0.420	0.848

Testing for temporal trends during the past 5 years for uranium at the Objective 5 springs (Table 3–23) indicated an upward trend at SP-6301 (Burgermeister Spring). The uranium levels at the remainder of the springs were considered stable.

Table 3–23. Trending Analysis for Uranium in Objective 5 MNA Springs

Location	No. of Samples	Trend	Slope (pCi/L/yr)	Confidence Intervals	
				Lower	Lower
SP-5303	19	None	5.285	-7.143	14.511
SP-5304	24	None	6.478	-1.051	15.153
SP-6301	25	Up	5.099	-0.339	11.467
SP-6303	23	None	0.060	-0.202	0.312

3.1.2 Weldon Spring Quarry

The *Record of Decision for the Quarry Residuals Operable Unit* (QROU ROD)(DOE 1998) was signed by the EPA on September 30, 1998. The QROU ROD specified long-term groundwater monitoring and ICs to limit groundwater use during the monitoring period. Groundwater north of the Femme Osage Slough will be monitored until a target level of 300 pCi/L is attained. Also groundwater south of the slough will be monitored to ensure protection of human health and the environment.

In 2000, DOE initiated a long-term monitoring program as outlined in the Remedial Design/Remedial Action Work Plan for the Quarry Residuals Operable Unit (DOE 2000). This network was modified to add wells upgradient of the quarry (MW-1012), downgradient of the area of impact (MW-1028), and within the area of highest uranium impact (MW-1051 and MW-1052).

3.1.2.1 Quarry 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 the bedrock, consists of up to 9.2 m (30 ft) of silty clay soil and loess deposits, and is not saturated (DOE 1989). Three Ordovician-age formations comprise the bedrock: the Kimmswick Limestone, the limestone and shale of the Decorah Group, and the Plattin Limestone. The alluvium associated with the Missouri River consists of clays, silts, sands, and gravels above the bedrock. The alluvium thickness increases with distance from the edge of the river floodplain toward the river, where the maximum thickness is approximately 31 m (100 ft).

Alluvium at the quarry is truncated by an erosional contact with the Ordovician bedrock bluff consisting of Kimmswick, Decorah, and Plattin formations. These same formations also form the rim wall of the Quarry. The bedrock unit underlying alluvial materials north of Femme Osage Slough is the Decorah Group. Primary sediments between the bluff and the slough are intermixed and interlayed clays, silts, and sands. Organic material is intermixed throughout the sediments.

The area between the bedrock bluff and the Femme Osage Slough contains a naturally occurring oxidation/reduction front, which acts as a barrier to the migration of dissolved uranium in groundwater by inducing its precipitation. This reducing zone has been determined to be the primary mechanism controlling the distribution south of the quarry.

The uppermost groundwater flow systems at the Quarry are composed of alluvial and bedrock aquifers. Water levels in the alluvial aquifer are primarily controlled by surface water levels in the Missouri River, and infiltration of precipitation and overland runoff that recharges the bedrock aquifer.

Eight groundwater monitoring wells in the Darst Bottom area, located approximately 1.6 km (1 mile) southwest of the former St. Charles County well field, were utilized to study the water quality of the Missouri River alluvium upgradient of the Quarry. Data collected from them during the remedial investigation phase by both the United States Geological Survey (USGS) (1992) and DOE (1994) provided a reference for background values of uranium in the well field area. A summary of the resulting uranium background values is provided in Table 3–24 (DOE 1998a).

Table 3–24. Background Uranium Concentrations for Aquifer Units at the Quarry

Unit	Uranium (pCi/L)	
	Background Value (UCL95)[d]	Background Range
Alluvium[a]	2.77 pCi/L	0.1−16
Kimmswick/Decorah[b]	3.41 pCi/L	0.5−8.5
Plattin[c]	3.78 pCi/L[e]	1.2−5.1

[a]Based on data from Darst Bottom wells (USGS and DOE)
[b]Based on data from MW-1034 and MW-1043 (DOE)
[c]Based on data from MW-1042 (DOE)
[d]UCL95 = 95th percentile upper confidence limit on the mean concentration
[e]This background value is lower than previously published as a result of recent data evaluation

3.1.2.2 Quarry Monitoring Program

Long-term monitoring at the Quarry is designed to (1) monitor uranium concentrations south of the slough to ensure they remain protective of human health and the environment, and (2) monitor uranium and 2,4-DNT levels within the area of groundwater impact north of the slough until they attain target levels that have been identified as having negligible impact on the groundwater south of the slough (DOE 2000a).

In order to implement these two monitoring objectives the wells were categorized into monitoring lines (Figure 3–18). Each line provides specific information relevant to long-term goals at the Site:

- The first line of wells (Line 1) monitors the area of impact within the bedrock rim of the Quarry proper. These wells (MW-1002, MW-1004, MW-1005, MW-1027, MW-1030) are sampled to establish trends in contaminant concentrations within areas of higher impact.
- The second line of wells monitors the area of impact within alluvial materials and shallow bedrock north of Femme Osage Slough (MW-1006, MW-1007, MW-1008, MW-1009, MW-1013, MW-1014, MW-1015, MW-1016, MW-1028, MW-1031, MW-1032, MW-1045, MW-1046, MW-1047, MW-1048, MW-1049, MW-1051, MW-1052). These wells are also sampled to establish trends in contaminant concentrations within the areas of higher impact and to monitor the oxidizing and reducing environments that are present within this area.

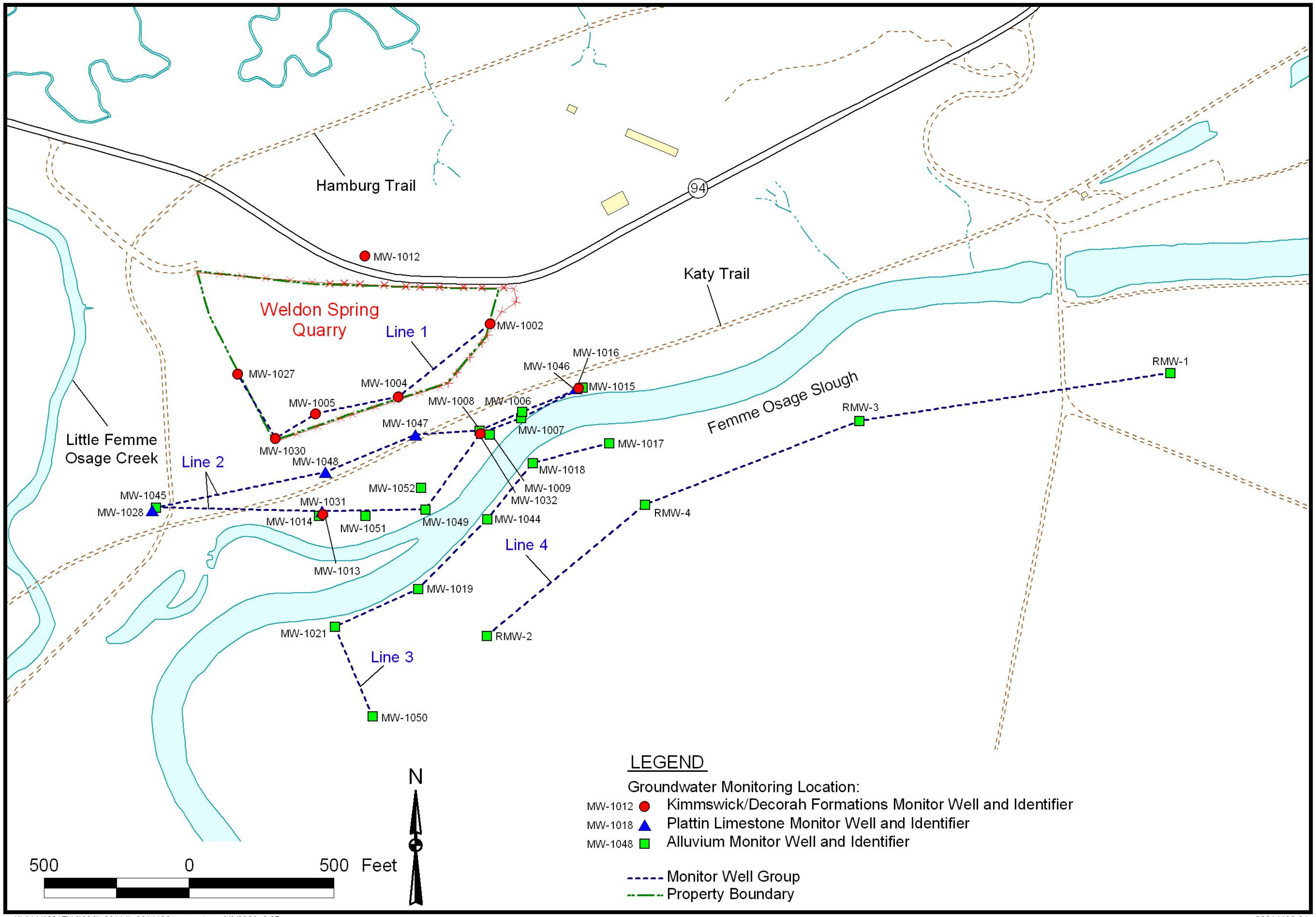

Figure 3–18. Groundwater Monitor Well Locations at the Quarry Area of the Weldon Spring, Missouri, Site

- The third line of wells monitors the alluvium found directly south of the slough. These wells (MW-1017, MW-1018, MW-1019, MW-1021, MW-1044, MW-1050) have shown no impact from Quarry contaminants and are monitored as the first line of warning for potential migration of uranium south of the slough.
- The fourth line of wells monitors the same portion of the alluvial aquifer that supplies the Public Water Supply District #2 (formerly St. Charles County) well field. These wells (RMW-1, RMW-2, RMW-3, RMW-4) are sampled to monitor the groundwater quality of the productive portions of the alluvial aquifer and to detect potential occurrences of uranium outside the range of natural variation.

Monitoring well MW-1012 has been retained as a background location for the quarry proper. This well is screened in the Kimmswick Limestone and Decorah Group.

The sampling frequency for each location is based on the travel times from the residual sources and areas of impact to potential receptors and to provide adequate reaction time. Monitoring wells on the Quarry rim and in the areas of highest impact are sampled quarterly. Locations south of the slough are sampled semiannually or annually. In 2006, all locations in the Quarry area were sampled for uranium, nitroaromatic compounds, sulfate, and iron.

3.1.2.3 Monitoring Results for Groundwater Within the Area of Impact at the Quarry

Contaminant concentrations are monitored using 23 wells screened in either the bedrock or alluvial materials in the area of uranium and 2,4-DNT impact, which is north of the Femme Osage Slough. The data is discussed in the following sections.

Uranium

Uranium values continue to indicate that the highest levels of this constituent occur in bedrock and alluvial materials between the Quarry rim and Femme Osage Slough. The 2006 annual averages for total uranium are summarized in Table 3–25. Eighteen locations north of the slough exceed applicable maximum background concentrations for uranium listed in . Nine of these locations exceed the target level of 300 pCi/L.

Table 3–25. Average Total Uranium (pCi/L) at the Weldon Spring Quarry During 2006

Location	Line	Geologic Unit	Average Concentration (pCi/L)	Number of Samples
MW-1002	1	Kimmswick-Decorah	3.7	4
MW-1004	1	Kimmswick-Decorah	**772**	4
MW-1005	1	Kimmswick-Decorah	**718**	4
MW-1027	1	Kimmswick-Decorah	**212**	4
MW-1030	1	Kimmswick-Decorah	7.2	4
MW-1006	2	Alluvium	**793**	4
MW-1007	2	Alluvium	46.5	4
MW-1008	2	Alluvium	**1630**	4
MW-1009	2	Alluvium	0.73	4
MW-1012	2[a]	Kimmswick-Decorah	2.1	4
MW-1013	2	Kimmswick-Decorah	**350**	4
MW-1014	2	Alluvium	**571**	4

Table 3−25 (continued). Average Total Uranium (pCi/L) at the Weldon Spring Quarry During 2006

MW-1015	2	Kimmswick-Decorah	170	4
MW-1016	2	Alluvium	79.3	4
MW-1028	2	Plattin	1.6	2
MW-1031	2	Plattin	12.4	4
MW-1032	2	Kimmswick-Decorah	**933**	4
MW-1045	2	Alluvium	8.3	4
MW-1046	2	Plattin	1.5	4
MW-1047	2	Plattin	1.1	4
MW-1048	2	Plattin	**319**	4
MW-1049	2	Alluvium	0.46	4
MW-1051	2	Alluvium	**304**	4
MW-1052	2	Alluvium	**76.5**	4

Concentrations in **BOLD** = Annual average exceeds target level of 300 pCi/L.
[a]Upgradient location.

Uranium levels in the Line 1 wells have shown a general decrease over time (Figure 3–19) as supported by trend analysis (Section 3.1.2.6). The levels in 2006 are similar to those measured during 2005. The average level of uranium in MW-1002, MW-1027, and MW-1030 are less than the target level of 300 pCi/L established for groundwater north of the Femme Osage Slough.

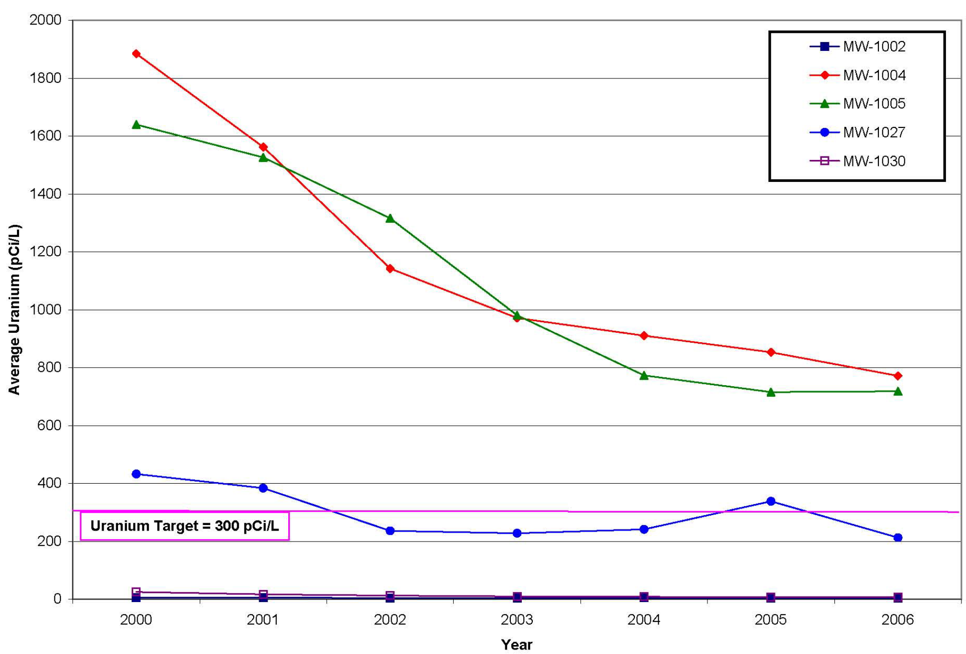

Figure 3–19. Average Uranium (pCi/L) in Line 1 Monitoring Wells

Uranium levels in Line 2 continue to fluctuate over time; however, the levels in the wells have generally decreased in 2006 (Figure 3–20 and Figure 3–21) most notably in wells MW-1008 and MW-1032. This may be due in part to the lower groundwater levels present in this area during 2006. Uranium levels in this area are correlated to the groundwater elevation. These decreases may also be attributed to decreases in uranium in the upgradient rim wells. The average level of uranium in MW-1007, MW-1015, MW-1016, MW-1031, MW-1047, MW-1049, and MW-1052 are less than the target level of 300 pCi/L. Reducing conditions are prevalent in MW-1007, MW-1009, and MW-1049 and explain the continued low levels of uranium seen at these locations. MW-1047 is screened in the Plattin Limestone and historically has shown no uranium impact.

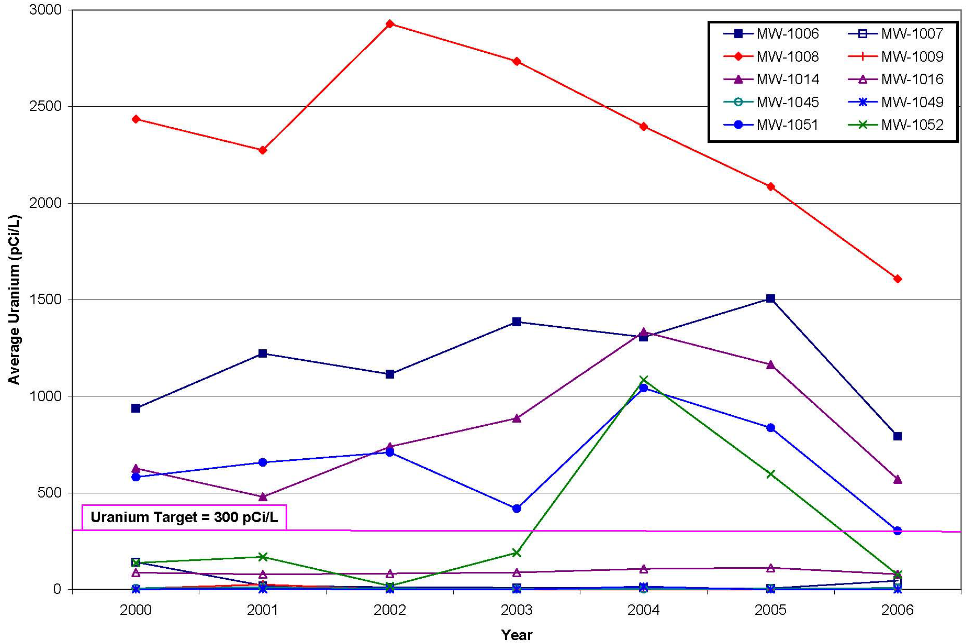

Figure 3–20. Average Uranium (pCi/L) in Alluvial Line 2 Wells

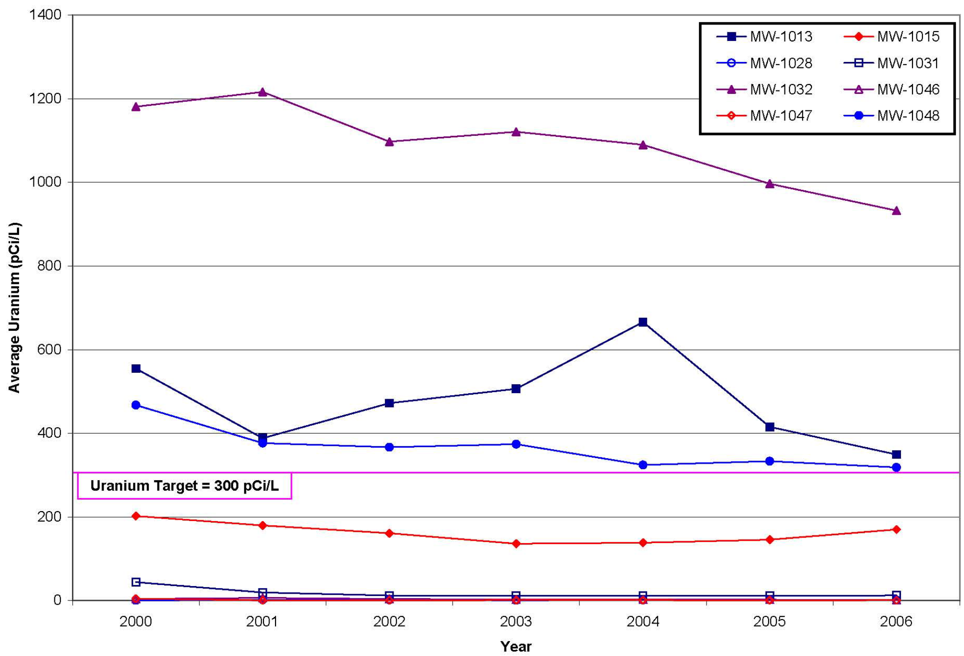

Figure 3–21. Average Uranium (pCi/L) in Bedrock Line 2 Wells

The attainment objective for the long-term monitoring of uranium in groundwater north of the slough is that the 90th percentile of the data within a monitoring year is below the target level of 300 pCi/L (DOE 2000a). Nine wells north of the slough exceeded the target level in 2006. The 90th percentile associated with the data from the Line 1 and 2 wells was 830 pCi/L. This value is considerably lower than pervious years (Figure 3–22). This decrease may be due to the lower than typical water levels in this area. Higher uranium levels have been correlated to occur with higher water levels. Uranium monitoring will continue in 2007 and subsequent data should be evaluated.

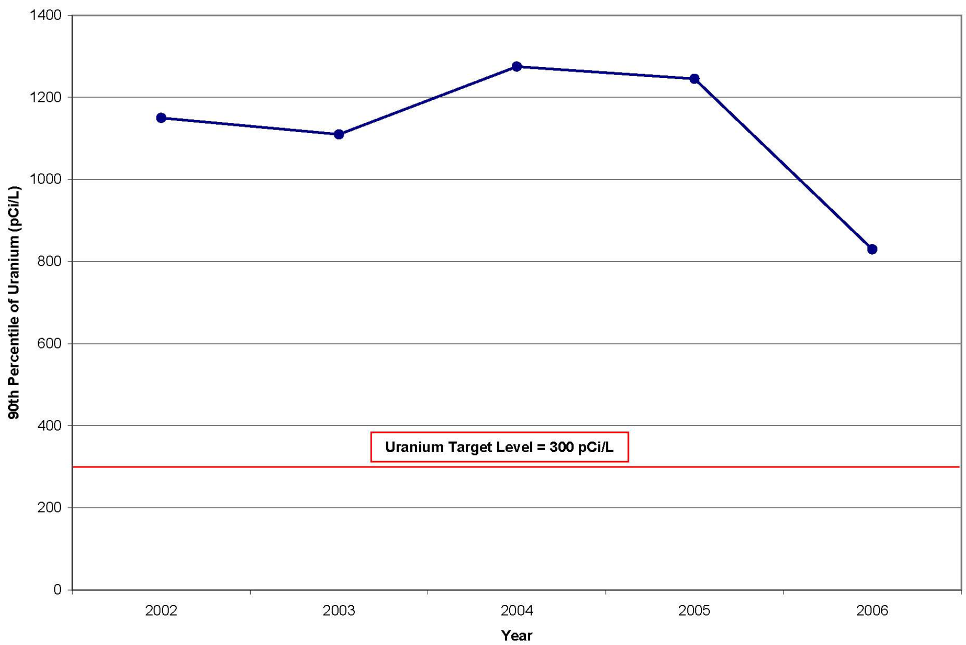

Figure 3–22. 90th Percentile of Uranium in Line 1 and 2 Wells – 2002 through 2006

<u>Nitroaromatic Compounds</u>

In 2006, samples from Quarry monitoring wells were analyzed for the nitroaromatic compounds, primarily 2,4-DNT. Monitoring wells that have historically been impacted by nitroaromatic compounds are screened in either alluvial materials or bedrock along the quarry rim or between the Quarry and Femme Osage Slough. During 2006, measured concentrations of the nitroaromatic compounds were generally similar to those reported for 2005. No detectable concentrations were reported in the well field south of the slough.

During the CERCLA Five-Year Review (DOE 2006), the monitoring of 2,4-DNT was evaluated. It was determined that at a large number of locations 2,4-DNT concentrations had been below the detection limit for a period of time. It was determined that only three locations had recently had detectable concentrations during 2005. These locations are MW-1004, MW-1006, and MW-1027. It was recommended that these three locations continue to be monitored to fulfill the required monitoring for 2,4-DNT. In conjunction with these three locations, five other locations will be included. These locations are MW-1002, MW-1005, and MW-1032, which have had detectable concentrations of 2,4-DNT in recent years, and MW-1045 and MW-1049, which are alluvial wells located downgradient of the wells with detectable concentrations.

Average concentrations of 2,4-DNT for the eight long-term locations are presented in Table 3–26. The average concentration of 2,4-DNT remained above the Missouri Water Quality Standard of 0.11 µg/L at MW-1027. The values reported in 2006 are lower than those reported in 2005.

Table 3–26. Average Concentrations of 2,4-DNT at the Weldon Spring Quarry During 2006

Location	Line	Geologic Unit	Average Concentration (µg/L)	Number of Samples
MW-1002	1	Kimmswick-Decorah	ND	4
MW-1004	1	Kimmswick-Decorah	ND	4
MW-1005	1	Kimmswick-Decorah	ND	4
MW-1006	2	Alluvium	ND	2
MW-1027	2	Kimmswick-Decorah	**2.6**	4
MW-1032	2	Kimmswick-Decorah	ND	4
MW-1045	2	Alluvium	ND	4
MW-1049	2	Alluvium	ND	4

Concentrations in **BOLD** – Exceeds the Missouri Water Quality Standard of 0.11 µg/L for 2,4-DNT

The concentration of 2,4-DNT has fluctuated over time (Figure 3–23). Increased concentrations were observed in wells MW-1006 and MW-1027 during 2005, but the average concentrations for 2,4-DNT in groundwater decreased substantially during 2006. This decrease may be due to the lower than typical water levels in this area. A correlation between water level and 2,4-DNT concentration has not been determined; however, another viable explanation cannot be provided. Concentrations less than the detection limit have historically been reported in MW-1045 and MW-1049.

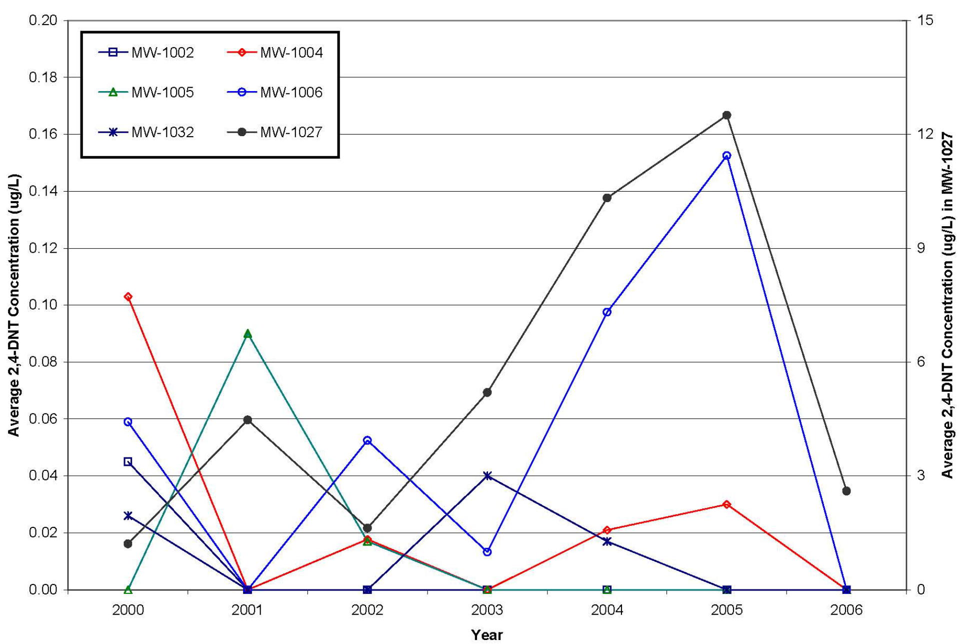

Figure 3–23. Average 2,4-DNT (µg/L) in Long-Term Wells

The attainment objective for the long-term monitoring of 2,4-DNT in groundwater north of the slough is that the 90th percentile of the data within a monitoring year is below the target level of 0.11 µg/L (DOE 2000a). The eight monitoring wells that have been selected for continued long-term monitoring were used to calculate this metric. Only MW-1027 exceeded the target level in 2006. The 90th percentile associated with the data from the eight wells was 0.11 µg/L. This value is considerably higher than previous years because a smaller set of wells is being used. Monitoring of 2,4-DNT in the eight wells will continue in 2007 and subsequent data should be evaluated.

Geochemical Parameters

The geochemistry of the shallow aquifer is monitored to verify the presence of the reduction zone and to confirm that the reduction zone is capable of ongoing attenuation of uranium in groundwater. Groundwater is analyzed for sulfate, dissolved iron, ferrous iron, and Eh. Sulfate is monitored as an indicator of oxidation-reduction (redox) conditions in the groundwater in the vicinity of the quarry. Higher sulfate concentrations are generally observed in an oxidizing environment and lower sulfate levels are indicative of a more reducing environment. Iron (total dissolved and ferrous) is also monitored as an indicator of redox conditions in the groundwater. Iron concentrations generally increase in a reducing environment. These results generally correlate with observed uranium concentrations upgradient and downgradient of the reduction zone, as uranium is generally more mobile in an oxidizing environment. A summary of the geochemical parameters for each monitoring location is presented in Table 3–27.

Table 3–27. Average Value for Geochemical Parameters for the Weldon Spring Quarry

Location	Line	Geologic Unit	Average Values			
			Sulfate (mg/L)	Dissolved Iron (µg/L)	Ferrous Iron (µg/L)	Eh (mV)
MW-1002	1	Kimmswick-Decorah	104	26.0	17.5	+160
MW-1004	1	Kimmswick-Decorah	85.6	53.1	20.0	+175
MW-1005	1	Kimmswick-Decorah	220	3,626	305	+29
MW-1027	1	Kimmswick-Decorah	71.4	102	80.0	+4
MW-1030	1	Kimmswick-Decorah	95.9	7,150	4,290	+183
MW-1006	2	Alluvium	51.4	1,405	655	-15
MW-1007	2	Alluvium	28.1	45,000	2,185	-111
MW-1008	2	Alluvium	112	23.1	ND	+81
MW-1009	2	Alluvium	25.3	215,200	1,770	-83
MW-1013	2	Kimmswick-Decorah	81.9	3,822	2,083	-29
MW-1014	2	Alluvium	110	2,387	820	+30
MW-1015	2	Kimmswick-Decorah	101	30.6	1,275	+76
MW-1016	2	Alluvium	104	25.6	243	+186
MW-1028	2	Plattin	55.3	775	590	+27
MW-1031	2	Alluvium	25.3	38.4	ND	+174
MW-1032	2	Kimmswick-Decorah	120	37.8	7.5	+104
MW-1045	2	Alluvium	42.2	ND	12.5	+145
MW-1046	2	Plattin	51.2	386	443	-26
MW-1047	2	Plattin	83.9	131	17.5	+90
MW-1048	2	Plattin	63.9	1,144	1,068	-25
MW-1049	2	Alluvium	0.10	56,625	2,512	-113
MW-1051	2	Alluvium	25.0	3,745	2,667	+12
MW-1052	2	Alluvium	0.33	38,900	8,595	-91

Review of the geochemical data indicates that reducing conditions are prevalent in the vicinity of wells MW-1007, MW-1009, MW-1049, and MW-1052. This is consistent with the uranium data (Table 3–28), as the levels in these wells are low compared to upgradient locations. The location of this reducing area is consistent with previous years and the attenuation of uranium in this area continues. Groundwater quality in the Missouri River alluvium is monitored using 10 wells screened in the alluvial materials. These wells are sampled to ensure that water quality is protective of human health. The data is discussed in the following sections.

3.1.2.4 Monitoring Results for the Missouri River Alluvium

Uranium

The six monitoring wells located immediately south of the slough (Line 3) and the RMW-series wells (Line 4) were analyzed for uranium during 2006 (Table 3–28) to verify that levels remain within the range of its natural variation in Missouri River alluvium. The results indicate that uranium levels in one well, RMW-2, exceed the statistical background value in the alluvium (Table 3–24). However, the value at this well is within the range measured at the background locations and does not indicate impact. None of the locations south of the slough have uranium levels that exceed the drinking water standard of 20 pCi/L.

Table 3–28. Average Concentration for Total Uranium in the Missouri River Alluvial Aquifer During 2006

Location	Line	Average (pCi/L)	Number of Samples
MW-1017	3	ND	2
MW-1018	3	ND	2
MW-1019	3	ND	2
MW-1021	3	ND	2
MW-1044	3	ND	2
MW-1050	3	ND	2
RMW-1	4	0.95	1
RMW-2	4	5.4	1
RMW-3	4	0.52	1
RMW-4	4	0.47	1

Background concentrations given in Table 3–24.
ND = nondetect

Nitroaromatic Compounds

During 2006, the Line 3 and 4 monitoring wells were sampled for nitroaromatic compounds. No detectable concentrations were observed at any of these locations.

During the CERCLA Five-Year Review, the monitoring of 2,4-DNT was evaluated. It was determined during this evaluation that the monitoring network would be reduced. Several wells that had recent impact and several wells downgradient of the impacted wells will continue to be monitored. None of the 10 wells in the Missouri River Alluvium Aquifer will continue to be monitored for nitroaromatic compounds.

Geochemical Parameters

The monitoring wells located south of the slough were sampled for sulfate and iron during 2006, for the purpose of assessing redox conditions in the Missouri River alluvium in this area (Table 3–29). The data indicate that a strongly reducing environment is prevalent in the groundwater immediately south of the slough as indicated by high dissolved iron concentrations, low sulfate concentrations, and negative Eh values. This environment is not favorable for the migration of uranium, if it were to pass beyond the reducing zone north of the slough.

Table 3–29. Average Iron and Sulfate Concentrations in the Missouri River Alluvial Aquifer During 2006

Location	Sulfate (mg/L)	Dissolved Iron (µg/L)	Ferrous Iron (µg/L)	Eh (mV)
MW-1017	0.1	31,400	12,065	-139
MW-1018	7.2	24,400	9,485	-140
MW-1019	.19	22,650	10,375	-137
MW-1021	0.21	17,100	9,005	-119
MW-1044	ND	19,850	6,890	-131
MW-1050	12.12	14,700	2,940	-132
RMW-1	45.1	9,730	1,970	-104
RMW-2	12.7	8,540	1,760	-105
RMW-3	24.7	16,000	2,330	-168
RMW-4	8.8	17,200	10,600	-159

3.1.2.5 Quarry Trend Analysis

Testing for temporal trends was performed on Quarry groundwater data for total uranium and 2,4-DNT collected between 2002 and 2006. These analyses were performed using the previously described nonparametric Mann-Kendall test (Section 3.1.1).

Testing for temporal trends was performed on total uranium and 2,4-DNT groundwater data from the Quarry collected between 2002 and 2006. These analyses were performed using the previously described nonparametric Mann-Kendall test (Section 3.1.1.4). Results for the trending analysis for uranium and 2,4-DNT are reported for Lines 1 and 2 of the Quarry monitoring network, as these lines monitor the area of groundwater impact.

The results for the Line 1 wells (Table 3–30), which are located along the Quarry rim, show that uranium concentrations over the past 5 years have been stable or have trended downward. Decreases in uranium along the Quarry rim are the result of bulk waste removal and restoration activities. Remedial activities in the Quarry have reduced and possibly prevented infiltration of precipitation and stormwater into the residually contaminated fracture system in the Quarry proper. Downward trends have been reported for MW-1004, MW-1005, and MW-1030 since 2003.

Table 3–30. Trending Analysis for Uranium in Line 1 Groundwater Monitoring Wells

Location	No. of Samples	Trend	Slope (pCi/L/yr)	Confidence Intervals	
				Lower	Upper
MW-1002	20	None	0.0	-0.128	0.103
MW-1004	20	Down	-66.595	-101.462	-41.584
MW-1005	20	Down	-102.801	-149.73	-65.195
MW-1027	20	None	8.668	-17.700	34.062
MW-1030	20	Down	-1.137	-2.175	-0.567

The results for the Line 2 wells (Table 3–31), which are located in the saturated alluvial and bedrock materials north of the Femme Osage Slough, show that uranium concentrations over the past 5 years have been stable and a few downward trends have started to be observed. No upward trends were calculated. The stabilizing uranium levels in this area are the result of bulk waste removal and restoration activities, as previously discussed, because there is less residual source to this area. Decreases in uranium groundwater will not occur as quickly as in the rim wells. Uranium does not bind as readily to the bedrock as it does the alluvial materials. Also, the groundwater velocity is slow in the area north of the Femme Osage Slough resulting in less flushing; however, the distribution of uranium in groundwater is still controlled by the precipitation of uranium along the oxidizing/reducing front located north of the Femme Osage Slough.

Table 3–31. Trending Analysis for Uranium in Line 2 Groundwater Monitoring Wells

Location	No. of Samples	Trend	Slope (pCi/L/yr)	Confidence Intervals	
				Lower	Lower
MW-1006	20	None	-14.777	-120.512	112.054
MW-1007	20	None	0.485	-2.944	5.431
MW-1008	20	Down	-321.949	-683.218	27.001
MW-1009	20	None	0.0	-0.146	0.145
MW-1013	20	None	-29.779	-68.417	14.977
MW-1014	20	None	4.226	-136.05	177.849
MW-1015	20	None	5.546	-5.705	15.883
MW-1016	20	None	1.291	-7.430	9.945
MW-1028	9	None	0.064	-0.248	0.325
MW-1031	20	None	0.051	-0.321	0.600
MW-1032	20	Down	-48.027	-79.482	-9.881
MW-1045	20	None	-0.035	-0.692	1.475
MW-1046	20	Down	-0.563	-0.839	0.396
MW-1047	20	None	0.013	0.049	0.075
MW-1048	20	Down	-11.575	-22.880	-1.612
MW-1051	18	None	-22.972	-228.696	85.432
MW-1052	18	None	-2.105	-284.801	101.618

Trend analyses for 2,4-DNT was performed for wells MW-1004, MW-1006, and MW-1027 (Table 3–32), as these are the only locations that had detectable concentrations of 2,4-DNT in the last 5 years. The lack of detectable concentrations of this nitroaromatic compound is the result of bulk waste removal. The reducing conditions in the area north of the slough also results in the attenuation of these compounds.

Table 3–32. Trending Analysis for 2,4-DNT in Select Quarry Groundwater Monitoring Wells

Location	No. of Samples	Trend	Slope (µg/L/yr)	Confidence Intervals	
				Lower	Lower
MW-1004	20	Up	182.621	182.621	182.621
MW-1006	18	None	182.621	-0.049	182.621
MW-1027	20	Up	3.045	0.271	4.221

Upward trends were reported for MW-1004 and MW-1027. A large number of non-detect values were reported for MW-1004; therefore, this upward trend may be artificial. The upward trend at MW-1027 has been reported since 2004. The continued upward trend in 2,4-DNT in MW-1027 may be the result of residual nitroaromatic source in the Quarry fractures and the oxidizing conditions of the aquifer that would not aid in the attenuation of this parameter in the groundwater.

3.1.3 Disposal Cell Monitoring

Five groundwater monitoring wells, one spring, and disposal cell leachate were sampled during 2006 as part of the detection monitoring program for the permanent disposal cell. This monitoring is performed 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 federal and state hazardous and/or solid waste regulations were identified as ARARs for the selected remedy in the *Record of Decision for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (DOE 1993). Monitoring of these wells, the spring, and the leachate was performed in accordance with the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan, Rev. 2* (DOE 2004b).

3.1.3.1 Disposal Cell Monitoring Program

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), one downgradient spring (SP-6301), and the disposal cell leachate. Semiannual detection monitoring began in mid-1998, after cell construction had begun and waste placement activities were initiated.

The monitoring program for the disposal cell consisted of semiannual sampling for the following parameters:

- Uranium.
- Anions (chloride, fluoride, nitrate [as N], and sulfate).
- Metals (arsenic, barium, chromium, cobalt, iron, lead, manganese, nickel, selenium, and thallium).
- Nitroaromatic compounds.
- Radiochemical parameters (Radium-226 [Ra-226], Radium-228 [Ra-228], Thorium-228 [Th-228], Thorium-230 [Th-230], and Thorium-232 [Th-232]).
- Polychlorinated biphenyls (PCBs) and polyaromatic hydrocarbons (PAHs).
- Miscellaneous indicator parameters (pH, specific conductance, chemical oxygen demand, total dissolved solids [TDS], and total organic carbon [TOC]).

Under the monitoring program, signature parameter (barium, iron, manganese, and uranium) data from each monitoring event are compared to the baseline tolerance limits (BTLs) to trace general changes in groundwater quality and determine whether statistically significant evidence of contamination due to cell leakage exists. Tolerance limits for signature parameters have been calculated using the dataset from 1997 through 2002, using 95 percent confidence limits.

The data from the remainder of the parameters are reviewed to evaluate the general groundwater quality in the vicinity of the disposal cell and to determine if changes are occurring in the groundwater system. Data are compared to the three most recent years of data to determine if statistically significant changes in concentrations are present. A measured concentration is considered statistically significant if it is greater than the arithmetic mean plus three times the standard deviation for a given location.

Wells with data showing statistically significant increases or decreases are resampled to confirm the exceedance. If the results of the resampling confirm the exceedance, historical leachate analytical data and volumes are evaluated to assess the integrity of the disposal cell. If the leachate data do not indicate that the exceedance could be the result of leakage from the cell, an assessment of the analytical data and review of sitewide monitoring data is performed. If the exceeding parameter is a contaminant of concern for the GWOU, this information is evaluated under the monitoring program for that operable unit.

3.1.3.2 Disposal Cell Monitoring Results

The 2006 monitoring results for the signature parameters are presented in Table 3–33 along with applicable BTLs. The results were less than the applicable BTLs indicating no evidence of leakage is evident in the groundwater beneath the disposal cell. The general groundwater quality (Table 3–34) in the detection monitoring wells and springs was similar to that measured in 2005.

Monitoring well MW-2032 has been under evaluation since December 2004 because of concentrations of sulfate, TOC, Chemical Oxygen Demand (COD), and nickel that were considered statistically significant increases from previous results. Subsequent re-sampling for these parameters in 2005 produced results that were lower than those measured in 2004. The changes in concentrations were attributed to biodegradation of natural organic material (ants) in the well as discussed in the *Cell Groundwater Monitoring Demonstration Report for the December 2004 Sampling Event* (DOE 2005). This well exhibited a conversion from fully oxidizing to chemically reducing due to the decay of ants in the well.

Several recommendations were made in the Demonstration Report in an effort to rectify the situation. Two of these recommendations were:

- Redevelop the well using purging techniques on a bimonthly basis.
- Monitor the oxidation reduction potential (ORP) levels bimonthly prior to purging.

The redevelopment activities were initiated in April 2005 and were continued until December 2006. The ORP measurements returned to oxidizing conditions starting with the April 2006 sampling (Figure 3–24). Purging of the well and measuring ORP will not continue into 2007.

Table 3–33. Signature Parameter Results and Associated BTLs at Disposal Cell Monitoring Locations

Parameter	Location	BTL	Results	
			June 2006	December 2006
Barium (µg/L)	MW-2032	337	186	155
	MW-2046	277	217	214
	MW-2047	471	403	373
	MW-2051	285	201	200
	MW-2055	98	19.1	19.6
	SP-6301	180	130	140
Iron (µg/L)	MW-2032	1,125	ND	ND
	MW-2046	1,578	80.6	ND
	MW-2047	1,485	ND	ND
	MW-2051	2,896	ND	ND
	MW-2055	10,579	30.2	ND
	SP-6301	2,608	299	228
Manganese (µg/L)	MW-2032	57	9.7	4.6
	MW-2046	187	5.2	5.3
	MW-2047	171	ND	4.4
	MW-2051	265	ND	1.3
	MW-2055	179	2.5	2.8
	SP-6301	88	3.5	5.0
Uranium (pCi/L)	MW-2032	6.4	2.5	4.2
	MW-2046	1.8	1.2	1.0
	MW-2047	2.7	1.3	1.2
	MW-2051	4.5	1.2	1.3
	MW-2055	7.5	2.1	1.8
	SP-6301	159	33.3	78.5

Table 3–34. Average Values for Monitoring Data for the Disposal Cell Well Network 2006

Parameter	MW-2032	MW-2046	MW-2047	MW-2051	MW-2055	SP-6301
Chloride (mg/L)	3.0	42.4	8.0	16.0	5.4	15.3
Fluoride (mg/L)	0.17	.010	0.10	0.17	0.11	0.16
Nitrate-N (mg/L)	1.68[a]	2.2	77.0	1.7	1.0	3.5
Sulfate (mg/L)	79.4	59.2	22.7	20.6	256	21.0
Arsenic (µg/L)	1.9	ND	ND	ND	ND	ND
Chromium (µg/L)	5.0	3.1	6.5	7.0	7.5	ND
Cobalt (µg/L)	ND	1.4	1.5	ND	ND	ND
Lead (µg/L)	ND	ND	ND	ND	ND	ND
Nickel (µg/L)	4.2	29.6	6.0	4.4	15.2	ND
Selenium (µg/L)	1.4	4.2	2.2	1.6	13.8	ND
Thallium (µg/L)	1.6	2.2	ND	ND	ND	ND
COD (mg/L)	11.0	6.6	21.0	5.6	ND	8.1
TDS (mg/L)	461	589	758	382	722	266
TOC (mg/L)	ND	ND	ND	18.1	ND	NS
1,3,5-TNB (µg/L)	ND	3.5	0.08	0.11	ND	ND
1,3-DNB (µg/L)	ND	0.09	ND	0.08	ND	ND
2,4,6-TNT (µg/L)	ND	3.0	ND	0.11	ND	ND
2,4-DNT (µg/L)	ND	0.13	0.11	0.05	ND	ND
2,6-DNT (µg/L)	ND	2.4	0.29	0.07	ND	ND
NB (µg/L)	ND	ND	ND	ND	ND	ND
Radium-226 (pCi/L)	ND	ND	0.45	ND	0.22	0.13
Radium-228 (pCi/L)	ND	ND	0.72	ND	ND	ND
Thorium-228 (pCi/L)	ND	ND	ND	ND	ND	ND
Thorium-230 (pCi/L)	0.33	0.25	0.19	0.30	0.22	0.46
Thorium-232 (pCi/L)	ND	ND	ND	ND	ND	ND
PCBs/PAHs (µg/L)	ND	ND	ND	ND	ND	ND
DO (mg/L)	4.9	7.6	5.80	8.2	6.0	6.9
ORP (mV)	108	252	227	232	240.	272
pH (s.u.)	7.2	6.80	7.0	7.2	6.9	6.7
SC (µmohs/cm)	646	960	1213	622	1086	456
Temperature (C)	15.9	15.9	17.2	16.2	16.9	13.0

[a]The nitrate (as N) result from the December 2006 sampling was rejected
ND Nondetect.
NS Not sampled

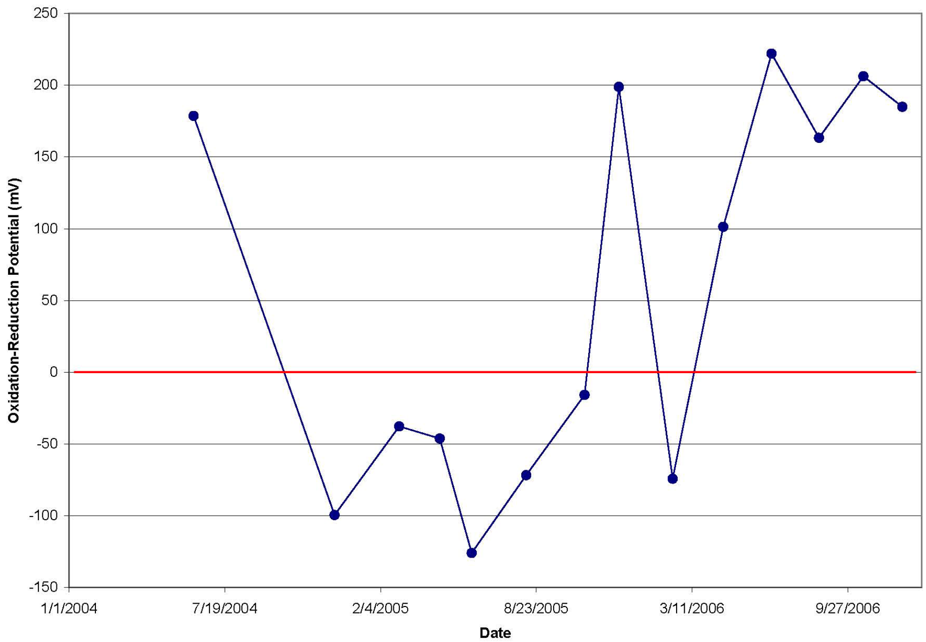

Figure 3–24. ORP Measurements in MW-2032 (2004 through 2006)

The 2006 monitoring results for the disposal cell leachate are presented in Table 3–35. The LCRS is sampled semiannually for disposal cell well analytes and the data are used for comparison with corresponding concentrations in wells if elevated levels of constituents are identified in the groundwater. The composition of the leachate is similar to that measured in 2005. The four signature parameters (barium, iron, manganese, and uranium) remain at concentrations higher than those measured in groundwater beneath the disposal cell.

3.1.3.3 Groundwater Flow

Groundwater flow rate and direction are evaluated annually as specified in the *Disposal Cell Groundwater Monitoring Plan* (DOE 2004b). The groundwater flow direction was determined by constructing a potentiometric surface map of the shallow aquifer using the available wells at the Chemical Plant (Figure 3–25). The potentiometric surface has remained relatively unchanged since the construction of the disposal cell. The groundwater flow direction is generally to the north. A groundwater divide is present along the southern boundary of the Site.

The average groundwater flow rate (average linear velocity) is calculated using the following equation:

$$v = -Ki/n_e$$

The average hydraulic conductivity (K) using data from the cell monitoring wells is 7×10^{-3} centimeters per second. An effective porosity (n_e) of 0.10 was selected to estimate the maximum groundwater flow rate in this area. The hydraulic gradient (i) in the disposal cell area is 0.011 ft per foot and is based on data from MW-2032 and MW-2055, located 2,100 ft apart. This approach is consistent with the calculations presented in the *Disposal Cell Groundwater Monitoring Plan* (DOE 2004b). The average flow rate for 2006 was 2.2 ft per day, which is the same as the average flow rate calculated in 2005 and similar to the average flow rates calculated since 1998 (DOE 2004b).

Table 3–35. Summary of Disposal Cell Leachate Monitoring Data During 2006

Parameter	Concentrations	
	June 2006	December 2006
Chloride (mg/L)	37.0	34.6
Fluoride (mg/L)	0.28	0.22
Nitrate-N (mg/L)	1.38	1.52
Sulfate (mg/L)	48.7	42.7
Arsenic (µg/L)	3.7	2.4
Barium (µg/L)	799	768
Chromium (µg/L)	ND	ND
Cobalt (µg/L)	ND	ND
Iron (µg/L)	1200	3010
Lead (µg/L)	ND	ND
Manganese (µg/L)	514	369
Nickel (µg/L)	ND	ND
Selenium (µg/L)	ND	ND
Thallium (µg/L)	2.8	ND
COD (mg/L)	37.0	27.0
TDS (mg/L)	683	619
TOC (mg/L)	ND	ND
1,3,5-TNB (µg/L)	ND	ND
1,3-DNB (µg/L)	ND	ND
2,4,6-TNT (µg/L)	ND	ND
2,4-DNT (µg/L)	ND	ND
2,6-DNT (µg/L)	ND	ND
NB (µg/L)	ND	ND
Radium-226 (pCi/L)	0.79	ND
Radium-228 (pCi/L)	0.74	ND
Thorium-228 (pCi/L)	ND	ND
Thorium-230 (pCi/L)	0.25	0.46
Thorium-232 (pCi/L)	ND	ND
Uranium (pCi/L)	20.2	24.7
PCBs/PAHs (µg/L)	ND	ND

ND = Nondetect.

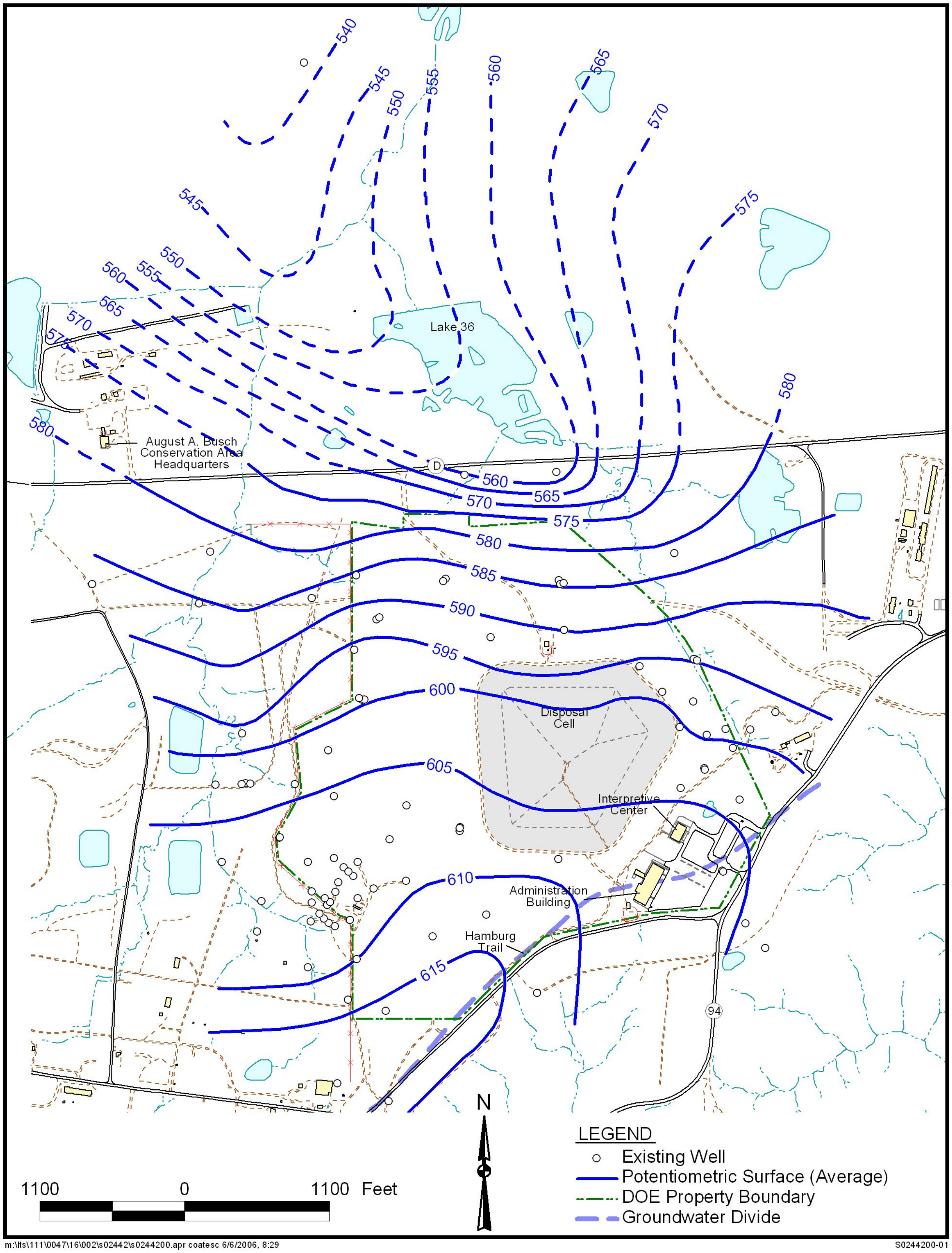

Figure 3–25. Potentiometric Surface of the Shallow Aquifer (Weathered Zone)

3.2 Surface Water

3.2.1 Chemical Plant Surface Water

The surface water locations, Schote Creek, Dardenne Creek, and Busch Lakes 34, 35, and 36 (Figure 3–26), were sampled annually for total uranium. This monitoring was conducted to measure the effects of groundwater and surface water discharges from the Site on the quality of downstream surface water.

The results for the Chemical Plant surface water sampling are presented in Table 3–36 along with the recent 3 year high for each location for comparison. Uranium levels at the off-site surface water locations for 2006 were similar to 2005 averages. The uranium levels at Busch Lake 34 continue to be elevated compared to the remainder of the locations; however, 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. These results are consistent with data from previous years.

Table 3–36. Average Concentrations of Total Uranium (pCi/L) at Weldon Spring Chemical Plant Area Surface Water Locations

Location	Uranium	Recent 3 Year High[a]
SW-2004 (Lake 34)	8.9	7.2
SW-2005 (Lake 36)	3.2	3.9
SW-2012 (Lake 35)	4.1	3.7
SW-2016 (Dardenne)	1.6	1.4
SW-2024 (Schote)	1.6	2.1

[a]2003−2005

3.2.2 Quarry Surface Water

Four locations within Femme Osage Slough were monitored semiannually to assess the water quality in the slough and potential impact of groundwater from north of the slough. Occasionally, groundwater north of the slough will discharge into the slough when the water table is high. These sampling sites, shown on Figure 3–28, are located in the upper section of the slough, which is adjacent to the area of groundwater impact. The 2006 semiannual uranium concentrations for the Quarry surface water locations are summarized in Table 3–37. Samples were not collected during the second half of the year except at the location SW-1004 because the slough did not contain water.

Table 3–37. Semiannual Results for Total Uranium (pCi/L) at Weldon Spring Quarry Surface Water Locations

Location	1st Semiannual	2nd Semiannual	Average	Recent 3 Year High[a]
SW-1003	26.9	NS	26.9	33.1
SW-1004	47.5	135	91.3	36.4
SW-1005	20.5	NS	20.5	25.6
SW-1010	18.3	NS	18.3	24.9

[a]2003−2005
NS = Not Sampled (slough was dry).

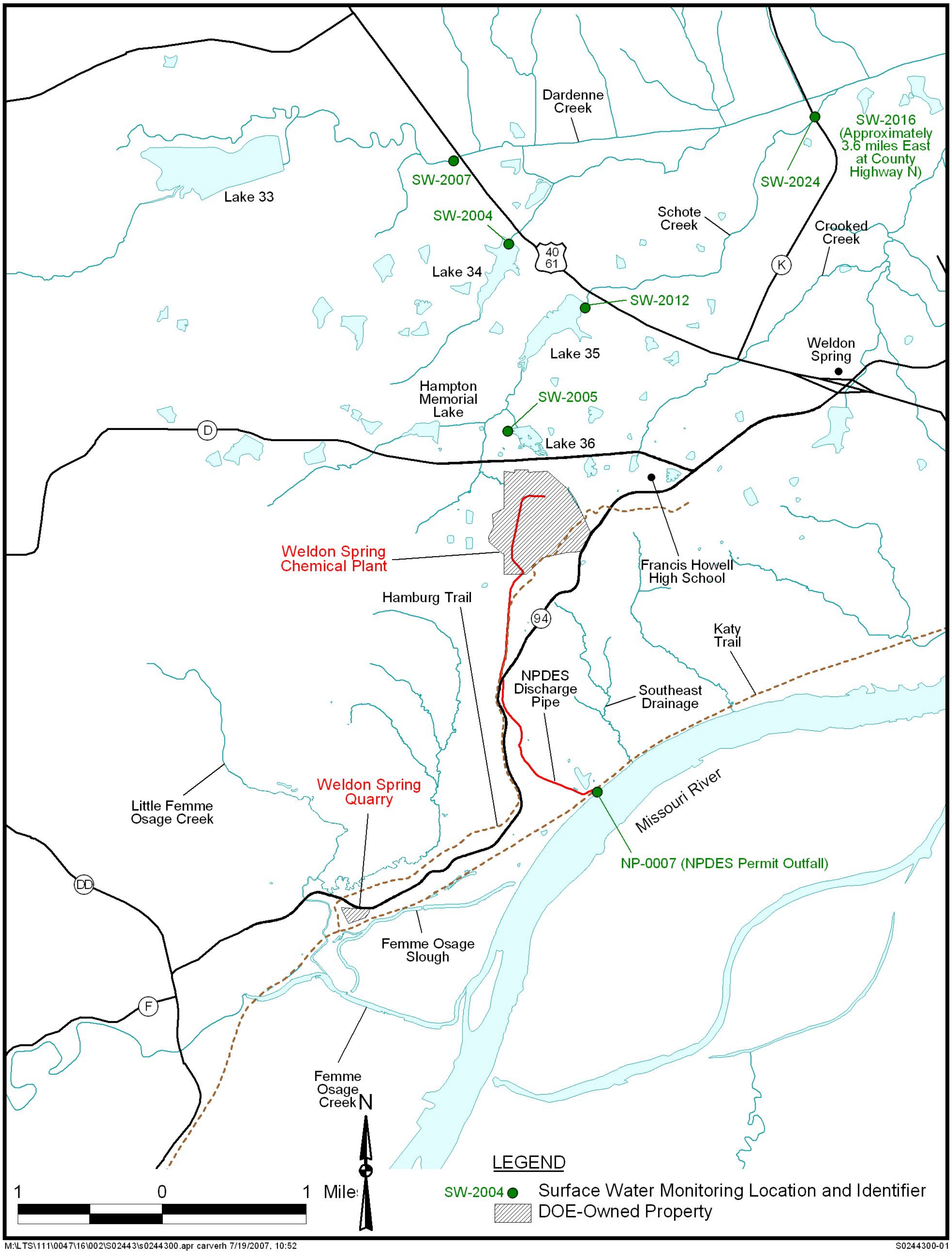

Figure 3–26. Surface Water Monitoring Locations at the Chemical Plant Area of the Weldon Spring, Missouri, Site

Uranium levels over time in the slough have generally been stable (Figure 3–27). During 2006, an elevated level of uranium was reported at location SW-1004. This sample was collected from an area that has occasionally had elevated uranium levels. This portion of the slough has a more direct connection to the impacted groundwater north of the slough, but typically during periods of high water levels. A value of 135 pCi/L was reported at this location for the November sampling event. The slough was dry; however, a small pool of water approximately 3 to 4 inches deep was present in the area. This sample does not represent what the actual surface water quality would be if the slough had not been dry. The specific conductance value for this sample was 2,023 micromhos per centimeter, which is approximately 4 to 5 times the value generally reported for water from the slough under normal conditions. This high specific conductance value indicates the presence of higher than typical dissolved solids and colloids which may have lead to the elevated dissolved uranium value. It is documented that uranium is transported by adhering to colloids, rather than being dissolved in the water. Low levels of uranium are present in the sediments in the bottom of the slough. When the sample was preserved by using acid, the uranium was stripped from the colloids and became part of the dissolved phase, leading to the elevated reading for this sampling event.

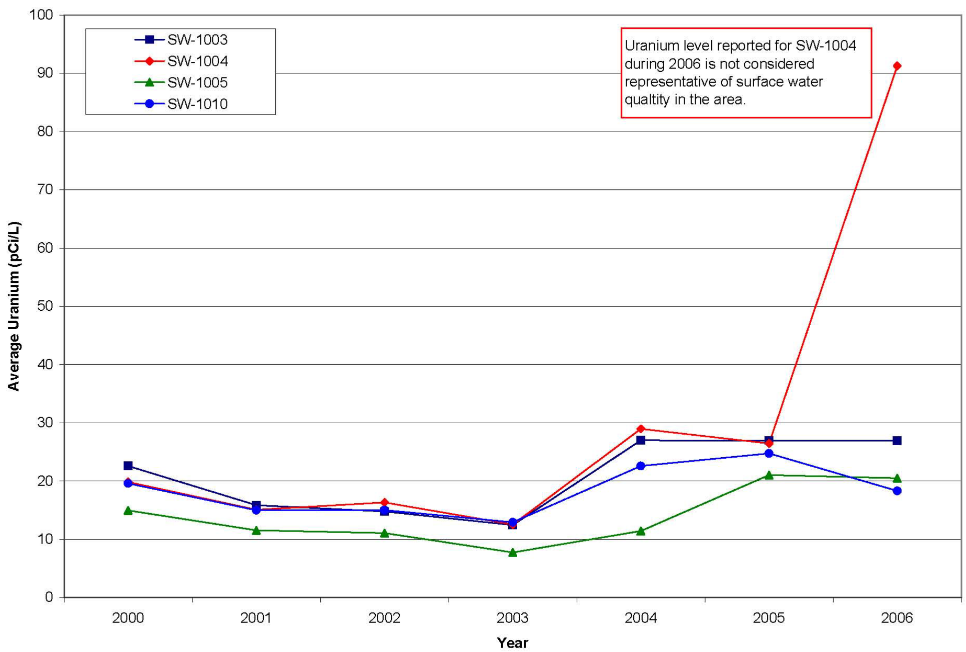

Figure 3–27. Uranium Levels in the Slough

3.3 Leachate Collection and Removal System

The LCRS collects leachate from the disposal cell. The leachate continued to be sampled in accordance with the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (DOE 2004b). The leachate analytical data for 2006 were discussed previously in Section 3.1.3.2 and are shown in Table 3–35.

As needed, the leachate is pumped from the sump, pretreated and then transported to MSD for final treatment in their Bissell Point plant wastewater treatment facility. A sample of leachate is collected and analyzed in accordance with MSD requirements for each hauling event. MSD requirements for the leachate are discussed in Section 2.1.3.3.

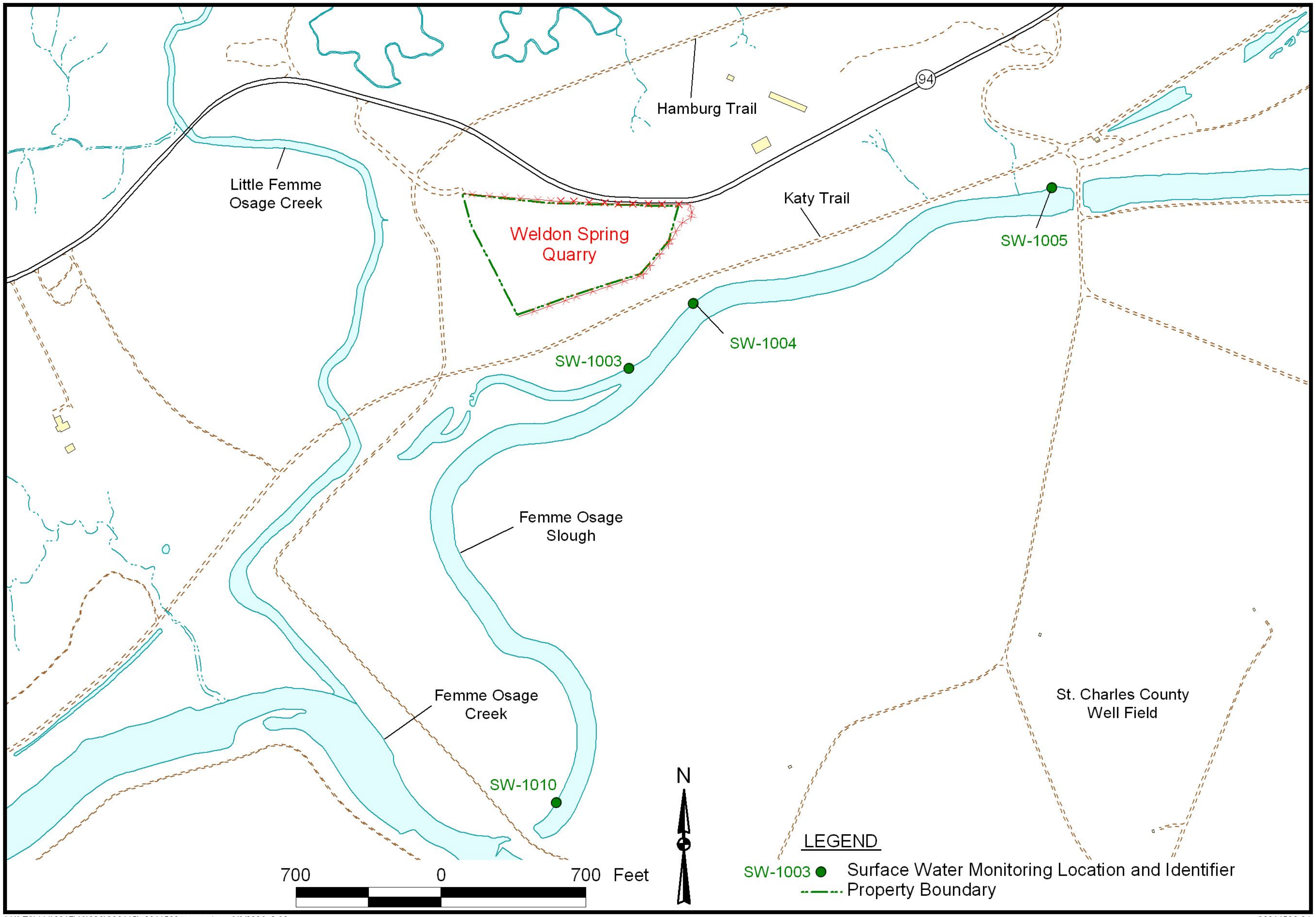

Figure 3–28. Surface Water Monitoring Locations at the Quarry Area of the Weldon Spring, Missouri, Site

Uranium concentrations in untreated leachate during 2006 averaged approximately 20 pCi/L. The concentration data were similar to the comparable data from 2005, as uranium levels remained near 20 pCi/L. The actual uranium concentrations in the untreated leachate are shown in Figure 3–29.

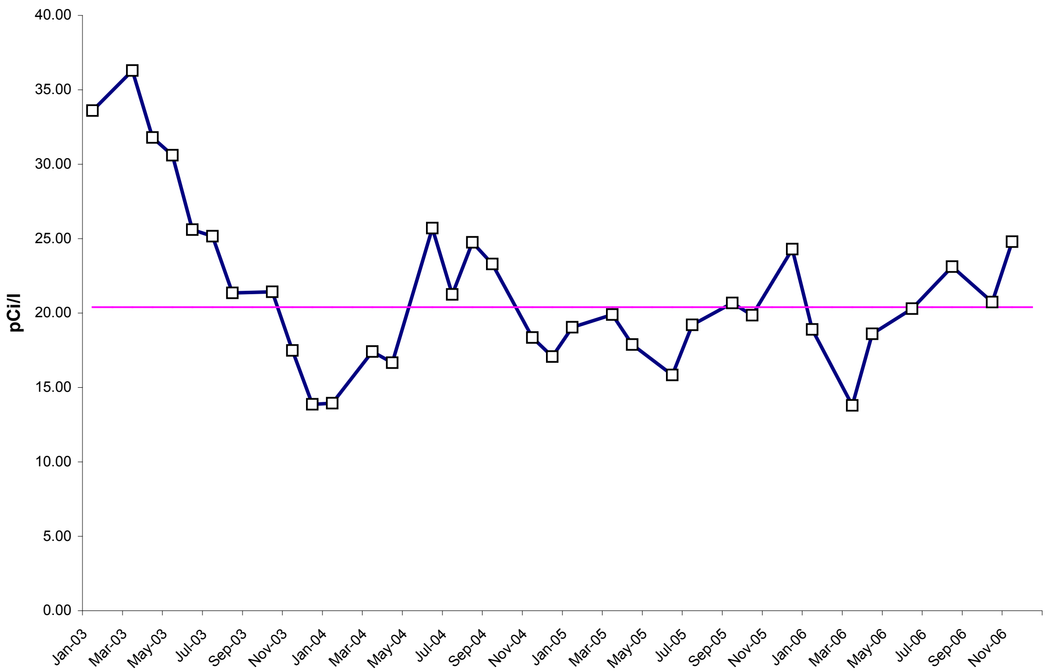

Figure 3–29. Average Uranium Concentrations in the Primary Leachate

Monitoring of leachate flow rates at the disposal cell and inspections of the LCRS continue to be performed biweekly. The measurement of the leachate levels was recorded on a data logger and was downloaded at least once per month. The regulations in 40 CFR 264.303(c) only require monthly recording and, if stable, quarterly flow recording thereafter. Leachate flow rates are reported in units of gallons per day and compared to the action leakage rate of 100 gallons/acre/day established for the secondary (or lower) leachate collection system.

During 2005 and 2006, discharge from the primary leachate collection system generated approximately 155 gallons per day and 135 gallons per day, respectively. The daily averages for the primary leachate flow rate are shown in Figure 3–30. The combined leachate flow rate from the secondary leachate collection system averaged approximately 13.6 gallons per day during 2005 and 12.0 gallons per day in 2006. On a per-acre basis, the average leakage rate for the secondary leachate collection system between 2005 and 2006 was approximately 0.57 and 0.50 gallons/acre/day. This rate continues to be significantly less than 1 percent of the action leakage rate of 100 gallons/acre/day.

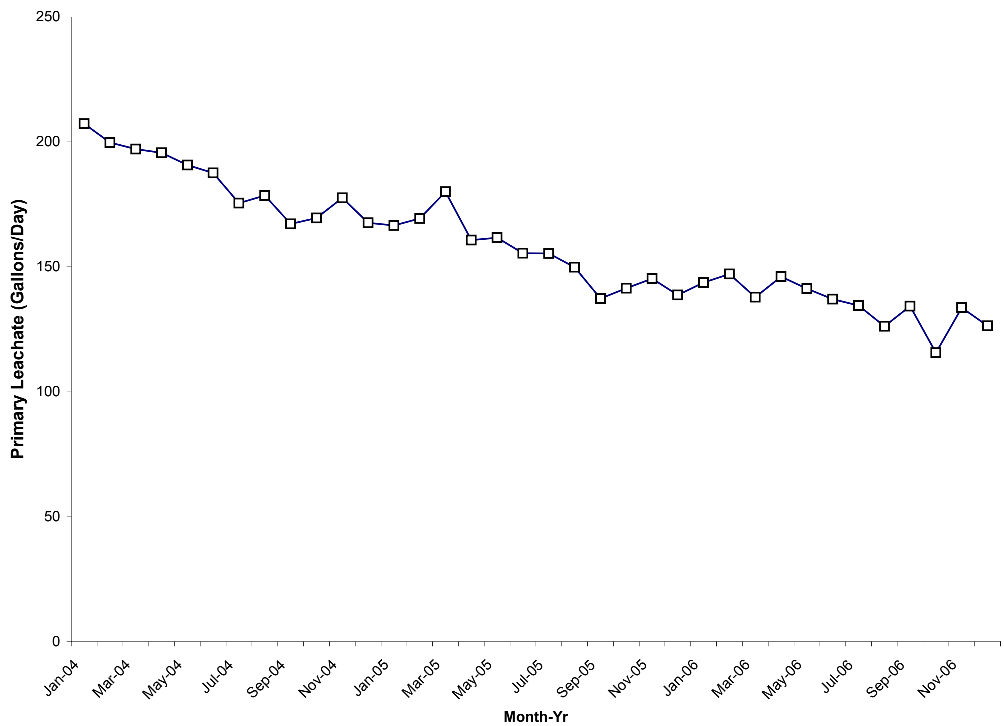

Figure 3–30. Daily Averages of the Primary Leachate Flow

3.4 Air

In the past, the WSSRAP operated an extensive environmental airborne monitoring and surveillance program in accordance with DOE orders, EPA and National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations, and the WSSRAP *Environmental Monitoring Plan* (DOE 2003a). 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. The potential for airborne release of radionuclides was eliminated with the final disposition of contaminated materials in the permanent disposal cell. With the completion of most Site activities, no air monitoring has been conducted since 2001 (DOE 2001a).

3.5 Radiation Dose Analysis

This section evaluates the potential effects of remaining surface water and groundwater discharges of radiological contaminants from the Weldon Spring Site in 2006. Effective dose equivalent has been calculated for 2006 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 potential exposure in terms of dose to an individual who consumes spring water contaminated with uranium is calculated. This calculation represents that exposure for the reasonable maximally exposed (RME) individual since data from the spring with the highest uranium concentration is used (i.e., for Burgermeister Spring with a reported uranium concentration of 78.5 pCi/L for 2005). The estimated total effective dose equivalent (TEDE) to this RME is about 0.17 mrem (1.7 E-3 mSv). This result is compared to DOE limits contained in DOE Order 5400.5 to demonstrate compliance with regulatory requirements.

3.5.1 Pathway Analysis and Exposure Scenario

In developing specific elements of the Weldon Spring Site environmental monitoring program, potential exposure pathways and health effects of the radioactive and chemical materials present on site are evaluated to determine if potential pathways of exposure exist. Under current Site conditions, the only potential pathway to consider is that of a recreational visitor to the Weldon Spring Conservation Area possibly coming into contact with spring water specifically at Burgermeister Spring. A dose calculation for a population within 80 km (49.6 miles) of the Site is not estimated since airborne release of radioactive contaminants is not a factor.

Consumption of contaminated groundwater both at the Chemical Plant/former Raffinate Pits and the Quarry areas is not a pathway of concern under current conditions as no drinking water wells are located in the vicinity of the contaminated groundwater in the Chemical Plant and raffinate pits area, and there is no access to the impacted groundwater at the Quarry area. Concentrations of uranium in the production wells near the Weldon Spring Quarry are comparable to background concentrations.

The inhalation of airborne particulates, radon gas, and external gamma irradiation pathways are also no longer pathways of concern since the contaminated soils and other materials have been remediated and placed in the on-site cell. Hence, these pathways were not included in the dose estimates for 2006.

The radiological public dose guideline contained in DOE Order 5400.5 is applicable for comparing potential doses at the Weldon Spring Site. This guideline provides for an annual limit of 100 mrem (1 mSv) total effective dose equivalent accounting for all exposure pathways (excluding background).

3.5.2 Dose Equivalent Estimates

TEDE estimate for the exposure scenario was calculated using 2006 environmental monitoring data. The dose is well below the standards set by DOE for annual public exposure.

This section discusses the estimated total effective dose equivalent to a hypothetical individual assumed to frequent Burgermeister Spring of the Weldon Spring Conservation Area. No private residences are adjacent to Burgermeister Spring, which is situated on land currently managed by MDC. Therefore, the calculation of dose equivalent is based on a recreational user of the Conservation Area who drank from Burgermeister Spring 20 times per year during 2006.

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

- The maximally exposed individual drank one cup (0.2 liter [L]) of water from the Spring 20 times per year (equivalent to 1.05 gallons (4.0 L) of water for the year).
- The maximum uranium concentration in water samples taken from spring locations during 2006 was found at Burgermeister Spring (78.5 pCi/L). This concentration was assumed to be present in all of the water ingested by the maximally exposed individual

On the basis of the following natural uranium activity ratios: U-234: 49.1%, U-235: 2.3%, and U-238: 48.6%, the dose conversion factors (DCFs) for ingestion for U-238 and U-234 were used for calculating the dose. These DCFs are 2.69E-4 mrem/pCi and 2.83E-4 for U-238 and U-234, respectively (Eckerman 1988).

The TEDE is calculated as shown below:

TEDE (ingestion of contaminated water for uranium) = Concentration (pCi/L) × Volume of Water Ingested (l) × DCF (U-238 + U-234) (mrem/pCi)

TEDE (total uranium) = 78.5 pCi/L × 4L × (2.69 E-4 mrem/pCi + 2.83E-4 mrem/pCi) = 0.17 mrem (1.7 E-3mSv)

This value represents less than 0.17 percent 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) (Beir 1990).

4.0 Environmental Quality

4.1 Highlights of the Quality Assurance Program

Quality assurance for sampling activities for 2006 followed the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (DOE 2006).

- Average relative percent differences calculated for groundwater, surface water, and springs were calculated.
- Trip and equipment blanks were assessed and summarized.
- The data validation program accepted 99.3 percent of the all data in 2006 (including field data).

4.2 Program Overview

The environmental quality assurance program includes management of the plans and procedures governing environmental monitoring activities at the Weldon Spring Site and at the subcontracted off-site laboratories. This section discusses the environmental monitoring standards at the Weldon Spring Site and the goals for these programs, plans, and procedures.

The environmental quality assurance program provides the Weldon Spring Site 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; use of quality control samples; complete documentation of field activities and laboratory analyses; and review of data documentation for precision, accuracy, and completeness (Data Validation).

The *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (DOE 2006) summarizes the data quality requirements for collecting and analyzing environmental data. The LTS&M Plan (DOE 2005a) lists the sampling locations and provides site-specific detail for quality control samples. These plans describe administrative procedures for managing environmental data, data validation, database administration, and data archiving.

Analytical data are received from subcontracted analytical laboratories. Uncensored data have been used in reporting and calculations of annual averages (when available). Uncensored data are data that do not represent a non-detect and instead report instrument responses that quantitative to values below the reported detection limit. When there was no instrument response, non-detect data were used in calculations of averages at a value of one-half the detection limit.

4.2.1 Applicable Standards

Applicable standards for environmental quality assurance include: (1) use of the approved 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.

4.2.2 Analytical and Field Measurement Methodologies

Analytical and field measurement methodologies used at the Weldon Spring Site comply with applicable standards required by DOE, EPA, and the American Public Health Association. Analytical methodologies used by subcontracted laboratories for environmental monitoring primarily follow the EPA SW-846 requirements and the EPA drinking water and radiochemical methodologies or methods that are reviewed prior to analysis. Field measurement methodologies typically follow the American Public Health Association *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association 1992).

4.3 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. Descriptions of the quality control samples collected at the Weldon Spring Site are detailed in Table 4–1.

Table 4–1. Quality Control Sample Description

Type of Quality Control Sample	Description
Equipment Rinsate Blank	Monitors the effectiveness of decontamination procedures used on non-dedicated sampling equipment. Equipment blanks include rinsate and filter blanks.
Trip Blank	Monitors volatile organic compounds that may be introduced during transportation or handling at the laboratory. Trip blanks are collected in the Weldon Spring Site laboratory with distilled water.
Field Duplicate	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.
Matrix Spike[a]	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[a]	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[a]	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.

[a]A laboratory sample is split from the parent sample.

4.3.1 Quality Control Sample Results

The quality control program is assessed by analyzing quality control sample results and comparing them to actual samples using the following methodology.

4.3.2 Duplicate Results Evaluation

Field duplicate analyses were evaluated in 2006. The matrix duplicate analyses were performed at subcontracted laboratories from aliquots of original samples collected at the Weldon Spring Site and are not summarized in this document. Matrix duplicates were used to assess the precision of analyses and also to aid in evaluating the homogeneity of samples or analytical interference of sample matrixes. Matrix duplicates were assessed during data validation process for each sample group.

Generally, field duplicate samples were analyzed for the same parameters as the original samples and are collected at the rate of approximately one for every 20 samples. Twenty field duplicates were collected in 2006 from 279 locations sampled (7.2 percent). Typically, duplicate samples were analyzed for more common parameters (e.g., uranium, inorganic anions, and metals).

When field duplicate samples were available, the average relative percent difference (RPD) was calculated. This difference represents an estimate of precision. The equation used was:

$$RPD = |S-D| /((S+D) /2) \times 100 \text{ percent}$$

Where: S = concentration in the normal sample
D = concentration in the duplicate analysis

Table 4–2 summarizes the calculated RPD for field duplicate samples for groundwater, springs, and surface water matrices. Parameters that were not commonly analyzed for and/or were not contaminants of concern were not evaluated. The RPD was calculated only for samples whose analytical results exceeded five times the detection limit and did not have any quality control problems, (i.e., blank contamination).

Table 4–2. Summary of Calculated Relative Percent Differences

Parameter	Number of Samples	Avg. RPD
Uranium	11	5.7
Iron	7	7.5
Barium	2	0.4
Nitrate-N	4	3.1
Chloride	2	1.3
Sulfate	10	5.3
Flouride	2	15.0
Total Dissolved Solids	2	0.5
Trichloroethene	3	3.6
Nitroaromatics	18	7.1

The results in Table 4–2 demonstrate that average RPDs calculated were within the 20 percent criterion. Several individual parameters exceeded the 20 percent criteria and were assessed in the data validation reports. As a result, the average field duplicate sample analyses in 2006 were of acceptable quality.

4.4 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 (trip blanks).
- Effectiveness of the decontamination procedure for sampling equipment used to collect samples (equipment blanks).

Sections 4.4.1 through 4.4.2 discuss the sample blank analyses and the potential impact of blank contamination upon the associated samples.

4.4.1 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 2006, 11 trip blanks were analyzed for volatile organic compounds. No compounds were detected in nine trip blanks and two trip blanks detected acetone, toluene, 1,2-dichloropropane, and 2-butanone above the detection limit; however, these compounds are common laboratory contaminants and not COCs at Weldon Spring. All environmental samples associated with these trip blank samples were evaluated and it was determined that the samples were not impacted.

4.4.2 Equipment Blank Evaluation

Equipment blanks are samples that are collected by rinsing decontaminated equipment with distilled water. The collected rinse water is then analyzed for COCs. This procedure is used to determine the effectiveness of the decontamination process. At the Weldon Spring Site, most of the groundwater samples are collected from dedicated equipment (e.g., pumps, dedicated bailers), and spring water is collected by placing the sample directly into a sample container. Therefore, no equipment blanks are required for groundwater or spring locations.

Surface water is collected using a dip cup or similar container. An equipment blank (rinsate) is collected to assess the cleanliness of the equipment. Two equipment rinsate blanks were collected in 2006 to assess the dip cups used for surface water sampling. Samples were analyzed for only total uranium. Uranium was not detected in either blank and therefore there is no concern of cross contamination in the dip cups in 2006.

4.5 Data Validation Program Summary

The data validation program at the Weldon Spring Site follows the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (DOE 2006). This program involves reviewing and qualifying 100 percent 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 4–3 identifies the number of quarterly and total data points that were validated in 2006, and indicates the percentage of those selected that were complete. Data points in this table include all sample types including field parameters.

Table 4–3. Validation Summary for Calendar Year 2006

Calendar Quarter	No. of Data Points Validated	No. of Validated Data Points Rejected	Completeness[a]
Quarter 1	1166	0	100
Quarter 2	1393	0	100
Quarter 3	471	7	98.5
Quarter 4	1641	26	98.4
2006 Total	4671	33	99.3

[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 4–4 identifies validation qualifiers assigned to the selected data points as a result of data validation. The Weldon Spring Site validation technical review was performed in accordance with the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (DOE 2006). For calendar year 2006, 100 percent of data validation has been completed. Data points in this table include groundwater, leachate, surface water, and spring water samples.

Table 4–4. Validation Qualifier Summary for Calendar Year 2006

Number of Data Points									
	Field	Anions	Metals	Misc.	Nitro-Aromatics	Radio-Chemical	Semi-Volatiles	Volatiles	Total
Accepted	1550	249	602	46	1240	101	400	450	4638
Rejected	0	1	10	8	14	0	0	0	33
Not Validatable	0	0	0	0	0	0	0	0	0
Total	1550	250	612	54	1254	101	400	450	4671
Percentages									
Accepted	100%	99.6%	98.4%	85.2%	98.9%	100%	100%	100%	99.3%
Rejected	0%	0.4%	1.6%	14.8%	1.1%	0%	0%	0%	0.7%
Not Validatable	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

End of current text

5.0 Long-Term Surveillance and Maintenance

The Site has entered the LTS&M phase of the project in many aspects. The status of these different aspects and activities which took place during 2006 is discussed in this section of the report.

5.1 Long-Term Surveillance and Maintenance Plan

The LTS&M Plan (DOE 2005a) took several years to develop. It was issued for several rounds of regulator and stakeholder review and comments and several public meetings/workshops were held on the development of this plan. The final LTS&M Plan was issued in July 2005. Minor revisions to the plan were issued as an appendix to the 2005 Annual Site Environmental Report. It is planned to issue a revised LTS&M Plan for review in late 2007.

5.2 Institutional Controls

The LTS&M Plan (DOE 2005a) includes Section 3 *Institutional Controls Implementation Plan for the Weldon Spring Site* which summarizes information pertinent to the implementation of ICs to meet the objectives of the use restrictions described in the Explanation of Significant Differences (ESD) (DOE 2005b) issued in February 2005. Section 3 of the LTS&M Plan includes current Site conditions and the risk-basis for why restrictions are needed, the objectives of the use restrictions, specific ICs already in place and additional mechanisms identified for implementation. The schedule, which is included in the LTS&M Plan, and the status for implementing the additional ICs is discussed below.

1) Special Area Designation Under the State Well Drillers' Act—DOE will submit a package that proposes special area designation to MDNR within 4 months of the effective date of this plan.

   Status: DOE and its contractor traveled to Kansas City, Missouri, and met with the U.S. Army Corps of Engineers and the 89th Readiness Reserves (Army) on September 15, 2005, to coordinate a request for special area designation for the overlapping contaminated groundwater areas from both sites. Both parties collaborated on a combined presentation for the Missouri Well Installation Board at their regularly scheduled meeting on November 4, 2005, at Springfield, Missouri.

   DOE and its contractor participated in a meeting with the Army and MDNR on October 18, 2005, at Rolla, Missouri, to discuss the presentation for the Missouri Well Installation Board.

   DOE and the Army made their presentation to the Missouri Well Installation Board at their regularly scheduled meeting of November 4, 2005. The presentation consisted of the history and background for the two sites and a request for a Special Area Designation for the groundwater restricted areas.

   An informational meeting was held on December 13, 2005, at the Weldon Spring Site by MDNR to present information to the public regarding the Special Use Area Designation for the DOE and Army sites and to receive feedback from stakeholders and the general public.

On February 20, 2006, DOE and the Army attended to regularly scheduled meeting of the Missouri Well Installation Board in Lake Ozark, Missouri, answering specific questions from the Board. The Board decided on certain elements of the proposal, including the size and shape of the Special Area and the method of imposing the restrictions via advance consultation between the drillers and MDNR. The Board thus decided to proceed with rulemaking process, but did not vote on the action at this meeting. Instead, they directed MDNR staff to prepare a revised draft rule based on the meeting discussions and to present it for a vote at their next meeting.

On May 19, 2006, DOE and the Army attended the regularly scheduled meeting of the Board at the Weldon Spring Site. The location had been selected by the Board to facilitate participation from the local community, as well as to provide an opportunity for Board members to gain knowledge of the Weldon Spring Site and visit the proposed restriction areas. The Board voted at this meeting and passed the draft regulation as prepared by MNDR Staff.

A draft of the rule was published in the Missouri Register on February 15, 2007, for a 30-day review period. The final rule was published by reference in the July 2, 2007, Missouri Register stating the rule would become effective 30 days after publication.

2) Memorandum of Understanding (MOU) with the Army—DOE will submit a draft updated (or revised) MOU to the Army for review and comment within 6 months of the effective date of this plan.

Status: DOE met with Army representatives on September 15, 2005, to discuss the updated MOU. DOE delivered a draft of the new MOU to the Army in January 2006, and copied MDNR and EPA. Minor changes were suggested by MDNR and were made by DOE. The Army had several changes to the U.S. Army Corps of Engineers project manager during 2006. Since the new MOU contains both “access” and “restrictive use” provisions, it must be approved by both the land owner, the 89th Regional Readiness Command, and the U.S. Army Corps of Engineers as the remedial action controlling agency. Until the new MOU is approved, the existing MOU, together with the existing land use on the Army property, provide a measure of control that is sufficient for current needs to monitor groundwater and prevent groundwater use.

3) Easements—DOE will submit proposed easements to the state agencies within 8 months of the effective date of this LTS&M Plan.

Status: DOE issued initial letters, dated October 12, 2005, to the surrounding state agency property owners in order to reinitiate discussions regarding the proposed easements. DOE through its realty section and its interagency agreement with the U.S. Army Corps of Engineers (Omaha Office) sent a draft easement and offer letter to MDC in May 2006. The letters were issued to MDNR-Parks and MoDOT in September 2006. DOE received a response from MDNR-Parks dated May 10, 2007.

5.3 Interpretive Center

5.3.1 Interpretive Center Operations

The Weldon Spring Site Interpretive Center is part of DOE’s LTS&M activities at the Weldon Spring Site. The purpose of this facility is to inform the public of Site history, remedial action activities, and final conditions. The center provides information about the long-term surveillance and maintenance program for the Site, provides access to surveillance and maintenance information, and supports community involvement activities.

Current exhibits in the Interpretive Center present:

- The history of the towns that once occupied this area.
- A timeline of significant events at the Weldon Spring Site from 1900 to the present.
- The legacy of the Weldon Spring Ordnance Plant and Uranium Feed Material Plant and the manufacturing wastes.
- The events and community efforts to cleanup the Site and the people that made it happen.
- The multi-faceted phases of the Weldon Spring Site Remedial Action Project.

These exhibits may be changed as appropriate to changing conditions or emerging issues at and near the Site. The hours of operation at the Interpretive Center are posted at the Site. The current hours of operation are Monday through Friday: 9:00 a.m. to 5:00 p.m., Saturday: 10:00 a.m. to 4:00 p.m. (10:00 a.m. to 2 p.m. November 1 – March 31), and Sunday: 12:00 p.m. to 4:00 p.m. The Interpretive Center is closed on holidays.

Attendance is tracked through the following types of public activities:

- Individuals that walk in the Interpretive Center from the street during normal hours of operation.
- Scheduled groups that participate in Interpretive Center educational programs.
- Community-based organizations that utilize the Paul T. Mydler meeting room to conduct business meetings.
- Scheduled groups unable to visit the Site but are recipients of Interpretive Center outreach presentations.

A significant number of individuals also make use of Site amenities (e.g., Hamburg Trail, disposal cell perimeter road for prairie viewing, disposal cell viewing platform, native plant garden), however, because this use does not involve entering the Interpretive Center and is often outside of normal hours of operation, it is not consistently tracked. It is estimated that between 5,000 and 15,000 individuals per year make use of Site amenities in this way.

Attendance at the Interpretive Center in 2006 was 16,722 (Table 5–1) and was similar to 2005 numbers. There continues to be significant interest from the K-12 educational community in Center programs. Field trips are usually scheduled several months in advance and available calendar dates fill up quickly. At times, this requires reservations to be made for the following school year. For a few school districts that have limited funding for field trips, outreach activities are scheduled and Center staff gives educational presentations at the school. Outreach activities usually involve several classes or the entire grade level of students.

Table 5–1. Interpretive Center Attendance

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002								301	224	190	40	31	786
2003	6	44	44	85	174	191	161	233	251	350	125	122	1,786
2004	52	61	166	182	104	324	192	353	379	850	556	354	3,573
2005	123	605	1056	2048	1888	1408	1370	1091	1511	1663	1739	903	15,405
2006	542	1136	1595	1874	1685	1226	1465	1431	1176	2215	1735	692	16,772
													38,322

Interpretive Center marketing efforts continue to be a critical component for communication of Center programs to the general public. For 2006, additional marketing of Site amenities has been focused on community-based organizations. This has resulted in a steady increase in the use of the Paul T. Mydler meeting room by these groups.

5.3.2 Special Events

On April 12, 2006, a celebration organized by MDNR was held at the Center to highlight a number of events including the opening of the Hamburg Trail. Representatives from state and federal agencies including MDNR, MDC, DOE, and EPA spoke at the event. Many other local agency representatives, stakeholders, and members of the public participated in the festivities.

5.3.3 Howell Prairie and Garden

The 150 acres surrounding the disposal cell has been planted with over 80 species of native prairie grasses and wildflowers. Plants such as Prairie Blazing Star, Little Bluestem, and Wild Bergamot will once again dominate this area which was a large native prairie prior to European settlement. Howell Prairie is one of the largest planting of its kind in the St. Louis metropolitan area.

A variety of prairie maintenance activities have been completed throughout 2006. Prescribed burning was performed in select portions of the prairie in March. Conventional burning techniques were utilized in the disposal cell drainage outlet areas due to their higher fuel load. Because fuel load was limited in other areas, an alternative burning technique utilizing an agricultural alfalfa burner was employed. Although limited in scope, this burning will act to limit annual weed growth, return nutrients to the soil, and mimic natural processes in general.

Control of noxious weeds such as *Sericea lespedeza* and *Robinia pseudoacacia* continued this season. Individual plants were spot-sprayed with herbicide as part of on-going efforts to reduce numbers and control encroachment of these species throughout the prairie area.

Overseeding in select areas of the prairie utilizing seeds harvested from the native plant garden was performed by volunteers in December 2006.

A garden that consists entirely of plants native to the state of Missouri was designed and planted during 2004. The Native Plant Educational Garden contains extensive planting of species from Howell Prairie as well as other perennials, shrubs, and trees. Walking paths, benches, and markers to identify the various plants are located through the 8-acre garden. Garden maintenance consisting of manual weeding, occasional irrigation, and mulching was performed throughout the growing season. In October and November 2006, dried seed heads from forbs were harvested from the garden to be utilized for hand overseeding on the prairie area of the Site. An increasing number of volunteers performed garden maintenance activities throughout 2006.

The Howell Prairie, Native Plant Educational Garden, and Interpretive Center were designed to serve as ICs. These areas will attract visitors to the Weldon Spring Site, thus ensuring long-term community education about the remediation project and enhancing the overall educational mission of the Site.

5.4 Inspections

The annual LTS&M inspection took place at the Weldon Spring Site on December 5 and 6, 2006. Due to ice and snow conditions at the Site during the inspection, inspection of the disposal cell transects and rock plots was postponed until December 15, 2006. Other inspection items completed on December 15 were additional erosion inspection, inspection of the buffer zone survey monuments, and re-inspection of the repaired survey monument at the Army Property. The inspection was conducted in accordance with the *Long-Term Surveillance and Maintenance Plan for the Weldon Spring, Missouri, Site* (DOE 2005a), and associated inspection checklist. Representatives from EPA and MDNR participated in the inspection. Representatives from the Weldon Spring Citizens Commission and MDC participated in portions of the inspection.

The main areas inspected at the Site were areas where future ICs will be established, the quarry, the disposal cell, LCRS, monitoring wells, and assorted general features.

The IC areas were inspected to ensure that pending restrictions such as excavating soil, groundwater withdrawal, residential use, etc., were not being violated. Each area was inspected and no indications of violations of future restrictions were observed.

The disposal cell was inspected by walking ten transects over the cell and around the cell perimeter at the grade break and the base. Hand-held global positioning system (GPS) equipment was used to navigate the ten transects. Five areas of the cell which had been marked and located by GPS survey equipment during the 2003 annual inspection were located and observed for any signs of rock degradation. The LCRS also was inspected and found to be in good condition. Forty-eight of the 119 groundwater monitoring wells were inspected and found to be in good condition. Other Site features including the prairie, site markers, and roads also were inspected. The inspection also included contacting stakeholders and IC contacts.

The third annual public meeting required by the LTS&M Plan (DOE 2005a) was held on April 11, 2006. This meeting was held to discuss the 2005 inspection which took place in November 2005. Also discussed were changes to the LTS&M Plan, a summary of environmental data and the interpretive center/prairie. The fourth annual public meeting to discuss the 2006 inspection was held on March 22, 2007.

End of current text

6.0 References

40 CFR 61, Subpart H. U.S. Environmental Protection Agency, "National Emission Standards for Emissions of Radionuclides other than Radon From Department of Energy Facilities," *Code of Federal Regulations,* July 1, 2005.

40 CFR 141. U.S. Environmental Protection Agency, "National Primary Drinking Water Regulations," *Code of Federal Regulations,* July 1, 2005.

40 CFR 192. U.S. Environmental Protection Agency, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," *Code of Federal Regulations,* July 1, 2005.

40 CFR 264. U.S. Environmental Protection Agency, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations,* July 1, 2005.

10 CSR 20-7.031. Missouri *Code of State Regulations,* Title 10, "Department of Natural Resources," Division 20, "Clean Water Commission," Chapter 7.031, "Water Quality Standards."

10 CSR 25-7.264. Missouri *Code of State Regulations,* Title 10, "Department of Natural Resources," Division 25, "Hazardous Waste Management Commission," Chapter 7.264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities."

DOE Orders: 231.1A *Environmental, Safety, and Health Reporting*
5400.5, *Radiation Protection of the Public and the Environment*

American Public Health Association, 1992. *Standard Methods for the Examination of Water and Wastewater*, 18 ed., American Public Health Association, American Water Works Association, Water Environment Federation. Washington, D.C.

Beir V. 1990. *Health Effects of Exposure to Low Levels of Ionizing Radiation.* National Research Council. Committed on the Biological Effects of Ionizing Radiations Board on Radiation Effects Research, Commission on Life Sciences. Published by National Academy Press. Washington, DC.

DOE (U.S. Department of Energy), 1989. *Remedial Investigation for Quarry Bulk Wastes.* Rev. 1., DOE/OR/21548-066. U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, December.

DOE (U.S. Department of Energy), 1990a. *Feasibility Study for Management of the Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri.* DOE/OR/21548-104. U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, February.

DOE (U.S. Department of Energy), 1990b. *Record of Decision for the Management of the Bulk Wastes at the Weldon Spring Q*uarry. DOE/OR/21548-317. U.S. Department of Energy Oak

Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, September.

DOE (U.S. Department of Energy), 1992a. *Remedial Investigation for the Chemical Plant area of the Weldon Spring Sites*. Rev. 0., DOE/OR/21548-074. U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, November.

DOE (U.S. Department of Energy), 1992b. *Agricultural Sampling Plan*, Rev. 1., DOE/OR/21548-229. U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, December.

DOE (U.S. Department of Energy), 1993. *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site,* OE/OR/21548-376, U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, September.

DOE (U.S. Department of Energy), 1996. *Engineering Evaluation/Cost Analysis for the Proposed Removal Action at the Southeast Drainage near the Weldon Spring Site, Weldon Spring, Missouri,* DOE/OR/21548-584, U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, August.

DOE (U.S. Department of Energy), 1997. *Remedial Investigation for the Groundwater Operable Units at the Chemical Plant Area and the Ordnance Works Area, Weldon Spring, Missouri,* DOE/OR/21548–571, U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, July.

DOE (U.S. Department of Energy), 1998a. *Remedial Investigation for the Quarry Residuals Operable Unit of the Weldon Spring Site, Weldon Spring, Missouri,* DOE/OR/21548–587, U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, February.

DOE (U.S. Department of Energy), 1998b. *Record of Decision for the Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site, Weldon Spring, Missouri,* DOE/OR/21548–725, U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, September.

DOE (U.S. Department of Energy), 1999a. *Long-Term Surveillance and Maintenance Program Plan,* GJO-99-93-TAR, U.S. Department of Energy Grand Junction Office, Grand Junction, Colorado, June.

DOE (U.S. Department of Energy), 1999b. *Southeast Drainage Closeout Report Vicinity Properties DA4 and MDC7*, Rev. 0, DOE/OR/21548-772. U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, September.

DOE (U.S. Department of Energy), 1999c. *Technical Guidance for the Long-Term Monitoring of Natural Attenuation Remedies at Department of Energy Sites*, October.

DOE (U.S. Department of Energy), 2000a. *Remedial Design/Remedial Action Work Plan for the Quarry Residuals Operable Unit*, DOE/OR/21548-787, U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, January.

DOE (U.S. Department of Energy), 2000b. *Interim Record of Decision for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site,* DOE/OR/21548-798, U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, September.

DOE (U.S. Department of Energy), 2001a. *Completion Report for Radon Flux Monitoring of the WSSRAP Disposal Facility,* DOE/OR/21548-876, U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, January.

DOE (U.S. Department of Energy), 2001b. Weldon Spring Site Environmental Report for Calendar Year 2000. DOE/OR/21548-886. U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, July.

DOE (U.S. Department of Energy), 2003a. *Environmental Monitoring Plan*, Rev. 11, DOE/OR/21548–424, U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, January.

DOE (U.S. Department of Energy), 2003b. Quarry Residuals Operable Unit Remedial Action Report , DOE/OR/21548–927, U.S. Department of Energy Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, November.

DOE (U.S. Department of Energy), 2003c. *Groundwater and Surface Water Sampling and Analysis Plan for GJO Projects,* GJO-2003-402-TAC (GJO–GWADM 19.1-1), Revision 6, U.S. Department of Energy Grand Junction Office, Grand Junction, Colorado, December.

DOE (U.S. Department of Energy), 2004a. *Chemical Plant Operable Unit Remedial Action Report*, DOE/GJ/79491−909, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, January.

DOE (U.S. Department of Energy), 2004b. *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan.* Rev 2., DOE/GJ/79491-646. Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, March.

DOE (U.S. Department of Energy), 2004c. *Remedial Design/Remedial Action Work Plan for the Final Remedial Action for the Groundwater Operable Unit at the Weldon Spring Site*, DOE/GJ/79491−943, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, July.

DOE (U.S. Department of Energy), 2004d. *Institutional Controls Evaluation (ICE) Report: Summary of Supporting Information for the Identification and Evaluation of Institutional*

Controls for the Weldon Spring Site. U.S. Department of Energy Office of Legacy Management, October.

DOE (U.S. Department of Energy), 2004e. *Weldon Spring Site Environmental Report for Calendar Year 2003.* U.S. Department of Energy Office of Legacy Management, DOE/GJ/79491-944.

DOE (U.S. Department of Energy), 2004f. *Record of Decision for the Final Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site*, DOE/GJ/79491−936a, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, January.

DOE (U.S. Department of Energy), 2005a. *Long-Term Surveillance and Maintenance Plan for the U.S. Department of Energy Weldon Spring, Missouri Site*. DOE-LM/GJ885-2005, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, July.

DOE (U.S. Department of Energy), 2005b. *Explanation of Significant Differences, Weldon Spring Site*. U.S. Department of Energy Office of Legacy Management, February.

DOE (U.S. Department of Energy), 2005c. *Weldon Spring Site Cell Groundwater Monitoring Demonstration Report for the December 2004 Sampling Event,* DOE-LM/GJ893-2005, U.S. Department of Energy Office of Legacy Management, May.

DOE (U.S. Department of Energy), 2005d. *Interim Remedial Action Report for the Groundwater Operable Unit of the Weldon Spring Site,* DOE/GJ/79491-952, U.S. Department of Energy Office of Legacy Management, February.

DOE (U.S. Department of Energy), 2006. *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites,* DOE-LM/GJ1197-2007, U.S. Department of Energy Office of Legacy Management, May.

Eckerman, K.F., A.B. Wolbarst, and A.C.B. Richardson, 1988. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, Federal Guidance Report No. 11. Prepared for U.S. Environmental Protection Agency, by Oak Ridge National Laboratory. Oak Ridge, Tennessee, September.

EPA (U.S. Environmental Protection Agency) Contract Laboratory Program, 1994. *Statement of Work for Organics Analysis,* Document Number OLMO3.1, August.

EPA (U.S. Environmental Protection Agency), *Statement of Work for Inorganics Analysis: Multi-Media, Multi-Concentration*, Document Number ILMO1.0, No Date.

EPA (U.S. Environmental Protection Agency), 1999. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, OSWER 9200.4-178, April.

Kleeschulte, M.J., L.F. Emmett, and J.H. Barks, 1986. *Hydrologic Data for the Weldon Spring Radioactive Waste-Disposal Sites, St. Charles, County, Missouri – 1984-1986*, U.S. Geologic Survey Open-File Report 86-488, Rolla, Missouri.

Ruffner, J.A., and F.E. Bair. Weather of U.S. Cities, City Reports, Alabama – Missouri, Volume 1, 3rd ed., Gale Research Company, Detroit, Michigan.

End of current text