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WELDON SPRING SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1991

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

JULY 1992 REV. 1

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

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Weldon Spring Site Remedial Action Project

EXECUTIVE SUMMARY
for the
Weldon Spring Site Environmental Report
for Calendar Year 1991

Revision 1

July 1992

Prepared by

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and
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for the

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

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EXECUTIVE SUMMARY

The *Weldon Spring Site Environmental Report for Calendar Year 1991* is the sixth in a series of annual reports produced by the Weldon Spring Site Remedial Action Project (WSSRAP) since 1986. It reports the results of a comprehensive, year-round program to monitor the impact of the Weldon Spring site (WSS) on the surrounding region's groundwater and surface waters; air quality; vegetation and wildlife; and, through these multiple pathways, the potential for exposure to receptor human populations. Information is also presented on the environmental monitoring quality assurance program, waste management activities, audits and reviews, and special environmental studies.

Data are included for both the Weldon Spring Chemical Plant and raffinate pits and the Weldon Spring Quarry. Based on the consistent exercise of quality assurance in both standard operating procedures and quality control sample collection, the WSSRAP asserts that the data presented in the *WSS Environmental Report for Calendar Year 1991* accurately reflect the environmental conditions monitored at the WSS. This report presents narratives, summaries, and conclusions on environmental monitoring at the WSS and surrounding vicinity properties for the entire 1991 monitoring year. During 1991 the WSSRAP also published quarterly data reports, wherein all routine monitoring data were tabulated and presented quarterly to allow the public to review the data in a timely fashion prior to issuance of the annual report.

SCOPE AND PURPOSE

While the annual report documents environmental conditions, effluents, emissions, and monitoring results, its ultimate concern is with potential impacts to human health and the environment. To this end, contaminant levels are reported both in absolute terms and in relation to discharge limits established by State and Federal regulatory bodies according to existing national guidelines and standards designed to protect human health and the environment.

The WSSRAP monitoring program provides a thorough and systematic ongoing assessment to ensure compliance with State and Federal regulations. The environmental data also provide a yardstick for measuring improvement in environmental conditions resulting from remedial actions.

The environmental management programs at the WSSRAP ensure that environmental releases from the site are at levels demonstrably and consistently "as low as reasonably achievable". This is being done concurrently with site remediation and contaminant clean-up through the course of the U.S. Environmental Protection Agency's (EPA) environmental documentation process under the Comprehensive Environmental Response Compensation, and Liability Act (CERCLA).

Therefore, the effluent and environmental monitoring program must (1) serve as an effective early indicator that detects and provides the data required to assess potentially adverse discharges and impacts, and (2) provide for continuing, regular verification of compliance with applicable State and Federal permits and regulations.

Routine monitoring for radiation, radioactive materials, and chemical substances on and off the WSS is an important tool to document compliance with appropriate standards, and to identify undesirable trends. Additionally, the monitoring programs provide information to the public in the St. Charles and St. Louis, Missouri areas, and contribute to the general scientific database of knowledge on the environmental effects of radiological and chemical substances.

MONITORING NETWORKS

The data reported in the *Environmental Report for Calendar Year 1991* have been collected from a growing complex of monitoring stations and a routine sampling program supplemented by the following:

- An air monitoring network of 22 stations located within and on the perimeters of the two operable remedial units of the site, and at critical receptor locations around the WSS.

- Six National Pollutant Discharge Elimination System (NPDES) locations and over 25 surface water sampling locations.

- Twenty-two locations for measuring external gamma radiation.

- Groundwater monitoring networks consisting of over 100 groundwater monitoring wells and piezometers.

- Dozens of soil and ground surface scanning locations for potential direct contact exposure.

- An on-site meteorological monitoring station.

REGULATORY COMPLIANCE

The WSSRAP is subject to meeting or exceeding the regulatory requirements of Federal, State, and local laws and statutes. Therefore, the WSSRAP maintains a compliance staff to monitor the progress and status of the project relative to environmental laws.

The major accomplishment under CERCLA during 1991 included the *Record of Decision for the Management of Bulk Waste at the Weldon Spring Quarry* (ANL 1990a) which was signed by the DOE on March 7, 1991. Several old and new compliance issues were identified, including the application of the Resource Conservation Recovery Act (RCRA) to residues on tanks and piping systems and storage prohibitions under both RCRA and Toxic Substance Control Act (TSCA).

Other compliance activities at the WSSRAP during 1991 include construction projects to support CERCLA remediation of the WSS. These construction activities include construction of two water treatment plants (for the quarry and the chemical plant), a temporary storage area, and a material staging area.

SUMMARY AND CONCLUSIONS:

In 1991, the WSSRAP continued to adhere to its mission of environmental protection and site remediation. The U.S. Department of Energy (DOE) is pursuing the WSSRAP as a coordinated effort among the DOE, the EPA, the Missouri Department of Natural Resources (MDNR), and others.

Comprehensive environmental monitoring data for 1991 show that emissions of radiological contamination from the WSS were approximately equal to the 1990 monitoring year. Groundwater and surface water pathways were monitored and data indicate no measurable impact to any drinking water sources from WSS contaminants.

The calculated total radiation dose to a hypothetical maximally exposed individual from the WSCP/WSRP was 0.07 mrem (7E-4 mSv). The calculated total radiation dose from the WSQ to a maximally exposed individual was 1.9 mrem (.019 mSv). The calculated total radiation dose to a hypothetical maximally exposed individual for the vicinity properties was 0.5 mrem (5E-3 mSv). The calculated total radiation dose to a maximally exposed individual via all exposure pathways (i.e., inhalation, ingestion, external gamma) was 2.4 mrem (0.024 mSv). This represents the maximum contribution by sources from all site properties.

The collective dose equivalent estimate for 1991 is 0.069 person-rem for an estimated exposed population of 61,840 persons. Section 4 of the report describes the assessment of collective population dose.

Additional investigations are underway to further characterize environmental conditions and contaminant distributions; these investigations will support planning for the next stage of remedial action. Waste consolidation and water treatment plant construction are examples of the efforts undertaken.

Total costs associated with the environmental and remedial activities at the WSS for 1991 were approximately $29.5 million. Remedial action at the WSS is presently slated to continue until the year 2001.

The 1991 environmental report pays particular attention to the following areas of health and environmental concern: Airborne discharges of radionuclides and air particulates; waterborne discharges and surface water monitoring; external gamma exposure levels; meteorological measurements and potential chemical and radiation exposures to the surrounding public and public-use areas. Key results by sampling program are highlighted below.

Groundwater

Groundwater at the WSSRAP is monitored at least semiannually for total natural uranium, nitroaromatic compounds, and inorganic anions in all monitoring wells at the Weldon Spring Chemical Plant/raffinate pits/vicinity properties (WSCP/RP/VP) and at the Weldon Spring Quarry (WSQ). The groundwater monitoring network for the WSCP/RP/VP area consists of 65 monitoring wells. The monitoring network at the WSQ consists of 36 DOE monitoring wells, four St. Charles County monitoring wells, eight St. Charles County production wells, and the St. Charles County Water Treatment Plant.

Overall, the 1991 groundwater analytical results for samples at the WSCP/RP/VP and the WSQ are consistent with previous monitoring. Trend analyses of available historical data from monitoring wells continue to suggest an upward trend in uranium concentrations in six wells between the WSQ and the Femme Osage Slough. The groundwater south of the slough and in the wellfield remains within the range of background, with no indication of an upward trend in either the DOE or the St. Charles County monitoring wells. Of the trends evident in the uranium concentration data from the WSCP/RP area, all are very slight and most are indicative of slightly decreasing concentrations.

Surface Water

During 1991, surface water and spring monitoring involved the collection of samples for radiological and chemical parameters from a total of 35 locations. Radiological parameters included uranium, thorium, and radium. Chemical parameters included nitrate, sulfate, and nitroaromatic compounds. All results were near or within their historical range of values. The results indicate that uranium continues to migrate from the site at relatively low levels in surface water and springs along known discharge pathways. The derived concentration guideline (DCG) for natural uranium was not exceeded based upon monthly measurements at the NPDES outfalls.

Effluent Monitoring (NPDES)

Surface water effluents from the WSS during 1991 were primarily due to precipitation runoff. The WSSRAP maintains discharge permits under the NPDES. During 1991, the permit at the WSCP applied to one sanitary discharge point and five stormwater discharge points or outfalls. The five monitored outfalls that discharge precipitation runoff are subject to "monitoring only" requirements under the permit. The sixth outfall (administration building's treated sanitary effluent) is subject to specific discharge limits.

The sanitary wastewater outfall was monitored for comparison to effluent limitations for biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform, and pH. NPDES permit levels were exceeded seven times in 1991 at this outfall. Operational adjustments and repairs to the treatment plant were performed by the operating subcontractor and levels returned to within the range of the permitted limits. The planned addition of a flow equalization tank should make operation easier and allow the effluent to meet permit limits in a more consistant manner.

Gamma Radiation Monitoring

To monitor exposure from gamma radiation, 22 permanent monitoring stations using spherical environmental thermoluminescent dosimeters (TLDs) were utilized. Monitoring stations are located at the WSCP, WSRP, WSQ and at off-site locations. None of the monitoring stations around the WSCP, the WSRP, or at the off-site locations detected gamma radiation levels above background, at a 95% confidence level. Two of the six stations around the quarry were statistically greater than background levels, although the measured exposure rate was less than the DOE guideline of 100 mrem/yr (1 mSv/yr) above background levels.

Radon Gas Monitoring

The radon gas monitoring program at the WSSRAP utilizes two radon gas detectors (track etch cups) at each of 22 permanent locations. These detectors are situated at the same locations as the above referenced gamma TLDs. The WSSRAP has concluded that none of the stations at the WSCP, the WSRP, or at off-site areas measured above background levels.

The results for the WSQ did indicate measurable levels above background. These measurable levels are due to the higher radium concentrations within the quarry, the contours of the terrain within and around the quarry, and the effects of those contours on wind direction within the quarry. The concentrations released were below the DOE guideline of 3 pCi/l (111 Bq/m^3) annual average above background.

The implementation of a continuous radon monitoring program in mid-summer of 1991 allowed continuous monitoring of radon concentrations and random fluctuations in the environment. The five stations were located at the WSCP, the WSRP, the WSQ, the Francis Howell High School, and August A. Busch Wildlife Area (background). Continous monitoring results also indicated that the concentrations measured at each location were below the DOE guideline of 3 pCi/l (111 Bq/m^3) annual average above background.

Radioactive Air Particulates

Eleven samplers are utilized to monitor the gross alpha concentrations of radioactive air particulates at the WSCP, the WSRP, the WSQ, and at off site locations. The WSSRAP has concluded that no measurable levels of radioactive air particulates were detected above background levels at any of these stations.

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ABSTRACT

The Weldon Spring Site Remedial Action Project (WSSRAP) environmental monitoring program provides a thorough and systematic ongoing assessment to ensure compliance with State and Federal regulations. The environmental data also provide a yardstick for measuring improvement in environmental conditions resulting from remedial actions.

The data reported in the *Environmental Report for Calendar Year 1991* have been collected from a growing complex of monitoring stations and a routine sampling program supplemented by the following:

- An air monitoring network of 22 stations located within and on the perimeters of the two operable remedial units of the site, and at critical receptor locations around the Weldon Spring site (WSS).
- Six National Pollutant Discharge Elimination System (NPDES) locations and over 25 surface water sampling locations.
- 22 locations for measuring external gamma radiation.
- Groundwater monitoring networks consisting of over 100 groundwater monitoring wells and piezometers.

Comprehensive environmental monitoring data for 1991 show that emissions of radiological contamination from the WSS were approximately equal to the 1990 monitoring year. Groundwater and surface water pathways were monitored and data indicate no measurable impact to any drinking water sources from WSS contaminants. The calculated total radiation dose to a maximally exposed individual via all exposure pathways (i.e., inhalation, ingestion, external gamma) was 2.4 mrem (0.024 mSv).

The collective dose equivalent estimate for 1991 is 0.069 person-rem for an estimated exposed population of 61,840 persons. Trend analyses of available historical data from monitoring wells continue to suggest an upward trend in uranium concentrations in six wells between the WSQ and the Femme Osage Slough. The groundwater south of the slough and the wellfield remains within the range of background, with no indication of an upward trend in either the U.S. Department of Energy (DOE) or the St. Charles County monitoring wells. All results for radiological and chemical surface water parameters were near or within their historical range of values. The results indicate that uranium continues to migrate from the site at relatively low levels in surface water and springs along known discharge pathways.

The WSSRAP maintains a compliance staff to monitor the progress and status of the project relative to environmental laws.

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1 INTRODUCTION

This report presents the findings of the environmental monitoring program conducted at the Weldon Spring site (WSS) in 1991. The report presents a summary of environmental data, discusses compliance with environmental standards, and highlights significant programs and efforts undertaken at the WSS. Annual environmental monitoring reports have been prepared for this site (or portions thereof) since 1981. The WSS is part of the U.S. Department of Energy (DOE) Environmental Restoration Program, one of the remedial action programs under the direction of the Office of Environmental Restoration and Waste Management. The WSS is comprised of the Weldon Spring raffinate pits (WSRP), the Weldon Spring Chemical Plant (WSCP), and the Weldon Spring Quarry (WSQ). These areas encompass 20.7, 67.2 and 3.6 ha (51, 166, and 9 acres), respectively. The WSRP and WSCP areas are contiguous. The WSQ is approximately 6.4 km (4 mi) to the south-southwest of the site.

When custody of the WSCP was transferred in 1985 from the U.S. Department of the Army (DA) to the DOE, the WSCP became part of the WSS. In conjunction with this transfer, the Weldon Spring Site Remedial Action Project (WSSRAP) was created as DOE Major Project Number 182 (DOE Order 4240.1E - May 14, 1985) and later designated as a Major System Acquisition as of May 4, 1988. Consistent with the DOE environmental restoration mission, the WSSRAP will eliminate potential hazards to the public and the environment and make surplus real property available for other uses.

DOE Order 5400.1, *General Environmental Protection Program* requires that an environmental radioactivity monitoring program be maintained at existing sites and, as determined on a case-by-case basis, at certain former sites to determine:

- Background levels and site contribution of radioactivity and other pollutants from DOE operations to the site environs.

- Compliance with applicable and appropriate environmental standards for radioactivity and other pollutants specified by the DOE and the U.S. Environmental Protection Agency (EPA).

- Compliance with environmental commitments in official documents such as environmental impact statements and Federal Facility Agreements (FFA).

- Confirmation of adherence to DOE environmental protection policies.

This DOE Order also requires a listing of environmental permits. Existing permits and compliance with those permits is discussed in Section 2 of this report.

This annual site *Environmental Report* is the DOE's vehicle for documenting the results of its extensive monitoring program at the WSSRAP. The report provides the public and concerned regulatory agencies with summary level discussions and supporting data regarding the routine environmental monitoring program. Further, the report indicates whether changes are occurring in contaminant distribution or contaminant source conditions on and around the site--changes which might equate to variations in potential exposure scenarios to the public or environmental receptors.

In addition to the routine environmental monitoring conducted in 1991, a number of related activities and special studies were performed. These activities and studies help assess the overall impact of site operations on the environment. The results of these activities are discussed in Section 9.

Section 4 presents calculations based on the 1991 sampling results, showing the maximum radiation dose to a hypothetical maximally exposed individual at the WSCP/WSRP and WSQ areas. Calculation of the doses to the general population in the vicinity of the WSS is also reported.

Appendix A contains individual data values for groundwater and surface water. Biological monitoring data are presented in Appendix B. Definitions of selected terms used in this reported are listed in Appendix C. Although each acronym used in this report is defined when it is first used in each main section, a list of all abbreviations and acronyms used is provided in Appendix D. Appendix E presents a discussion of the environmental guidelines that apply to the monitoring program. Appendix F provides a useful conversion table, Appendix G is Dose Assessment Calculations and Appendix H is the result of trend analysis on historical groundwater data. Appendix I contains figures which represent groundwater data. Appendix J is the distribution list for this report.

1.1 Location and Description

The WSS is located in St. Charles County, Missouri, about 48 km (30 mi) west of St. Louis. The WSRP and WSCP areas are reached from Missouri State Route 94, 3.2 km (2 mi) southwest of the junction of Route 94 and U.S. Route 40/61. The WSQ is also reached from Route 94, 6.4 km (4 mi) south-southwest of the WSRP and WSCP areas. The Missouri River is approximately 2.4 km (1.5 mi) southeast of the WSRP and WSCP areas and 1.6 km (1 mi) east of the WSQ. The Mississippi River lies approximately 22 km (14 mi) northeast of the WSRP and WSCP areas and roughly 29 km (18 mi) northeast of the WSQ. The general locations of these properties are illustrated in Figure 1-1.

Uranium and thorium residues, waste materials, and contaminated rubble are stored at the WSS. In addition to environmental monitoring, engineering activities are being conducted to minimize the migration of contaminants from these facilities into surface water, groundwater, and air.

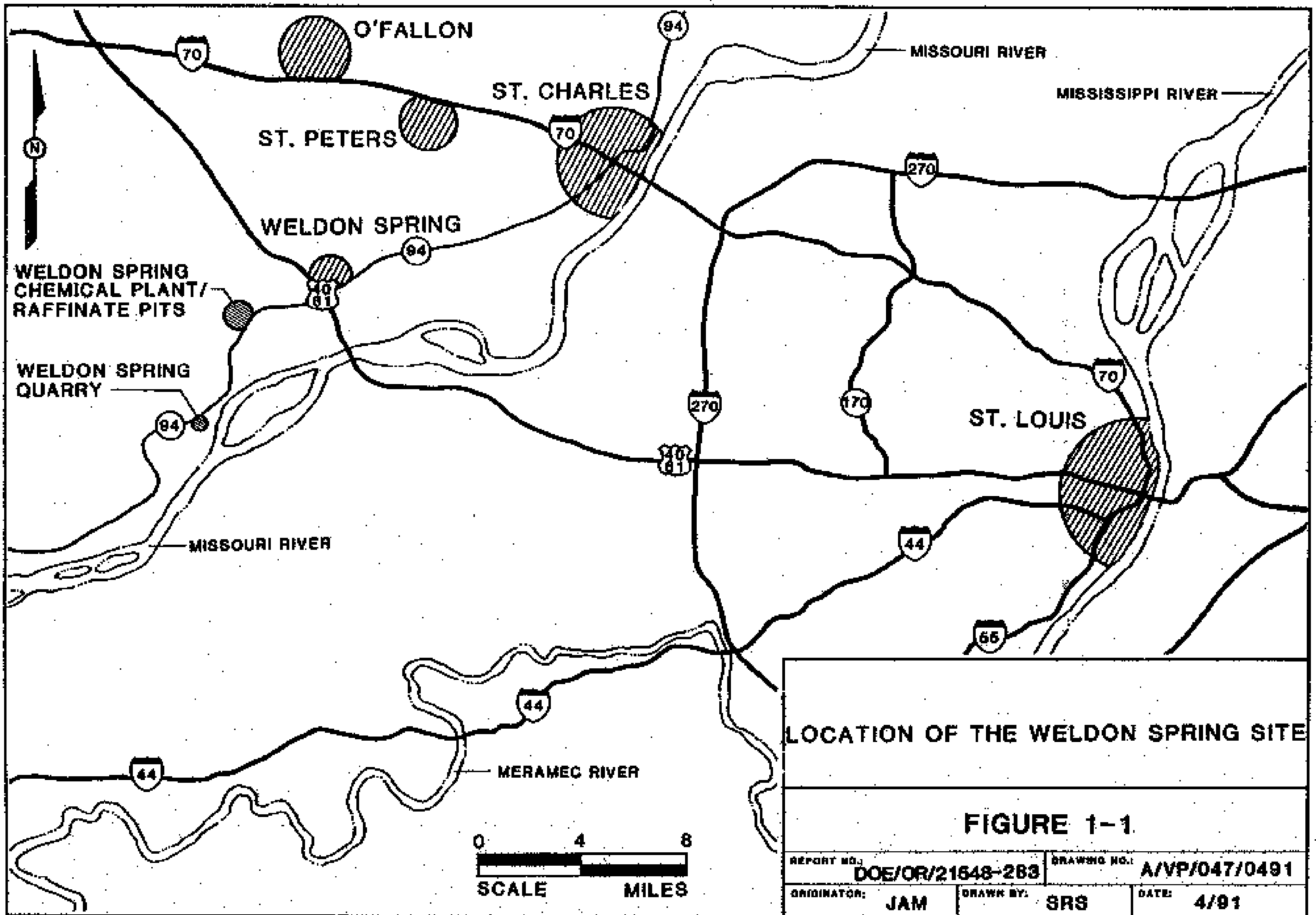
Additional characterization activities have been conducted at the WSCP and WSRP during 1991. These activities provide information on the types and magnitudes of the contamination.

Brief descriptions of each major area of the site are given below.

<u>Weldon Spring Raffinate Pits</u>

Figure 1-2 is map of the WSCP/WSRP area. The 20.7-ha (51-acre) area includes four pits that cover approximately 10.5 ha (26 acres). The raffinate pits were constructed by excavating into the existing clay soils and using the removed clay for construction of dikes. These pits contain radioactive residues (raffinates) from uranium and thorium processing operations at the former Weldon Spring Uranium Feed Materials Plant (WSUFMP) which is now the WSCP. It is estimated that the four raffinate pits hold a total of 2.15×10^8 liters (57,000,000 gal) of materials.

Access to the area is controlled by a 2.1-m (7-ft) high fence that encloses the DOE property. In addition, each pit is enclosed by a fence at least 1.3 m (4 ft) high. All drains and transfer lines from the pits to the WSCP process sewer have been sealed (Ficker 1981). During the 1991 monitoring year, surface water covered most of the residues in the pits.



LOCATION OF THE WELDON SPRING SITE

FIGURE 1-1

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Weldon Spring Chemical Plant

The 67.2-ha (166-acres) WSCP is located to the north and east of the WSRP area (Figure 1-2). The WSCP, which operated as the WSUFMP until 1966, contains 13 major buildings and 27 smaller buildings. Of the former, five were used as process buildings, and eight were major support buildings. The entire site is fenced. Access is controlled at a manned gate-house and site security continues to be maintained by guards periodically patrolling the site 24 hr/day.

The interiors of the eight major support buildings are heavily contaminated with uranium that is mostly "fixed" on surfaces. The rest of the buildings contain only small quantities of uranium contamination.

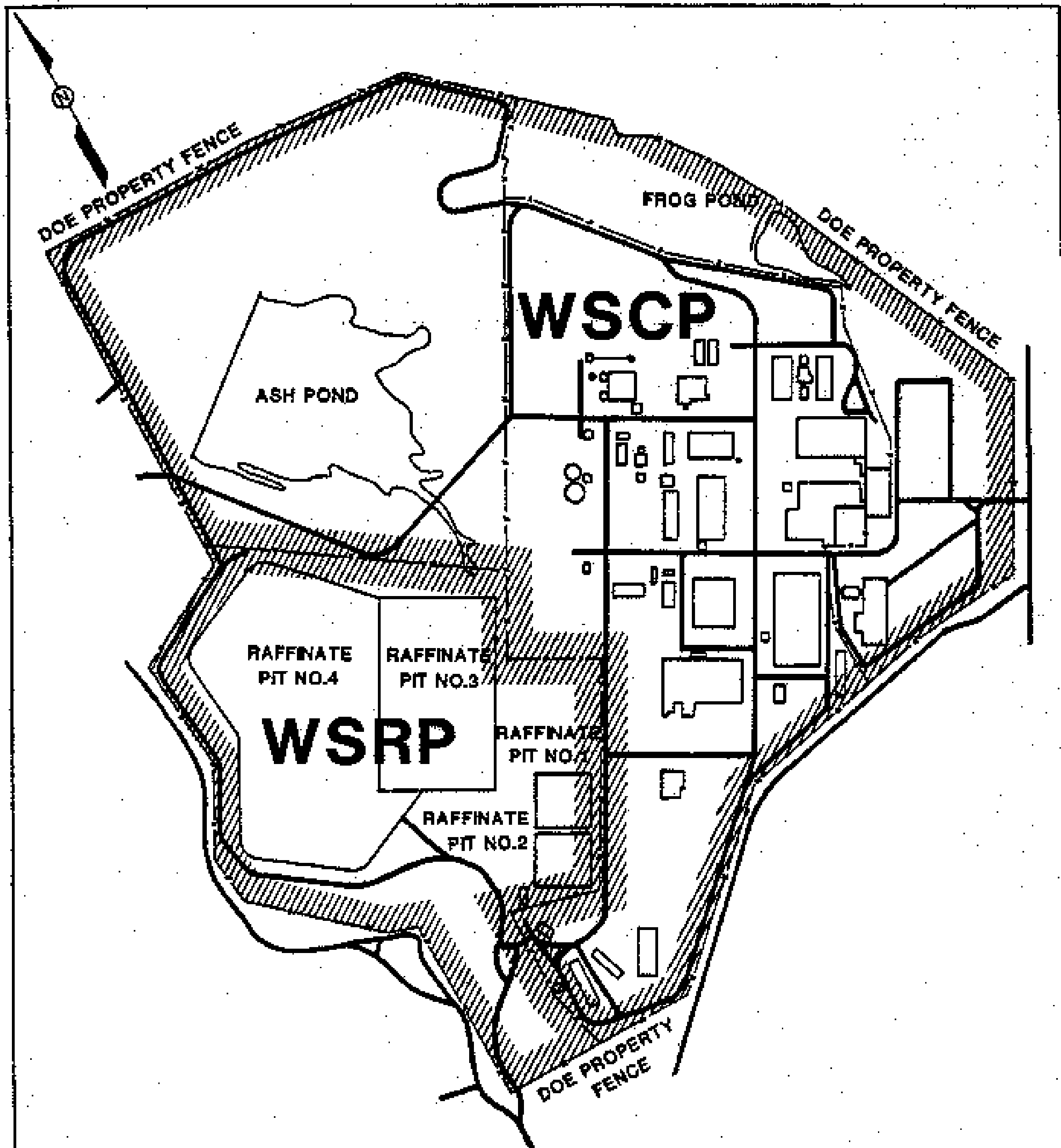
Surface water runoff from the WSCP drains primarily along three corridors. These include the natural drainageways leading to Ash Pond and Frog Pond, and the complex of tributaries which exits the site to the southeast. Surface water drains into these ponds and drainageways where it transports uranium off-site.

Chemically hazardous substances are also present both in the buildings and as contamination in the soil in several areas of the site. These substances include asbestos, polychlorinated biphenyls (PCBs), nitroaromatic compounds, ammonia, hydrofluoric acid, sulfuric acid, and nitric acid.

Weldon Spring Quarry

The WSQ, an abandoned 3.6-ha (9-acres) limestone quarry, is located approximately 6.4 km (4 mi) south-southwest of the WSRP/WSCP area. As shown in Figure 1-3, the WSQ is accessible at both the upper and lower levels from Missouri State Route 94. The WSQ is essentially a closed basin; surface water within the rim flows to the quarry floor and into a pond which covers approximately 0.2 ha (0.5 acres). The pond contains approximately 12 million liters (3 million gal) of water and is 6.1 m (20 ft) deep at its deepest point. The amount of water in the pond varies according to seasonal variations in precipitation and evaporation.

Construction continued throughout 1991 on the WSQ wastewater treatment plant that will be used to treat the contaminated water within the quarry pond and the influent



MAP OF THE
WELDON SPRING CHEMICAL PLANT AND
WELDON SPRING RAFFINATE PIT AREA

FIGURE 1-2

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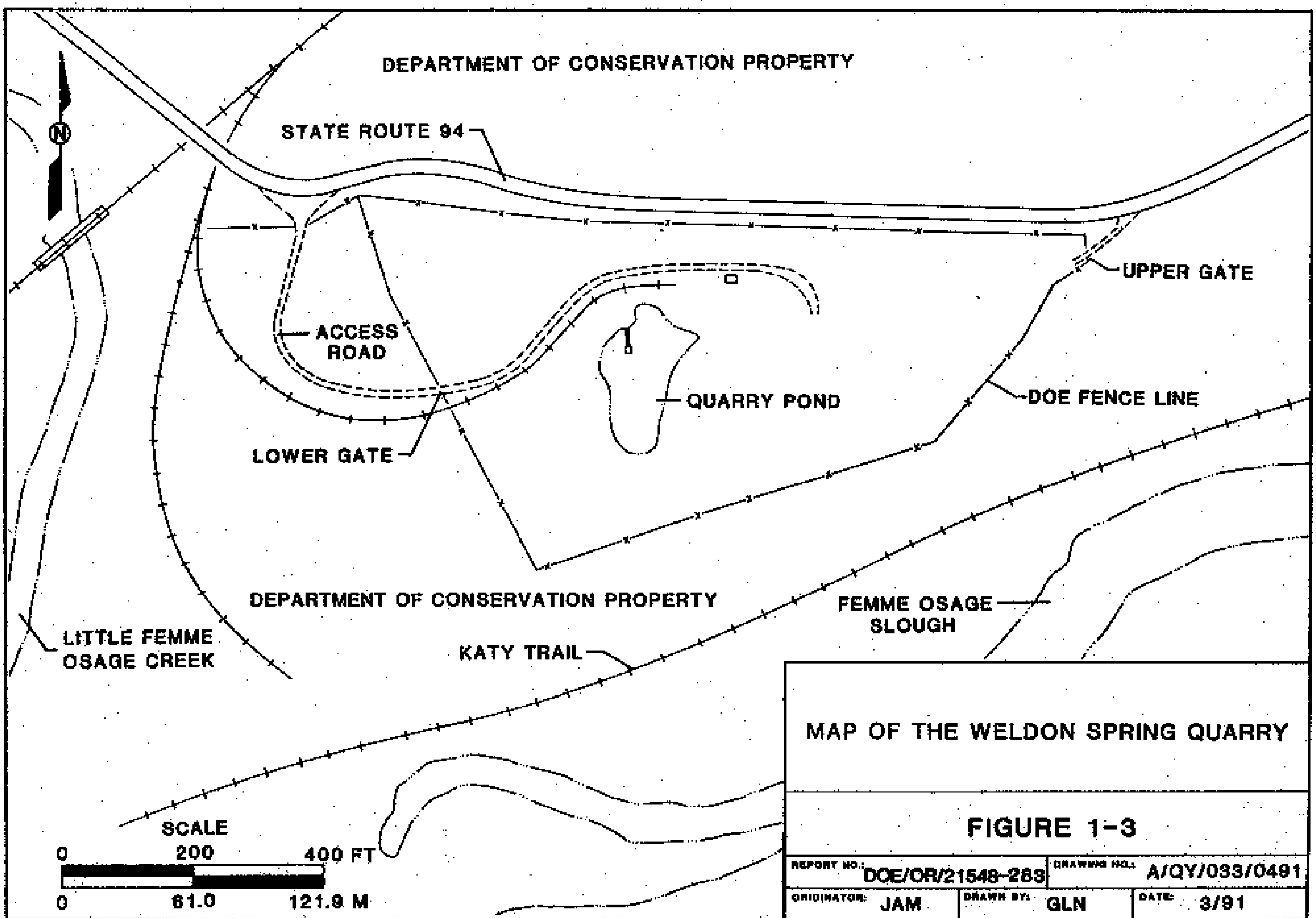

MAP OF THE WELDON SPRING QUARRY

FIGURE 1-3

REPORT NO.: DOE/OR/21548-283	DRAWING NO.: A/QY/033/0491	
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groundwater. Access to the site is restricted by a locked, 2.1-m (7-ft) high chain link fence. The amounts and types of wastes in the WSQ are summarized in the *Remedial Investigation Report for Quarry Bulk Wastes* (MKF and JEG 1989a).

1.2 Site History

In April 1941, the Department of the Army acquired 17,232 acres (6,974 ha) of land where, from November 1941 through January 1944, Atlas Powder company operated four of its 20 trinitrotoluene (TNT) and dinitrotoluene (DNT) explosives production lines as part of the facility known as the Weldon Spring Ordnance Works (WSOW). The remaining 16 production lines were distributed across an adjacent property which is now referred to as the US Army Reserve and National Guard Training Area (WSTA). By 1949, all but about 809 ha (2,000 acres) had been transferred to the State of Missouri (August A. Busch Wildlife Area) and to the University of Missouri (agricultural land). Except for several small parcels transferred to Saint Charles County, the remaining property became the WSTA.

Through a Memorandum of Understanding between the Secretary of the Army and the General Manager of the Atomic Energy Commission (AEC), 83 ha (205 acres) of the former ordnance works property were transferred in May 1955 to the AEC for construction of the Weldon Spring Uranium Feed Materials Plant. Considerable explosives decontamination was performed by Atlas Powder Company and the DA prior to WSUFMP construction. Until 1966, the WSUFMP was operated as an integrated facility for the conversion of 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 on the site property.

In 1958, the AEC acquired title to the limestone quarry (WSQ) from the DA. The quarry is located approximately 5.6 km (3.5 mi) south of the WSUFMP. The WSQ had been used since 1942 by the DA for the burning of wastes from the manufacture of TNT and DNT and the disposal of TNT-contaminated rubble during the operation of the WSOW. Prior to 1942, the WSQ was mined for limestone aggregate during construction of the WSOW. The AEC used the WSQ from 1963 to 1969 as a disposal area for uranium residues and a small amount of thorium residue. Most of the material disposed of there consisted of uranium and radium contaminated building ruble and soils from the demolition of a uranium ore processing facility in Saint Louis. Other radioactive materials include drummed wastes, uncontained wastes, and contaminated process equipment.

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

The WSS was placed in caretaker status from 1981 through 1985, when custody of the WSCP and WSQ was transferred from the DA to the Department of Energy. In 1985, the DOE proposed designating the control and decontamination of the WSRP, WSCP, and WSQ as a major project. Designation was effected by DOE Order 4240.1E dated May 14, 1985. A Project Management Contractor (PMC) for the Weldon Spring Site Remedial Action Project was selected in February 1986. In July 1986, a DOE project office was established on site, and the PMC, MK-Ferguson Company and Jacobs Engineering Group, Inc., assumed control of the WSS on October 1, 1986. The WSQ was placed on the Environmental Protection Agency's National Priorities List (NPL) in July 1987. The site was re-designated by DOE as a Major Acquisition System in May 1988. The WSCP and WSRP were added to the NPL in March 1989.

Remedial investigations were conducted at the WSCP/WSRP area in 1988 and 1989. These investigations included characterization of the groundwater, on-site soil contamination, contaminated sediments in off-site surface drainages and lakes, surface water, and springs; the chemical and radiological characteristics of the raffinate wastes; and other smaller scale efforts. The results of each of these investigations are presented in stand-alone documents on the respective efforts and are brought together and summarized in the RI report for the WSCP/WSRP, which is in the final stage of production following agency review.

Several small-scale actions have been conducted to mitigate or eliminate conditions that pose immediate or potential threats to worker safety, public health, or the environment. These have included removing exposed friable asbestos and overhead piping, PCB electrical equipment, power poles and wires; and nonprocess-building demolition; Ash Pond isolation; and containerized chemical consolidation.

The WSSRAP evolved from a National Environmental Policy Act (NEPA) authority decommissioning and cleanup project in 1986 into a remedial action project under combined NEPA-Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) authority requiring a Remedial Investigation/Feasibility Study (RI/FS) and complete environmental documentation in July of 1987. The environmental documentation process necessary to begin the excavation of the bulk waste from the WSQ is completed. The residual contamination within the quarry confines can be characterized when the excavation is completed.

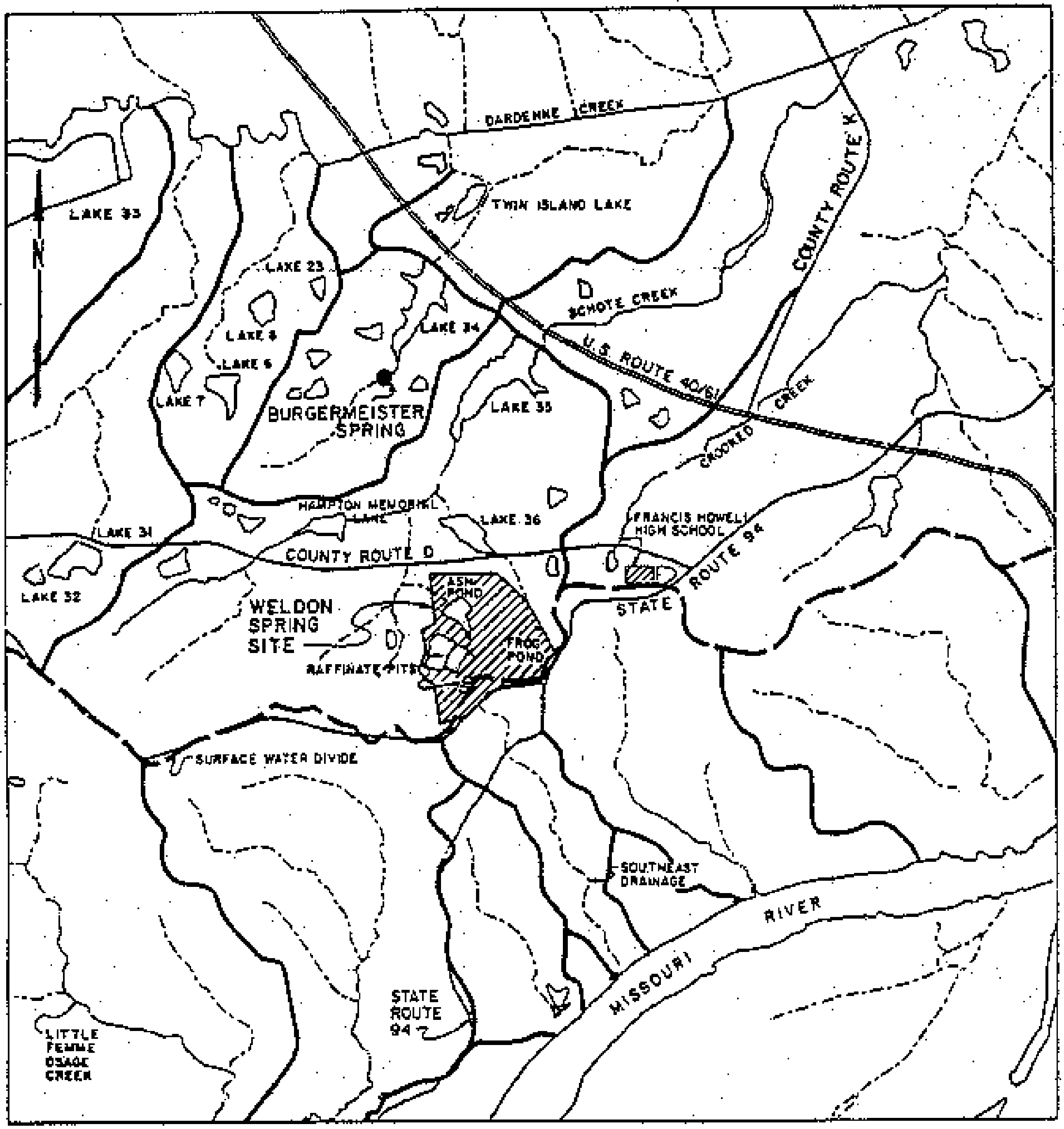
A more detailed presentation of the production, ownership, and waste history of the WSS is available in the RI reports for the WSQ and the draft WSCP/WSRP reports prepared by the DOE Project Office.

1.3 Environmental Setting

The environmental setting of the WSCP/WSRP and the WSQ are described briefly below. A more detailed description is provided in the *Work Plan for the Remedial Investigation/Feasibility Study-Environmental Impact Statement for the Weldon Spring Site, Weldon Spring, Missouri* (Peterson et al. 1988). The WSRP/WSCP area is located on the Missouri-Mississippi River surface-drainage divide. The topography is gently undulating and generally slopes northward toward the Mississippi River. To the southeast are bluffs that overlook the Missouri River floodplain. Though the bedrock under the site is fractured, it is overlain by low permeability clays ranging from 1 m to 9 m (3 ft to 30 ft) thick.

Most surface water runoff from the WSCP/WSRP area discharges either through an intermittent stream in the WSTA or through the Ash Pond diversion structure on the WSCP property to Schote Creek. An additional surface drainage system reaching Schote Creek exits the WSCP area along the Frog Pond drainage. That drainageway carries storm water from most of the plant area where concrete surfaces drain into a storm water sewer system. The Frog Pond drainageway also carries runoff from the northeastern portion of the WSCP. Drainage from the southern portion of the WSCP property travels southeast to the Missouri River through a natural drainage known as the Southeast Drainage. Schote Creek joins with Dardenne Creek and flows northeast to the Mississippi River. Schote Creek and several of its tributaries are impounded on the August A. Busch Memorial Wildlife Area (ABWA). Dardenne Creek, portions of Schote Creek, and lakes on the ABWA support aquatic life and are accessible to the public for recreational activities, such as fishing. The WSQ is located on the northern bluff of the

Missouri River valley. The unconsolidated upland material overlying bedrock consists of up to 10 m (30 ft) of silty clay soil developed from loess deposits. A residual soil is present in some areas between the silty clay and bedrock. Figure 1-4 shows the environmental setting of the WSCP/WSRP site.



LEGEND:

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

0 3200 6400 FT
0 975.4 1950.7 M
SCALE

ENVIRONMENTAL SETTING OF THE WELDON SPRING SITE

FIGURE 1-4

REPORT NO. DOE/OR/21548-283		EXHIBIT NO. A/VP/068/0591	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 5/91	

2 COMPLIANCE SUMMARY

2.1 Compliance Status for 1991

The Department of Energy's (DOE) Weldon Spring Site Remedial Action Project (WSSRAP) has been listed on the National Priorities List (NPL), and therefore is governed by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) process. Under CERCLA the WSSRAP is subject to meeting or exceeding the regulatory requirements of Federal, State, and local laws and statutes, such as Resource Conservation Recovery Act (RCRA), Clean Water Act (CWA), Clean Air Act (CAA), Toxic Substance Control Act (TSCA), and Missouri regulations. Because the U.S. Department of Energy (DOE) is the lead agency for the site, the procedural and documentation requirements of National Environmental Policy Act (NEPA) must be met, in addition to the requirements of DOE Orders. WSSRAP maintains a compliance staff to monitor the progress and status of the project relative to the environmental laws and requirements. Section 2.1.1.1 is a summary of applicable regulations and the WSSRAPs current compliance status. Section 2.1.1.2 is a summary of the WSSRAPs current compliance status with major DOE Orders.

2.1.1 Compliance Status

2.1.1.1 Regulatory Compliance

CERCLA

The WSSRAP has successfully integrated the procedural and documentation requirements of the CERCLA as amended by the Superfund Amendment and Reauthorization Act (SARA) and the National Environmental Policy Act (NEPA), as required by the policy stated in DOE Order 5400.4. Site documents are published as integrated documents, such as the site's Remedial Investigation/Feasibility Study-Environmental Impact Statement (RI/FS-EIS) documents. For example, Engineering Evaluation/Cost Analysis (EE/CA) and RI/FS documents, which are CERCLA documents, are adopted by the DOE as Environmental Assessments (EAs) or Environmental Impact Statements (EISs) and contain the required NEPA information. Proposed plans and actions are evaluated in terms of both the NEPA and the CERCLA.

The *Record of Decision (ROD) for the Management of Bulk Wastes at the Weldon Spring Quarry* was signed by the U.S. Environmental Protection Agency (EPA) September 9, 1990 (ANL 1990a). The DOE signed the ROD on March 7, 1991, which makes this the first DOE-approved CERCLA ROD. An EE/CA-EA and a Remedial Action Decision Document (RADD) were prepared for the dismantling of numerous contaminated structures at the chemical plant.

The WSSRAP removal and remedial actions are performed according to the requirements of the following acts, laws, and regulations (other than NEPA) as applicable or relevant and appropriate requirements (ARARs) for the site. The WSSRAP is developing a document that lists the ARARs for each major action that is planned at the site.

NEPA

A finding of no significant impact (FONSI) was approved and published in October 1991 for the dismantlement of process and non-process buildings/structures at the chemical plant. Two EE/CAs for the non-process buildings and contaminated process structures were adopted as EAs by the DOE. The FONSI covers both EE/CA-EAs because of the similarities in dismantling process and non-process buildings.

The categorical exclusion (CX) actions at the WSSRAP that have been approved are: (1) the off-site removal of tributyl phosphate (TBP) for disposal, (2) removal and disposal of transformers and equipment contaminated with polychlorinated biphenyls (PCBs) from an out-of-service electrical substation, (3) site characterization and environmental monitoring activities, (4) construction of a composite building, which will house an updated access control and a warehouse, (5) an annex to the administration building, and (6) a variety of general plant projects, e.g., repaving the administration building parking lot. Two CXs that were submitted to the DOE for approval in 1991 will allow continued site characterization and routine maintenance activities.

Resource Conservation and Recovery Act

Hazardous wastes at the Weldon Spring site (WSS) are managed as required by the RCRA (as substantive ARARs). This includes the characterization, consolidation, inventory, storage, transportation, and disposal of hazardous and other wastes that remained on site after closure of the Weldon Spring Uranium Feed Materials Plant (WSUFMP) and wastes that were generated during remedial activities. The WSSRAP has completed the containerization of unknown abandoned chemicals at the chemical plant; detailed characterization of the containerized chemicals is ongoing. Other RCRA issues during 1991 included the application of RCRA to residues on tanks and piping systems, the removal of three underground storage tanks, and applicability of the land disposal restriction storage prohibitions for approximately 20 containers of California List Wastes. More information is offered in the section on Issues and Actions.

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

Toxic Substances Control Act

Polychlorinated biphenyls (PCBs) are managed at the WSS under the requirements of the TSCA. A shipment of nonradiologically contaminated PCBs was sent off site on August 20, 1991. More information is offered in the section on issues and actions.

Clean Air Act

The portion of the CAA that pertains to the WSSRAP is the National Emission Standards for Hazardous Air Pollutants (NESHAPs). The standards contain maximum levels for radionuclides and asbestos. The WSSRAP plan for monitoring radionuclide emissions has been approved by the Environmental Protection Agency (EPA), and is explained in more detail in the section on issues and actions.

Clean Water Act

Compliance with the CWA includes meeting parameter limits set in three National Pollutant Discharge Elimination System (NPDES) permits. Both effluent and erosion control monitoring are performed. NPDES permit limits were exceeded for biochemical oxygen demand (BOD), total suspended solids (TSS), and/or fecal coliform during four of the monthly monitoring events in 1991 at the administration building sanitary wastewater plant. Operational adjustments to the plant were made by the subcontractor, bringing levels to below permit limits.

The permitted stormwater outfalls at the site were in compliance with the conditions of the NPDES permit for the site.

Construction of a water treatment plant located at the Weldon Spring Quarry (WSQ) is almost complete. The quarry water-treatment plant (QWTP) is designed to remove the chemical and radioactive components of the contaminated water in the quarry to, or below, levels established in the applicable NPDES operating permit for the quarry. No effluent is currently discharged at the quarry. The NPDES permit for the QWTP will be in effect when the plant is operational which is scheduled for September 1992. Once operational, batch analyses of treated effluent water will verify compliance with NPDES limits set by the permit.

Construction of a water treatment plant located at the chemical plant began in November 1991. This water treatment plant has been designated as the site water treatment plant (SWTP) - Train 1. The SWTP will treat shower and decontamination water generated during the upcoming building dismantlement and demolition activities and runoff from the temporary storage area, where bulk waste will be stored after excavation from the quarry. The SWTP is scheduled to begin operation in the fall of 1992. Once operational, batch analysis of treated effluent water will verify compliance with NPDES limits.

Archaeological and Historical Preservation Act

In 1986, the Missouri Department of Natural Resources determined that any archaeological resources present in the chemical plant area would have been so severely damaged or destroyed during plant construction that further investigation would not be warranted. A qualified archeologist was consulted for the quarry and the quarry haul road construction activities. The archaeologist found six sites in the quarry vicinity; the sites are not expected to be disturbed and therefore, will need no mitigation. The archaeologist identified one site along the haul road that required data recovery. On July 7, 1991, the WSSRAP received approval from the Advisory Council on Historic Preservation for the proposed data recovery plan for an archaeological site on the quarry haul road. The work promptly commenced following the approval and was successfully completed by September 1991. Artifacts of chert reduction from the Dalton age were recovered and curated. The data recovery report for the quarry haul road will be finalized by June 1992.

Endangered Species Act

The U.S. Fish and Wildlife Service (USFWS) has been consulted under Section 7(a) of the Endangered Species Act. The Missouri Department of Conservation has also been consulted pertaining to State-listed threatened and endangered species. No threatened or endangered species or designated critical habitat is known to exist at the quarry. Therefore, no impacts from construction activities to threatened or endangered species are expected.

Consultation with USFWS continued in 1991 in conjunction with an ecological evaluation of the quarry haul road and the chemical plant site. The evaluation of the haul road was completed before construction began in July. The ecological evaluation of the chemical plant initiated in 1991 continued into 1992 and will be incorporated into the *Baseline Assessment for the Chemical Plant Area of the Weldon Spring Site* (ANL 1992). The *Baseline Assessment* will evaluate risks to human health and the environment in support of overall site waste management decisions and cleanup criteria.

Executive Order 11988 Floodplain Management

The *Engineering Evaluation/Cost Analysis Environmental Assessment For the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (ANL 1989a) contains a floodplain assessment that describes the impact to the Missouri River floodplain as a result of construction activities at the quarry. The structure located on the floodplain is a portion of one of the effluent ponds associated with the quarry water treatment plant. The floodplain assessment was written in accordance with 10 CFR 1022.12 of the DOE *Floodplains/Wetlands Environmental Review Requirements* which establishes policy and procedures for discharging the DOEs compliance responsibilities for EO 11988. A notice of floodplain involvement was published in the Federal Register in November 1989.

Executive Order 11990 Protection of Wetlands

Four raffinate pits and two drainage ponds (Ash Pond and Frog Pond) are located in the chemical plant area. These pits and ponds are classified as wetlands according to the current U.S. Fish and Wildlife Service Wetlands Inventory Map. A wetlands survey that describes the existing ponds in terms of the soil, vegetation, saturation regime, and wildlife was initiated in 1991 and will be continued into 1992. The documentation may be used as a baseline description if mitigation is required later. The wetlands assessment for these areas will be included in the FS-EIS for the chemical plant.

2.1.1.2 DOE Order Compliance.

2.1.1.2.1 Order 5400.5 Radiation Protection of the Public and the Environment. DOE Order 5400.5 establishes standards and requirements for DOE operations with respect to protecting members of the public and the environment against undue risk from radiation. The DOE operates its facilities and conducts its activities so that radiation exposures to members of the public are maintained within established limits. As low as reasonably achievable (ALARA) practices are implemented to minimize exposures to the public as far below the limits as is reasonably achievable.

There are nine primary requirements for radiation protection of the public and the environment outlined in Chapter II of the Order. The WSS is in compliance with all applicable portions of DOE Order 5400.5. A summary of the compliance status is given as follows:

1. Public Dose Limits. The annual dose to the maximally exposed member of the public as a result of activities at the WSS was below the 100 mrem (1 mSv) guideline for all potential exposure modes as detailed in Section 4.2. The 10 mrem (0.1 mSv) annual dose limit for public exposure to airborne emissions excluding radon and its respective decay products as specified in 40 CFR Part 61 was not exceeded at the WSS in 1991. Section 4.1.3.4 provides an assessment of all exposure scenarios and conclusions.

   The WSS was not used as a disposal facility during the subject period, and thus is not subject to the requirements given in 40 CFR Part 191. In addition, the WSS does not operate a public drinking water supply, and therefore is not subject to the requirements of 40 CFR Part 141.

2. The ALARA Process. The ALARA process is implemented at the WSS on a continual basis. Each time a different remediation activity is initiated on the site, ALARA objectives are established to maintain potential exposures as low as reasonably achievable. Routine ALARA inspections are conducted to ensure that

appropriate actions are being implemented during work activities. These methods are specified in standard operating procedure ES&H 1.1.5a.

3. Management and Control of Radioactive Materials in Liquid Discharges and Phaseout of Soil Columns. Paragraph 3.C of this section states "contaminated soil columns, drainage systems, and groundwater to which contaminated liquid discharges have been discontinued shall be managed or decontaminated pursuant to the procedures and requirements of DOE Order 5480.4, *Environmental Protection, Safety, and Health Protection Standards.*" The natural drainage systems at the WSS are not governed by this paragraph. The terms "contaminated liquid discharges" and "liquid wastes" refer to discharges from operating facilities. The WSS facilities ceased operations in 1966. In CY 1991, the WSS did not affect contaminated liquid discharges or discharge liquid wastes from an operating facility. Stormwater runoff did, on occasion, exceed the Derived Concentration Guideline (DCG) for natural uranium of 600 pCi/l (22.2 Bq/l), but the annual averages for the runoff were below the 600 pCi/l (22.2 Bq/l) criteria. Clean-up operations at the WSS are underway to eliminate the source areas and to reduce the levels of contaminated discharge in accordance with the provisions of NEPA and CERCLA.

4. Management of Low-Level Radioactive Solid Waste. In 1991 management of low-level wastes at the WSS was in compliance with the guidelines given in DOE Order 5400.1, *General Environmental Protection Program Requirements*, and DOE Order 5820.2A, *Radioactive Waste Management*, as specified in this requirement.

5. Release of Property Having Residual Radioactive Material. The WSS is in compliance with the guidelines for release of real property, release of personal property, and release of materials and equipment, when applicable, as outlined in this requirement. The release of real property did not occur at the WSS in 1991, but all equipment utilized on site was properly surveyed to ensure that contamination levels given in DOE Order 5400.5 were not exceeded prior to release.

6. Demonstration of Compliance with the Dose Limits. The appropriate dose evaluation techniques were used to assess 1991 environmental monitoring and surveillance data in compliance with this requirement. Specific exposure scenarios and subsequent public dose estimates are outlined in Sections 4.1.3.4 and 4.2.

7. Reporting Requirements. The reporting requirements specified in DOE Order 5400.5 have not been utilized by the WSS due to the absence of occurrences that would require such reporting. However, records and reports are maintained according to DOE Order 5400.1 and DOE Order 5484.1, which are both referenced in this requirement.

8. Records. All environmental monitoring and surveillance activities conducted at the WSS in 1991 are maintained in accordance with this requirement.

9. Units. All reports and records generated at the WSS in 1991 pursuant to DOE Order requirements presented data in the units referenced in the applicable regulation or order.

2.1.1.2.2 Order 5820.2A Radioactive Waste Management. DOE Order 5820.2A establishes policies, guidelines and minimum requirements by which the DOE manages its radioactive and mixed waste and contaminated facilities.

The Order is divided into six chapters. Chapters I through IV cover specific types of radioactive waste; those being high-level, transuranic, low-level, and NORM/accelerator produced. Chapter V addresses the decommissioning of radioactively contaminated facilities and Chapter VI addresses the administrative activities related to the Waste Management Plan. The Weldon Spring Site (WSS) is in compliance with the applicable portions of Chapters III, V, and VI of the Order. The types of wastes addressed in Chapters I, II and IV are not present at the WSS. A summary of the compliance status for each applicable Chapter is given as follows:

Chapter III

Chapter III is divided into sections that outline the requirements for the various activities within waste management. A summary of the compliance status for each activity is provided below:

1. Performance objectives - the WSS is in compliance with the requirements for protection of the public health and safety, external exposure limits, and protection of ground water resources.

2. Performance assessment - the WSS is not a disposal facility therefore the requirements are not applicable.

3. Waste generation - the WSS has implemented a waste minimization program in an effort to reduce the quantity of radioactive and mixed waste generated. The program is described in the *Waste Minimization/Pollution Prevention Awareness Plan* (MKF and JEG 1991a) developed as a requirement of DOE Order 5400.1. The requirement for waste segregation is documented in the WSS *Waste Management Plan* (MKF and JEG 1992a).

4. Waste characterization - the WSS is in compliance with the requirements for conducting characterization of waste materials in order to permit proper segregation, treatment, storage, and disposal.

5. Waste acceptance criteria - Since the WSS does not receive waste from other facilities, these requirements are not applicable.

6. Waste treatment - the WSS is not performing waste treatment at this time.

7. Shipment - the WSS is not shipping low-level waste at this time.

8. Long-term storage - The requirements of this section are not applicable since waste storage at the WSS is not considered long-term.

9. Disposal - the WSS is not considered a disposal facility.

10. Quality assurance - Management of low-level waste is conducted in accordance with the requirements of NQA-1.

11. Records and Reports - All records and reports, including analytical data and waste manifests, are maintained as permanent records.

Chapter V

Chapter V outlines the requirements for the planned decommissioning of radioactively contaminated facilities. The WSS is in compliance with the requirements of this chapter by conducting the site remediation under the CERCLA process which include the requirements for characterization, environmental review, engineering, and site closure.

Chapter VI

Chapter VI of the Order provides guidance on the development and maintenance of a waste management plan including plan format and content requirements. Although the Order requires that each site develop a waste management plan to serve as a annual report, the WSS plan was developed to serve as a guidance document for day-to-day waste management operations.

The WSS *Waste Management Plan* (MKF and JEG 1992a) is submitted to DOE Headquarters (HQ) for review and comment annually.

2.1.2 Issues and Actions

2.1.2.1 New Issues

1. Disposal of PCB wastes beyond allowable time limits. On August 24, 1990, eight drums of nonradioactive PCB contaminated oil and a nonradioactive PCB transformer were removed from a concrete pad (Substation 411) and placed into storage in Building 434.

   The PCB oils and transformer were sent off site for treatment and/or disposal on August 20, 1991. Pursuant to 40 CFR 761.65(a), PCB containers and articles must be removed from storage and disposed of within one year from the date when first placed into storage. The required disposal date for the Substation 411 PCB items was August 24, 1991.

   The certificates of disposal for the eight drums of PCB oils and the transformer list August 27, and September 3, 1991, respectively, as the final disposal dates. An

Occurrence Report (DOE Order 5000.3A) was submitted due to the exceedence of the one year storage limitation. The receiving facility notified the EPA of the late destruction of the PCBs per 40 CFR 761.215(c)(1).

Corrective Action

The PCB items were disposed of past the August 24, 1991, deadline due to delays caused by recent changes in the DOE's nationwide policy regarding off-site release of nonradioactive material. The policy required the WSSRAP to develop procedures and obtain headquarters' approval for off-site shipment and disposal of nonradioactive material. The procedures have been developed and were submitted to DOE-HQ on September 20, 1991. DOE-HQ sent back the procedures with comments. The WSSRAP incorporated the comments and returned the procedures to DOE-HQ for final approval on January 1, 1992.

2. Application of RCRA to residues on tanks and piping systems. The Missouri Department of Natural Resources (MDNR) has taken a position, in the form of comments provided on the WSSRAP *Contaminated Structures EE/CA* (ANL 1991a), that any RCRA listed or characteristic residues on the surfaces of tanks and pipes must be managed in accordance with the RCRA. The MDNR defines residue as anything that can be removed by rinsate. The regulatory basis for the State's position is the closure of tank systems addressed in 40 CFR 264.197 and closure performance standards stated in 40 CFR 264.111. The ramifications of the State's position, with regard to WSSRAP building dismantlement activities, is that no removable hazardous waste residues should remain on tank systems (including ancillary components) that will be stored at the newly constructed material staging area (MSA). Of immediate concern was the possibility that the pipes and tanks removed to date could be contaminated with RCRA residues and thus would be improperly stored. Specific cases include the overhead piping removal conducted under IRA 6 and dismantlement of the steam plant, Building 401.

Corrective Action

The WSSRAP has identified the chemical species associated with overhead piping currently stored near Pads 109 and 110. Selected piping has been examined to determine if visible residues are present. In addition, representative swipe testing was performed to detect removable residues. None of the samples showed any RCRA characteristics present.

At the steam plant, three chemical systems--the water softener (ion exchange resins and acid/base regenerates), the refrigeration units, and the feedwater treatment system (consisting of phosphate and sodium sulfite components)--were identified as potential sources of hazardous waste. During the dismantlement, samples of the ion exchange resin from the water softening system and coolant from the refrigeration units were obtained and analyzed for RCRA characteristics. None were detected. As a follow-up, the sodium sulfite mix tank was sampled to determine if residual hazardous wastes were present; the results demonstrated that the tank was free of RCRA characteristics. An acid storage tank, which was a component of the water softener, was sampled and found to contain no RCRA characteristic waste.

The identification and characterization of residues in building tanks, equipment, and piping is ongoing. The WSSRAP has determined that there are no listed waste residues present in the building tanks, equipment, or piping. To date, a small quantity of RCRA characteristic residue has been found in the process piping in Building 108.

For proposed building dismantlement, the WSSRAP has agreed to coordinate and review the RCRA issue with the State on a building-by-building basis. The State and the WSSRAP agreed that the WSSRAP would submit a list of buildings and structures to be excluded from individual review based upon the nature and type of building and/or structure. This list of buildings has been compiled and was sent to the MDNR.

A site visit from the MDNR resolved State questions and supported the WSSRAP determination of buildings excluded from review. Approval from the MDNR was received in early 1992.

2.1.2.2 Old Issues

1. Storage of PCB wastes beyond allowable time limits (40 CFR 761.65(a)).

   Approximately 28,120 liters (7,400 gal) of tributyl phosphate (TBP) contaminated with radionuclides and with PCBs in excess of 50 ppm are contained in tanks on the Weldon Spring site. In addition, preliminary analyses indicate the TBP is also contaminated with mercury exceeding the regulatory level for toxicity characteristic (TC), thereby making it a RCRA hazardous waste. Also contained on site are small amounts of radiologically contaminated PCB wastes, including electrical capacitors and PCB-contaminated soil and oil.

   All PCB wastes identified to date by investigative and remedial activities have been present since the plant was operational in the 1950s and 1960s. The WSSRAP continues to locate and identify all PCB-containing material and to place it in proper storage.

   Corrective Action

   In December 1989, the WSSRAP-DOE sent a letter to the EPA (Region VII) notifying them that the one-year storage limitations had been exceeded.

   The WSSRAP planned to send the TBP to the Oak Ridge Gaseous Diffusion Plant Incinerator for destruction, and during 1991, awaited word on whether the State of Tennessee would allow the TBP to be shipped to Oak Ridge.

   An attempt by the WSSRAP to decontaminate the radiologically contaminated PCB capacitors failed. Therefore, the capacitors will remain on site and eventually be disposed of with other radiologically contaminated material when a viable disposal option is identified.

2. Storage of Land Disposal Restricted Waste Beyond Allowable Time Limits (40 CFR 268.50)

The Weldon Spring site is currently storing 20 containers of mixed waste in Building 434 that are classified under the land disposal restrictions (LDRs) as California List Waste. This waste is prohibited from storage under 40 CFR 268.50, which prohibits storage of LDR waste unless solely for the purpose of accumulation of such quantities as are necessary to facilitate recovery, treatment, or disposal.

Corrective Action

The August 29, 1991, Federal Register announced the EPA policy of placing a low enforcement priority on the storage of certain mixed wastes that are prohibited from land disposal under the RCRA Land Disposal Restrictions (LDRs). The wastes affected included spent solvents, dioxins, and California List Wastes. The EPA recognized the lack of treatment and disposal options for these wastes and stated this policy will apply at least until December 31, 1993.

The Weldon Spring site has submitted a request to the EPA for an ARAR waiver for storage of LDR waste based on the fact that the schedule for final disposition of the wastes is controlled by the decision making process for remediation of the chemical plant area. The EPA has not yet responded to this request.

3. Complete detailed analysis has not been conducted on all containers of chemicals prior to placement in storage.

When the uranium processing plant was shut down in 1966, large quantities of organic and inorganic chemicals were abandoned in both process and non-process buildings. Phase I characterization activities included an initial effort to identify and containerize these chemicals. As Phase I progressed, more chemicals were discovered; these were addressed by Phase II. Chemicals were found in tanks, sumps, process vehicles, and abandoned buildings during both phases. Phase I and Phase II were completed in January 1989 and March 1991, respectively.

In carrying out Phase I and II chemical containerization actions, the WSSRAP observed a conflict between the requirements of the RCRA and what the WSSRAP considers the best conduct of operations for expediting secure storage of chemicals.

The WSSRAPs primary concern was to move chemicals into the RCRA storage area as quickly as possible. To accomplish this a gross field analysis was conducted to determine compatibility; the material was then moved into the RCRA storage area, and a detailed chemical analysis conducted, as required, to fully meet the requirements of 40 CFR 264.13. This regulation requires, however, that the detailed analysis be performed prior to placing the material in the RCRA storage area and that the containers be properly labelled during the entire storage period. Therefore, there was a period of time during which the WSSRAP was not in compliance.

Corrective Action

The WSSRAP labels all containers based on all information currently available; the containers will be relabelled as detailed chemical analyses become available. For the most part, all required information for labelling is provided by the gross field analyses. Additionally, all chemical waste is being packaged in U.S. Department of Transportation (DOT) approved containers regardless of its RCRA standing.

The WSSRAP received concurrence from the MDNR in 1990 on this method of handling potentially hazardous materials.

4. Surpassing the Missouri State maximum permissible exposure limit for radon at the quarry (19 CSR 20 - 10.040)

The Missouri Code of State Regulations limits quarterly-averaged radon concentrations outside controlled areas to 1 pCi/l. This concentration is regularly exceeded at one quarry perimeter monitoring station and occasionally exceeded at other quarry perimeter monitoring stations.

Corrective Action

The long term solution is the excavation and final disposal of the bulk waste (which is the primary radon source). This is addressed in the quarry ROD.

2.1.2.3 Actions

As part of the work scope for construction of the temporary storage area (TSA), the WSS removed three underground storage tanks (USTs). The USTs were used for storage of diesel fuel, gasoline, and fuel oil, respectively, and were taken out of service in the 1960s. There are two additional confirmed USTs located on site which will be removed during future foundation removal activities.

Various waste streams were generated during the removal of the USTs and were managed as follows:

1. Water - water inside the tank was analyzed by the toxicity characteristic leaching procedure (TCLP), and one tank contained water above the regulatory level of 0.5 mg/l for benzene. This water was characterized as a hazardous waste and was pumped into 55-gallon drums. The drums are currently stored in Building 434 as a RCRA hazardous waste DO18. The nonhazardous water in the remaining tanks was treated with a carbon adsorption system and pumped into the raffinate pits. This action was discussed with, and approved by, MDNR.

2. Soil - petroleum contaminated soil outside of a UST is deferred from regulation under the toxicity characteristic (TC) rule for DO18-DO43 (40 CFR 261.4(b)(10)). The soil was analyzed for TC metals and radioactivity and was below the regulatory level for the metals, and below background for radioactivity. The soil was sent off site to a sanitary landfill as recommended by the MDNR.

3. Tanks - the tanks were cut up and sent off site to a scrap metal facility for reclamation as recommended by the MDNR.

2.1.2.4 Significant Accomplishments

1. The *Record of Decision* (ROD) *for Quarry Bulk Waste Management* (ANL 1990a) was signed by the EPA (September 1990). The DOE signed the ROD on March 7, 1991, which makes this the first DOE-approved CERCLA ROD.

2. The amended Federal Facility Agreement (FFA) was signed by the DOE and the EPA. A draft implementation plan has been prepared to define an approach towards compliance with the requirements of the FFA, and the schedule impacts of complying with the FFA have been assessed. The FFA will become effective upon issuance of a notice to the DOE by the EPA, which will follow a public comment period scheduled for March 24 to May 7, 1992.

3. The WSSRAP received final written approval from the MDNR on October 24, 1991, for an equivalent design for the liners of the site water treatment plant equalization basin and the TSA pond. A synthetic liner plus Claymax was proposed as equivalent to the State requirement (for surface impoundments), which is 90 cm (3 ft) of compacted clay with a permeability of, at most, 1×10^{-8} cm/sec. This substitution is termed "equivalency" and requires State rather than EPA approval because Missouri is an authorized state for RCRA and the requirement is more stringent than the Federal RCRA requirement of 90 cm (3 ft) of compacted clay with a permeability of 1×10^{-7} cm/sec.

4. Construction of Phase I of the MSA was completed in 1991 and the MSA is in operation. The MSA Phase I will accommodate, but is not limited to, the debris, equipment, and building materials associated with dismantlement of IRA 15A series Buildings 302, 435, 436, 437, and 438 and the outside debris consolidation and railroad track removal project.

   The MSA Phase I consists of a 1.2 ha (3-acre) (approximate) gravel pad and a runoff collection system with a .32 ha (0.8) acre storage pond. The runoff collection system consists of corrugated metal piping and manholes. An embankment/dike surrounds the facility to control runon and runoff water. The MSA will be operated in accordance with *Missouri Solid Waste Management Regulations*, 10 CSR 80-5.

5. The containerization of unknown abandoned chemicals at the chemical plant was completed in 1991. Detailed characterization of the containerized chemicals is continuing into 1992.

6. Several documents and systems were developed to aid in ensuring regulatory compliance at the WSSRAP, including the following:

   a. A document listing the ARARs for each major activity at the site.

   b. A database that lists each container of RCRA waste, its applicable EPA waste codes, land disposal restriction (LDR) status, LDR treatment standards and best demonstrated available technology (BDAT).

   c. Fact sheets for each work package documenting all ARARs, regulatory commitments, Federal Facility Agreement (FFA) requirements, waste management requirements, and waste profiles.

   d. Databases used for tracking permits and permit requirements, regulatory notifications, and environmental reports and plans.

2.1.2.5 NESHAPs Compliance. The WSSRAP has developed an alternate method for NESHAP compliance as provided in 40 CFR 61.93 paragraph (b)(5), whereby air concentrations are monitored at five designated critical receptor locations on and around the Weldon Spring site. The WSSRAP plan is contained in the report *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (MKF and JEG 1990a), which has been approved by the EPA. The EPA has also approved the WSSRAP plan to report annual monitoring results and effective dose equivalents at critical receptor locations via the annual site environmental report.

The air at each critical receptor location is continuously sampled for radionuclides. The air sampling filters from each critical receptor location are separately composited and analyzed annually for the radionuclides that are major contributors to the effective dose equivalent, i.e., U-234, U-238, Th-228, Th-230, Th-232, Ra-226, and Ra-228. Air sampling filter collection, handling, and analysis methods are regimented by the EPA such that radionuclide concentrations that would cause an effective dose equivalent of 10% of the standard (i.e., 1 mrem) are readily detectable and distinguishable from background. Radionuclide detection levels and sampled air volumes are sufficient to meet the sensitivity requirements of Table 2, Appendix E of 40 CFR 61 which determines compliance with the standard. The quality assurance program described in Section 5 of the WSSRAP NESHAPs compliance plan (MKF and JEG 1990a) meets the requirements of 40 CFR 61 Appendix B. Detailed information, including calculations on radiation monitoring and dose calculations are found in Section 4 and Appendix G. During calendar year 1991, no significant asbestos abatement activities were performed at the site.

2.1.2.6 Satisfaction of Reporting Requirements

2.1.2.6.1 Release Reporting. There have been no reportable quantity releases from the WSS that were not exempted as a Federally permitted release. Consequently, no release reports under CERCLA or SARA Title III have been required.

2.1.2.6.2 SARA Title III Report. For the 1991 calendar year, the WSSRAP reported the following hazardous chemicals in the SARA Title III *Annual Chemical Inventory Report*: 15 drums of PCBs; two process tanks containing a solution of TBP/uranyl nitrate; four raffinate pits containing sludge and water contaminated with uranium, thorium, radium, lead, arsenic, and other inorganic contaminants; approximately 1,011 cu m (1,330 cu yd) of bagged asbestos; and 16 drums of elemental magnesium and magnesium oxide. The WSSRAP is not a manufacturing facility according to the Standard Industrial Classification (SIC) Codes 20-39, and is therefore not required to submit the annual *Toxic Release Inventory* under Section 313 of the SARA.

2.1.2.7 Audit Summary. The Department of Energy Office of Environmental Audit conducted an audit of the WSSRAP April 15 through 30, 1991. Draft findings were transmitted to the WSSRAP on April 30, 1991. The audit team identified a total of 32 findings; seven findings associated with lack of conformance with Federal and State laws and regulations and DOE Orders; 22 findings in which best management practices were not achieved, and three findings in which internal project procedures were not followed. A response to the audit in the form of an action plan was submitted to the DOE in June 1991. On January 22, 1992, the WSSRAP transmitted the final action plan to EM-421, having incorporated responses to comments presented by EH on the plan.

2.1.3 Summary of Permits for 1991

The WSSRAP maintains the following permits:

Three NPDES permits (quarry and chemical plant).

Three construction permits from the Missouri Department of Natural Resources (two for the quarry water treatment plant and one for the chemical plant).

Three driveway permits from the Missouri Highway and Transportation Department for the entrance at the quarry, entrances to the quarry haul road, and the entrance to the Missouri Department of Conservation parking lot.

One Floodplain Development permit from St. Charles County Planning and Zoning Commission for construction of a portion of one of the effluent ponds at the quarry.

2.2 Compliance Status for the Period January 1 - April 15, 1992

A functional appraisal of selected environmental, safety, health and quality assurance programs, and conduct of operations was conducted by the Oak Ridge Field Office March 2 through 6, 1992. The appraisal was performed to assist the WSSRAP site office in their self-assessment program. The following is a list of each area that was appraised along with the number of proficiencies and deficiencies reported for each area. Also listed is the number of past audit findings that were corrected and closed out during this audit.

	Proficiency	Deficiency	Past Deficiency Closed
NEPA	1	4	3
Water Pollution Control	1	6	4
RCRA	2	3	3
Groundwater	1	0	6
Radioactive Waste Management	0	0	1
Field Monitoring QA	0	6	3
Laboratory QA/Data Validation	0	5	5

Clean Air Act	1	3	8
Health Physics	2	5	4
Industrial Hygiene	1	6	6
Industrial and Construction Safety	3	6	3
Transportation Safety	0	4	0
Fire Protection	0	4	7
Conduct of Operations	4	10	0

Status remains unchanged under the RCRA, the TSCA, the CAA, the Endangered Species Act, the Archaeological and Historic Preservation Act, and Executive Order 11988.

CERCLA

Construction of the TSA began in February 1992. The TSA will be used to store waste excavated during the quarry bulk waste remedial action. This action is documented in the CERCLA ROD discussed in Section 2.1.1.

Construction of MSA Phase II and Phase III has begun. The primary purpose of the MSA will be to provide temporary storage of material generated by decontaminating and dismantling site structures. The dismantlement and management of 30 contaminated structures is documented in the *EE/CA for the Proposed Management of Contaminated Structures at the Weldon Spring Chemical Plant*, May 1991 (ANL 1991a).

NEPA

A routine maintenance CX was approved January 30, 1992. Approval of a revised site characterization CX and one brief EA and FONSI covering the composting of radiologically contaminated wood debris is anticipated mid-1992. A wetlands assessment is included in the EA that discusses any potential impacts to the wetlands (the area around a man-made raffinate pit) from the composting activities. A notice of wetland involvement will be published in the Federal Register allowing for a public comment period.

CWA

Construction of the QWTP is nearing completion and construction of the SWTP - Train 1 has begun. The Weldon Spring site has received two additional permits to support the SWTP: (1) an NPDES operating permit for discharge of uncontaminated water used for leakage testing of the ponds and for testing of the plant, which was approved in March 1992, and (2) a construction permit for construction of the treatment plant system was approved in April 1992.

Planning has begun for the required information and sampling for the stormwater permit application due to be submitted by October 1, 1992.

2.2.1 Summary of Permits for 1992

The WSSRAP currently maintains the following permits:

Four NPDES permits (quarry and chemical plant).

Four construction permits from the MDNR (two for the quarry water treatment plant and two for the chemical plant).

Three driveway permits from the Missouri Highway and Transportation Department for the entrance at the quarry, entrance to the quarry haul road, and the entrance to the Missouri Department of Conservation parking lot.

One Floodplain Development permit from St. Charles County Planning and Zoning Commission for construction of a portion of one of the effluent ponds at the quarry.

3 ENVIRONMENTAL PROTECTION/RESTORATION PROGRAM OVERVIEW

3.1 Project Purpose

The U.S. Department of Energy (DOE), under the Surplus Facilities Management Program (SFMP) is responsible for cleanup activities at the Weldon Spring site, Weldon Spring, Missouri. The DOE designated the Weldon Spring site (WSS) as a major project in May 1985, and since then has redefined the WSS as a major system acquisition. The program is known as the Weldon Spring Site Remedial Action Project (WSSRAP). The major goals of the WSSRAP are to eliminate potential hazards to the public and the environment, and to make surplus real property available for other uses, to the extent possible.

Remedial actions carried out at the WSS are subject to U.S. Environmental Protection Agency (EPA) oversight under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). Response actions at the WSS are subject to the CERCLA requirements because the site is listed on the EPAs National Priorities List (NPL). The DOE is also responsible for complying with the National Environmental Policy Act (NEPA) of 1969, which requires Federal agencies to consider the environmental consequences of a proposed action as part of the decision-making process for that action.

The proposed management of the clean-up of the WSS is organized into four separate operable units: quarry bulk waste, waste from the chemical plant and raffinate pits, chemical plant groundwater, and the quarry residuals area. A Feasibility Study-Environmental Impact Statement (FS-EIS) will be prepared for each of the operatable units to analyze various alternatives for conducting remedial action at the WSS. Prior to issuance of the record of decision (ROD), various interim response actions (IRAs) will be performed to mitigate actual or potential uncontrolled releases of radioactively or chemically hazardous substances to the environment. The scope of the IRAs is limited to those actions that can be performed under the CERCLA and within the constraints of the NEPA regulations. It is DOE policy to integrate the requirements of the NEPA and the CERCLA processes in order to minimize documentation and expenditures.

DOE Order 5400.1 *General Environmental Protection Program* requires the preparation of an *Environmental Protection Program Implementation Plan* (EPPIP) (MKF and JEG 1989b) at all DOE sites. The WSS EPPIP details the methods by which the program is administered under CERCLA as amended by SARA and by NEPA. With these additional remedial action requirements, the WSSRAP has a different overall goal from the standard operating and/or production facilities for which DOE Order 5400.1 was developed.

As a result, the WSSRAP EPPIP has been prepared to meet the intent of DOE Order 5400.1 while being tailored to the unique aspects of a remedial action project. One mechanism used to meet WSSRAP requirements is the annual preparation of an Environmental Monitoring Plan (EMP) required by DOE Order 5400.1. All requirements for air, groundwater, water, effluent, sediment, biological, radiological, and non-radiological monitoring are satisfied by the plan. Results of the annual monitoring prescribed by the EMP are reported in this annual site environmental report.

3.2 Environmental Program Overview

The monitoring of remedial activities and selected remedial alternatives as directed by the CERCLA, the SARA, and the NEPA regulations and the environmental monitoring requirements set forth by DOE Orders has been developed for incorporation at the WSS. The program is specifically designed to reduce the threats to health and/or safety to on-site workers and the public, and to mitigate actual or potential uncontrolled contaminant releases by a combination of active and routine periodic monitoring of various environmental media. Currently, routine monitoring at the WSS provides baseline data (prior to remedial action) and documents releases and exposures to the public and the environment at a no-action clean-up level. Environmental monitoring will continue to be performed to assess the impact of remedial action on all affected media. Over the long term, this environmental monitoring data will be used to demonstrate the effectiveness of engineering controls and remediation.

New requirements of DOE Order 5400.1, effective November 1991, have been successfully incorporated into the 1991 program on a characterization or preliminary study level. These new program elements include sampling of sediments, benthic invertebrates, zooplankton, and agricultural crops as part of the overall biological monitoring activities.

Additions to the overall 1991 EMP program include a surface water management program that includes sampling of the material staging area (MSA) effluent pond prior to discharge, and an increase in geochemical monitoring including sampling and analysis of constituents such as alkalinity and metals. A continuous radon monitoring program was initiated for the project and includes five monitoring locations: quarry perimeter, southwestern corner of the chemical plant near Raffinate Pit 4, Francis Howell High School, the administration building at the chemical plant; and a background location at the Busch Wildlife Area. Other compliance activities include the preoperational sampling of the Missouri River prior to start up of the quarry water treatment plant and increased data interpretation such as trend analysis and statistical review.

In all, a total of 111 groundwater locations were monitored, 33 surface water locations, 22 radon and TLD stations, five radon and radon daughter stations, 11 air particulate, six asbestos locations and 10 NPDES locations with one location awaiting the quarry water treatment plant operational start.

3.3 Summary of Project Accomplishments for 1991

Several activities have been completed in 1991 under the overall plan for remediation of the Weldon Spring site. The ROD for the quarry bulk waste removal was approved by the EPA and the DOE on September 28, 1990, and March 7, 1991, respectively. As part of the remediation of bulk wastes, the design for the temporary storage area (TSA) for bulk wastes was completed and approved by the EPA in August 1991. The wastes will be removed and transported via a dedicated haul road from the quarry to the chemical plant where the TSA is to be constructed. The quarry haul road work, which was started in 1991, is nearly completed and includes the realignment of Highway 94 by the Missouri Department of Transportation. The preparation of the TSA area included the demolition of Building 302 and the 15A series buildings and clearing of debris and brush in the TSA area. Construction of the quarry water treatment plant was initiated in 1991 and included excavation and grading. In conjunction with the quarry water treatment plant, the quarry decontamination pad was built to support bulk waste removal, and general construction and road work was completed in the immediate quarry area.

The construction of the chemical plant water treatment facility was initiated in 1991, according to the approved EE/CA of July 1990. Activities included grading of the treatment plant area, Building 401 slab removal, and clearing and grubbing in the area.

The *EE/CA for the Proposed Management for the Contaminated Structures At The Chemical Plants* (ANL 1991a) was completed in May 1991; reviewed and approved by the EPA and a Finding of No Significant Impact (FONSI) was issued by the DOE. The removal action document (RAD) for contaminated structures was issued in November 1991.

The MSA Phase I at the WSCP was completed in 1991, and included grading and lining of the effluent pond, placement of storage compacted liners in the MSA area, and beginning of transfer of debris materials to the storage area. Phase II and III of the MSA, the final portion, was started in 1991.

The Resource Conservation Recovery Act (RCRA) and Toxic Substances Control Act (TSCA) storage facility received an upgrade in 1991 in order to support storage capabilities and operational needs. The upgrade included the installation of a compactor to manage personal protective equipment (PPE) debris and waste.

Efforts have also begun on the development of a work plan for long term remediation of the quarry and surrounding areas, defined as the quarry residuals area. The development of the quarry residual area work plan was started in 1991 and will identify potential routes of human exposures to site contaminants, identify data gaps, and summarize the process and proposed studies for the residuals investigation.

3.4 Waste Management

Consolidation of containerized wastes at the WSS was completed in a two-phase effort in January 1991. Over 1000 containers (varying in size from 209 liters [55 gallon drums] to small vials) were collected, field analyzed, consolidated, and placed in interim storage pending a final disposition. The field analysis provided qualitative data to support the consolidation effort. Treatment and disposal options are being supported by a comprehensive off-site analysis program. This detailed characterization program is guided by the *Weldon Spring Site Waste Analysis Plan* (MKF and JEG 1991b). The wastes are stored in the on-site RCRA and TSCA storage facility, Building 434, until a final treatment or disposal option is available. The WSSRAP has not shipped any RCRA waste off-site and therefore has not been required to comply with RCRA manifest or biennial report requirements. The biennial report requirement under 40 CFR 264.75, which includes the requirement for hazardous waste minimization certifications and waste reduction reports, is an adminstrative requirement and therefore does not meet the definition of an ARAR under CERCLA. If RCRA waste is shipped off-site administrative requirements must be complied with and a biennial report will be prepared.

The on-site RCRA storage facility provides approximately 1,767 sq m (19,000 sq ft) of storage area. The building, originally a warehouse, was renovated to meet the RCRA standards for containerized storage areas. Most of the wastes are contained in U.S. Department of Transportation (DOT) approved 209 liters (55 gallon) drums and overpacks. The current containerized inventory includes 25 drums of asbestos containing material, 249 drums of RCRA-regulated material, 38 drums of the Missouri Department of Natural Resources (MDNR) regulated material, 39 drums of TSCA-regulated material, 83 drums of other DOT hazardous material, and 804 drums of nonhazardous material. There are also 77 sling bags of non-hazardous material stored in Building 434. The drums are stored in accordance with all applicable RCRA and TSCA standards.

A number of areas on site are used for long term storage of bulk waste. The active bulk waste storage areas consist of two soil spoils areas, the MSA, Building 103, and the mulch pile.

The two soils spoil areas are used to store soil and concrete rubble generated during on-site construction activities. One area is used for the storage of material with U-238 contamination levels less than 15 pCi/g (0.56 Bq/g). The other area is used for the storage of material with U-238 contamination levels greater than 15 pCi/g (0.56 Bq/g). Material is placed in the appropriate area based upon representative on-site sampling.

The MSA is a 52 ha (13 acre) staging area for radioactive building demolition material. Construction of Phase I was completed in the spring of 1991. It is used to stage building demolition and site clean-up material. MSA Phases II and III are scheduled to be completed in the spring of 1992. The entire MSA will be used to stage all building demolition and site clean-up material, excluding concrete rubble, asbestos-containing materials (ACM) and soil. No RCRA waste will be staged at the MSA.

Building 103 is presently used for temporary storage of ACM and PPE generated on site. Future plans include the development of a storage area for storing the ACM until final disposition is determined. The PPE is scheduled to be compacted and placed in Building 434 for long-term storage.

All wastes at the WSS are tracked using the Waste Inventory/Tracking System (WITS), a computer inventory database which facilitates tracking of bulk and containerized waste data. The WITS has four functions: inventory, tracking, disposal, and report generation. The inventory function consists of original material inventory. The tracking function is capable of tracking material and volumes from its original location or tracking a specific container. The disposal function is capable of providing information on the disposal of material from its original location or disposal of a specific container. The report generation function is capable of producing reports based on data contained in the WITS program.

3.5 Safety and Security

During 1991, the WSSRAP maintained a seven person Safety Department staff. The department is responsible for all phases of site safety including construction, industrial, and laboratory. One safety supervisor acts as the site Emergency Response Coordinator and oversees a 20 member Emergency Response Team. This team incorporates staff from various departments on the project and is trained beyond the required 40 hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training under 29 CFR 1910.120 to respond to all site emergencies, including hazardous material incidents. The team has a complete spill response inventory to control and contain any spill incidents on site. The department also maintains safety programs and procedures at the WSSRAP, including staff training and emergency drills.

Site security is also under the direction of the Safety Department. Security guards provide 24-hr coverage at the main site and the quarry. The security program also addresses all applicable DOE orders including lock and key programs, which include on and off-site air monitoring equipment and groundwater wells.

3.6 Incident Reporting

The WSSRAP follows all applicable DOE orders pertaining to occurrence reporting, i.e., Order 5000.3A. All local, State, and Federal reporting requirements are also followed. An Emergency Management Team consisting of site management has been trained to coordinate all incident reporting requirements during and after any such emergency and non-emergency incidents. This organization ensures timely response to categorizing and notification of all involved agencies.

Environmental incidents that occurred are described in the following sections.

3.6.1 Reported Environmental Occurrences During 1991

The following information is included to satisfy the requirements of DOE Order 5400.1, Part II, 2(b). Two events of environmental significance were reported during 1991 as off-normal occurrences under the DOE Order 5000.3A, *Occurrence Reporting and Processing of Operations Information*. These events were reported due to heightened sensitivity regarding issues of potential groundwater contamination near the St. Charles County water production well field and did not represent a real threat to the quality of the county's water supply.

Elevated Uranium in Monitoring Well(MW)-1011

On February 26, 1991, an elevated uranium concentration (20 pCi/l) for MW-1011 located east of the quarry (Figure 6-3) was reported by a subcontract laboratory. Validation of the reported value was performed and a second sample was collected and found to have a uranium concentration of 30 pCi/l. Conclusions regarding the cause of the elevated uranium concentration are that contaminated surface water is migrating from the Femme Osage Slough into the groundwater south of the slough. As a result of these elevated concentrations sampling frequency for MW-1011 and adjacent MW-1010 was increased from quarterly to weekly; continuous water level monitoring was initiated at selected monitoring wells; packer tests were conducted on several other wells south of the slough; and preparation of a draft contingency plan to address worst case scenarios was initiated to ensure protection of a quality water supply to residents of St. Charles County. The incident was reported as an off-normal occurrence under DOE Order 5000.3A.

Elevated Uranium in Femme Osage Slough

On May 6, 1991, routine monitoring (first quarter 1991) revealed a significant increase in the uranium concentration of the surface water contained in the Femme Osage Slough (Figure 6-3). The detected uranium concentration in the slough was reported to be 326 pCi/l. Additional samples were taken and the data was validated. The data was also compared with historical data and found to be below the historical high value of 557 pCi/l. No further action was required.

3.7 Embankment Safety Activities

Federal regulations require that embankments greater than 7.6 m (25 ft) in height, or embankments that would pose a significant downstream hazard, be regulated by an embankment safety program. The Federal Energy Regulatory Commission has the overall responsibility for DOE-owned embankments and will perform formal inspections at least every five years. The Project Management Contractor (PMC) is responsible for development and implementation of an embankment safety program, maintaining the embankments, and performing routine surveillance and intermediate inspections.

The WSSRAP began developing a formal embankment safety program in 1991. This program consists of an embankment safety manual and an inspection procedure. These documents will define regulatory and inspection requirements, identify training programs, document inspection requirements, and provide documentation of all embankment safety activities. This formal program will be implemented in 1992.

All embankments at the WSS were informally inspected during 1991. These inspections noted only minor deficiencies that did not threaten embankment integrity. Maintenance activities performed during 1991 included mowing and brush removal.

3.8 Waste Minimization/Pollution Prevention Program

The waste minimization/pollution prevention activities at the WSS have been combined and are described in the *Waste Minimization and Pollution Prevention Awareness Plan* (MKF and JEG 1991a). The program's key elements include:

- Chemical Control - To minimize the generation of hazardous waste a review and approval mechanism has been developed for chemical control. New purchase orders that are initiated by site personnel for chemically related materials are reviewed, evaluated, and approved by qualified personnel prior to purchase.

- Training and Awareness - Personnel at the WSSRAP maintain awareness of waste minimization concepts and on-site policy through periodic presentations, seminars, and other training.

- Work Activity Review - The site has developed and implemented a subcontractor work package review system that allows each affected site organization to review and comment on all proposed subcontracted work. Each package is reviewed to ensure that proper measures have been incorporated into the subcontractors requirements in support of waste minimization and pollution prevention.

- Recycling Program - A small, but successful, office recycling program was initiated by the WSSRAP in 1990. Conceived by the employees and endorsed by project management, the site presently reuses office materials and recycles office paper to the extent practical. It is also standard practice to purchase recycled paper products in an effort to increase the markets for recyclable materials. The program exemplifies the effectiveness of the site's employee participation program.

3.9 Airborne Asbestos Monitoring

From February 11 through March 25, 1991, an asbestos abatement operation was conducted at the Weldon Spring Chemical Plant. As specified in the WSSRAP *Environmental Monitoring Plan* (MKF and JEG 1992b), routine airborne asbestos monitoring is conducted on a weekly basis at the site perimeter stations and on a daily basis at Francis Howell High School (FHHS) during on-site asbestos abatement operations.

During the subject period, a total of 28 environmental air samples were collected. Eighteen of these samples were collected at FHHS and 10 were collected at site perimeter stations located both upwind and downwind of the site. Each sample was collected over a 7 hr to 8 hr sampling period, during normal site working hours, and was analyzed by Phase Contrast Microscopy (PCM). This method provides a measurement of total airborne concentrations for fibers having the same size and shape characteristics typical of asbestos fibers. PCM methodology does not distinguish between airborne asbestos and nonasbestos fibers having similar morphology. One sample collected at FHHS on February 19, 1991, was analyzed by transmission electron microscopy (TEM), which is capable of positively identifying asbestos fibers. No asbestos fibers were detected in the TEM analysis.

The results of the PCM air samples collected at the site perimeter stations ranged from 0.0001 fibers per cubic centimeters (f/cc) of air to .0006 f/cc; results from the samples collected at FHHS ranged from 0.0001 f/cc to 0.003 f/cc. Based on a comparison of sample results collected at the site perimeter stations and sample results collected at FHHS to the limit of 0.01 f/cc, no significant trends or findings were identified. Also, no significant difference was identified when the samples collected upwind of the site were compared to the samples collected downwind of the site. The environmental air samples indicate background airborne fiber concentrations.

Following completion of the on-site asbestos abatement operation, site perimeter and off-site airborne asbestos monitoring was discontinued for the remainder of 1991. Routine airborne asbestos monitoring at the site perimeter stations and at FHHS will resume during the on-site asbestos abatement operations scheduled to start in the second quarter of 1992.

In addition to environmental asbestos monitoring, periodic workplace and employee exposure monitoring were conducted throughout 1991. This monitoring was conducted in the vicinity, or in the breathing zone of, site personnel engaged in nonabatement activities such as building characterization, sump sampling, pre-bid tours, waste oil collection, and soil or debris excavation. Results of these samples indicated no personnel exposures above the U.S. Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) of 0.2 f/cc, 8 hr time weighted average. These data further demonstrate that there were no significant environmental fiber releases during these activities.

Two of the personnel exposure samples were analyzed by TEM. No asbestos fibers were detected on one of the TEM samples and the other TEM sample was found to have asbestos fibers well below the PEL.

3.10 Meteorological Monitoring

The WSSRAP installed a new meteorological observation tower to provide data on meteorological conditions and transport and diffusion qualities of the atmosphere at the site. Efforts are underway calibrate the equipment and to establish a quality assurance plan, performance audits, and system audits. Until such efforts are completed, the meteorological data collected cannot be assumed to be valid. Therefore, no meteorological data are presented in this section. The maintenance and data inspection requirements of the system are detailed in procedure ES&H 4.8.3s.

Located near the main entrance to the chemical plant site, the meteorological station monitors the following parameters: wind speed, wind direction, horizontal wind fluctuation, ambient air temperature, barometric pressure, and precipitation intensity and accumulation. Data collected at the tower will facilitate dispersion and diffusion modeling to supplement ambient air monitoring in the determination of off-site radiological dose assessment in the event of an airborne release. Data will also be used to support the WSSRAP environmental surveillance program. Precipitation measurements will be correlated to aquifer water level fluctuations in the Femme Osage Slough and the Weldon Spring Quarry (WSQ). Water level fluctuations will be studied to aid in the determination of the cause of fluctuating uranium concentrations at the aforementioned locations. Wind direction results may be analyzed to determine if studies on foliar absorption of radiological or chemical contaminants by vegetation are needed.

3.11 Training

Training is a key element of the environmental protection program. Through training, each employee is instructed in the policies and procedures related to environmental protection. On-going training sessions also continually reinforce the objectives of the program.

The training program can essentially be broken into four main areas; (1) documents, (2) procedures, (3) special courses taught on-site to convey specific policies or issues and, (4) off-site courses designed to provide instruction for specific areas. Each new employee at the WSSRAP is assigned training requirements based on job assignment. The department manager establishes a unique training matrix for each employee that includes documents, procedures, on, and possibly off-site, training courses.

Course selection for each employee is specifically designed to ensure a comprehensive understanding of position requirements and overall policies and program requirements. The need for off-site training to augment site training is evaluated annually and included in the fiscal year budget. Courses specific to waste management are reviewed and planned throughout the year for general employee training. Other off-site courses are mandated for key individuals as a part of on-going training or certification requirements.

The status of employee training is reported to the various departmental managers and the individual employees on a monthly basis. Monthly reports include status of documents and procedures reviewed, as well as training programs and off-site courses taken during the current year.

4 AIRBORNE, GAMMA AND ENVIRONMENTAL RADIATION DETECTION PROGRAM AND MONITORING RESULTS

4.1 Radiological Monitoring Program Information

The Weldon Spring Site Remedial Action Project (WSSRAP) operates its environmental monitoring and surveillance program in accordance with the U.S. Department of Energy (DOE) Orders in the 5400 series. The substances present as wastes on the site require monitoring for both radiological and nonradiological constituents. This section describes radiological monitoring results for radon, external gamma radiation, and airborne radioactive particulates at various site perimeter and off-site locations.

The assessment of potential radiological impacts to potential receptors and populations from activities at the Weldon Spring site (WSS) is performed through statistical comparisons of the data acquired through the monitoring program, as well as the demonstration of compliance with regulatory requirements. In cases where data collection is performed under similar conditions, hypothesis testing is done to compare, at the 95% confidence level, the results measured at all on-site and off-site monitoring locations to those measured at background locations. Monitoring results that are statistically different from background monitoring results are documented and the potential impacts evaluated. The environmental radiation monitoring programs, monitoring results, and related environmental impacts from site-related radiological contaminants are described below.

4.1.1 Radon Gas Monitoring

Radon is a naturally occurring radioactive gas found in both the uranium and thorium decay series. Rn-222 is formed by the natural radioactive decay of Ra-226. Both Rn-222 and Ra-226 are nuclides of the U-238 decay series. Rn-220 (also historically described as thoron) is formed by the natural radioactive decay of Ra-224. Rn-220 and Ra-224 are nuclides of the Th-232 decay series. Both U-238 and Th-232 are naturally occurring radionuclides in soil and rock. A fraction of the radon produced from the radioactive decay of naturally occurring U-238 and Th-232 diffuses from the soil and rock into the atmosphere, accounting for natural background airborne radon concentrations. Radon is produced at the WSS from these natural sources as well as from the Ra-226 and Ra-224 contained in contaminated waste materials.

Airborne radon concentrations fluctuate with both soil conditions and meteorological conditions. The amount of radon that actually enters the atmosphere varies depending on the following parameters: radium concentrations in soil, soil moisture content, soil porosity, soil density, emanating fraction, and atmospheric pressure.

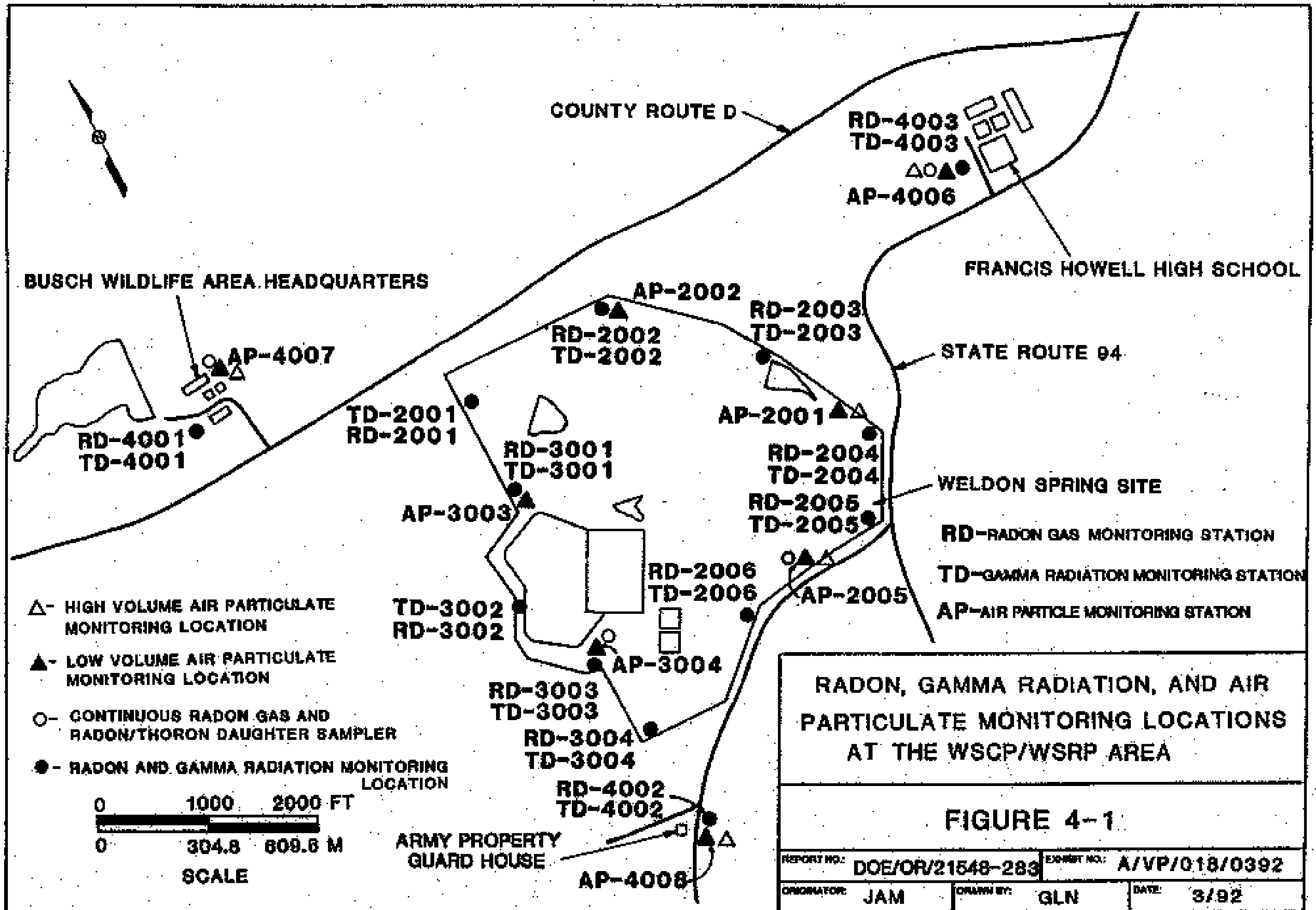
The emanating fraction is the fraction of radon produced in soil that escapes from soil particles into the pore spaces, the air-filled voids present in soils. Only the radon entering these pore spaces is available for release to the atmosphere.

Porosity is a measure of the pore space or fraction of total soil volume occupied by the pore spaces. The higher the soil porosity the greater the number of available pore spaces for radon migration.

Some fraction of the total pore space volume is typically filled with water. Soil moisture content provides a measure of this fraction. Radon diffuses easier through air-filled pore spaces than water-filled spaces. Therefore, the higher the soil moisture content, the lower the radon emanation rate into the atmosphere. The moisture content of the soil is the most variable of these parameters and is primarily responsible for quarterly and annual changes in airborne radon concentrations.

The radon gas environmental monitoring program utilizes a pair of radon detectors at each of 22 permanent monitoring locations; six locations at the WSCP perimeter, six locations at the WSQ perimeter, four locations at the WSRP perimeter, and six off-site locations. Radon monitoring locations are identified with an "RD" prefix and are shown in Figures 4-1, 4-2, and 4-3. On-site monitoring locations are distributed around the perimeter fences to ensure adequate detection of radon dissipating from the WSS under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005 and RD-4006 monitor background radon gas concentrations.

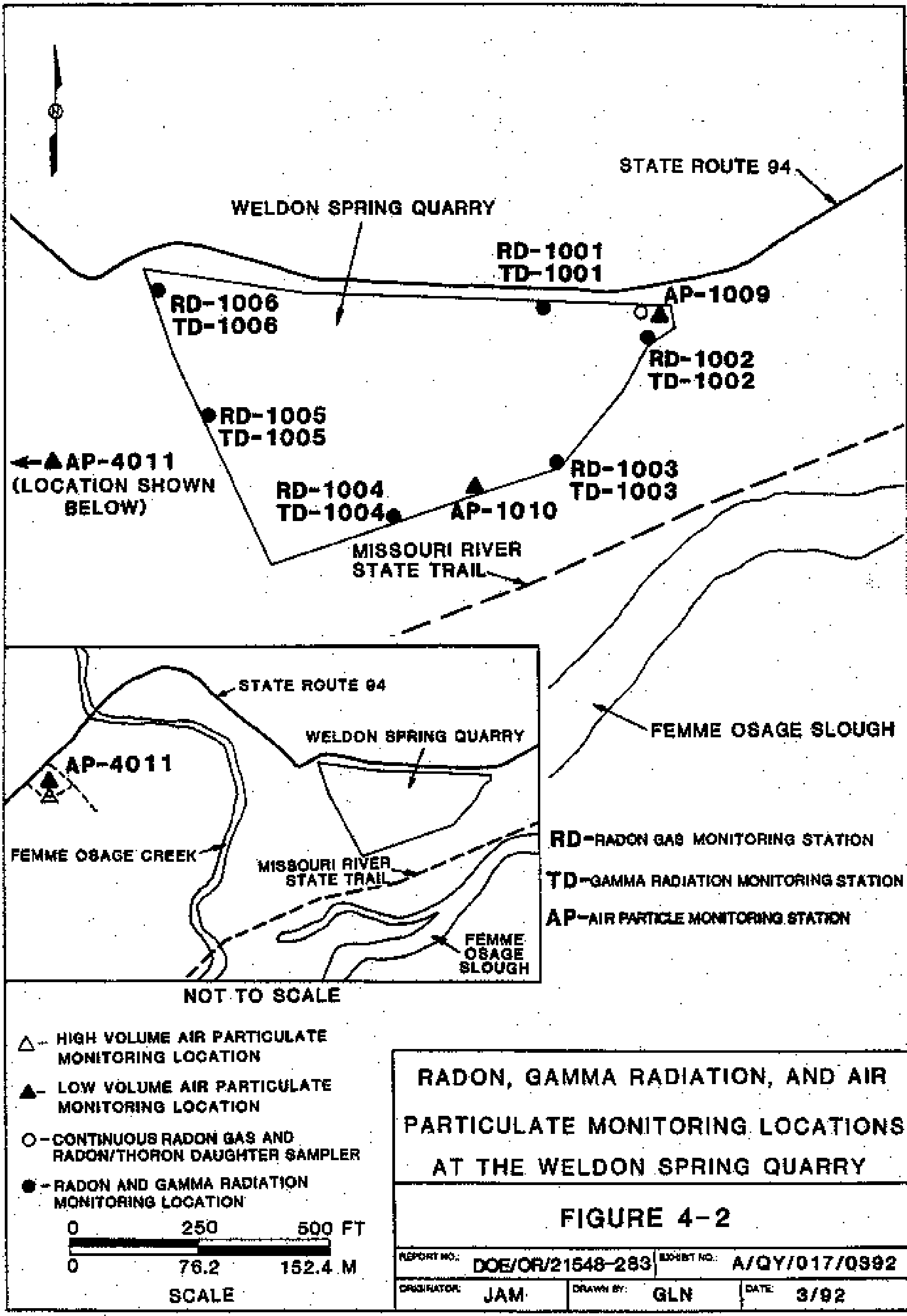
The radon detectors used in this program are Terradex Track Etch Type F. Type F detectors are sensitive to all isotopes of radon. These detectors are housed in protective plastic cups and are mounted in an inverted fashion on posts. The detectors are exchanged at the beginning of each calendar quarter and are analyzed off site. The detectors are deployed in pairs to evaluate and reduce the natural uncertainties associated with this type of measurement.



RADON, GAMMA RADIATION, AND AIR PARTICULATE MONITORING LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 4-1

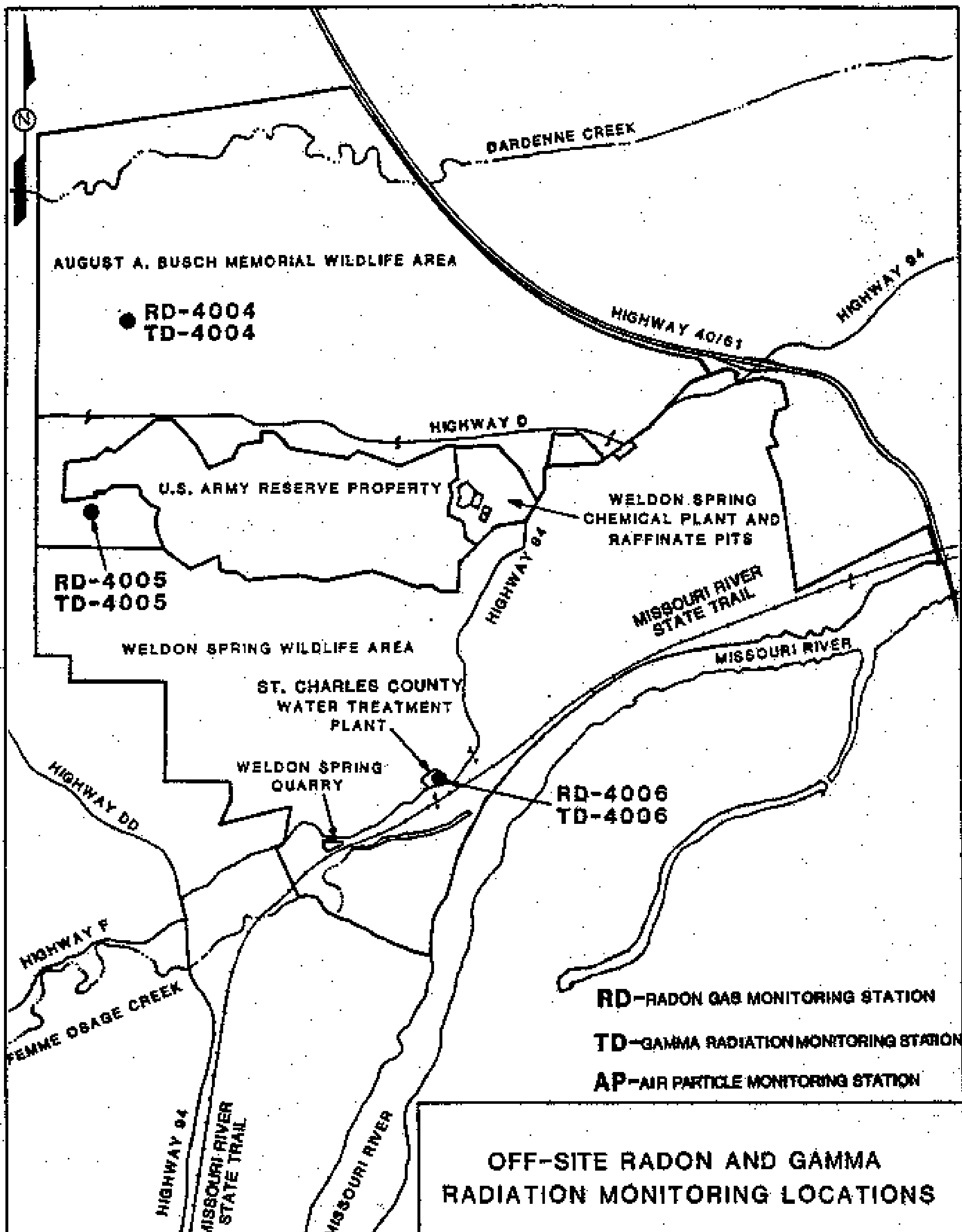
REPORT NO.: DOE/OR/21548-283		EXHIBIT NO.: A/VP/018/0392	
ORIGINATOR: JAM	DRAWN BY: GLN		DATE: 3/92



RADON, GAMMA RADIATION, AND AIR PARTICULATE MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 4-2

REPORT NO.: DOE/OR/21548-283	EXHIBIT NO.: A/QY/017/0392	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/92



OFF-SITE RADON AND GAMMA RADIATION MONITORING LOCATIONS

FIGURE 4-3

REPORT NO: DOE/OR/21548-283		EXHIBIT NO.: A/VP/019/0392	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/92	

For each monitoring station, the results obtained from the pair of detectors at each location were averaged to achieve a quarterly average radon concentration for the location. These quarterly averages were then utilized to determine annual average radon concentrations at each location. The annual standard deviation was calculated by taking the square root of the sum of the squared quarterly standard deviations.

In cases where the results for the quarter were reported as below the detection limit, the "less than detect value" was replaced with one half of the detection limit. This approach is recommended by the U.S. Environmental Protection Agency (EPA 1980). This value was then used in calculating annual averages and standard deviations.

Table 4-1 summarizes the quarterly and annual average radon (Rn-220 and Rn-222) concentrations detected at all WSS perimeter and off-site monitoring locations. Also contained in Table 4-1 is a comparison of the measured annual average concentration to the derived concentration guideline (DCG) for unrestricted areas of 3 pCi/l (111 Bq/m^3) above background specified in DOE Order 5400.5.

The annual background concentration was determined by calculating the arithmetic average of concentrations reported for the four background monitoring locations. These four locations are: RD-4001, RD-4004, RD-4005, and RD-4006. These data yielded an annual average background radon concentration (Rn-222 and Rn-220) in 1991 of 0.3 pCi/l (11.1 Bq/m^3). The average background radon concentration did not change from the 1990 average and was less than the 1989 average of 0.6 pCi/l (22.2 Bq/m^3).

The quarterly radon concentrations at each monitoring location were compared statistically, at the 95% confidence level, to the quarterly concentrations of the four background locations. Those locations that were statistically greater than background were compared to the DCG for unrestricted areas (3 pCi/l). In order to make the comparisons, the average annual background concentration was subtracted from the annual average concentration obtained at the monitoring location. This value was then compared to the DCG. The results are presented in Table 4-1.

4.1.1.1 Chemical Plant/Raffinate Pits. Radon concentrations at the WSS perimeter and at the raffinate pit locations obtained in 1991 were comparable to those obtained in 1990. The perimeter stations yielded an overall average that was slightly less than in 1990.

TABLE 4-1 1991 Radon Track Etch Monitoring Results for the WSCP/RP and WSQ Areas[a]

Location I.D.	1st Quarter pCi/l	2nd Quarter pCi/l	3rd Quarter pCi/l	4th Qurater pCi/l	Annual Average pCi/l	Std. Dev.	Percent of DCG [b][c]
WSQ							
RD-1001	0.4	1.3	1.9	1.1	1.2	0.3	30
RD-1002	0.9	1.3	2.0	1.8	1.5	0.4	40
RD-1003	0.7	0.5	0.8	0.8	0.7	0.2	13
RD-1004	0.1	0.4	0.9	0.4	0.4	0.2	
RD-1005	0.5	0.8	0.8	0.6	0.7	0.2	13
RD-1006	0.2	0.4	0.7	0.2	0.4	0.2	
WSCP							
RD-2001	0.5	0.3	0.5	0.3	0.4	0.2	
RD-2002	0.1	0.1	0.7	0.2	0.3	0.1	
RD-2003	0.1	0.3	0.5	0.1	0.2	0.1	
RD-2004	0.1	0.3	0.4	0.2	0.2	0.1	
RD-2005	0.04	0.2	0.5	0.03	0.2	0.1	
RD-2006	0.1	0.2	0.7	0.3	0.3	0.1	
WSRP							
RD-3001	0.04	0.2	0.8	0.3	0.3	0.1	
RD-3002	0.1	0.3	0.8	0.2	0.3	0.2	
RD-3003	0.1	0.3	0.5	0.2	0.3	0.1	

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TABLE 4-1 1991 Radon Track Etch Monitoring Results for the WSCP/RP and WSQ Areas[a] (Continued)

Location I.D.	1st Quarter pCi/l	2nd Quarter pCi/l	3rd Quarter pCi/l	4th Qurater pCi/l	Annual Average pCi/l	Std. Dev.	Percent of DCG [b][c]
RD-3004	0.1	0.3	0.5	0.1	0.3	0.1	
OFF SITE							
RD-4001*	0.1	0.3	0.5	0.2	0.2	0.1	
RD-4002	0.2	0.2	0.6	0.2	0.3	0.1	
RD-4003	0.2	0.2	0.6	0.2	0.3	0.1	
RD-4004*	0.1	0.3	0.6	0.2	0.3	0.1	
RD-4005*	0.1	0.2	0.6	0.1	0.3	0.1	
RD-4006*	0.04	0.3	0.7	0.2	0.3	0.1	

(a) Results include natural background radon concentration.

(b) Percent of Derived Concentration Guideline (DCG) calculated by taking the annual average minus the average background concentration (i.e., 0.3 pCi/l), divided by the DOE DCG for Rn-222 (i.e., 3 pCi/l [111 Bq/M^3]).

(c) Percent of guideline calculated only for stations that are statistically different from background.

* Denotes background station.

None of the monitoring locations in the chemical plant and raffinate pit areas provided results that were statistically different from background concentrations. Both 1990 and 1991 radon concentrations are substantially lower in these areas than in 1988. Elevated radon concentrations were recorded in 1988 because of a regional drought. The 1988 drought reduced the moisture content of the soils and the radium-containing wastes, allowing a greater fraction of radon present in the soil and waste voids to diffuse into the atmosphere. The lower radon concentrations recorded in the last two years are typical of values expected during years of normal precipitation levels and are comparable to concentrations reported prior to 1988.

4.1.1.2 Quarry. Radon concentrations at the quarry were found to be statistically greater, at the 95% confidence level, than background radon concentrations. Radon concentrations measured at the quarry perimeter are typically greater than concentrations measured at other WSS monitoring locations. Increased radon concentrations at the quarry are due to the radium present in the quarry bulk wastes, which is much greater than the radium present in most other contaminated areas. Also, the quarry is a large depression in the terrain with side walls ranging from 3 m to 15 m high (10 ft to 50 ft), which tends to trap emanating radon within the quarry and elevate the concentrations along the quarry perimeter. However, none of the locations at the quarry showed annual average radon concentrations above the DOE DCG annual average radon concentration of 3 pCi/l (111 Bq/m^3). Overall, the concentrations at the quarry were slightly less than the concentrations measured in 1990 and reflect values expected during years of normal precipitation.

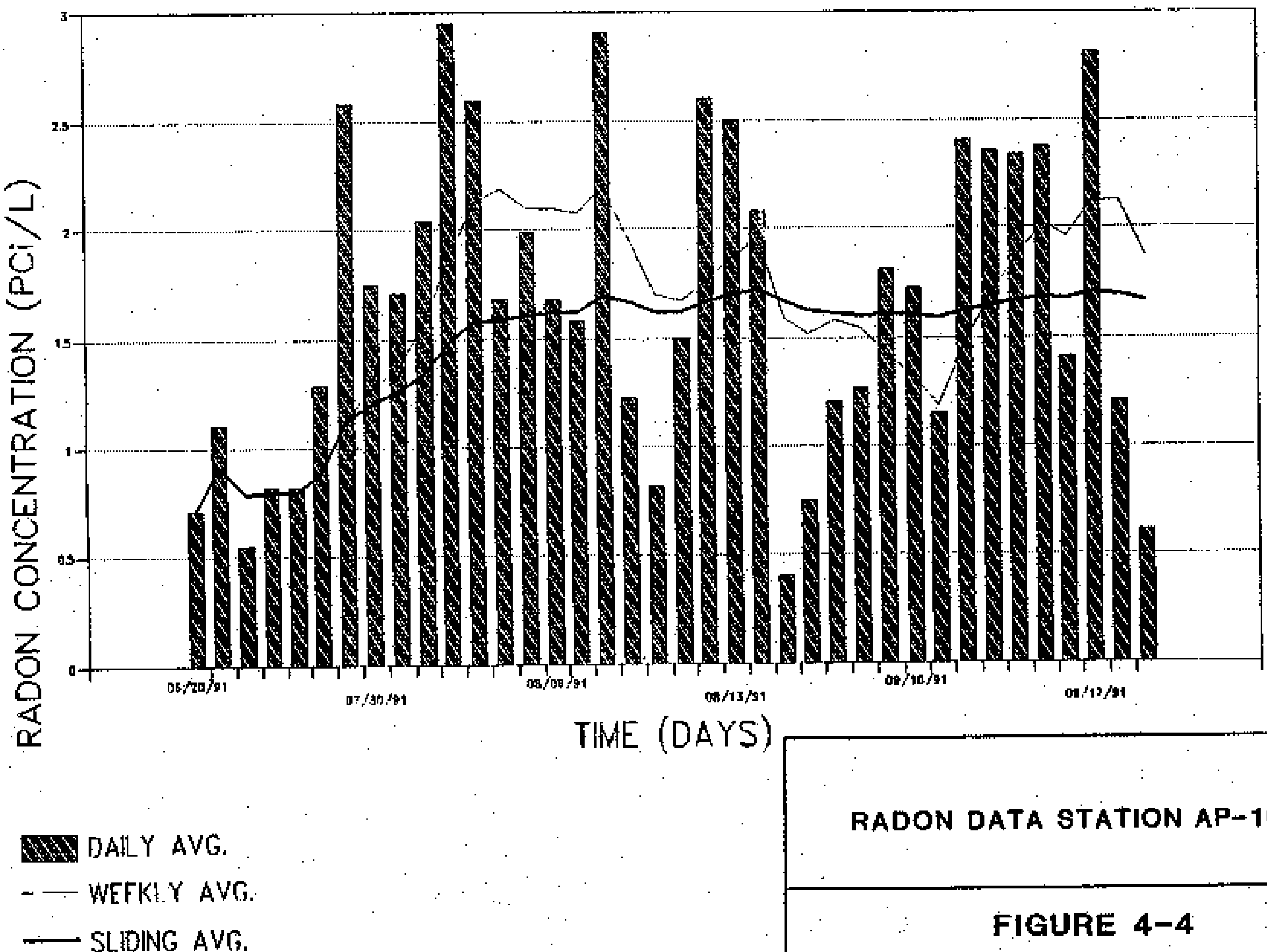
4.1.1.3 Off-Site. Radon concentrations found at the off-site locations in 1991 were similar to those obtained in 1990. The concentration levels measured in 1991 are representative of typical background concentrations and reflect those measured in years with normal precipitation.

4.1.1.4 Continuous Radon Monitoring. A new facet was added to the radon environmental monitoring program at the WSS in mid-1991. Continuous radon gas and radon daughter monitors were placed at locations AP-2005, AP-4007, AP-3004, AP-1009, and AP-4006 as shown on Figures 4-1 and 4-2. The continuous monitors are portable, fully automated instruments capable of continuously monitoring for radon gas, and radon and thoron progeny (daughters). The data are retrieved from the sampler locations by downloading the data from the monitor's internal storage center to a portable computer. The continuous radon gas and radon daughter samplers were placed in operation in mid-June and remained in place until early October. Prior to installation in June, the monitors were calibrated at the DOE radon calibration facility in Grand Junction, CO. The samplers were removed from service in early October to conduct a test of operational comparativeness. The test was performed during October to December and indicated that the samplers operate in the same manner. A major hindrance to the continuous radon gas monitoring program is the reoccurrence of malfunctions within the monitor's framework causing the sampler to shut down. On average, each monitor required approximately six weeks of off-site maintenance during the 17 week operational period.

For each monitoring station, the hourly concentration measurements, which are obtained on a daily basis, are averaged to achieve a daily average for the location. Daily averages are used to calculate weekly averages, which are used to calculate sliding averages. Sliding averages represent the average of all data collected at each monitoring station from the actual day the monitor began operation to date.

Figures 4-4 through 4-8 show the daily averages, weekly averages, and sliding averages for each continuous radon monitoring station. Figure 4-8 illustrates the results of the background continuous radon monitoring station, AP-4007. The graphs show that the sliding average, including background, at locations AP-1009, AP-2005, AP-3004, and AP-4006, is below the derived concentration guideline for unrestricted areas of 3 pCi/l (111 Bq/m^3) above background.

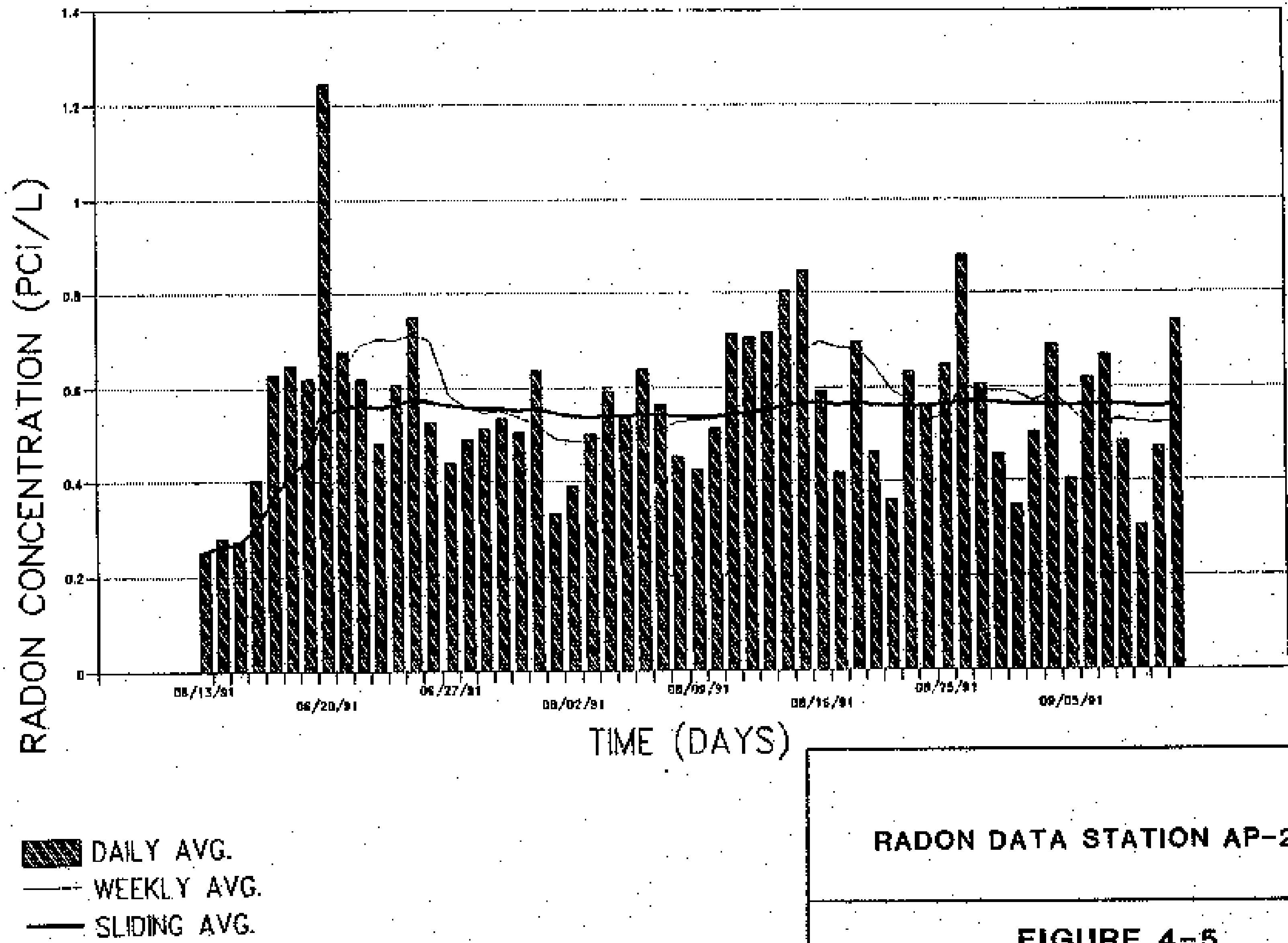
The initiation of the continuous radon monitoring program during 1991 provided another mechanism for evaluating possible effects of radon gas and radon progeny on the surrounding environment. Although valuable information concerning the operational structure of this program was gathered through the first year of the program, the statistical comparisons that were performed for the radon track-etch monitoring data are not applicable to the data obtained through the continuous radon monitoring program. Reliable comparisons of radon concentrations at each continuous sampler monitoring location to the recorded background radon concentration are not appropriate due both to the operational problems of the samplers and the variation in atmospheric radon concentrations. Since radon concentrations in the atmosphere fluctuate due to both soil and meteorological conditions, monitoring stations that are not sampling over identical time intervals do not provide data sets representative of collection under identical conditions. For statistical comparisons of data sets to be valid, the data collection conditions must be approximately the same. It is not appropriate to compare the results obtained at two different locations when sample collection occurs under dissimilar conditions.



RADON DATA STATION AP-1009

FIGURE 4-4

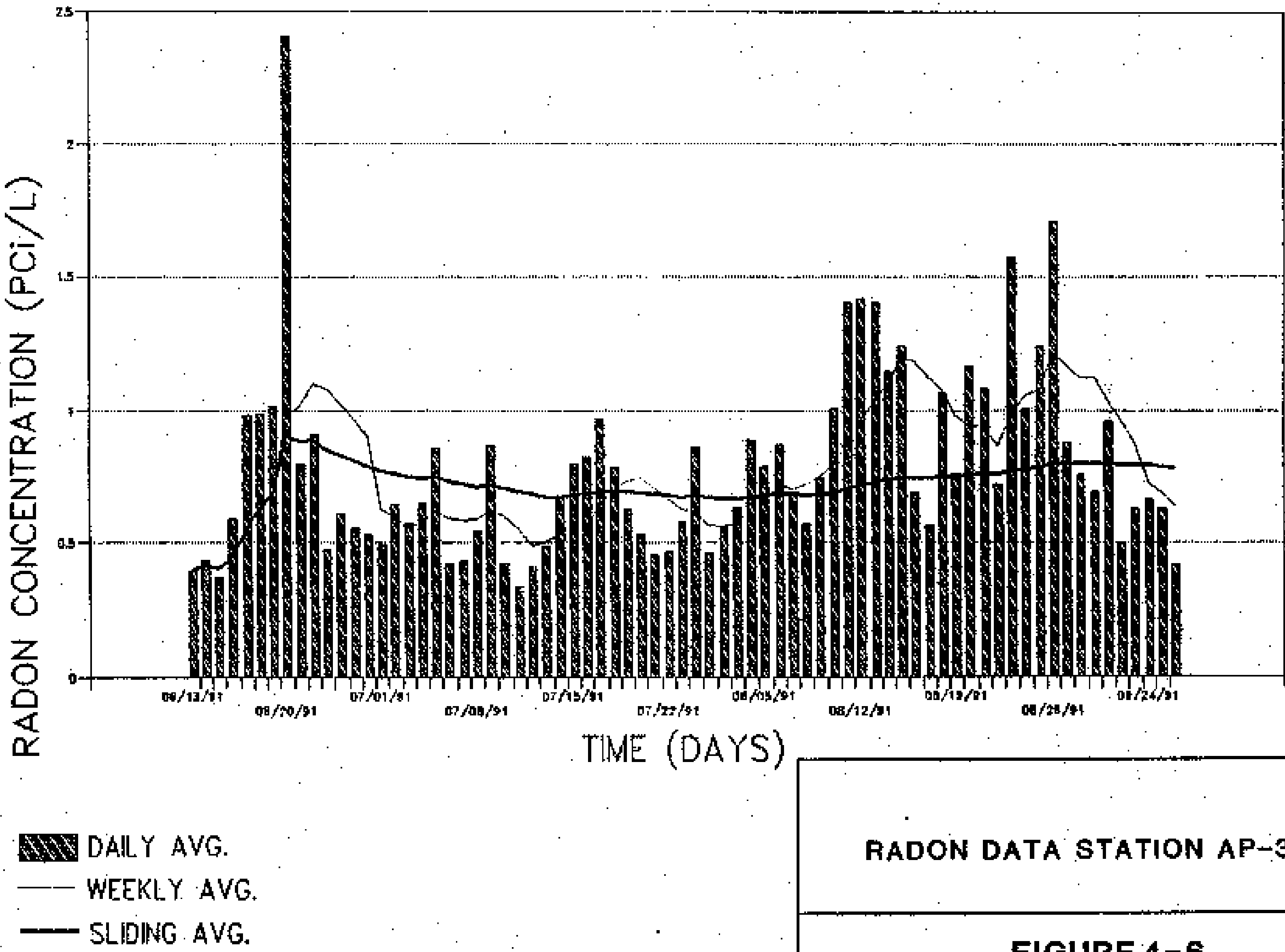
REPORT NO.:	DOE/OR/21548-283	EXHIBIT NO.:	A/PI/051/0392		
ORIGINATOR:	JAM	DRAWN BY:	SRS	DATE:	3/92



RADON DATA STATION AP-2005

FIGURE 4-5

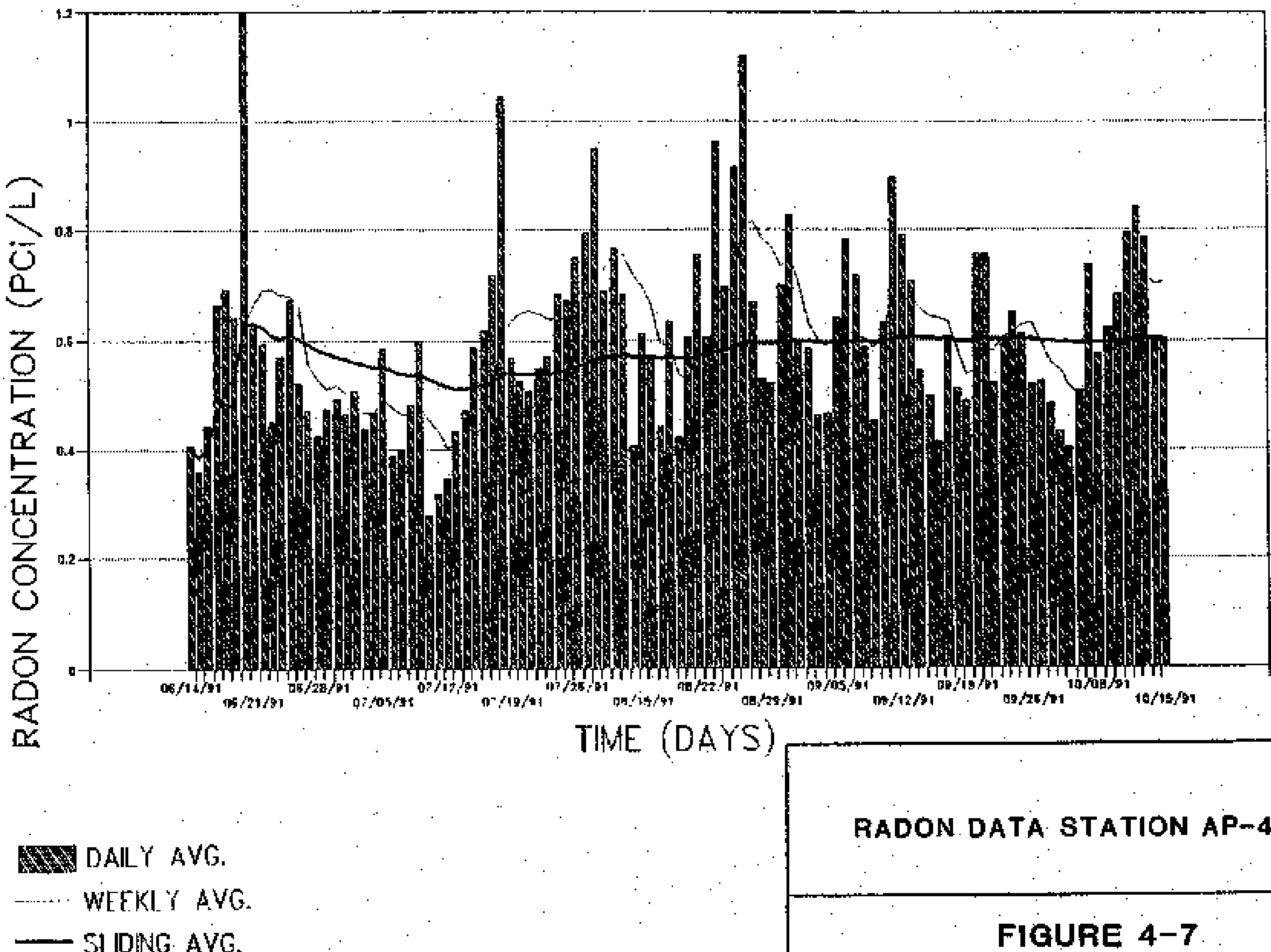
REPORT NO.: DOE/OR/21548-283		EXHIBIT NO.: A/PI/062/0392	
ORIGINATOR: JAM	DRAWN BY: SRS	DATE: 3/92	



RADON DATA STATION AP-3004

FIGURE 4-6

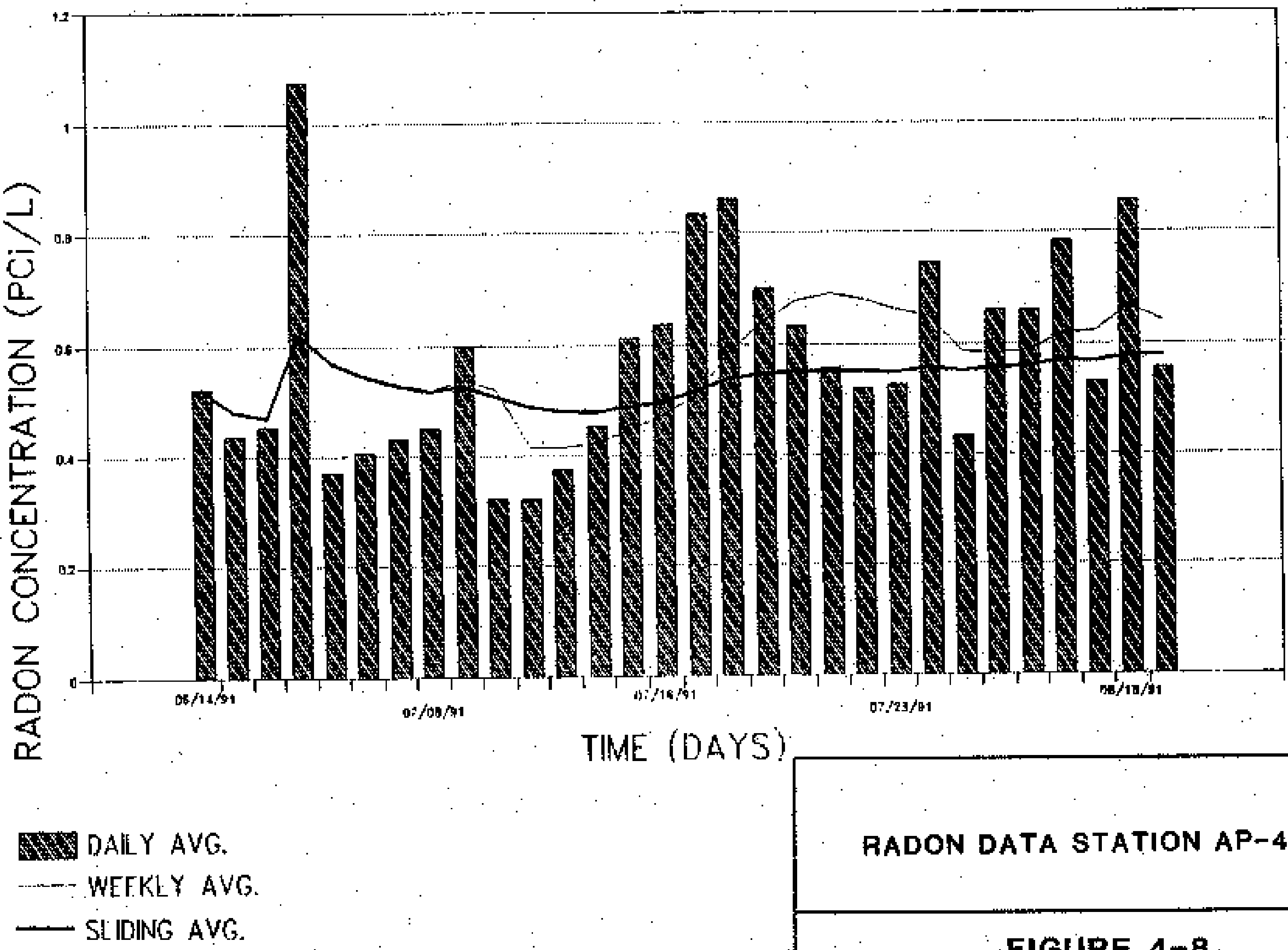
REPORT NO.: DOE/OR/21548-283		EXHIBIT NO.: A/PI/053/0392	
ORIGINATOR: JAM	DRAWN BY: SRS	DATE: 3/92	



RADON DATA STATION AP-4006

FIGURE 4-7

REPORT NO.: DOE/OR/21548-283		EXHIBIT NO.: A/PI/054/0392	
ORIGINATOR: JAM	DRAWN BY: SRS	DATE: 3/92	



RADON DATA STATION AP-4007

FIGURE 4-8

REPORT NO.:	DOE/OR/21548-283	EXHIBIT NO.:	A/PI/066/0392		
ORIGINATOR:	JAM	DRAWN BY:	SRS	DATE:	3/92

4.1.1.5 Five Year Trend Analysis of Radon Gas. Figure 4-9 graphically presents the track etch radon detector results from the last five years. The graph shows the annual average radon concentration for the monitoring stations at the quarry, chemical plant, raffinate pits, and off-site locations. The results shown include natural background radon concentrations.

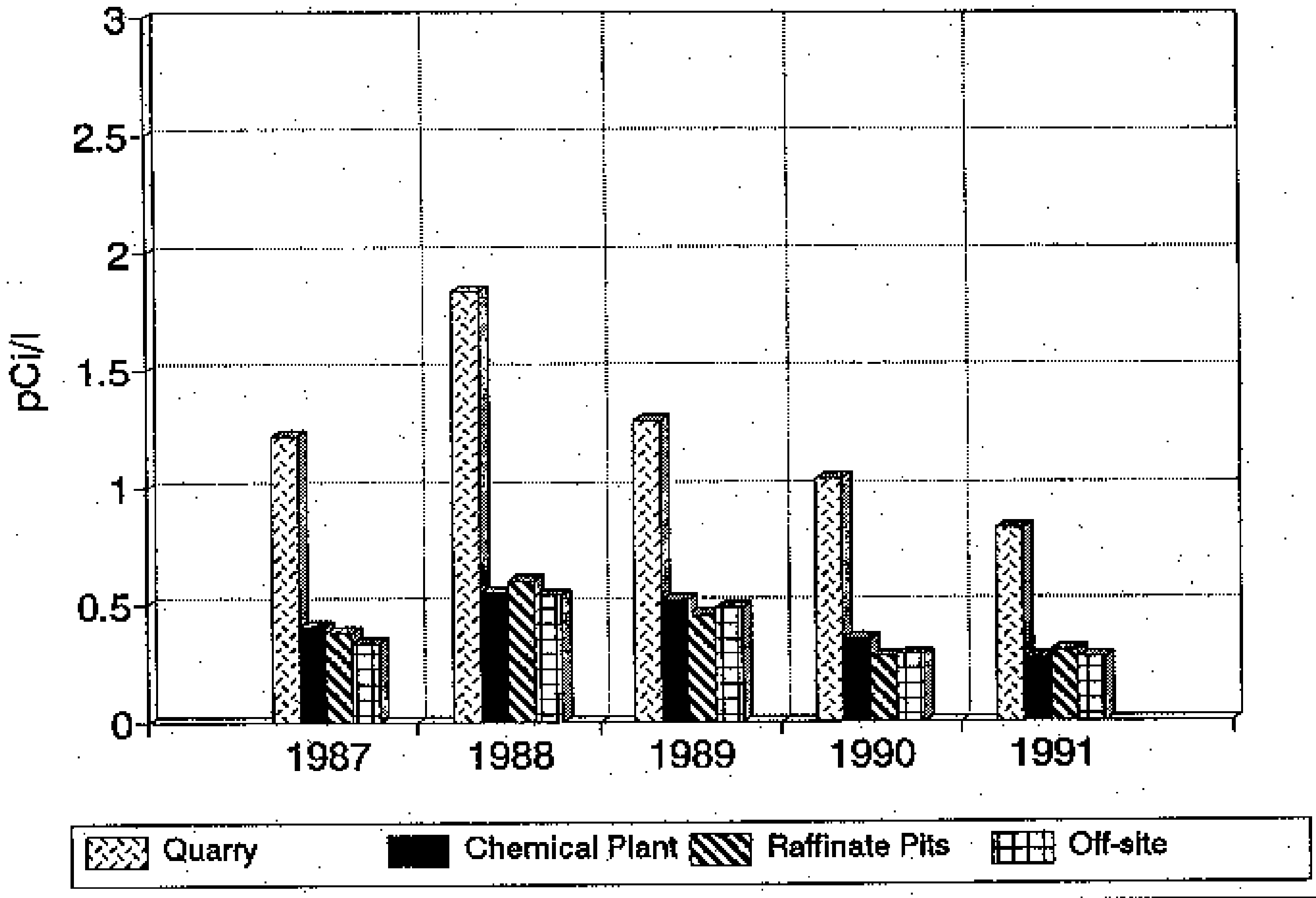
The graph depicts a distinct decrease in radon concentration after 1988, a year in which dry climatic conditions led to increased levels of radon emanation from local soils and quarry bulk wastes.

The average radon concentrations in 1991 were lower than those recorded annually over the last five years. The quarry annual average concentration for 1991 was higher than concentrations measured in other areas which maintains the annual trend at the Weldon Spring Quarry (WSQ). As stated previously, the higher concentrations recorded at the quarry are a result of the higher radium concentrations present in the quarry bulk wastes. In addition, the shape and size of the large depression tends to trap radon within the quarry walls and consequently, elevate the concentrations at the perimeter.

4.1.2 Gamma Radiation Monitoring

Gamma rays are ionizing electromagnetic radiation emitted from the nucleus of atoms. The environment contains natural radioactive substances which emit gamma radiation. Terrestrial radiation sources refers to natural radioactive elements in the environment, primarily Potassium-40, and radioactive isotopes of the uranium and thorium series found in the earth. Cosmic radiation is high-energy radiation that originates in outer space and filters through the atmosphere reaching the earth's surface.

Together, these two sources account for natural background gamma radiation. The average annual dose equivalent to people in the United States from cosmic radiation is approximately 30 mrem (0.3 mSv). The magnitude of the resulting dose from cosmic radiation increases with altitude above the earth's surface. The annual dose from terrestrial gamma radiation varies geographically across the United States, from about 16 mrem (0.16 mSv) at the Atlantic and Gulf Coastal plains to about 63 mrem at the eastern slopes of the Rocky Mountains. The United Nations (UNSCEAR 1982) estimates the typical external annual effective dose equivalent from all naturally occurring radiation to be 30 mrem/yr (0.3 mSv/yr) from cosmic



TRACK ETCH RADON RESULTS

FIGURE 4-9

REPORT NO.: DOE/OR/21548-283			EXHIBIT NO.: A/PI/72/0492		
ORIGINATOR: JAM	DRAWN BY: SRS		DATE: 4/92		

sources and 35 mrem/yr (0.35 mSv/yr) from terrestrial radiation for a total of 65 mrem/yr (0.65 mSv/yr).

Gamma radiation is emitted by many radionuclides in the U-238 and Th-232 decay series. These radionuclides are found in above-background concentrations in many areas of the WSS. Gamma radiation is monitored using environmental thermoluminescent dosimeters (TLDs). The TLDs are composed of five lithium fluoride chips in a durable spherical polyethylene holder. The TLDs are deployed at 22 monitoring stations. Ten monitoring stations are located at the Weldon Spring Chemical Plant/Weldon Spring raffinate pits (WSCP/WSRP) along the perimeter fence (Figure 4-1), six stations are located along the Weldon Spring quarry (WSQ) perimeter fence (Figure 4-2), and six monitoring stations are located off site (Figures 4-1 and 4-3). Monitoring stations TD-4001, TD-4004, TD-4005, and TD-4006 measure natural background at locations unaffected by the site. Environmental TLDs are exchanged on a quarterly basis.

To determine background levels of gamma radiation as measured with the TLDs, the quarterly gamma radiation measurements at the four background monitoring stations were averaged to produce the annual average background gamma radiation dose rate. This yielded an average gamma radiation dose rate of 69 mrem/yr (0.69 mSv/yr) with a standard deviation of 3.4 mrem/yr (0.034 mSv/yr). This average background dose rate is comparable to the UNSCEAR estimate of 65 mrem/yr (0.65 mSv/yr) for this area.

Table 4-2 summarizes the quarterly and annual average gamma radiation monitoring results at the 16 WSS perimeter monitoring stations, Francis Howell High School, the Weldon Spring Army Reserve Training Area (WSTA), and at the four background monitoring stations. The results reported in the table include quarterly averages and annual totals for each monitoring station with the standard deviation. The standard deviations reported in this table reflect the error propagated by summing the square of the quarterly standard deviations and then taking the square root. TLDs were found missing at station TD-4004 during the second and fourth quarters and at Station TD-4001 during the third quarter. In order to calculate an annual total gamma exposure rate, the missing data were replaced with the average of the remaining quarterly TLD results for those monitoring stations.

The 1991 gamma radiation monitoring results were slightly higher for the first quarter and consistently lower for the third quarter than the results recorded in 1990 at all locations. The second quarter results were very similar to those obtained in the previous year. The most

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Table 4-2 1991 Environmental TLD Results[a]

Location I.D.	1st Quarter (mrem)	2nd Quarter (mrem)	3rd Quarter (mrem)	4th Quarter (mrem)	Annual Total (b) (mrem/yr)	Standard Deviation
WSO						
TD-1001	24	17	21	28	90	6.0
TD-1002	20	15	17	28	80	6.3
TD-1003	20	20	19	28	87	3.5
TD-1004	19	17	18	29	83	4.2
TD-1005	20	17	18	29	88	5.7
TD-1006	19	18	17	23	77	3.7
WSCP						
TD-2001	18	16	15	27	76	4.3
TD-2002	17	16	17	25	75	4.5
TD-2003	18	17	16	25	76	4.9
TD-2004	19	17	17	29	82	5.5
TD-2005	18	14	15	22	68	5.1
TD-2006	17	15	16	24	72	4.0

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Table 4-2 1991 Environmental TLD Results[a] (Continued)

Location I.D.	1st Quarter (mrem)	2nd Quarter (mrem)	3rd Quarter (mrem)	4th Quarter (mrem)	Annual Total (b) (mrem/yr)	Standard Deviation
WSRP						
TD-3001	22	14	15	20	65	3.9
TD-3002	17	13	13	28	77	4.7
TD-3003	19	17	16	24	76	3.4
TD-3004	16	14	16	30	61	6.8
OFF-SITE						
*TD-4001	18	16	--	20	72	4.1
TD-4002	16	13	14	20	63	4.4
TD-4003	16	12	12	19	63	2.7
*TD-4004	19	--	16	--	70	1.9
*TD-4005	16	12	11	25	64	4.2
*TD-4006	17	15	17	20	69	4.7

(a) Results include natural background gamma radiation.

(b) Annual totals for locations where quarterly data is unavailable were calculated using the average of the existing quarterly data in place of the unavailable data.

-- Denotes lost or damaged TLD.

* Denotes background station.

To convert to mSv/yr, divide by 100.

significant difference was observed in the results obtained in the fourth quarter of 1991. The average increase in the fourth quarter results from 1990 to 1991 was approximately 38%. In addition, the 1991 fourth quarter measurements were approximately 33% greater than the average values obtained during the other three quarters of 1991 for all gamma radiation monitoring stations. Fifteen percent of the increase in the 1991 fourth quarter results can be accounted for by the fact that the gamma response factor incorporated for the processing of the environmental TLDs was revised to reflect the findings of a study conducted by the off-site subcontract laboratory on October 31, 1991. The change to the response factor was made in order to compensate for the radiation attenuation due to the material used to fabricate the spherical TLD badges and was incorporated by the off-site laboratory in the fourth quarter environmental monitoring report.

The elevated readings for the fourth quarter have resulted in an overall increase of about 10% for annual totals for the WSQ, WSCP, WSRP, and off-site locations from 1990 to 1991. However, the change incorporated by the laboratory, in their mechanism for processing the TLDs during the fourth quarter of 1991, accounts for only 15% of this increase. There were no activities performed at the WSSRAP during the quarter that would indicate the potential for an increase in the gamma exposure rate above this laboratory adjustment. Additional investigations are being conducted to evaluate possible explanations for the anomalous results. Any findings related to this investigation will be reported in future monitoring reports.

4.1.2.1 Chemical Plant/Raffinate Pits. The annual total gamma radiation measurements ranged from 61 mrem to 82 mrem (0.61 mSv to 0.82 mSv) at the WSCP/WSRP site perimeter. It was determined through statistical comparison of these values to the measurements obtained at the four background stations that, at the 95% confidence level, none of the stations provided results that were different from natural background levels.

4.1.2.2 Quarry. The annual total gamma radiation measurements ranged from 77 mrem to 90 mrem (0.77 mSv to 0.90 mSv) at the quarry. Total annual results at two of the six monitoring stations at the quarry, TD-1001 and TD-1003, located on the north and southeast perimeter respectively, were statistically greater than the average background dose rate at the 95% confidence level. Although gamma radiation dose rates were above background at these two stations, the effective dose equivalent guideline of 100 mrem (1.0 mSv) above background for all exposure modes as cited in DOE 5400.5 was not exceeded. Table 4-3 presents a comparison of the annual effective dose equivalent from external gamma radiation measured at

TD-1001 and TD-1003, to the DOE 100 mrem/yr guideline for all exposure modes. The percent of the DOE standard was calculated by subtracting the annual average background dose equivalent rate (69 mrem/yr ± 3.4 mrem/yr [0.69 ±0.034 mSv/yr]) from the annual dose equivalent rate measured at stations TD-1001 and TD-1003 and then dividing by the 100 mrem/yr (1.0 mSv/yr) DOE standard.

Table 4-3 Summary of Gamma Radiation Monitoring Results of Stations Statistically Different From Background at the 95% Confidence Level

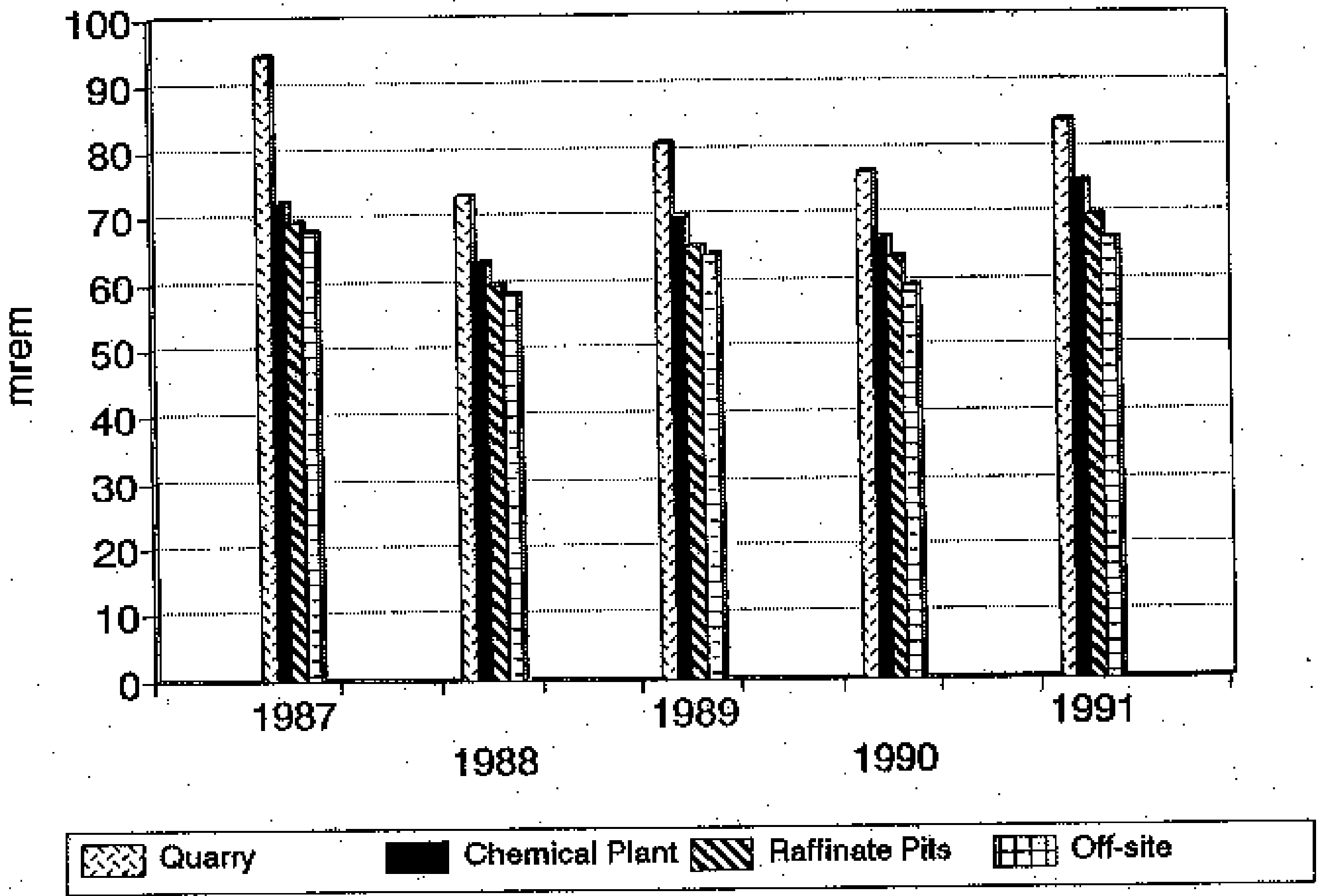
Station Number	Location	Annual Dose Rate (mrem/yr)[a]	Percent of DOE Guidelines [b]
TD-1001	WSQ North Perimeter	90	21
TD-1003	WSQ Southeast Perimeter	87	18

(a) Results include natural background gamma radiation.
(b) Percent of the DOE guideline is calculated by dividing the net annual dose rate (i.e., annual total minus background) by the DOE guideline of 100 mrem. The 100 mrem guideline applies to the sum of all exposure pathways.

4.1.2.3 **Off-Site.** At the off-site locations, the annual total gamma radiation dose rates ranged from 63 mrem to 72 mrem (0.63 mSv to 0.72 mSv); the annual gamma radiation dose rates at the Francis Howell High School and at the U.S. Army Reserve were both 63 mrem (0.63 mSv). At these two locations, there was no reason to suspect, at the 95% confidence level, that the measured exposure levels were greater than background.

4.1.2.4 **Five Year Trend Analysis of TLDs.** Gamma radiation exposure monitoring results from the last five years are represented graphically in Figure 4-10; the graph represents the yearly averages of results from monitoring stations at the quarry, chemical plants, raffinate pits, and off-site locations. The results shown include natural background dose rates.

As shown in the graph, there is a difference of approximately 20 mrem (0.20 mSv) between the 1987 data and the 1988-1991 data. The 20 mrem (0.20 mSv) change between the



ENVIRONMENTAL TLD RESULTS

FIGURE 4-10

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two time periods cannot be explained by changes in the radionuclide inventory, since the radionuclide inventory at the WSSRAP has not significantly changed since 1987. The control TLD results reported in 1987 were also approximately 20 mrem (0.20 mSv) higher than the control TLD results reported in 1988 through 1991. Control TLDs are included in every quarterly shipment of environmental TLDs and are used as a quality control check to verify that the environmental TLDs were not exposed to a radioactive source during transportation from the WSSRAP to the subcontract laboratory. A possible cause for the change between 1987 and 1988 may be the result of improvements in analytical accuracy, based on additional testing and research, in the estimation of effective dose equivalents measured by the environmental TLDs.

The slight increase in the 1991 results can partially be attributed to a change in the TLD response factor used by the processing laboratory during the fourth quarter of 1991. The overall increase in the annual totals at the WSQ, WSCP, WSRP, and off-site locations from 1990 to 1991 was approximately 10%. However, the graph shows that while there has been small variations in the effective dose equivalents measured with the environmental TLDs during the period from 1988 to 1991, there is no statistical significant increase in the effective dose equivalents resulting from gamma exposure.

4.1.3 Radioactive Air Particulate Monitoring

Radioactive air particulates are airborne dust particles that carry radioactive contaminants. The radioactive isotopes, which are the primary contributors to long-lived natural background radioactivity on dust particles, are Po-210 and Pb-210, both of which are naturally occurring Rn-222 progeny (daughters). Background concentrations of radioactive air particulates vary depending on soil moisture, wind, and geological conditions.

Many areas of the WSS contain above-background concentrations of radionuclides in the soil, which could result in increased airborne radioactive particulate concentrations. Increased airborne radioactive particulate emissions from the WSS could result from work activities such as movement of equipment or vehicles in contaminated areas or from wind erosion.

The WSS operates 11 air particulate monitoring stations. Five of these (AP-2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the WSCP perimeter as shown on Figure 4-1. Three stations are located off site at critical receptor locations, which are the Francis Howell High School (AP-4006), the WSTA (AP-4008) and near two residences located approximately 0.7 km (0.4 mi) west of the quarry (AP-4011). The monitoring station at the August A. Busch Wildlife Area (ABWA), (AP-4007), is used to monitor background levels in the vicinity of the WSCP. This station is approximately 0.8 km (0.5 mi) from the WSCP perimeter in a northwestern direction. The terrain between the WSCP and this sampling station is hilly and forested, providing a significant physical barrier to airborne particulates originating from the WSCP/WSRP. In addition, winds from the southeast are relatively rare in this region. The off-site monitoring stations are shown on Figures 4-1 and 4-2. Two monitors (AP-1009 and AP-1010) are located at the quarry. The quarry monitoring stations are also shown on Figure 4-2.

All air particulate monitoring stations operated by the WSSRAP utilize constant flow dual diaphragm units and are set to operate at a continuous total flow of 2.4 cu m/hr (85 ft^3/hr). These monitors use open-face sampling heads and do not segregate the air flow according to particle size. This results in the collection of respirable and non-respirable particles. Since respirable particles pose the most significant detrimental human health impacts, the analysis of both respirable and non-respirable radioactive air particulates will overestimate the respirable radioactive air particulate concentrations as well as the associated potential health hazard. Radioactive air particulate samples are collected on 47-mm (1.88 in.) diameter membrane filters with an effective pore size of 0.45 μm. The filters are exchanged on a weekly basis.

Most of the radionuclides present at the WSS are members of the U-238 and Th-232 series. Many of these radionuclides emit alpha particles during decay, which pose the greatest hazard when deposited internally in the respiratory tract and lungs. Therefore, the air sampler filters were analyzed for long-lived gross alpha activity. The long-lived gross alpha method of analysis sums the alpha activity from all of the long-lived alpha-emitting radionuclides. The long-lived gross alpha measurements were made with a Canberra HT-1000 gas flow proportional counter. The alpha counts per filter were converted to radioactivity per volume of air drawn through the filter and reported in units of μCi/ml (Bq/m^3).

The annual average long-lived gross alpha concentrations and the calculated standard deviations for the 11 air monitoring stations are summarized in Table 4-4. The annual averages were calculated by averaging the uncensored weekly air particulate analysis results. Uncensored data refers to all reported values whether less than, or near, the counting instruments minimum detectable amount. The use of uncensored data complies with the requirements of the DOE *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental*

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Table 4-4 1991 Radioactive Air Particulate Results for the WSCP/WSRP and WSQ Areas

Monitoring Station Identification Number	Annual Average Long-Lived Gross Alpha Concentration (x 10^{-15} μCi/ml)[b]	Standard Deviation (x 10^{-15} μCi/ml)	Number of Sample Values Above MDC[c]/Total Number of Samples
AP-2001	1.39	0.68	42/49
AP-2002	1.42	0.68	41/47
AP-3003	1.33	0.78	39/47
AP-3004	1.40	0.81	31/38
AP-2005	1.46	0.69	38/48
AP-4006	1.36	0.62	42/52
AP-4007[a]	1.37	0.49	45/47
AP-4008	1.59	0.76	44/50
AP-1009	1.55	0.68	39/44
AP-1010	1.49	0.65	43/47
AP-4011	1.43	0.72	42/46

(a) Indicates background monitoring station.

(b) The annual average gross alpha concentrations were calculated using uncensored data, which includes analysis results which are less than reported minimum detectable concentration.

(c) MDC - minimum detectable concentration.

Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (DOE 1991). Utilizing uncensored data in all data manipulation minimizes any bias in the arithmetic averages and standard deviations.

The typical MDC for air particulate samples collected at the WSS monitoring stations is approximately 6.9×10^{-16} μCi/ml (0.026 mBq/m^3). This MDC is low enough to allow detection of Th-232, the radionuclide with the lowest derived concentration guideline (DCG) found at the WSS. The most restrictive inhalation DCG for Th-232 is 7×10^{-15} μCi/ml (0.26 mBq/m^3) (DOE 5400.5). Inhalation DCGs are airborne radioactive contaminant concentrations which, if inhaled by a member of the public continuously for 1 yr, would result in a committed effective dose equivalent of 100 mrem (1 mSv).

4.1.3.1 Chemical Plant/Raffinate Pits. Statistical hypothesis tests were used to compare the long-lived gross alpha concentrations measured at each monitoring station to the concentrations measured at the background monitoring station (AP-4007). There was no statistically significant difference, at the 95% confidence level, between the long-lived gross alpha concentrations measured at the five WSCP/WSRP perimeter monitoring stations and those concentrations measured at the background station (AP-4007) during 1991.

4.1.3.2 Quarry. Statistical hypothesis tests were used to compare the long-lived gross alpha concentrations measured at each monitoring station to the concentrations measured at the background monitoring station (AP-4007). Both airborne radioactive particulate monitoring stations at the quarry, AP-1009 and AP-1010, located on the northeastern and southern perimeter respectively, provided long-lived gross alpha activities that were not statistically different, at the 95% confidence level, from the long-lived gross alpha activity measured at the background station.

4.1.3.3 Off-Site. Statistical hypothesis tests were used to compare the long-lived gross alpha concentrations measured at each monitoring station to the concentrations measured at the background monitoring station (AP-4007). The annual average long-lived gross alpha concentrations at all off-site monitoring stations were not significantly different, at the 95% confidence level, from the long-lived background alpha activity measured at the background station during 1991. This is significant because it indicates that there were no releases from the WSQ or chemical plant that could be distinguished from background levels at these locations.

4.1.3.4 NESHAPs Annual Report. In 1990, the WSS initiated an environmental airborne particulate monitoring and quality assurance program sensitive enough to detect airborne radionuclide concentrations other than radon at the levels specified in the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR 61 Subpart H), Appendix E. Subpart H of 40 CFR 61 requires that radionuclide emissions other than radon be determined and effective dose equivalents to members of the public be calculated using EPA approved procedures and computer models, or other procedures for which EPA has granted prior approval. The WSS has chosen to meet the NESHAPs emission monitoring and dose assessment requirements by measuring airborne radionuclide concentrations at designated critical receptor locations rather than through the use of computer modeling. The WSS monitoring plan is contained in the *Plan For Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (MKF and JEG 1990a) which has been approved by the EPA Region VII.

Airborne emissions at the WSS result from wind dispersal of surface soils, dust and dirt within the deteriorating buildings, and fugitive dust generated during remedial actions. Accurate monitoring of these emission sources is not practical because of uncertainties associated with the emissions inventory, dust particle entrainment, and micro-meteorology associated with these emission sources. The most accurate method of dose estimation at receptor locations near the WSS is via measurement of airborne concentrations at these locations, which are designated as critical receptor locations. Critical receptors are locations where members of the public abide or reside, and have a potential to encounter off-site concentrations of radionuclides other than radon during remediation of the WSS.

Five critical receptor locations have been identified around the WSS. These locations are designated with the following identification numbers: AP-2001, AP-2005, AP-4006, AP-4008, and AP-4011. Critical receptor AP-2001 is the common boundary of the WSCP and the Missouri Highway Maintenance Facility. Critical receptor AP-2005 is located near the WSSRAP administration building. Critical receptor AP-4006 is located at the Francis Howell High School. Critical receptor AP-4008 is located on the WSTA. Critical receptor AP-4011 is within 150 m (0.1 mi) of the nearest residence to the quarry.

In order to evaluate the impact of activities conducted at the WSSRAP at these critical receptors, an assessment of the exposure scenarios at each receptor is necessary. The exposure scenario for critical receptor AP-2001 accounts for the nine workers at the highway maintenance facility. The exposure time at this critical receptor location is 40 hr/wk for 50 wk/yr, or 2,000 hr/yr. The WSSRAP administration building houses approximately 220 workers for an exposure time of 50 hr/wk for 50 wk/yr, or 2,500 hr/yr. The exposure scenario for the Francis Howell High School involves two separate depictions. The first accounts for the approximately 1,800 students, faculty, and staff members at the high school, whereas the second represents the exposure for the one employee who lives on the high school grounds. The exposure time for the students, faculty, and staff members at the high school is 45 hr/wk for 50 wk/yr or 2,250 hr/yr. The employee's exposure time is assumed to be continuous, i.e., 24 hr/day, 365 day/yr, or 8,760 hr/yr. Critical receptor AP-4008 is located on the WSTA. A remedial investigation is being conducted at the WSTA where subcontract workers intermittently perform site characterization tasks. One employee of the Department of the Army works 40 hr/wk, 50 wk/yr, which yields an exposure time of 2,000 hr/yr. The last critical receptor, AP-4011, is located just west of the quarry and directly in line with a residence. The exposure time at the residence is assumed to be continuous, i.e., 8,760 hr/yr.

As outlined in the *Plan for Monitoring Radionuclides Other Than Radon at Weldon Spring Site Critical Receptor Locations* (MKF and JEG 1990a), air at critical receptor locations is sampled continuously and the air sample filters are collected weekly. All filters collected weekly in 1991 were composited separately for each critical receptor location, and the composited samples were sent to a subcontract laboratory for radiochemical analysis. The subcontract laboratory separated each composite sample into three aliquots to allow for a determination of analytical precision. Each aliquot was analyzed for isotopic uranium, isotopic thorium, Ra-226, and Ra-228. The reported radionuclide activities shown in Tables 4-6 through 4-10 are the weighted averages of the results for the three aliquots. The gross airborne radionuclide concentrations were determined by dividing the reported gross activity average for each radionuclide by the volume of air pulled through the sampler for the calendar year 1991. The net radionuclide concentrations equal the reported gross airborne radionuclide concentrations for the specific critical receptor monitoring station minus the airborne concentrations for the background monitoring station, AP-4007. The reported background results and subsequent airborne concentrations are given in Table 4-5. Each airborne concentration is reported as a range (i.e., annual average $\pm$ two standard deviations) which would include 95% of all samples collected at the particular monitoring location. The estimated committed effective dose equivalent (CEDE) is then calculated for each designated critical receptor monitoring location as is required by the EPA-approved NESHAPs compliance monitoring program for the WSS (MKF and JEG 1990a). Effective dose equivalents were calculated using net measured airborne

Table 4-5 Reported Results at Critical Receptor Location AP-4007 (Background Station)

Radionuclide	Reported Analysis Results[a] (pCi)	Airborne Radionuclide Concentration ± 2σ (μCi/m³)[b]
U-238	0.6	3.1E-11 ± 6.7E-12
U-234	0.7	3.6E-11 ± 7.6E-12
U-235	0.03	1.6E-11 ± 3.0E-12
Ra-226	-2.3[c]	-1.2E-10 ± 3.3E-10
Ra-228	6.7	3.5E-10 ± 7.9E-11
Th-228	0.3	1.6E-11 ± 1.6E-11
Th-230	1.2	6.2E-11 ± 1.8E-11
Th-232	0.3	1.6E-11 ± 8.5E-12

(a) Reported results are the weighted average of three separate analyses performed on three sample aliquots.

(b) The average annual flow rate for this sampler was 2.44 m³/hr for 47 weeks of operation.

(c) Negative radiological data results from the subtraction of background from the measured value. Negative values imply a measured level within the range of background.

Table 4-6 Estimated Effective Dose Equivalent at Critical Receptor Location AP-2001 (Missouri Highway Maintenance Facility)

Radionuclide	Reported Analysis Results[a] (pCi)	Airborne Radionuclide Concentration $\pm 2\sigma$ (μCi/m^3)[b]	Net Airborne Concentration $\pm 2\sigma$ (μCi/m^3)[c]	DCF[d] (mrem/μCi)	CEDE [e] (mrem)
U-238	1.1	5.4E-11 ± 1.1E-11	2.3E-11 ± 1.3E-11	1.2E+05	6.9E-03
U-234	1.1	5.4E-11 ± 1.1E-11	1.8E-11 ± 1.4E-11	1.3E+05	5.7E-03
U-235	0.01	4.9E-11 ± 6.6E-12	-1.1E-12 ± 7.2 E-12	1.2E+05	0.0E+00
Ra-226	-2.0	-9.8E-11 ± 3.1E-10	0 ± 4.5E-10*	8.6E+03	0.0E+00
Ra-228	5.0	2.5E-10 ± 8.0E-11	-1.0E-10 ± 1.1E-10	4.8E+03	0.0E+00
Th-228	0.7	3.4E-11 ± 1.3E-11	1.9E-11 ± 2.2E-11	3.4E+05	1.6E-02
Th-230	1.0	4.9E-11 ± 1.0E-11	-1.3E-11 ± 2.0E-11	3.3E+05	0.0E+00
Th-232	0.3	1.5E-11 ± 5.7E-12	-8.5E-13 ± 1.0E-11	1.6E+06	0.0E+00
				TOTAL EDE =	2.9E-02

(a) Reported results are the weighted average of three separate analyses performed on three sample aliquots.
(b) The average annual flow rate for this sampler was 2.47 m^3/hr for 49 wk of operation.
(c) Net results obtained by subtracting background station concentrations from the reported concentrations in Column two.
(d) Dose conversion factors were taken from the *EPA Federal Guidance Report No. 11* (Eckerman et al. 1988).
(e) Committed Effective Dose Equivalent (CEDE). Exposure time assumed for the critical receptor location was 2,000 hr.
* The Ra-226 airborne concentrations reported for the background station and this station were both less than zero.

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Table 4-7 Estimated Effective Dose Equivalent at Critical Receptor Location AP-2005 (WSSRAP Administration Building)

Radionuclide	Reported Analysis Results[a] (pCi)	Airborne Radionuclide Concentration $\pm 2\sigma$ (μCi/m^3)[b]	Net Airborne Concentration $\pm 2\sigma$ (μCi/m^3)[c]	DCF[d] (mrem/μCi)	CEDE [e] (mrem)
U-238	1.1	6.1E-11 ± 1.9E-11	3.0E-11 ± 1.2E-11	1.2E+05	1.1E-02
U-234	1.2	6.6E-11 ± 1.0E-11	3.0E-11 ± 1.3E-11	1.3E+05	1.2E-02
U-235	0.03	1.7E-12 ± 3.2E-12	1.0E-13 ± 4.4 E-12	1.2E+05	3.8E-05
Ra-226	-2.0	-1.1E-10 ± 3.5E-10	0 ± 4.8E-10*	8.6E+03	0.0E+00
Ra-228	6.8	3.8E-10 ± 9.7E-11	2.8E-10 ± 1.3E-10	4.8E+03	4.2E-04
Th-228	0.7	3.9E-11 ± 1.5E-11	2.3E-11 ± 2.3E-11	3.4E+05	2.5E-02
Th-230	1.0	5.5E-11 ± 1.3E-11	-7E-12 ± 2.2E-11	3.3E+05	0.0E+00
Th-232	0.3	1.7E-11 ± 6.4E-12	1E-12 ± 1.1E-11	1.6E+06	5.1E-03
				TOTAL EDE =	5.4E-02

(a) Reported results are the weighted average of three separate analyses performed on three sample aliquots.
(b) The annual average flow rate for this sampler was 2.24 m^3/hr for 48 wk of operation.
(c) Net results obtained by subtracting background station concentrations from the reported concentrations in Column two.
(d) Dose conversion factors were taken from the *EPA Federal Guidance Report No. 11* (Eckerman et al. 1988).
(e) Committed Effective Dose Equivalent (CEDE). Exposure time assumed for the critical receptor location was 2,500 hr.
* The Ra-226 airborne concentrations reported for the background station and this station were both less than zero.

Table 4-8 Estimated Effective Dose Equivalent at Critical Receptor Location AP-4006 (Francis Howell High School)

Radionuclide	Reported Analysis Results[e] (pCi)	Airborne Radionuclide Concentration $\pm 2\sigma$ (μCi/m^3)[b]	Net Airborne Concentration $\pm 2\sigma$ (μCi/m^3)[c]	DCF[d] (mrem/μCi)	CEDE [e] (mrem)
U-238	0.6	3.0E-11 ± 7.2E-12	-1.5E-12 ± 9.8E-12	1.2E+05	0.0E+00
U-234	0.6	3.0E-11 ± 7.2E-12	-6.7E-12 ± 1.0E-11	1.3E+05	0.0E+00
U-235	0.03	1.5E-12 ± 2.9E-12	-7.7E-14 ± 4.1 E-12	1.2E+05	0.0E+00
Ra-226	-2.3	-1.1E-10 ± 3.1E-10	0 ± 4.6E-10*	8.6E+03	0.0E+00
Ra-228	8.4	4.2E-10 ± 9.4E-11	6.7E-11 ± 1.2E-10	4.8E+03	9.0E-04
Th-228	0.5	2.5E-11 ± 1.4E-11	9.1E-12 ± 2.3E-11	3.4E+05	8.8E-03
Th-230	0.7	3.5E-11 ± 1.1E-11	-2.8E-11 ± 2.1E-11	3.3E+05	0.0E+00
Th-232	0.3	1.5E-11 ± 5.7E-12	-7.7E-13 ± 1.0E-11	1.6E+06	0.0E+00
				TOTAL EDE =	9.7E-03

(a) Reported results are the weighted average of three separate analyses performed on three sample aliquots.
(b) The average annual flow rate for this sampler was 2.32 m^3/hr for 52 wk of operation.
(c) Net results obtained by subtracting background station concentrations from the reported concentrations in Column two.
(d) Dose conversion factors were taken from the *EPA Federal Guidance Report No. 11* (Eckerman et al. 1988).
(e) Committed Effective Dose Equivalent (CEDE). Exposure time assumed for the critical receptor location was 2,250 hr.
* The Ra-226 airborne concentrations reported for the background station and this station were both less than zero.

Table 4-9 Estimated Effective Dose Equivalent at Critical Receptor Location AP-4008 (Weldon Spring Army Reserve Training Area)

Radionuclide	Reported Analysis Results[a] (pCi)	Airborne Radionuclide Concentration ± 2σ (μCi/m³)[b]	Net Airborne Concentration ± 2σ (μCi/m³)[c]	DCF[d] (mrem/μCi)	CEDE [e] (mrem)
U-238	0.8	4.2E-11 ± 9.2E-12	1.1E-11 ± 1.1E-11	1.2E+05	3.4E-03
U-234	1.0	5.3E-11 ± 9.9E-12	1.7E-11 ± 1.2E-11	1.3E+05	5.4E-03
U-235	0.1	3.7E-12 ± 3.1E-12	2.2E-12 ± 4.3 E-12	1.2E+05	6.5E-04
Ra-226	-3.0	-1.6E-10 ± 3.4E-10	0 ± 4.7E-10*	8.6E+03	0.0E+00
Ra-228	5.1	2.7E-10 ± 5.7E-11	-7.8E-11 ± 9.8E-11	4.8E+03	0.0E+00
Th-228	0.4	1.6E-11 ± 1.4E-11	3.2E-13 ± 2.2E-11	3.4E+05	2.7E-04
Th-230	1.2	6.4E-11 ± 1.3E-11	1.3E-12 ± 2.2E-11	3.3E+05	1.1E-03
Th-232	0.3	1.6E-11 ± 6.1E-12	3.2E-13 ± 1.0E-11	1.6E+06	1.3E-03
				TOTAL EDE =	1.2E-02

(a) Reported results are the weighted average of three separate analyses performed on three sample aliquots.
(b) The average annual flow rate for this sampler was 2.24 m³/hr for 50 wk of operation.
(c) Net results obtained by subtracting background station concentrations from the reported concentrations in Column two.
(d) Dose conversion factors were taken from the *EPA Federal Guidance Report No. 11* (Eckerman et al. 1988).
(e) Committed Effective Dose Equivalent (CEDE). Exposure time assumed for the critical receptor location was 2,000 hr.
* The Ra-226 airborne concentrations reported for the background station and this station were both less than zero.

Table 4-10 Estimated Effective Dose Equivalent at Critical Receptor Location AP-4011 (0.6 miles west of WSQ)

Radionuclide	Reported Analysis Results[a] (pCi)	Airborne Radionuclide Concentration $\pm 2\sigma$ (μCi/m^3)[b]	Net Airborne Concentration $\pm 2\sigma$ (μCi/m^3)[c]	DCF[d] (mrem/μCi)	CEDE [e] (mrem)
U-238	0.6	3.0E-11 ± 6.3E-12	-1.6E-12 ± 9.2E-12	1.2E+05	0.0E+00
U-234	0.6	3.0E-11 ± 7.2E-12	-6.8E-12 ± 1.0E-11	1.3E+05	0.0E+00
U-235	0.0	0 ± 2.8E-12	-1.6E-12 ± 4.1E-12	1.2E+05	0.0E+00
Ra-226	-2.0	-9.9E-11 ± 3.1E-10	0 ± 4.5E-10*	8.6E+03	0.0E+00
Ra-228	6.0	3.0E-10 ± 7.8E-11	-5.3E-11 ± 1.1E-10	4.8E+03	0.0E+00
Th-228	0.2	9.9E-12 ± 1.4E-11	-5.7E-12 ± 2.3E-11	3.4E+05	0.0E+00
Th-230	1.4	6.9E-11 ± 1.2E-11	6.6E-12 ± 2.1E-11	3.3E+05	2.4E-02
Th-232	0.1	4.9E-12 ± 4.0E-12	-1.1E-11 ± 9.4E-12	1.6E+06	0.0E+00
				TOTAL EDE =	2.4E-02

(a) Reported results are the weighted average of three separate analyses performed on three sample aliquots.
(b) The average annual flow rate for this sampler was 2.47 m^3/hr for 49 wk of operation.
(c) Net results obtained by subtracting background station concentrations from the reported concentrations in Column two.
(d) Dose conversion factors were taken from the *EPA Federal Guidance Report No. 11* (Eckerman et al. 1988).
(e) Committed Effective Dose Equivalent (CEDE). Exposure time assumed for the critical receptor location was 8,760 hr.
* The Ra-226 airborne concentrations reported for the background station and this station were both less than zero.

radionuclide concentrations in μCi/ml, the amount of time members of the public are assumed to reside or abide at the critical receptor location as stated in the NESHAPs compliance monitoring program, an assumed breathing rate of 1.25 m^3/hr (44.14 ft^3/hr), and the radionuclide-specific committed dose conversions factors provided in *EPA Federal Guidance Report No. 11* (Eckerman, et al. 1988).

The analyses results for Ra-226 are reported as negative values at all critical receptor monitoring stations. This is possible as environmental samples often contain very low levels of radioactivity (i.e., amount of radioactivity falls within the range of background). Since all measurements involve statistical variations, the net sample activity is sometimes negative after the background measured by the laboratory instrument has been subtracted. Thus, the reporting of negative results is very possible when measuring radiation levels that are comparable to background radiation levels. The negative values are reported, but can be thought of in terms of background equivalent levels of radiation. Thus, these values have no effective net airborne concentration (i.e., reported results minus background results) and do not contribute a dose equivalent above background.

The CEDEs calculated for the critical receptor locations are all less than 0.1 mrem (0.001 mSv) as is shown in Tables 4-6 through 4-10. Specifically, estimated CEDEs ranged from 0.01 mrem (0.0001 mSv) at the critical receptor located at Francis Howell High School to 0.05 mrem (0.0005 mSv) at the critical receptor located at the administration building. The 40 CFR 61 Subpart H for the emission of radionuclides other than radon limits the effective dose equivalent to any member of the public to 10 mrem (0.10 mSv) per year. The maximum estimated CEDE obtained at WSS critical receptor AP-2005 amounts to only 0.5% of this standard. It is likely, however, that the airborne radionuclide concentration measured at critical receptors AP-4006, AP-4008, and AP-4011 are all measurements of background radionuclide concentrations. The one-tailed student T hypothesis statistical comparison of the average airborne radionuclide concentrations at these critical receptor locations to the average concentrations measured at the background station revealed, at the 95% confidence level, that there was no significant difference between the two average concentrations for each radionuclide. However, the U-234 and U-238 analyses at stations AP-2001 and AP-2005 did not pass the statistical test at the same confidence level when compared to the average background radionuclide concentrations. Although this difference occurred, the average U-234 and U-238 airborne concentrations at both the WSSRAP administration building (AP-2005) and the Missouri Highway Maintenance Facility (AP-2001) resulted in estimated CEDEs that were within 0.5%

of the standard (10 mrem/yr). In addition, there is no reason to suspect, at the 95% confidence level, that there is a difference between the long-lived gross alpha concentrations measured at the background monitoring station and the concentrations measured at any of the critical receptor locations as reported in Sections 4.1.3.1 through 4.1.3.3. Also, data quality objectives for the radiochemical data, as well as atmospheric transport and dispersion modeling performed at the site, do not support these analysis results from stations AP-2001 and AP-2005 for U-234 and U-238.

In order to meet the detection limits specified in 40 CFR 61 Subpart H, a strict quality control program must be maintained. The quality control program for the critical receptors includes spikes, blanks, duplicates, and control charts. In addition, analytical data quality objectives for precision and accuracy are described in the NESHAPs compliance monitoring plan for the WSS (MKF and JEG 1990a). Accuracy, as determined with the results of spiked samples, is considered acceptable if analytical results of spiked samples are within ±50% of known values for 85% of all samples. Precision is determined by averaging the results of the three duplicate analyses for all composite sample data sets. Precision is considered acceptable if the absolute value of the coefficient of variability (i.e., the standard deviation divided by the average and multiplied by 100) is less than, or equal to, 50% for 85% of the duplicate data sets. Analytical precision is also calculated for the U-238/U-234 ratio for each composite sample. Precision is considered acceptable if the standard deviation of the U-238/U-234 ratio results for each composite sample is within ±50% of the average for 85% of all samples.

In order to determine the accuracy of the reported data, two samples were spiked with different concentrations of both U-238 and Th-230. Each spiked sample contained 13 filters; these were divided into thirds and each composite third was analyzed separately. In both cases, the three composite thirds that contained the higher spike of U-238 and Th-230 met the established criteria for the measurement of accuracy. However, the three composite thirds that contained the lower spike concentrations for both U-238 and Th-230 did not meet the established criteria. Consequently, only 50% of all the spiked samples met accuracy criteria. The reported results for the lower concentration spikes provided laboratory results that were approximately two times greater than the actual concentration, which indicates a probable high bias for Th-230 and U-238 results at lower concentrations. Since the lower spiked samples for both Th-230 and U-238 were about 10 times greater than the activities being measured on the filter composite for each monitoring station, the statistical confidence associated with these low level measurements was very small and the laboratory's results could not be assessed as accurate at these levels of radioactivity. Thus, the net airborne concentrations and subsequent effective dose equivalent calculations for the very low U-238 and Th-230 concentrations measured at the critical receptor locations would also be high.

Precision quality objectives were also evaluated for the 1991 reported data. The standard deviation of duplicate analyses was within ±50% of the sample average for 79% of the duplicate data sets. In the case of the U-238/U-234 ratio for each composite sample, 77% of all samples analyzed met the established criteria for precision. The established criteria requires that 85% of the data sets pass both of these tests for precision.

When the critical receptor sampling stations are measuring background concentrations of airborne radionuclides, as has been the case in the past and is expected to continue given the strict WSS dust minimization policies, most isotopic analyses of composite air filter samples yield concentrations that are near or below the laboratory's lower limit of detection (LLD). Strict analytical precision requirements for data that are near or below the LLD are not appropriate. This is because the statistical confidence associated with data values below the LLD is low, and data values at or slightly above the LLD typically have relatively large uncertainties associated with them. Since nearly one third of all measured values were at or less than the reported LLDs, strict data quality objectives were difficult to meet due to the many uncertainties associated with the reported results.

Atmospheric transport modeling was used to predict radionuclide concentrations at the critical receptor locations in an attempt to substantiate the laboratory's reported results since accuracy and precision data quality objectives did not pass the established criteria. Radioactive materials released to the atmosphere are known to be diluted and dispersed within the air mass as they are carried by the prevailing wind. AIRDOS, a personal computer-based atmospheric transport model, simulates the airborne movement, radioactive decay, and deposition of the released radionuclides to predict concentrations in the air near ground level and concentrations on the ground surface at specified locations. These concentrations, if distinguishable from background, are used to estimate radiation doses to individuals at those locations. The atmospheric transport of radioactive materials from the WSSRAP is calculated based on meteorological observations made in the St. Louis area over a 5 yr period. The wind rose data for the St. Louis area compares well with corresponding data from the WSS according to figures in Appendix C, *Feasibility Study For Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (ANL 1991b). The atmospheric transport model accounts for the motion of the wind, the vertical and horizontal dispersion of the released radionuclides within the moving air mass, and the removal of the radionuclides from the air by deposition and radioactive decay. AIRDOS-PC calculates an estimate of the radionuclide concentration in air per unit release rate at prescribed ground level positions near the point of release.

The code utilizes a modified Gaussian plume equation to estimate both horizontal and vertical dispersion of radionuclides released from the area source. The source of potential release at the WSCP was assumed to encompass the areas on site where activities such as excavation and building dismantlement occurred in 1991. Dismantlement of Buildings 302, 435, 436, 437, and 438, as well as excavation of the buried brick area, were done in order to facilitate construction of the site water treatment plant. The source area was designed to include the area covered by these activities and was determined to be 8.2E04 m^2 (8.8E05 ft^2). AIRDOS was then utilized to evaluate what type of source term (Ci/yr) would yield releases, as recorded for U-234 and U-238, that correlated with the results obtained at stations AP-2001 and AP-2005. Since station AP-2001 is at a greater distance from the source area, this station was used to evaluate the potential release rate from the site. This station is located on the northeast perimeter of the site and sits on the common boundary between the WSCP and the Missouri Highway Maintenance Facility. When the release rate is estimated to yield concentrations equivalent to those recorded at station AP-2001, the atmospheric modeling predicts concentrations greater than, or comparable to, the recorded results in the southwestern, western, northwestern, northern, and eastern directions. Thus, if releases from the WSCP did occur, perimeter stations AP-2002, AP-3004, and AP-3003 would have measured similar, if not higher, results than those recorded at stations AP-2001 and AP-2005.

Results of the data quality objective comparisons, the atmospheric transport and modeling scenario results, and the low volume gross alpha results indicate that there is no reason to suspect that there is a difference between radionuclide concentrations measured at the critical receptor locations and background radionuclide concentrations. Thus, all indications show that no above background radionuclide releases occurred from the WSS in 1991.

It should be noted that the Ra-228 analyses for the five critical receptor locations have gross radionuclide concentrations higher than those for the other isotopes of radium, thorium, and uranium and do not differ from background Ra-228 concentrations. The higher Ra-228 results were consistent for all samples including blanks and spikes. The Ra-228 results are higher because the procedure for extracting Ra-228 also extracts other beta emitters into the analyte. This high bias for the method used is noted in the EPA document *Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA 1980). The procedure for measurement of Ra-228 in drinking water is applicable to the analysis of air filters because the same radiochemistry procedure is applicable for both matrixes.

Estimated dose equivalents (EDE) are calculated at the five critical receptor locations for isotopic uranium, isotopic thorium, Ra-226, and Ra-228. However, the estimated dose equivalent for Th-228 at all critical receptors was not reported in the *Annual Site Environmental Report for Calendar Year 1990* (MKF and JEG 1991c). This was an oversight on the part of personnel preparing the 1990 report. The addition of the Th-228 component affects the reported EDE at two critical receptor stations; the Missouri Highway Department building (AP-2001) and the WSSRAP administration building (AP-2005). At AP-2001 the EDE reported in the 1990 ASER (which does not include the Th-228 component) was 0.11 mrem (1.1E-3 mSv); however, if the Th-228 component is included, the EDE is 0.27 mrem (2.7E3 mSv). At AP-2005 the EDE reported in the 1990 ASER was 0.18 mrem (1.8E3 mSv), but with the Th-228 component the EDE is 0.52 mrem (5.2E-3 mSv).

The addition of the Th-228 component to the EDE gives monitoring station AP-2005 the highest EDE of all critical receptor monitoring stations for calendar year 1990. The EDE at station AP-2005 for 1990, 0.52 mrem (5.2E-3 mSv), is about 5% of the 10 mrem/yr standard found in 40 CFR 61 Subpart H. The increase in the EDE estimate for calendar year 1990 at stations AP-2001 and AP-2005 does not change any statements made in the 1990 ASER text, but it does change the results reported for these stations. (Refer to Tables 4-13 and 4-14).

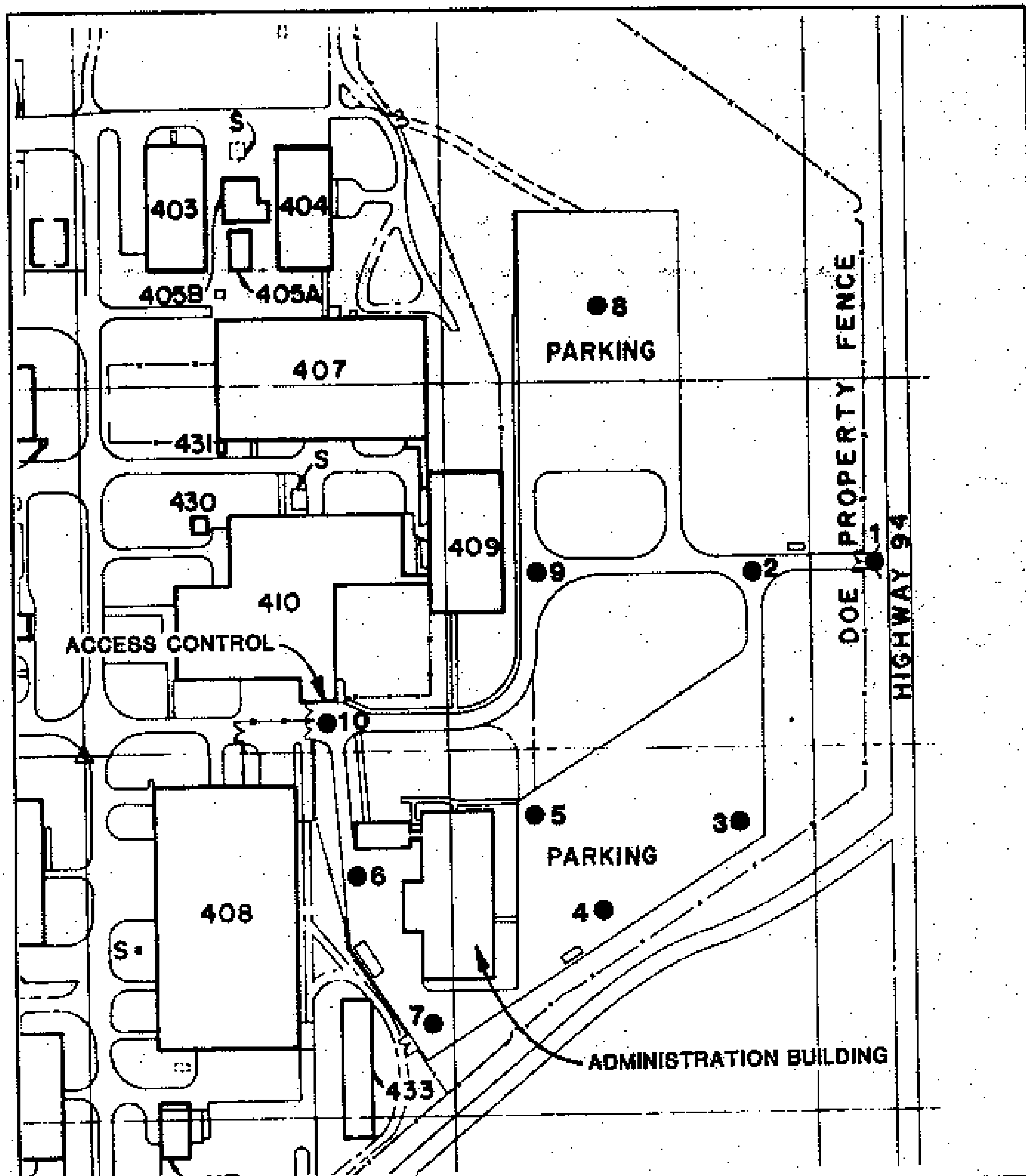
4.1.4 Unrestricted Area Radioactive Contamination Monitoring

The WSS contains areas of radioactive contamination resulting from work practices during former uranium and thorium refining operations. The majority of the processing involved refining uranium, and thus uranium is the primary contaminant at the site. This program includes radiological surveys of locations in both the controlled and uncontrolled areas at the WSS. Site roadways are monitored to ensure that removable contamination is kept free from these accessible areas. In addition, the Katy Trail is surveyed as it represents an area accessible to public use. The radiological surveys are usually performed monthly or at least on a quarterly basis. Performance of these surveys to date confirms that radioactive contamination is not being carried into unrestricted areas.

Since 1986, the WSSRAP has employed an unrestricted-area monitoring program to ensure that radioactive contamination is not migrating from the site as a result of remedial action operations in areas used by the general public. The unrestricted area contamination monitoring program focused on performing in situ measurements and collecting swipe samples. In situ measurements are taken with either an alpha detector or a beta-gamma detector. Measurements are collected over a 1 min counting interval and then converted to disintegrations per minute per 100 cm^2 (dpm/100 cm^2 or dpm/15.5 $in.^2$). These measurements determine the total radioactivity on the surface. The total radioactivity is interpreted as being contained within the material and removable radioactivity is loose surficial radioactivity.

Measurements of removable surficial contamination levels are made at each measurement location using a dry cloth or paper swipe. The swipes are wiped (smeared) over a surface area of approximately 100 cm^2 (15.5 $in.^2$). Swipes are analyzed for 1 min using an alpha scintillation detector. The count rate results are corrected for detector efficiency to yield measurement results in dpm/100 cm^2 (dpm/15.5 $in.^2$).

Figure 4-11 shows the monitoring locations for the roadways outside the controlled area and Figure 4-12 illustrates the approximate 1,130 m (1,243 yd) stretch of the Katy Trail that is included in the monitoring program. This section of the trail was selected for monitoring purposes due to its proximity to the WSQ and Femme Osage Slough. The 10 monitoring locations are selected along the trail to cover the area diagramed on Figure 4-12. Variations in monitoring locations are made in the general vicinity of the 10 locations to check for any possible mobile contamination over the entire length of the investigated portion of the trail. Table 4-11 lists the annual average beta-gamma and alpha monitoring results at each road survey location, and Table 4-12 gives the average beta-gamma and alpha monitoring results for each location along the Katy Trail. The tables reflect annual averages and standard deviations based upon actual net survey results, even though some of the values obtained throughout the year are below the minimum detectable activity (MDA) or detection limit of the instruments. For the purpose of calculating arithmetic means and standard deviations, the reporting and use of actual net concentrations whether negative, positive, or zero results is highly recommended so that complete uncensored data sets result (DOE 1991). Therefore, the negative results reported for the removable alpha results at some of the locations are acceptable and allow the use of uncensored data sets, which ensures that the annual averages and standard deviations remain unbiased parameters.



● · SURVEY LOCATIONS

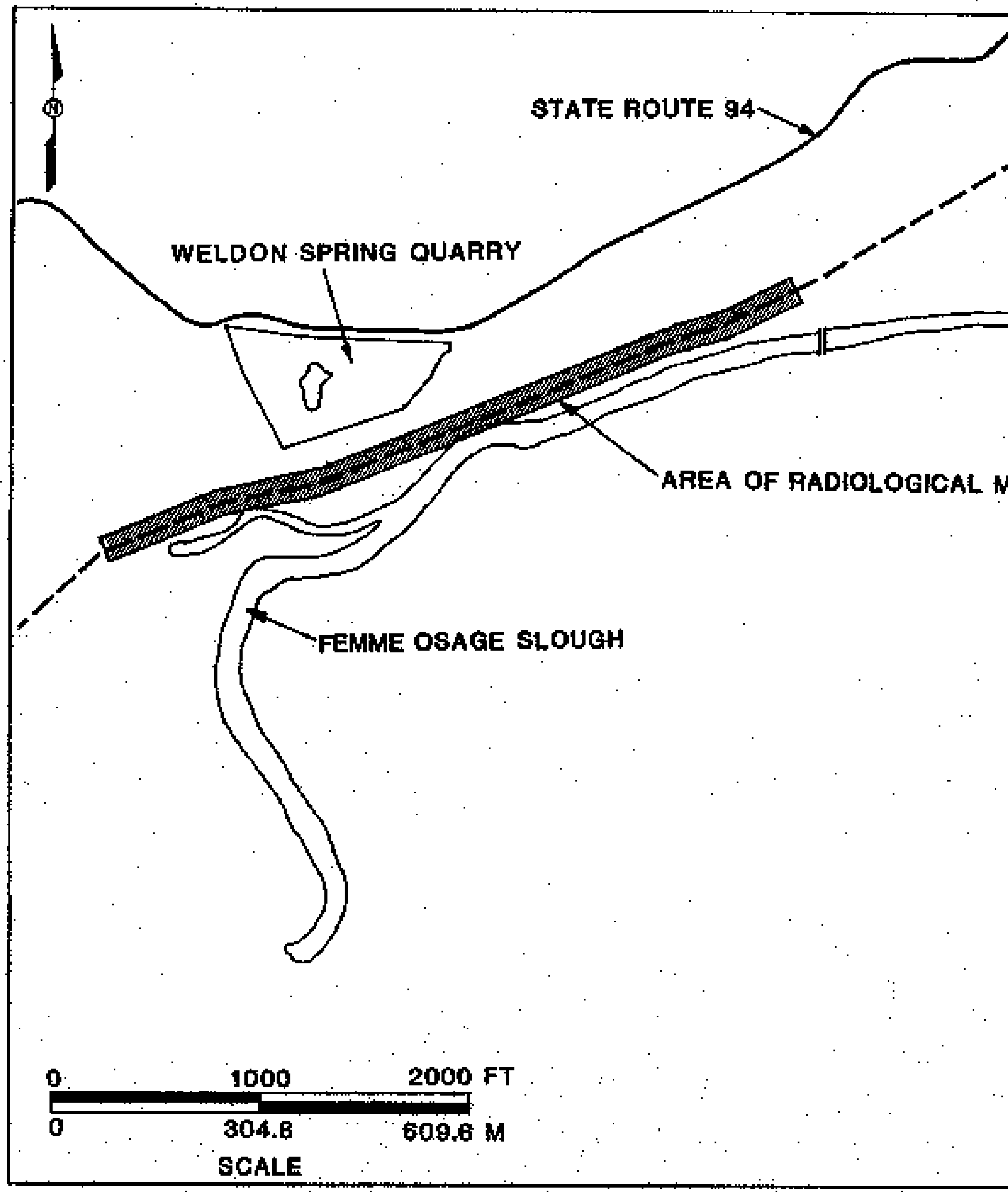
0	200	400 FT
0	61.0	121.9 M

SCALE

ROAD SURVEY LOCATIONS

FIGURE 4-11

REPORT NO. DOE/OR/21548-283		EXHIBIT NO.: A/CP/019/0392	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/92	



KATY TRAIL RADIOLOGICAL MONITORING

FIGURE 4-12

REPORT NO.: DOE/OR/21548-283 EXHIBIT NO.: A/VP/020/0392

ORIGINATOR: JAM DRAWN BY: GLN DATE: 3/92

Table 4-11 1991 Site Roads Periodic Radiological Survey Results

Survey Location Number	Total Beta-Gamma Results (dpm/100 cm^2)[(a)]			Removable Alpha Results (dpm/100 cm^2)[(b)]		
	Annual Average	Standard Deviation	Number of Sample Values Above MDA/Number of Samples	Annual Average	Standard Deviation	Number of Sample Values Above MDA/Number of Samples
1	315	261	2/13	0.63	3.63	1/13
2	628	307	3/13	0.63	2.67	1/13
3	391	253	4/12	0.27	2.36	0/12
4	488	407	3/12	0.70	2.28	0/12
5	519	414	5/12	1.50	2.82	1/12
6	424	205	4/12	-0.96	0.28	0/12
7	741	749	4/12	1.74	3.03	1/12
8	1745	386	13/13	0.41	2.67	1/13
9	935	206	13/13	0.72	0.76	0/13
10	701	348	7/13	0.41	2.60	0/13

(a) Minimum detectable activities (MDA) ranged from 387 to 604 dpm/100 cm^2.
(b) MDA ranged from 3 to 6 dpm/100 cm^2.

Table 4-12 1991 Katy Trail Periodic Radiological Survey Results

Location I.D.	Total Beta-Gamma Results (dpm/100 cm^2)[a]			Removable Alpha Results (dpm/100 cm^2)[b]		
	Annual Average	Standard Deviation	Number of Sample Values Above MDA/Number of Samples	Annual Average	Standard Deviation	Number of Sample Values Above MDA/Number of Samples
1	296	388	1/8	1.76	2.96	1/8
2	327	383	1/8	-0.95	0.35	0/8
3	214	178	0/8	0.96	2.67	0/8
4	139	137	0/8	-0.14	2.07	0//8
5	229	122	0/8	1.33	2.61	0/8
6	261	199	1/8	0.86	3.56	2/8
7	275	167	0/8	-0.14	2.07	0/8
8	155	250	1/8	0.21	2.40	1/8
9	171	231	0/8	0.59	2.81	1/8
10	169	295	0/8	0.23	2.09	0/8

(a) Minimum detectable activities (MDA) ranged from 397 to 604 dpm/100 cm^2.
(b) MDA ranged from 3 to 6 dpm/100 cm^2.

The results of the monitoring for the site show that fixed contamination is present at a few locations, but at levels well below the DOE uranium surface contamination guidelines for unrestricted use of 5,000 dpm/100 cm^2 (5,000 dpm/15.5 $in.^2$). The probable cause of the contamination is the deposition of atmospheric releases of uranium during the operation of the Weldon Spring Uranium Feed Material Plant (WSUFMP). Since the environmental program has been instigated, there has been no increase in the removable contamination levels on the uncontrolled area roadways at the WSS.

The results from all monitoring locations along the Katy Trail indicate background radiation levels. This monitoring data shows that there is no radioactive contamination migrating from the WSQ or the Femme Osage Slough onto the Katy Trail, and thus, there is no identifiable probability of radiological contamination to users of the Katy Trail.

4.2 Radiological Exposure Assessments

In assessing the health effects of the radioactive materials present at the WSCP/WSRP, WSQ, and Weldon Spring vicinity properties (WSVP) as required by DOE Order 5400.1 Section II.8.C; radiological exposure was evaluated for a maximally exposed individual at the WSCP/WSRP, the WSQ, the WSVP, and for the affected populations within 80 km (50 mi) of the WSS. Most of the scenarios and models used to evaluate radiological exposures are conservative and simplistic, but are realistic in the attempt to estimate exposures attributable to the WSSRAP. This is appropriate when the magnitude of the dose to a hypothetical maximally exposed individual is small. The above-background airborne radioactive particulate concentrations, radon concentrations, and external gamma radiation measured during 1991, in addition to the ingestion scenarios described in the following sections, result in an estimated effective dose equivalent of less than 2.4 mrem (2.4E-2 mSv) to a hypothetical maximally exposed individual as shown in Table 4-13.

Many of the parameter values and assumptions used in the calculation of effective dose equivalents to hypothetical maximally exposed individuals and to the potentially exposed population are provided in subsections 4.2.1 through 4.2.4. A more detailed account of assumptions, parameter values, and equations used to calculate effective dose equivalents is provided in Appendix G, Dose Assessment Calculations.

TABLE 4-13 Estimated Annual Effective Dose Equivalent to a Maximally Exposed Individual and Estimated Collective Population Dose for the Weldon Spring Site

	Airborne Particulates EDE	Gamma EDE	Radon EDE	Ingestion EDE[c]	Total EDE	Percent of EPA[a] Standard	Percent of DOE[b] Guideline
Radiation dose equivalent to a maximally exposed individual	0	0.50 mrem	1.8 mrem	0.07 mrem	2.4 mrem	0	2.4
Radiation collective population dose equivalent	0	0.004 person-rem	0.026 person-rem	0.039 person-rem	0.069 person-rem	N/A	N/A

(a) The EPA standard limits effective dose equivalent (EDE) to members of the public from airborne emissions other than radon to 10 mrem annually. The effective dose equivalent from airborne particulates was compared to the EPA standard.

(b) The DOE Order 5400.5 guideline limits effective dose equivalents from all exposure modes to 100 mrem annually. The total effective dose equivalent was compared to the DOE guideline.

(c) Ingestion of fish, water, and sediment from lakes that receive runoff from the WSS was included in both the maximally exposed individual and population dose estimates.

Individuals could be exposed to radioactivity from the WSS via five principal pathways: (1) direct external gamma radiation, (2) inhalation of radon and progeny, (3) inhalation of airborne radioactive particulates, (4) ingestion of fish from nearby lakes that receive runoff from the WSS, and (5) ingestion of drinking water from sources contaminated with radionuclides from the WSS. All five pathways were included for the hypothetical maximally exposed individual. The population dose assessments included the first four pathways, but did not consider the ingestion of drinking water from sources contaminated with radionuclides. Pathway 5 was not considered in the population dose estimate since none of the surface water or groundwater receiving runoff or recharge from the WSS is used as a drinking water source. However, an evaluation of radiological exposures from these lakes, when they are used for recreational purposes, was included in both the maximally exposed individual dose estimates and the population dose estimates. The recreational use of the Katy Trail, the August Busch Wildlife area, and the largest WSS vicinity property (i.e., Little Femme Osage Slough) was included to ensure a thorough pathway assessment.

Although radiation doses can be calculated or measured for individuals, it is not appropriate to predict the health risk to a single individual. Estimates of health risks are based on statistical data collected from large groups of people exposed to radiation under various circumstances. Statistical models are not applicable to a single individual. Therefore, dose equivalents to a single individual are estimated by hypothesizing a maximally exposed individual and placing this individual in a reasonable, but very conservative scenario.

Exposures of maximally exposed individuals and individuals near the off-site water bodies are given in terms of an EDE in units of mrem (mSv). Exposures of people in neighboring facilities and populations within 80 km (50 mi) of the WSS are expressed in terms of collective effective dose equivalent in units of person-rems (person-sieverts). Table 4-13 shows the estimated effective dose equivalents to the hypothetical maximally exposed individual and the estimated collective population dose. The effective dose equivalents to the hypothetical maximally exposed individual near the WSCP/WSRP, WSQ, and WSVP are <1 mrem, 1.9 mrem, and <1 mrem (<0.01 mSv, 0.019 mSv, and <0.01 mSv) respectively. The highest effective dose equivalent results from each pathway (i.e., inhalation, external gamma, and ingestion) independent of location, were included in Table 4-13 and equals 2.4 mrem/yr. All calculations were performed using the methodology described in *International Commission on Radiation Protection* (ICRP) Reports 26 and 30 for a 50-yr committed effective dose equivalent

(ICRP 1977, 1979). Fifty-year committed effective dose equivalent conversion factors were obtained from the *EPA Federal Guidance Report No. 11* (Eckerman 1988).

In Table 4-13, the estimated effective dose equivalent for the hypothetical maximally exposed individual due to airborne radioactive particulates is compared to the EPA standard of 10 mrem (0.10 mSv) annually for airborne emissions other than radon. Also, the estimated effective dose equivalent is compared to the DOE guideline of 100 mrem (1 mSv) annually for all exposure modes, as shown in Table 4-13.

4.2.1 Radiation Dose From the WSCP/WSRP to a Hypothetical Maximally Exposed Individual

This section provides the estimated committed effective dose equivalent to a hypothetical individual assumed to frequent the perimeter of the WSCP/WSRP and to receive a radiation dose by the five pathways identified above. No private residences are adjacent to the WSCP/WSRP sites; therefore, all calculations of dose equivalent due to direct gamma exposure, airborne radioactive particulate inhalation, and radon progeny inhalation assume a realistic less than 100% residence time. Recreational use of the Busch Wildlife area is considered in the assessment of the exposure to a maximally exposed individual at the WSCP/WSRP area since some of the lakes in the area receive effluent from the WSCP/WSRP. None of these bodies are used as sources of drinking water, but recreational use of the wildlife area includes fishing and boating activities. Thus, fish ingestion, as well as incidental water and sediment ingestion, is a potential pathway for exposure.

Direct gamma radiation dose rates, radon gas concentrations, and airborne radioactive particulate concentrations were sampled continuously at all WSCP/WSRP and off-site locations. There is no reason to suspect, at the 95% confidence level, that the results recorded in 1991 for these monitoring locations were different from the measured background results. Also, a high laboratory bias for results of Th-230 and U-238 spiked samples, as well as atmospheric transport of radionuclides U-234 and U-238, does not support data indicative of airborne releases from the WSCP during remediation activities in 1991. Consequently, there is no reason to suspect that the potential for exposure to external gamma, radon gas, and airborne radioactive particulates above background levels exists, and thus there should not be an increase in the effective dose equivalent above background due to exposure through these pathways.

Three off-site bodies of water (Busch Lakes 34, 35, and 36) receive runoff from the WSCP/WSRP site. All three lakes are used for fishing and boating. In 1991, a bio-uptake investigation was conducted to determine the possible exposure of humans to chemical and radioactive contamination from the ingestion of fish and game affected by previous operations at the WSS. This investigation included collecting fish samples from the three Busch lakes. A variety of fish, including bass, catfish, sunfish, and crappie were collected from the lakes. Fillets representing the edible portion of the fish were sent for analysis. The fish were analyzed for uranium only because radium and thorium concentrations in lake sediments and water were not above normal background levels.

The analysis results for the various fish were combined and averaged. The average U-238 concentrations in the fish collected from Lakes 34, 35, and 36 were 0.010 pCi/g (3.7E-4 Bq/g), 0.012 pCi/g (4.4E-4 Bq/g), and 0.042 pCi/g (1.6E-3 Bq/g), respectively. Using an average consumption rate of 6.5 g/day (0.23 oz/day) for fresh-water fish (EPA 1988) and EPA dose conversion factors (Eckerman et al. 1988), the highest calculated annual dose from ingestion of fish living in these lakes would be 5.6E-2 mrem (5.6E-4 mSv).

None of these lakes are presently used for drinking or irrigation. Swimming is not permitted in these lakes; however, it is realistic to assume the hypothetical maximally exposed individual would swim in the lakes despite the rules. On average, an individual spends 5.7 hr boating per visit at the Busch Wildlife area (Missouri Department of Conservation 1991a). While boating, the hypothetical individual is assumed to spend 25% of the time swimming. If the individual makes 10 boating trips per year in Lake 36, which has the highest average surface water concentration (51 pCi/l, or 1,887 Bq/m^3), the total amount of time spent swimming would be 14.3 hr/yr. Swimming can result in the ingestion of 0.05 liters/hr (0.05 qt/hr) of water on average (EPA 1988). Using the EPA dose conversion factors (Eckerman et al., 1988), the calculated dose would be 1E-2 mrem (1E-4 mSv).

It is also possible for an individual to ingest lake sediments during visits to the lakes. It is assumed that the hypothetical individual makes 10 trips during the year of an average duration of 5.7 hr per trip as described above. Thus, the individual would spend an average of approximately 57 hr/yr or 2.4 d/yr at the lakes consuming 200 mg/day (7.1E-3 oz/day). Using the average uranium concentration of surface sediments for Lake 34, which has the highest value of 46.8 pCi/g (1.7 Bq/g) and EPA dose conversion factors, the calculated effective dose equivalent would be 1.6E-3 mSv (1.6E-5 mSv).

Based on the exposure scenarios discussed above, a maximally exposed individual at the WSCP/WSRP would therefore receive a total effective dose equivalent of 0.07 mrem (7E-4 mSv) from direct gamma radiation, inhalation of airborne radioactive particulates, inhalation of radon progeny, ingestion of water and sediment, and ingestion of fish from contaminated waters.

4.2.2 Radiation Dose From the WSQ to a Hypothetical Maximally Exposed Individual

This section discusses the estimated committed effective dose equivalent to a hypothetical individual assumed to frequent the perimeter of the WSQ and receive a radiation dose by three of the five pathways identified above. No private residences are adjacent to the WSQ site; therefore, all calculations of direct gamma radiation, airborne radioactive particulate concentrations, and radon progeny inhalation assume a realistic less than 100% residence time. Access to the quarry is controlled by an 2.4 m (8 ft) chain link fence topped with barbed wire; thus fishing, swimming, and drinking water from the quarry pond need not be evaluated.

The exposure scenario consists of a hypothetical individual who routinely walks along the northern boundary of the quarry on State Route 94. The individual is assumed to make this trip twice per day, 250 day/yr. Average residence time per day is estimated to be 12 min (ANL 1989b), resulting in an annual exposure time of 50 hr/yr. An individual driving by the site twice per day, could receive an exposure, but it would be insignificant relative to the walking scenario and therefore was not considered in the calculation.

Data from three gamma radiation monitoring stations were used to evaluate the dose by direct gamma exposure of the hypothetical individual. The dose from external gamma radiation was calculated by multiplying the length of time the individual would be exposed by the radiation field strength. Using these conservative assumptions and the highest measured gamma exposure rate (2.4 μrem/hr above background at TD-1001), the calculated dose equivalent would be 0.12 mrem (1.2E-3 mSv).

Analysis of long-lived gross alpha activity from airborne radioactive particulate data from 1991 indicated that results from monitoring stations at the quarry were not significantly different than background at the 95% confidence level. Therefore, the effective dose equivalent to a hypothetical individual receiving the maximum exposure from the inhalation of radioactive particulates is not measurable above normal background exposure.

The risk associated with Rn-222 is due primarily to inhalation of its short-lived daughter products (progeny). Data from the three alpha track-etch radon gas monitoring stations closest to State Route 94 were used to evaluate the dose by inhalation of radon progeny for the hypothetical individual. The assumed breathing rate for all inhalation pathway calculations is 1.25 m^3/hr (44.1 ft^3) (Cember 1983). The highest annual average measured radon gas concentration at these monitoring stations was 1.2 pCi/l (44 Bq/m^3) above normal background. Assuming a 50% equilibrium between radon gas and its progeny and the 1.0 rem/ working level month (WLM) (10 mSv/WLM) effective dose equivalent conversion factor taken from ICRP Publication (ICRP 1981), the estimated effective dose equivalent from inhalation of radon daughters is 1.8 mrem (0.018 mSv).

The dose to the hypothetical maximally exposed individual at the WSQ consists of a total of 1.9 mrem (0.019 mSv) from direct gamma exposure and inhalation of radon daughters.

4.2.3 Radiation Dose From WSVPs to a Hypothetical Maximally Exposed Individual

This section discusses the estimated effective dose equivalent to a hypothetical individual assumed to frequent the largest vicinity property, the Femme Osage Slough, located south of the WSQ. This scenario provides a very conservative but plausible exposure assessment. No private residences are adjacent to the slough (it is on land that is currently managed by the Missouri Department of Conservation as part of the Weldon Spring Wildlife Area); therefore, all direct gamma exposure calculations assume a realistic less than 100% residence time. The slough is not suspected of having airborne radioactive particulate concentrations and radon progeny concentrations above normal background because it is in a floodplain with saturated soil. The water in the soil minimizes airborne migration. In addition, the slough is contaminated only with uranium, implying that above-background concentrations of radon are not possible.

The amount of fish obtained and ingested from the Femme Osage Slough assumes the average consumption rate of 6.5 g/day (0.23 oz/day) according to EPA estimates (EPA 1988a). Because of the stagnant water conditions, the slough is not a source of drinking water, nor is it a place for recreational swimming. Therefore, these pathways were not included in the dose calculations, and airborne radioactive particulates and radon daughter concentrations were not measured.

External gamma dose rate measurements were used to derive the effective dose equivalent by direct gamma exposure for the maximally exposed individual who is assumed to sit on the bank of the slough and fish 4 hr/wk, 50 wk/yr. External gamma dose rate measurements were taken with a pressurized ion chamber (PIC) on the bank of the slough in an area of known radioactive soil contamination. Using the measured external gamma dose equivalent rate of 10.3 μrem/hr, which is 2.4 μrem/hr in excess of natural background, the calculated dose equivalent would be 0.5 mrem (5E-3 mSv).

As part of the biouptake study, fish samples were collected and analyzed for total uranium. Uranium is the only radionuclide in the slough sediments and water that is elevated above background concentrations; therefore, uranium and its decay products are the only radionuclides that were considered for possible uptake. The average U-234, U-235 and U-238 concentrations recorded from the 10 fish samples taken from the slough on May 1, 1991, are 0.003 pCi/g, 0.0007 pCi/g, and 0.003 pCi/g, respectively. Assuming the fish caught to hours fished ratio is 0.41, and the fish kept to fish caught ratio is 0.48 (MDOC 1991a), the hypothetical individual that spends 4 hr/wk, 50 wk/yr fishing at the slough could potentially consume 39 fish in a single year. The edible portion of an average fish weighs approximately 200 g which would yield a consumption rate of 21 g/day. Using this consumption rate, and the EPA dose conversion factors, the calculated committed effective dose equivalent to the maximally exposed individual from ingestion of fish living in contaminated waters would be 1E-3 mrem (1E-5 mSv).

The dose to the maximally exposed individual at the WSVP from direct gamma exposure and consumption of fish tissue as discussed above consists of a total of 0.5 mrem (5E-3 mSv).

4.2.4 Collective Population Dose

The risk from radiation exposure to the general population is a function of the number of persons exposed, duration of exposure, and concentration or exposure rate to which the population is exposed. Below an absorbed dose of 10 rad (0.1 Gy) the projection of risk is uncertain. This is more than 30 times the typical yearly natural background exposure in the United States. In fact, no statistically significant adverse effects of radiation exposure have ever been proven at low doses of radiation. This is substantiated by studies of human populations exposed in regions of the world where natural background exposures are several times higher than those typically incurred in the United States. In these regions of higher background radiation exposures, the rate of adverse health effects has not been shown to increase above those which occur due to other factors (BEIR IV 1988).

The collective effective dose equivalent estimate is the product of the effective dose equivalent estimate at the exposure point and the number of persons exposed. Exposure points are locations where members of the public are potentially being exposed to airborne radioactive particulate concentrations, radon gas concentrations, external gamma radiation, or radionuclide concentration in water or food at above-background levels. The effective dose equivalent is calculated by estimating radionuclide concentrations in the air, water, food, and external gamma pathways at a given exposure point and developing reasonable exposure scenarios to estimate the amount of radioactivity ingested and inhaled and external gamma radiation received by the potentially exposed population.

The collective dose equivalent estimate for 1991 is 0.069 person-rem as shown in Table 4-13. The following paragraphs discuss the exposure points, estimated radionuclide concentrations in the various pathways, and summaries of exposure scenarios used to develop the collective effective dose equivalent estimate.

The potential exposure point locations were chosen on the basis of analytical results from critical receptor monitoring stations, WSQ perimeter monitoring stations, and recreational use of areas directly adjacent to the WSS. None of the analytical results from critical receptor monitoring stations were significantly different from background concentrations at the 95% confidence level for long-lived gross alpha concentrations of airborne radioactive particulates, radon gas, and external gamma exposure. Since the results from all critical receptor monitoring locations were not significantly different from background concentrations, no collective effective dose equivalent estimate was made for populations at or beyond the critical receptor locations.

Analytical results from the WSQ perimeter monitoring stations were used to estimate radon gas concentrations and the resulting collective effective dose equivalent estimate at the Katy Trail, which is a recreational trail located on state-owned land south of the quarry. The Katy Trail lies approximately 45 m (46 ft) south of the quarry at its closest point and about 25 m (27.5 ft) below the southern quarry rim. It parallels the southern rim for approximately 260 m (286 ft). The Katy Trail was chosen as the only potential exposure point location for radon and external gamma, because only at the WSQ were measured concentrations found to be statistically different, at the 95% confidence level, from the measured background concentrations for radon, and external gamma radiation. The estimated number of people using the Katy Trail for 1991 is 50,770 (Fleming 1992), which is about 71% of the number estimated in the 1990 ASER. This year's estimate is more realistic, however, since it is based on an entire year's worth of data, whereas the 1990 estimate was based on one quarter's worth of data multiplied by four. Results from the monitoring stations at other potentially affected populations near the WSQ (e.g., monitoring stations RD-4006 and TD-4006) are not significantly different from background levels. Figure 4-2 shows the locations of all WSQ perimeter monitoring stations as well as the Katy Trail.

The collective effective dose equivalent estimate for exposure to radon and its progeny was determined using the computer program CAP-88, which is a program developed by the EPA to estimate airborne radioactivity concentrations at locations up to 80 km (50 mi) away from a source. (Beres 1990). The exposure time assumed for a person walking along the Katy Trail was 5 min, which corresponds to a 3.2 km/hr (2 mi/hr) walking speed along the 260 m (286 yd) length of trail which parallels the WSQ. The above-background radon gas concentration at the Katy Trail was 0.6 pCi/l (0.22 Bq/l) and the dose equivalent conversion factor for Rn-222 progeny was obtained from ICRP Publication 32 (ICRP 1981). The estimated collective population dose due to radon inhalation for the 50,770 Katy Trail users is 0.026 person-rem (2.6E-4 person-Sv). The external gamma contribution to the Katy Trail population dose was estimated using the inverse square law modified for an area source (Cember 1983). The estimated external gamma dose equivalent rate at the Katy Trail exposure point was 9.8E-04 mrem/hr (1E-5 mSv/hr), and the resulting population dose estimate for this pathway was estimated to be 0.004 person-rem (4E-5 person-Sv). Thus, the total collective population dose estimate for the Katy Trail exposure point for all applicable pathways (i.e., radon inhalation and external gamma exposure) was 0.030 person-rem (3E-4 person-SV) for the 1991 calendar year. Details on calculations and assumptions used to calculate the effective dose equivalent are provided in Appendix G.

None of the surface water or groundwater bodies that receive runoff or recharge from the WSS are used as drinking water sources; therefore, this pathway was not included in the dose evaluation. However, the Missouri Department of Conservation estimates on an annual basis that approximately 15,000 persons use the Busch Wildlife area, which is adjacent to the WSCP/WSRP area, while another 3,800 persons participate in recreational boating activities. Lakes 34, 35, and 36 receive runoff from the WSCP/WSRP site and all three lakes are utilized for fishing and boating purposes. Therefore, a second exposure point for potential exposure of a population through ingestion of fish, water, and sediment from these lakes would be these 18,800 persons.

On average, 7,232 fish are kept from the Busch Lakes on an annual basis (MDOC 1991). Assuming that all 7,232 fish are caught in contaminated waters and one person consumes only one fish, the affected population would be 7,232 persons. The highest U-238 concentration in the fish collected from Lakes 34, 35, and 36 was 0.042 pCi/g. Assuming that the edible portion of average fish weighs 200 g (7.1 oz), and using EPA dose conversion factors, the estimated population dose for fish ingestion is 0.034 person-rem.

The average time spent at the Busch Wildlife area per boating trip is approximately 5.7 hr. Assuming that each of 3,800 visitors make only one visit to the area and spend 25% of their time swimming during these visits, a total of 1.4 hr per trip would be spent swimming in the lakes. Using average ingestion rates of 0.05 l/hr and 200 mg/day for water and sediment, respectively, and the maximum water concentrations of 51 pCi/l (1.9 Bq/l) and sediment concentration 46.8 pCi/g (1.7 Bq/g), the estimated population doses for these scenarios are 0.004 person-rem (4E-5 person-SV) and 0.0006 person-rem (6E-6 person-Sv). Consequently, the collective population dose estimate for the ingestion scenarios for the Busch Wildlife exposure point was 0.039 person-rem (3.9E-4 person-Sv). Details on calculations and assumptions used to calculate the effective dose equivalent are provided in Appendix G.

In 1991, the estimated collective population dose for recreational users of the portions of the Katy Trail and Busch Wildlife area that are affected by the WSS was 0.069 person-rem.

4.3 Radiological Release Estimates

During 1991 air monitoring results and site modeling indicated that releases from the Weldon Spring site were at background levels. Air particulate monitoring gross alpha results were not found to statistically differ from background results, at the 95% confidence level, for all on-site and off-site monitoring stations. In addition, air modeling techniques using the EPA approved computer program AIRDOS do not substantiate the potential for above background releases from the site during excavation and demolition activities in 1991. Therefore, no airborne radionuclide releases from the WSS in calendar year 1991 resulted in above-background airborne concentrations at site-perimeter and off-site locations. The dashes in Table 4-14 reflect that the amount of radioactivity released to the environment was not distinguishable from background levels of radiation. However, above background radon gas concentrations were observed at two locations at the WSQ in 1991 as discussed in Section 4.1.1.2. A box model was utilized to predict the radon release rate for the year from the WSQ. The box model assumes that airborne contaminants are dispersed homogeneously within the modeled volume of air. The major contaminated area within the quarry was used to estimate the radon release. In 1991, the estimated Rn-222 release was 14.2 Ci (53×10^{10} Bq). The Rn-222 release calculations are provided in Appendix G. Table 4-14 provides a list of those radionuclides that are considered in laboratory analyses of air samples collected at the WSS as well as their half-lives.

Intermittent surface water runoff was found to have transported uranium from the site area during 1991 through five major discharge routes. These routes are monitored through monthly sampling of the runoff water, as is required under the site's NPDES permit. The discharge of natural uranium from the NPDES outfalls is identified in Section 5 (refer to Table 5-3). Since uranium is assumed to occur naturally on WSS properties, the estimated activity by isotope is calculated and shown in Table 4-14. Other radionuclides were not measured in surface water during 1991.

Table 4-14 Radionuclide Emissions to the Environment

Radionuclide	Activity of Radionuclide Released to Air (Ci)	Activity of Radionuclide Released to Water (Ci)	Half-Life (Yrs)
U-238	--	2.9E-02	3.47E09
U-235	--	1.8E-03	7.04E08
U-234	--	2.9E-02	2.34E05
Th-232	--	NA	1.40E10
Th-230	--	NA	7.40E04
Th-228	--	NA	1.910
Ra-228	--	NA	5.76
Ra-226	--	NA	1,600
Rn-222	14.2	NA	3.82 days

NA Not analyzed for this radionuclide

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5 SURFACE WATER PROTECTION PROGRAM AND MONITORING RESULTS

5.1 Surface Water Protection and Monitoring Program Description

The surface water protection program is made up of a variety of efforts and initiatives that control and monitor the quality of water resident on, and discharging from, the Weldon Spring site (WSS). During 1991 those programs included:

- Maintenance and operation of permitted effluent outfalls under the National Pollutant Discharge Elimination System (NPDES).
- Routine monitoring of on-site and off-site surface water bodies for water quality parameters and contaminants.
- Initiation of the on-site surface water management program to systematize the management of construction waters and impounded precipitation runoff.
- Design and initial construction of two wastewater treatment facilities to treat contaminated surface (and influent ground) waters to levels permittable for release to the environment.

The effluent monitoring program, described in Section 5.2, demonstrates the WSSRAP's compliance with the Clean Water Act regulations and DOE Order requirements. The scope and the results of that program are described in detail below. Section 5.3, Non-Effluent Monitoring, is the monitoring program designed to maintain a database on the water quality of lakes and streams downgradient of the WSS property and will, in the long term, provide the baseline data to assess the effectiveness of remedial activities undertaken at the WSS.

The on-site surface water management program plan was initiated during 1991 and completion of the plan is expected in mid-1992. Certain aspects of the program were put in place during 1991, including the testing of impounded waters of unknown chemical or radiological constituent quality prior to their discharge from the site boundary. Efforts were made to define the types of waters (i.e., construction water and runoff water) to aid in categorizing and determining the measures necessary to facilitate their management. This plan will ultimately include the application of a standard operating procedure that systematizes how all surface waters on the WSS are to be managed or released.

5.2 Effluent Monitoring Results

Effluent samples were collected and analyzed in compliance with the Weldon Spring site NPDES permit. This permit (Number MO-0107701) was issued in October 1990 and addresses storm water and wastewater discharge criteria for the seven discharge points, or outfalls, indicated on Figure 5-1. Outfalls NP-0001 through NP-0005 represent surface water discharges and NP-0006 represents the treated effluent discharge associated with the administration building sanitary wastewater treatment plant. Outfall NP-0007 represents the proposed site water treatment plant outfall, which will be routinely sampled once the plant is operational. Currently NP-0006 is the only outfall with effluent limitations. The five surface water outfalls have monitoring requirements only. A summary of permit requirements including monitoring parameters and frequencies is shown in Table 5-1 (except for NP-0007).

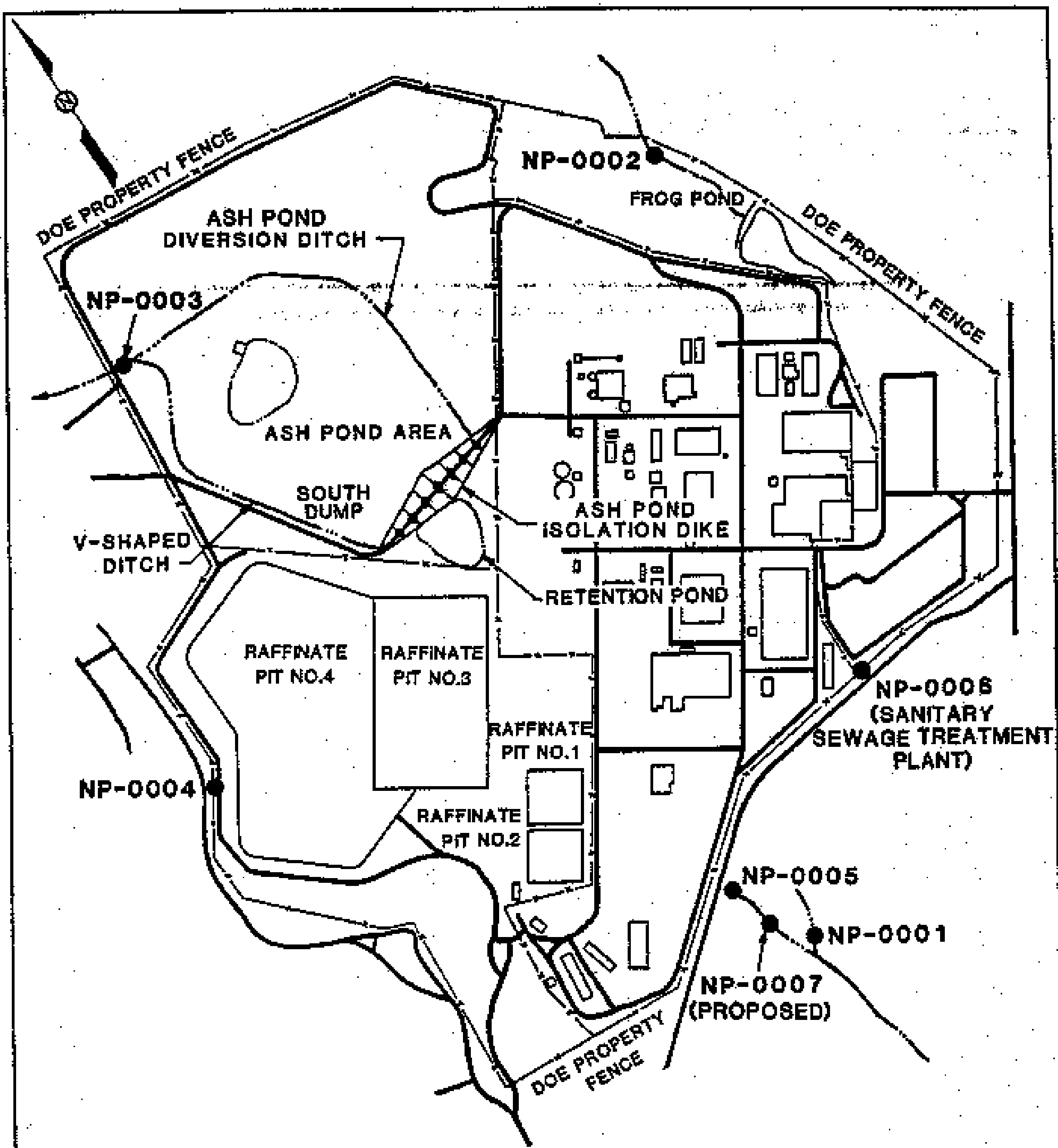
Annual averages of analytical results for the storm water locations are presented in Table 5-2. This table presents an annual summary of the individual sampling events. Analytical results for the individual NPDES sampling events (including NP-0006) are presented in Appendix A.

5.2.1 Radiological Analysis

Annual average uranium levels ranged from 6.4 pCi/l (.24 Bq/l), about 1% of the derived concentration guideline (DCG) of 600 pCi/l (22.20 Bq/l), at the minimum concentration discharge point (NP-0004) to 581 pCi/l (21.50 Bq/l), about 97% of the DCG, at the maximum concentration discharge point (NP-0005) (Table 5-2).

The old process sewer off-site discharge (NP-0001) exhibited an annual average uranium concentration of 475 pCi/l (17.60 Bq/l), 79% of the DCG. Individual measurements ranged from 198 pCi/l to 816 pCi/l (7.32 Bq/l to 30.19 Bq/l).

Frog Pond's off-site discharge (NP-0002) exhibited an annual average uranium concentration of 158 pCi/l (5.84 Bq/l), 26% of the DCG. Individual monthly measurements ranged from 40.1 pCi/l to 332 pCi/l (1.48 Bq/l to 12.28 Bq/l).



NPDES SURFACE WATER SAMPLING LOCATIONS AT THE WSCP/RP

FIGURE 5-1

REPORT NO. DOE/OR/21548-283		EXHIBIT NO.: A/CP/049/0592	
ORIGINATOR: TW	DRAWN BY: GLN	DATE: 5/92	

TABLE 5-1 National Pollutant Discharge Elimination System Permit Monitoring Requirements

	Outfall					
Parameters	0001	0002	0003	0004	0005	0006
Flow*	Q	M	M	Q	M	M
Settleable Solids*	Q	M	M	Q	M	NR
Total Suspended Solids (TSS) *F	Q	M	M	Q	M	Q
Nitrate *	Q	M	M	Q	M	NR
Uranium*	Q	M	M	Q	M	NR
Lithium*	Q	M	M	Q	M	NR
Gross Alpha*	Q	M	M	Q	M	NR
pH* F	Q	M	M	Q	M	Q
BOD F	NR	NR	NR	NR	NR	Q
Fecal Coliforms F	NR	NR	NR	NR	NR	Q

* - Monitoring requirements only; no effluent limitations.
F - Limits set for Outfall NP-0006 (BOD, 10 mg/l monthly average, 15 mg/l weekly average; TSS, 15 mg/l monthly average, 20 mg/l weekly average, Fecal Coliforms, 400 colonies/100 ml monthly average, 1,000 colonies/100 ml daily maximum; pH 6.0 - 9.0 units).
Q - Once per quarter sampling.
M - Once per month required.
NR - Monitoring for this parameter not required.

TABLE 5-2 1991 Annual Average NPDES Results for WSS Outfalls

Location	No. of Samples*	pH	Total Uranium pCi/l**	Gross Alpha pCi/l**	Nitrate mg/l**	Lithium mg/l**	Suspended Solids mg/l**	Settleable Solids ml/l/hr**	Flow GPD ***
NP-0001	4	7.5	475	331	8.9	.022	274	.16	416,483
NP-0002	10****	6.6	158(11)	117	3.1	.026	39	.06	176,283
NP-0003	12	6.5	456(14)	504	6.5(11)	.043(11)	691	.06	149,763
NP-0004	4	7.1(5)	6.4	25.8	13.4	.032	342	.05(2)	576
NP-0005	10****	6.6	581(11)	500	13.9	.027	30	.14	33,049

* Numbers in parenthesis indicate total number of samples for that parameter where the number differs from that noted in this column.

** Non-detects (ND) are averaged in at one half the detection limit. Values of settleable solids shown as ND (<0.1 ml/l/hr) are averaged in at .05 ml/l/hr.

*** Flows are averaged by using only the flow from the days that samples were collected.

**** No discharge during two months.

Ash Pond's off-site discharge (NP-0003) exhibited an annual average uranium concentration of 456 pCi/l (16.87 Bq/l), 76% of the DCG. Individual monthly measurements ranged from 13.6 pCi/l to 3400 pCi/l (.50 Bq/l to 125.79 Bq/l). The 3400 pCi/l (126 Bq/l) value from a January 3, 1991, sample along with a 1290 pCi/l (48 Bq/l) value from a March 1, 1991, sample raised the average appreciably. The next highest value was 313 pCi/l (12 Bq/l). The two high values appear to be a seasonally-related fluctuation. During the winter of 1990-91, when the two high values were obtained, there was a heavy cover of ice. The freeze-thaw cycles, along with the water saturated soil, could have caused the water to have greater contact time with soil resulting in higher uranium levels in the effluent. No other circumstances were noted that could have raised the levels.

Outfall NP-0004, as noted above, had the lowest average uranium concentration at 6.4 pCi/l (0.24 Bq/l). Individual measurements ranged from 1.43 pCi/l to 10.0 pCi/l (.05 Bq/l to .37 Bq/l). The NPDES permit requires this outfall to be sampled four to 10 days after a stormwater runoff event. This requirement was included to help ascertain if the flow at this outfall was from the raffinate pits. Consistently, low uranium levels indicate that the flow is not from the raffinate pits.

As noted, outfall NP-0005 (at the head of the southeast drainage) had the highest annual average. Individual monthly measurements ranged from 48.2 pCi/l to 2,240 pCi/l (.56 Bq/l to 82.87 Bq/l). The second highest value measured was 748 pCi/l (27.67 Bq/l). The high uranium value at NP-0005 was contemporary with the elevated levels at NP-0003, again suggesting the suspected freeze/thaw mechanism as a probable explanation.

Outfall NP-0006 (the administration building sewage treatment plant) was sampled quarterly for uranium. Uranium concentrations in all four samples were below detection limits.

Annual average gross alpha levels generally follow the pattern of the natural uranium results. This similarity between the average uranium and gross alpha values indicates that most of the off-site radionuclide released in surface water is in the form of soluble uranium.

Estimated quantities of total uranium released off site through surface water runoff are presented in Table 5-3. If it is assumed that the entire annual precipitation runoff is discharged from these points, and the discharge from each point is proportional to the site drainage area for each point, an estimate of the total uranium released can be calculated. The percent of

TABLE 5-3 1991 Estimated Annual Release of Natural Uranium from NPDES Outfalls

Outfall Location*	Drainage Area (acres)	% of Precipitation as Runoff	Average Concentration (pCi/l)	Total Volume (Mgal/yr)	Total Runoff (Mgal/yr)	Total Uranium Release (Ci/yr)	Total Uranium Release (Kg/yr)
NP-0001 and NP-0005	20.2	50**	528	20.24	10.12	.0202	29.71
NP-0002	57.3	28.9***	158	57.41	16.59	0.009	14.6
NP-0003	60.1	28.0***	456	60.22	16.86	.0290	42.65
NP-0004	5.6	52.0**	6.4	5.61	2.92	.00007	.103
Totals	143.2	--	--	143.48	46.49	.0592	87.1

* See Figure 5-1 for outfall locations.
** Estimated using runoff numbers.
*** Estimated using actual rainfall and weir data for May 1991.

precipitation as runoff was estimated using actual rainfall and weir data, or runoff numbers, as indicated on Table 5-3. The estimated total uranium released for 1991 is 31.7 kg (70 lb) greater than that estimated for 1990. The major factor contributing to this greater estimated value was the increased average value at outfall NP-0003 (due to the two high sample results discussed previously). Excluding outfall NP-0003 (from both years), the uranium released during 1991, 44.4 kg (98 lb), was less than the 1990 release of 48.8 kg (108 lb) (MKF and JEG 1991c).

5.2.2 Physical/Chemical Analysis

Physical analyses (settleable solids and total suspended solids) and chemical analyses (nitrate, pH, and lithium) were also performed on NPDES samples in 1991. The annual averages for these parameters are shown in Table 5-2. One half the detection limit was substituted for non-detect (ND) values in the calculation of the averages.

Similarly, 0.05 ml/l/hr was substituted for settle solids values reported as <0.1 ml/l/hr in the calculation of settleable solids averages.

Settleable solids for outfall NP-0004 were <0.1 ml/l/hr for both samples analyzed. Settleable solids were not determined for two quarters due to heavy algae growth in the water. Outfalls NP-0001, NP-0002, NP-0003 had one value each that was >0.1 ml/l/hr and outfall NP-0005 had two values >0.1 ml/l/hr. Increased construction activity and off-site water line installation contributed to the values >0.1 ml/l/hr at NP-0005.

Total suspended solids annual average values ranged from 30 mg/l at NP-0005 to 691 mg/l at NP-0003. Again, increased construction activity contributed to the higher values at NP-0001 and NP-0003. Outfall NP-0004 is a shallow drainage way that is sampled during dry weather. The NPDES permit requires sampling four to 10 days after a storm event. High total suspended solids values could result from difficulties in collecting samples from the shallow stream bed without stirring up the stream bed.

Nitrate values for 1991 were higher than values for 1990, except for outfall NP-0003, which was much lower. Annual average values ranged from 3.1 mg/l for outfall NP-0002 to 13.9 mg/l for outfall NP-0005.

Lithium values for 1991 were slightly higher than 1990 values. This slight increase was probably because 34 of the 39 samples analyzed were below the detection limit, and one half the detection limit was used for averaging purposes; where in previous years, "non detects" were not used in averaging.

Average 1991 pH values, for the five stormwater outfalls, were similar to 1990 averages and ranged from 6.5 to 7.5. Values of pH of 6.0 to 9.0 are generally acceptable to regulatory agencies.

5.2.2.1 Sanitary Wastewater. Outfall NP-0006 is the discharge for the site administration building sanitary wastewater treatment facility. The NPDES permit contains effluent limitations on biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform and pH. Samples were analyzed at least quarterly for these parameters by the subcontractor operating this facility. A table illustrating these results is presented in Appendix A. NPDES limits were exceeded seven times during 1991 at this outfall (see Table 5-1 for the effluent limits). When the effluent was in noncompliance for any parameter, the subcontractor initiated operational changes to bring the effluent back into compliance.

5.2.2.2 Erosion Control Monitoring. An erosion control monitoring program was initiated during 1991. Samples were collected downstream of erosion control structures to assess their effectiveness. Analytical results of samples collected at NPDES outfalls in conjunction with this program were reported to the Missouri Department of Natural Resources. The samples were analyzed for settleable solids and natural uranium. The program, to date, shows that erosion control measures have been effective.

5.2.2.3 Uranium Trend Analysis. Annual average uranium concentrations in NPDES outfalls from 1987 through 1991 are presented in Table 5-4. Uranium concentrations show an overall decline for 1987 through 1990, with an increase in 1991. All outfall average values for 1989 through 1991 are below the DCG of 600 pCi/l (22.20 Bq/l). The greatest increases for 1991 occurred at NP-0003 and NP-0005.

A comparison of values between outfall locations indicates the following:

- Uranium concentrations at NP-0004 remain extremely low indicating that the dry weather flow at this outfall is not coming from the raffinate pits.

Table 5-4 Annual Average Uranium Concentrations at NPDES Outfalls 1987-1991

Uranium Concentrations pCi/l					
Outfall Location	1987	1988	1989	1990	1991
NP-0001	680	539	368	413	475
NP-0002	210	141	145	139	158
NP-0003	2240	1178	280	89	456
NP-0004	9.5	6.2	6.5	7.6	6.4
NP-0005	780	497	347	364	581

- Uranium concentrations at NP-0002 do not indicate any significant fluctuation. This is expected, since very little excavation or disruption has occurred within this watershed.

- The uranium concentration at NP-0003 has increased, but still remains well below the pre-Ash Pond diversion project levels. Two very high levels during winter weather raised the average considerably. It is speculated that saturated ground conditions due to heavy ice cover contributed to the high readings. No other circumstances were noted that could have contributed to the high levels.

- Uranium levels at outfall NP-0001 increased slightly in 1991 and levels at NP-0005 increased by approximately 220 pCi/l (8.1 Bq/l). The increases at these outfalls are due to increased construction activity in the watershed feeding these outfalls. A continuing program of erosion control has been implemented to keep levels as low as reasonably achievable (ALARA). Also, the construction activities mentioned above removed approximately 19,116 m^3 (25,000 cu yd) of radioactively contaminated soil material from the watershed feeding NP-0005. It is anticipated that this effort will, in the long term, improve the quality of stormwater runoff through that outfall.

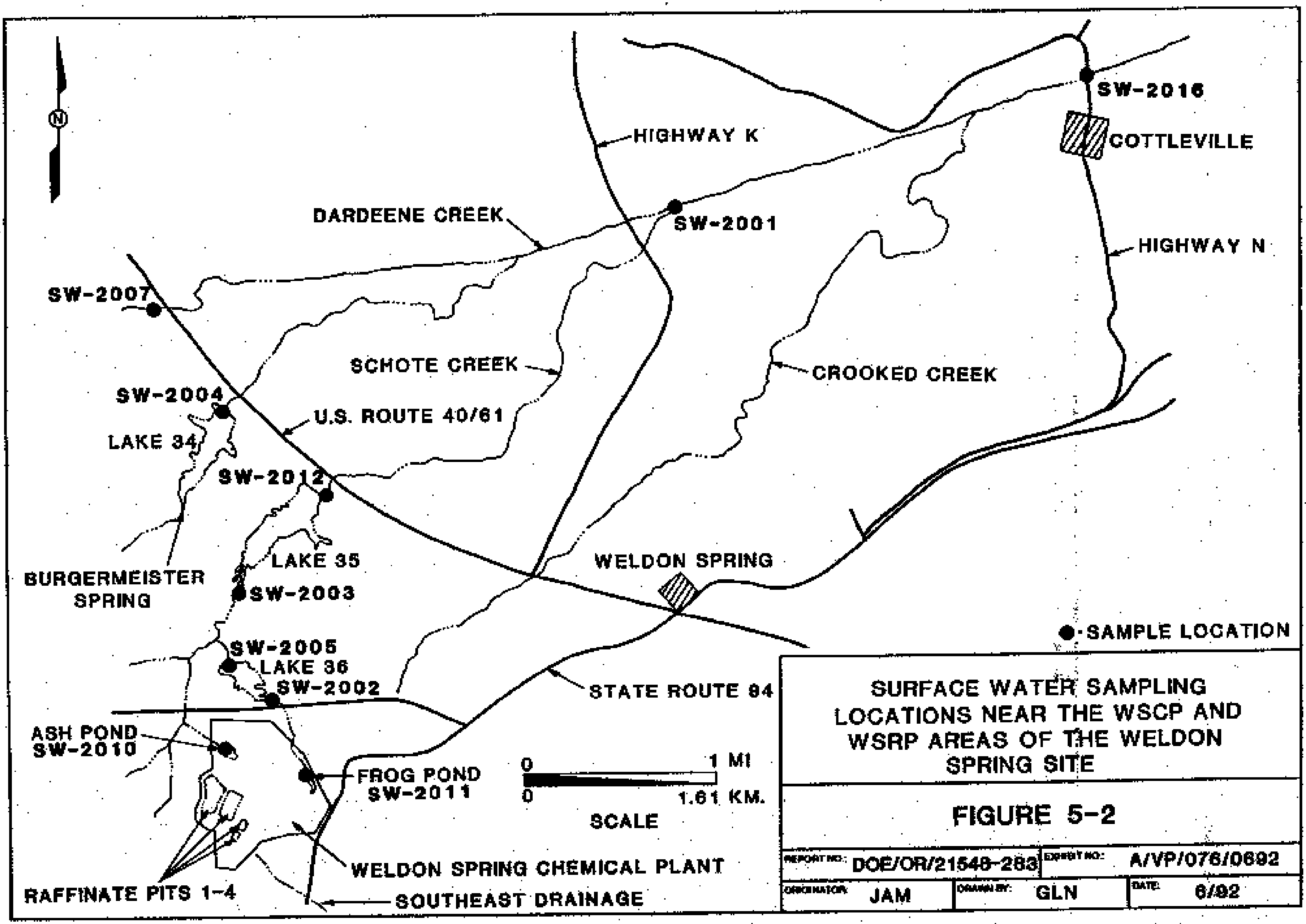
5.3 Surface Water and Spring Monitoring

Surface water samples were collected and analyzed for radiological parameters from a total of 26 locations; 12 within or near the Weldon Spring Chemical Plant/Weldon Spring raffinate pits (WSCP/WSRP) and 14 near the quarry. A total of 11 springs were monitored both north and south of the WSCP/WSRP for radiological parameters. Many of these locations have been sampled by the WSSRAP for four consecutive monitoring years, and are therefore considered the most representative for monitoring contaminants that may pose a risk to the public health or the environment. All samples were analyzed for uranium and selected sites were analyzed for Ra-226, Th-230, and Th-232. Radium and thorium isotopes have been analyzed in water samples from surface water runoff from the WSS in past years. The analyses of those samples indicate that radium and thorium do not constitute a radiological contaminant in surface water leaving the site perimeter. Because the water solubility of those radionuclides in the environment is low, and because there was no significant disturbance in radium or thorium contaminated soil materials during 1991, it is not expected that the discharge of those nuclides in surface water would differ significantly from previous years.

In an effort to maintain a current understanding of site-related contaminant concentrations in potentially affected surface water features, surface water samples were collected from six on-site and six off-site locations. Locations SW-2007 and SW-2001 are upstream and downstream, respectively, of the surface water migration pathway from the site. Locations SW-2002, SW-2003, SW-2004, and SW-2005 are located within or near August A. Busch Wildlife Area (ABWA) lakes while SW-2010 (Ash Pond), SW-2011 (Frog Pond), and SW-3001 through SW-3004 (raffinate pits) are located on site. These locations are shown on Figure 5-2.

Springs SP-5201, SP-5203, and SP-5301 through SP-5304 (southeast drainage) are located south of the site; while springs SP-6301 (Burgermeister Spring), SP-6302, SP-6303, and SP-6306 are located north of the site as shown on Figure 5-3.

Twelve surface water locations were selected for routine monitoring to evaluate and document the possibility that surface waters near the Weldon Spring Quarry (WSQ) might pose a risk to human health or the environment. Locations SW-1001 and SW-1002 monitor the Little Femme Osage Creek at points upstream and downstream of the WSQ, respectively. Six sampling locations, SW-1003 through SW-1005, SW-1007, SW-1009, and SW-1010 are distributed along the Femme Osage Slough. Location SW-1008 monitors the ponded water



SURFACE WATER SAMPLING LOCATIONS NEAR THE WSCP AND WSRP AREAS OF THE WELDON SPRING SITE

FIGURE 5-2

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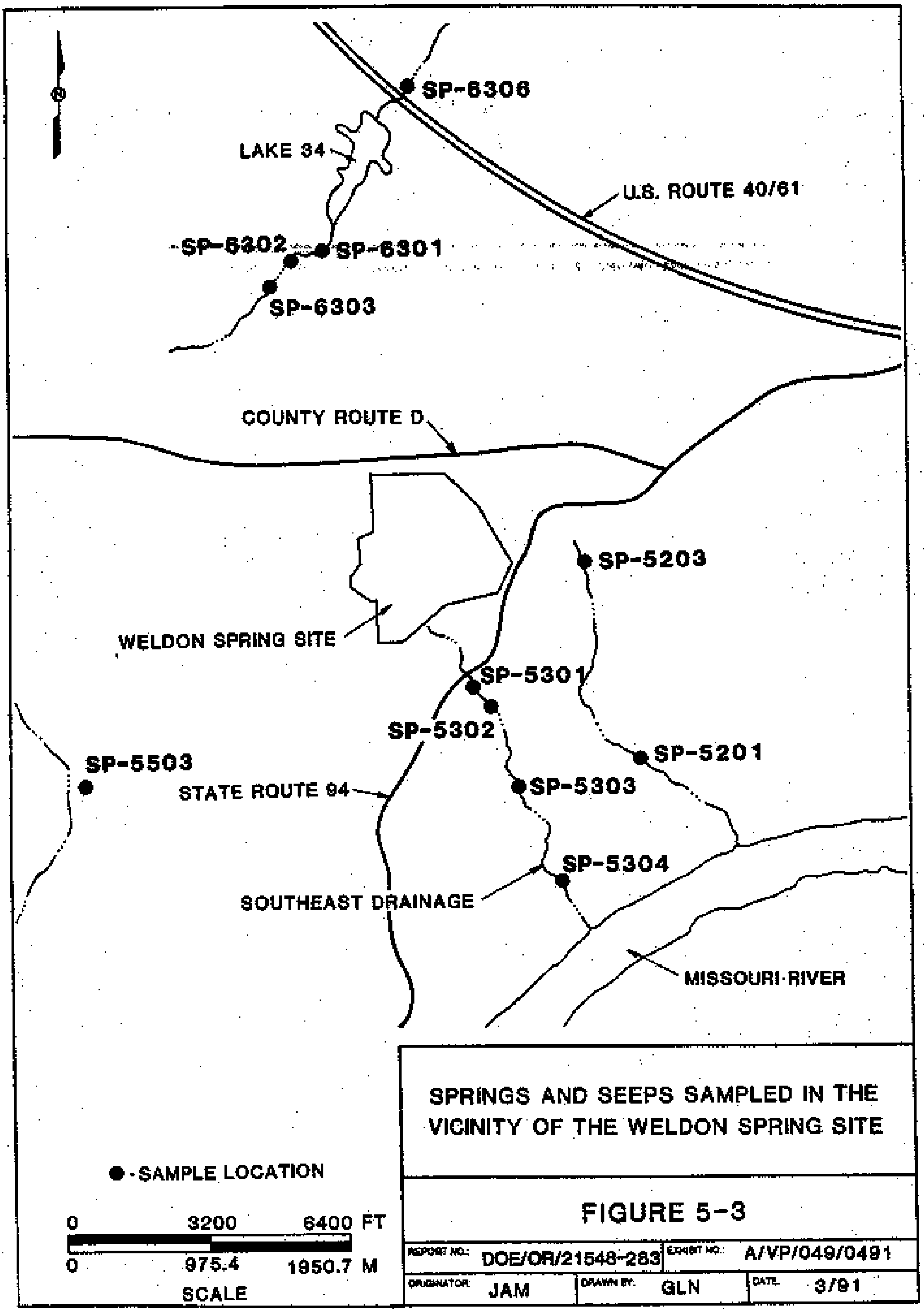
ORIGINATOR: JAM DRAWN BY: GLN DATE: 6/92



SPRINGS AND SEEPS SAMPLED IN THE VICINITY OF THE WELDON SPRING SITE

FIGURE 5-3

within the WSQ. The samples from this location permit a rough determination of the concentrations of the various contaminants in the ponded surface water (in contact with the quarry wastes) that may migrate to groundwater. Locations SW-1011, SW-1012, and SW-1013 were added to the monitoring program in 1989 to provide baseline water quality data from the Missouri River. SW-1011 is the upstream Missouri River location above potential influences from Weldon Spring site (WSS) contamination, while SW-1013 is furthest downstream below the outfall point of the Southeast Drainage easement. SW-1014 was added to the monitoring program in 1991 to provide additional surface water monitoring downgradient of the quarry.

5.3.1 Surface Water Radiological Monitoring Results for the Weldon Spring Chemical Plant/Raffinate Pits

The average uranium concentrations at off-site locations including Dardenne Creek, both upstream and downstream of its confluence with Schote Creek, were within the range of natural background of 4 pCi/l (0.15 Bq/l). Also within background were the waters of Springs 5201, 5203, 5503 and 6303, which have historically been at or near background uranium levels in previous monitoring years. Off-site locations SW-2002, SW-2003, SW-2004, and SW-2005, which represent the waters of Busch Wildlife area lakes 34, 35, and 36; ranged from a low of 7.6 pCi/l (0.28 Bq/l) or 1% of the DCG at Lake 35, to a high of 20 pCi/l (0.74 Bq/l) or 3% of the DCG at the head end of Lake 36. These values were within their historical ranges.

Springs in the area, which have historically exhibited radiological and chemical contamination from site-related sources, continued to undergo quarterly monitoring and the measured contaminant levels remained within their historical ranges. Burgermiester Spring displayed an annual average uranium concentration of 81 pCi/l (3 Bq/l); the springs along the Southeast Drainage also remained consistent between 139 pCi/l (5.1 Bq/l) and 289 pCi/l (10.7 Bq/l), or 48% of the DCG. Table 5-5 contains the results of this monitoring. Burgermeister Spring (SP-6301) is monitored for nitrate and sulfate. The average nitrate concentration of 109 mg/l and sulfate concentration of 41 mg/l indicate an influence by site contaminated groundwater from near the raffinate pit area.

On-site surface water bodies include the four raffinate pits, Ash Pond, and Frog Pond. The raffinate pits, which contain process sludge from the uranium production operations, also contain supernatant surface water contaminated by radiochemical and chemical constituents.

Table 5-5 1991 Annual Average Uranium and Inorganic Anion Results at Springs Near WSCP/RP Area

WSSRAP ID	Uranium, Total pCi/l
SP-5201	ND
SP-5203	0.95
SP-5301	289
SP-5302	276
SP-5303	194
SP-5304	139
SP-5503	ND
SP-6301	81
SP-6302	63
SP-6303	2.7
SP-6306	7.0

These waters are monitored annually for uranium, radium and thorium isotopes, as well as for nitrate and sulfate. Uranium levels range from 96 pCi/l (3.6 Bq/l) in Pit 1 to 1473 pCi/l (54.5 Bq/l) in Pit 4. Tables 5-6 and 5-7 display these results. These levels were down from measured levels in 1990. Although these averages are within the historical range of measurements for those locations, Pit 1 concentrations varied widely throughout the monitoring year. No explanation is currently available for these variations and sampling procedures are being reviewed as a possible cause. There is no direct surface discharge from the raffinate pits to off-site drainageways.

Ash Pond (SW-2010) water was measured for uranium during 1991 and contained an average concentration of 908 pCi/l (33.6 Bq/l). Frog Pond contained an average uranium concentration of 163 pCi/l (6 Bq/l). These values are also within the historical range for those locations.

Table 5-6 Annual Average Uranium and Inorganic Anion Concentrations for Surface Water Near the WSCP/RP During 1991

WSSRAP ID	Uranium, Total pCi/l	Nitrate mg/l	Sulfate mg/l
Off-Site			
SW-2001	2.1	NS	NS
SW-2002	20	NS	NS
SW-2003	7.6	NS	NS
SW-2004	15	NS	NS
SW-2005	13	NS	NS
SW-2007	ND	NS	NS
On-Site			
SW-2010	908	2.4	NS
SW-2011	163	NS	NS
SW-3001	96	368	225
SW-3002	782	2.2	796
SW-3003	503	2378	502
SW-3004	1473	1.4	44

Table 5-7 Radium and Thorium Concentrations from the Raffinate Pits During 1991

WSSRAP ID	Radium-226 pCi/l	Thorium-228 pCi/l	Thorium-230 pCi/l	Thorium-232 pCi/l
SW-3001-Q291	138	1.3	179	10.8
SW-3002-Q291	74	ND	156	36.3
SW-3003-Q291	105	5.4	9.2	1.8
SW-3004-Q291	3.5	2.5	4.3	1.5

No significant changes were observed between the average values measured in 1991 and 1990 at any of the 12 surface water or the 11 spring locations within or near the site. At the furthest downstream location, SW-2001 (the confluence of Schote and Dardenne creeks), the average and the maximum of the quarterly measurements remained within the range of background as in previous years.

The sampling results indicate that uranium continues to migrate from the site at relatively low levels in surface water and springs along known discharge pathways. The concentration (activity) of total uranium is reduced by dilution and natural processes to the point that the level falls to within the range of natural background at the farthest downstream measurement location, SW-2001.

Other radiological species (radium and thorium) were monitored in 1991 only at the raffinate pits (see Table 5-7). Historically, no other monitoring locations have detected elevated levels of those species. The raffinate pits were sampled once in 1991 to maintain a baseline on the radioisotope levels. The radium and thorium values within the pits for 1991 were very similar to those of 1990.

5.3.2 Surface Water Monitoring for the Weldon Spring Quarry

5.3.2.1 Results for Radiological Analyses. The primary radionuclide of concern at the Weldon Spring Quarry is uranium. The measured levels ranged from below the detection limit of 1 pCi/l (<0.037 Bq/l) to a quarterly high of 1950 pCi/l (72 Bq/l) or 325% of the DCG in the water of the quarry pond. Table 5-8 exhibits the annual average contaminant levels of concern for locations near the WSQ. Figures 5-4 and 5-5 exhibit the sampling locations near the WSQ.

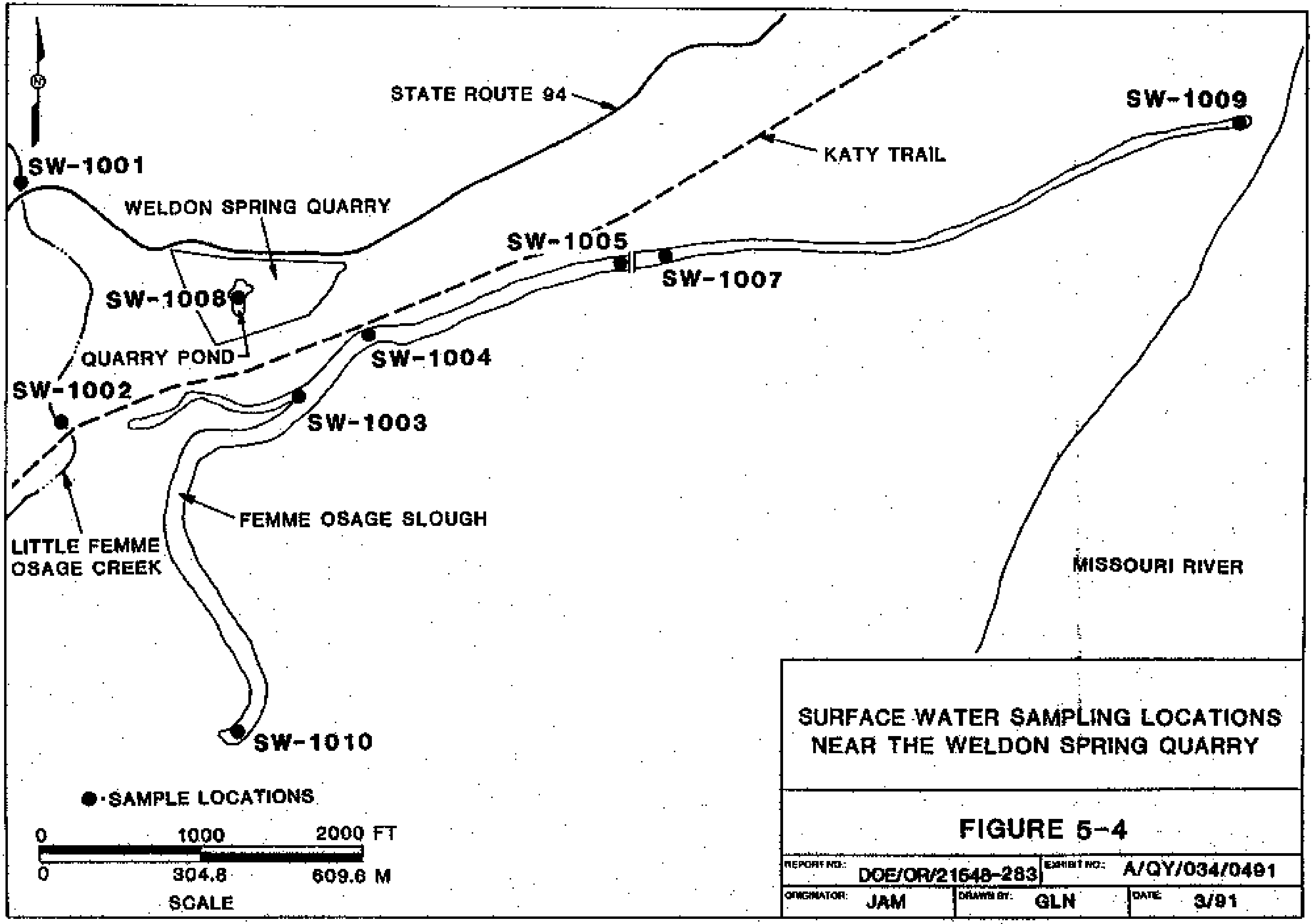
The quarry pond is within the access controlled area of the quarry site. Quarterly samples collected in 1991 display an annual average of 969 pCi/l (36 Bq/l), or 161% of the DCG. This average concentration is down from the annual average during 1990 of over 2000 pCi/l (74 Bq/l). However, this is not believed to represent a trend in contaminant conditions, but is rather a function of precipitation and dilutional effects prior to sampling. Due to the restricted access and security systems in place at the WSQ, the waters in the quarry pond are of little direct threat to the public health.

TABLE 5-8 Annual Average Uranium and Inorganic Anion Concentrations For Surface Water Near the WSQ During 1991

WSSRAP ID	Uranium (pCi/l) (0.68)*	Chloride (mg/l) (0.25)*	Fluoride (mg/l) (0.25)*	Nitrate (mg/l) (0.1)*	Sulfate (mg/l) (1.0)*
SW-1001	2.3	NS	NS	NS	NS
SW-1002	3.2	NS	NS	NS	NS
SW-1003	93	NS	NS	NS	NS
SW-1004	127	NS	NS	NS	NS
SW-1005	47	NS	NS	NS	NS
SW-1007	15	NS	NS	NS	NS
SW-1008	969	12.4	0.68	.39	68
SW-1009	15	NS	NS	NS	NS
SW-1010	77	NS	NS	NS	NS
SW-1011	4.0	23.5	0.65	7.1	126
SW-1012	3.9	24	0.56	7.5	122
SW-1013	3.1	26	0.51	6.3	139
SW-1014	1.8	NS	NS	NS	NS
SW-1015	2.1	21.6	0.48	6.6	102

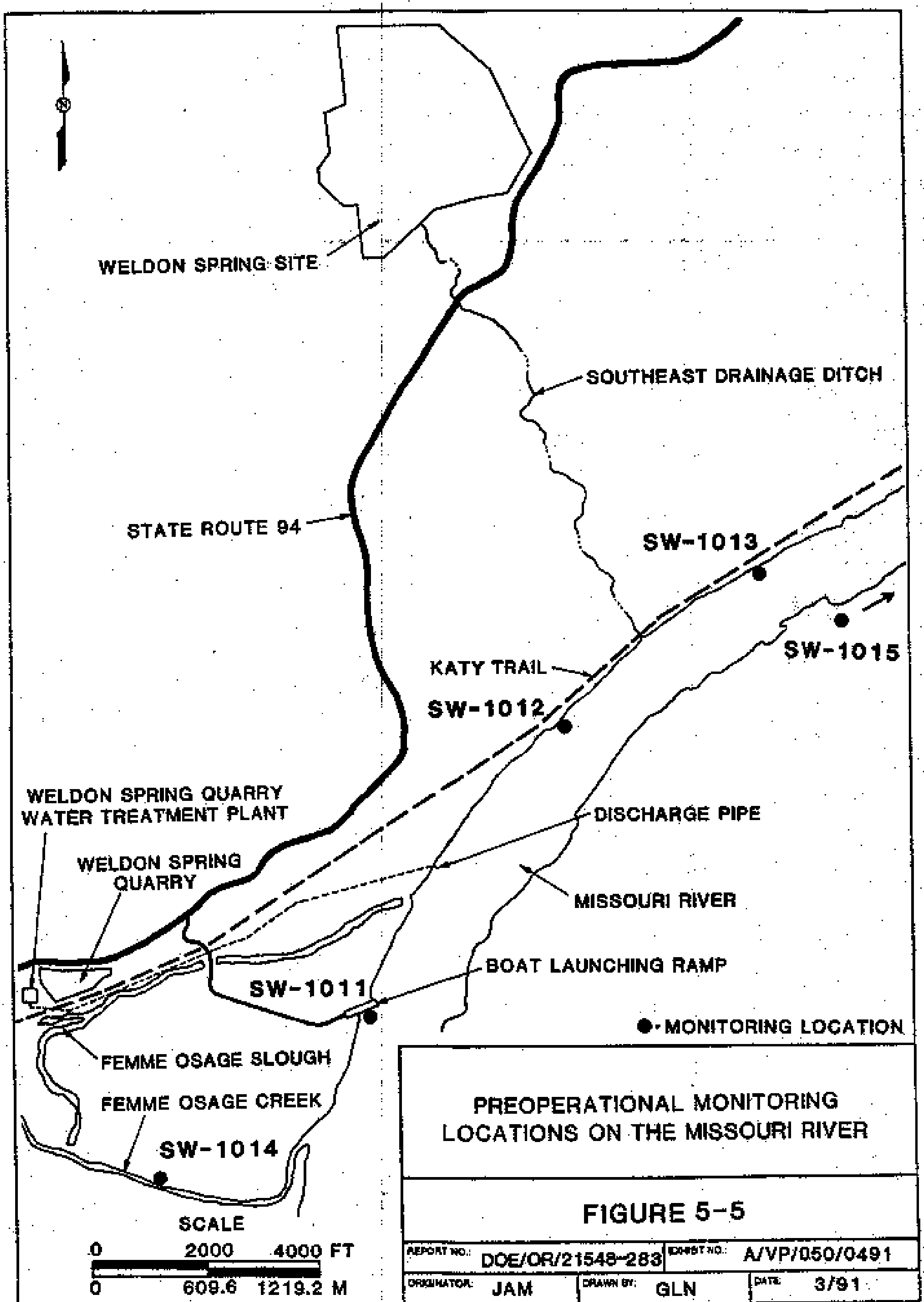
Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

* Detection limit
ND - Not Detected
NS - Not Scheduled For Sampling



SURFACE WATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 5-4



PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

FIGURE 5-5

REPORT NO.: DOE/OR/21548-283	EXHIBIT NO.: A/VP/050/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91

Locations SW-1011 to SW-1013 are distributed along the north bank of the Missouri River for preoperational water quality testing in preparation for effluent discharge from the WSQ water treatment plant (WTP). The annual average results of the measurements were less than 1 pCi/l for uranium activities at SW-1013 (downstream), 3.02 pCi/l (0.11 Bq/l) at SW-1012, and 4.01 pCi/l 0.15 Bq/l) at SW-1011 (upstream). The highest quarterly measured uranium activity in the Missouri River was detected during the first quarter of 1991 at 4.8 pCi/l (0.18 Bq/l), or 0.8% of the DCG at both SW-1011 and SW-1012. These values fluctuate due to natural variations in the river water.

Location SW-1014 is located on the Femme Osage Creek between the west end of the Femme Osage Slough and the Missouri River to monitor contamination which might migrate from the slough. The uranium results from SW-1014 represent background levels with an annual average of 1.8 pCi/l (6.7E-2 Bq/l).

Location SW-1015 is a new sampling location positioned 7 mi downstream from the St. Charles County well field at the St. Louis County Howard Bend Water Treatment Plant. This location was monitored for natural uranium, radium, and thorium isotopes. Average uranium concentration in river water at that location was 2.1 pCi/l (0.08 Bq/l). Table 5-8 presents these results. Other detected radiochemical isotopes included Th-230 at 3.72 pCi/l (0.14 Bq/l) and Th-232 at 1.34 pCi/l (0.05 Bq/l).

The Femme Osage Slough, which is the former channel of the Femme Osage Creek prior to the rerouting of that stream during the 1960s, is a nearly stagnant water body. The slough receives uranium contamination from the contaminated groundwater in the bedrock and alluvial aquifer to the north. Total uranium was detected at an annual average ranging from 15 pCi/l (0.56 Bq/l/2.5% of the DCG) in the eastern portion of the slough (SW-1007 and SW-1009) to 128 pCi/l (4.7 Bq/l/21.3% of the DCG) at SW-1004 located adjacent to the quarry. In 1991, the uranium activities within the slough ranged from a low of 8.6 pCi/l (0.32 Bq/l), or 1.4% of the DCG at SW-1005, to a high of 326 pCi/l (23.2 Bq/l), or 54% of the DCG at SW-1004. This is attributed to uranium contaminated groundwater discharging to the slough from the north side. The stage of water in the slough is managed by the Missouri Department of Conservation, whereby water is allowed to fill the slough during high river stage and the control valve is closed at high stage retaining the water in the slough. These fluctuating water levels create an additional mechanism for migration in an otherwise more stationary situation. The average uranium levels for the slough remained within their historical ranges.

According to the 1991 measurements, the quarry pond water contained an average concentration of 2.5 pCi/l (0.09 Bq/l) for Ra-226 less than 1.0 pCi/l for Ra-228, and Th-230 activities were measurable at 3.66 pCi/l (0.14 Bq/l) while Th-232 remained undetected. See Table 5-9. These values remain within their historical ranges.

TABLE 5-9 1991 Annual Average Radiological Results For Surface Water in the WSQ (pCi/l)

WSSRAP ID	Radium-226	Radium-228	Thorium-230	Thorium-232
SW-1008	2.50	ND	3.66	ND

Average is calculated using quantified results. An ND is reported in this table only if all results from that location were below the associated detection limit.

ND - Not Detected

5.3.2.2 **Inorganic Anion Results.** Inorganic anions were analyzed on an annual basis for chloride and fluoride and quarterly for nitrate and sulfate and only on water in the quarry pond. Table 5-8 shows the annual averages for each parameter measured.

The measured chloride value detected in the quarry sump was 12.4 mg/l, comparable to historical numbers. The relatively slight variations can be accounted for by natural dilution effects. Fluoride level also remained within its historical range at SW-1008. The annual measurement for fluoride at SW-1008 was 0.68 mg/l. The nitrate levels for SW-1008 remained below 0.4 mg/l for 1991. The sulfate measurements average 68.5 mg/l at SW-1008. This level remains within historical values at this location. All measured levels remained well below the U.S. Environmental Protection Agency (EPA) secondary drinking water standard for sulfate of 250 mg/l.

5.3.2.3 **Results for Nitroaromatic Analyses in WSQ Surface Water.** The quarry pond (SW-1008) was sampled during the second, third and fourth quarters for nitroaromatic compounds. The total quantified concentrations of all six compounds ranged form 1.57 μg/l during the second quarter to 73.42 μg/l during the fourth quarter. These levels represent the levels planned for treatment by the WSQ water treatment plant when it is operational. Samples will continue to be collected from the quarry pond to maintain accurate information on the levels in the water. The ponded water will ultimately be treated for nitroaromatic compounds and other organics upon completion of the quarry water treatment plant.

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6 GROUNDWATER PROTECTION PROGRAM AND MONITORING RESULTS

The groundwater protection program at the Weldon Spring site (WSS) is founded on the concept of source control from potential new sources and the characterization and monitoring of existing contamination until final decisions may be made on the need for remediation. These concepts are reflected in the Weldon Spring Site Remedial Action Project (WSSRAP) *Groundwater Protection Program Management Plan* (GWPPMP) (MKF and JEG 1991d) discussed below. Also discussed below are the activities of well abandonment, and the results of groundwater monitoring.

6.1 Groundwater Protection Program Management Plan

The WSSRAP Groundwater Protection Program (GWPP) has gradually increased in scope since 1981, when the U.S. Department of Energy (DOE) appointed Bechtel National, Inc. (BNI) as its custodial contractor. BNI installed the first groundwater monitoring wells and began investigating water quality beneath the Weldon Spring site. With the establishment of the WSSRAP in 1986, the current Project Management Contractor (PMC) initiated an informal organization devoted to the protection, investigation, and remediation of the groundwater system at the WSS. The purpose of the WSSRAP GWPPMP (MKF and JEG 1991d) is to formalize and structure the program both for internal consistency and to facilitate external review. This plan and the WSSRAP *Environmental Monitoring Plan* (MKF and JEG 1992b) meet the requirements for a Groundwater Protection/Management Program and Groundwater Monitoring Plans as described in DOE Order 5400.1. The contents of the plan have been assembled to reflect the following scope:

- To define the purpose, policies, and objectives of the WSSRAP GWPP.
- To define the organizational roles and responsibilities of departments involved in the GWPP.
- To define the interfaces between the GWPP and other programs.
- To define the methods, procedures, and schedules to be utilized in meeting the GWPP objectives.

- To provide effective quality maintenance for the GWPP. (A quality assurance[QA] plan that meets NQA-1 requirements has been developed for the project.)

- To provide the most effective management for the GWPP.

The WSSRAP GWPPMP (MKF and JEG 1991d) is routinely updated and reissued. The plan as a whole will be reviewed at least annually, and will be revised and reissued as appropriate.

Many wells, piezometers, and borings have been installed at the WSS for groundwater monitoring, aquifer testing, geologic characterization, and geotechnical studies. These wells are designated with numbers that pertain to their location. Monitoring wells with 1000 series numbers are located at the Weldon Spring Quarry (WSQ); wells with 2000 series numbers are located within the chemical plant area; wells with 3000 series numbers are located in the raffinate pit area; and wells with 4000 series numbers are located outside the site boundaries.

6.2 Well Abandonment Activities

The proper plugging of a groundwater monitoring device that is being removed from service is essential to maintaining the integrity of the associated aquifer or aquifers. For this reason, the WSSRAP has established requirements for plugging wells at the WSS. The lines of authority, procedures, and plugging criteria are established by this plan. Specific procedures (procedure ES&H 4.4.4s) have been developed specifying the activities required to properly plug and abandon a well. The policy for managing cuttings and waste materials from abandonment operations is covered under WSSRAP procedure RC-30.

During calendar year 1991, 15 wells and piezometers were plugged and abandoned. These abandonments were conducted to facilitate construction activities at or near the area occupied by the monitoring devices. All abandonment activities were conducted in accordance with the applicable WSSRAP procedure ES&H 4.4.4, *Subsurface Monitoring Device Plugging and Abandonment*. In summary, this procedure requires overdrilling of the well casing and construction material (grout, filter pack, etc.) and tremie grouting the hole closed to surface. The wells and piezometers abandoned during 1991 included: MW-1025, MW-2031, PW-2, OB-2A through 2J, GT-63P, and MW-3010.

6.3 Groundwater Monitoring Program and Results

6.3.1 Groundwater Monitoring Program

6.3.1.1 Groundwater Evaluation. Groundwater within and around the Weldon Spring Chemical Plant/raffinate pits (WSCP/RP) and WSQ has been radiologically and chemically characterized through sampling and analyses. A surveillance program that includes monitoring potentially impacted groundwater has been established to monitor radiological and chemical conditions. The extent of the groundwater environmental surveillance program has been determined based upon applicable regulations, hazard potential of effluents, quantities and concentrations of effluents, public interest, and the potential or actual impacts on groundwater. The environmental surveillance program for groundwater is conducted in accordance with the requirements of the U.S. Department of Energy (DOE) Orders 5400.1, 5400.5 and the *Regulatory Guide.*

6.3.1.2 Groundwater Characterization. Groundwater within or near the WSCP/RP and the WSQ was sampled to determine potential exposure pathways. Chemical and radiological characterization of the groundwater within or near the WSCP/RP and WSQ was provided through the implementation of work plans, sampling plans, and other characterization plans. These plans, which were approved by the DOE and the EPA, include environmental monitoring; sampling locations, procedures, equipment, frequency, and analysis required; minimum detection levels; and quality assurance and quality control components. The evaluation of the characterization data and potential exposure pathways has provided the basis for the environmental surveillance program for groundwater as described in the groundwater monitoring program section of the *Environmental Monitoring Plan* (MKF and JEG 1992b).

The objective of the groundwater monitoring program at both the WSCP/RP and WSQ is to collect sufficient data to estimate the approximate quantity of radionuclides released along that migration route. The radionuclide release information may be used to calculate the public dose to hypothetical groundwater users. At present, no wells are actively pumped as water supplies within a 1.6 km (1 mi) radius of the WSCP/RP site. Wells outside that area have been sampled in the past and have shown no evidence of radionuclide contamination from the WSSRAP. Those private wells will continue to be routinely sampled and analyzed by the Missouri Department of Health as part of an independent program by that agency. The results are also made available for review by WSSRAP staff. Section 6.5 discusses this independent sampling and analysis program.

The data collected from the WSQ and county well field region will allow a determination to be made on whether the WSQ presents an increased incremental risk to users of that water. No measurable increases in uranium levels above background at the well field have been seen to date.

6.3.1.3 Groundwater Monitoring Program for the WSQ. Forty-eight groundwater wells, including 36 DOE monitoring wells, four St. Charles County monitoring wells, and eight municipal wells owned by St. Charles County have been chosen for routine monitoring to investigate and document the possibility that groundwater near the WSQ may pose a risk to human health or the environment.

Chemical and radiological wastes at the quarry are of particular concern because of their proximity to the St. Charles County well field approximately 0.8 km (0.5 mi) to the south. The issue of protection of the well field is one of great sensitivity to the public, the DOE, and other regulatory agencies. The DOE has issued a number of orders providing direction on the assessment of exposure to the public, including directions for protection from radiation and other chemical species, where applicable. The monitoring strategy for the quarry and surrounding area has been developed to ensure the protection of public health and the environment.

Previous groundwater quality studies performed at the WSQ indicated the presence of several contaminants in or near the quarry. Elevated uranium concentrations have been detected in the immediate WSQ area, and in the alluvial groundwater north of the Femme Osage Slough. Elevated nitroaromatics, arsenic, barium, and inorganic anion concentrations have also been observed.

The geology of the WSQ area is generally separated into upland soil materials, Missouri River alluvium, and bedrock. The Missouri River alluvium and bedrock units produce groundwater and the groundwater within these units is monitored.

The unconsolidated upland material overlying bedrock consists of up to 9.1 m (30 ft) of silty clay soil and loess deposits. The upland soils near the WSQ are generally not saturated, therefore associated groundwater is not monitored.

The sediments comprising the alluvium along the Missouri River vary from clays, silts, and sands; to gravels, cobbles, and boulders. The maximum alluvium thickness near the WSQ is approximately 30.5 m (100 ft). The alluvium is truncated at the erosional contact with Paleozoic bedrock bluffs along the now-abandoned Missouri, Kansas, and Texas (MK&T) railroad bed. The alluvium thickness increases dramatically with distance from the bluff. Silts and clays with minor amounts of sand are the primary sediments between the bluff and the Femme Osage Slough. The thick, water-producing sands and gravels of the alluvial aquifer give way to fine-grained organically rich overbank deposits beneath the Femme Osage Slough. The potentiometric surface of the alluvial aquifer fluctuates in rapid response to pumping of the St. Charles County production wells and the stage of the Missouri River. The Missouri River serves as the primary recharge source for the alluvial aquifer.

Currently there are 33 wells, including eight municipal production wells, four county-owned monitoring wells, and 21 DOE-owned monitoring wells that are screened within the alluvial material located between the quarry and the Missouri River. Five of the wells, MW-1035 through MW-1039, are located west of the quarry to monitor the immediate area surrounding the quarry water treatment plant equalization basin and effluent ponds. Six wells, MW-1006 through MW-1009, MW-1014, and MW-1016 are located between the quarry and the slough to monitor contaminant migration south of the quarry within the alluvium. Monitoring wells MW-1010, MW-1011, and MW-1017 through MW-1024 are located south of the slough within the alluvium and are monitored to enable detection of contaminants south of the slough. County monitoring wells RMW-1 through RMW-4 are monitored to (1) ensure that the quarry contaminants are not migrating toward the municipal well field, and (2) enable an early warning of contaminant migration toward the county production well field if this should occur. The eight county municipal wells, PW-2 through PW-9, are also monitored to ensure that the quarry contaminants are not affecting the quality of the municipal well field water supply.

Bedrock at the WSQ consists of three distinct Ordovician formations. In descending order, they are the Kimmswick Limestone, limestone and shale of the Decorah Group, and the Plattin Limestone. The Kimmswick Limestone is a coarsely crystalline limestone with numerous solution-enlarged joints. The Decorah Group consists of interbedded limestone and green shale approximately 9.1 m (30 ft) thick and horizontally fractured. The Plattin Limestone is a thinly bedded limestone about 30.5 m (100 ft) to 38.5 m (125 ft) thick. There are currently 15 DOE monitoring wells screened within either the Kimmswick-Decorah or Plattin Formations to monitor contaminants near the quarry within the bedrock. Monitoring wells MW-1002,

MW-1004, MW-1005, MW-1012, MW-1013, MW-1015, MW-1026, MW-1027, MW-1029, MW-1030, MW-1032, and MW-1034 were installed to monitor contaminants within the Kimmswick-Decorah Formation surrounding the quarry. It should be noted that MW-1012 and MW-1034 are north and upgradient of the quarry and have been designated as background wells. Monitoring wells MW-1028, MW-1031, and MW-1033 are located south of the quarry within the Plattin Limestone to determine whether vertical contaminant migration has occurred.

6.3.1.4 Groundwater Monitoring Programs for the Weldon Spring Chemical Plant/Raffinate Pit Area. The groundwater flow and contaminant transport mechanisms that make up the groundwater pathway are very different between the WSCP and the WSQ due to different geologic conditions. Groundwater monitoring at the chemical plant is conducted under two distinct monitoring programs. The first is the conventional application of monitoring wells at the site close to the contaminant source areas. The second is the monitoring of water from springs that represent the resurgence point for discrete flow paths receiving recharge in part from the site. For 1991, this monitoring program and results are discussed in Section 5 - Surface Water Monitoring.

Geology at the WSCP/RP may be divided into two major units based on gross lithologic characterization: the unconsolidated glacial and residual soils, and the underlying bedrock. The unconsolidated material consists of topsoil, loess, glacially derived sediments, and residuum. Unconsolidated material is present to a depth of 6.1 m (20 ft) to 15.3 m (50 ft) at the WSCP/RP. These glacial soils are generally silty clays with minor amounts of gravel. The unconsolidated materials are generally not saturated and therefore are not monitored.

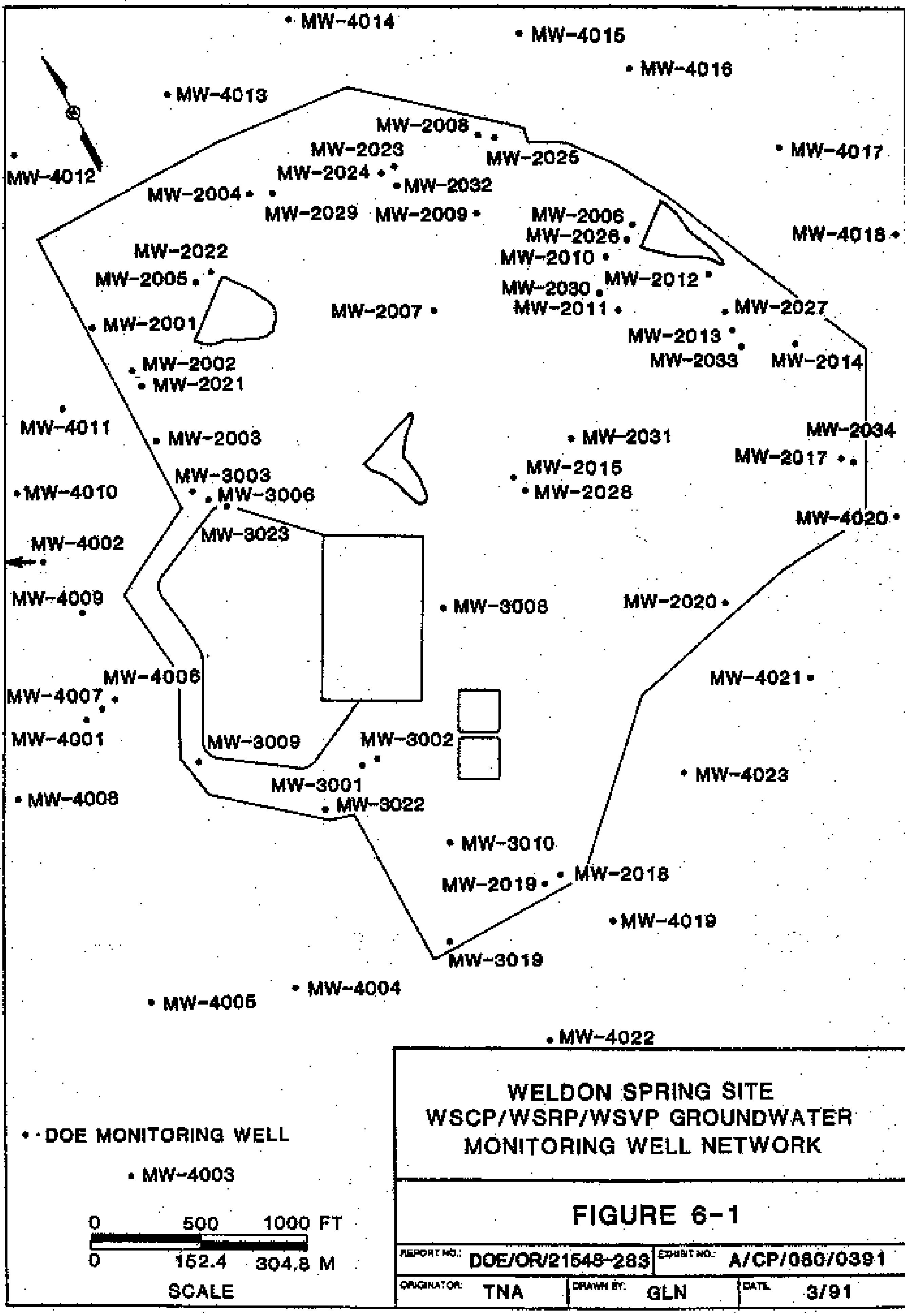
Groundwater occurs in the bedrock underlying the WSCP/RP. The first bedrock unit encountered is the Burlington-Keokuk Limestone. The Burlington-Keokuk Limestone consists of two zones containing different lithologic characteristics: competent (unweathered), and weathered. The shallow, weathered Burlington-Keokuk Limestone is typically a grayish-orange to yellowish-gray, argillaceous limestone commonly containing as much as 60% chert nodules and interbeds. The weathered limestone is a low-yield, semi-confined, heterogeneous, anisotropic aquifer that is fractured and susceptible to natural solution processes. At the site, the aquifer generally exhibits diffuse flow properties overlain by discrete flow zones such as saturated highly weathered bedrock and saturated residuum in paleochannels. The fracture flow, solution-effected discrete flow, and conduit flow are most effectively monitored by sampling springs at the resurgence points for that flow (Quinlan 1989). The competent (unweathered) portion of the Burlington-Keokuk Limestone is thinly to massively bedded, gray to light gray, finely to coarsely crystalline, stylolitic, and fossiliferous. The fracture densities are significantly lower and apertures smaller in the competent limestone than in the weathered limestone.

Monitoring well locations are shown in Figure 6-1. All monitoring wells are completed in the Burlington-Keokuk Limestone and are constructed of stainless steel or polyvinyl chloride (PVC). Monitoring wells are installed and developed in accordance with accepted procedures as discussed in the U.S. Environmental Protection Agency Resource Conservation and Recovery Act (RCRA), *Technical Enforcement Guidance Document* (EPA 1986) and Missouri State regulations, *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells* (EPA 1989) and the *Groundwater Protection Program Management Plan* (GWPPMP) (MKF and JEG 1991d). Fifty-seven of these wells monitor the upper portion of the formation. Eight wells monitor deeper portions of the bedrock aquifer, especially near potential source areas and in areas of known groundwater contamination. By monitoring these locations and depths, changes in the horizontal and vertical components of contaminant migration can be detected.

6.3.2 Groundwater Monitoring Results

All WSCP/RP/VP and WSQ monitoring wells were sampled during 1991 for radiological parameters. An understanding of groundwater quality and hydrogeology has been established over the past four years through routine monitoring and investigations at the site. Therefore, the groundwater monitoring program has been modified each year to include areas where more information is needed, and to avoid unnecessary or redundant sampling and analysis.

All wells sampled at the WSCP/RP/VP and the WSQ were monitored at least semi-annually for total natural uranium. The St. Charles County pumping wells, the treated and untreated water from the St. Charles County Water Treatment Plant, and a select group of monitoring wells in the county well field were monitored for total natural uranium and gross alpha on a quarterly basis. These same locations were also monitored on an annual basis for Th-230, Th-232, Ra-226, Ra-228 and gross beta. This quarterly and annual sampling was performed to ensure the safety of the St. Charles County water supply from contaminant migration originating from the WSQ.



WELDON SPRING SITE
WSCP/WSRP/WSVP GROUNDWATER
MONITORING WELL NETWORK

FIGURE 6-1

REPORT NO.: DOE/OR/21548-283		EXHIBIT NO.: A/CP/060/0391	
ORIGINATOR: TNA	DRAWN BY: GLN	DATE: 3/91	

An "ND" in the data tables indicates "Not Detected" and appears only if a particular parameter was not measurable above the detection limit in any analyses performed on samples obtained from that well during 1991. If the analytical laboratory reported an "ND" for a particular parameter during a particular sampling event, the ND was used in calculating the annual concentration at one-half of the detection limit. The individual data points are presented in data tables in Appendix A.

6.3.2.1 Groundwater Monitoring Results for Chemical Plant/Raffinate Pits. Groundwater at the WSCP/RP area became radiologically and chemically contaminated as a result of operations and wastes from the Weldon Spring Uranium Feed Materials Plant (WSUFMP) during the 1950s and 1960s.

The groundwater monitoring network consists of 65 wells; 33 on the WSCP area, nine within the WSRP area, and 23 surrounding these areas. Figure 6-1 shows the locations of individual wells in the WSCP/RP/VP monitoring well network. All of these wells are screened in the uppermost unconfined aquifer although their screened intervals and elevations vary within that geologic unit. The wells are completed at a range of depths so that portions of the entire uppermost aquifer are monitored. Detailed well construction information for individual wells is available in the 1991 *Environmental Monitoring Plan* (MKF and JEG 1992b). The upper bound for total natural uranium background concentrations in groundwater at the WSCP/RP/VP has been determined to be 3.4 pCi/l (0.125 Bq/l) (MKF and JEG 1989c). The EPA has proposed a primary drinking water standard for total uranium of 20 μg/l (EPA 1991 proposed 40 CFR Parts 141, 142). Applying a ratio of equal activities for U-238 and U-234 in the groundwater at the WSS, this equates to 14 pCi/l (0.52 Bq/l) as an equivalent standard.

Forty-nine of the 65 wells have average total uranium concentrations below the site-determined, upper-bound for natural background in the Burlington-Keokuk aquifer of 3.4 pCi/l (0.13 Bq/l). As shown in Table 6-1, 12 monitoring wells have annual average concentrations above background but below the EPAs proposed maximum contaminant level (MCL) concentration of approximately 14 pCi/l (0.52 Bq/l) (assuming U-234/U-238 equilibrium). Four wells, MW-3003, MW-3009, MW-4005, and MW-4020 have annual average concentrations that range between 14 pCi/l (0.52 Bq/l) and 44 pCi/l (1.63 Bq/l). Three of these four wells (all but MW-3009) had average levels in that same range during 1990. The wells with the highest average concentrations during 1990 (MW-3008 and MW-3009) both declined during 1991.

Table 6-1 Uranium and Inorganic Anion Data for Groundwater at the WSCP/RP Area of the Weldon Spring Site

WSSRAP ID	Nitrate (as N)* DL = 0.1 mg/l	Sulfate mg/l	Uranium, Total pCi/l
MW-2001	20	5.8	ND
MW-2002	288	108	ND
MW-2003	267	126	ND
MW-2004	0.96	2.3	ND
MW-2005	162	21	1.2
MW-2006	6.2	33	ND
MW-2007	ND	11	1.5
MW-2008	2.8	33	0.82
MW-2009	3.1	386	1.8
MW-2010	1.1	35	1.4
MW-2011	3.1	59	2.5
MW-2012	0.86	68	1.4
MW-2013	1.9	20	1.1
MW-2014	1.9	35	0.64
MW-2015	0.16	98	2.4
MW-2017	0.43	366	7.3
MW-2018	0.40	8.5	1.3
MW-2019	ND	40	2.0
MW-2020	0.61	139	4.2
MW-2021	ND	14	ND
MW-2022	0.34	14	ND
MW-2023	ND	17	1.5
MW-2024	ND	30	0.97
MW-2025	ND	15	ND
MW-2026	ND	16	0.7

Table 6-1 Uranium and Inorganic Anion Data for Groundwater at the WSCP/RP Area of the Weldon Spring Site (Continued)

WSSRAP ID	Nitrate (as N)* DL = 0.1 mg/l	Sulfate mg/l	Uranium, Total pCi/l
MW-2027	ND	10	ND
MW-2028	ND	100	1.5
MW-2029	ND	24	1.3
MW-2030	1.4	36	6.5
MW-2031**	0.38	34	6.1
MW-2032	78	30	1.3
MW-2033	0.92	12	0.76
MW-2034	0.34	345	9.0
MW-3001	606	21	3.0
MW-3002	0.16	327	1.3
MW-3003	354	199	19.7
MW-3006	0.28	22	1.3
MW-3008	872	304	4.1
MW-3009	71	63	25
MW-3019	ND	4.9	4.9
MW-3022	88	1.2	3.4
MW-3023	325	407	7.1
MW-4001	34	63	1.8
MW-4002	1.3	18	0.75
MW-4003	0.76	23	1.3
MW-4004	0.67	20	2.3
MW-4005	1.7	19	43
MW-4006	4.7	28	0.84
MW-4007	0.12	16	ND
MW-4008	0.13	21	ND
MW-4009	0.50 (0.11)	21	2.1

Table 6-1 Uranium and Inorganic Anion Data for Groundwater at the WSCP/RP Area of the Weldon Spring Site (Continued)

WSSRAP ID	Nitrate (as N)* DL = 0.1 mg/l	Sulfate mg/l	Uranium, Total pCi/l
MW-4010	ND	28	1.0
MW-4011	29	54	3.8
MW-4012	0.45	49	3.8
MW-4013	106	42	0.82
MW-4014	2.2	26	ND
MW-4015	1.9	11	1.8
MW-4016	ND	7.8	4.4
MW-4017	0.29	8.3	1.5
MW-4018	6.6	5.8	0.9
MW-4019	0.2	4.6	2.1
MW-4020	ND	112	19.9
MW-4021	ND	271	4.9
MW-4022	0.2	47	1.5
MW-4023	2.6	61	0.76

ND Not detected above referenced lower limit of detection.
* The concentration in parentheses is converted to nitrate as nitrogen.
** Well abandoned during this monitoring year.

Monitoring well MW-3008 averaged 4 pCi/l (.15 Bq/l); MW-3009 averaged 25 pCi/l (0.93 Bq/l).

6.3.2.1.1 Chemical Results for WSCP/RP Area.

<u>Inorganic Anions</u>

Nitrate and sulfate concentrations were also analyzed in the groundwater beneath the chemical plant/raffinate pit area. Nitrate concentrations ranged from below the detection limit to a high of 872 mg/l at MW-3008 adjacent to Raffinate Pit 3. The EPAs drinking water standard for nitrate is 10 mg/l as nitrogen. Eleven of the 65 wells indicate nitrate levels in excess of the EPAs drinking water standard as indicated on the figure in Appendix I. All but one of these wells are located within approximately 305 m (1,000 ft) of the raffinate pits, the primary source for nitrate-contaminated water on site. Although potentially a function of the greater density of monitoring wells to the north, nitrate concentrations suggest a pattern of elevation northward from the raffinate pits. This migration direction is consistent with the flow gradient for groundwater north of the groundwater divide. Nitrate levels elevated above background, but below the drinking water standard, are evident of other wells west and north of the raffinate pit areas.

Sulfate is also regularly monitored at the WSS due to its presence as a waterborne contaminant in the raffinate pits. The U.S. Environmental Protection Agency (EPA) maintains a secondary drinking water standard for sulfate of 250 mg/l. Seven wells measured in excess of the 250 mg/l standard with the highest measured at 407 mg/l at well MW-3023, a shallow well near Raffinate Pit 4, as illustrated on the figure in Appendix I.

Similar to the measured uranium levels, the chemical constituents of concern do, to a limited extent, migrate beyond the current, most distant lateral line of monitoring wells of levels detectable above background. This limited migration does not pose an imminent threat to any local public or private water supplies. This is supported by the independent sampling conducted by the Missouri Department of Health, as discussed in Section 6.5.

Nitroaromatic Compounds

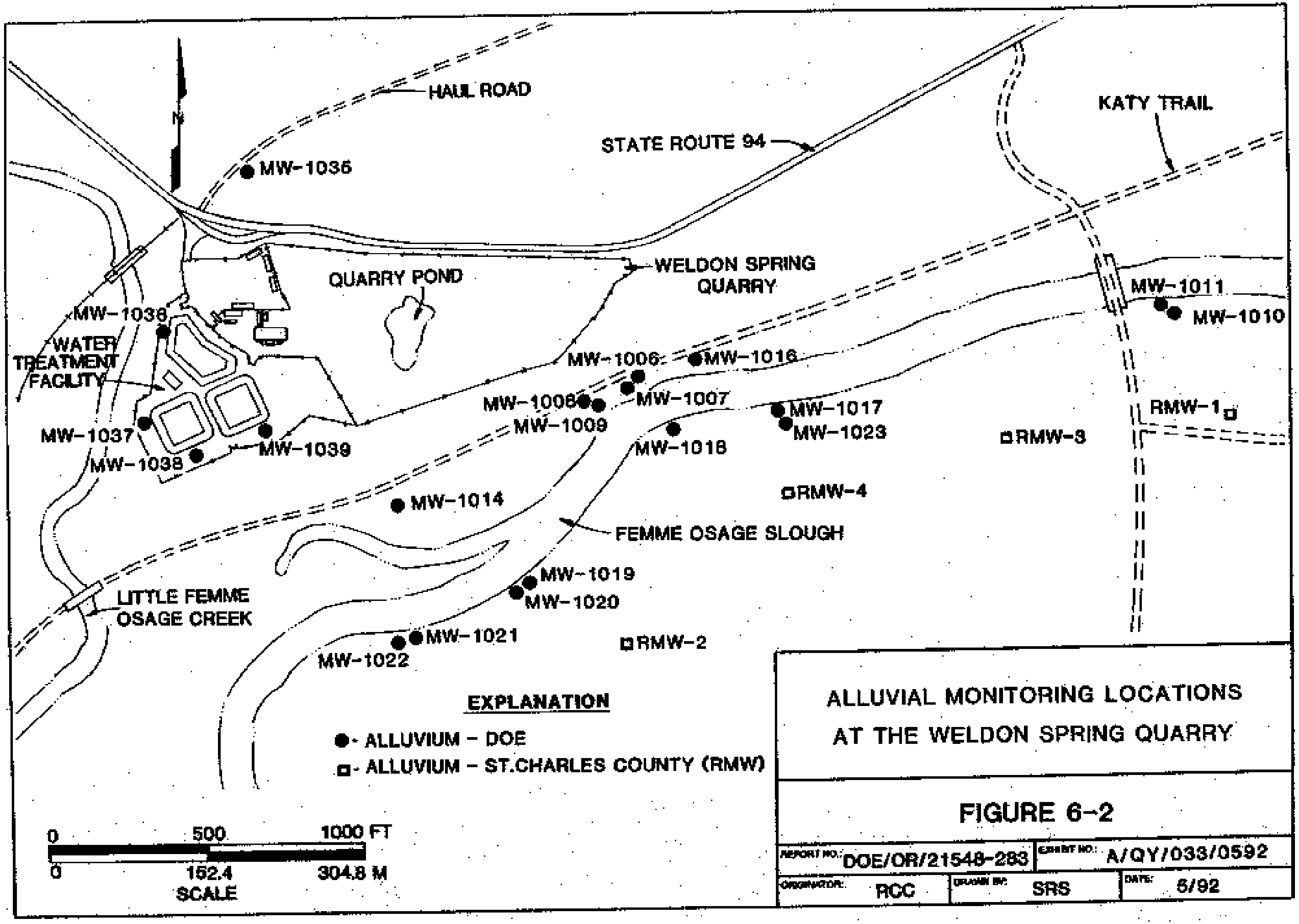
Six nitroaromatic compounds are monitored in groundwater beneath the WSCP/RP area. Historically, very low levels (near the detection limits) have been observed in the shallow groundwater system beneath the site. Results of 1991 monitoring continue to indicate these very low levels ranging from less than the detection limit to approximately 62 μg/l for average total nitroaromatic compounds (i.e., the sum of the annual average concentrations of all six measure compounds). Eight wells maintained annual average concentrations of 2,4-DNT greater than the ambient water quality criteria of 0.11 μg/l for that compound as illustrated on the figure in Appendix I. The site has historically been aware of two areas of generally higher concentrations of nitroaromatics centered around monitoring wells MW-2013 and MW-4001. These areas continue to exhibit nitroaromatic levels consistent with historical levels. [redacted] Monitoring well MW-4013 again displayed elevated levels primarily of 1,3,5-trinitrobenzene, the compound which generally represents the largest fraction of the total nitroaromatic compounds present in the groundwater. Table 6-2 contains the 1991 results of nitroaromatic analyses, representing those wells where detectable levels were measured.

6.3.2.2 Groundwater Monitoring Radiological Results for the WSQ Area. Groundwater near the WSQ has become radiologically contaminated as a result of contact with, or migration from, the radioactive substances present in the WSQ. Thirty-six DOE groundwater monitoring wells located at or near the WSQ were sampled and analyzed during 1991 to monitor for the presence of WSQ related contaminants. The four St. Charles County monitoring wells, eight production wells, and the treated and untreated water from the St. Charles County Water Treatment Plant were also monitored for the presence of these contaminants. Figures 6-2 through 6-4 show the locations of the alluvial and bedrock monitoring wells, pumping wells, and the St. Charles County Water Treatment Plant. The groundwater monitoring wells are screened in a range of geologic formations from the Ordovician-aged Plattin Limestone to, and including, the unconsolidated Quaternary-aged Missouri River alluvium.

During 1988 and 1989, samples of groundwater were taken from a private water well that produces from the Missouri River alluvium and is located several kilometers upstream of the WSQ and St. Charles County well field. These samples were analyzed for a suite of parameters

Table 6-2 WSCP/RP Groundwater Monitoring Locations with Detectable Nitroaromatic Concentrations (µg/l)

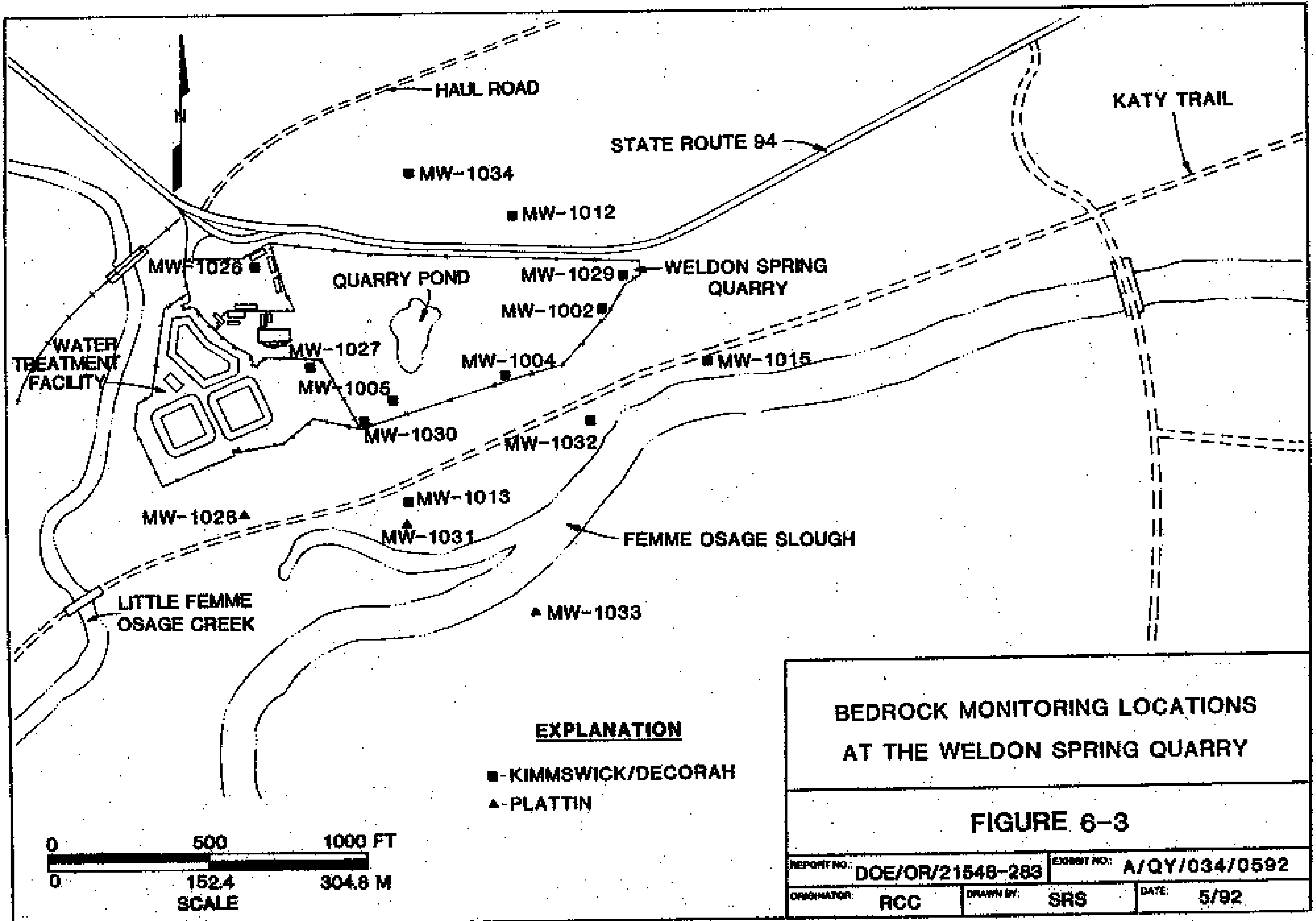
Location	1,3,5-TNB (0.03)	1,3-DNB (0.09)	2,4,6-TNT (0.09)	2,4-DNT (0.02)	2,6-DNT (0.01)	NB (0.03)	Sum of Measured Averages
GW-2001	.02	ND	ND	0.07	0.06	ND	0.15
GW-2002	.02	ND	ND	0.06	0.41	ND	0.49
GW-2003	ND	ND	ND	0.17	0.81	ND	0.98
GW-2005	ND	ND	ND	0.08	0.13	ND	0.21
GW-2006	11	ND	ND	0.07	2.2	ND	13.3
GW-2007	18	ND	ND	ND	ND	ND	18
GW-2008	ND	ND	0.02	0.05	0.94	ND	1.0
GW-2010	0.18	0.07	0.4	0.04	0.16	ND	0.85
GW-2011	0.18	ND	ND	0.07	0.84	0.02	1.1
GW-2012	0.91	ND	0.32	0.04	ND	ND	1.3
GW-2013	6	0.17	0.98	0.05	21	ND	28
GW-2014	3	ND	ND	0.12	0.08	ND	3.2
GW-2030	4	ND	8.3	0.15	20	ND	33
GW-2032	4	ND	6.7	0.06	40	ND	16
GW-2033	2.3	ND	1.0	0.16	6.1	ND	9.6
GW-3001	0.05	ND	ND	0.44	0.25	ND	0.74
GW-3003	ND	ND	ND	0.05	0.08	ND	0.13
GW-3008	ND	ND	ND	0.09	0.24	ND	0.33
GW-3009	0.12	ND	ND	0.15	0.1	ND	0.37
GW-4001	54	ND	0.8	3.7	ND	ND	58
GW-4002	0.1	ND	0.6	0.21	0.09	ND	1.0
GW-4006	13	ND	ND	0.09	3.2	ND	16
GW-4013	60	ND	0.06	0.07	1.4	ND	62
GW-4014	0.38	ND	ND	ND	0.03	ND	0.41
GW-4015	0.56	ND	ND	0.05	1.1	ND	1.7
GW-4023	0.13	ND	ND	0.08	0.05	ND	0.26



ALLUVIAL MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 6-2

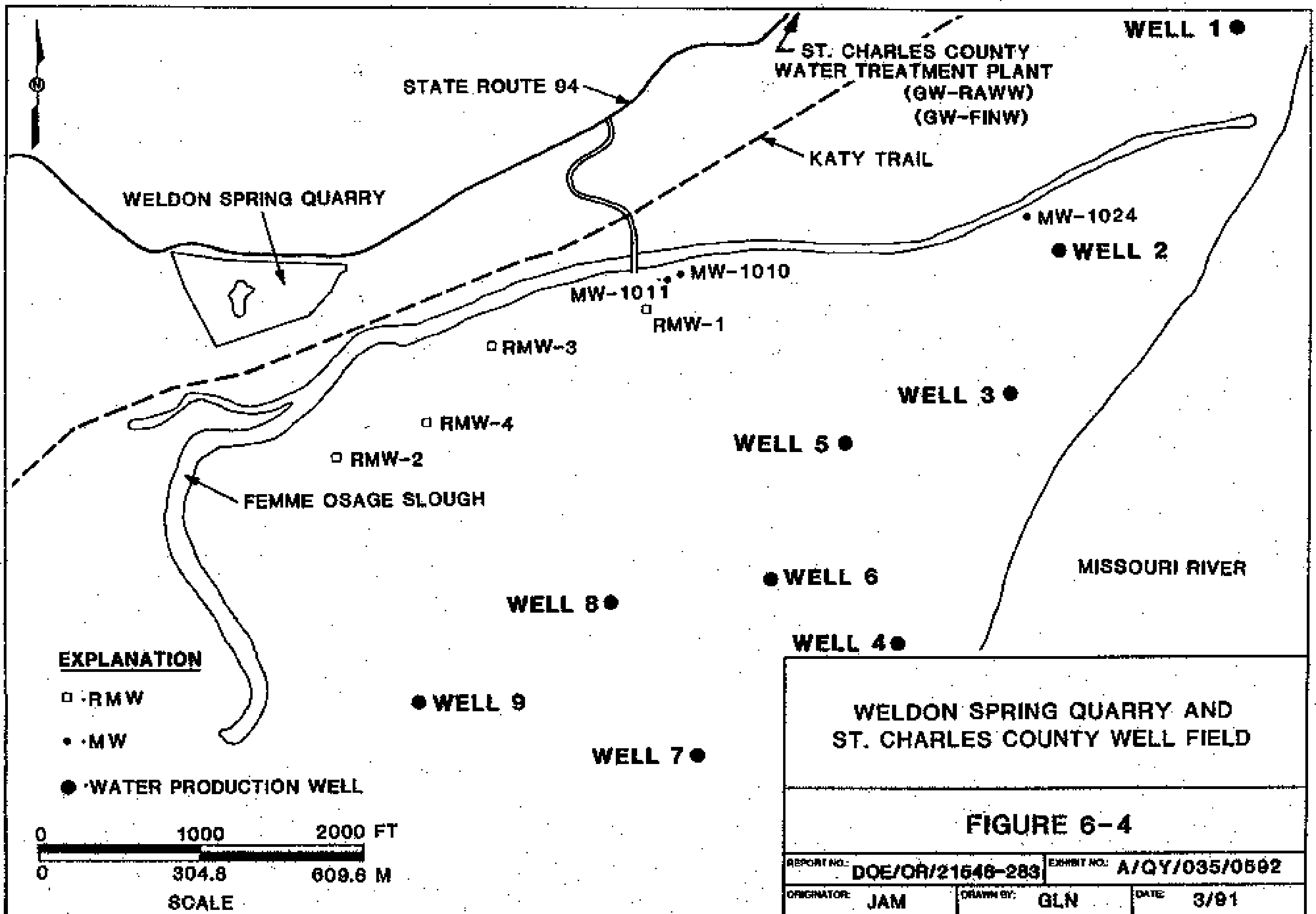
REPORT NO.:	DOE/OR/21548-283	EXHIBIT NO.:	A/QY/033/0592		
ORIGINATOR:	RCC	DRAWN BY:	SRS	DATE:	5/92



BEDROCK MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 6-3

REPORT NO.: DOE/OR/21548-283		EXHIBIT NO.: A/QY/034/0592	
ORIGINATOR: RCC	DRAWN BY: SRS	DATE: 5/92	



WELDON SPRING QUARRY AND
ST. CHARLES COUNTY WELL FIELD

FIGURE 6-4

REPORT NO.: DOE/OR/21548-283	EXHIBIT NO.: A/QY/035/0592	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91

including total natural uranium. Four separate total natural uranium analyses were run on samples from this background well and the results ranged from 4.8 pCi/l to 9.0 pCi/l (0.18 Bq/l to 0.33 Bq/l) with an average value of 6.8 pCi/l (0.25 Bq/l). Although not a comprehensive study, results of the monitoring suggest that background uranium concentrations in the Missouri River alluvium may range more widely than in the bedrock aquifers.

All groundwater sampling locations at the WSQ were sampled for total natural uranium during 1991. Table 6-3 and figures in Appendix I show the results of analyses performed on these samples. The average 1991 uranium results continue to show elevated uranium levels in the bedrock adjacent to the quarry and in the alluvium on the north side of the Femme Osage Slough.

Eight locations from the St. Charles county well field were sampled for gross alpha in 1991. Table 6-4 presents the results of analyses performed on these samples that indicate results below the detection limit of all sample events, except for a slight value at the MW-1024 location during the third quarter. The fourth quarter results for PW03, PW05, and RMW3 were erroneously high due to laboratory interferences and were rejected based upon data validation. Data are validated to review analytical documentation and to determine the validity of any subject data point or data group. The county well field locations were also sampled for Th-230/Th-232, Ra-226/Ra-228 and gross beta in 1991. The results of these sample analyses are shown in Appendix A. No elevated values of thorium, radium, or gross beta were detected.

6.3.2.3 Groundwater Monitoring Chemical Results for the WSQ Area. Groundwater near the WSQ has become contaminated as a result of contact with or migration from the hazardous substances present in the WSQ. The analytical results for chemical contaminants in groundwater at the WSQ are discussed in the following sections.

6.3.2.4 Analytical Results for Nitroaromatic Compounds. During 1991, samples from all WSQ wells were analyzed for nitroaromatic compounds. Twelve monitoring wells yielded detectable concentrations of the six nitroaromatic compounds analyzed. The analytical results are presented in Table 6-5 and in figures in Appendix I. The twelve wells yielding detectable concentrations are located north of the Femme Osage Slough. No groundwater samples taken south of the Femme Osage Slough exhibited detectable concentrations of nitroaromatic compounds. Overall the nitroaromatic results are consistent with past

Table 6-3 Summary of 1991 Averages for Inorganic Anions and Total Uranium in Groundwater Around the WSQ

WSSRAP ID	Uranium, Total pCi/l	Nitrate mg/l	Sulfate mg/l
MW-1002	2.6	1.0	135
MW-1004	4810	0.17	234
MW-1005	1986	ND	211
MW-1006	3397	1.2	236
MW-1007	118	0.11	51
MW-1008	4076	0.14	254
MW-1009	5.2	0.16	286
MW-1010	ND	ND	ND
MW-1011	16	ND	20
MW-1012	3.0	1.3	60
MW-1013	910	0.16	112
MW-1014	954	0.13	114
MW-1015	1081	3.1	320
MW-1016	618	1.3	262
MW-1017	0.91	ND	3.1
MW-1018	ND	ND	19
MW-1019	ND	ND	8.9
MW-1020	0.82	ND	17
MW-1021	1.1	ND	7.1
MW-1022	0.87	ND	15
MW-1023	ND	ND	4.2
MW-1024	0.98	ND	2.4
MW-1026	ND	ND	3.9
MW-1027	665	0.11	115
MW-1028	19	ND	91
MW-1029	1.8	0.26	231

Table 6-3 Summary of 1991 Averages for Inorganic Anions and Total Uranium in Groundwater Around the WSQ (Continued)

WSSRAP ID	Uranium, Total pCi/l	Nitrate mg/l	Sulfate mg/l
MW-1030	7.4	ND	253
MW-1031	33	ND	42
MW-1032	666	ND	244
MW-1033	1.8	ND	28
MW-1034	1.4	1.2	86
MW-1035	ND	0.11	39
MW-1036	3.4	0.11	62
MW-1037	3.4	0.19	18
MW-1038	3.0	ND	47
MW-1039	7.4	ND	52
MW-FINW	ND	ND	81
MW-PW02	ND	ND	96
MW-PW03	ND	ND	82
MW-PW04	ND	ND	90
MW-PW05	ND	ND	50
MW-PW06	ND	ND	59
MW-PW07	0.91	ND	13
MW-PW08	ND	ND	12
MW-PW09	ND	ND	43
MW-RAWW	ND	ND	64
MW-RMW1	0.91	ND	86
MW-RMW2	5.4	1.5	82
MW-RMW3	2.1	5.0	19
MW-RMW4	2.9	1.5	108

ND Not Detected

Table 6-4 Gross Alpha Data From St. Charles County Well Field, 1991*

WSSRAP Location	Q191 pCi/l	Q291 pCi/l	Q391 pCi/l	Q491 pCi/l
MW-PW02	ND	ND	ND	ND
MW-PW03	ND	ND	ND	DR
MW-PW04	ND	ND	ND	ND
MW-PW05	ND	ND	ND	DR
MW-PW06	ND	ND	ND	NS
MW-PW07	ND	ND	ND	ND
MW-PW08	ND	ND	ND	ND
MW-PW09	NS	ND	ND	ND
MW-RMW1	ND	ND	ND	ND
MW-RMW2	ND	ND	ND	ND
MW-RMW3	ND	ND	ND	DR
MW-RMW4	ND	ND	ND	ND
MW-RAWW	ND	ND	ND	ND
MW-FINW	ND	ND	ND	ND
MW-1024	ND	ND	7.9	NS

MW-RAWW Untreated Water From St. Charles County Water Treatment Plant.
MW-FINW Treated Water From St. Charles County Water Treatment Plant.
NS Not Sampled.
DR Data rejected based upon validation.
* Detection limit is variable but generally less than 10 pCi/l.

Table 6-5 Summary of 1991 Data Averages for Nitroaromatic Compounds, Weldon Spring Quarry

WSSRAP ID	1,3,5-TNB µg/l	1,3-DNB µg/l	2,4,6-TNT µg/l	2,4-DNT µg/l	2,6-DNT µg/l	Nitrobenzene µg/l
MW-1002	174	0.16	32	.03	13	ND
MW-1004	4.9	ND	12	2.8	5.3	ND
MW-1005	ND	ND	ND	0.13	0.05	ND
MW-1006	117	ND	21	0.19	4.4	ND
MW-1007	ND	ND	ND	ND	ND	ND
MW-1008	0.09	ND	0.54	ND	0.21	ND
MW-1009	ND	ND	ND	ND	ND	ND
MW-1010	ND	ND	ND	ND	ND	ND
MW-1011	ND	ND	ND	ND	ND	ND
MW-1012	ND	ND	ND	ND	ND	ND
MW-1013	ND	.06	ND	0.13	0.04	ND
MW-1014	ND	ND	ND	ND	0.01	ND
MW-1015	126	0.13	17	0.04	0.68	ND
MW-1016	58	ND	7.2	ND	0.30	ND
MW-1017	ND	ND	ND	ND	ND	ND
MW-1018	ND	ND	ND	ND	ND	ND
MW-1019	ND	ND	ND	ND	ND	ND
MW-1020	ND	ND	ND	ND	ND	ND
MW-1021	ND	ND	ND	ND	ND	ND
MW-1022	ND	ND	ND	ND	ND	ND
MW-1023	ND	ND	ND	ND	ND	ND
MW-1024	ND	ND	ND	ND	ND	ND
MW-1026	ND	ND	ND	ND	ND	ND
MW-1027	0.09	ND	25	6.4	5.0	ND
MW-1028	ND	ND	ND	ND	ND	ND
MW-1029	ND	ND	ND	ND	ND	ND
MW-1030	ND	ND	ND	.05	ND	ND
MW-1031	ND	ND	ND	ND	ND	ND

Table 6-5 Summary of 1991 Data Averages for Nitroaromatic Compounds, Weldon Spring Quarry (Continued)

WSSRAP ID	1,3,5-TNB µg/l	1,3-DNB µg/l	2,4,6-TNT µg/l	2,4-DNT µg/l	2,6-DNT µg/l	Nitrobenzene µg/l
bbvbvcMW-1032	.03	ND	0.64	0.22	0.49	ND
MW-1033	ND	ND	ND	ND	ND	ND
MW-1034	ND	ND	ND	ND	ND	ND
MW-1035	ND	ND	ND	ND	ND	ND
MW-1036	ND	ND	ND	ND	ND	ND
MW-1037	ND	ND	ND	ND	ND	ND
MW-1038	ND	ND	ND	ND	ND	ND
MW-1039	ND	ND	ND	ND	ND	ND
MW-FINW	ND	ND	ND	ND	ND	ND
MW-PW02	ND	ND	ND	ND	ND	ND
MW-PW03	ND	ND	ND	ND	ND	ND
MW-PW04	ND	ND	ND	ND	ND	ND
MW-PW05	ND	ND	ND	ND	ND	ND
MW-PW06	ND	ND	ND	ND	ND	ND
MW-PW07	ND	ND	ND	ND	ND	ND
MW-PW08	ND	ND	ND	ND	ND	ND
MW-PW09	ND	ND	ND	ND	ND	ND
MW-RAWW	ND	ND	ND	ND	ND	ND
MW-RMW1	ND	ND	ND	ND	ND	ND
MW-RMW2	ND	ND	ND	ND	ND	ND
MW-RMW3	ND	ND	ND	ND	ND	ND
MW-RMW4	ND	ND	ND	ND	ND	ND

ND Not Detected

environmental monitoring and characterization. The ambient water quality level for 2,4-dinitrotoluene in groundwater is 0.11 μg/l. No maximum contaminant levels have been established for nitroaromatics in groundwater.

6.3.2.5 Analytical Results for Inorganic Anions. All monitoring wells in the WSQ area were sampled for nitrate and sulfate, in 1991. Table 6-3 and figures in Appendix I present the annual averages for these inorganic anions.

Groundwater samples collected at the WSQ area in 1991 continued to indicate no notable groundwater contamination by nitrate. The highest annual average of 3.14 mg/l was observed at MW-1015, which is adjacent to the WSQ. Nitrate does not constitute a particular threat to the groundwater system near the WSQ. It should be noted that a nitrate result greater than 3,000 mg/l was detected at RMW3; however, this result is attributed to a sampling error in which the samples were inadvertently preserved with nitric acid.

The quarry bulk waste is a source of sulfate contamination to the surface water in the WSQ pond and subsequently to the groundwater surrounding the quarry. Sulfate levels in most of the wells adjacent to the quarry, and in the alluvium north of the Femme Osage Slough, appear to be elevated as a result of migration from the quarry and exceed the Federal and State secondary contaminant level of 750 μg/l. The highest 1991 sulfate average value of 435.50 mg/l was measured in MW-1006 located north of the slough. Wells to the south of the slough continue to remain at background concentration levels. It should be noted that an excessive sulfate result greater than 12000 mg/l was detected in a sample from MW-1018 located south of the slough. This measured value is suspected to be the result of a sample preservation error using sulfuric acid. The results of this analysis are being validated; however, subsequent sampling shows the level has returned to historical sulfate concentrations. Groundwater samples collected in 1988 and 1989 from the upgradient background well referenced in Section 6.3.2.2 indicate a background level of 95 mg/l for sulfate in the alluvial groundwater.

6.3.2.6 Analytical Results for Metals. In 1991 all groundwater samples were analyzed for arsenic and barium and the results are presented in Table 6-6 and in figures in Appendix I. Arsenic was added to the list for all DOE monitoring wells in 1991, although St. Charles County has analyzed for this and other heavy metals on a routine basis in the past.

Table 6-6 Metals Data Averages From the WSQ and St. Charles County Well Field, 1991

WSSRAP ID	Arsenic µg/l	Barium µg/l	Cadmium µg/l	Lead µg/l	Mercury µg/l
MW-1002	ND	105	NS	NS	NS
MW-1004	ND	37	NS	NS	NS
MW-1005	ND	63	NS	NS	NS
MW-1006	ND	42	NS	NS	NS
MW-1007	21	401	NS	NS	NS
MW-1008	ND	40	NS	NS	NS
MW-1009	5.4	348	NS	NS	NS
MW-1010	92	338	NS	NS	NS
MW-1011	3.1	174	NS	NS	NS
MW-1012	ND	124	NS	NS	NS
MW-1013	3.0	139	NS	NS	NS
MW-1014	ND	149	NS	NS	NS
MW-1015	ND	114	NS	NS	NS
MW-1016	ND	122	NS	NS	NS
MW-1017	154	966	NS	NS	NS
MW-1018	114	570	NS	NS	NS
MW-1019	77	712	NS	NS	NS
MW-1020	20	376	NS	NS	NS
MW-1021	82	708	NS	NS	NS
MW-1022	129	460	NS	NS	NS
MW-1023	54	313	NS	NS	NS
MW-1024	6.6	447	NA	NA	NA
MW-1026	23	380	NS	NS	NS
MW-1027	ND	113	NS	NS	NS
MW-1028	2.8	300	NS	NS	NS
MW-1029	ND	112	ND	ND	ND
MW-1030	5.2	283	5.4	84	ND
MW-1031	ND	88	ND	ND	ND

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Table 6-6 Metals Data Averages From the WSO and St. Charles County Well Field, 1991 (Continued)

WSSRAP ID	Arsenic µg/l	Barium µg/l	Cadmium µg/l	Lead µg/l	Mercury µg/l
MW-1032	2.4	123	ND	ND	ND
MW-1033	ND	286	ND	ND	ND
MW-1034	ND	146	NS	NS	NS
MW-1035	ND	244	NS	NS	NS
MW-1036	ND	283	ND	ND	ND
MW-1037	9.8	864	ND	ND	ND
MW-1038	ND	244	ND	ND	ND
MW-1039	2.3	496	ND	ND	ND
MW-FINW	ND	89	ND	ND	ND
MW-PW02	ND	287	ND	ND	ND
MW-PW03	ND	261	ND	ND	ND
MW-PW04	ND	253	ND	ND	ND
MW-PW05	ND	328	ND	ND	0.330
MW-PW06	2.4	328	ND	2.900	ND
MW-PW07	ND	475	ND	ND	ND
MW-PW08	3.6	425	ND	ND	0.260
MW-PW09	2.8	405	ND	ND	ND
MW-RAWW	ND	337	ND	ND	ND
MW-RMW1	6.2	507	NA	NA	NA
MW-RMW2	11	209	NA	NA	NA
MW-RMW3	32	539	NA	NA	NA
MW-RMW4	6.4	161	NA	NA	NA

ND Not Detected
1 St. Charles County finished water
2 St. Charles County raw water

Arsenic results above the MCL of 50 μg/l for drinking water have been encountered in seven DOE alluvial wells, all located south of the Femme Osage Slough. Preliminary conclusions are that the elevated arsenic values are the results of a natural geological concentration mechanism rather than being the results of past disposal activities in or around the quarry.

All barium results are in the expected background range and do not differ from previous years. None of the annual averages exceed the MCL of 1,000 μg/l for drinking water.

The St. Charles County production and monitoring wells, and the DOE wells installed in 1991 (MW-1030 through MW-1039), were also analyzed for the heavy metals: cadmium, lead, and mercury. The results of these metals are in the non detect or low background levels, except for one sample from monitoring well MW-1030 which contains anomalous cadmium and lead values, probably as a result of sample or laboratory contamination.

6.3.2.7 Analytical Results for Organics. The St. Charles County pumping wells, treated and untreated water from the St. Charles County Water Treatment Plant, the St. Charles County RMW series monitoring wells, and monitoring well MW-1024 were sampled once in 1991 for PCBs, pesticides, and volatile and semi-volatile organics. Results of this analysis indicated slight concentrations of organics normally associated with laboratory procedures and are not considered to be representative of quarry sources. The levels encountered do not pose a health or environmental threat.

6.4 Trend Analysis Summary

Mathematical and statistical tests for seasonal and overall trends were performed on the existing data from groundwater at the WSCP/RP and WSQ areas on a well-by-well basis. The tests were conducted as described below and the results are presented in Appendix H. In summary, strong upward trends are evident in the data of several wells between the WSQ and the Femme Osage Slough. Data for wells south of the slough were not sufficient to determine any trend. The levels south of the slough continue to show background levels of uranium. Data from the RMW series wells were of sufficient quantity to conclude, at the 95% confidence level, that there is no upward trend in the levels of uranium. These data reinforce the conclusion that the waterborne contaminants present in and around the WSQ do not pose an imminent threat to the quality of the well field water.

At the WSCP/RP, slightly upward trends in uranium levels were concluded from the data from three of the 56 wells on and around the site for which trends were tested. All of these trends had rates of concentration increase less than 0.01 pCi/l/day. Continued monitoring will provide the necessary data to better define and quantify these apparent trends.

6.4.1 Description of Methodology for Trend Analysis

In the cases where a trend has been detected using the Mann-Kendall test, the slope of this trend is calculated using the Sen's nonparametric slope estimator. Sen's estimator is closely related to the Mann-Kendall test. The same general procedure as is used in the Mann-Kendall test to obtain the $N' = n(n-1)/2$ possible differences $x_j - x_k$, where $j > k$, is used in Sen's slope estimator. First, the N' slope estimates (Q) are calculated:

$$Q = x_j - x_k / j - k,$$

where x_j and x_k are data values at times j and k respectively, and where $j > k$. The median value of these N' values of Q is Sen's slope estimate.

The values of individual slope estimates Q are obtained by dividing the differences obtained in the Mann-Kendall test for trend by the time difference, j-k. The median of the N' values of Q is obtained by ranking the N' values from smallest to largest ($Q_1 \leq Q_2 \leq Q_3 \leq \ldots Q_{N'}$) and computing:

$$\text{Sen's estimator} = \text{median slope}$$

$$= Q_{[(N'+1)/2]} \quad \text{if N' is odd}$$
$$= 1/2(Q_{[N'/2]} + Q_{[(N'+2)/2]}) \quad \text{if N' is even.}$$

6.5 Missouri Department of Health Private Drinking Water Well Sampling

6.5.1 Sampling History

In 1982 sampling of private drinking water wells was initiated because a new section was developed within the Missouri Department of Health (MDOH) to monitor health impact associated with hazardous waste sites. The study area initially consisted of eight private drinking water wells, five located northeast of the WSCP/RP and three located southwest of the WSQ. The study area was expanded over time in an effort to fully investigate possible impacts to private drinking water wells from the Army property and the WSS. Additional wells were added upon request by the public, and if the well was located within the study area. Wells were removed from the sampling plan when they were no longer used for consumption. A total of 60 wells were incorporated into the sampling program and were sampled sometime between 1982 and the present. During 1991, 37 drinking wells were sampled either quarterly or annually depending upon their location from the sites. These wells are located within a 4.8 km (3-mi) radius of the WSCP/RP or a 2.4 km (1.5-mi) radius of the WSQ.

6.5.2 1991 Sampling Results

During 1991, 37 private drinking water wells comprised the sampling program. From these sampling events, 32 were analyzed for a gross alpha, two were analyzed for uranium, and 38 were analyzed for nitrates, sulfates, and lithium. The two wells analyzed for uranium are located approximately 2.4 km (1.5 mi) southwest of the WSCP/RP. The uranium content for these two wells was <0.1 pCi/l and 0.4 pCi/l (0.01 Bq/l), respectively.

Discussions with the MDOH concerning the results of the analytical sampling over the period of 1982 to the present indicate the results for the parameters analyzed are considered to be representative of background levels.

7 BIOLOGICAL MONITORING PROGRAM

7.1 Program Description

Environmental surveillance programs outlined in DOE Orders 5400.1 and 5400.5 require monitoring activities at the Weldon Spring Site Remedial Action Project (WSSRAP) that may have an effect on the public and the environment from facility operations or remedial actions. Monitoring programs are developed to include activities that characterize and define trends in the physical, chemical, and biological conditions of environmental media. In 1991, the WSSRAP completed monitoring for environmental media activities in fulfillment of Order 5400.1. Other activities in 1991 were conducted to establish an ecological baseline for the site and vicinity properties. Public concern issues were a component in the monitoring of game species that reside on site or within the area surrounding the Weldon Spring site (WSS). The biological monitoring program included two main study habitats; terrestrial and aquatic, and two monitoring components; human consumption and ecological conditions. The biological monitoring program primarily monitors the effects of radionuclides that are significant on the list of the contaminants of concern at the WSSRAP (MKF and JEG 1992b).

7.2 Environmental Chemistry of Radionuclides

Ecological monitoring also included an analysis of the behavior of radionuclides in the environment and biota, and the presence of these nuclides at the WSS. Actinides, which include thorium and uranium have no known biological function and do not show a tropism for muscle tissue (Potson and Klopfer 1988). Uranium is one of the more mobile elements of the actinide series and in a pH range of 5.0 to 9.0, forms soluble uranyl complexes with carbonate ions (Brookins, D.G. 1988). Carbonate-rich soils and carbonate bedrock in the WSS area account for relatively high concentrations of uranium in some surface waters in the WSS area. Thorium forms insoluble hydrolysis products that readily sorb to particulate matter (Poston and Klopfer 1988). The mobility of thorium is extremely low. Therefore, measurable quantities found in biological tissues are probably due to decay of Ra-228, which is taken up by biota to a far greater extent than thorium (Whicker and Schlutz 1982). This can be determined if Th-228 is found at higher levels than Th-232. At the WSS, potential exposures to thorium include ingestion of contaminated soils and water found at the north dump and raffinate pit areas.

Radium is another radionuclide of importance at the WSS, and when in soluble form, is chemically similar to calcium, an essential nutrient for biota. Radium will tend to follow ecological pathways in a similar fashion (Whicker and Schultz 1982). Radium, as a nutrient analog can be a particular problem in aquatic environments that are nutrient-poor or limited. The lakes under study that surround WSS are not considered nutrient-poor and therefore, "usually harbor organisms with reduced levels of radionuclides" (Whicker and Schultz 1982). Water hardness is high within the surrounding groundwater-fed lakes and is principally related to calcium and magnesium content of the bedrock. Poston and Klopfer (1988) state that bioaccumulation of radium is inversely related to water hardness.

Ingested uranium and thorium accumulate to the highest level in bone tissue (ICRP 1979). Radium, like uranium and thorium, is considered a bone-seeking radionuclide. Other critical organs for uranium accumulation are the gastrointestinal tract, liver, and kidneys. The critical organs for the inhalation pathway of uranium and thorium are the lungs. The dose from all actinide elements from the gastrointestinal tract is assumed to be less than 0.01%. Some 80% or more of the total body burden is expected to be found in bone, with 1 to 10% in both the liver and kidney. Retention time for thorium is relatively long, with a biological half life of 10,000 days. Uranium is excreted more rapidly, with a half life of 100 days. The biological half life of both radium and thorium is considered "high" (years) versus uranium which is considered "moderate" (months) (Whicker and Schultz 1982). This summary of the chemical and biological behavior of radionuclides is integrated into the monitoring programs and a further discussion of pathways and dose potential is provided in Section 4.

7.3 Aquatic Monitoring

The analysis of the transport and effect of contaminants is very complex when monitoring aquatic habitats. Unlimited variability exists among a pond, lake, or stream; but certain elements and features common to all aquatic ecosystems provide a basis for general monitoring applications (Whicker and Schultz 1982). Within the 1991 biological monitoring program, efforts were made to begin characterizing the aquatic systems by documenting specific limnological elements including sediment type, water pH, temperature, conductivity, and dissolved oxygen. Characterization of the lakes and streams helps to determine the availability of radionuclides in these habitats and to assess the potential for bioaccumulation.

Possible modes of transportation for contaminants in aquatic systems include absorption and ingestion. Radionuclides, particularly thorium and uranium, can be adsorbed by plants and zooplankton and thus enter the food chain; however, concentrations of radionuclides generally decline substantially with the higher tropic levels (Whicker and Schultz 1982). In addition to reviewing the environmental chemistry of radionuclides and their availability for uptake by organisms, bioaccumulation can be analyzed by reviewing specific trophic processes and behaviors, such as feeding habits, pH preferences, and nutrients requirements (Poston and Klopfer 1988). A better understanding of the dynamics at work in the aquatic ecosystems of the WSS is necessary to determine the effects of contaminants on these ecosystems.

7.3.1 Fish

The monitoring of fish from aquatic habitats at the surrounding wildlife areas was first initiated in 1987. The purpose of sampling was to determine whether humans were at risk from consuming tissues of game fish that may contain elevated levels of chemical or radiological constituents attributed to wastes migrating from the WSS. Radionuclides that have accumulated in fish represent a route of exposure to humans when fish are consumed. Since the initial study, fish have been monitored biennially as part of the environmental surveillance program. An evaluation of biouptake by specific species within the community, as well as the risk to humans associated with the consumption of game species, is reviewed as part of the *Environmental Monitoring Plan* (EMP) (MKF and JEG 1992b).

In conjunction with the Missouri Department of Conservation (MDOC) and using electrofishing methods, fish were sampled in May 1991 from Lakes 34, 35, and 36 in the Busch Wildlife area and from the Femme Osage Slough located in the Weldon Spring Wildlife Area south of the Weldon Spring Quarry (WSQ). Elevated levels of uranium are known to exist in surface waters of these lakes, the slough, and the drainages to the lakes (MKF and JEG 1991a). Sediment samples have also shown measurable levels of uranium. Fish were also taken from background (control) lakes, and Busch Lakes 33 and 37. These lakes have demonstrated no surface or subsurface connection to the WSS along the water flow paths (MKF and JEG 1989c). In addition, these background lakes were selected because they resemble the study lakes in size.

The Busch lakes are carefully managed by the MDOC for public recreational use. Fingerling stocking of specific game species are conducted at each of the lakes. Lake 34, 35, and 36 were stocked in 1991 with channel catfish and hybrid bass. Some flathead catfish are transferred to Lake 36 from other Busch lakes. Lake 33 is also stocked with channel catfish and hybrid bass, however Lake 37 was not stocked in 1991. Lakes 33 and 35 have a length limit for black bass of 18 in., while all other lakes have a 15 in. limit. Lake 33, the background lake, has a recruitment problem which results in large numbers of smaller sized crappie and sunfish populations. These conditions are frequently managed by encouraging harvesting of these species by fisherman or in this case, taking smaller sized fish for samples.

Species of varying feeding preference; piscivorous (fish-eating), planktivorous, and bottom-feeders were selected for study as well as game species; bass, sunfish, crappie, catfish, and carp. Dose commitments to humans depend upon on the distribution of the radionuclides among edible fish tissues (Poston and Klopfer 1988). Edible portion (fillets) and whole fish samples were analyzed for isotopic uranium. Fishcake (beheaded, scaled, and eviscerated) samples were also prepared since this is another method of preparing sunfish and crappie for human consumption.

Results from the 1991 sampling are presented in Appendix B along with a comprehensive review of previous years' data (1987-1990). All data are presented as total uranium concentrations with detection limits ranging from 0.01 pCi/g (3.7E-4 Bq/g) (1987) to 0.001 pCi/g (3.7E-5 Bq/g) (1991). All non-detect data results are presented and used in calculations as half of the detection limit (DL/2) according to EPA guidance (EPA 1989). All results are presented as wet weight concentrations.

Uranium concentrations from the 1991 sampling ranged from not detected (0.001 pCi/g) to 0.351 pCi/g (1.3E-2 Bq/g) for whole sunfish samples and 0.204 pCi/g for sunfish fishcake samples from Busch Lake 36. The highest result for fillet samples was detected in bass fillets from Lake 35 at 0.072 pCi/g (2.7E-3 Bq/g). Results from background samples, for all sample types, ranged from 0.002 pCi/g to 0.009 pCi/g (7.4E-5 Bq/g to 3.3E-4 Bq/g).

Average concentrations were calculated for the 1987-1991 fish data and are presented in Table 7-1. The highest average concentrations for 1987 to 1991 were found in whole catfish samples (0.933 pCi/g [3.4E-2 Bq/g]) and whole sunfish samples (0.440 pCi/g [1.6E-2 Bq/g]) from Lake 36. Fillets samples from the Busch Lakes averaged from not detected (0.002 pCi/g [7.4E-5 Bq/g]) to 0.027 pCi/g (1E-3 Bq/g). The uranium concentrations found in fish samples from the Femme Osage Slough are not significantly different from those recorded from the background lakes. Only one sample, whole sunfish was shown to have above-background Table

Table 7-1 Average Concentration of Uranium and Bioaccumulation Factors for Fish Sampled 1987-1991

Monitoring Locations	Species/Sample Type	Average Concentration (pCi/g)	Detection Limit (pCi/g)	Bio-accumulation Factor
Frog Pond	Sunfish Cakes	ND	(0.05)	0.24
Lake 34	Bass Fillet	0.006		0.31
	Bass Whole	0.013		0.671
	Catfish Fillet	0.002		0.103
	Catfish Whole	ND	(0.002)	0.103
	Crappie Fillet	ND	(0.005)	0.258
	Sunfish Cakes	0.018		0.93
	Sunfish Fillet	0.003		0.16
	Sunfish Whole	0.046		2.37
Lake 35	Bass Fillet	0.027		1.69
	Bass Whole	0.020		1.25
	Catfish Fillets	0.014		0.88
	Catfish Livers	0.070		4.31
	Catfish Whole	0.197		12.31
	Crappie Cakes	0.008		0.50
	Crappie Fillet	0.007		0.44
	Crappie Whole	0.018		1.13
	Sunfish Cakes	0.033		2.06
	Sunfish Fillet	0.012		0.75
	Sunfish Whole	0.144		9.00
Lake 36	Bass Fillet	0.006		0.13
	Bass Whole	0.153		3.36
	Catfish Fillet	0.013		0.29
	Catfish Whole	0.933		20.50

Table 7-1 Average Concentration of Uranium and Bioaccumulation Factors for Fish Sampled 1987-1991 (Continued)

Monitoring Locations	Species/Sample Type	Average Concentration (pCi/g)	Detection Limit (pCi/g)	Bio-accumulation Factor
Lake 36 (continued)	Crappie Cakes	0.021		0.462
	Crappie Fillet	0.009		0.198
	Crappie Whole	0.042		0.923
	Sunfish Cakes	0.105		2.31
	Sunfish Fillet	0.025		0.55
	Sunfish Whole	0.440		9.67
Femme Osage Slough	Bass Fillet	ND	(0.005)	0.096
	Bass Whole	0.005		0.096
	Buffalo Fillet	ND	(0.005)	0.096
	Carp Fillet	ND	(0.005)	0.096
	Carp Whole	0.003		0.058
	Catfish Fillet	ND	(0.002)	0.039
	Catfish Whole	0.005		0.096
	Crappie Cakes	0.007		0.135
	Crappie Fillet	0.004		0.077
	Crappie Whole	0.002		0.039
	Sunfish Cakes	0.005		0.096
	Sunfish Whole	0.032		0.617
Lake 33	Bass Fillet	0.003		NA
	Bass Whole	0.002		NA
	Carp Fillet	0.002		NA
	Carp Whole	ND	(0.002)	NA
	Crappie Cakes	0.002		NA
	Crappie Fillet	0.003		NA
	Crappie Whole	0.007		NA

Table 7-1 Average Concentration of Uranium and Bioaccumulation Factors for Fish Sampled 1987-1991 (Continued)

Monitoring Locations	Species/Sample Type	Average Concentration (pCi/g)	Detection Limit (pCi/g)	Bio-accumulation Factor
Lake 33 (continued)	Sunfish Cakes	ND	(0.003)	NA
	Sunfish Fillet	ND	(0.002)	NA
	Sunfish Whole	0.004		NA
Lake 37	Bass Fillet	ND	(0.003)	NA
	Bass Whole	0.004		NA
	Catfish Fillet	0.003		NA
	Catfish Whole	0.008		NA
	Sunfish Cakes	0.004		NA
	Sunfish Fillet	0.003		NA
	Sunfish Whole	0.005		NA

Values represent U-234,U-235 and U-238 concentrations and non-detects averaged as 1/2 of the detection limit.

Detection limit is shown in parenthesis for non-detected concentrations.

ND represents concentrations were below the detection limit.

concentrations. Average background concentrations were ranged from not detected (0.002 pCi/g [7.4E-5 Bq/g]) to 0.008 pCi/g (3.0E-4 Bq/g).

Statistical tests were completed to determine if uranium concentrations in fish are significantly different in lakes with contaminated sediments and surface water (Lakes 34, 35, 36, and the Femme Osage Slough) as opposed to lakes showing no contamination (Lakes 33, 37). The Kruskal-Wallis test is a non-parametric analyses of variance test and is selected to test data of small sample size. Correlations were drawn between uranium concentrations in fish, lake, fish species, sampling year and sample type to determine if significant relationships are found between these variables. In tests to compare all fish from contaminated lakes to background lakes, the results showed that the uranium concentration in fish from Lakes 35 and 36 were significantly higher at a 95% confidence level. Whole body and fillet samples were also found to be significantly higher (at the 95% confidence level) at Lakes 35 and 36. No significance was found between sampling year and concentration of uranium in fish. Other correlations were inconclusive due to small sample size.

The significance of uranium concentrations must be further interpreted by calculating potential dose to humans from consumption of fish from these lakes. Dose calculations are presented in Appendix G. Exposure scenarios for the ingestion pathways for fish are discussed in Section 4.2. The calculated dose from ingestion of fish was found to be less than 1 mrem per year.

Bioaccumulation factors (BF) are an expression of the potential concentration of radionuclides in biota caused by contaminated soil, sediment, or water. These factors are used in human dose calculations to characterize levels of radionuclides in biota when actual concentrations are not available. Bioaccumulation factors can also be used to determine whether actual concentrations of radionuclides in fish fall into residual guidelines established by the National Council on Radiation Protection (NCRP) (1985). Gilbert (1986) standardizes the bioaccumulation factor for freshwater fish at 2.0. The NCRP standard (1985) considers feeding preferences and habitats, noting that "innate characteristics and behavioral attributes of organisms markedly affect the degree to which they accumulate radionuclides" (Whicker and Schultz 1982). The NCRP (1985) sets their bioaccumulation factors at 0.5 to 0.7 for predators (bass, gar), 0.3 to 0.6 for planktivourous species (shad) and 0.7 to 38 for omnivorous species (sunfish, catfish, carp).

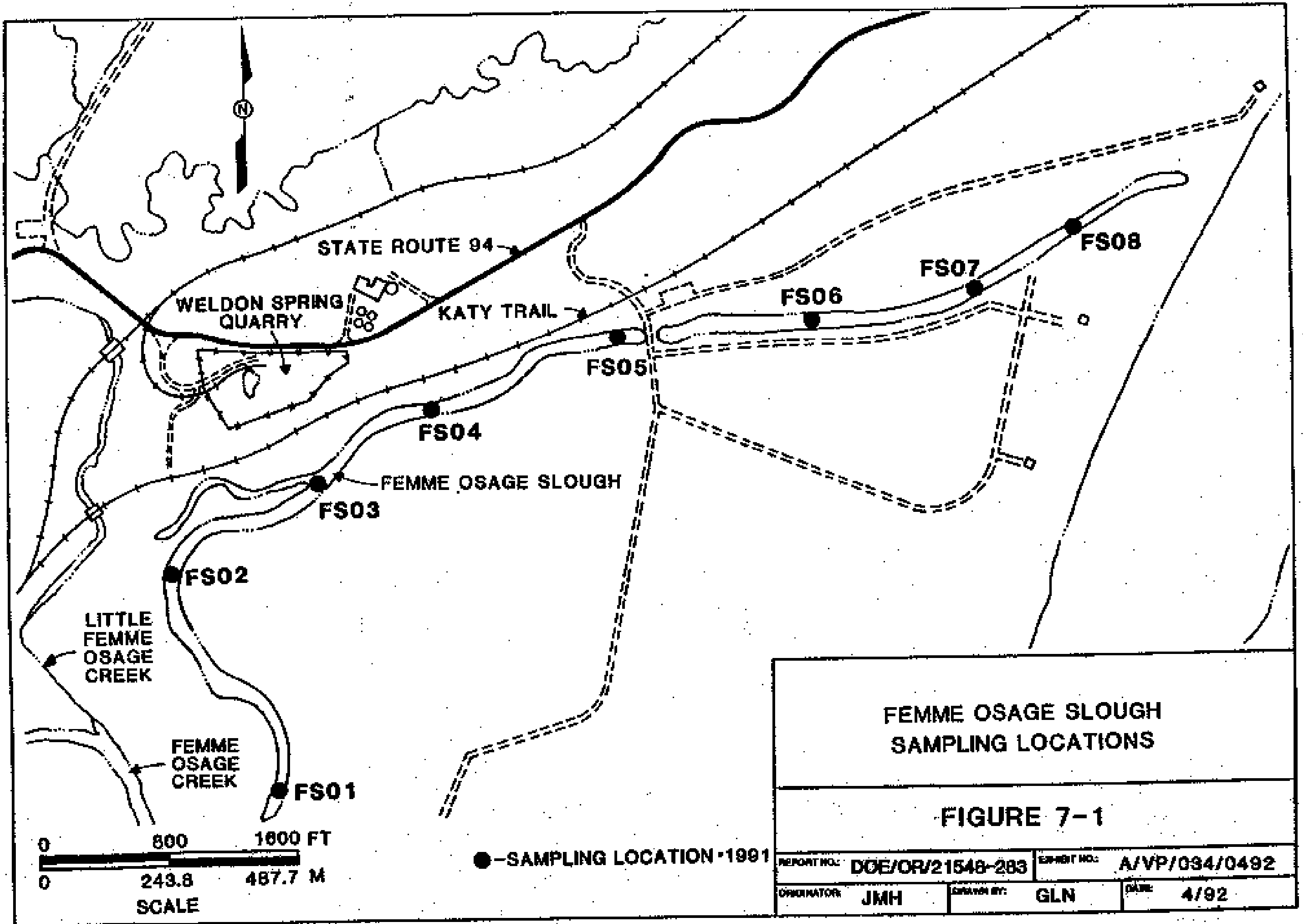
The bioaccumulation factors have been calculated for fish and are shown in Table 7-1. The majority of the fillet samples fall into the ranges published by the NCRP and Gilbert. The exception is bass fillet from Lake 35 which has a bioaccumulation factor of 1.69 which is within guidelines of Gilbert but above those of the NCRP. In comparing the bass fillet to the bass whole from the same lake, the bioaccumulation factor for the whole samples (1.25) is lower. This result is not consistent with the accepted standard that the contribution to whole-body concentration is greater than the contribution to muscle or fillet tissues (NCRP 1985). All other samples tested for at the WSS follow the accepted standard. This data point is considered an anomaly, an inconsistent result as compared to the remaining data results, which are found to be more evenly distributed around the mean.

7.3.2 Invertebrates

An evaluation of aquatic ecosystems can be conducted by characterizing and monitoring benthic invertebrates (insect larvae and worms) and zooplankton communities. Invertebrates are routinely used as indicators of water quality, and assessing impacts of contaminants on aquatic systems generally involves a comparison of species at sites influenced by contaminants and adjacent unaffected sites (APHA 1989). DOE Order 5400.1 specifically calls for sampling organisms within the sediments of lakes and streams and within the water column. Benthic invertebrates are more closely compared to sediment of aquatic habitats and zooplankton are more influenced by the waters of these habitats.

Benthic invertebrates and zooplankton were sampled once in 1991 during May and June. Quantitative samples were taken at monitoring locations and background locations in order to estimate population densities and species diversities in each location. In addition, physical parameters were measured for water and sediments to characterize the dynamics of the aquatic ecosystem.

Benthic invertebrates and zooplankton were sampled from Frog Pond, Busch Lakes 34, 35, 36, and the Femme Osage Slough as monitoring locations. Busch Lake 37 was used as a control lake for the other Busch lakes and Lake 26 was used as a control lake for Frog Pond. Because of it's unique nature, no background lake was sampled for the Femme Osage Slough. Instead, samples were interpreted as a gradient from the source of contamination to the most distant sampling location in the slough (Figure 7-1).



FEMME OSAGE SLOUGH SAMPLING LOCATIONS

FIGURE 7-1

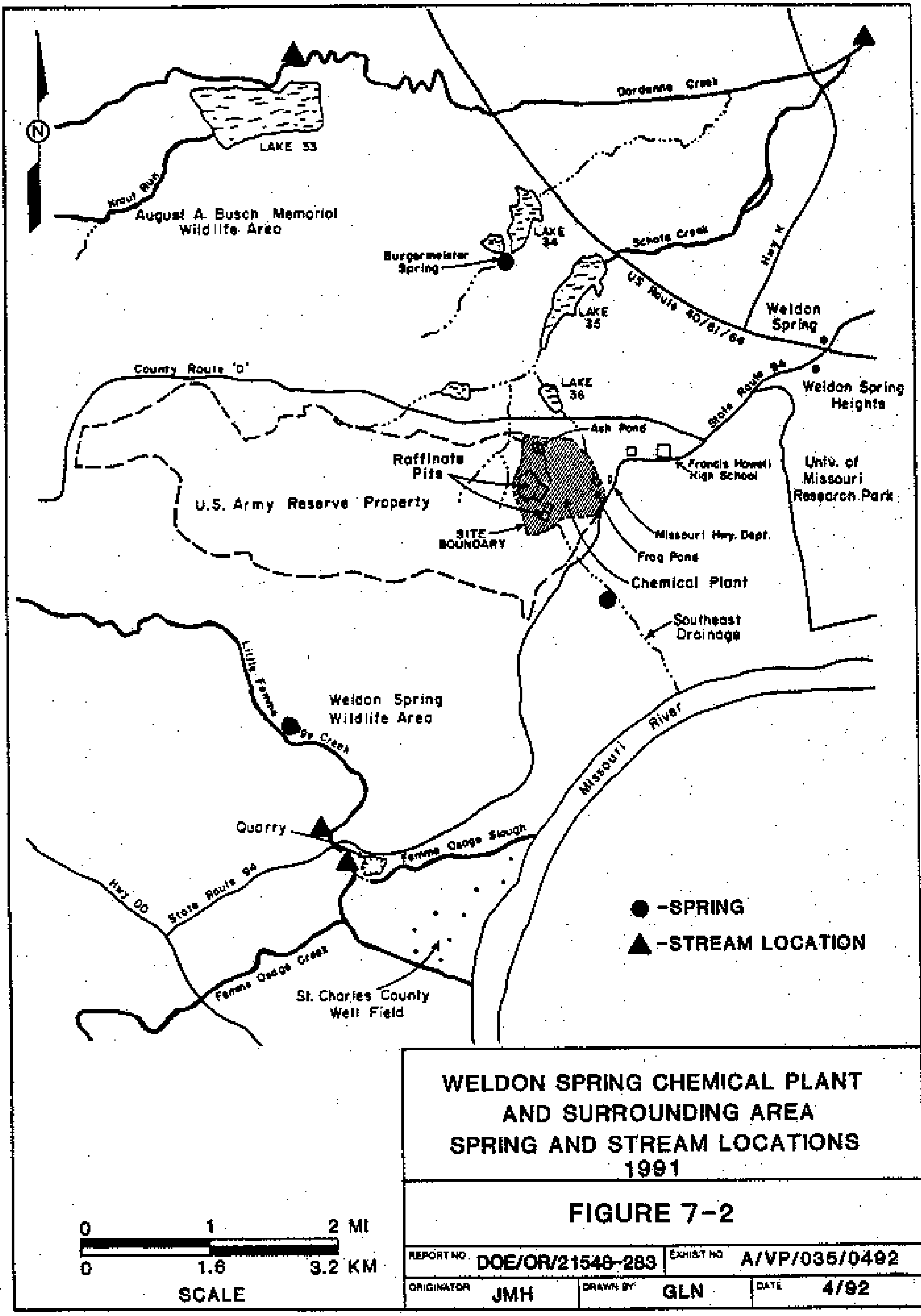
REPORT NO.: DOE/OR/21548-283		EXHIBIT NO.: A/VP/034/0492	
ORIGINATOR: JMH	DRAWN BY: GLN		DATE: 4/92

Benthic invertebrates were sampled from pool and riffle habitats at four stream and three spring locations. These locations included two locations in the Little Femme Osage Creek, a downstream location (from the Weldon Spring Quarry), and an upstream location to serve as background. Two other locations are Dardenne Creek; the upstream branch near Busch Lake 33, (background) and downstream of Schote Creek confluence. Burgermeister Spring in the Busch Wildlife Area and the Southeast Drainage within the Weldon Spring Wildlife area were sampled, since surface and groundwater contamination have been detected in the springs. Goeke's Spring, also designated as SP-5601, was used as a background location. Figure 7-2 shows the sampling locations for the stream and spring locations.

Benthic invertebrates were also sampled for bioaccumulation of uranium. Samples were separated into taxonomic families and/or genus and analyzed for total uranium. Surface water samples were collected and analyzed for total uranium, toxicity metals (As, Ag, Ba, Cr, Zn, Pb, Hg, Se), total suspended solids, nitrate, and chlorophyll. Lake sediments were analyzed for total uranium and toxicity metals. A final report is being prepared that summarizes the results from the 1991 *Aquatic Biological Screening Investigation* (ABSI) (MKF and JEG 1991e) and will include sampling methods, locations, results and interpretation of the data. Preliminary results are available and are discussed briefly below.

It was found that all of the Busch Wildlife Area lakes monitored as part of the 1991 ABSI (background and study lakes), are extremely eutrophic with a strong thermal stratification. As a result of this, the deep water sediments are anaerobic (low oxygen) for much of the year. The sediments of the lakes contain sulfide-rich, anaerobic sediments called sapropels and are sinks for heavy metal sulfides (Brugam et al., 1992). It is not atypical for lakes within this region to be eutrophic in nature. The sediments of Femme Osage Slough and Frog Pond are also anaerobic in nature, yet are only 1 m - 2 m (3 ft - 7 ft) deep. This is probably due to the abundance of aquatic vegetation in the slough and pond, rather than to water depth. Freshwater lakes that are eutrophic in nature have less tendency to produce biota with radionuclide accumulation, although long-termed buildup of radionuclides found in the sediments of lake bottoms may ultimately lead to high concentrations of radioactive material in fish and other organisms (Whicker and Schultz 1982).

Total density and the Shannon-Weiner species diversity index for benthic invertebrates were calculated for each study location. All lakes showed no significant correlation between uranium concentrations and species densities or diversities. The benthic communities of the



WELDON SPRING CHEMICAL PLANT
AND SURROUNDING AREA
SPRING AND STREAM LOCATIONS
1991

FIGURE 7-2

REPORT NO. DOE/OR/21548-283	EXHIBIT NO. A/VP/035/0492	
ORIGINATOR JMH	DRAWN BY GLN	DATE 4/92

study lakes are similar to those of many eutrophic lakes of this area (Brugam et al., 1992). The strongest influence on lake benthos appear to be oxygen levels in the sediment. In the Busch lakes, oxygen status is mainly controlled by water depth. Many species of "deep water" fauna (*Limnodrilus hoffmeisteri, Chaoborus, Psectrotanypus*) were found. Other differences were attributed to distribution of organisms in shallow versus deep water within each of the lakes. Sediments of shallow areas are buff in color, indicating an aerobic environment and dominated by species such as burrowing mayflies of the genus *Hexagenia* and chironomid larvae of the genus *Tanytarsus*. There was, however, a strong correlation between the composition of species in contaminated and uncontaminated lakes; but the Mann-Whitney U-test determined that this was not significant when compared to uranium concentrations. Some additional environmental factors are controlling the composition of benthos in the lakes.

Results from the analysis of uranium in benthic organisms (biomass) showed a relationship between uranium concentrations and lake sediment. The differences do not seem to be related to the taxonomic status of the organisms taken for analysis, but are dependent on the particular study lake. Concentrations of uranium in benthic biomass samples are shown in Appendix B.

Zooplankton analysis showed that differences were found in the composition of zooplankton monitoring and background lakesm, but are not conclusively attributable to uranium concentrations. No significant differences were found in densities or diversity of zooplankton. It was found that the differences in zooplankton communities were based upon the presence of smaller zooplankton in the monitoring lakes versus small and large zooplankton in the background lakes. Other factors that may be attributed to differences in zooplankton populations are fish stocking practices and angling pressure at the Busch Lakes. Research has shown that when ponds were stocked with planktivorous fish, zooplankton communities shifted to a dominance of smaller sized zooplankton species (Wetzel 1983). Some considerations are being investigated including fish stocking practices and angling pressure at Busch lakes. It is well documented that intense fish predation removes larger crustacea from a lake.

Another factor that may contribute to the differences found between the composition of zooplankton populations is the toxicity of uranium. The toxicity of uranium has been documented at 6 mg/l LD50 for *Daphnia* (Poston et al., 1984). Poston (1984) also found that the LD50 decreased as alkalinity of the test water increased, and that reductions in reproductive rates occurred at concentrations of 0.5 mg/l. The highest concentration of uranium in surface water was found in the Femme Osage Slough at 0.3 mg/l.

It is inappropriate to compare densities and diversities of zooplankton because Busch Lake 37 has been shown to be a poor background location. The alkalinity of Lake 37 is very low, as compared to the other monitoring locations, and alkalinity levels have been shown to affect the availability of uranium in surface waters. Other environmental factors may contribute to the difference in the zooplankton of the background lake versus that of the monitoring lakes, but an alternative background location must first be selected.

Zooplankton species at Frog Pond and the Femme Osage Slough were very different from those found at the Busch lakes. At Frog Pond, zooplankton species identified in the samples were those species characteristic of environments with an abundance of aquatic vegetation. At the Femme Osage Slough, a predatory cladoceran called *Polyphemus pediculus* was found in low numbers.

Stream and spring data were found to be too variable to draw conclusions. The background spring showed low benthic invertebrate density, which makes for poor comparison. This has been attributed to the intermittent nature of the spring. In the 1992 sampling, a new background spring will be selected for study. In addition, the number of samples taken from the streams was insufficient to draw conclusions, considering the wide variation in samples.

Modifications to the aquatic invertebrate sampling program will be made in 1992 and will include the elimination of Lake 37 as the control or background lake. It has been shown that the conductivity of Lake 37 is much lower than all of the other lakes at the Busch Wildlife Area. This is probably because the lake water comes from surface water run-off rather than being spring-fed. The monitored lakes (Lakes 34, 35, 36) are predominantly groundwater-fed lakes. The groundwater is concentrated with major ions because of the calcareous soils and bedrock in the area. This difference can be misleading when monitoring the effects of contaminants within aquatic habitats. Busch Lake 33 has been shown to have similar alkalinity and conductivity to the monitored lakes, and since it is a spring-fed lake, it will be used as a background lake in 1992 monitoring.

7.3.3 Waterfowl

Eight aquatic habitats are located within or near the Weldon Spring site; Ash Pond, Frog Pond, four raffinate pits, and at the Weldon Spring quarry, including the quarry pond and Femme Osage slough located immediately south of the quarry. These aquatic habitats attract various waterfowl to the site; both resident species (common to Missouri) and migratory species. Since waterfowl are transient species, the potential exists for individuals to travel on and off site and to be killed by hunters for human consumption. In 1990, in response to public concern, monitoring of waterfowl utilizing the aquatic habitats at the WSS began. Common resident waterfowl species are mallards, wood ducks, and Canada geese.

The biouptake sampling of waterfowl was conducted in October of 1990. Raffinate Pit 4 is predominantly used by waterfowl over all other aquatic habitats at WSS, therefore individuals from Raffinate Pit 4 were selected for sampling. Waterfowl were collected by flushing birds from the pond and shoreline of the pit and shooting them using a 12-gauge shotgun. A total of five individuals were collected including three wood ducks, one mallard, and one Canada goose. Waterfowl were prepared as flesh and internal organ samples and were analyzed for isotopic uranium, isotopic thorium, and Ra-226/228. Results are shown in Appendix A.

Overall, low levels of specific radionuclides were detected in all samples, primarily in the organ samples. Ra-226 ranging from 0.001 pCi/g (3.7×10^{-5} Bq/g) to 0.028 pCi/g (1×10^{-3} Bq/g) were detected in all organ samples. Concentrations of Ra-226 in tissue samples were recorded at or below the detection limit. Ra-228 was detected in less than half of samples with concentrations ranging from below the detection limit to 0.030 pCi/g (1×10^{-3} Bq/g). Th-230 was found in concentrations of 0.017 pCi/g (6×10^{-4} Bq/g) and 0.483 pCi/g (0.018 Bq/g) in organ samples and at low levels in tissue samples. Detectable concentrations of total uranium were also found in the organ sample (0.669 pCi/g[2.5×10^{-2} Bq/g]), which was a composite of organs from three individuals.

No survey was conducted prior to the 1990 sampling event to document residency or duration of use of the water bodies by the waterfowl that were collected. No waterfowl were collected from background (control) locations in conjunction with on-site sampling. The primary focus of the 1990 survey was to determine if any detectable concentrations of radionuclide were present in the edible portions of waterfowl. Acquiring the numbers of samples (monitoring and background) necessary to make conclusions is extremely difficult. "Many samples must be collected to determine the normal range of radionuclide concentrations due to the wide ranges of naturally occurring radionuclide concentrations" (NCRP 1976).

In order to determine usage of the pits by waterfowl, a survey was conducted during the summer and fall of 1991. Table 7-2 lists all resident waterfowl observed on the WSS, the number of individuals, and the average total sighted per survey day. Individuals were not counted twice on a given day, but may be represented many times during the month if present on the site for more than one day. Observations were made for at least 15 min at each location and notes were made of species, numbers, sex, activities (such as feeding, swimming, or resting), and neck band numbers. Waterfowl surveys were conducted on an average of five days per month.

Table 7-2 Occurrence of Missouri Resident Waterfowl at the WSS

Species	July	August	September	October	November	December
Mallard	11	13	51	45	33	14
Wood Duck	6	0	1	40	0	0
Canada Goose	4	13	41	18	137	20
Total count	21	26	93	103	170	34
Total survey days	5	5	7	6	6	4
Average Individuals/Day	4.2	5.2	13.2	17.2	28.3	8.5

The survey indicated that the WSS aquatic habitats were used by waterfowl in 1991 for resting and foraging. Raffinate Pit 4 attracted most of the waterfowl, probably because it is the largest surface area pond at the WSS, has an availability of aquatic vegetation, and offers protection from winds due to the high sides (berms) of the pit. During July an average of four individuals were observed on site per survey day. The highest number of individuals (common residents) were found in November of 1991 with an average of 28 individuals. No individuals were found to reside on site for longer than four weeks. Some individuals and species were sighted only once during the six month period. Other species found to utilize the ponds and pits included canvasback, hooded merganser, Bufflehead, ruddy duck, American coot, northern shoveler, and northern pintail. The greatest number of individuals observed on site occurred in November of 1991 with a monthly total of 328, a survey-day-average of 55, and a total of 15 species. Additional data from the waterfowl survey are listed in Appendix B. Up to 30 species of waterfowl utilize the Mississippi River flyway during spring and autumn migrations (MDOC 1976). Ten waterfowl species are listed as common in the Weldon Spring area during migratory periods (MKF and JEG 1991b).

The pied-billed grebe (*Podilymbus podiceps*) was sighted in Raffinate Pits 2 and 4 during the month of September 1991, and once in Raffinate Pit 4 during November 1991. The pied-billed grebe is listed as rare in the state of Missouri by the MDOC (MDOC 1991b). This listing denotes small numbers present in Missouri and indicates the need for monitoring and protection of this species.

7.4 Terrestrial Monitoring

Although biota consumed by man is an important consideration in any ecological monitoring program, of special concern are Federal and State threatened and endangered species and their habitats. In addition to the special concern species, additional flora and fauna have been selected for investigation at the WSS because they consume foods of special interest, inhabit particular areas, or are a potential food source for special concern species. It is difficult to directly study bioaccumulation in special concern species or game species. Radionuclide concentrations in tissues tend to range widely and it is difficult to sample a sufficient number of animals in order to define the normal range and concentrations (NCRP 1976). The WSS terrestrial monitoring is based primarily on the study of other biota within the food chain or within contaminated habitats that will serve as biomarkers for environmental risk.

Transport pathways for terrestrial vegetation include foliar deposition by both air and water particulates and by uptake through the root's system. Terrestrial fauna can receive radionuclides via ingestion of soil, and/or water, by inhalation of air particulates, by ingestion of contaminated biota, or by direct contact with contaminated soils and water.

7.4.1 Agricultural products

The *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE Draft Order 5400.5) requires the analysis of "foodstuffs" (crops, dairy products, etc.) within a 16 km (17,490 yd) radius of all U.S. Department of Energy (DOE) facilities. At the WSS, primarily agricultural products are grown within the designed 16km (17,490 yd) radius. Seventeen percent of the surrounding wildlife areas, e.g., Busch Wildlife Area, the Weldon Spring Wildlife Area, and Howell Island are comprised of cropland (MDOC 1991a). These wildlife areas produce corn, soybeans, milo, wheat, and sunflowers. The crops grown on MDOC property are not produced for direct human consumption, but are used for livestock feed or left in the field for wildlife consumption.

A preliminary sampling of agricultural products was conducted in October and November of 1991 at the Busch Wildlife area, the Weldon Spring Wildlife area, the St. Charles County well field, and background locations. Grain products such as, corn, milo and soybeans are primarily grown in these areas and were sampled. Grain portions were collected for the samples, with the exception of corn, in which case stalks (excluding roots), leaves, and cobs were also prepared for analysis. Soil samples were collected at each sampling location. Both agricultural and soil samples were analyzed for natural uranium, isotopic thorium, and Ra-226/228.

Results from the 1991 sampling are not currently available, but will be reviewed prior to 1992 sampling and presented at a later date. An agricultural sampling plan has been prepared for 1992 sampling that discusses objectives, sampling, and interpretation methods (MKF and JEG 1991f).

7.4.2 Mammals

Informal mammal surveys have been conducted at the WSS as part of ongoing environmental protection activities. White-tailed deer, groundhogs, muskrats, rabbits and squirrels have been regularly sighted within the chemical plant boundaries. Tracks and burrows have been sighted along the shores of the raffinate pits, Ash Pond, and Frog Pond.

While sampling of large mammals is not part of the annual monitoring program, all specimens are analyzed when available and may include roadkills, accidental deaths, and hunter donations. In 1991, during the construction of the retention basin of the material staging area (MSA), an injured adult male white-tailed deer was destroyed by the MDOC and samples of tissue, bone, antlers, and major organs were taken and analyzed for isotopic uranium, isotopic thorium and Ra-226/228.

Concentrations of radionuclides were found primarily in bone and organ samples. The highest concentrations were the isotopes of thorium with Th-230 found to occur in the bone samples from 0.80 pCi/g (0.03 Bq/g) to 2.48 pCi/g (0.92 Bq/g). Th-230 is primarily a bone-seeking radionuclide with a relatively long half-life. Uranium concentrations ranged from the detection limit (0.001 pCi/g) to 0.118 pCi/g (4.4E-3 Bq/g) in bone, organ and intestine samples. Radionuclide concentrations ranged from not detected to 0.002 pci/g in muscle samples. Ra-226 and Ra-228 concentrations were found in the bone, antler, and intestine samples ranging from the detection limit (0.001 pCi/g) to 0.260 pCi/g (9.6E-3 Bq/g). Table 7-3 presents the results from the sampling of the white-tailed deer.

7.4.3 Birds

Although bird surveys were not formally conducted in 1991, sightings of birds were documented during other monitoring activities, particularly during the waterfowl surveys. Over 40 species of birds were observed on site during 1991. All species observed have been sighted at the Busch Wildlife Area and/or are listed as common or abundant, daily in large numbers in their respective season (MDOC 1991b).

Species observed on site include those commonly associated with aquatic habitats. Green-backed herons, great blue herons, spotted sandpipers, killdeer and belted kingfishers were observed foraging along the raffinate pits, Ash Pond, and Frog Pond. Species commonly found in Missouri during the spring/summer months and observed at the WSS include eastern kingbirds, barn swallows, ruby-throated hummingbirds, and great-crested flycatchers. During the winter months, cardinals, yellow-rumped warblers, dark-eyed juncos, and white-crowned sparrows were observed in woodland and open areas. Species observed year-round include American robins, mourning doves, eastern bluebirds and field sparrows. Common birds of prey observed on site include red-tailed hawk, American kestrel and great-horned owl. Table 7-4 presents a list of all species sighted at the WSS during 1991.

Table 7-3 Radionuclide Concentration in One Male White-Tailed Deer (pCi/g) wet weight

Description	U-233/U-234	U-235	U-238	Th-228	Th-230	Th-232	Ra-226	Ra-228
Bone	0.118	ND	ND	0.601	2.476	0.374	0.136	ND
Bone-Duplicate	ND	ND	ND	0.648	0.799	0.299	0.104	ND
Antlers	ND	ND	ND	0.360	0.062	ND	0.056	0.063
Heart	ND	ND	ND	ND	0.005	ND	ND	ND
Kidney	0.001	ND	ND	ND	ND	ND	ND	0.260
Liver	ND	ND	ND	0.007	0.003	ND	ND	ND
Rib	0.009	ND	0.007	ND	0.707	ND	0.088	0.123
Muscle	ND	ND	ND	ND	0.002	ND	ND	ND
Muscle-Duplicate	0.002	ND	0.002	ND	0.004	ND	0.001	ND

Detection Limits ranging from 0.001 pCi/g to 0.159 pCi/g.

Table 7-4 Bird and Waterfowl Species Observed at the Weldon Spring Site 1991

American coot	Hooded merganser
American crow	House sparrow
American goldfinch	Killdeer
American kestrel	Lesser scaup
American robin	Mallard
American wigeon	Meadowlark
Barn Swallow	Mockingbird
Belted kingfisher	Mourning dove
Black-capped chickadee	Nighthawk
Blue jay	Northern cardinal
Blue-winged teal	Northern flicker
Bufflehead	Northern oriole
Canada goose	Northern pintail
Canvasback	Northern shoveler
Cedar waxwing	Pied-billed grebe
Common nighthawk	Pileated woodpecker
Common snipe	Red-headed woodpecker
Dark-eyed junco	Red-tailed hawk
Downy woodpecker	Red-winged blackbird
Eastern bluebird	Ring-necked duck
Eastern kingbird	Rock dove
Eastern meadowlark	Ruby-throated hummingbird
European starling	Ruddy duck
Field sparrow	Spotted sandpiper
Great blue heron	Tufted titmouse
Great crested flycatcher	White-crowned sparrow
Great-horned owl	White-throated sparrow
Green-backed heron	Wild turkey
Hairy woodpecker	Wood duck
	Yellow-billed cuckoo
	Yellow-rumped warbler

7.5 Special Ecological Studies

7.5.1 Quarry Haul Road Ecological Survey

As part of the remediation activities planned for the Weldon Spring Quarry bulk waste removal, a waste haulage road was constructed along an abandoned railroad track from the quarry north to the chemical plant. A finding of no significant impact (FONSI) was determined for the haul road as part of the Remedial Investigation/Feasibility Study (RI/FS) process completed for the quarry bulk waste (ANL 1990b). In order to establish a baseline for the presence of biota and their use of the haul road area, a summer survey was conducted along the haul road prior to construction.

During June, July, and August of 1991, surveys were conducted along the haul road route to document occurrence of biota and identification of habitats located along the haul road. Separate bird and vegetation surveys were conducted along the haul road, but mammals and reptiles were documented as sighted during the bird and vegetation surveys.

The habitat along the quarry haul road included mixed deciduous forest and old field habitats; typical habitats expected for eastern Missouri. Sixty-five species of birds, 10 species of mammals and five species of herptofauna were recorded along the quarry haul road. While there were no Federal or State threatened or endangered species found along the haul road route during these surveys, the Wood Frog, (*Rana sylvatica*), listed as rare in Missouri, was encountered at one location along the haul road. The MDOC has exempted the work being performed at the quarry and the haul road from mitigative measures due to the local abundance of wood frogs in this area.

7.5.2 Wetlands

Identified wetlands at the WSS include the raffinate pits, Frog Pond, and Ash Pond (U.S. Fish and Wildlife Service 1990). These areas are all man-made impoundments (storage of waste products) or dammed drainage basins. These areas are severely to slightly contaminated with radionuclides and waste products. Remediation activities proposed for the raffinate pits and ponds within the chemical plant area include the removal of contaminated sludge, soil, and water and the filling of the pits and possibly the ponds. The Wetlands

Protection Act, 40 CFR requires a wetlands assessments be completed prior to any construction, dredging, or filling activities.

As part of documentation process for the RI/FS for the Weldon Spring Chemical Plant (WSCP), the wetlands were identified according to Federal guidance. Three criteria must be met in order to designate an area as a jurisdictional wetland: presence of water; saturated soil conditions that exist for seven or more days during the growing season; presence of hydrophytic vegetation or potential presence, and presence of hydric soils (FICWD 1989). Hydric soil conditions were reviewed utilizing the St. Charles County soil survey information (USDA 1982). Soils at the chemical plant area are considered part of the Armster-Mexico-Hatton association and consist of moderately well drained to poorly drained soils.

The raffinate pits are saturated year round, but some shoreline portions along Raffinate Pits 3 and 4 are exposed in the late summer, particularly the north and southeast corners of Raffinate Pit 4. Ash Pond is completely dry in late August and the water level in Frog Pond falls from 1 m (3.28 ft) to 0.3 m (1 ft) (MKF and JEG 1991f).

A vegetation survey was conducted at Raffinate Pits 3 and 4 and at Ash Pond in August 1991 to determine the presence of wetlands species. The survey documented the existence of facultative wetland and obligate wetland species in Raffinate Pit 4 and Ash Pond. Facultative wetland species are usually found in wetlands (67%-97% occurrence) and obligate species are always found in wetlands under natural conditions (FICWD 1989). The obligate species identified include cattails, Canada rush, broadleaf arrowhead, and water smartweed. Facultative wetland species documented include spanish needles, spotted touch-me-not, American elm and sycamore (Reed 1986).

Further investigation and interpretation of the wetland criteria is required prior to establishing wetland habitats and boundaries within the chemical plant area. The soil characteristics of these areas must be reviewed to determine if hydric soils exist.

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8 ENVIRONMENTAL QUALITY ASSURANCE PROGRAM INFORMATION

8.1 Quality Assurance Program Plan

The Weldon Spring Site Remedial Action Project's (WSSRAPs) *Quality Assurance Program Plan* (QAPP) (MKF and JEG 1987) establishes the Quality Assurance Program for those activities performed by the Project Management Contractor (PMC) during the WSSRAP. The QAPP requires compliance with the criteria of American National Standards American Society of Mechanical Engineers (ANSI/ASME) Nuclear Quality Assurance Program (NQA-1) 1986 and DOE Order 5700.6B, which are required by the PMC and the U.S. Department of Energy (DOE) contract document DE-AC05-86OR21548 and the MK-Environmental Services *NQA-1 Quality Assurance Program Manual* (MKE 1990).

All criteria of NQA-1 are applicable to the WSSRAP. Compliance to the criteria is ensured through performance of quality assurance (QA) audits, QA surveillances, and through implementation of the WSSRAP self assessment program. The QAPP is used as the generic working document to control and document the quality of work at the WSSRAP. This document requires that specific procedures and plans be generated to address Quality Level 1 and Quality Level 2 work activities and inspection criteria. These specific procedures will specify the requirements of all applicable documents, codes, standards, and regulations.

8.2 Environmental Quality Assurance Program Plan

Environmental compliance issues applicable to the WSSRAP are addressed in the WSSRAP *Environmental Quality Assurance Program Plan* (EQAPP) (MKF and JEG 1991g) which outlines the specific U.S. Environmental Protection Agency/Quality Assurance Management Staff (EPA/QAMS) 005-80 Quality Assurance requirements for the characterization and routine monitoring at the WSSRAP. The EQAPP does not supersede the QAPP, but rather it expands on specific requirements.

The primary purpose of this document is to provide a complete and accurate framework of information for assessing the amount and extent of hazardous materials present on site and it is supported by the *WSSRAP Quality Assurance Program Plan*, (QAPP) (MKF and JEG 1987) as required by the DOE. The EQAPP is supported by the WSSRAP standard operating procedures (SOPs), the WSSRAP Health and Safety Program, the *Environmental Monitoring Plan* (MKF and JEG 1992b), and sampling plans written for specific environmental tasks.

8.2.1 Audits and Tracking

Quality assurance objectives for the WSSRAP will be met in part by audits of field sampling and laboratory analysis activities. The goals or objectives of the WSSRAP Quality Assurance/Quality Control (QA/QC) audit program are to ensure that:

- QA/QC requirements are clearly established.
- All sampling and analytical efforts are described by an approved sampling plan.
- Standard operating procedures are developed for each measurement activity.
- Qualified personnel are assigned to perform these activities in accordance with the procedures.
- Proper documentation is performed in order to establish data validity.
- Audits are performed to determine compliance with the established QA/QC requirements.
- Corrective actions are proposed and implemented to address deficiencies identified during audits.

An audit program is implemented to ensure compliance with the QA/QC program requirements established for the WSSRAP in the approved QAPP. This program is intended to assess the effectiveness of WSSRAP systems and procedures.

The types of audits to be conducted during the course of actions for the WSSRAP will include performance and systems audits. These audits will be performed both internal and external to the PMC.

Each audit will result in an audit report that details findings. A response will then be prepared and corrective actions defined and scheduled. All audit-related information is entered into a site-wide audit tracking system (SWATS) which tracks findings from initiation through corrective action by both internal and external entities. The status of all audits is routinely reviewed by project management and QA personnel to ensure that progress is being made and to ensure that adequate resources are applied to correcting problems.

8.3 Environmental Data Administration and Data Quality Control

Laboratory management at the WSSRAP includes laboratory coordination, data verification, and data validation to ensure that the environmental samples collected are properly processed, analyzed, and reported by the off-site laboratories and to ensure that the data generated at the WSSRAP are representative of sample conditions.

Laboratory coordination at the WSSRAP involves communicating with off-site laboratories by the laboratory coordinator. Samples collected are sent to an appropriate laboratory that can perform the analyses within the required turnaround and holding times. The laboratory coordinator contacts off-site laboratories on a daily basis to determine and evaluate the laboratories' performance and capacity. Additionally, the laboratory coordinator coordinates sample bottle orders, approves sample authorization requests, and coordinates accelerated and special sample analyses.

The verification program is designed to ensure that documentation and data are reported in compliance with established reporting requirements and standard operating procedures (SOPs), and to ensure that all requested analyses are performed. This process is completed in accordance with procedure ES&H 4.9.1, *Environmental Monitoring Data Verification* by the verification group. The data verification program consists of the following: (1) data delivery tracking and analytical costing; (2) review of sample identification, signed chain of custody (COC), analytical holding times, requested turnaround time, and data review information; (3) editing and merging of completed data into WSSRAP databases Generic Universal Report Utility (GURU). The results of the verification program are documented with the verification checklist. One hundred percent of the data reported in the annual site environmental report have been verified.

Data validation is the process of reviewing laboratory records of analytical data and quality related field data to assess laboratory performance as compared to quality control (QC) criteria, data quality requirements, and procedural requirements. The purpose of validation is to document the quality and usefulness of the data and the documentation developed during sample analysis. Data validation consists of (1) identifying data to be validated (10% of data); (2) technically reviewing selected data; (3) and documenting of findings. The validation process is completed in accordance with RC-31a, *Environmental Monitoring Data Validation*, by the validation group. At least 10% of the data reported in the WSS Environmental Report for Calendar 1991 are validated.

Both the verification and validation programs that are summarized above are described in the *WSSRAP Environmental Data Administration Plan* (MKF and JEG 1992c).

8.3.1 Environmental Data Administration Plan

This *Environmental Data Administration Plan* (EDAP) (MKF and JEG 1992c) summarizes standard operating procedures and data quality requirements developed for use in the collection and analysis of environmental data. Guidance on developing investigation-specific data quality objectives (DQOs) is also detailed. Data quality review programs are conducted to ensure data integrity and validity. The EDAP describes administrative procedures adopted by the WSSRAP to manage the use of environmental data. The EDAP does not superseded the EQAPP, but rather expands on specific requirements.

Environmental monitoring and surveillance activities at the WSSRAP result in data and documentation that are used to develop remedial action alternatives and demonstrate compliance with U.S. Department of Energy (DOE) environmental protection policies.

8.3.2 Data Quality Control Summary

Quality control samples are collected during all phases of the routine environmental monitoring program at the Weldon Spring site (WSS). In some programs such as the external gamma and radon monitoring, the results are directly incorporated into the discussion of the data. Quality control data for groundwater, surface water, springs and National Pollutant Discharge Elimination System (NPDES) monitoring are discussed in this chapter. The QA samples include trip blanks, water and bottle blanks, field blanks, and duplicates. The results from these quality control samples are discussed in the following sections, and a summary of the analytical data and the number of samples collected is given in Tables 8-1 and 8-2. Quality control data have been reviewed to evaluate their impact on the conclusions and interpretations presented in this report. The detection of uranium in water and bottle blanks and in field blanks has not impacted the dose calculations discussed in this report.

8.3.3 Duplicate Sample Results

Two types of duplicate samples were collected and analyzed during 1991 for groundwater, surface water, spring, and NPDES samples. The first type is the blind duplicate (labelled "duplicate" in Table 8-1), which is collected at the same time and in the same manner as a regular sample, given a unique sample number, and analyzed by the laboratory analyzing the regular sample. These samples monitor laboratory precision. The second duplicate type is the replicate sample, which is collected at the same time and in the same manner as a regular sample, but is analyzed by a different laboratory. These samples provide a means of monitoring the performance of the primary laboratory. In the first quarter of 1992, the WSSRAP began participation in the DOE interlab comparison program.

Duplicate samples were analyzed for the same parameters as the original samples at the rate of approximately one per 20 samples. Therefore, duplicate samples were typically analyzed for uranium, nitroaromatic compounds, and inorganic anions. A summary of the duplicate data is given in Table 8-1 for nitroaromatic compounds, arsenic, barium, nitrate, sulfate, and uranium in groundwater, surface water, and spring/seep samples. Where applicable, the average relative percent difference (RPD), which represents an estimate of the laboratory precision, is given for the listed elemental parameters in each sample type. The equation for determining the RPD (as given in the EPA *Contract Laboratory Program, Inorganic Scope of Work*, [EPA-CLP] [EPA 1988b]) is:

(A) $$RPD = (S-D)/((S+D)/2) \times 100,$$

where S=the normal sample and D=the duplicate. The RPD has been calculated only for samples having concentration levels that exceed five times the detection limit. Below this limit, the relative precision typically decreases rapidly. The number of sample-pairs used to calculate the average RPD and the total number of duplicate samples are also given in the table. With the

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Table 8-1 Duplicate Data for 1991 Groundwater

	Groundwater				Surface Water				Springs/Seeps			
	Duplicate		Replicate		Duplicate		Replicate		Duplicate		Replicate	
Parameter	RPD	Count	RPD	Count	RPD	Count	RPD	Count	RPD	Count	RPD	Count
1,3,5-Trinitrobenzene	2.14	3(17)	6.90	2(10)	*	*(1)	*	*(1)	*	*(4)	*	*(3)
1,3-Dinitrobenzene	*	*(17)	*	*(10)	*	*(1)	*	*(1)	*	*(4)	*	*(3)
2,4,6-TNT	2.36	4(17)	21.43	2(10)	*	*(1)	*	*(1)	*	*(4)	*	*(3)
2,4-DNT	2.29	4(17)	30.43	2(10)	*	*(1)	*	*(1)	*	*(4)	*	*(3)
2,6-DNT	1.68	5(17)	18.41	2(10)	*	*(1)	*	*(1)	*	*(4)	*	*(3)
Nitrobenzene	*	*(17)	*	*(10)	*	*(1)	*	*(1)	*	*(4)	*	*(3)
Arsenic	0.85	1(11)	*	*(6)	*	*(1)	*	*(4)	*	*(1)	*	*(1)
Barium	1.58	8(11)	1.28	1(6)	1.76	1(1)	*	*(4)	0.48	1(1)	2.27	1(1)
Nitrate	3.57	4(19)	19.17	4(10)	*	*(2)	*	*(7)	4.51	1(1)	4.17	1(1)
Sulfate	2.12	17(19)	9.67	10(10)	0.9	1(2)	2.88	1(2)	2.68	1(1)	5.08	1(1)
Uranium, Total	8.32	15(19)	13.94	3(12)	4.72	10(11)	5.13	[illegible]	10.45	2(4)	5.2	3(5)

* All data for this constituent are < 5 x detection limit and are not included in calculation of average % error.

RPD Relative percent difference.

Count number of sample pairs in calculation of average (total number duplicate samples).

exception of uranium, barium, sulfate in groundwater, and uranium in surface water, sufficient data are not available to calculate statistically valid average RPD values. Nevertheless,the other RPD values do provide a qualitative measure of the precision of sample data. RPDs are below 5% for all but groundwater uranium, which has an RPD of 8.32%. Overall the duplicate and replicate analyses indicate good agreement between the original and duplicate samples and are well below the 20% control limit suggested in the EPA-CLP.

In addition to monitoring laboratory performance, the duplicate data can be used in conjunction with laboratory control data to determine analytical errors. The analytical error associated with a given data point provides a confidence envelope within which the "true value" is expected to occur at the stated probability level. This error is a function of both the accuracy and the precision associated with a given measurement and may be calculated if data for these parameters are available. At present, these data are only obtained when data validation is requested from a laboratory. According to the WSSRAP data validation procedure, 10 % of the data are scheduled for routine validation. Not all accuracy and precision information derived from the routine validations is appropriate for error determination, because concentration levels in the randomly selected samples may be near, or below, detection limits. Although the analytical errors calculated from this relatively limited data base must be considered somewhat qualitative, these errors do provide an estimate of the confidence envelopes for the 1991 data. In 1992, documentation of laboratory accuracy and precision will be increased, which should allow more rigorous evaluation of analytical errors in the future.

The measurement errors computed for a suite of analytes are presented in Table 8-2. These errors were calculated according to the following formulae and rationale.
The concentration of a given element (X) is given by:

(B) $$X = M + Cf$$

where M is the measured value and Cf is a correction factor that accounts for machine bias but is assumed to be 0 by convention. An error is associated with each of these numbers: for M, the error is the reported relative precision (σ_M) and for Cf the error is the difference between the reported relative accuracy and 1 (i.e., perfect accuracy) (σ_{Cf}). Average values for these errors may be calculated and propagated through this equation to determine the average relative error associated with the measurement of element X. For equation B, the error propagation calculation takes the following form:

Table 8-2 1991 Blank Samples

Blanks	Location	No. of Samples
Field Blanks	Groundwater	3
	Surface Water	1
	Springs	1
	NPDES	0
Trip Blanks	Groundwater	8
	Surface Water	1
	Springs	0
	NPDES	1
Water Blanks	Groundwater	25(U) 8(I) 5(M) 6(N)
	Surface Water	3
	Springs	1
	NPDES	1
Bottle Blanks	Groundwater	1

U Uranium, total
I Sulfate and nitrate
M Arsenic and barium
N Nitroaromatic

(C) $$\sigma_X^2 = \sigma_M^2 + \sigma_{Cf}^2$$

The errors calculated for arsenic, barium, nitrate, sulfate, total uranium, and the nitroaromatics are presented in Table 8-3. In cases where insufficient laboratory precision data were available, the RPD calculated from the WSSRAP duplicate data (Table 8-1) was substituted or averaged with the laboratory data. For nitrate, insufficient accuracy data were available, which resulted in a greater than expected error value. It was not possible to properly weight the errors in these calculations because the relationship between the reported accuracy/precision values and the number of samples analyzed during the period for which these values were determined is unknown.

8.3.4 Trip Blanks

Trip blank samples were collected to assess the impact of sample shipping on analytical results. Trip blanks are sent with each shipment of samples to be analyzed for volatile organic compounds. During 1991, 11 trip blank samples were analyzed for volatile organic compounds. Analysis of these samples detected only low concentrations of acetone (two samples), benzene (one sample), methylene chloride (six samples), and toluene (one sample). These compounds were also detected in laboratory blanks, indicating that their source is probably in the laboratory and does not reflect adverse trip conditions.

8.3.5 Water and Bottle Blanks

Water and bottle blank samples are collected to evaluate the cleanliness of the sampling containers and the purity of the distilled water used to decontaminate nondedicated sampling equipment. These samples also serve as additional laboratory blanks. Thirty water samples and one bottle blank sample were collected during 1991. These samples were analyzed for combinations of the following parameters: inorganic anions, metals, uranium, gross alpha, and nitroaromatic compounds. With few exceptions, which are noted below, concentration levels for these constituents were very low or below detection limits. The relatively high barium value (215 μg/l) measured for a water blank is thought to reflect a label switch with a normal sample that was analyzed at the same time. Slightly elevated uranium levels were measured for two water blanks (10.2 pCi/l and 9.52 pCi/l) (0.38 Bq/l to 0.35 Bq/l), both are from the first half of 1991. Although these data may reflect minor uranium contamination in these water blank

Table 8-3 Calculated Analytical Errors

Constituent	Relative Error (%)
1,3,5-TNB	10.0
1,3-DNB	*
2,4,6-TNT	8.3
2,4-DNT	6.5
2,6-DNT	6.3
NB	*
Arsenic	10.8
Barium	5.5
Nitrate	17.6+
Sulfate	6.6
Uranium, total	9.1

* Not enough data above detection limit.
\+ High value - discussed in text

samples, further investigation revealed that the laboratory methods for extrapolating calibration curves may have biased uranium concentrations in low-level samples to higher values. It is not possible to determine which of these alternatives was the source of the high values; however, subsequent to a change in laboratories at mid-year, uranium levels in all water blanks have remained below 1.78 pCi/l (6.5E-2 Bq/l), with most values being below detection limits. The low, but measurable, levels of uranium in the blank analyses may indicate that the uranium results for water samples (presented in Section 6) are biased to higher values by a few pCi/l. This is especially true for samples analyzed prior to the second half of 1991; these values may overestimate true uranium levels by as much as 10 pCi/l (.37 Bq/l).

8.3.6 Field Blanks

Field blank samples are collected by filling sample containers with distilled water at an actual sampling location. These samples evaluate potential contamination resulting from actual sample collection activities. Field blank results must be used in conjunction with water and bottle blank sample results to accurately assess the total impact associated with actual sample collection. Five field blank samples were collected during 1991 and analyzed for nitroaromatics, inorganic anions, metals, and uranium. Concentrations for these constituents are near or below detection limits for these constituents, with the exception of one uranium value (7.8 pCi/l) (0.29 Bq/l) in a sample collected in the first quarter of 1991. Potential problems associated with analytical protocols, as described in the previous section for the water blank data, are a plausible source of the elevated uranium in this sample.

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9 SPECIAL STUDIES AND REMEDIAL ACTIVITIES

9.1 Archaeological Studies (National Historic Preservation Act of 1966, as amended)

The bulk waste haul road project encompasses approximately 92 acres of land in the East Missouri Study Unit. The initial Phase I cultural resources survey of the project area identified a total of 20 archaeological sites in or near the proposed bulk waste haul road project. A Phase II survey was conducted at three of these sites to determine if any of the sites were eligible for inclusion into the National Register of Historic Places. The results of the National Register evaluation program indicated that one of these sites was eligible. This prehistoric archaeological site, 23SC744, would have been impacted by project construction, therefore a Phase III archaeological data recovery program was determined to be an appropriate mitigation measure. The data recovery program for site 23SC744 was initiated in May of 1991 and completed in August 1991.

9.2 Phase I Containerized Chemical Reassessment

The objective of the Phase I waste container assessment work plan was to ensure that the chemicals which were handled during Phase I activities have been properly identified, classified, consolidated, containerized, and labeled. This activity encompassed all Phase I materials stored in Building 434, the Weldon Spring site (WSS) Resource Conservation Recovery Act (RCRA) waste storage facility. The various tasks involved were (1) identification of all Phase I containers, (2) the visual observation of container contents, (3) the evaluation of container integrity sampling for field and off-site analysis, (4) consolidation where possible, and (5) the documentation of findings. This activity was initiated during 1991 and is still under way at the writing of this document.

9.3 Lung Solubility Studies

Based on radiological characterization of the contaminated material remaining at the WSS, the most significant radionuclides from an internal radiation dosimetry perspective are the uranium and thorium isotopes of U-238, U-234, Th-228, Th-230, and Th-232. The chemical nature of the compound in which the uranium or thorium is bound is a very important parameter for accurate estimation of the radiation dose equivalent received from an inhalation intake. For example, the International Commission on Radiation Protection (ICRP), in its dosimetric model for the respiratory system (ICRP 1978) defines three different solubility classes for uranium deposited in the lung. Uranium-containing chemical compounds which fall in the least soluble class (i.e., Class Y) deliver about 48 times more committed effective dose equivalent than does an equal amount (on a radioactivity basis) of uranium-containing compounds which belong to the most soluble (i.e., Class D) class.

In order to accurately determine the solubility classifications of uranium and thorium compounds at the WSS, both bulk samples and area air samples were collected in 1991 from the Weldon Spring Chemical Plant (WSCP), Weldon Spring raffinate pits (WSRP), and Weldon Spring Quarry (WSQ), and sent to an off-site laboratory for special analysis. These samples were placed in a fluid which is chemically similar to human lung fluid. The fluid temperature is maintained at the human body temperature of 37°C (98.6°F). The fluid is collected at various times and analyzed for uranium and thorium isotopes. Fresh fluid is then added and the samples are maintained at 37°C (98.6°F) until another fluid extraction is made.

Once the last extraction is completed, currently scheduled for July 1992, graphs of uranium and thorium activity present in the fluid versus time of extraction will be plotted for each sample. These graphs will reveal the fraction of uranium and thorium which belongs to each ICRP lung solubility class. This knowledge will be used to produce a more accurate estimate of radiation dose equivalent resulting from inhalation intakes of radioactively-contaminated material.

9.4 Alpha Self Absorption Studies

Studies were initiated in 1991 to evaluate, and possibly quantify, the amount of alpha self absorption that occurs for a given dust loading on filters utilized in area air sampling. Alpha self absorption is a classic problem that has evaded practical analysis for many years. Alpha radiation consists of heavy charged particles which have very limited ranges when interacting with matter. For example, a piece of notebook paper could serve as a shield against alpha radiation. As a result, alpha radiation can be stopped easily; leaving the potential for alpha self absorption, or absorption of alpha radiation within the layer of dust collected on air sample filters, as a recognizable problem.

When air samples are collected in areas where the potential to encounter airborne radioactivity exists, there is also potential for the collection of a good deal of dust on the filters.

In effect, the radioactive airborne constituents representative of the area are most likely carried by the airborne dust particles. Consequently, the alpha constituents of the collected sample have the potential to be absorbed within the dust particles, thereby reducing the amount of detectable radioactivity on the filter.

The study is performed by counting previously used air filters to determine the net activity contained on the filters, placing the filters in an uncontrolled area to collect uncontaminated dust via sampling pumps, and then recounting the filters to assess the amount of decrease in the net activity on each filter. Blank filters are also used to collect air particulate samples in the uncontrolled area in order to determine an average background level of radiation in the area. Simultaneous collection of total dust samples, which are analyzed by an off-site laboratory, yields the airborne dust concentration over the time of sample collection. Thus, the total amount of dust collected on each filter can be determined and associated with the percentage decrease in activity on that filter. This study will assist in determining at what amount of dust loading per filter, the reduction in gross alpha activity becomes significant. An attempt will also be made to quantify a correction factor which can be utilized to more accurately determine the gross alpha activity representative of the area where the air sample is collected. Preliminary conclusions have necessitated further investigation into this problem and have warranted continuance of the study into 1992.

9.5 Particle Sizing Study

A knowledge of particle size within different areas or buildings on the WSS is vital to assessing the potential health effects associated with exposures to airborne particulates. Particle size distributions are essential in order to determine the probable point of respiratory deposition, particle behavior in the air, the best methods of dust control, and an overall evaluation of chemical and radiological hazards. Thus, the particle sizing study should reproduce, to a reasonable degree, the dust collecting characteristics of the human respiratory system so that lung penetration by airborne particles can be predicted from sampling data. The more penetrable particles (smaller particles) possess a greater potential to deliver radiation dose as well as other hazardous effects. The ICRP dosimetric models apply a default value of one micron in the determination of dose conversion factors. However, average particle sizes are anticipated to be larger than this default value. Consequently, internal dose estimates can be more accurately assessed through knowledge of the particle size distribution in a particular location.

A cascade impactor which has the capacity to separate particles into eight different aerodynamic sizes ranging from 0 μ - 0.3 μ to > 10 μ was purchased in 1991. The actual data collection was initiated in the latter part of 1991 for the process buildings scheduled for dismantlement in early 1992. The particle sizing study will continue throughout 1992 in order to determine the particle size distributions for all work areas on the WSS. A personal breathing zone cascade impactor has also been purchased which will allow the collection of particle size information specific to the activity performed during the time of collection.

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DOE ORDERS

5000.3A	*Occurrence Reporting and Processing of Information*
5400.1	*General Environmental Protection Program*

5400.4	*Comprehensive Environmental Response, Compensation, and Liability Act Requirements*
5400.5	*Radiation Protection of the Public and the Environment*
5480.4	*Environmental Protection, Safety and Health Protection Standards*
5484.1	*Environmental Protection, Safety, and Health Protection Information Reporting Requirements*
5820.2A	*Radioactive Waste Management*

REGULATIONS

10 CFR 1022.12 - *Department of Energy, Compliance with Floodplain/Wetlands Environmental Review Requirements*

29 CFR 1910.120 - *Regulations Relating to Labor, Hazardous Waste Operations, and Emergency Response*

40 CFR 61 Appendix B - *Code of Federal Regulations, Appendix B - Test Methods*

40 CFR Part 141 - *National Primary Drinking Water Regulations*

40 CFR Part 171 - *Pesticide Programs, Certification of Pesticide Applicators*

40 CFR 61 Subpart H - *National Emission Standards for Hazardous Air Pollutants.*

40 CFR 261.4(b)(20) - *Identification and Listing (Exclusions)*

40 CFR 261.111 - *Identification and Listing of Hazardous Wastes*

40 CFR 264 - *Code of Federal Regulations, Part 264 - Standards for Owners and Operators and Disposal Facilities, July 1, 1990*

40 CFR 264.13 - *Standards for Treatment Storage and Disposal - General Waste Analysis*

40 CFR 264.75 - *Standards for Treatment Storage and Disposal - (Biennial Report)*

40 CFR 264.197 - *Standards for Treatment Storage and Disposal - Closure/Post Closure Care*

40 CFR 268.50 - *Land Disposal Restrictions*

40 CFR 761.65(a) - *Polychlorinated Biphenyls (PCBs) Manufacturing, Processing Distribution in Commerce, and Use Prohibitions.*

40 CFR 761.215(c)(1) - *Polychlorinated Biphenyl Management*

10 CSR 80-5 - *Missouri Solid Waste Management Regulations*

19 CSR 20-10.040 - *Maximum Permissible Exposure Limits*

PROCEDURES

ES&H 1.1.5a	*The WSSRAP ALARA Procedure*
ES&H 4.4.4s	*Subsurface Monitoring Device Plugging and Abandonment Procedure*
ES&H 4.8.3s	*The WSSRAP Meteorological Monitoring Station*
ES&H 4.9.1	*Environmental Monitoring Data Verification*
RC-31a	*Environmental Monitoring Data Validation*

APPENDIX A
Quarterly, Bimonthly and Annual Data for Groundwater, Surface Water, Springs and NPDES.

NS	=	Not Sampled
ND	=	Not Detected
R	=	Rejected Data
NS*	=	Not Sampled in Quarter

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
NITRATE							
GW-1002	0.82	NS	0.67(2)	1.93	0.79	1.30	mg/l
GW-1004	0.32	NS	0.135(2)	0.113	ND	0.25	mg/l
GW-1005	ND	NS	ND	ND	ND	ND	mg/l
GW-1006	1.69	1.27	0.57	1.27	0.62	1.89	mg/l
GW-1007	ND	ND	ND	0.24	0.12	0.16	mg/l
GW-1008	ND	ND	ND	ND	NS	0.52	mg/l
GW-1009	ND	ND	ND	ND	0.10	0.69	mg/l
GW-1012	1.73	1.54	1.10	1.57	NS	1.05(2)	mg/l
GW-1013	0.31	ND	ND	ND	0.14	0.37	mg/l
GW-1014	ND	ND	ND	ND	ND	0.55	mg/l
GW-1015	2.22	NS	2.5(2)	5.50	2.30	3.78	mg/l
GW-1016	0.46	NS	0.525(2)	2.95	1.70	1.89	mg/l
GW-1026	ND	ND	ND	ND	ND	ND	mg/l
GW-1027	ND	ND	ND	0.18	0.21	0.11	mg/l
GW-1028	ND	ND	ND	ND	NS	.095(2)	mg/l
GW-1029		NS	ND	ND	0.11	ND	mg/l
GW-1030		NS	.075(2)	0.13	ND	ND	mg/l
GW-1031		NS	ND	0.184	ND	NS	mg/l
GW-1032		NS	ND	ND	ND	0.54	mg/l
GW-1033			ND	NS	ND(2)	NS	mg/l
GW-1034		3.16	1.14	0.27	NS	0.22	mg/l
GW-1035			ND	0.14	NS	0.19	mg/l
GW-1036			ND	0.12	0.155(2)	0.21	mg/l
GW-1037			0.12	ND	0.89	ND	mg/l
GW-1038			ND	ND	ND	ND	mg/l
GW-1039			ND	ND	ND	ND	mg/l
SULFATE							
GW-1002	51.0	NS	45.8(2)	49.5	49.5	569	mg/l
GW-1004	283	NS	164.6(2)	305	230	254	mg/l
GW-1005	218	NS	212(2)	201	214	207	mg/l
GW-1006	375	424	580	418	417	399	mg/l
GW-1007	50.6	26.6	ND	12.7	2.80	209	mg/l
GW-1008	271	243	236	245	NS	273	mg/l
GW-1009	218	319	208	341	349	281	mg/l
GW-1012	69.5	60.7	51.8	49.6	NS	63(2)	mg/l
GW-1013	95.0	97.2	135	116	114	115	mg/l
GW-1014	101	138	134	88.6	108	114	mg/l
GW-1015	221	NS	356.5(2)	306	387	294	mg/l
GW-1016	168	NS	238(2)	341	343	242	mg/l
GW-1026	ND	10.8	10.0	ND	ND	0.84	mg/l
GW-1027	153	112	95.6	129	118	83.0	mg/l

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
GW-1028	64.0	58.4	187	72.3	NS	82.5(2)	mg/l
GW-1029		184	75.1	89.1	77.4	731	mg/l
GW-1030		91.0	ND	58.5	105	1000	mg/l
GW-1031		53.5	37.7	42.6	37.8(2)	NS	mg/l
GW-1032		208	208	274	253	255	mg/l
GW-1033			45.0	NS	19.3(2)	NS	mg/l
GW-1034		60.0	92.1	104	NS	86.7	mg/l
GW-1035			44.8	33.9(2)	NS	41.9	mg/l
GW-1036			58.0	57.3	57.4	66.6	mg/l
GW-1037			13.9	19.3	19.3	17.0	mg/l
GW-1038			35.5	45.5	44.5	51.3	mg/l
GW-1039			28.7	45.2	73.1	73.1	mg/l
<u>ALUMINUM</u>							
GW-1029					ND		µg/l
GW-1030					54700		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					ND		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					1200		µg/l
GW-1039					ND		µg/l
<u>ANTIMONY</u>							
GW-1029					ND		µg/l
GW-1030					ND		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					ND		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					ND		µg/l
GW-1039					ND		µg/l
<u>ARSENIC</u>							
GW-1002	ND	NS	ND	ND	ND	ND	µg/l
GW-1004	ND	NS	ND	ND	ND	ND	µg/l
GW-1005	ND	NS	ND	ND	ND	ND	µg/l
GW-1006	ND	5.86	ND	ND	ND	ND	µg/l
GW-1007	18.7	9.09	17.6	30.4	26.3	26.8	µg/l

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
GW-1008	ND	ND	ND	ND	NS	ND	µg/l
GW-1009	5.70	3.59	2.57	5.88	5.90	8.80	µg/l
GW-1012	ND	ND	ND	ND	NS	ND	µg/l
GW-1013	5.50	2.64	ND	2.63	2.90	3.10	µg/l
GW-1014	ND	ND	ND	ND	ND	ND	µg/l
GW-1015	ND	NS	ND	ND	ND	ND	µg/l
GW-1016	4.40	NS	ND	ND	ND	ND	µg/l
GW-1026	26.2	23.1	19.0	25.8	19.6	22.4	µg/l
GW-1027	ND	ND	ND	ND	ND	ND	µg/l
GW-1028	ND	3.83	ND	ND	NS	2.00	µg/l
GW-1029			ND	ND	ND	ND	µg/l
GW-1030			4.00(2)	6.20	5.05(2)	7.10	µg/l
GW-1031			ND	ND	ND	NS	µg/l
GW-1032			3.95(2)	ND	ND	ND	µg/l
GW-1033			ND	NS	ND(3)	NS	µg/l
GW-1034		ND	ND	ND	NS	ND	µg/l
GW-1035			ND	ND	NS	ND	µg/l
GW-1036			ND	ND	ND	ND	µg/l
GW-1037			62.5	2.85	ND	ND	µg/l
GW-1038			ND	ND	ND	ND	µg/l
GW-1039			5.17	ND	ND	ND	µg/l

BARIUM

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
GW-1002	118	NS	86.5(2)	116	104	122	µg/l
GW-1004	31.0	NS	50.1(2)	32.4	22.6	37.2	µg/l
GW-1005	43.3	NS	79.1(2)	50.0	67.7	61.7	µg/l
GW-1006	22.3	42.3	33.0	31.4	71.9	51.0	µg/l
GW-1007	243	408	435	374	566	381	µg/l
GW-1008	38.6	31.0	40.7	43.9	NS	47.7	µg/l
GW-1009	333	303	394	311	357	390	µg/l
GW-1012	118	135	112	125	NS	128(2)	µg/l
GW-1013	153	119	131	126	144	161	µg/l
GW-1014	123	94.5	117	128	192	234	µg/l
GW-1015	97.2	NS	122.5(2)	118	113	110	µg/l
GW-1016	101	NS	122(2)	122	141	123	µg/l
GW-1026	389	375	358	357	386	420	µg/l
GW-1027	111	137	129	86.7	110	104	µg/l
GW-1028	288	282	301	283	NS	322(2)	µg/l
GW-1029			125(2)	96.6	111	109	µg/l
GW-1030			215(2)	266	370	383	µg/l
GW-1031			98.1(2)	111	88.8(2)	106	µg/l
GW-1032			129(2)	138	122	116(2)	µg/l

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
GW-1033			140	NS	308(3)	NS	µg/l
GW-1034		153	106	161	NS	166	µg/l
GW-1035			198	259(2)	NS	258	µg/l
GW-1036			315	264	291(3)	272	µg/l
GW-1037			3130	604(2)	523(2)	503.5(2)	µg/l
GW-1038			230	218(2)	254(2)	264(2)	µg/l
GW-1039			595	434(2)	491(2)	516(2)	µg/l
BERYLLIUM							
GW-1029					ND		µg/l
GW-1030					ND		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					ND		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					ND		µg/l
GW-1039					ND		µg/l
CADMIUM							
GW-1029					ND		µg/l
GW-1030					5.40		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					ND		µg/l
GW-1039					ND		µg/l
CALCIUM							
GW-1029					140000		µg/l
GW-1030					87800		µg/l
GW-1031					81600		µg/l
GW-1032					154000		µg/l
GW-1033					80300		µg/l
GW-1036					177000		µg/l
GW-1037					131000		µg/l
GW-1038					152000		µg/l
GW-1039					178000		µg/l

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Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
CHROMIUM							
GW-1029					ND		µg/l
GW-1030					ND		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					ND		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					ND		µg/l
GW-1039					ND		µg/l
COBALT							
GW-1029					ND		µg/l
GW-1030					ND		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					ND		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					ND		µg/l
GW-1039					ND		µg/l
COPPER							
GW-1029					ND		µg/l
GW-1030					78.2		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					ND		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					ND		µg/l
GW-1039					ND		µg/l
IRON							
GW-1029					ND		µg/l
GW-1030					55600		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					ND		µg/l
GW-1036					ND		µg/l

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
GW-1037					3600		µg/l
GW-1038					1490		µg/l
GW-1039					1140		µg/l
LEAD							
GW-1029					ND		µg/l
GW-1030					83.8		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					ND		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					ND		µg/l
GW-1039					ND		µg/l
LITHIUM							
GW-1029					ND		µg/l
GW-1030					ND		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					ND		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					ND		µg/l
GW-1039					ND		µg/l
MAGNESIUM							
GW-1029					30100		µg/l
GW-1030					177000		µg/l
GW-1031					42700		µg/l
GW-1032					47900		µg/l
GW-1033					30900		µg/l
GW-1036					40000		µg/l
GW-1037					31800		µg/l
GW-1038					30400		µg/l
GW-1039					35300		µg/l
MANGANESE							
GW-1029					65.0		µg/l
GW-1030					2920		µg/l

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
GW-1031					ND		μg/l
GW-1032					46.8		μg/l
GW-1033					80.8		μg/l
GW-1036					365		μg/l
GW-1037					1870		μg/l
GW-1038					1250		μg/l
GW-1039					2560		μg/l
MERCURY							
GW-1029					ND		μg/l
GW-1030					ND		μg/l
GW-1031					ND		μg/l
GW-1032					ND		μg/l
GW-1033					ND		μg/l
GW-1036					ND		μg/l
GW-1037					ND		μg/l
GW-1038					ND		μg/l
GW-1039					ND		μg/l
MOLYBDENUM							
GW-1029					ND		μg/l
GW-1030					ND		μg/l
GW-1031					ND		μg/l
GW-1032					ND		μg/l
GW-1033					ND		μg/l
GW-1036					ND		μg/l
GW-1037					ND		μg/l
GW-1038					ND		μg/l
GW-1039					ND		μg/l
NICKEL							
GW-1029					ND		μg/l
GW-1030					137		μg/l
GW-1031					ND		μg/l
GW-1032					ND		μg/l
GW-1033					18.4		μg/l
GW-1036					11.2		μg/l
GW-1037					ND		μg/l
GW-1038					ND		μg/l
GW-1039					ND		μg/l

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
POTASSIUM							
GW-1029					ND		µg/l
GW-1030					26500		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					5580		µg/l
GW-1036					5790		µg/l
GW-1037					ND		µg/l
GW-1038					5220		µg/l
GW-1039					ND		µg/l
SELENIUM							
GW-1029					ND		µg/l
GW-1030					ND		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					ND		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					ND		µg/l
GW-1039					ND		µg/l
SILVER							
GW-1029					ND		µg/l
GW-1030					ND		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					ND		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					ND		µg/l
GW-1039					ND		µg/l
SODIUM							
GW-1029					22700		µg/l
GW-1030					35000		µg/l
GW-1031					10300		µg/l
GW-1032					31800		µg/l
GW-1033					45900		µg/l
GW-1036					39000		µg/l

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
GW-1037					14000		µg/l
GW-1038					13500		µg/l
GW-1039					20800		µg/l
<u>THALLIUM</u>							
GW-1029					ND		µg/l
GW-1030					ND		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					ND		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					ND		µg/l
GW-1039					ND		µg/l
<u>VANADIUM</u>							
GW-1029					ND		µg/l
GW-1030					57.8		µg/l
GW-1031					ND		µg/l
GW-1032					ND		µg/l
GW-1033					ND		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					ND		µg/l
GW-1039					ND		µg/l
<u>ZINC</u>							
GW-1029					ND		µg/l
GW-1030					259		µg/l
GW-1031					21.5		µg/l
GW-1032					ND		µg/l
GW-1033					22.8		µg/l
GW-1036					ND		µg/l
GW-1037					ND		µg/l
GW-1038					23.0		µg/l
GW-1039					ND		µg/l

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
ALKALINITY							
GW-1002			296	310	299	270	mg/l
GW-1004			241	239	250	240	mg/l
GW-1005			229	236	210	220	mg/l
GW-1006		374	353	316	334	350	mg/l
GW-1007		752	768	701	730	495	mg/l
GW-1008		338	321	325	NS	336	mg/l
GW-1009		494	485	414	380	440	mg/l
GW-1012		494	515	509	NS	460	mg/l
GW-1013		412	427	389	320	380	mg/l
GW-1014		446	464	425	400	405	mg/l
GW-1015		NS	364	351	370	380	mg/l
GW-1016		NS	388	344	350	360	mg/l
GW-1026		395	398	378	396	380	mg/l
GW-1027		348	440	394	421	474	mg/l
GW-1028		474	489	438	NS	450	mg/l
GW-1029			350	355	260	340	mg/l
GW-1030			1970	2230	1960	1100	mg/l
GW-1031			359	353	340	NS	mg/l
GW-1032			357	342	320	370	mg/l
GW-1033			404	NS	430(2)	NS	mg/l
GW-1034		290	340	389	NS	390	mg/l
GW-1035			225	214	NS	210	mg/l
GW-1036			456	523	500	500	mg/l
GW-1037			524	459	428	440	mg/l
GW-1038			462	459	430	430	mg/l
GW-1039			614	558	540	550	mg/l
TOTAL PETROLEUM HYDROCARBONS							
GW-1029					ND		mg/l
GW-1030					ND		mg/l
GW-1031					ND		mg/l
GW-1032					ND		mg/l
GW-1033					ND		mg/l
GW-1036					ND		mg/l
GW-1037					ND		mg/l
GW-1038					ND		mg/l
GW-1039					ND		mg/l

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
1,3,5-TRINITROBENZENE							
GW-1002	75.0	NS	150(2)	280	140	250	µg/l
GW-1004	2.80	NS	6.7(2)	7.20	3.00	2.80	µg/l
GW-1005	ND	NS	ND(2)	ND	ND	ND	µg/l
GW-1006	92.0	130	45.0	220	160	55.0	µg/l
GW-1007	ND	ND	ND	ND	ND	ND	µg/l
GW-1008	0.15	ND	ND	ND	NS	0.25	µg/l
GW-1009	ND	ND	ND	ND	ND	ND	µg/l
GW-1012	ND	ND	ND	ND	NS	ND(2)	µg/l
GW-1013	ND	ND	ND	ND	ND	ND	µg/l
GW-1014	ND	ND	ND	ND	ND	ND	µg/l
GW-1015	34.0	NS	95(2)	300	110	120	µg/l
GW-1016	1.60	NS	118(2)	75.0	14.0	17.0	µg/l
GW-1026	ND	ND	ND	ND	ND	ND	µg/l
GW-1027	0.11	0.05	0.03	0.12	0.12	0.12	µg/l
GW-1028	ND	ND	ND	ND	NS	ND(2)	µg/l
GW-1029			ND(2)	ND	ND	ND	µg/l
GW-1030			ND(2)	ND	ND	ND	µg/l
GW-1031			ND(2)	ND	ND(2)	NS	µg/l
GW-1032			.034(2)	ND	ND	.047(2)	µg/l
GW-1033			ND	NS	ND(2)	NS	µg/l
GW-1034		ND	ND	ND	NS	ND	µg/l
GW-1035			ND	ND(2)	NS	ND	µg/l
GW-1036			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1037			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1038			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1039			ND	ND(2)	ND(2)	ND(2)	µg/l
1,3-DINITROBENZENE							
GW-1002	0.12	NS	0.17(2)	0.19	0.13	0.19	µg/l
GW-1004	ND	NS	ND(2)	ND	ND	ND	µg/l
GW-1005	ND	NS	ND(2)	ND	ND	ND	µg/l
GW-1006	ND	ND	ND	ND	ND	ND	µg/l
GW-1007	ND	ND	ND	ND	ND	ND	µg/l
GW-1008	ND	ND	ND	ND	NS	ND	µg/l
GW-1009	ND	ND	ND	ND	ND	ND	µg/l
GW-1012	ND	ND	ND	ND	NS	ND(2)	µg/l
GW-1013	ND	ND	ND	0.13	ND	ND	µg/l
GW-1014	ND	ND	ND	ND	ND	ND	µg/l
GW-1015	ND	NS	ND(2)	ND	0.33	0.25	µg/l
GW-1016	ND	NS	ND(2)	ND	ND	ND	µg/l
GW-1026	ND	ND	ND	ND	ND	ND	µg/l

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
GW-1027	ND	ND	ND	ND	ND	ND	µg/l
GW-1028	ND	ND	ND	ND	NS	ND	µg/l
GW-1029			ND(2)	ND	ND	ND	µg/l
GW-1030			ND(2)	ND	ND	ND	µg/l
GW-1031			ND(2)	ND	ND(2)	NS	µg/l
GW-1032			ND	ND	ND	ND	µg/l
GW-1033			ND	NS	ND(2)	NS	µg/l
GW-1034		ND	ND	ND	NS	ND	µg/l
GW-1035			ND	ND(2)	NS	ND	µg/l
GW-1036			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1037			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1038			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1039			ND	ND(2)	ND(2)	ND(2)	µg/l

2,4,6-TNT

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
GW-1002	14.0	NS	24.0(2)	54.0	19.0	60.0	µg/l
GW-1004	8.50	NS	16.5(2)	13.0	8.00	7.00	µg/l
GW-1005	ND	NS	ND(2)	ND	ND	ND	µg/l
GW-1006	15.0	28.0	15.0	32.0	24.0	10.0	µg/l
GW-1007	ND	ND	ND	ND	ND	ND	µg/l
GW-1008	0.44	0.16	0.090	ND	NS	1.90	µg/l
GW-1009	ND	ND	ND	ND	ND	ND	µg/l
GW-1012	ND	ND	ND	ND	NS	ND(2)	µg/l
GW-1013	ND	ND	ND	ND	ND	ND	µg/l
GW-1014	ND	ND	ND	ND	ND	ND	µg/l
GW-1015	5.40	NS	11.0(2)	34.0	19.0	20.0	µg/l
GW-1016	0.46	NS	14.1(2)	9.50	2.10	3.20	µg/l
GW-1026	ND	ND	ND	ND	ND	ND	µg/l
GW-1027	19.0	6.50	6.20	68.0	32.0	17.0	µg/l
GW-1028	ND	ND	ND	ND	NS	ND(2)	µg/l
GW-1029	NS	NS	ND(2)	ND	ND	ND	µg/l
GW-1030	NS	NS	ND(2)	ND	ND	ND	µg/l
GW-1031	NS	NS	ND(2)	ND	ND(2)	NS	µg/l
GW-1032	NS	NS	0.248(2)	0.12	1.00	1.13(2)	µg/l
GW-1033	NS	NS	ND	NS	ND(2)	NS	µg/l
GW-1034	NS	ND	ND	ND	NS	ND	µg/l
GW-1035	NS	NS	ND	ND(2)	NS	ND	µg/l
GW-1036	NS	NS	ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1037	NS	NS	ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1038	NS	NS	ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1039	NS	NS	ND	ND(2)	ND(2)	ND(2)	µg/l

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
2,4-DNT							
GW-1002	ND	NS	ND(2)	0.031	0.042	0.093	µg/l
GW-1004	2.00	NS	2.70(2)	4.00	2.60	2.60	µg/l
GW-1005	0.14	NS	0.13(2)	0.14	0.14	0.11	µg/l
GW-1006	0.15	0.09	ND	0.21	0.40	0.28	µg/l
GW-1007	ND	ND	ND	ND	ND	ND	µg/l
GW-1008	ND	ND	ND	ND	NS	0.030	µg/l
GW-1009	ND	ND	ND	ND	ND	ND	µg/l
GW-1012	ND	ND	ND	ND	NS	ND(2)	µg/l
GW-1013	0.15	0.17	0.070	ND	0.11	0.12	µg/l
GW-1014	ND	ND	ND	0.037	0.060	0.068	µg/l
GW-1015	ND	NS	ND(2)	0.065	0.053	0.055	µg/l
GW-1016	ND	NS	ND(2)	ND	ND	ND	µg/l
GW-1026	ND	ND	ND	ND	ND	ND	µg/l
GW-1027	12.0	12.0	8.50	0.10	3.00	3.00	µg/l
GW-1028	ND	ND	ND	ND	NS	ND(2)	µg/l
GW-1029			ND(2)	ND	ND	ND	µg/l
GW-1030			0.038(2)	0.056	0.054	0.047	µg/l
GW-1031			ND	ND	ND	0.81(2)	µg/l
GW-1032			0.29(2)	0.040	0.091	0.81(2)	µg/l
GW-1033			ND	NS	ND(2)	NS	µg/l
GW-1034		ND	ND	ND	NS	ND	µg/l
GW-1035			ND	ND	NS	ND	µg/l
GW-1036			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1037			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1038			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1039			ND	ND(2)	ND(2)	ND(2)	µg/l
2,6-DNT							
GW-1002	6.50	NS	9.8(2)	19.0	7.00	28.0	µg/l
GW-1004	3.80	NS	6.55(2)	6.00	4.60	4.20	µg/l
GW-1005	0.05	NS	0.060(2)	0.061	0.050	0.046	µg/l
GW-1006	3.00	4.10	2.10	6.10	7.20	4.20	µg/l
GW-1007	ND	ND	ND	ND	ND	ND	µg/l
GW-1008	0.22	0.09	0.090	0.037	NS	0.60	µg/l
GW-1009	ND	ND	ND	ND	ND	ND	µg/l
GW-1012	ND	ND	ND	ND	NS	ND(2)	µg/l
GW-1013	0.04	0.05	0.020	0.040	0.035	0.042	µg/l
GW-1014	ND	ND	ND	0.013	0.016	0.017	µg/l
GW-1015	0.40	NS	0.46(2)	1.00	0.85	0.93	µg/l
GW-1016	0.07	NS	0.56(2)	0.30	0.13	0.20	µg/l
GW-1026	ND	ND	ND	ND	ND	ND	µg/l

Table A-1. 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
GW-1027	6.60	5.50	6.90	3.60	4.40	2.80	µg/l
GW-1028	ND	ND	ND	ND	NS	ND(2)	µg/l
GW-1029			ND(2)	ND	ND	ND	µg/l
GW-1030			ND(2)	ND	ND	ND	µg/l
GW-1031			ND(2)	ND	ND(2)	NS	µg/l
GW-1032			0.16(2)	0.36	1.10	0.67	µg/l
GW-1033			ND	NS	ND(2)	NS	µg/l
GW-1034		ND	ND	ND	NS	ND	µg/l
GW-1035			ND	ND	NS	ND	µg/l
GW-1036			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1037			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1038			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1039			ND	ND(2)	ND(2)	ND(2)	µg/l

NITROBENZENE

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
GW-1002	ND	NS	ND(2)	ND	ND	ND	µg/l
GW-1004	ND	NS	ND(2)	ND	ND	ND	µg/l
GW-1005	ND	NS	ND(2)	ND	ND	ND	µg/l
GW-1006	ND	ND	ND	ND	ND	ND	µg/l
GW-1007	ND	ND	ND	ND	ND	ND	µg/l
GW-1008	ND	ND	ND	ND	NS	ND	µg/l
GW-1009	ND	ND	ND	ND	ND	ND	µg/l
GW-1012	ND	ND	ND	ND	NS	ND(2)	µg/l
GW-1013	ND	ND	ND	ND	ND	ND	µg/l
GW-1014	ND	ND	ND	ND	ND	ND	µg/l
GW-1015	ND	NS	ND(2)	ND	ND	ND	µg/l
GW-1016	ND	NS	ND(2)	ND	ND	ND	µg/l
GW-1026	ND	ND	ND	ND	ND	ND	µg/l
GW-1027	ND	ND	ND	ND	ND	ND	µg/l
GW-1028	ND	ND	ND	ND	NS	ND(2)	µg/l
GW-1029			ND(2)	ND	ND	ND	µg/l
GW-1030			ND(2)	ND	ND	ND	µg/l
GW-1031			ND	ND	ND	NS	µg/l
GW-1032			ND(2)	ND	ND	ND(2)	µg/l
GW-1033			ND	NS	ND(2)	NS	µg/l
GW-1034		ND	ND	ND	NS	ND	µg/l
GW-1035			ND	ND	NS	ND	µg/l
GW-1036			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1037			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1038			ND	ND(2)	ND(2)	ND(2)	µg/l
GW-1039			ND	ND(2)	ND(2)	ND(2)	µg/l

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
GROSS ALPHA							
GW-1029					ND		pCi/l
GW-1030					ND		pCi/l
GW-1031					22.0		pCi/l
GW-1032					430		pCi/l
GW-1033					ND		pCi/l
GW-1036					ND		pCi/l
GW-1037					ND		pCi/l
GW-1038					ND		pCi/l
GW-1039					ND		pCi/l
GROSS BETA							
GW-1029					ND		pCi/l
GW-1030					185		pCi/l
GW-1031					12.0		pCi/l
GW-1032					195		pCi/l
GW-1033					ND		pCi/l
GW-1036					14.0		pCi/l
GW-1037					ND		pCi/l
GW-1038					ND		pCi/l
GW-1039					ND		pCi/l
URANIUM, TOTAL							
GW-1002	2.04	NS	0.51(2)	4.08	4.61	3.14	pCi/l
GW-1004	6320	NS	4930(2)	4950	2770	5040	pCi/l
GW-1005	2520	NS	2175(2)	447	2260	2350	pCi/l
GW-1006	2720	2990	2520	2880	4730	4540	pCi/l
GW-1007	129	313	46.2	18.8	44.0	155	pCi/l
GW-1008	4690	3540	3600	4260	NS	5330	pCi/l
GW-1009	11.6	8.84	ND	9.79	ND	ND	pCi/l
GW-1012	4.08	ND	4.08	2.31	NS	3.50(2)	pCi/l
GW-1013	884	884	952	891	959	925	pCi/l
GW-1014	1160	1220	1220	1160	511	511	pCi/l
GW-1015	605	NS	796(2)	1690	1620	1300	pCi/l
GW-1016	163	NS	837(2)	857	5000	602	pCi/l
GW-1026	ND	ND	ND	ND	ND	ND	pCi/l
GW-1027	496	605	408	336	1085	1070	pCi/l
GW-1028	86.4	ND	2.04	1.73	NS	0.98(2)	pCi/l
GW-1029			ND(2)	2.86	2.86	2.65	pCi/l
GW-1030			3.23(2)	10.9	8.43	11.2	pCi/l
GW-1031			36.7(2)	41.8	25.8(2)	NS	pCi/l

Table A-1 1991 Bimonthly Groundwater Data For Weldon Spring Quarry (Continued)

WSSRAP_ID	B1	B2	B3	B4	B5	B6	UNITS
GW-1032			392(3)	714	952	942(2)	pCi/l
GW-1033			2.04	NS	1.69(2)	NS	pCi/l
GW-1034		ND	ND	2.31	NS	2.68	pCi/l
GW-1035			ND	ND	NS	1.01	pCi/l
GW-1036			ND	4.03(2)	3.72(2)	4.10(2)	pCi/l
GW-1037			17.0	0.74(2)	1.18(2)	1.36(2)	pCi/l
GW-1038			1.36	2.91(2)	2.6(2)	4.25(2)	pCi/l
GW-1039			1.36	20.6(2)	2.31(2)	2.14(2)	pCi/l
URANIUM-234							
GW-1026					ND		pCi/l
GW-1027					480		pCi/l
URANIUM-235							
GW-1026					ND		pCi/l
GW-1027					57.6		pCi/l
URANIUM-238							
GW-1026					ND		pCi/l
GW-1027					586		pCi/l

1 Blank space indicate that no sampling was planned for the location and sampling period.
2 ND indicate that a concentration was not found at the detection limit.
3 NS indicate that a planned sample was not taken.
4 (n) indicates the total number (n) of samples calculated.
5 Indicates that the sample was not taken during the schedule period but taken in the next period.

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
BROMIDE					
GW-2001	0.680	ND	0.976	ND	mg/l
GW-2002	0.880	ND	1.250	ND	mg/l
GW-2003	ND	ND	ND	ND	mg/l
GW-3003	ND	ND	ND	ND	mg/l
GW-3006	0.560	ND	0.900	ND	mg/l
GW-3008	242.00	ND	0.990	ND	mg/l
GW-3009	ND	ND	ND	ND	mg/l
GW-3023	ND	ND	ND	ND	mg/l
GW-4012	0.610	ND	0.800	ND	mg/l
GW-4013	0.450	0.880	NS	0.93	mg/l
CHLORIDE					
GW-2001	50.700	6.600	5.060	5.900	mg/l
GW-2002	10.700	8.210	8.710	10.200	mg/l
GW-2003	8.970	8.680	7.800	9.690	mg/l
GW-3003	9.430	10.800	9.200	13.000	mg/l
GW-3006	ND	1.510	1.400	2.100	mg/l
GW-3008	17.000	15.100	15.900	24.400	mg/l
GW-3009	3.600	3.400	3.650	5.000	mg/l
GW-3023	15.100	15.900	15.800	16.500	mg/l
GW-4012	3.510	2.800	2.600	3.100	mg/l
GW-4013	10.400	5.670	NS	8.190	mg/l
NITRATE					
GW-1010	ND	ND	ND	ND	mg/l
GW-1011	ND	ND	ND	ND	mg/l
GW-1017	ND	ND	ND	ND	mg/l
GW-1018	ND	ND	ND	ND	mg/l
GW-1019	ND	ND	ND	ND	mg/l
GW-1020	ND	ND	ND	ND	mg/l
GW-1021	ND	ND	ND	R	mg/l
GW-1022	ND	ND	ND	R	mg/l
GW-1023	ND	ND	ND	ND	mg/l
GW-1024	ND	ND	ND	ND	mg/l
GW-1033		ND	ND	ND	mg/l
GW-2001	20.700	19.600	18.800	22.500	mg/l
GW-2002	230.00	189.00	232.00	501.00	mg/l
GW-2003	414.00	51.600	223.00	380.00	mg/l
GW-2004		1.020		0.890	mg/l
GW-2005		253.00	70.600		mg/l
GW-2006		5.980		6.500	mg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-2007	ND	ND	ND	ND	mg/l
GW-2008	3.270		2.400		mg/l
GW-2009	5.540		0.630		mg/l
GW-2010	1.190		1.000		mg/l
GW-2011	2.040		4.180		mg/l
GW-2012	1.320		0.400		mg/l
GW-2013	1.170		R	0.570	mg/l
GW-2014	1.910		1.855		mg/l
GW-2015	0.270	ND	ND	ND	mg/l
GW-2017	0.693		0.160		mg/l
GW-2018	0.579		0.400	0.220	mg/l
GW-2019	ND	ND	ND	ND	mg/l
GW-2020		0.840		0.380	mg/l
GW-2021	ND	ND	ND	ND	mg/l
GW-2022	ND	0.620	ND	ND	mg/l
GW-2023	ND	ND	ND	ND	mg/l
GW-2024	ND	ND	ND	ND	mg/l
GW-2025	ND	ND	0.240	ND	mg/l
GW-2026	ND	ND	ND	ND	mg/l
GW-2027	ND	ND	ND	ND	mg/l
GW-2028	ND	ND	ND	ND	mg/l
GW-2029	ND	ND	ND	ND	mg/l
GW-2030		1.300		1.400	mg/l
GW-2031		0.380			mg/l
GW-2032		79.000		76.700	mg/l
GW-2033		0.900		0.930	mg/l
GW-2034	ND	ND	ND	0.640	mg/l
GW-3001	336.00			874.00	mg/l
GW-3002	ND	ND	0.320	ND	mg/l
GW-3003	3.970	806.00	253.00	354.00	mg/l
GW-3006	0.980	ND	ND	ND	mg/l
GW-3008	1050.0	1010.0	667.00	760.00	mg/l
GW-3009	89.000	0.720	94.500	98.700	mg/l
GW-3019	ND	ND	ND	ND	mg/l
GW-3022		88.000		NS	mg/l
GW-3023	275.00	389.00	290.00	347.00	mg/l
GW-4001	43.300		25.600		mg/l
GW-4002	1.180		1.480		mg/l
GW-4003	0.810		0.710		mg/l
GW-4004	0.780		0.560		mg/l
GW-4005	1.880	1.640	1.510		mg/l
GW-4006	5.280		4.170		mg/l
GW-4007			0.120		mg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-4008	ND	ND	0.210	ND	mg/l
GW-4009	ND	ND	0.950	ND	mg/l
GW-4010	ND	ND	ND	ND	mg/l
GW-4011	23.000		31.500		mg/l
GW-4012	ND	ND	ND	0.320	mg/l
GW-4013	84.100	75.800	83.100	182.00	mg/l
GW-4014		1.550	2.860		mg/l
GW-4015		1.990		1.800	mg/l
GW-4016	ND	ND	ND	ND	mg/l
GW-4017	ND	ND	ND	0.490	mg/l
GW-4018		2.180	11.000		mg/l
GW-4019		0.210	0.180		mg/l
GW-4020	ND	ND	ND	ND	mg/l
GW-4021	ND	ND	ND	ND	mg/l
GW-4022		0.100		0.250	mg/l
GW-4023		0.220		4.900	mg/l
GW-FINW	0.160	ND	ND	ND	mg/l
GW-PW02	ND	ND	ND	ND	mg/l
GW-PW03	ND				mg/l
GW-PW04	ND				mg/l
GW-PW05	ND				mg/l
GW-PW06	ND				mg/l
GW-PW07	ND				mg/l
GW-PW08	ND				mg/l
GW-PW09		ND	ND		mg/l
GW-RAWW	ND		ND		mg/l
GW-RMW1	ND	ND	ND	ND	mg/l
GW-RMW2	ND	ND	ND	5.80	mg/l
GW-RMW3	ND	ND	ND	3020	mg/l
GW-RMW4	0.52	0.70	0.51	4.20	mg/l

NITRITE

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-2001	ND	ND	ND	ND	mg/l
GW-2002	ND	ND	ND	ND	mg/l
GW-2003	ND	ND	ND	ND	mg/l
GW-3003	ND	0.190	0.350	0.160	mg/l
GW-3006	0.620	ND	ND	ND	mg/l
GW-3008	ND	ND	ND	ND	mg/l
GW-3009	ND	ND	ND	ND	mg/l
GW-3023	0.220	1.020	1.080	1.390	mg/l
GW-4012	ND	ND	ND	ND	mg/l
GW-4013	ND	ND	ND	ND	mg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
SULFATE					
GW-1010	ND	ND	ND	ND	mg/l
GW-1011	14.200	32.250	9.710	NS	mg/l
GW-1017	ND	ND	ND	ND	mg/l
GW-1018	29.000	12400.	ND	25.800	mg/l
GW-1019	ND	29.000	ND	3.5	mg/l
GW-1020	ND	50.000	ND	16.700	mg/l
GW-1021	4.410	20.800	3.000	ND	mg/l
GW-1022	3.200	54.500	3.540	ND	mg/l
GW-1023	8.080	ND	ND	5.70	mg/l
GW-1024	ND	ND	6.400	ND	mg/l
GW-1033		45.0	19.5	19.2	mg/l
GW-2001	5.420	5.810	4.100	7.700	mg/l
GW-2002	109.00	122.00	97.500	105.00	mg/l
GW-2003	114.00	133.00	121.00	135.00	mg/l
GW-2004		2.570		2.000	mg/l
GW-2005		20.100	21.200		mg/l
GW-2006		32.900		33.800	mg/l
GW-2007	11.000				mg/l
GW-2008	30.900		35.600		mg/l
GW-2009	10.600		762.00		mg/l
GW-2010	32.700		36.900		mg/l
GW-2011	107.00		11.800		mg/l
GW-2012	73.500		62.900		mg/l
GW-2013	18.000		24.000	17.700	mg/l
GW-2014	21.000		41.800		mg/l
GW-2015	102.00		93.900		mg/l
GW-2017	617.00		114.00		mg/l
GW-2018	6.540		9.360	9.600	mg/l
GW-2019		30.700	49.500		mg/l
GW-2020		136.00		142.00	mg/l
GW-2021		10.700	16.300		mg/l
GW-2022		12.900	14.100		mg/l
GW-2023		16.000		17.700	mg/l
GW-2024		31.400	28.100		mg/l
GW-2025		14.500	14.700		mg/l
GW-2026		14.500	18.000		mg/l
GW-2027		10.500	10.100		mg/l
GW-2028		74.100		126.00	mg/l
GW-2029		27.700		19.400	mg/l
GW-2030		28.500		43.600	mg/l
GW-2031		33.700			mg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-2032		10.000		49.200	mg/l
GW-2033	ND	ND	ND	21.600	mg/l
GW-2034		15.500		674.00	mg/l
GW-3001	20.900			20.500	mg/l
GW-3002		637.00	17.300		mg/l
GW-3003	149.00	255.00	227.00	164.00	mg/l
GW-3006	24.200	21.600	22.000	21.900	mg/l
GW-3008	51.600	1030.0	59.000	74.200	mg/l
GW-3009	39.800	55.700	82.500	72.700	mg/l
GW-3019	4.680		5.200		mg/l
GW-3022		1.210		NS	mg/l
GW-3023	558.00	268.00	432.00	370.00	mg/l
GW-4001	62.500		63.200		mg/l
GW-4002	18.100		17.800		mg/l
GW-4003	14.000		32.100		mg/l
GW-4004	20.200		20.600		mg/l
GW-4005	17.900	16.400	21.500		mg/l
GW-4006	25.500		29.800		mg/l
GW-4007			16.100		mg/l
GW-4008	27.400		14.100		mg/l
GW-4009	20.900		21.900		mg/l
GW-4010		24.900	25.000		mg/l
GW-4011	45.400		58.400		mg/l
GW-4012	54.000	9140.0	44.700	48.100	mg/l
GW-4013	42.000	35.200	43.000	47.000	mg/l
GW-4014		25.900	26.500		mg/l
GW-4015		7.330		14.500	mg/l
GW-4016	ND	ND	ND	14.600	mg/l
GW-4017		9.830		6.700	mg/l
GW-4018		4.430	7.100		mg/l
GW-4019		3.740	5.400		mg/l
GW-4020		100.00		125.00	mg/l
GW-4021		221.00	320.00		mg/l
GW-4022		43.700		49.900	mg/l
GW-4023		46.400		75.500	mg/l
GW-FINW	84.000		78.000		mg/l
GW-PW02	95.800				mg/l
GW-PW03	82.0				mg/l
GW-PW04	89.5				mg/l
GW-PW05	49.8				mg/l
GW-PW06	59.0				mg/l
GW-PW07	13.4				mg/l
GW-PW08	12.0				mg/l

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Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-PW09		49.6	36.6		mg/l
GW-RAWW	57.5		71.5		mg/l
GW-RMW1	4.91	22.8	38.2	279	mg/l
GW-RMW2	19.4	31.7	28.9	249	mg/l
GW-RMW3	ND	37.2	ND	34.2	mg/l
GW-RMW4	27.3	34.2	31.3	340	mg/l

ARSENIC

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-1010	92.8	82.05	98.7	107	µg/l
GW-1011	2.85(2)	2.75(2)	4.39	NS	µg/l
GW-1017	153.00	149.00	144.00	169.00	µg/l
GW-1018	123.00	112.00	110.00	113.00	µg/l
GW-1019	83.600	71.400	80.900	70.800	µg/l
GW-1020	25.100	13.700	21.500	21.400	µg/l
GW-1021	86.600	72.300	90.200	79.600	µg/l
GW-1022	115.00	117.00	146.00	138.00	µg/l
GW-1023	71.600	3.650	67.000	75.600	µg/l
GW-1024	8.300	6.220	5.870	6.600	µg/l
GW-1033	NS	ND	ND	ND	µg/l
GW-2001	ND	ND	ND	ND	µg/l
GW-2002	ND	ND	ND	ND	µg/l
GW-2003	ND	ND	ND	ND	µg/l
GW-3003	ND	ND	ND	ND	µg/l
GW-3006	ND	ND	ND	ND	µg/l
GW-3008	ND	ND	ND	ND	µg/l
GW-3009	ND	ND	ND	ND	µg/l
GW-3023	ND	ND	ND	ND	µg/l
GW-4012	ND	ND	ND	ND	µg/l
GW-4013	ND	ND	ND	ND	µg/l
GW-FINW	ND	ND	ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03	ND	ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND	ND	ND	µg/l
GW-PW06	ND	3.98	ND	NS	µg/l
GW-PW07	ND	ND	ND	ND	µg/l
GW-PW08	4.20	4.88	4.35	ND	µg/l
GW-PW09	NS	ND	3.62	3.00	µg/l
GW-RAWW	ND	ND	ND	ND	µg/l
GW-RMW1	8.30	6.43	4.06	6.10	µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-RMW2	9.20	14.2	6.82	12.9	µg/l
GW-RMW3	45.3	34.5	10.3	36.5	µg/l
GW-RMW4	10.2	5.69	ND	8.00	µg/l
<u>BARIUM</u>					
GW-1010	376.00	314.50	317.00	367.00	µg/l
GW-1011	110.35	236.00	178.00	NS	µg/l
GW-1017	950.00	1030.0	835.00	1050.0	µg/l
GW-1018	550.00	597.00	533.00	601.00	µg/l
GW-1019	657.00	710.00	794.00	688.00	µg/l
GW-1020	340.00	418.00	357.00	391.00	µg/l
GW-1021	543.00	745.00	680.00	863.00	µg/l
GW-1022	410.00	455.00	429.00	545.00	µg/l
GW-1023	276.00	320.00	275.00	381.00	µg/l
GW-1024	478.00	436.00	412.00	462.00	µg/l
GW-1033	NS	140	310(2)	307	µg/l
GW-2001	200.00	189.00	222.00	ND	µg/l
GW-2002	161.00	152.00	176.00	24.700	µg/l
GW-2003	112.00	109.00	140.00	153.00	µg/l
GW-3003	150.00	157.00	109.00	150.00	µg/l
GW-3006	109.00	133.00	110.00	152.00	µg/l
GW-3008	343.00	322.00	274.00	292.00	µg/l
GW-3009	1400.0	835.00	1210.0	1090.0	µg/l
GW-3023	39.900	230.00	179.00	90.300	µg/l
GW-4012	90.900	77.100	66.200	30.000	µg/l
GW-4013	124.00	148.00	NS	147.00	µg/l
GW-FINW	104.00	71.400	82.300	98.3	µg/l
GW-RAWW	345	295	320	389	µg/l
GW-RMW1	511	510	516	492	µg/l
GW-RMW2	204	206	218	207	µg/l
GW-RMW3	516	505	538	596	µg/l
GW-RMW4	134	145	166	198	µg/l
GW-PW02	288.00	268.00	241.00	351.00	µg/l
GW-PW03	238.00	239.00	240.00	286.00	µg/l
GW-PW04	253	244	221	295	µg/l
GW-PW05	300	334	310	368	µg/l
GW-PW06	304	376	303	NS	µg/l
GW-PW07	478	530	437	456	µg/l
GW-PW08	385	392	423	501	µg/l
GW-PW09	NS	297	403	514	µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
<u>CADMIUM</u>					
GW-1033			ND		µg/l
GW-RAWW	ND				µg/l
GW-FINW	ND				µg/l
GW-PW02	ND				µg/l
GW-PW03	ND				µg/l
GW-PW04	ND				µg/l
GW-PW05	ND				µg/l
GW-PW06	ND				µg/l
GW-PW07	ND				µg/l
GW-PW08	ND				µg/l
GW-PW09		ND			µg/l
<u>CALCIUM</u>					
GW-2001	75200.	78000.	83600.	87100.	µg/l
GW-2002	244000	231000	237000	290000	µg/l
GW-2003	268000	234000	244000	263000	µg/l
GW-3003	258000	231000	202000	253000	µg/l
GW-3006	47300.	50000.	53100.	62400.	µg/l
GW-3008	736000	684000	600000	662000	µg/l
GW-3009	80300.	72100.	111000	112000	µg/l
GW-3023	344000	440000	409000	385000	µg/l
GW-4012	49400.	47900.	40100.	17900.	µg/l
GW-4013	125000	123000	NS	146000	µg/l
<u>CHROMIUM</u>					
GW-2001	ND	ND	ND	ND	µg/l
GW-2002	ND	ND	ND	ND	µg/l
GW-2003	ND	ND	ND	ND	µg/l
GW-3003	ND	ND	ND	ND	µg/l
GW-3006	ND	ND	ND	ND	µg/l
GW-3008	ND	ND	ND	ND	µg/l
GW-3009	ND	ND	ND	ND	µg/l
GW-3023	ND	55.000	128.00	32.400	µg/l
GW-4012	ND	9.800	34.000	99.000	µg/l
GW-4013	ND	ND	ND	ND	µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
COBALT					
GW-2001	ND	ND	ND	ND	µg/l
GW-2002	ND	ND	ND	ND	µg/l
GW-2003	ND	ND	ND	ND	µg/l
GW-3003	ND	ND	ND	ND	µg/l
GW-3006	ND	ND	ND	ND	µg/l
GW-3008	ND	ND	ND	ND	µg/l
GW-3009	10.300				µg/l
GW-3023	ND	ND	ND	ND	µg/l
GW-4012	ND	ND	ND	ND	µg/l
GW-4013	ND	ND	ND	ND	µg/l
IRON					
GW-2001	ND	ND	ND	ND	µg/l
GW-2002	ND	ND	ND	ND	µg/l
GW-2003	ND	ND	ND	85.500	µg/l
GW-3003	ND	ND	ND	ND	µg/l
GW-3006	133.00	145.00	100.00	169.00	µg/l
GW-3008	ND	ND	ND	ND	µg/l
GW-3009	90.000	ND	ND	ND	µg/l
GW-3023	36.000	21700.	19000.	8860.0	µg/l
GW-4012	38.000	115.00	ND	55.600	µg/l
GW-4013	ND	ND	ND	ND	µg/l
LEAD					
GW-1033			ND		µg/l
GW-RAWW	ND				µg/l
GW-FINW	ND				µg/l
GW-PW02	ND				µg/l
GW-PW03	ND				µg/l
GW-PW04	ND				µg/l
GW-PW05	ND				µg/l
GW-PW06	2.90				µg/l
GW-PW07	ND				µg/l
GW-PW08	ND				µg/l
GW-PW09		ND			µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
LITHIUM					
GW-2001	ND	ND	ND	ND	µg/l
GW-2002	362.00	392.00	404.00	453.00	µg/l
GW-2003	433.00	405.00	404.00	503.00	µg/l
GW-3003	518.00	417.00	441.00	501.00	µg/l
GW-3006	ND	ND	ND	ND	µg/l
GW-3008	177.00	204.00	228.00	255.00	µg/l
GW-3009	ND	ND	ND	ND	µg/l
GW-3023	768.00	729.00	813.00	851.00	µg/l
GW-4012	ND	ND	ND	ND	µg/l
GW-4013	ND	ND	ND	ND	µg/l
MAGNESIUM					
GW-2001	39200.	35700.	43300.	40600.	µg/l
GW-2002	82600.	72100.	91500.	96300.	µg/l
GW-2003	97100.	85700.	83400.	92300.	µg/l
GW-3003	90800.	122000	112000	143000	µg/l
GW-3006	43800.	40900.	41600.	50100.	µg/l
GW-3008	87400.	161000	156000	175000	µg/l
GW-3009	49600.	43900.	64100.	62000.	µg/l
GW-3023	87400.	108000	92400.	87400.	µg/l
GW-4012	32100.	30300.	29500.	31600.	µg/l
GW-4013	43800.	45600.	NS	52900.	µg/l
MANGANESE					
GW-2001	ND	ND	ND	ND	µg/l
GW-2002	ND	ND	ND	ND	µg/l
GW-2003	ND	ND	ND	ND	µg/l
GW-3003	155.00	85.600	27.900	17.900	µg/l
GW-3006	90.300	36.900	77.500	158.00	µg/l
GW-3008	ND	ND	ND	ND	µg/l
GW-3009	18.800	ND	8.400	7.000	µg/l
GW-3023	18.400	538.00	372.00	176.00	µg/l
GW-4012	ND	9.100	ND	ND	µg/l
GW-4013	ND	ND	ND	ND	µg/l
MERCURY					
GW-1033			ND		µg/l
GW-RAWW	ND				µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-FINW	ND				µg/l
GW-PW02	ND				µg/l
GW-PW03	ND				µg/l
GW-PW04	ND				µg/l
GW-PW05	0.33				µg/l
GW-PW06	ND				µg/l
GW-PW07	ND				µg/l
GW-PW08	0.26				µg/l
GW-PW09		ND			µg/l
NICKEL					
GW-2001	ND	ND	ND	ND	µg/l
GW-2002	ND	ND	146.00	ND	µg/l
GW-2003	ND	ND	ND	ND	µg/l
GW-3003	ND	ND	ND	ND	µg/l
GW-3006	ND	ND	ND	ND	µg/l
GW-3008	ND	ND	97.100	ND	µg/l
GW-3009	ND	52.400	78.600	20.100	µg/l
GW-3023	ND	54.200	327.00	ND	µg/l
GW-4012	ND	ND	ND	ND	µg/l
GW-4013	ND	99.000	ND	ND	µg/l
POTASSIUM					
GW-2001	1670.0	1300.0	1250.0	1500.0	µg/l
GW-2002	8720.0	8100.0	8590.0	9670.0	µg/l
GW-2003	7660.0	6940.0	6870.0	6870.0	µg/l
GW-3003	10200.	8830.0	8580.0	9520.0	µg/l
GW-3006	1490.0	1290.0	ND	1260.0	µg/l
GW-3008	2610.0	2450.0	1910.0	2000.0	µg/l
GW-3009	1060.0	1530.0	2180.0	869.00	µg/l
GW-3023	4630.0	4430.0	4160.0	5260.0	µg/l
GW-4012	13200.	11200.	27000.	71600.	µg/l
GW-4013	6350.0	ND	ND	7000.0	µg/l
SODIUM					
GW-2001	9050.0	8000.0	9050.0	8080.0	µg/l
GW-2002	96300.	87800.	117000	113000	µg/l
GW-2003	127000	96600.	102000	117000	µg/l
GW-3003	177000	135000	100000	162000	µg/l
GW-3006	16800.	15500.	14500.	17600.	µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-3008	231000	213000	196000	244000	µg/l
GW-3009	18900.	17500.	22900.	25900.	µg/l
GW-3023	231000	213000	186000	228000	µg/l
GW-4012	33200.	32300.	29000.	45500.	µg/l
GW-4013	33300.	27300.	NS	35100.	µg/l
STRONTIUM					
GW-2001	91.400	8.900	101.00	87.700	µg/l
GW-2002	319.00	306.00	330.00	360.00	µg/l
GW-2003	463.00	344.00	415.00	490.00	µg/l
GW-3003	620.00	538.00	531.00	597.00	µg/l
GW-3006	200.00	196.00	197.00	207.00	µg/l
GW-3008	620.00	1300.0	2620.0	1750.0	µg/l
GW-3009	620.00	164.00	225.00	225.00	µg/l
GW-3023	630.00	683.00	670.00	664.00	µg/l
GW-4012	172.00	169.00	152.00	63.000	µg/l
GW-4013	200.00	147.00	NS	154.00	µg/l
1,3,5-TRINITROBENZENE					
GW-1010	ND	ND(2)	ND	ND	µg/l
GW-1011	ND(2)	ND	ND	ND	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	ND	ND	µg/l
GW-1020	ND	ND	ND	ND	µg/l
GW-1021	ND	ND	ND	ND	µg/l
GW-1022	ND	ND	ND	ND	µg/l
GW-1023	ND	ND	ND	ND	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-2001	ND		0.039		µg/l
GW-2002	ND		0.037		µg/l
GW-2003	ND		ND		µg/l
GW-2004		ND		ND	µg/l
GW-2005		ND	ND		µg/l
GW-2006		10.000		12.000	µg/l
GW-2007	17.500		ND		µg/l
GW-2008	0.690		0.900		µg/l
GW-2009	ND		ND		µg/l
GW-2010	0.190		0.170		µg/l
GW-2011	ND		0.36		µg/l
GW-2012	ND		1.80		µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-2013	5.000		7.000	6.200	µg/l
GW-2014	2.800		3.200(2)		µg/l
GW-2015	ND			ND	µg/l
GW-2017	ND		ND		µg/l
GW-2018	ND		ND	ND	µg/l
GW-2019		ND	ND		µg/l
GW-2020		ND		ND	µg/l
GW-2021		ND	ND		µg/l
GW-2022		ND	ND		µg/l
GW-2023		ND		ND	µg/l
GW-2024		ND	ND		µg/l
GW-2025		ND	ND		µg/l
GW-2026		ND	ND		µg/l
GW-2027		ND	ND		µg/l
GW-2028		ND		ND	µg/l
GW-2029		ND		ND	µg/l
GW-2030		4.200		3.100	µg/l
GW-2031		ND			µg/l
GW-2032		4.000		3.100	µg/l
GW-2033		2.000		2.600	µg/l
GW-2034		ND		ND	µg/l
GW-3001	0.090				µg/l
GW-3002		ND	ND		µg/l
GW-3003	ND		ND		µg/l
GW-3006	ND		ND	ND	µg/l
GW-3008	ND		ND		µg/l
GW-3009	0.130		0.110		µg/l
GW-3019	ND		ND		µg/l
GW-3022		ND		NS	µg/l
GW-3023	ND		ND		µg/l
GW-4001	43.300		64.000		µg/l
GW-4002	0.094		0.100		µg/l
GW-4003	ND		ND		µg/l
GW-4004	ND		ND		µg/l
GW-4005	ND	ND	ND	NS	µg/l
GW-4006	ND		26.000		µg/l
GW-4007	ND		ND		µg/l
GW-4008	ND		ND		µg/l
GW-4009	ND		ND		µg/l
GW-4010		ND	ND		µg/l
GW-4011	ND		ND		µg/l
GW-4012	ND		ND		µg/l
GW-4013	34.000		86.000		µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-4014		0.220	0.530		µg/l
GW-4015		0.560		0.560	µg/l
GW-4016	ND			ND	µg/l
GW-4017	ND			ND	µg/l
GW-4018		ND	ND		µg/l
GW-4019		ND	ND		µg/l
GW-4020		ND		ND	µg/l
GW-4021		ND		ND	µg/l
GW-4022		ND			µg/l
GW-4023		0.130		0.130	µg/l
GW-FINW	ND	ND	ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03	ND	ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND	ND	ND	µg/l
GW-PW06	ND	ND	ND	NS	µg/l
GW-PW07	ND	ND	NS	ND	µg/l
GW-PW08	ND	ND	NS	ND	µg/l
GW-PW09	NS	ND	ND	ND	µg/l
GW-RMW1	ND	NS	ND	ND	µg/l
GW-RMW2	ND	ND	ND	ND	µg/l
GW-RMW3	ND	ND	ND	ND	µg/l
GW-RMW4	ND	ND	ND	ND	µg/l

1,3-DINITROBENZENE

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-1010	ND	ND(2)	ND	ND	µg/l
GW-1011	ND(2)	ND	ND	ND	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	ND	ND	µg/l
GW-1020	ND	ND	ND	ND	µg/l
GW-1021	ND	ND	ND	ND	µg/l
GW-1022	ND	ND	ND	ND	µg/l
GW-1023	ND	ND	ND	ND	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-2001	ND		ND		µg/l
GW-2002	ND		ND		µg/l
GW-2003	ND		ND		µg/l
GW-2004		ND		ND	µg/l
GW-2005		ND	ND		µg/l
GW-2006		ND		ND	µg/l
GW-2007	ND		ND		µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-2008	ND		ND		µg/l
GW-2009	ND		ND		µg/l
GW-2010	0.140		ND		µg/l
GW-2011	ND		ND		µg/l
GW-2012	ND		ND		µg/l
GW-2013	0.180		0.200	0.130	µg/l
GW-2014	ND		ND(2)		µg/l
GW-2015	ND			ND	µg/l
GW-2017	ND		ND		µg/l
GW-2018	ND		ND	ND	µg/l
GW-2019		ND	ND		µg/l
GW-2020		ND		ND	µg/l
GW-2021		ND	ND		µg/l
GW-2022		ND	ND		µg/l
GW-2023		ND		ND	µg/l
GW-2024		ND	ND		µg/l
GW-2025		ND	ND		µg/l
GW-2026		ND	ND		µg/l
GW-2027		ND	ND		µg/l
GW-2028		ND		ND	µg/l
GW-2029		ND		ND	µg/l
GW-2030		ND	ND		µg/l
GW-2031		ND			µg/l
GW-2032		ND		ND	µg/l
GW-2033		ND		ND	µg/l
GW-2034		ND		ND	µg/l
GW-3001	ND				µg/l
GW-3002		ND	ND		µg/l
GW-3003	ND		ND		µg/l
GW-3006	ND		ND	ND	µg/l
GW-3008	ND		ND		µg/l
GW-3009	ND		ND		µg/l
GW-3019	ND		ND		µg/l
GW-3022		ND		NS	µg/l
GW-3023	ND		ND		µg/l
GW-4001	ND		ND		µg/l
GW-4002	ND		ND		µg/l
GW-4003	ND		ND		µg/l
GW-4004	ND		ND		µg/l
GW-4005	ND	ND	ND	NS	µg/l
GW-4006	ND		ND		µg/l
GW-4007			ND		µg/l
GW-4008	ND		ND		µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-4009	ND		ND		µg/l
GW-4010		ND	ND		µg/l
GW-4011	ND		ND		µg/l
GW-4012	ND		ND		µg/l
GW-4013	ND		ND		µg/l
GW-4014		ND	ND		µg/l
GW-4015		ND		ND	µg/l
GW-4016	ND			ND	µg/l
GW-4017	ND			ND	µg/l
GW-4018		ND	ND		µg/l
GW-4019		ND	ND		µg/l
GW-4020		ND		ND	µg/l
GW-4021		ND	ND		µg/l
GW-4022		ND			µg/l
GW-4023		ND	ND		µg/l
GW-FINW	ND	ND	ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03	ND	ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND	ND	ND	µg/l
GW-PW06	ND	ND	ND	NS	µg/l
GW-PW07	ND	ND	NS	ND	µg/l
GW-PW08	ND	ND	NS	ND	µg/l
GW-PW09	NS	ND	ND	ND	µg/l
<u>2,4,6-TNT</u>					
GW-1010	ND	ND(2)	ND	ND	µg/l
GW-1011	ND(2)	ND	ND	ND	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	ND	ND	µg/l
GW-1020	ND	ND	ND	ND	µg/l
GW-1021	ND	ND	ND	ND	µg/l
GW-1022	ND	ND	ND	ND	µg/l
GW-1023	ND	ND	ND	ND	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-2001	ND		ND		µg/l
GW-2002	ND		ND		µg/l
GW-2003	ND		ND		µg/l
GW-2004		ND		ND	µg/l
GW-2005		ND	ND		µg/l
GW-2006		ND		ND	µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-2007	ND		ND		µg/l
GW-2008	ND		0.031		µg/l
GW-2009	ND		ND		µg/l
GW-2010	0.440		0.340		µg/l
GW-2011	ND		ND		µg/l
GW-2012	ND		0.64		µg/l
GW-2013	0.850		1.200	0.880	µg/l
GW-2014	ND		ND(2)	ND	µg/l
GW-2015	ND			ND	µg/l
GW-2017	ND		ND		µg/l
GW-2018	ND		ND	ND	µg/l
GW-2019		ND	ND		µg/l
GW-2020		ND		ND	µg/l
GW-2021		ND	ND		µg/l
GW-2022		ND	ND		µg/l
GW-2023		ND		ND	µg/l
GW-2024		ND	ND		µg/l
GW-2025		ND	ND		µg/l
GW-2026		ND	ND		µg/l
GW-2027		ND	ND		µg/l
GW-2028		ND		ND	µg/l
GW-2029		ND		ND	µg/l
GW-2030		8.500		8.000	µg/l
GW-2031		ND			µg/l
GW-2032		7.800		5.600	µg/l
GW-2033		1.100		0.800	µg/l
GW-2034		ND		ND	µg/l
GW-3001	ND				µg/l
GW-3002		ND	ND		µg/l
GW-3003	ND		ND		µg/l
GW-3006	ND		ND	ND	µg/l
GW-3008	ND		ND		µg/l
GW-3009	ND		ND		µg/l
GW-3019	ND		ND		µg/l
GW-3022		ND		NS	µg/l
GW-3023	ND		ND		µg/l
GW-4001	ND		1.60		µg/l
GW-4002	1.100		0.093		µg/l
GW-4003	ND		ND		µg/l
GW-4004	ND		ND		µg/l
GW-4005	ND	ND	ND	NS	µg/l
GW-4006	ND		ND		µg/l
GW-4007		NS	ND		µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-4008	ND		ND		µg/l
GW-4009	ND		ND		µg/l
GW-4010		ND	ND		µg/l
GW-4011	ND		ND		µg/l
GW-4012	ND		ND		µg/l
GW-4013	0.060		0.066		µg/l
GW-4014		ND	ND		µg/l
GW-4015		ND		ND	µg/l
GW-4016	ND			ND	µg/l
GW-4017	ND			ND	µg/l
GW-4018		ND	ND		µg/l
GW-4019		ND	ND		µg/l
GW-4020		ND		ND	µg/l
GW-4021		ND	ND		µg/l
GW-4022		ND			µg/l
GW-4023		ND		ND	µg/l
GW-FINW	ND	ND	ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND	ND	ND	µg/l
GW-PW06	ND	ND	ND	NS	µg/l
GW-PW07	ND	ND	NS	ND	µg/l
GW-PW08	ND	ND	NS	ND	µg/l
GW-PW09	NS	ND	ND	ND	µg/l
<u>2,4,6-TNT</u>					
GW-PW03	ND	ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PWO5	ND	ND	ND	ND	µg/l
GW-PW06	ND	ND	ND	NS	µg/l
GW-PW07	ND	ND	NS	ND	µg/l
GW-PW08	ND	ND	NS	ND	µg/l
GW-PW09	NS	ND	ND	ND	µg/l
<u>2,4-DNT</u>					
GW-1010	ND	ND(2)	ND	ND	µg/l
GW-1011	ND(2)	ND	ND	ND	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	ND	ND	µg/l
GW-1020	ND	ND	ND	ND	µg/l

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Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-1021	ND	ND	ND	ND	µg/l
GW-1022	ND	ND	ND	ND	µg/l
GW-1023	ND	ND	ND	ND	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-2001	0.070		0.073		µg/l
GW-2002	0.060		0.052		µg/l
GW-2003	0.150		0.180		µg/l
GW-2004		ND		ND	µg/l
GW-2005		0.070	0.089		µg/l
GW-2006		ND		0.130	µg/l
GW-2007	ND		ND		µg/l
GW-2008	0.050		0.048		µg/l
GW-2009	ND		0.074		µg/l
GW-2010	0.060		0.078		µg/l
GW-2011	ND		ND	0.10	µg/l
GW-2012	ND		ND	0.11	µg/l
GW-2013	0.700		0.500	0.310	µg/l
GW-2014	0.140		0.108(2)		µg/l
GW-2015	ND			ND	µg/l
GW-2017	ND		ND		µg/l
GW-2018	ND		ND	ND	µg/l
GW-2019		ND	ND		µg/l
GW-2020		ND		ND	µg/l
GW-2021		ND	ND		µg/l
GW-2022		ND	ND		µg/l
GW-2023		ND		ND	µg/l
GW-2024		ND	ND		µg/l
GW-2025		ND	ND		µg/l
GW-2026		ND	ND		µg/l
GW-2027		ND	ND		µg/l
GW-2028		ND		ND	µg/l
GW-2029		ND		ND	µg/l
GW-2030		0.090		0.200	µg/l
GW-2031		ND			µg/l
GW-2032		0.033		0.094	µg/l
GW-2033		0.090		0.230	µg/l
GW-2034		ND		ND	µg/l
GW-3001	0.440				µg/l
GW-3002		ND	ND		µg/l
GW-3003	0.060		0.032		µg/l
GW-3006	ND		ND	ND	µg/l
GW-3008	0.080		0.096		µg/l
GW-3009	0.140		0.160		µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-3019	ND		ND		µg/l
GW-3022		0.120		NS	µg/l
GW-3023	2.600		6.000		µg/l
GW-4001	ND		7.4		µg/l
GW-4002	0.420		ND		µg/l
GW-4003	ND		ND		µg/l
GW-4004	ND		ND		µg/l
GW-4005	ND	ND	ND	NS	µg/l
GW-4006	ND		0.19		µg/l
GW-4007			ND		µg/l
GW-4008	ND		ND		µg/l
GW-4009	ND		ND		µg/l
GW-4010		ND	ND		µg/l
GW-4011	ND		ND		µg/l
GW-4012	ND		ND		µg/l
GW-4013	0.050		0.086		µg/l
GW-4014		ND	ND		µg/l
GW-4015		0.031		0.070	µg/l
GW-4016	ND		ND		µg/l
GW-4017	ND		ND		µg/l
GW-4018		ND	ND		µg/l
GW-4019		ND	ND		µg/l
GW-4020		ND		ND	µg/l
GW-4021		ND	ND		µg/l
GW-4022		ND			µg/l
GW-4023		0.100		0.059	µg/l
GW-FINW	ND	ND	ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03	ND	ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND	ND	ND	µg/l
GW-PW06	ND	ND	ND	NS	µg/l
GW-PW07	ND	ND	NS	ND	µg/l
GW-PW08	ND	ND	NS	ND	µg/l
GW-PW09	NS	ND	ND	ND	µg/l
2,6-DNT					
GW-1010	ND	ND(2)	ND	ND	µg/l
GW-1011	ND(2)	ND	ND	ND	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	ND	ND	µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-1020	ND	ND	ND	ND	µg/l
GW-1021	ND	ND	ND	ND	µg/l
GW-1022	ND	ND	ND	ND	µg/l
GW-1023	ND	ND	ND	ND	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-2001	0.050		0.061		µg/l
GW-2002	0.340		0.490		µg/l
GW-2003	0.650		0.960		µg/l
GW-2004		ND		ND	µg/l
GW-2005		0.110	0.140		µg/l
GW-2006		2.000		2.400	µg/l
GW-2007	ND		ND		µg/l
GW-2008	0.890		1.000		µg/l
GW-2009	ND		0.33		µg/l
GW-2010	0.930		0.750		µg/l
GW-2011	ND		ND		µg/l
GW-2012	ND		ND		µg/l
GW-2013	15.000		28.000	19.000	µg/l
GW-2014	0.740		0.890(2		µg/l
GW-2015	ND			ND	µg/l
GW-2017	ND		ND		µg/l
GW-2018	ND		ND	ND	µg/l
GW-2019		ND	ND		µg/l
GW-2020		ND		ND	µg/l
GW-2021		ND	ND		µg/l
GW-2022		ND	ND		µg/l
GW-2023		ND		ND	µg/l
GW-2024		ND	ND		µg/l
GW-2025		ND	ND		µg/l
GW-2026		ND	ND		µg/l
GW-2027		ND	ND		µg/l
GW-2028		ND		ND	µg/l
GW-2029		ND		ND	µg/l
GW-2030		10.000		30.000	µg/l
GW-2031		ND			µg/l
GW-2032		4.600		3.500	µg/l
GW-2033		9.300		2.800	µg/l
GW-2034		ND		ND	µg/l
GW-3001	0.250				µg/l
GW-3002		ND	ND		µg/l
GW-3003	0.080		0.082		µg/l
GW-3006	ND		ND	ND	µg/l
GW-3008	0.160		0.320		µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-3009	0.080		0.110		µg/l
GW-3019	ND		ND		µg/l
GW-3022		0.030		NS	µg/l
GW-3023	4.500		9.600		µg/l
GW-4001	ND		ND		µg/l
GW-4002	1.100		0.069		µg/l
GW-4003	ND		ND		µg/l
GW-4004	ND		ND		µg/l
GW-4005	ND	ND	ND	NS	µg/l
GW-4006	ND		6.4		µg/l
GW-4007		NS	ND		µg/l
GW-4008	ND		ND		µg/l
GW-4009	ND		ND		µg/l
GW-4010		ND	ND		µg/l
GW-4011	ND		ND		µg/l
GW-4012	ND		ND		µg/l
GW-4013	1.100		1.900		µg/l
GW-4014		0.028	0.053		µg/l
GW-4015		1.300		1.000	µg/l
GW-4016	ND			ND	µg/l
GW-4017	ND			ND	µg/l
GW-4018		ND	ND		µg/l
GW-4019		ND	ND		µg/l
GW-4020		ND		ND	µg/l
GW-4021		ND	ND		µg/l
GW-4022		ND			µg/l
GW-4023		0.060		0.045	µg/l
GW-FINW	ND	ND	ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03	ND	ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND	ND	ND	µg/l
GW-PW06	ND	ND	ND	NS	µg/l
GW-PW07	ND	ND	NS	ND	µg/l
GW-PW08	ND	ND	NS	ND	µg/l
GW-PW09	NS	ND	ND	ND	µg/l
<u>NITROBENZENE</u>					
GW-1010	ND	ND(2)	ND	ND	µg/l
GW-1011	ND(2)	ND	ND	ND	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-1019	ND	ND	ND	ND	µg/l
GW-1020	ND	ND	ND	ND	µg/l
GW-1021	ND	ND	ND	ND	µg/l
GW-1022	ND	ND	ND	ND	µg/l
GW-1023	ND	ND	ND	ND	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-2001	ND		ND		µg/l
GW-2002	ND		ND		µg/l
GW-2003	ND		ND		µg/l
GW-2004		ND		ND	µg/l
GW-2005		ND	ND		µg/l
GW-2006		ND		ND	µg/l
GW-2007	ND		ND		µg/l
GW-2008	ND		ND		µg/l
GW-2009	ND		ND		µg/l
GW-2010	ND		ND		µg/l
GW-2011	ND		0.034		µg/l
GW-2012	ND		ND		µg/l
GW-2013	ND		ND	ND	µg/l
GW-2014	ND		ND(2)		µg/l
GW-2015	ND			ND	µg/l
GW-2017	ND		ND		µg/l
GW-2018	ND		ND		µg/l
GW-2019		ND	ND		µg/l
GW-2020		ND		ND	µg/l
GW-2021		ND	ND		µg/l
GW-2022		ND	ND		µg/l
GW-2023		ND		ND	µg/l
GW-2024		ND	ND		µg/l
GW-2025		ND	ND		µg/l
GW-2026		ND	ND		µg/l
GW-2027		ND	ND		µg/l
GW-2028		ND		ND	µg/l
GW-2029		ND		ND	µg/l
GW-2030		ND		ND	µg/l
GW-2031		ND			µg/l
GW-2032		ND		ND	µg/l
GW-2033		ND		ND	µg/l
GW-2034		ND		ND	µg/l
GW-3001	ND				µg/l
GW-3002		ND	ND		µg/l
GW-3003	ND		ND		µg/l
GW-3006	ND		ND	ND	µg/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-3008	ND		ND		µg/l
GW-3009	ND		ND		µg/l
GW-3019	ND		ND		µg/l
GW-3022		ND			µg/l
GW-3023	ND		ND		µg/l
GW-4001	ND		ND		µg/l
GW-4002	ND		ND		µg/l
GW-4003	ND		ND		µg/l
GW-4004	ND		ND		µg/l
GW-4005	ND	ND	ND		µg/l
GW-4006	ND		ND		µg/l
GW-4007	D		ND		µg/l
GW-4008	ND		ND		µg/l
GW-4009	ND		ND		µg/l
GW-4010		ND	ND		µg/l
GW-4011		ND	ND		µg/l
GW-4012	ND		ND		µg/l
GW-4013	ND		ND		µg/l
GW-4014		ND	ND		µg/l
GW-4015		ND		ND	µg/l
GW-4016	ND			ND	µg/l
GW-4017	ND			ND	µg/l
GW-4018		ND	ND		µg/l
GW-4019		ND	ND		µg/l
GW-4020		ND		ND	µg/l
GW-4021		ND	ND		µg/l
GW-4022		ND			µg/l
GW-4023		ND	ND		µg/l
GW-FINW	ND	ND	ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND	ND	ND	µg/l
GW-PW06	ND	ND	ND	NS	µg/l
GW-PW07	ND	ND	NS	ND	µg/l
GW-PW08	ND	ND	NS	ND	µg/l
GW-PW09	NS	ND	ND	ND	µg/l
GROSS ALPHA					
GW-1010	2.3(5)	2.00			pCi/l
GW-1011	16.5(4)	2.000			pCi/l
GW-1024	2.00	ND	7.900	NS	pCi/l
GW-FINW		ND	ND	ND	pCi/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-PW02	ND	ND	ND	ND	pCi/l
GW-PW03	1.00	ND	ND	38.0	pCi/l
GW-PW04	ND	ND	ND	ND	pCi/l
GW-PW05	ND	1.00	ND	19.2	pCi/l
GW-PW06	2.00	ND	ND	NS	pCi/l
GW-PW07	ND	ND	ND	6.59	pCi/l
GW-PW08	2.00	ND	ND	ND	pCi/l
GW-PW09	NS	ND	ND	ND	pCi/l
GW-RAWW			ND	ND	pCi/l
GW-FINW		ND	ND	ND	pCi/l
GW-RMW1	ND(2)	ND	ND	ND	pCi/l
GW-RMW2	8.00	5.00	ND	ND	pCi/l
GW-RMW3	3.00	ND	ND	17.7	pCi/l
GW-RMW4	1.00	3.00	ND	ND	pCi/l
<u>GROSS BETA</u>					
GW-1024	4.000				pCi/l
GW-PW02	6.00				pCi/l
GW-PW03	6.00				pCi/l
GW-PW04	6.00				pCi/l
GW-PW05	5.00				pCi/l
GW-PW06	6.00				pCi/l
GW-PW07	7.00				pCi/l
GW-PW08	5.00				pCi/l
GW-PW09	4.00				pCi/l
GW-RAWW	6.00				pCi/l
GW-RMW1	3.00				pCi/l
GW-RMW2	7.00				pCi/l
GW-RMW3	4.00				pCi/l
GW-RMW4	2.00				pCi/l
<u>RADIUM-226</u>					
GW-1024	0.40				pCi/l
GW-PW02	0.70				pCi/l
GW-PW03	0.40				pCi/l
GW-PW04	0.50				pCi/l
GW-PW05	0.60				pCi/l
GW-PW06	0.40				pCi/l
GW-PW07	0.50				pCi/l
GW-PW08	0.50				pCi/l
GW-PW09		ND			pCi/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-RAWW	0.60				pCi/l
GW-RMW1	0.80				pCi/l
GW-RMW2	0.40				pCi/l
GW-RMW3	0.70				pCi/l
GW-RMW4	0.10				pCi/l
<u>RADIUM-228</u>					
GW-1024	2.30				pCi/l
GW-PW02	1.80				pCi/l
GW-PW03	1.70				pCi/l
GW-PW04	1.60				pCi/l
GW-PW05	1.20				pCi/l
GW-PW06	2.10				pCi/l
GW-PW07	2.60				pCi/l
GW-PW08	1.80				pCi/l
GW-PW09		1.10			pCi/l
GW-RAWW	1.30				pCi/l
GW-RMW1	1.20				pCi/l
GW-RMW2	ND				pCi/l
GW-RMW3	2.20				pCi/l
GW-RMW4	0.30				pCi/l
<u>THORIUM-228</u>					
GW-2001		ND			pCi/l
GW-2002		ND			pCi/l
GW-2008	ND				pCi/l
GW-2012	ND				pCi/l
GW-2015	0.100				pCi/l
<u>THORIUM-230</u>					
GW-1024	0.100				pCi/l
GW-2001		ND			pCi/l
GW-2002		ND			pCi/l
GW-2008	0.200				pCi/l
GW-2012	ND				pCi/l
GW-2015	ND				pCi/l
GW-PW02	ND				pCi/l
GW-PW03	ND				pCi/l
GW-PW04	ND				pCi/l
GW-PW05	ND				pCi/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-PW06	ND				pCi/l
GW-PW07	0.10				pCi/l
GW-PW08	ND				pCi/l
GW-PW09		ND			pCi/l
GW-RMW1	ND				pCi/l
GW-RMW2	ND				pCi/l
GW-RMW3	0.10				pCi/l
GW-RMW4	0.10				pCi/l
GW-RAWW	ND				pCi/l
<u>THORIUM-232</u>					
GW-1024	ND				pCi/l
GW-2001		ND			pCi/l
GW-2002		ND			pCi/l
GW-2008	ND				pCi/l
GW-2012	ND				pCi/l
GW-2015	ND				pCi/l
GW-PW02	ND				pCi/l
GW-PW03	ND				pCi/l
GW-PW04	ND				pCi/l
GW-PW05	ND				pCi/l
GW-PW06	ND				pCi/l
GW-PW07	ND				pCi/l
GW-PW08	ND				pCi/l
GW-PW09	ND				pCi/l
GW-RAWW	ND				pCi/l
GW-RAW1	ND				pCi/l
GW-RAW2	ND				pCi/l
GW-RAW3	ND				pCi/l
GW-RAW4	ND				pCi/l
GW-RMW1	ND				pCi/l
GW-RMW2	ND				pCi/l
GW-RMW3	ND				pCi/l
GW-RMW4	ND				pCi/l
<u>URANIUM, TOTAL</u>					
GW-1010	ND(4)	ND(2)	0.577(2)	ND(2)	pCi/l
GW-1011	20.9(6)	8.84(3)	15(2)		pCi/l
GW-1017	2.720	ND	ND	ND	pCi/l
GW-1018	ND	ND	0.86	ND	pCi/l
GW-1019	0.68	ND	ND	ND	pCi/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-1020	1.360	1.360	ND	ND	pCi/l
GW-1021	0.680	ND	2.900	0.577	pCi/l
GW-1022	1.360	ND	1.200	0.577	pCi/l
GW-1023	ND	ND	ND	1.16	pCi/l
GW-1024	0.68	ND	ND	2.60	pCi/l
GW-2001	ND		ND		pCi/l
GW-2002	ND		ND		pCi/l
GW-2003	0.680		0.600		pCi/l
GW-2004		ND		0.75	pCi/l
GW-2005		ND	2.000		pCi/l
GW-2006		ND		ND	pCi/l
GW-2007	2.040		0.865		pCi/l
GW-2008	1.360		ND		pCi/l
GW-2009	1.360		2.310		pCi/l
GW-2010	0.680		2.020		pCi/l
GW-2011	4.760		ND		pCi/l
GW-2012	2.040		0.865		pCi/l
GW-2013	2.720		ND	ND	pCi/l
GW-2014	1.360		ND(2)		pCi/l
GW-2015	4.080			0.810	pCi/l
GW-2017	7.480		7.210		pCi/l
GW-2018	1.360		ND	1.16	pCi/l
GW-2019		1.360	2.590		pCi/l
GW-2020		3.400		4.930	pCi/l
GW-2021		ND	ND		pCi/l
GW-2022		ND	ND		pCi/l
GW-2023		ND		2.740	pCi/l
GW-2024		1.360	0.577		pCi/l
GW-2025		ND	ND		pCi/l
GW-2026		0.680	ND		pCi/l
GW-2027		ND	ND		pCi/l
GW-2028		0.680		2.340	pCi/l
GW-2029		0.680		1.990	pCi/l
GW-2030		12.200		0.894	pCi/l
GW-2031		6.120			pCi/l
GW-2032		2.040		0.577	pCi/l
GW-2033		ND		1.180	pCi/l
GW-2034		3.400		14.700	pCi/l
GW-3001	4.080			1.900	pCi/l
GW-3002		1.360	1.140		pCi/l
GW-3003	19.000		20.500		pCi/l
GW-3006	ND		2.310	1.410	pCi/l
GW-3008	4.080		4.040		pCi/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GW-3009	49.600		0.900		pCi/l
GW-3019	8.160		1.700		pCi/l
GW-3022		3.400		NS	pCi/l
GW-3023	7.480		6.630		pCi/l
GW-4001	3.400		ND		pCi/l
GW-4002	ND		1.16		pCi/l
GW-4003	ND		2.300		pCi/l
GW-4004	ND		4.320		pCi/l
GW-4005	6.800	122.00	2.020		pCi/l
GW-4006	1.360		ND		pCi/l
GW-4007		NS	ND		pCi/l
GW-4008	ND		ND		pCi/l
GW-4009	2.720		1.400		pCi/l
GW-4010		0.680	1.360		pCi/l
GW-4011	4.760		2.880		pCi/l
GW-4012	4.080		3.460		pCi/l
GW-4013	1.360	ND	ND		pCi/l
GW-4014	ND	ND	ND		pCi/l
GW-4015		0.680		2.860	pCi/l
GW-4016	5.440			3.290	pCi/l
GW-4017	2.720			ND	pCi/l
GW-4018		ND	0.865		pCi/l
GW-4019		3.400	0.865		pCi/l
GW-4020		24.500		15.300	pCi/l
GW-4021		8.160	1.730		pCi/l
GW-4022		ND		2.710	pCi/l
GW-4023		ND		1.180	pCi/l
GW-FINW		ND	ND	ND	pCi/l
GW-PW02	0.68	ND	0.864	ND	pCi/l
GW-PW03	ND	ND	0577	ND	pCi/l
GW-PW04	ND	ND	ND	ND	pCi/l
GW-PW05	ND	ND	ND	ND	pCi/l
GW-PW06	ND	ND	ND	NS	pCi/l
GW-PW07	2.72	ND	ND	ND	pCi/l
GW-PW08	ND	ND	ND	ND	pCi/l
GW-PW09	NS	ND	0.58	ND	pCi/l
GW-RAWW	ND	ND	ND	ND	pCi/l
GW-RMW1	0.68	ND	1.73	1.44	pCi/l
GW-RMW2	6.80	4.76	5.77	2.59	pCi/l
GW-RMW3	0.68	4.76	2.59	ND	pCi/l
GW-RMW4	5.44	ND	2.02	NS	pCi/l

Table A-2 1991 Quarterly Groundwater Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
URANIUM-234					
GW-2021			1.700		pCi/l
GW-2027			2.800		pCi/l
GW-2028				ND	pCi/l
GW-4016				ND	pCi/l
GW-4020				9.100	pCi/l
GW-4021			2.400		pCi/l
URANIUM-235					
GW-2021			ND		pCi/l
GW-2027			ND		pCi/l
GW-2028				ND	pCi/l
GW-4016				ND	pCi/l
GW-4020				ND	pCi/l
GW-4021			ND		pCi/l
URANIUM-238					
GW-2021			ND		pCi/l
GW-2027			ND		pCi/l
GW-2028				ND	pCi/l
GW-4016				ND	pCi/l
GW-4020				5.650	pCi/l
GW-4021			2.300		pCi/l

1 Blank space indicate that no sampling was planned for the location and sampling period.
2 ND indicate that a concentration was not found at the detection limit.
3 NS indicate that a planned sample was not taken.
4 (n) indicates the total number (n) of samples calculated.
5 Indicates that the sample was not taken during the schedule period but taken in the next period.

Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSQ

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
CHLORIDE					
SW-1008		NS	12.400		mg/l
SW-1011		25.600	21.400		mg/l
SW-1012		28.900	18.100		mg/l
SW-1013		28.500	24.000		mg/l
SW-1015		28.300	15.000		mg/l
SW-5311		6.370	NS		mg/l
FLUORIDE					
SW-1008		NS	0.680		mg/l
SW-1011		0.830	0.460		mg/l
SW-1012		0.450	0.660		mg/l
SW-1013		0.440	0.573		mg/l
SW-1015		0.430	0.530		mg/l
SW-5311		0.260	NS		mg/l
NITRATE					
SW-1008	ND	ND	1.300	0.190	mg/l
SW-1011		11.900	2.320		mg/l
SW-1012		12.600	2.320		mg/l
SW-1013		10.000	2.540		mg/l
SW-1015		10.900	2.320		mg/l
SW-2010	ND	4.750			mg/l
SW-2012	29.100				mg/l
SW-2014		5.630	1.250		mg/l
SW-2015		11.210	0.855	0.7	mg/l
SW-3001		388.00			mg/l
SW-3002		ND	4.250		mg/l
SW-3003		110.00	4255.0	854.00	mg/l
SW-3004		0.130	2.700		mg/l
SW-3012			7350.0		mg/l
SW-5311		2.220	NS		mg/l
NITRITE					
SW-1008					
SW-1011		0.010			mg/l
SW-1012		0.080			mg/l
SW-1013		0.040			mg/l
SW-1015		0.050			mg/l
SW-2010		ND			mg/l

Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
SW-2014		0.010			mg/l
SW-2015		ND	ND	ND	mg/l
SW-5311		0.040			mg/l
SULFATE					
SW-1008	56.9	67.8	69.200	79.900	mg/l
SW-1011		100.00	152.00		mg/l
SW-1012		110.00	134.00		mg/l
SW-1013		109.00	169.00		mg/l
SW-1015		103.00	101.00		mg/l
SW-3001		225.00			mg/l
SW-3002		796.00			mg/l
SW-3003		502.00			mg/l
SW-3004		44.300			mg/l
SW-5311		38.300			mg/l
ALUMINUM					
SW-1008			1140.0		µg/l
SW-1011		3440.0	2170.0		µg/l
SW-1012		3930.0	691.00		µg/l
SW-1013		2200.0	822.00		µg/l
SW-1015		2260.0	698.00		µg/l
SW-5311		73.000			µg/l
ANTIMONY					
SW-1008			ND		µg/l
SW-1011		201.00	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5305				ND	µg/l
SW-5307				ND	µg/l
SW-5309				ND	µg/l
SW-5311		R		ND	µg/l
ARSENIC					
SW-1001	ND				µg/l
SW-1002	ND				µg/l
SW-1003	ND				µg/l
SW-1004	ND				µg/l

Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
SW-1005	5.170				µg/l
SW-1007	ND				µg/l
SW-1008	NS*	7.130	ND		µg/l
SW-1009	5.360				µg/l
SW-1010	ND				µg/l
SW-1011	3.710	3.100	19.700		µg/l
SW-1012	3.020	4.500	4.140		µg/l
SW-1013	3.270	4.000	3.810		µg/l
SW-1014	ND				µg/l
SW-1015		3.900	3.700		µg/l
SW-5305				ND	µg/l
SW-5307				ND	µg/l
SW-5309				ND	µg/l
SW-5311		ND		ND	µg/l
BARIUM					
SW-1001	54.100				µg/l
SW-1002	56.100				µg/l
SW-1003	123.00				µg/l
SW-1004	129.00				µg/l
SW-1005	177.00				µg/l
SW-1007	114.00				µg/l
SW-1008	NS*	179.00	220.00		µg/l
SW-1009	167.00				µg/l
SW-1010	126.00				µg/l
SW-1011	143.00	171.00	152.00		µg/l
SW-1012	137.00	162.00	142.00		µg/l
SW-1013	139.00	154.00	146.00		µg/l
SW-1014	61.700				µg/l
SW-1015		153.00	137.00		µg/l
SW-5305				78.300	µg/l
SW-5307				74.100	µg/l
SW-5309				84.100	µg/l
SW-5311		97.000		105.00	µg/l
BERYLLIUM					
SW-1008	NS*	ND	ND		µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l

Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
SW-2010		ND			µg/l
SW-2011			ND		µg/l
SW-3001			ND		µg/l
SW-3002			ND		µg/l
SW-3003			ND		µg/l
SW-3004			ND		µg/l
SW-3012			ND		µg/l
SW-5305			ND		µg/l
SW-5307			ND		µg/l
SW-5309			ND		µg/l
SW-5311		ND		ND	µg/l
<u>CADMIUM</u>					
SW-1008	NS*	ND	ND		µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-2010		ND			µg/l
SW-5305				ND	µg/l
SW-5307				ND	µg/l
SW-5309				ND	µg/l
SW-5311		ND		ND	µg/l
<u>CALCIUM</u>					
SW-1008			63800		µg/l
SW-1011		63700	134000		µg/l
SW-1012		61300	58600		µg/l
SW-1013		60300	59300		µg/l
SW-1015		60100	56100		µg/l
SW-5311		R			µg/l
<u>CHROMIUM</u>					
SW-1008	NS*	33.550	ND		µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-2010			4.450		µg/l
SW-2011			9.685		µg/l

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Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
SW-3001			7.675		µg/l
SW-3002			3.560		µg/l
SW-3003			8.131		µg/l
SW-3004			4.585		µg/l
SW-3012			9.360		µg/l
SW-5305				ND	µg/l
SW-5307				ND	µg/l
SW-5309				ND	µg/l
SW-5311		ND		ND	µg/l
COBALT					
SW-1008			ND		µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5311		ND			µg/l
COPPER					
SW-1008			ND		µg/l
SW-1011		ND	21.100		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5311		ND			µg/l
IRON					
SW-1008			1560.0		µg/l
SW-1011		4490.0	17200		µg/l
SW-1012		4640.0	982.00		µg/l
SW-1013		3310.0	1080.0		µg/l
SW-1015		3400.0	1010.0		µg/l
SW-5311		93.000			µg/l
LEAD					
SW-1008	NS*	15.300	9.060		µg/l
SW-1011		3.900	52.000		µg/l
SW-1012		3.700	2.930		µg/l
SW-1013		4.200	2.910		µg/l

Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
SW-1015		8.000	4.380		µg/l
SW-2010		1.600			µg/l
SW-2011			21.000		µg/l
SW-3001			2.200		µg/l
SW-3002			6.500		µg/l
SW-3003			ND		µg/l
SW-3004			1.400		µg/l
SW-3012			2.700		µg/l
SW-5305				5.200	µg/l
SW-5307				2.050	µg/l
SW-5309				ND	µg/l
SW-5311		ND		2.200	µg/l
<u>LITHIUM</u>					
SW-1008			ND		µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	151		µg/l
SW-1013		ND	164		µg/l
SW-1015		ND	163		µg/l
SW-2010		ND			µg/l
SW-2014		ND	ND		µg/l
SW-2015		ND	ND	ND	µg/l
SW-5311		ND			µg/l
<u>MAGNESIUM</u>					
SW-1008			12100		µg/l
SW-1011		17400	23900		µg/l
SW-1012		16800	18200		µg/l
SW-1013		16400	18600		µg/l
SW-1015		16800	17800		µg/l
SW-5311		R			µg/l
<u>MANGANESE</u>					
SW-1008			326.00		µg/l
SW-1011		236.00	2120.0		µg/l
SW-1012		ND	ND		µg/l
SW-1013		215.00	171.00		µg/l
SW-1015		221.00	161.00		µg/l
SW-5311		ND			µg/l

Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSQ (Continued)

WSSRAP ID	Q1	Q2	Q3	Q4	UNITS
MERCURY					
SW-1008			ND		µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5305				ND	µg/l
SW-5307				ND	µg/l
SW-5309				ND	µg/l
SW-5311		ND		ND	µg/l
MOLYBDENUM					
SW-1008			ND		µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5311		ND			µg/l
NICKEL					
SW-1008			ND		µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5311		ND			µg/l
POTASSIUM					
SW-1008			8100		µg/l
SW-1011		6200	ND		µg/l
SW-1012		6010	6120		µg/l
SW-1013		5260	5640		µg/l
SW-1015		5340	5820		µg/l
SW-5311		R	1750		µg/l
SELENIUM					
SW-1008			ND		µg/l
SW-1011		ND	ND		µg/l

Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5305				ND	µg/l
SW-5307				ND	µg/l
SW-5309				ND	µg/l
SW-5311		ND		ND	µg/l
SILVER					
SW-1008			ND		µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5305				ND	µg/l
SW-5307				ND	µg/l
SW-5309				ND	µg/l
SW-5311		ND		ND	µg/l
SODIUM					
SW-1008			10000		µg/l
SW-1011		38200	18000		µg/l
SW-1012		37700	62000		µg/l
SW-1013		37100	62800		µg/l
SW-1015		35900	59200		µg/l
SW-5311		R	9330.0		µg/l
THALLIUM					
SW-1008			ND		µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5305				ND	µg/l
SW-5307				ND	µg/l
SW-5309				ND	µg/l
SW-5311		ND		ND	µg/l

Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
VANADIUM					
SW-1008			ND		µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5311			ND		µg/l
ZINC					
SW-1008			ND		µg/l
SW-1011		56.0	163		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		111	ND		µg/l
SW-5311		18.0			µg/l
1,3,5-TRINITROBENZENE					
SW-1008	NS*	.051	ND	0.320	µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5311		ND		ND	µg/l
1,3-DINITROBENZENE					
SW-1008	NS*	ND	ND	ND	µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5311		ND		ND	µg/l
2,4,6-TNT					
SW-1008	NS*	0.565	0.100	60	µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l

Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5311		ND		0.033	µg/l
2,4-DNT					
SW-1008	NS*	.80	2.50	11.0	µg/l
SW-1011	NS*	ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5311		ND		0.037	µg/l
2,6-DNT					
SW-1008	NS*	0.150	0.280	2.1	µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5311		ND		0.096	µg/l
NITROBENZENE					
SW-1008	NS*	ND	ND	ND	µg/l
SW-1011		ND	ND		µg/l
SW-1012		ND	ND		µg/l
SW-1013		ND	ND		µg/l
SW-1015		ND	ND		µg/l
SW-5311		ND		ND	µg/l
SW-1008			637.00		pCi/l
SW-1011		ND	ND	ND	pCi/l
SW-1012		ND	ND	ND	pCi/l
SW-1013		ND	ND	ND	pCi/l
SW-1015		ND	ND	ND	pCi/l
SW-2010	2051.0	836.00			pCi/l
SW-2012	330.00				pCi/l
SW-2014		78.100	ND		pCi/l
SW-2015		ND	ND	31.300	pCi/l
SW-5311		130.00		111.50	pCi/l

Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSO (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
GROSS ALPHA					
SW-1008			637		pCi/l
SW-1011		2.7(2)	ND	4.7(2)	pCi/l
SW-1012		7.0	ND	ND(2)	pCi/l
SW-1013		3.0	ND	5.4(2)	pCi/l
SW-1015		8.00	ND	9.5(2)	pCi/l
SW-5311				111.5(2)	pCi/l
GROSS BETA					
SW-1008			158.00		pCi/l
SW-1011		9.000	9.690	4.700	pCi/l
SW-1012		ND	ND	ND	pCi/l
SW-1013		11.000	7.840	4.950	pCi/l
SW-1015		13.000	6.520	9.150(2)	pCi/l
SW-5311		66.000		57.100(2)	pCi/l
RADIUM-226					
SW-1008	NS*	1.450(2)	6.420	0.687	pCi/l
SW-1011		ND	ND	ND	pCi/l
SW-1012		ND	ND	ND	pCi/l
SW-1013		ND	ND	ND	pCi/l
SW-1015		ND	ND	ND(2)	pCi/l
SW-3001		138.00			pCi/l
SW-3002		74.000			pCi/l
SW-3003		105.00			pCi/l
SW-3004		3.500			pCi/l
SW-5305				0.480	pCi/l
SW-5307				0.520	pCi/l
SW-5311		1.600		1.05(2)	pCi/l
RADIUM-228					
SW-1008	NS*	ND	ND		pCi/l
SW-1011		ND	ND		pCi/l
SW-1012		ND	ND		pCi/l
SW-1013		ND	ND		pCi/l
SW-1015		ND	ND		pCi/l
SW-5311		ND			pCi/l

Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
THORIUM-228					
SW-1008	NS*	2.200	ND		pCi/l
SW-1011			ND		pCi/l
SW-1012			ND		pCi/l
SW-1013			ND		pCi/l
SW-1015			ND		pCi/l
SW-3001		1.300			pCi/l
SW-3002		ND			pCi/l
SW-3003		5.400			pCi/l
SW-3004		2.500			pCi/l
THORIUM-230					
SW-1008	NS*	3.800	3.210	3.820	pCi/l
SW-1011		ND	ND		pCi/l
SW-1012		ND	2.390		pCi/l
SW-1013		ND	8.800		pCi/l
SW-1015		ND	6.940		pCi/l
SW-3001		R			pCi/l
SW-3002		R			pCi/l
SW-3003		R			pCi/l
SW-3004		R			pCi/l
SW-5305				4.370	pCi/l
SW-5307				2.170	pCi/l
SW-5311		ND		4.570	pCi/l
THORIUM-232					
SW-1008	NS*	ND	ND	ND	pCi/l
SW-1011		ND	2.040		pCi/l
SW-1012		ND	ND		pCi/l
SW-1013		ND	1.010		pCi/l
SW-1015		ND	2.190		pCi/l
SW-3001		10.800			pCi/l
SW-3002		36.300			pCi/l
SW-3003		1.800			pCi/l
SW-3004		1.500			pCi/l
SW-5305				ND	pCi/l
SW-5307				ND	pCi/l
SW-5311		ND		ND	pCi/l

Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
URANIUM, TOTAL					
SW-1001	0.680	ND	6.120	2.15	pCi/l
SW-1002	6.800	ND	3.400	2.050	pCi/l
SW-1003	156.00	144.3	57.1	55.03	pCi/l
SW-1004	326.00	197.7	65.7	54.6	pCi/l
SW-1005	81.600	96.3	27.5	7.48	pCi/l
SW-1007	13.300	17.7	13.5	16.750	pCi/l
SW-1008	NS*	629.00	667	1950.0	pCi/l
SW-1009	28.600	14.97	12.73	13.07	pCi/l
SW-1010	74.800	135.4	61.97	36.0	pCi/l
SW-1011	4.760	2.040	5.645	3.39	pCi/l
SW-1012	4.760	ND	5.335	1.99	pCi/l
SW-1013	3.400	0.850	4.470	2.51	pCi/l
SW-1014	2.040	0.680	1.360	3.000	pCi/l
SW-1015	NS	0.680	2.310	3.37	pCi/l
SW-2001	2.040	4.080	ND	1.47	pCi/l
SW-2002	43.500	16.300	10.655	45.6	pCi/l
SW-2003	7.480	8.160	2.720	12.200	pCi/l
SW-2004	16.300	19.000	6.120	17.600	pCi/l
SW-2005	2.720	18.400	4.760	27.100	pCi/l
SW-2007	2.040	ND	ND	ND	pCi/l
SW-2010	1134.2	277.15	363.00	897.0	pCi/l
SW-2011	197.00	121.00	171.00	993.0	pCi/l
SW-2012	326.00	NS	NS	NS	pCi/l
SW-2014	NS	6.870	20.100	NS	pCi/l
SW-2015	NS	2.585(2)	16.723(2)	17.450(2)	pCi/l
SW-3001	102.00	128.00	82.300	72.100	pCi/l
SW-3002	952.00	448.00	359.00	1370.0	pCi/l
SW-3003	163.00	165.00	1590.0	95.900	pCi/l
SW-3004	2180.0	1750.0	213.00	1750.0	pCi/l
SW-5301				18.200	pCi/l
SW-5302				21.900	pCi/l
SW-5305				27.100	pCi/l
SW-5307				81.150	pCi/l
SW-5309				95.900	pCi/l
SW-5311		177.00		138(2)	pCi/l
URANIUM-234					
SW-1012				2.63	pCi/l
SW-1013				1.94	pCi/l
SW-5311				63.900	pCi/l

Table A-3 1991 Quarterly Surface Water Data For Weldon Spring Site and WSQ (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
URANIUM-235					
SW-1012				ND	pCi/l
SW-1013				ND	pCi/l
SW-5311				3.610	pCi/l
URANIUM-238					
SW-1012				ND	pCi/l
SW-1013				ND	pCi/l
SW-5311				62.700	pCi/l

1 Blank space indicate that no sampling was planned for the location and sampling period.
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4 (n) indicates the total number (n) of samples calculated.
5 Indicates that the sample was not taken during the schedule period but taken in the next period.

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Table A-4 1991 Quarterly Springs Data For Weldon Spring Site

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
NITRATE					
SP-6301	8.68		210		mg/l
SULFATE					
SP-6301	31.8		50.3		mg/l
ALUMINUM					
SP-6301	143		ND		µg/l
SP-6306	153	1150	ND	ND	µg/l
ANTIMONY					
SP-6301	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l
ARSENIC					
SP-6301	ND		ND		µg/l
SP-6306	6.7	285	9.700	4.9	µg/l
BARIUM					
SP-6301	76.8		141.00		µg/l
SP-6306	308	3230	403.00	324	µg/l
BERYLLIUM					
SP-6301	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l
CADMIUM					
SP-6301	ND		ND		µg/l
SP-6306	ND	24.6	ND	ND	µg/l
CALCIUM					
SP-6301	43100		107000		µg/l
SP-6306	33600	53500	38000	34400	µg/l

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Table A-4 1991 Quarterly Spring Data For Weldon Spring Site (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
CHROMIUM					
SP-6301	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l
COBALT					
SP-6301	ND		ND		µg/l
SP-6306	ND	30	ND	ND	µg/l
COPPER					
SP-6301	ND	ND			µg/l
SP-6306	ND	ND	ND	16.5	µg/l
IRON					
SP-6301	156		158.00		µg/l
SP-6306	4150	401000	5840.0	4470	µg/l
LEAD					
SP-6301	ND		ND		µg/l
SP-6306	ND	15.7	ND	2.0	µg/l
LITHIUM					
SP-6301	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l
MAGNESIUM					
SP-6301	9290		28100.		µg/l
SP-6306	7870	10500.	8990.0	8190	µg/l
MANGANESE					
SP-6301	4.8		ND		µg/l
SP-6306	6710	19700.	9140	7380	µg/l
MERCURY					
SP-6301	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l

Table A-4 1991 Quarterly Spring Data For Weldon Spring Site (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
MOLYBDENUM					
SP-6301	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l
NICKEL					
SP-6301	ND		ND		µg/l
SP-6306	ND	44	ND	11.1	µg/l
POTASSIUM					
SP-6301	1570		2540		µg/l
SP-6306	1710	3620	2280	2970	µg/l
SELENIUM					
SP-6301	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l
SILVER					
SP-6301	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l
SODIUM					
SP-6301	14700.		42200.		µg/l
SP-6306	10200.	12000.	11000.	9870	µg/l
THALLIUM					
SP-6301	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l
VANADIUM					
SP-6301	ND		16.2		µg/l
SP-6306	ND	33.4	ND	ND	µg/l
ZINC					
SP-6301	8.5		9.7		µg/l
SP-6306	ND	51.2	46.8	10.0	µg/l

Table A-4 1991 Quarterly Spring Data For Weldon Spring Site (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
ALKALINITY					
SP-6301			218		mg/l
1,3,5-TRINITROBENZENE					
SP-6301	ND		0.088		µg/l
SP-6302	ND				µg/l
SP-6303	0.050		0.300		µg/l
SP-6306	ND	ND	ND	ND	µg/l
1,3-DINITROBENZENE					
SP-6301	ND		ND		µg/l
SP-6302	ND				µg/l
SP-6303	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l
2,4,6-TNT					
SP-6301	0.050		0.290		µg/l
SP-6302	ND				µg/l
SP-6303	0.360		0.510		µg/l
SP-6306	ND	ND	ND	ND	µg/l
2,4-DNT					
SP-6301	ND		0.038		µg/l
SP-6302	ND				µg/l
SP-6303	0.050		0.085		µg/l
SP-6306	ND	ND	ND	ND	µg/l
2,6-DNT					
SP-6301	0.190		0.460		µg/l
SP-6302	0.020				µg/l
SP-6303	0.830		0.860		µg/l
SP-6306	ND	ND	ND	1.05	µg/l
NITROBENZENE					
SP-6301	ND		ND		µg/l
SP-6302	ND				µg/l
SP-6303	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l

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Table A-4 1991 Quarterly Spring Data For Weldon Spring Site (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
URANIUM, TOTAL					
SP-5201	ND		ND		pCi/l
SP-5203				0.95	pCi/l
SP-5301	177	433	314	231	pCi/l
SP-5302	156.4	320	365	264	pCi/l
SP-5303	163	129	300	183	pCi/l
SP-5304	81.6	163	172	141	pCi/l
SP-5503	ND		ND		pCi/l
SP-6301	49.0	139	66.6	70.0	pCi/l
SP-6302	63.2				pCi/l
SP-6303	2.04	4.08	2.31	2.51	pCi/l
SP-6306	6.12	16.5	1.44	4.18	pCi/l

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5 Indicates that the sample was not taken during the schedule period but taken in the next period.

Table A-5 Quarterly NPDES Data for WSS

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
SETTLEABLE SOLIDS					
NP-0001	ND	ND	0.5	ND	ml/l
NP-0004	ND	NS	NS	ND	ml/l
TOTAL SUSPENDED SOLIDS					
NP-0001	2.00	4.00	538	554	mg/l
NP-0004	11.0	892	15.0	451	mg/l
NP-0006	10(3)	5.3(3)	6.00(4)	13.8(5)	mg/l
FECAL COLIFORM					
NP-0006	77	ND	ND	2100	
BIOLOGICAL OXYGEN DEMAND					
NP-0006	19.1	9.3	ND	13.9	mg/l
pH					
NP-0001	7.14	7.60(2)	6.85	8.01	
NP-0004	6.76	7.35	6.92	7.3	
NP-0006	6.70(3)	5.83	7.30	6.31(6)	
LITHIUM					
NP-0001	7.80	ND	ND	ND	µg/l
NP-0004	ND	ND	ND	ND	µg/l
NP-0006	NR	NR	ND	NR	µg/l
NITRATE					
NP-0001	1.56	1.08	32.4	0.64	mg/l
NP-0004	1.97	48.0	1.81	1.70	mg/l
NP-0006	NR	NR	15.7	NR	mg/l
GROSS ALPHA					
NP-0001	560	480	133	150	pCi/l
NP-0004	15	ND	43.2	ND	pCi/l
NP-0006	NR	ND	ND	ND	pCi/l

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Table A-5 1991 Quarterly NPDES Data for WSS (Continued)

WSSRAP_ID	Q1	Q2	Q3	Q4	UNITS
URANIUM, TOTAL					
NP-0001	816	666	198	220	pCi/l
NP-0004	9.52	1.43	4.52	10.0	pCi/l
NP-0006	NR	ND	ND	ND	pCi/l

1 Blank space indicate that no sampling was planned for the location and sampling period.
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Table A-6 1991 Monthly NPDES Data Results for WSS

WSSRAP_ID	Jan	Feb	Mar	April	May	June	UNITS
SETTEABLE SOLIDS							
NP-0002	ND	ND	ND	ND	ND	NS	ml/l
NP-0003	ND	ND	ND	0.2	ND	NS	ml/l
NP-0005	ND	ND	ND	ND	ND	NS	ml/l
TOTAL SUSPENDED SOLIDS							
NP-0002	3.0	8.0	13.0	26.0	9.0	NS	mg/l
NP-0003	5.0	4.0	13.0	7930	26.3(3)	NS	mg/l
NP-0005	13.0	5.0	5.0	7.0	16.0	NS	mg/l
pH							
NP-0002	6.1	6.10	6.25	7.27	6.01	NS	units
NP-0003	6.09	6.27	6.42	7.18	6.66(2)	NS	
NP-0005	6.66	5.95	6.51	7.58	5.54	NS	
LITHIUM							
NP-0002	ND	12.7	ND	ND	ND	NS	µg/l
NP-0003	8.40	ND	ND	176	ND(2)	NS	µg/l
NP-0005	ND	16.2	ND	ND	ND	NS	µg/l
NITRATE							
NP-0002	1.68	2.31	4.72	1.09	ND	NS	mg/l
NP-0003	2.04	20.5	13.5	0.96	7.35(2)	NS	mg/l
NP-0005	29.6	ND	29.4	6.10	9.17	NS	mg/l
GROSS ALPHA							
NP-0002	180	94	120	110	140	NS	pCi/l
NP-0003	3200	210	1100	640	120	NS	pCi/l
NP-0005	1800	510	550	440	550	NS	pCi/l

Table A-6 1991 Monthly NPDES Data Results for WSS (Continued)

WSSRAP_ID	Jan	Feb	Mar	April	May	June	UNITS
URANIUM, TOTAL							
NP-0002	197	95.2	136	136	150	NS	pCi/l
NP-0003	3400	190	1290	88.4	130(2)	NS	pCi/l
NP-0005	2240	537	748	571	503	NS	pCi/l

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2 ND indicate that a concentration was not found at the detection limit.
3 NS indicate that a planned sample was not taken.
4 (n) indicates the total number (n) of samples calculated.
5 Indicates that the sample was not taken during the schedule period but taken in the next period.

Table A-7 1991 Monthly NPDES Data Results - Second Half

WSSRAP_ID	July	Aug	Sept	Oct	Nov	Dec	UNITS
SETTLEABLE SOLIDS							
NP-0002	0.2	NS	ND	ND	ND	ND(2)	ml/l
NP-0003	ND	NS	ND	ND(2)	ND(2)	ND(2)	ml/l
NP-0005	0.7	NS	ND	0.3	ND	ND(2)	ml/l
TOTAL SUSPENDED SOLIDS							
NP-0002	283	NS	ND	4.0	6.0	33.0	mg/l
NP-0003	38	NS	ND	109(2)	11.0	18.0	mg/l
NP-0005	212	NS	ND	ND	23.0	16.0	mg/l
pH							
NP-0002	6.85(2)	NS	6.87	8.07	8.42	6.61(2)	
NP-0003	6.73	NS	6.75	7.16(2)	8.52(2)	6.66(2)	
NP-0005	6.64	NS	6.45	8.05	7.01	6.3(2)	
LITHIUM							
NP-0002	ND	NS	ND	ND	ND	ND	µg/l
NP-0003	ND	NS	ND	ND	ND	ND	µg/l
NP-0005	ND	NS	ND	ND	ND	ND	µg/l
NITRATE							
NP-0002	19.3	NS	ND	ND	0.25	1.20	mg/l
NP-0003	8.81	NS	0.41	ND(2)	1.20	17.5	mg/l
NP-0005	33.9	NS	5.07	1.27	3.20	21.2	mg/l
GROSS ALPHA							
NP-0002	31.8	NS	40.1	49.0	164	237	pCi/l
NP-0003	13.3	NS	94.8	96.5(2)	119.5(2)	232	pCi/l
NP-0005	48.7	NS	134	150	500	314	pCi/l

Table A-7 1991 Monthly NPDES Data Results - Second Half (Continued)

WSSRAP_ID	July	Aug	Sept	Oct	Nov	Dec	UNITS
URANIUM, TOTAL							
NP-0002	40.1	NS	96.6	62.0	246	289(2)	pCi/l
NP-0003	13.6	NS	254	58.6(2)	160(2)	224(2)	pCi/l
NP-0005	48.3	NS	284	160	614	341(2)	pCi/l

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2 ND indicate that a concentration was not found at the detection limit.
3 NS indicate that a planned sample was not taken.
4 (n) indicates the total number (n) of samples calculated.
5 Indicates that the sample was not taken during the schedule period but taken in the next period.

APPENDIX B
Biological Monitoring Data

Table B-1 Concentrations of Total Uranium in Fish Sampled 1987-1991 pCi/g

MONITORING LOCATIONS	SPECIES	1991	1990/1989	1987	Average	DL
Frog Pond	Sunfish Cakes			ND	ND	(0.05)
Lake 34	Bass Fillet	0.010a	ND	ND	0.006	
Lake 34	Bass Whole	0.003a	0.024a		0.013	
Lake 34	Catfish Fillet	ND			0.002	
Lake 34	Catfish Whole	ND	ND		ND	(0.002)
Lake 34	Crappie Fillet			ND	ND	(0.005)
Lake 34	Sunfish Cakes	0.010a	0.041a	ND	0.018	
Lake 34	Sunfish Fillet	0.004a	ND		0.003	
Lake 34	Sunfish Whole	0.057a	0.036a		0.046	
Lake 35	Bass Fillet	0.072	0.005a	ND	0.027	
Lake 35	Bass Whole	0.014a	0.027a		0.020	
Lake 35	Catfish Fillets	0.030a	ND	ND	0.014	
Lake 35	Catfish Livers	0.070a			0.070	
Lake 35	Catfish Whole	0.009	0.385		0.197	
Lake 35	Crappie Cakes	0.003a	0.012a		0.008	
Lake 35	Crappie Fillet	0.006a	0.006a	ND	0.007	
Lake 35	Crappie Whole	0.002b	0.035		0.018	
Lake 35	Sunfish Cakes	0.049a	0.040a	ND	0.033	
Lake 35	Sunfish Fillet	0.016	0.008a		0.012	
Lake 35	Sunfish Whole	0.007a	0.282		0.144	
Lake 36	Bass Fillet	0.005a	0.008a	ND	0.006	
Lake 36	Bass Whole	0.003a	0.303		0.153	
Lake 36	Catfish Fillet	0.016a	0.018a	ND	0.013	
Lake 36	Catfish Whole	0.004a	1.863		0.933	
Lake 36	Crappie Cakes	0.021a			0.021	
Lake 36	Crappie Fillet	0.014a	0.006a		0.009	
Lake 36	Crappie Whole	0.009a	0.075a		0.042	
Lake 36	Sunfish Cakes	0.204		ND	0.105	

Table B-1 Concentrations of Total Uranium in Fish Sampled 1987-1991 pCi/g (Continued)

MONITORING LOCATIONS	SPECIES	1991	1990/1989	1987	Average	DL
Lake 36	Sunfish Fillet	0.029a	0.041	ND	0.025	
Lake 36	Sunfish Whole	0.351	0.529		0.440	
Femme Osage Slough	Bass Fillet			ND	ND	(0.005)
Femme Osage Slough	Bass Whole	0.005a			0.005	
Femme Osage Slough	Buffalo Fillet			ND	ND	(0.005)
Femme Osage Slough	Carp Fillet			ND	ND	(0.005)
Femme Osage Slough	Carp Whole	0.003a			0.003	
Femme Osage Slough	Catfish Fillet	ND			ND	(0.002)
Femme Osage Slough	Catfish Whole	0.005a			0.005	
Femme Osage Slough	Crappie Cakes	0.010a		ND	0.007	
Femme Osage Slough	Crappie Fillet	0.004a		ND	0.004	
Femme Osage Slough	Crappie Whole	0.002a			0.002	
Femme Osage Slough	Sunfish Cakes	0.005a			0.005	
Femme Osage Slough	Sunfish Whole	0.032			0.032	
BACKGROUND LOCATIONS						
Lake 33	Bass Fillet	0.003a			0.003	
Lake 33	Bass Whole	0.002a			0.002	
Lake 33	Carp Fillet	0.002a			0.002	
Lake 33	Carp Whole	ND			ND	(0.002)
Lake 33	Crappie Whole	0.002a			0.002	
Lake 33	Crappie Fillet	0.003a			0.003	
Lake 33	Crappie Cakes	0.007a			0.007	
Lake 33	Sunfish Cakes	ND			ND	(0.003)
Lake 33	Sunfish Fillet	ND			ND	(0.002)
Lake 33	Sunfish Whole	0.004a			0.004	
Lake 37	Bass Fillet	ND	ND	ND	ND	(0.003)
Lake 37	Bass Whole	0.007a	ND		0.004	
Lake 37	Catfish Fillet		0.003a		0.003	

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Table B-1 Concentrations of Total Uranium in Fish Sampled 1987-1991 pCi/g (Continued)

MONITORING LOCATIONS	SPECIES	1991	1990/1989	1987	Average	DL
Lake 37	Catfish Whole	0.003a	0.013a		0.008	
Lake 37	Sunfish Cakes	0.002a		ND	0.004	
Lake 37	Sunfish Fillet	0.003a	ND	ND	0.003	
Lake 37	Sunfish Whole	0.009a	ND		0.005	

** Values represent U-234,U-235 and U-238 concentrations and non-detects averaged as 1/2 of the detection limit.
a includes non-detect concentration
DL detection limit

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Table B-2 Concentrations of Total uranium in Benthic Invertebrates (pCi/g)

Location	Benthic Family	Concentration	DL	Habitat
Femme Osage Slough	Others	2.6	0.14	Pool
	Chirinomide	ND	1.30	Pool
Frog Pond	Others	0.57	0.034	Pool
Lake 34	Others	0.23	0.07	Pool
	Chironomide	0.56	0.07	Pool
	Ephemoptera	2.86	0.07	Pool
Lake 35	Oligochaete	12.2	0.68	Pool
	Chirinomide	6.80	0.68	Pool
	Others	16.3	0.68	Pool
Lake 36	Ephemoptera	8.43	0.68	Pool
	Others	49.5	0.68	Pool
Lake 26	Ephemoptera	0.184	0.075	Pool
	Others	ND	0.048	Pool
Lake 37	Naidadae (clams)	ND	0.204	Pool
	Chirinomide	0.143	0.027	Pool
	Ephemoptera	0.075		Pool
	Others	0.218	0.041	Pool
Dardenne Creek	Others	R*	0.014	Upper Riffle
	Others	R*	0.014	Upper Pool
	Others	R*	0.034	Lower Riffle
Little Femme Osage	Others	ND	1.29	Lower Pool
	Others	ND	4.01	Upper Riffle
	Others	ND	4.01	Upper Pool
Burgermeister Spring	Others	0.489	0.014	Riffle
	Gamarus	R*	0.68	Lower Pool
	Others	R*	0.68	UpperPool
	Gamarus	R*	0.014	Riffle
Southeast Drainage	Others	28.2	2.86	Riffle
	Others	29.2	2.86	Pool
Background Spring	Amphipods/Ephemoptera	0.014	0.014	Riffle

Table B-2 Concentrations of Total uranium in Benthic Invertebrates (pCi/g) (Continued)

Location	Benthic Family	Concentration	DL	Habitat
	Oligochaete/Chirinomids	0.70	0.020	Pool
Background Spring	Crayfish	0.020	0.007	Riffle
	Amphipods/Ephemoptera	0.014	0.007	Pool

* Rejected by validation process

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Table B-3 Radionuclide Concentrations in Waterfowl from Raffinate Pit 4

	Ra-226		Ra-228		Th-227	Th-228		Th-230		Th-232		U-232, -234	U-235		U-238
Wood Duck - Flesh	ND	(0.001)	ND	(0.006)	0.239	ND	(0.011)	0.009		ND	(0.001)	0.003	ND	(0.001)	0.003
Wood Duck - Flesh	ND	(0.001)	0.025		0.238	ND	(0.021)	0.030		ND	(0.002)	0.008	ND	(0.001)	0.006
Wood Duck - Flesh	0.002		0.028		0.800	ND	(0.102)	ND	(0.007)	ND	(0.007)	0.002	ND	(0.001)	0.002
Goose - Flesh	ND	(0.001)	ND	(0.004)	0.014	ND	(0.002)	0.010		ND	(0.001)	0.002	ND	(0.001)	0.002
Goose - Organs	0.006		ND	(0.003)	0.037	0.008		0.483		0.006		0.054	ND	(0.001)	0.056
Mallard - Organs	0.026		0.030		0.061	0.022		0.040		ND	(0.001)	0.053	0.005		0.057
Mallard - Flesh	0.001		ND	(0.002)	0.061	ND	(0.011)	ND	(0.001)	ND	(0.001)	0.005	ND	(0.001)	0.005
Composite Ducks - Organs	0.028		ND	(0.007)	0.066	ND	(0.018)	0.170		ND	(0.002)	0.315	0.020		0.334

pCi/g wet weight
Detection limits in parenthesis

Table B-4 Total Individuals of Waterfowl Weldon Spring Site, 1991

	July	August	September	October	November	December
Mallards	11	13	51	45	33	14
Blue-winged teal	03			08		
Wood duck	06		01	40		
Canada geese	04	13	41	18	137	20
Pied-billed grebe			04		01	
Lesser scaup			03	01	27	01
Canvasback				01	54	02
Ringed-necked duck				40	31	
American coot				02		
American wigeon				01		
Northern pintail					03	
Northern shoveler					03	
Hooded merganser					04	
Bufflehead					16	
Ruddy duck					12	
Unknown	04	04	18	02	07	

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APPENDIX C
GLOSSARY OF TECHNICAL TERMS

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APPENDIX C
GLOSSARY OF TECHNICAL TERMS

ABSORBED DOSE: The amount of energy absorbed in any material from incident radiation. Measured in rads, where 1 rad equals 100 ergs of energy absorbed in 1 gram of matter.

ACTIVITY: A measure of the rate at which radioactive material is undergoing radioactive decay; usually given in terms of the number of nuclear disintegrations occurring in a given quantity of material over a unit of time. The unit of activity is the Curie (Ci) (see also Bequerel and Curie).

ALARA: An acronym for "As Low as Reasonably Achievable." This refers to the U.S. Department of Energy goal of keeping releases of radioactive substances to the environment and exposures of humans to radiation as far below regulatory limits as "reasonably achievable."

ALLUVIAL AQUIFER: A subsurface zone, formed by the deposition of sediments by running water, capable of yielding usable quantities of groundwater to wells.

ALPHA PARTICLE: A positively charged particle emitted from the nucleus during the radioactive decay of certain radionuclides. It consists of two protons and two neutrons bound together; it is identical to the nucleus of a helium-4 atom.

BACKGROUND RADIATION: Radiation due to cosmic rays and radiation from the naturally radioactive elements in the surface of earth.

BEDROCK: A rock formation usually underlying one or more unconsolidated formations.

BEQUEREL: SI unit for activity. 1 bequerel (Bq) = 1 disintegration/second = 2.703×10^{-11} Ci (curie).

BETA PARTICLE: Charged particle emitted from the nucleus of an atom, with a mass and charge equal in magnitude to that of the electron.

CHAIN OF CUSTODY: Standardized form tracing the possession and handling of individual samples from the time of field collection through laboratory analysis.

COMMITTED DOSE EQUIVALENT: The total dose equivalent averaged throughout a tissue in the 50 years after intake of a radionuclide into the body.

CONTAMINATION: A foreign substance in or on the surfaces of soils, structures, areas, objects, or personnel.

COUNTING STATISTICS: Statistical analysis required to process the results of nuclear counting experiments and to make predictions about the expected precision of quantities derived from these measurements.

CURIE: A measure of the rate of radioactive decay. One Curie (Ci) is equal to 37 billion disintegrations per second (3.7×10^{10} dps), which is equal to the decay rate of one gram of radium-226.

DAUGHTER: An element that results immediately from the disintegration of a radioactive element.

DECAY PRODUCTS: Isotopes that are formed by the radioactive decay of some other isotope. In the case of radium-226, for example, there are 10 successive decay products, ending in the stable isotope Lead-206.

DERIVED CONCENTRATION GUIDE (DCG): Concentrations of radionuclides in water and air that could be continuously consumed or inhaled and not exceed an effective dose equivalent of 100 mrem/year.

DISCHARGE: In groundwater hydrology, the rate of flow (usually from a well or spring) at a given instant in terms of volume per unit of time.

DOSE: Total radiation delivered to a specific part of the body, or to the body as a whole; also called dose equivalent.

DOSE RATE: Dose or dose equivalent per unit of time (i.e., millirem per year) as it is being delivered to the body.

DOSIMETER: A device used in measuring radiation dose, such as a lithium fluoride (LiF) thermoluminescent detector (TLD).

EFFECTIVE DOSE EQUIVALENT: The proportion of the stochastic risk resulting from irradiation of a tissue to the total risk when the whole body is irradiated uniformly. A term used to express the amount of effective radiation when modifying factors have been considered, it is the product of absorbed dose (rads) multiplied by a quality factor and any other modifying factors. It is measured in rem (Roentgen Equivalent Man).

ERG: 1 ERG = 2.8×10^{-14} KWH

EXPOSURE PATHWAY: The route by which a contaminant/health hazard may enter and move through the environment or individual.

EXPOSURE RADIATION: The amount of ionization produced in air by X-rays or gamma rays, measured in Roentgens (R).

GAMMA RADIATION: Penetrating high energy, short wave-length, electromagnetic radiation (similar to x-rays) emitted during radioactive decay. Gamma rays are very penetrating and can be attenuated only by dense materials such as lead.

GROSS ALPHA: Measurement of all alpha-emitting radionuclides in a sample.

GROSS BETA: Measurement of all beta-emitting radionuclides in a sample. Gross alpha and beta are useful analyses for screening to determine whether further analyses for specific radionuclides are merited.

HALF LIFE: The time it takes for half the atoms of a quantity of a particular radioactive element to decay into another form. Half-lives of different isotopes vary from millionths of a second or less to billions of years.

HECTARE: A unit of area in the metric system equal to 10,000 square meters. It is approximately 2.5 acres.

HYDROLOGIC: Pertaining to study of the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

ISOTOPE: Nuclides having the same atomic number but different mass numbers.

MDA/LLD: The minimum amount of a material or characteristic property being measured that can be detected with reasonable certainty by the analytical procedure being used.

NATURAL URANIUM: A naturally occurring radioactive element that consists of 99.2830% by weight uranium-238, 0.7110% uranium-235 and 0.0054% uranium-234.

NUCLIDE: A general term referring to isotopes, both stable (279) and unstable (about 500), of the chemical elements.

PERCHED LENSES: A small, localized water-saturated zone of subsurface material surrounded by unsaturated material.

RAD: Unit of absorbed dose; acronym for radiation absorbed dose.

RADIATION: A very general term that covers many forms of particles and energy, from sunlight and radiowaves to the energy that is released from inside an atom. Radiation can be in the form of electromagnetic waves (gamma rays, x-rays) or particles (alpha particles, beta particles, protons, neutrons).

RADIONUCLIDE: An unstable nuclide that undergoes radioactive decay.

RAFFINATE: A waste product from a refining process, i.e., that portion of a treated liquid mixture that is not dissolved and not removed by a selective solvent.

REM (Roentgen Equivalent Man): A quantity used in radiation protection to express the effective dose equivalent for all forms of ionizing radiation. A rem is the product of the absorbed dose in rads and factors related to relative biological effectiveness.

SI: International System of Units.

SIEVERT: SI unit used to express the effective dose equivalent for all forms of ionizing radiation. 1 Sv = 100 rem

STOCHASTIC: "Stochastic" effects are those for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose, without a threshold.

WORKING LEVEL: Any combination of radon-222 decay products in 1 liter of air that will result in the ultimate emission of 0.21 erg of alpha energy is defined as 1 WL. It is based on the 0.21 erg of alpha energy that would be emitted by the decay products of 100 pCi of Ra-222 in 1 liter of air, where the decay products are in radioactive equilibrium with the parent.

WORKING LEVEL MONTH: The product of WL and duration of exposure, normalized to a 1-month exposure period.

X-RAYS: Penetrating electromagnetic radiation having a wave length that is much shorter than that of visible light. It is customary to refer to rays originating in the nucleus as gamma rays and to those originating in the electron field of the atom as x-rays.

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APPENDIX D
ACRONYMS AND ABBREVIATIONS

APPENDIX D
ACRONYMS AND ABBREVIATIONS

ABWA	August A. Busch Memorial Wildlife Area
AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ARAR	applicable and/or relevant and appropriate requirements
BNI	Bechtel National Inc.
BOD	Biochemical Oxygen Demand
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CM&O	Construction Management and Operations
CWA	Clean Water Act
CX	categorical exclusion
DA	Department of the Army
DCG	Derived Concentration Guideline
DNT	dinitrotoluene
DOE	U.S. Department of Energy
DOT	Department of Transportation
DQO	data quality objectives
EA	Environmental Assessment
EDAP	Environmental Data Administration Plan
EDE	effective dose equivalent
EE/CA	engineering evaluation/cost analysis
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ES&H	Environmental Safety and Health
FFA	Federal Facility Agreement
FHHS	Francis Howell High School
GWPP	Groundwater Protection Program
HpGe	high purity germanium
IRA	interim response action
LLD	lower limit of detection
MCL	maximum contaminant level (Safe Drinking Water Act)
MDA	minimum detectable activity
MDNR	Missouri Department of Natural Resources
MDOC	Missouri Department of Conservation
NCO	NEPA Compliance Officer
ND	non detect
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants

NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
OSHA	Occupational Safety & Health Administration
PCB	polychlorinated biphenyl
PCM	phase contrast microscopy
PEL	permissible exposure limit
PIC	pressurized ionization chamber
PIP	Productivity Improvement Program
PMC	Project Management Contractor
QA/QC	Quality Assurance/Quality Control
QCSA	quarry construction staging area
QWTP	quarry water treatment plant
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SFMP	Surplus Facilities Management Program
SWATS	Site Wide Audit Tracking System
SWTP	site water treatment plant
SOP	Standard Operating Procedures
TBP	tributyl phosphate
TCLP	toxicity characteristic leaching procedure
TEM	transmission electron microscopy
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TSCA	Toxic Substance Control Act
TSS	total suspended solid
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
WITS	Waste Inventory Tracking System
WLM	Working Level Monitor
WSCP	Weldon Spring Chemical Plant
WSCP/RP/VP	Weldon Spring Chemical Plant/raffinate pits/vicinity properties
WSOW	Weldon Spring Ordnance Works
WSQ	Weldon Spring Quarry
WSRP	Weldon Spring raffinate pits
WSS	Weldon Spring site
WSSRAP	Weldon Spring Site Remedial Action Project

WSUFMP	Weldon Spring Uranium Feed Materials Plant
WTP	water treatment plant

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APPENDIX E
ENVIRONMENTAL GUIDELINES

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APPENDIX E
ENVIRONMENTAL GUIDELINES

This Appendix contains standards and guidelines that are either applicable to the WSS or are presented to provide a frame of reference for discussion.

RADIATION STANDARDS (DOE Order 5400.5, *Radiation Protection of the Public and the Environment*)

A. <u>DOSE LIMITS</u>

1. All Pathways
The effective dose equivalent for any member of the public from all routine DOE operations[1] (natural background and medical exposures excluded) shall not exceed the values given below:

	Effective dose equivalents[2] mrem/year	(mSv/year)
Occasional annual exposures	100	(1)

2. Air Pathway Only (Limits of 40 CFR 61, Subpart H)

Effective Dose Equivalent 10 mrem/year or 0.1 mSv/year

1. Routine DOE operations means normal planned operations and does not include actual or potential accidental or unplanned releases.

2. Effective dose equivalent will be expressed in rem (or millirem) with the corresponding value in sievert (or millisievert) in parenthesis. As used in this standard, effective dose equivalent includes both the effective dose equivalent from external radiation and the committed effective dose equivalent to individual tissues from ingestion and inhalation during the calendar year.

1 Routine DOE operations mean normal planned operations and does not include actual or potential accidental or unplanned releases.

2 Effective dose equivalent will be expressed in rem (or millirem) with the corresponding value in sievert (or millisievert) in parenthesis. As used in this standard, effective dose equivalent includes both the effective dose equivalent from external radiation and the committed effective dose equivalent to individual tissues from ingestion and inhalation during the calendar year.

B. DERIVED CONCENTRATION GUIDES (DCG)

The following table contains a listing of the DCG values for the ingestion of drinking water and inhalation of air for members of the public. The values are based on a committed dose equivalent rate of 100 mrem/yr. Five columns of information are shown in the table: (1) radionuclide; (2) drinking water ingestion DCG in units of μCi/ml; (3) drinking water DCG in units of Bq/ml; (4) inhalation DCG in units of μCi/ml; (5) inhalation DCG in units of Bq/mL.

Only a single mode of exposure was considered--either ingestion or inhalation.

The DCG values are given for individual radionuclides. For known mixtures of radionuclides, the sum of the ratio of the observed concentration of a particular radionuclide and its corresponding DCG for all radionuclides in the mixture must not exceed 1.0.

It should be noted that the values given in the table only account for drinking water and inhaling air, and do not include other potentially significant environmental pathways. A more complete pathway analysis is required for calculating public radiation dose equivalent resulting from the operation of DOE facilities when more complex environmental pathways are involved.

Radionuclide	Drinking Water μCi/mL	Drinking Water Bq/mL	Inhaled Air μCi/mL	Inhaled Air Bq/mL
Natural Uranium	6.0E-07	2.2E-02		
Uranium-238	6.0E-07	2.2E-02	1.0E-13	3.07-09
Uranium-235	6.0E-07	2.2E-02	1.0E-13	3.7E-09
Uranium-234	5.0E-07	1.9E-02	9.0E-14	3.3E-09
Thorium-232	5.0E-08	1.9E-03	7.0E-15	2.6E-10
Thorium-230	3.0E-07	1.1E-02	4.0E-14	1.5E-09
Radium-228	1.0E-07	3.7E-03	3.0E-12	1.1E-07
Radium-226	1.0E-07	3.7E-03	1.0E-12	3.7E-08

C. RADON

DCGs for radon (Rn-220) are being assessed by DOE. Until the review has been completed and new values issued, the value of 3.E-09 μCi/ml stated in DOE Order 5400.5 shall be used for radon releases from DOE facilities. In addition, interim storage facilities will not exceed an annual average concentration of 3 pCi/l at or above any location outside the facility site.

CHEMICAL STANDARDS

U.S. EPA Drinking Water Standards (mg/l) as noted in 40 CFR Parts 141 and 143, and Missouri 10 CSR 60-4.

Drinking water standards are presented only for comparison purposes. These should not necessarily be construed as applicable or relevant cleanup standards.

A. HSL-Metals

Aluminum	NS	Lthium	NS
Antimony	NS	Magnesium	NS
Arsenic	0.05*	Manganese	0.05**
Barium	1.0*	Mercury	0.002
Beryllium	NS	Nickel	NS
Cadmium	0.01*	Potassium	NS
Calcium	NS	Selenium	0.01
Chromium	0.05*	Silver	0.05
Cobalt	NS	Sodium	NS
Copper	1.0**	Thallium	NS
Iron	0.3**	Vanadium	NS
Lead	0.05	Zinc	5.0**

B. Inorganic Anion and Water Quality

Nitrate (as N)	10*
Sulfate	250**
Chloride	250**
Fluoride	4*/2**
Hardness	NS
TDS	500**
TOC	NS

C. Maximum Contaminant Levels for Organic Chemicals:

	Contaminant	Level, Milligrams Per Liter
(A)	Chlorinated Hydrocarbons: Endrin (1,2,3,4,10,10-hexa-chloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4,-endo,endo-5,8-dimethanonaphth-alene).	0.0002
	Lindane (1,2,3,4,5,6-hexa-chlorocyclohexane, gamma isomer).	0.004
	Methoxychlor (1,1,1-Tricholoro-2,2- bis-(p-methoxy-phenyl) ethane).	0.1
	Toxaphene ($C_{10}H_{10}Cl_8$. Technical chlorinated camphene, 67-69 percent chlorine).	0.005
(B)	Chlorophenoxys: 2,4-D,(2,4-Dichlorophen-oxyacetic acid).	0.1
	2,4,5-TP Silvex (2,4,5-Tri-chlorophenoxy-propionic acid).	0.01

* Primary maximum contaminant level
** Secondary maximum contaminant level
NS No Drinking Water Standard

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APPENDIX F
CONVERSION FACTORS

CONVERSION FACTORS

1 millisievert (mSv)	=	100 mrem
1 milliroentgen (mR)	=	1 mrem (for gamma radiation)
1 Curie (Ci)	=	3.7 X 10^{10}dps (disintegrations/sec)
1 Bequerel (Bq)	=	1 disintegration per second
1 M^3	=	1000 litres
1 pCi/l	=	0.037 Bq/l
1 km	=	.62 miles
1 m	=	3.28 ft
1 m^3	=	1.31 cu yd
1 mm	=	.039 inches
1 ha	=	2.47 acres
1 Gy	=	100 RAD

APPENDIX G
DOSE ASSESSMENT CALCULATIONS

A. Dose from the WSCP/WSRP to a maximally exposed individual.

1. Inhalation pathway and external gamma pathways:

   Not applicable since there is no reason to suspect at the 95% confidence level that airborne radioactive particulate, radon gas, and external gamma radiation data are greater than the respective background concentrations.

2. Ingestion pathway:

   Lakes that receive effluent from the WSCP/WSRP are used in order to determine the estimated effective dose equivalent to a maximally exposed individual via ingestion of fish, water, and sediment obtained from these lakes.

   On average, fishing at the Busch Wildlife Area required 2.5 hr per visit (MDOC 1991). Assume that the maximally exposed individual visited the lakes for the purpose of fishing 25 times during the year. The fish caught to hours spent fishing ratio was reported as 0.41, while the fish kept to fish caught ratio was reported as 0.48 (MDOC 1991). Thus on an annual basis, the maximally exposed individual would keep 12.3 fish from the lakes. Assume that the edible portion of a fish has an average mass of 200 g. Thus, the annual consumption rate of 6.5 g/day (EPA 1988) provides a good estimate of the consumption rate for fish caught from the three affected lakes for the hypothetical individual.

   Boating at the Busch Wildlife Area required more hours per visit than any other activity; therefore, boating was assumed to be the activity in which the maximally exposed individual participated for the water and sediment ingestion scenarios. Assume the average time spent by the maximally exposed individual per boating trip is 5.7 hr, (MDOC 1991) and the hypothetical individual visits the area for the purpose of boating ten times in a year. Assume that 25% of the time is devoted to swimming during each visit. Thus, 14.3 hr are spent swimming in the lakes.

   a. Fish: Assume a 6.5 g/day fresh water fish consumption rate (EPA 1988) from Lake 36 at the Busch Wildlife Area and a 0.083 pCi/g total uranium content in fish, which is the highest average net uranium concentration in fish of all lakes receiving runoff from the WSS.

b. Water: Assume a 0.05 l/hr swimming ingestion rate (EPA 1988) for the 14.3 hr for a total annual consumption of 0.72 liters. The water is assumed to have a total uranium concentration as detected in Lake 36 of 51 pCi uranium/l, which is the highest uranium water concentrations of all lakes receiving runoff from the WSS.

c. Sediment: Assume a 200 mg/day ingestion rate for the 14.3 hr for a total of 120 mg of sediment. The sediment is assumed to have a total uranium concentration as detected in Lake 34 of 46.8 pCi uranium/g sediment, which is the highest uranium concentration of all lakes receiving runoff from the WSS.

CEDE (ingestion) = annual fish consumption x uranium concentration x uranium DCF[1]
+ annual water consumption x uranium concentration x uranium DCF[1] + annual sediment ingestion x uranium concentration x uranium DCF[1].

= 6.5 g/day x 365 day/yr x 0.083 pCi/g x 2.83E-4 mrem/pCi + 0.72 liter/yr x 51 pCi/liter x 2.83E-4 mrem/pCi + 0.12 g/yr x 46.8 pCi/g x 2.83E-4 mrem/pCi

= 0.070 mrem

The total estimated committed effective dose equivalent to the maximally exposed individual at the WSCP/WSRP area is 0.070 mrem (0.0007 mSv).

1 Uranium dose conversion factor (DCF) was the greater of the two DCFs reported for each uranium isotope (U-234 and U-238) in Table 2.2 of Eckerman et al. (1988).

B. Dose from the WSQ to a maximally exposed individual.

1. Inhalation pathway:

a. Airborne radioactive particulate: Not applicable since there is no reason to suspect at the 95% confidence level that airborne radioactive particulate data are greater than the background concentrations.

b. Radon gas: Assume the concentration at State Route 94 is equal to the measured net concentration at RD-1002 of 1.2 pCi/l. Assume an annual exposure time of 50 hrs (Section 4.2.2).

Radon concentrations are often expressed in units of working levels (WL) where 1 WL = 100 pCi/liter for Rn-222. Radon exposure is often expressed in terms of working level months (WLM) which corresponds to an exposure of 1 WL during the reference working period of 1 month (i.e., 2000 working hours per 12 months or 170 hours). Assume a working level ratio for Rn-222 of 50% and a dose conversion factor of 1 rem/WLM (ICRP 1981).

CEDE (inhalation) = net radon concentration x exposure time x working level ratio x dose conversion factor x working month conversion factor.

= 1.2 pCi/l x 50 hrs x 0.50 x 1 WL/100 pCi/l x 1.00 rem/WLM x 1 working month/170 hrs x 1000 mrem/rem

= 1.765 mrem

2. External gamma radiation pathway: assume that the net gamma exposure was that measured at monitoring station TD-1001 (the highest rate measured at the quarry) of 0.0024 mrem/hr. Assumed an annual residence time of 50 hrs (Section 4.2.2).

EDE (gamma radiation) = Exposure rate x exposure time
= 0.12 mrem

3. Ingestion pathway: because the quarry is controlled by a 2.4 m (8 ft) high barbed wire fence; fishing, swimming, and drinking water at the quarry do not constitute realistic scenarios.

The total estimated committed effective dose equivalent to the maximally exposed individual at the WSQ is 1.9 mrem (0.019 mSv).

C. Dose from the WSVPs to a maximally exposed individual.

1. Inhalation pathway: the Femme Osage Slough, that the hypothetical individual is assumed to frequent, is not suspected of having airborne radioactive particulate concentrations or radon daughter concentrations above normal background levels (Section 4.2.3), and thus there should be no effective dose equivalent to the exposed individual via this pathway.

2. External gamma pathway: assumed that the hypothetical individual sat on the bank of the slough a total of 200 hr/yr (Section 4.2.3). In addition, the measured net gamma exposure rate of 2.4 μrem/hr was used to calculate the effective dose equivalent.

EDE (gamma radiation) = Exposure time x exposure rate
= 200 hr/yr x 2.4 μrem/hr
EDE = 0.5 mrem

3. Ingestion pathway:

Fish: Assume a 6.5 g/day fresh water fish consumption rate (EPA 1988) from the slough. Assume the uranium concentration in fish is the average of 10 samples taken from the slough on May 1, 1991, (Section 4.1.8.3) i.e., 0.007 pCi uranium/g fish. Net uranium concentrations in fish were obtained by subtracting the background uranium concentration in fish of 0.005 pCi total uranium/gram fish. The net uranium concentration was used to calculate the effective dose equivalent via the ingestion pathway.

CEDE (ingestion) = Fish consumption x uranium concentration x DCF[1]

= 6.5 g/day x 365 d/yr x 0.002 pCi/g x 2.83E-04 mrem/pCi

= 0.001 mrem

The total estimated committed effective dose equivalent for the maximally exposed individual at the Little Femme Osage Slough is 0.5 mrem (0.005 mSv).

D. Collective Population Dose Estimate

Exposure Points - Exposure points are locations where members of the public are potentially being exposed to above-background concentrations of (1) airborne radioactive particulates, (2) radon gas concentrations, (3) external gamma radiation, or (4) radionuclides in food or water. All three pathways will be addressed for the collective population dose estimate. Exposure to above-background radionuclide concentrations in food or water will be addressed only for users of the Busch Wildlife Area, a recreational area which sits adjacent to the WSCP/WSRP area. Three of the lakes on this property receive runoff from the WSS and are used by the general population for fishing and boating purposes. None of these bodies of water are used as drinking water sources.

Exposure points, by definition, must be located where there is potential for public exposure as a result of activities performed at the WSS or from materials stored at the WSS. If there is no reason to suspect that environmental monitoring results are different than the appropriate background monitoring results, then the area surrounding the environmental monitoring station cannot be considered an exposure point; therefore, the population near the station as well as the population beyond the station is not included in the collective population dose estimate.

The only area where there was reason to suspect that environmental monitoring results could be different than the appropriate background monitoring results was at the WSQ perimeter. This was true only for radon concentrations and external gamma radiation. The only potential receptors near the WSQ perimeter are people using the Katy Trail, a recreational

(1) Uranium dose conversion factor (DCF) was obtained from the EPA Federal Report No. 11 (Eckerman et al. 1988).

hiking and biking trail located on state-owned land south of the quarry. The Katy Trail lies approximately 45 m (49 yd) south of the quarry at its closest point and about 25 m (28 yd) below the southern quarry rim. It parallels the southern rim for approximately 260 m (286 yd). The estimated annual population using the trail is 50,770 persons, which is derived from a one-calendar-year estimate made by the Missouri State Parks Department (Fleming 1992). The exposure time estimate is approximately 5 min, which corresponds to a 3.2 km/hr (2 mi/hr) walking speed along the 260 m (286 yd) length of trail paralleling the quarry.

The Katy Trail was chosen as the only public exposure point near the quarry because there currently are no environmental monitoring stations near the trail, and therefore, it could not be concluded with confidence that an above-background concentration could be measured there. At all environmental monitoring locations near the WSQ (i.e., AP-4011, RD-4006, and TD-4006), there was no reason to suspect at the 95% confidence level that the monitoring results were different than the background monitoring results. Since there was no reason to suspect that environmental monitoring results at all WSCP/WSRP perimeter stations and at all off-site stations were different than the background monitoring results, no exposure points other than the Katy Trail were included in the population dose estimate for the radon and external gamma exposure pathways.

The only area where there was reason to suspect that a significant amount of the general population could consume fish, water, and sediments from waters that receive runoff from the WSS was at the Busch Wildlife Area. The only potential receptors at the area are the people who actually use the Busch Wildlife property for recreational purposes. Three of the lakes at the area (i.e., Lakes 34, 35, and 36) receive runoff from the WSS and are utilized for fishing and boating activities. The Missouri Department of Conservation recently conducted a year long survey to determine the number of visitors to the area, the types of activities in which users participate, and the amount of time allocated for these activities.

Fishing at the Busch Wildlife Area averaged 2.5 hr per visit for the approximately 15,000 visits to the area for that purpose. On average, 7,232 fish are kept from the lakes each year. Assuming that one person keeps one fish, the population of concern would be 7,232 persons (MDOC 1991). For the water and sediment ingestion scenarios, boating is the activity assumed to provide the potential for incidental water and sediment ingestion. An estimated 3,838 visits were made for the purpose of boating with an average of 5.7 hr per visit. Assuming that each visit constitutes one individual, the total population would be 3,838 persons. Each of these ingestion scenarios are further addressed in calculations six, seven, and eight.

Models

In order to estimate airborne radon progeny concentrations at the Katy Trail, the above-background radon results measured at the WSQ perimeter were incorporated into a box model. A box model predicts the radon release rate in pCi/y by multiplying the measured net airborne or radon concentration by the assumed box model parameters for length, height, and average annual wind speed. The box model assumes that airborne contaminants are dispersed homogeneously within the modeled volume of air. The selected value for model length is 122 m (134 yd); for height it is 3 m (3.3 yd); and the value for average annual wind speed is 2 m/s (4.4 mi/hr). The model length value corresponds to the length of the major contaminated area within the quarry. A simplified box model is justified for calculating the airborne radon release rate since the effective dose equivalent and population doses are low as indicated by the calculation results.

The net annual average radon concentration at the WSQ is 0.6 pCi/l and is calculated by averaging the results from stations RD-1001 through RD-1006 less the average background result of 0.25 pCi/l.

1. Box Model: length = 122 m (134 yd), height = 3 m (3.3 yd), average wind speed (μ) = 2 m/s (4.4 mi/hr)

   a. Release rate = length x height x μ x net annual average radon concentration

      = 14.2 Ci/y

2. The EPA computer program CAP-88 is used to estimate the radon progeny concentration, in units of working levels, expected at the Katy Trail. The input parameters required by CAP-88 include:

   - Radon release rate (14.2 Ci/y).

- Area of contamination within the WSQ is equal to the total area of the four contaminated zones within the quarry (15,900 m^2) (MKF and JEG 1989a).

- Distance from the quarry rim to the Katy Trail (45 m at the closest point).

3. Using these parameters, the highest estimated radon progeny concentration at 45 m from the quarry rim was 0.0011 WL. The effective dose equivalent (EDE) from radon progeny exposure is given by:

   EDE (mrem) = radon progeny concentration (WL) x exposure time (h) x dose conversion factor (mrem/WLM)/170

   where: - exposure time = 5 min = 0.08h (assumed)
   - dose conversion factor = 1000 mrem/WLM (ICRP 1981)

   therefore; EDE (mrem) = 0.0011 WL x 0.08h x (1000 mrem/WLM)/170

   = 5.2E-4 mrem.

4. The population dose estimate for radon progeny exposure is simply the estimated EDE multiplied by 50,700, which is the estimated number of people using the Katy Trail near the WSQ during 1991 (Fleming 1992):

$$\textit{Population Dose Estimate (radon progeny exposure)} = 5.2E{-}4\ mrem\ x \left(\frac{1E{-}3\ rem}{mrem}\right) x\ 50{,}770\ persons$$
$$= 0.026\ person\ rem$$

5. Population dose estimate due to external gamma radiation

   a. Assumptions: the quarry is modeled as a circular planar area source of diameter D = 215 m (same as for previous estimates).

   b. The distance from the quarry plane to the top rim of the quarry is h_1 = 23 m.

c. The distance from the quarry plane to the Katy Trail is $h_2 = h_1$ + distance from quarry rim to the Katy Trail = 64 m.

d. The formula to determine the ratio of external gamma dose equivalent rates at two points near a circular planar source is defined as

$$\frac{H_1}{H_2} = \frac{\ln[(R^2+h_1^2)/h_1^2]}{\ln[(R^2+h_2^2)/h_2^2]} \qquad \text{(\textit{Cember} 1983)}$$

where,

H_1 = Average above-background dose equivalent rate at the quarry rim = 20.0 mrem/yr
H_2 = Estimated dose equivalent rate at Katy Trail
R = D/2 = 108 m (118.8 yd)
h_1 = 23 m (25.3 yd)
h_2 = 64 m (70.4 yd)

Calculations:

A. The dose equivalent rate at the Katy Trail exposure point:

$$H_2 = H_1 \frac{\ln[(R^2+h_2^2)/h_2^2]}{\ln(R^2+h_1^2)/h_1^2]}$$

$$= 20 \frac{mrem}{yr}\left(\frac{\ln[(108^2+64^2)/64^2]}{\ln[(108^2+23^2)/23^2]}\right)$$

$$= 8.6 \frac{mrem}{yr} \times 1 \frac{yr}{365\ d} \times 1 \frac{d}{24\ hr} = 9.8E{-}04 \frac{mrem}{hr}$$

B. The population dose estimate from external gamma at the Katy Trail is thus

$$\textit{Population Dose Estimate} = 50{,}770\ persons \times 9.8E{-}04 \frac{mrem}{h} \times 0.08h \times \left(\frac{rem}{10^3\ mrem}\right)$$
$$= 0.004\ person\ rem$$

6. Population dose estimate due to ingestion of fish obtained at the Busch Wildlife Area.

   a. Assuming that each person of the 7,232 population consumes one fish and that the edible portion of a fish has a mass of 200 g, the average consumption rate specific to the affected population is 0.55 g/person/day.

   b. Using the total uranium fish content of 0.083 pCi/g obtained from samples collected in Lake 36 and the population specific consumption rate derived from Missouri Department of Conservation data, the estimated population dose is

Population Dose Estimate (fish ingestion) = consumption rate x total uranium concentration in fish x exposure time x dose conversation factor[1] x persons

1 Uranium dose conversion factor (DCF) was the greater of the two DCFs reported for each uranium isotope (U-234 and U-238) in Table 2.2 of Eckerman et al. (1988)

$$= 0.55 \frac{g}{day} \times 0.083 \frac{pCi}{g} \times 365\ day \times 2.83E{-4} \frac{mrem}{pCi}$$
$$\times 7{,}232\ persons \times \frac{1\ rem}{1{,}000\ mrem}$$
$$= 0.034\ person{-}rem$$

7. Population dose estimate due to incidental ingestion of water at the Busch Wildlife lakes.

   a. Assume that each person of the 3,838 population makes one boating visit on an annual basis and 25% of the visit is spent swimming (1.425 hr/visit).

   b. Using the total uranium surface water content of 51 pCi/l obtained from Lake 36 and an ingestion rate of 0.05 l/hr (EPA 1988) the estimated population dose is

Population Dose Estimate (water ingestion) = ingestion rate x total uranium concentration in surface water x exposure time x dose conversation factor[1] x persons

$$= 0.05 \frac{l}{hr} \times 51 \frac{pCi}{l} \times 1.425\ hr \times 2.83E{-4} \frac{mrem}{pCi}$$
$$\times 3{,}838\ persons \times \frac{1\ rem}{1{,}000\ mrem}$$
$$= 0.004\ person\ rem$$

8. Population dose estimate due to ingestion of sediments at the Busch Wildlife lakes.

   a. Assume that each person of the 3,838 population makes one boating visit on an annual basis and 25% of the visit is spent swimming (1.425 hr/visit).

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1 Uranium dose conversion factor (DCF) was the greater of the two DCFs reported for each uranium isotope (U-234 and U-238) in Table 2.2 of Eckerman et al. (1988).

b. Using the total uranium sediment content of 46.8 pCi/g obtained from Lake 34 and an ingestion rate of 200 mg/day, the estimated population dose is

Population Dose Estimate (sediment ingestion) = ingestion rate x total uranium concentration in sediment x exposure time x dose conversion factor(1) x persons

$$= 200 \frac{mg}{day} x \frac{1\ g}{1{,}000\ mg} x\ 46.8 \frac{pCi}{g} x\ 1.425\ hr\ x \frac{1\ day}{24\ hr} x\ 2.83E\text{-}4 \frac{mrem}{pCi}$$

$$x\ 3{,}838\ persons\ x \frac{1\ rem}{1{,}000\ mrem}$$

$$= 0.0006\ person\text{-}rem$$

The total estimated population dose for all potential exposure pathways for calendar year 1991 is 0.069 person-rem.

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APPENDIX H
Groundwater Trend Analysis

063092

Table H-1 Seasonality and Trend Analysis - Total Uranium

			Test for Seasonality Mann Whitney U		Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	p-value	Seasonality?	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pCi/l/day)
Weldon Spring Quarry									
GW-1002	16	6%	0.664	No	-2	2	38	No	NA
GW-1004	16	0%	0.957	No	41	41	38	Yes	1.04
GW-1005	17	0%	0.088	No	82	82	42	Yes	1.09
GW-1006	15	0%	0.510	No	71	71	35	Yes	1.35
GW-1007	15	0%	0.515	No	-49	49	35	Yes	-0.11
GW-1008	14	0%	0.724	No	53	53	33	Yes	2.13
GW-1009	15	20%	0.854	No	-4	4	35	No	NA
GW-1010	24	83%	0.739	No	-3	3	68	No	NA
GW-1011*	19	32%	0.881	No*	61	61*	49	Yes*	0.01*
GW-1012	20	10%	0.263	No	-52	52	52	Yes	-0.002
GW-1013	17	0%	0.336	No	0	0	42	No	NA
GW-1014	17	0%	0.372	No	-6	6	42	No	NA
GW-1015	17	0%	0.229	No	50	50	42	Yes	0.28
GW-1016	16	0%	0.371	No	72	72	38	Yes	0.24

Table H-1 Seasonality and Trend Analysis - Total Uranium (Continued)

			Test for Seasonality Mann Whitney U		Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	p-value	Seasonality?	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pCi/l/day)
GW-1017	19	74%	NA	NA	NA	NA	NA	NA	NA
GW-1018	20	85%	NA	NA	NA	NA	NA	NA	NA
GW-1019	18	83%	NA	NA	NA	NA	NA	NA	NA
GW-1020	14	57%	0.338	No	-5	5	33	No	NA
GW-1021	14	71%	NA	NA	NA	NA	NA	NA	NA
GW-1022	14	69%	1.000	No	-7	7	33	No	NA
GW-1023	13	77%	NA	NA	NA	NA	NA	NA	NA
GW-1024	18	72%	NA	NA	NA	NA	NA	NA	NA
GW-1026	13	92%	NA	NA	NA	NA	NA	NA	NA
GW-1027	13	0%	0.943	No	14	14	28	No	NA
GW-1028	13	16%	0.568	No	-13	13	28	No	NA
GW-1029	5	40%	0.564	No	4	4	8	No	NA
GW-1030	5	20%	0.387	No	8	8	8	Yes	0.05
GW-1031	5	0%	0.149	No	-4	4	8	No	NA
GW-1032	7	0%	0.052	No	16	16	13	Yes	2.82
GW-1033	3	0%	NA	NA	NA	NA	NA	NA	NA

Table H-1 Seasonality and Trend Analysis - Total Uranium (Continued)

			Test for Seasonality Mann Whitney U		Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	p-value	Seasonality?	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pCi/l/day)
GW-1034	4	50%	NA	NA	4	4	6	No	NA
GW-1035	4	75%	NA	NA	NA	NA	NA	NA	NA
GW-1036	7	14%	0.860	No	5	5	13	No	NA
GW-1037	7	14%	1.000	No	-4	4	13	No	NA
GW-1038	7	0%	0.480	No	12	12	13	No	NA
GW-1039	7	0%	0.596	No	-5	5	13	No	NA
Weldon Spring Chemical Plant/Raffinate Pits									
GW-2001	13	69%	0.3105	No	-43	43	28	Yes	-0.0003
GW-2002	7	71%	0.8465	No	-15	15	13	Yes	-0.0003
GW-2003	13	15%	0.398	No	-33	33	28	Yes	-0.001
GW-2004	12	17%	0.9323	No	-9	9	26	No	NA
GW-2005	12	42%	0.4447	No	27	27	26	Yes	0.002
GW-2006	12	33%	0.6261	No	-7	7	26	No	NA
GW-2007	12	17%	0.6261	No	-21	21	26	No	NA
GW-2008	13	38%	0.9385	No	-12	12	28	No	NA

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Table H-1 Seasonality and Trend Analysis - Total Uranium (Continued)

			Test for Seasonality Mann Whitney U		Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	p-value	Seasonality?	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pCi/l/day)
GW-2009	12	8%	1	No	-24	24	26	No	NA
GW-2010	12	33%	0.7989	No	-19	19	26	No	NA
GW-2011	12	83%	0.2696	No	-7	7	26	No	NA
GW-2012	13	69%	1	No	8	8	28	No	NA
GW-2014	13	38%	0.4469	No	-38	38	28	Yes	-0.001
GW-2015	13	15%	0.0538	No	-10	10	28	No	NA
GW-2017	13	0%	NA	NA	NA	NA	NA	NA	NA
GW-2018	14	14%	0.5101	No	-18	18	33	No	NA
GW-2019	10	0%	0.754	No	-14	14	21	No	NA
GW-2020	13	0%	0.3413	No	-38	38	28	Yes	-0.01
GW-2021	10	30%	NA	NA	NA	NA	NA	NA	NA
GW-2022	9	56%	0.1556	No	-19	19	18	Yes	0.0004
GW-2023	8	25%	0.3123	No	11	11	16	No	NA
GW-3001	10	40%	0.7491	No	14	14	21	No	NA
GW-3002	9	0%	0.5403	No	-8	8	18	No	NA
GW-3003	9	0%	0.4624	No	18	18	18	Yes	0.01

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Table H-1 Seasonality and Trend Analysis - Total Uranium (Continued)

			Test for Seasonality Mann Whitney U		Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	p-value	Seasonality?	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pCi/l/day)
GW-3006	11	27%	0.0679	No	-2	2	23	No	NA
GW-3008	11	0%	0.6098	No	-1	1	23	No	NA
GW-3009	13	8%	0.1427	No	10	10	28	No	NA
GW-3019	8	0%	0.8852	No	-2	2	16	No	NA
GW-3022	3	0%	NA	No	NA	NA	NA	NA	NA
GW-3023	4	0%	NA	No	2	2	6	No	NA
GW-4001	10	30%	0.6953	No	2	2	21	No	NA
GW-4002	11	55%	1	No	-4	4	23	No	NA
GW-4004	9	11%	1	No	-1	1	18	No	NA
GW-4005	10	0%	0.6485	No	11	11	21	No	NA
GW-4006	9	78%	NA	NA	1	1	18	No	NA
GW-4007	8	13%	1	No	-1	1	16	No	NA
GW-4008	9	33%	0.1556	No	-21	21	18	Yes	-0.003
GW-4009	8	0%	0.8676	No	3	3	16	No	NA
GW-4010	9	0%	0.3662	No	-15	15	18	No	NA
GW-4011	9	11%	0.1779	No	8	8	18	No	NA

Table H-1 Seasonality and Trend Analysis - Total Uranium (Continued)

			Test for Seasonality Mann Whitney U		Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	p-value	Seasonality?	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pCi/l/day)
GW-4012	9	0%	0.2453	No	15	15	18	No	NA
GW-4013	9	33%	0.7133	No	-4	4	18	No	NA
GW-4014	9	78%	0.9025	No	-5	5	18	No	NA
GW-4015	8	25%	1	No	12	12	16	No	NA
GW-4016	8	0%	0.7656	No	12	12	16	No	NA
GW-4017	9	11%	0.9025	No	-8	8	18	No	NA
GW-4018	9	22%	0.3913	No	-8	8	18	No	NA
GW-4019	11	9%	0.2193	No	-23	23	23	Yes	-0.001
GW-4020	8	0%	0.136	No	0	0	16	No	NA
GW-4021	9	0%	0.1556	No	-14	14	18	No	NA
GW-4022	9	22%	0.8065	No	-9	9	18	No	NA
GW-4023	9	22%	0.4386	No	-13	13	18	No	NA
GW-RMW1	17	47%	0.8651	No	-10	10	42	No	NA
GW-RMW2	20	0%	0.2565	No	7	7	52	No	NA
GW-RMW3	14	50%	0.1857	No	0	0	33	No	NA

Table H-1 Seasonality and Trend Analysis - Total Uranium (Continued)

			Test for Seasonality Mann Whitney U		Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	p-value	Seasonality?	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pCi/l/day)
GW-RMW4	13	15%	0.9214	No	24	24	28	No	NA

Table H-2 Trend Analysis - Nitrate

			Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pci/l/day)
Weldon Spring Quarry							
GW-1002	16	13%	-3	3	38	No	NA
GW-1004	16	19%	-47	47	38	Yes	-0.001
GW-1005	17	82%	NA	NA	NA	NA	NA
GW-1006	16	0%	-33	38	38	No	NA
GW-1007	16	31%	-53	53	38	Yes	-0.0006
GW-1008	15	53%	-25	25	35	No	NA
GW-1009	16	63%	-14	14	38	No	NA
GW-1010	16	81%	NA	NA	NA	NA	NA
GW-1011*	13	77%	NA	NA	NA	NA	NA
GW-1012	17	6%	-40	40	42	No	NA
GW-1013	18	83%	NA	NA	NA	NA	NA
GW-1014	18	83%	NA	NA	NA	NA	NA
GW-1015	15	0%	14	14	35	No	NA
GW-1016	14	14%	22	22	33	No	NA
GW-1017	15	80%	NA	NA	NA	NA	NA
GW-1018	16	94%	NA	NA	NA	NA	NA
GW-1019	15	93%	NA	NA	NA	NA	NA
GW-1020	11	100%	NA	NA	NA	NA	NA
GW-1021	11	100%	NA	NA	NA	NA	NA
GW-1022	11	100%	NA	NA	NA	NA	NA
GW-1023	9	100%	NA	NA	NA	NA	NA
GW-1024	12	92%	NA	NA	NA	NA	NA
GW-1026	10	100%	NA	NA	NA	NA	NA

Table H-2 Trend Analysis - Nitrate (Continued)

			Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data < D.L.	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pci/l/day)
GW-1027	10	50%	1	1	21	No	NA
GW-1028	10	80%	NA	NA	NA	NA	NA
GW-1029	5	60%	-3	3	8	No	NA
GW-1030	5	60%	0	0	8	No	NA
GW-1031	5	80%	NA	NA	NA	NA	NA
GW-1032	7	86%	NA	NA	NA	NA	NA
GW-1036	7	57%	8	8	13	No	NA
GW-1037	7	71%	-1	1	13	No	NA
GW-1038	7	100%	NA	NA	NA	NA	NA
GW-1039	7	86%	NA	NA	NA	NA	NA
Weldon Spirng Chemical Plant/Raffinate Pits							
GW-2001	15	0%	1	1	35	No	NA
GW-2002	9	0%	-22	22	18	Yes	-1.14
GW-2003	14	0%	-47	47	33	Yes	-1.87
GW-2004	13	0%	-20	20	28	No	NA
GW-2005	13	8%	0	0	28	No	NA
GW-2006	14	0%	-22	22	33	No	NA
GW-2007	11	91%	NA	NA	NA	NA	NA
GW-2008	13	0%	-48	48	28	Yes	-0.02
GW-2009	12	0%	-37	37	26	Yes	-0.01
GW-2010	13	0%	-13	13	28	No	NA
GW-2011	12	0%	-19	19	26	No	NA
GW-2012	13	0%	-19	19	28	No	NA
GW-2013	15	0%	-22	22	35	No	NA

Table H-2 Trend Analysis - Nitrate (Continued)

			Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pci/l/day)
GW-2014	13	0%	-38	38	28	Yes	-0.01
GW-2015	12	8%	-14	14	26	No	NA
GW-2017	13	0%	-30	30	28	Yes	-0.002
GW-2018	14	0%	-46	46	33	Yes	-0.002
GW-2019	10	70%	-10	10	21	No	NA
GW-2020	13	0%	-18	18	28	No	NA
GW-2021	9	100%	NA	NA	NA	NA	NA
GW-2022	9	89%	NA	NA	NA	NA	NA
GW-2023	9	44%	-20	20	18	Yes	-0.0003
GW-2024	9	100%	NA	NA	NA	NA	NA
GW-2025	8	88%	NA	NA	NA	NA	NA
GW-2026	9	89%	NA	NA	NA	NA	NA
GW-2027	9	56%	-20	20	18	Yes	-0.0003
GW-2028	9	89%	NA	NA	NA	NA	NA
GW-2029	9	89%	NA	NA	NA	NA	NA
GW-2030	3	0%	NA	NA	NA	NA	NA
GW-2031	2	0%	NA	NA	NA	NA	NA
GW-2032	3	0%	NA	NA	NA	NA	NA
GW-2033	3	0%	NA	NA	NA	NA	NA
GW-2034	3	33%	NA	NA	NA	NA	NA
GW-3001	10	0%	-13	13	21	No	NA
GW-3002	9	67%	0	0	18	No	NA
GW-3003	11	9%	-11	11	23	No	NA
GW-3006	12	67%	-4	4	26	No	NA

Table H-2 Trend Analysis - Nitrate (Continued)

			Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pci/l/day)
GW-3008	13	0%	-30	30	28	Yes	-2.87
GW-3009	15	0%	-15	15	35	No	NA
GW-3019	8	63%	-14	14	16	No	NA
GW-3022	2	0%	NA	NA	NA	NA	NA
GW-3023	5	0%	-2	2	8	No	NA
GW-4001	11	0%	-45	45	23	Yes	-0.14
GW-4002	11	0%	-23	23	23	Yes	-0.006
GW-4003	9	0%	-14	14	18	No	NA
GW-4004	9	0%	-14	14	18	No	NA
GW-4005	10	0%	-23	23	21	Yes	-0.006
GW-4006	9	0%	-24	24	18	Yes	-0.02
GW-4007	8	75%	NA	NA	NA	NA	NA
GW-4008	9	78%	NA	NA	NA	NA	NA
GW-4009	8	38%	-1	1	16	No	NA
GW-4010	9	33%	-29	29	18	Yes	-0.0005
GW-4011	9	22%	0	0	18	No	NA
GW-4012	10	40%	-3	3	21	No	NA
GW-4013	11	9%	-15	15	23	No	NA
GW-4014	9	0%	-18	18	18	Yes	-0.01
GW-4015	9	0%	-20	20	18	Yes	-0.006
GW-4016	9	100%	NA	NA	NA	NA	NA
GW-4017	9	22%	-20	20	18	Yes	-0.003
GW-4018	9	0%	-3	3	18	No	NA
GW-4019	12	0%	-18	18	26	No	NA

Table H-2 Trend Analysis - Nitrate (Continued)

			Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pci/l/day)
GW-4020	9	56%	-19	19	18	Yes	-0.0002
GW-4021	9	78%	NA	NA	NA	NA	NA
GW-4022	9	22%	-8	8	18	No	NA
GW-4023	9	0%	-24	24	18	Yes	-0.03
GW-RMW1	12	83%	NA	NA	NA	NA	NA
GW-RMW2	13	77%	NA	NA	NA	NA	NA
GW-RMW3	12	83%	NA	NA	NA	NA	NA
GW-RMW4	13	38%	7	7	28	No	NA

Table H-3 Trend Analysis - Sulfate

			Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pCi/l/day)
Weldon Spring Quarry							
GW-1002	16	0%	-17	17	38	No	NA
GW-1004	16	0%	-15	15	38	No	NA
GW-1005	17	0%	20	20	42	No	NA
GW-1006	16	0%	28	28	38	No	NA
GW-1007	16	6%	-28	28	38	No	NA
GW-1008	15	0%	31	31	35	No	NA
GW-1009	16	0%	70	70	38	Yes	0.12
GW-1010	16	63%	-3	3	38	No	NA
GW-1011*	13	0%	-12	12	28	No	NA
GW-1012	17	0%	-57	57	42	Yes	-0.07
GW-1013	18	0%	-24	24	45	No	NA
GW-1014	18	0%	-11	11	45	No	NA
GW-1015	15	0%	39	39	35	Yes	0.09
GW-1016	14	0%	45	45	33	Yes	0.09
GW-1017	15	47%	19	19	35	No	NA
GW-1018	16	6%	-44	44	38	Yes	-0.03
GW-1019	15	67%	35	35	35	Yes	0.0003
GW-1020	11	45%	13	13	23	No	NA
GW-1021	11	45%	7	7	23	No	NA
GW-1022	11	55%	17	17	23	No	NA
GW-1023	9	33%	1	1	18	No	NA
GW-1024	12	33%	5	5	26	No	NA
GW-1026	10	50%	-3	3	21	No	NA

Table H-3 Trend Analysis - Sulfate (Continued)

			Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pCi/l/day)
GW-1027	10	0%	-1	1	21	No	NA
GW-1028	10	0%	23	23	21	Yes	0.02
GW-1029	5	0%	0	0	8	No	NA
GW-1030	5	20%	6	6	8	No	NA
GW-1031	5	0%	-4	4	8	No	NA
GW-1032	6	0%	7	7	11	No	NA
GW-1033	3	0%	NA	NA	NA	NA	NA
GW-1034	4	0%	2	2	6	No	NA
GW-1035	4	0%	0	0	6	No	NA
GW-1036	7	0%	-3	3	13	No	NA
GW-1037	7	0%	2	2	13	No	NA
GW-1038	7	0%	1	1	13	No	NA
GW-1039	7	0%	14	14	13	Yes	0.37
Weldon Spring Chemical Plant/Raffinate Pits							
GW-2001	15	0%	-5	5	35	No	NA
GW-2002	9	0%	-20	20	18	Yes	-0.07
GW-2003	14	0%	2	2	33	No	NA
GW-2004	13	8%	-17	17	28	No	NA
GW-2005	13	0%	29	29	28	Yes	0.007
GW-2006	13	8%	-7	7	28	No	NA
GW-2007	11	0%	-38	38	23	Yes	-0.004
GW-2008	13	0%	-14	14	28	No	NA
GW-2009	12	0%	14	14	26	No	NA
GW-2010	13	0%	-22	22	28	No	NA

Table H-3 Trend Analysis - Sulfate (Continued)

			Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pCi/l/day)
GW-2011	12	0%	24	24	26	No	NA
GW-2012	13	0%	8	8	28	No	NA
GW-2013	15	0%	-35	35	35	Yes	-0.008
GW-2014	13	0%	13	13	28	No	NA
GW-2015	13	8%	-34	34	28	Yes	-0.03
GW-2017	13	0%	10	10	28	No	NA
GW-2018	14	0%	-31	31	33	No	NA
GW-2019	9	0%	28	28	18	Yes	0.02
GW-2020	13	0%	-45	45	28	Yes	-0.06
GW-2021	9	0%	-8	8	18	No	NA
GW-2022	9	0%	-10	10	18	No	NA
GW-2023	9	0%	-30	30	18	Yes	-0.02
GW-2024	9	0%	-18	18	18	Yes	-0.009
GW-2025	8	0%	-17	17	16	Yes	-0.003
GW-2026	9	0%	11	11	18	No	NA
GW-2027	8	0%	-11	11	16	No	NA
GW-2028	9	0%	3	3	18	No	NA
GW-2029	9	0%	2	2	18	No	NA
GW-2030	3	0%	NA	NA	NA	NA	NA
GW-2031	2	0%	NA	NA	NA	NA	NA
GW-2032	3	0%	NA	NA	NA	NA	NA
GW-2033	3	0%	NA	NA	NA	NA	NA
GW-2034	3	0%	NA	NA	NA	NA	NA
GW-3001	10	0%	-6	6	21	No	NA

Table H-3 Trend Analysis - Sulfate (Continued)

			Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pCi/l/day)
GW-3002	9	11%	0	0	18	No	NA
GW-3003	11	0%	-9	9	23	No	NA
GW-3006	12	0%	-36	36	26	Yes	-0.03
GW-3008	13	0%	14	14	28	No	NA
GW-3009	14	0%	25	25	33	No	NA
GW-3019	8	0%	-10	10	16	No	NA
GW-3022	2	0%	NA	NA	NA	NA	NA
GW-3023	5	0%	2	2	8	No	NA
GW-4001	10	0%	-12	12	21	No	NA
GW-4002	11	0%	-1	1	23	No	NA
GW-4003	9	0%	-2	2	18	No	NA
GW-4004	9	0%	-20	20	18	Yes	-0.01
GW-4005	10	0%	11	11	21	No	NA
GW-4006	10	0%	-32	32	21	Yes	-0.008
GW-4007	8	0%	10	10	16	No	NA
GW-4008	9	0%	-2	2	18	No	NA
GW-4009	8	0%	8	8	16	No	NA
GW-4010	9	0%	-12	12	18	No	NA
GW-4011	9	0%	-4	4	18	No	NA
GW-4012	11	0%	9	9	23	No	NA
GW-4013	11	0%	-34	34	23	Yes	-0.02
GW-4014	9	0%	-4	4	18	No	NA
GW-4015	9	11%	2	2	18	No	NA
GW-4016	9	11%	-22	22	18	Yes	-0.04

Table H-3 Trend Analysis - Sulfate (Continued)

			Test for Trend Mann-Kendall				
Well ID	No. of Samples	% data <D.L.	S-calc.	S-calc.	S-crit.	Trend Yes/No	Sen's Slope Est. (pCi/l/day)
GW-4017	9	0%	-8	8	18	No	NA
GW-4018	9	0%	-24	24	18	Yes	-0.01
GW-4019	12	0%	-39	39	26	Yes	-0.003
GW-4020	9	0%	20	20	18	Yes	-0.05
GW-4021	9	0%	4	4	18	No	NA
GW-4022	9	0%	-14	14	18	No	NA
GW-4023	9	0%	-6	6	18	No	NA
GW-RMW1	13	0%	12	12	28	No	NA
GW-RMW2	13	8%	-3	3	52	No	NA
GW-RMW3	13	15%	-18	18	28	No	NA
GW-RMW4	12	0%	12	12	26	No	NA

052092

APPENDIX I
Groundwater Figures

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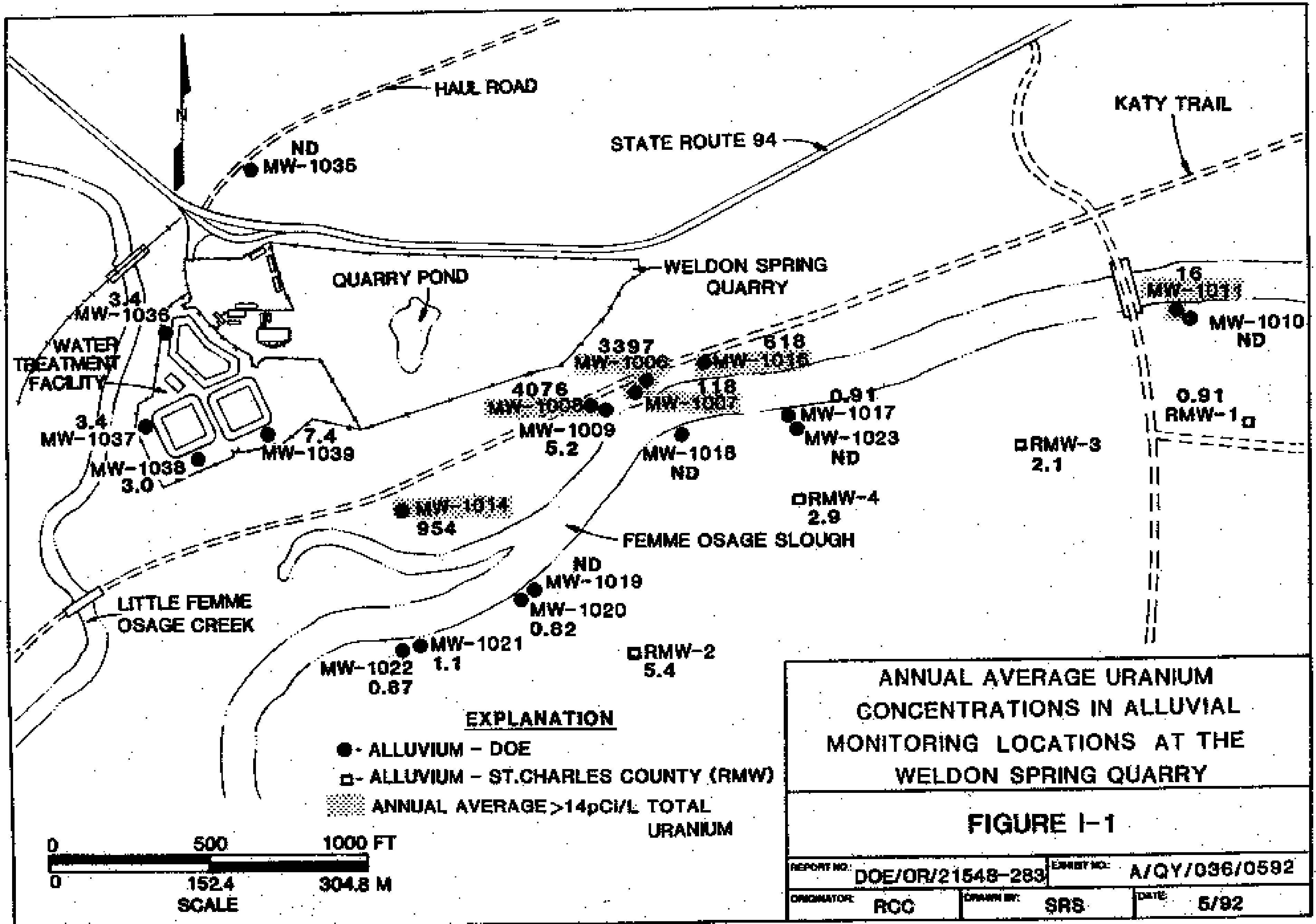
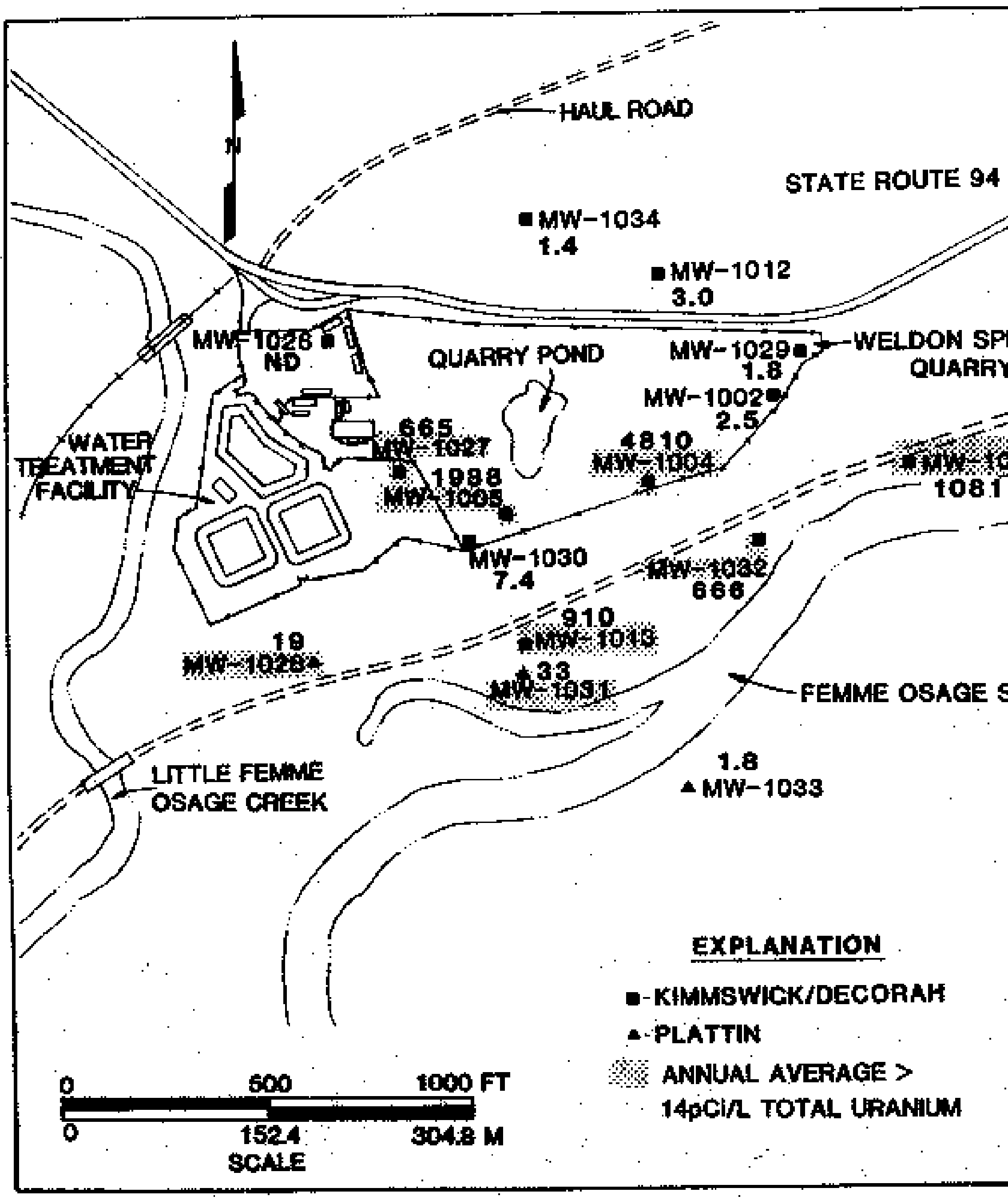


ANNUAL AVERAGE URANIUM CONCENTRATIONS IN ALLUVIAL MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE I-1

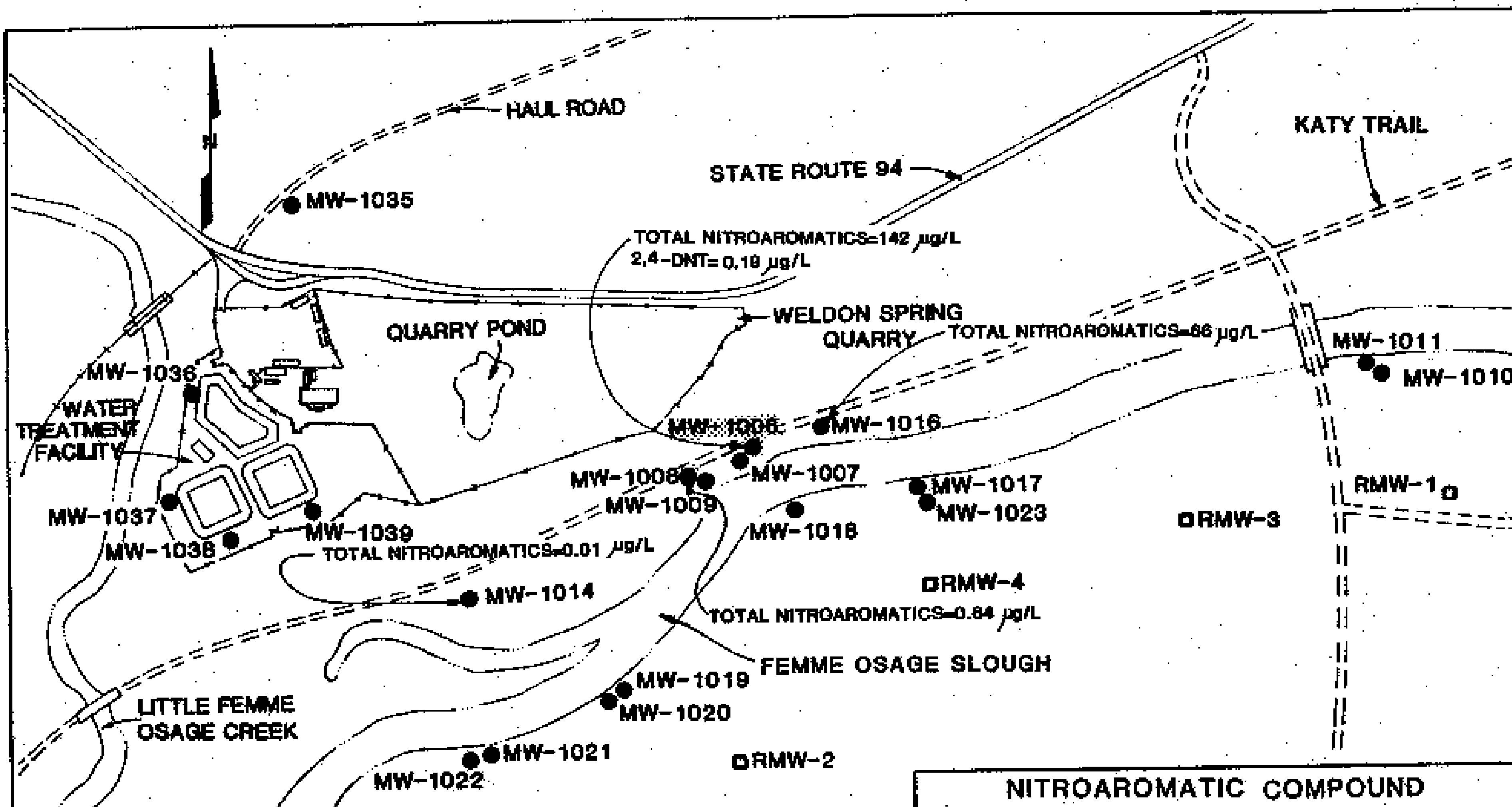
REPORT NO: DOE/OR/21548-283		EXHIBIT NO: A/QY/036/0592
ORIGINATOR: RCC	DRAWN BY: SRS	DATE: 5/92



ANNUAL AVERAGE URANIUM CONCENTRATIONS IN BEDROCK MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE I-2

REPORT NO.: DOE/OR/21548-283		EXHIBIT NO.: A/QY/037/0592	
ORIGINATOR: RCC	DRAWN BY: SRS	DATE: 5/92	



EXPLANATION

- ● - ALLUVIUM - DOE
- □ - ALLUVIUM - ST.CHARLES COUNTY (RMW)
- ANNUAL AVERAGE>0.11µg/L 2,4-DNT

0 500 1000 FT

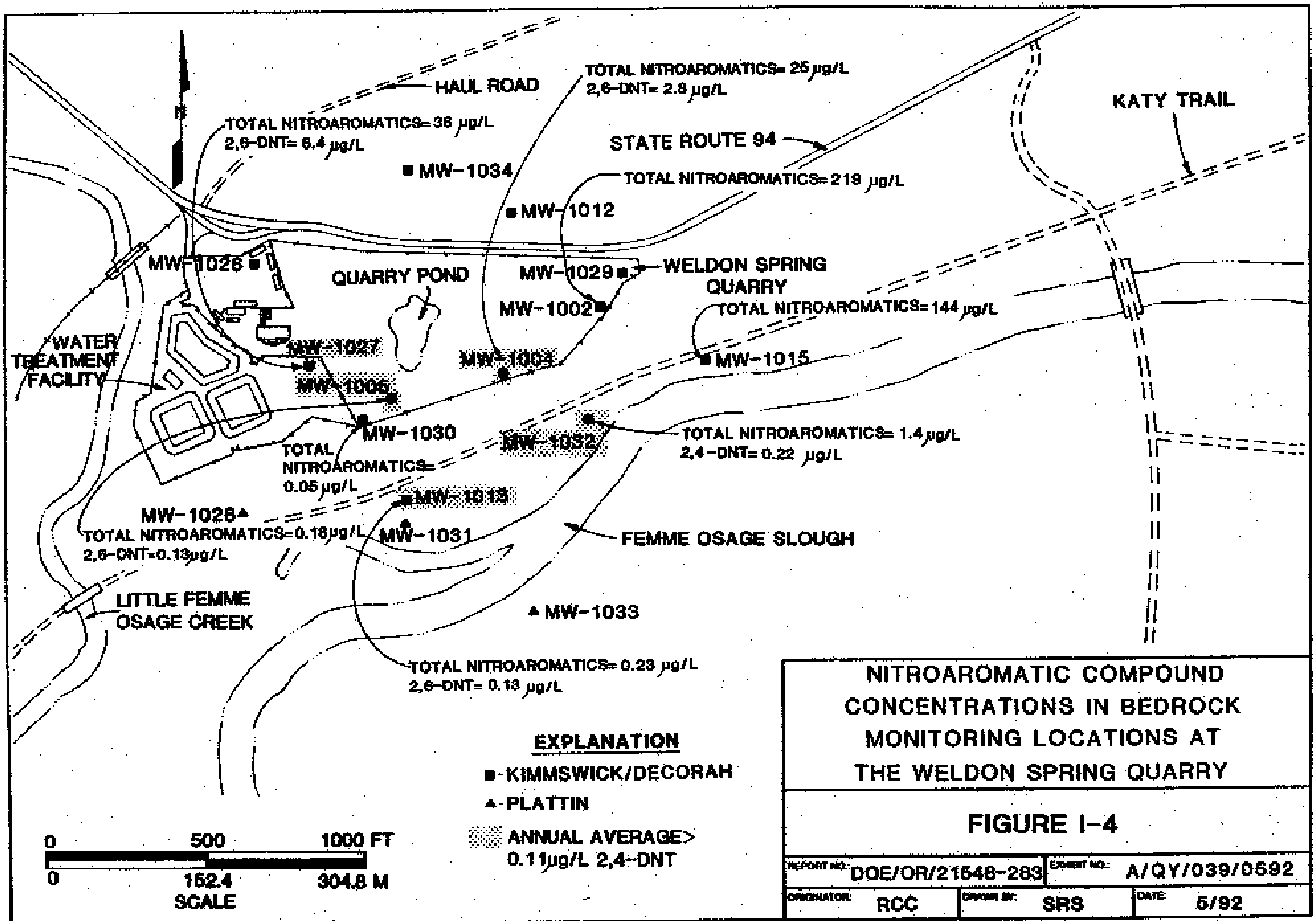
0 152.4 304.8 M

SCALE

NITROAROMATIC COMPOUND CONCENTRATIONS IN ALLUVIAL MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE I-3

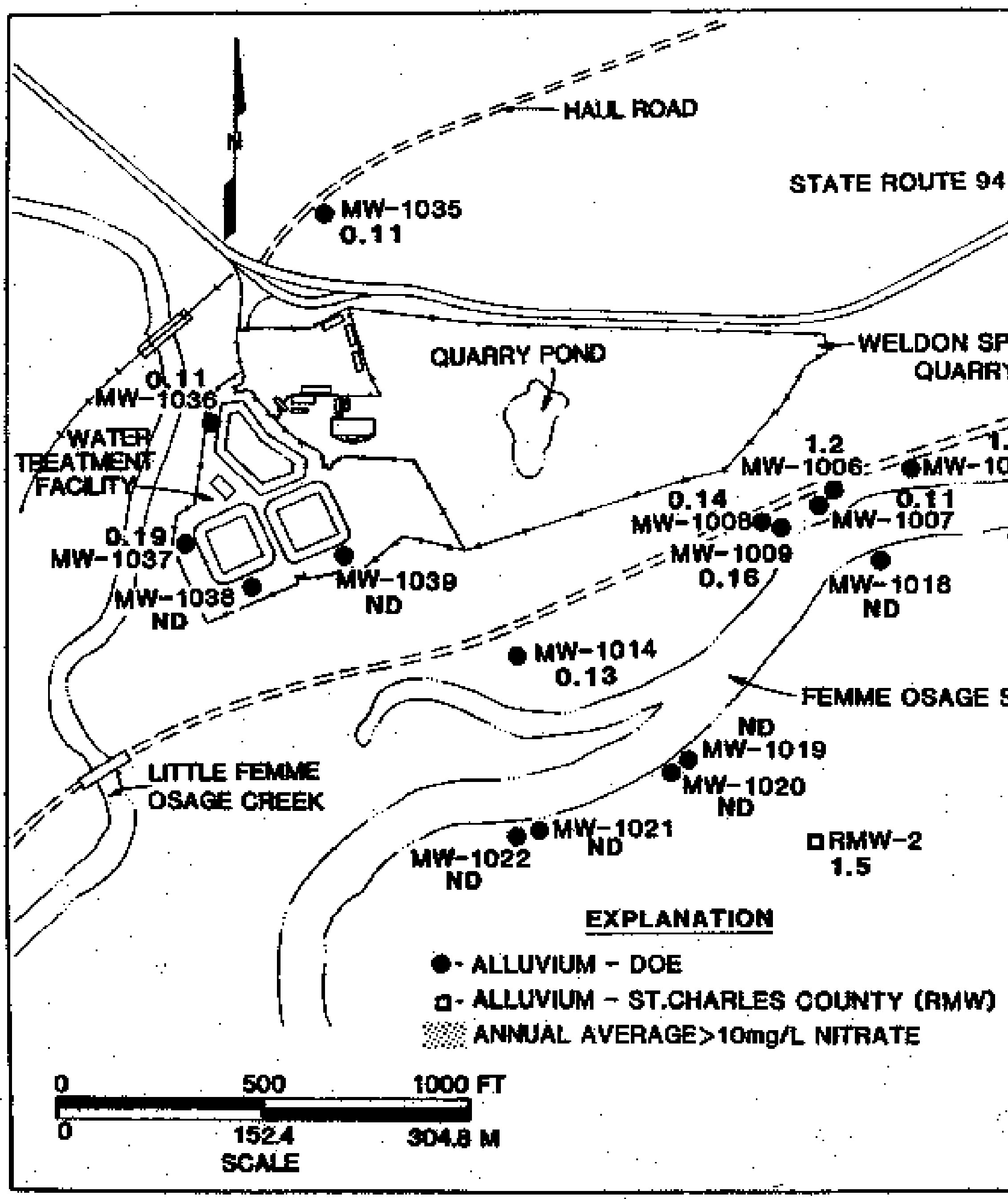
REPORT NO. DOE/OR/21548-283		EXHIBIT NO. A/QY/038/0592
ORIGINATOR RCC	DRAWN BY SRS	DATE 5/92



NITROAROMATIC COMPOUND CONCENTRATIONS IN BEDROCK MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE I-4

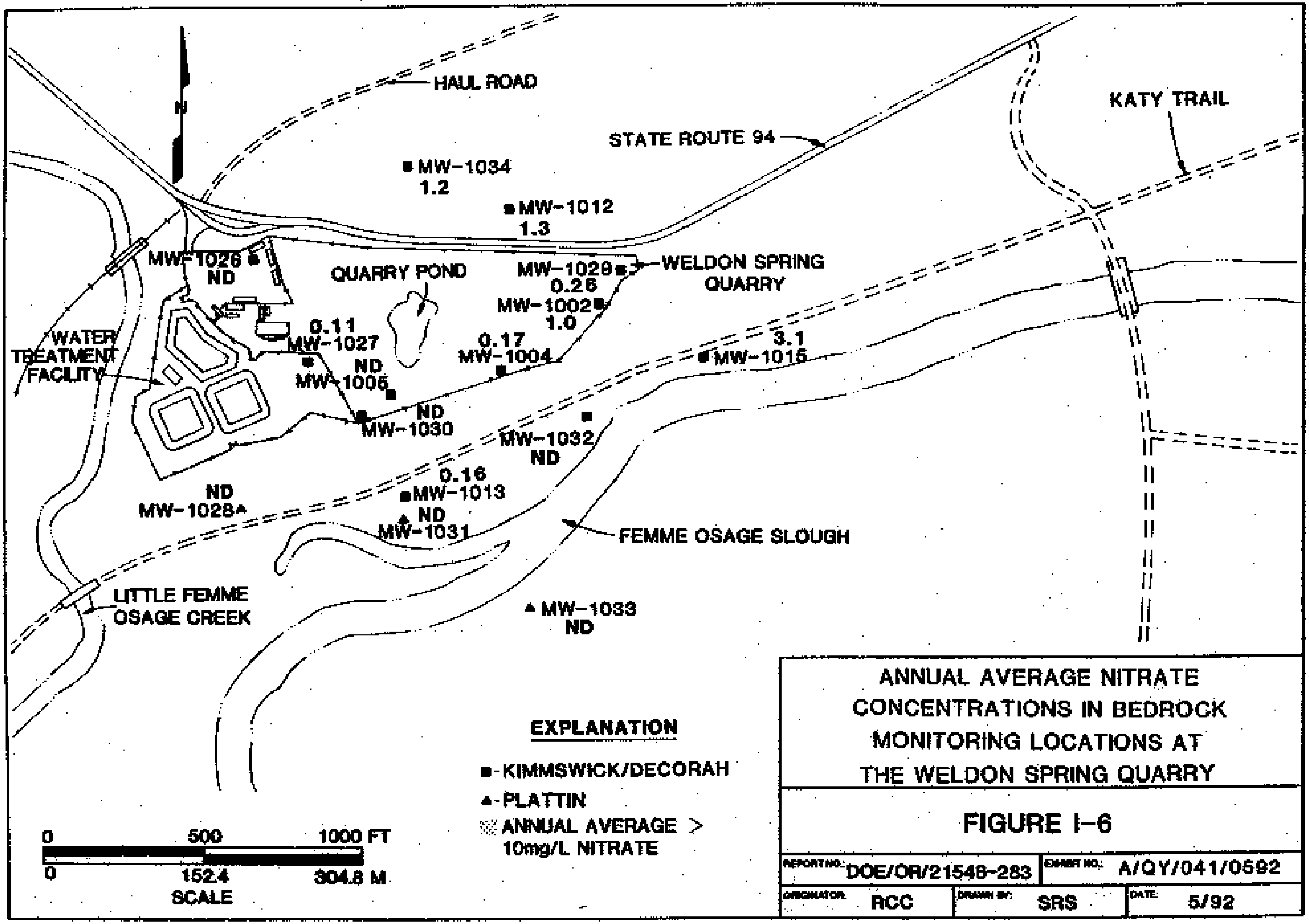
REPORT NO: DOE/OR/21548-283	EXHIBIT NO: A/QY/039/0592	
ORIGINATOR: RCC	DRAWN BY: SRS	DATE: 5/92



ANNUAL AVERAGE NITRATE CONCENTRATIONS IN ALLUVIAL MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE I-5

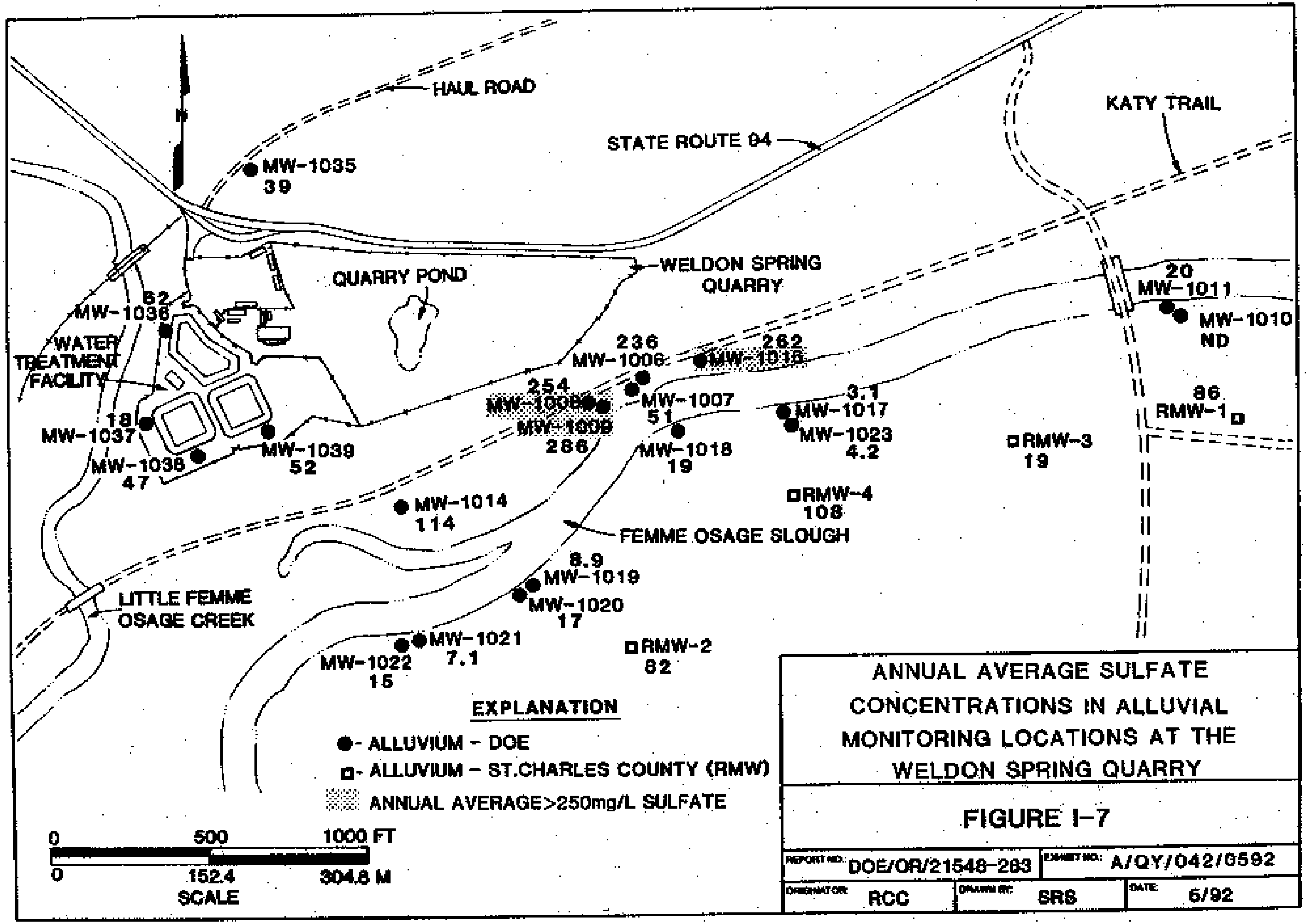
REPORT NO.: DOE/OR/21548-283	EXHIBIT NO.: A/QY/040/0592	
ORIGINATOR: RCC	DRAWN BY: SRS	DATE: 5/92



ANNUAL AVERAGE NITRATE CONCENTRATIONS IN BEDROCK MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE I-6

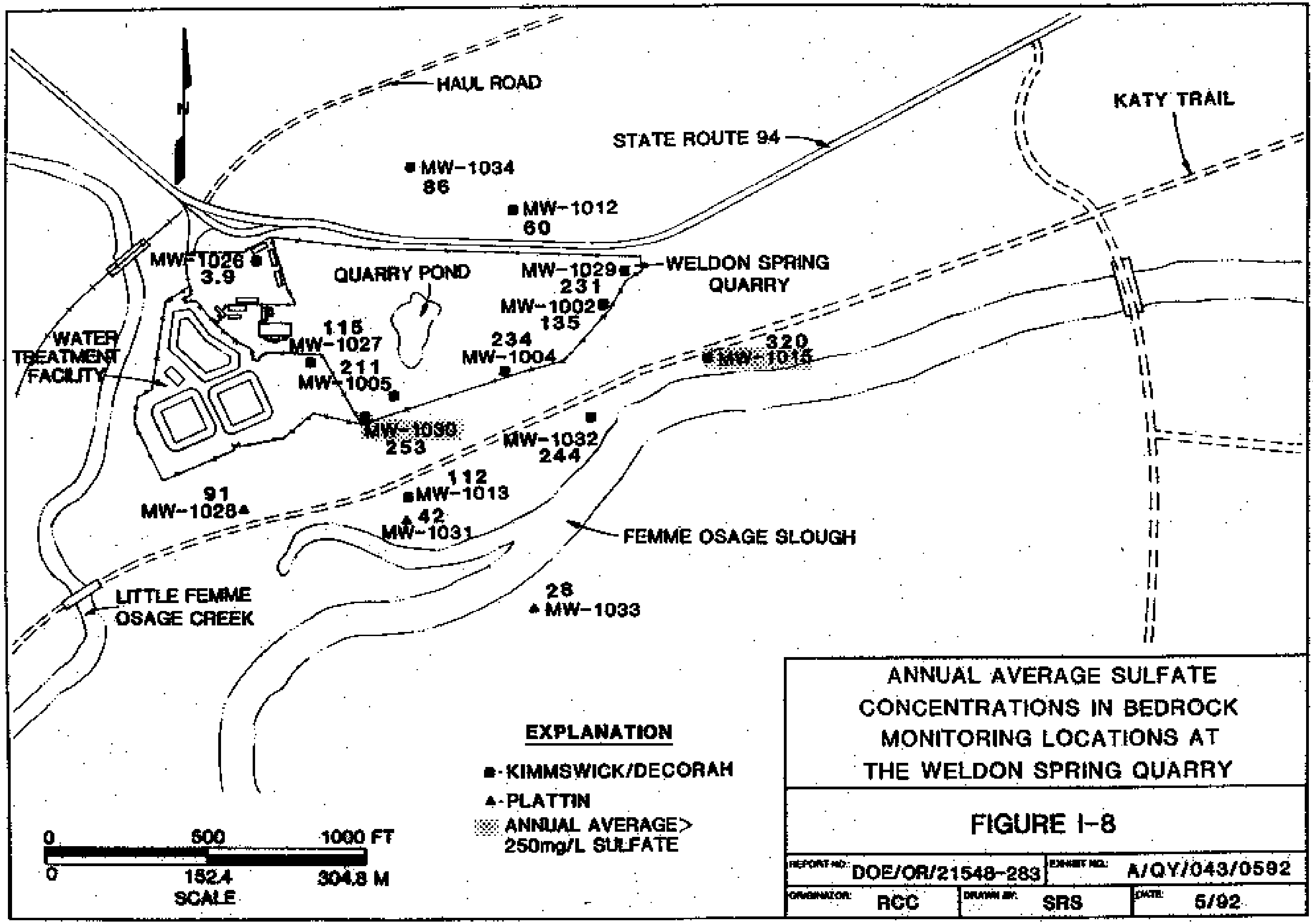
REPORT NO.: DOE/OR/21548-283		EXHIBIT NO.: A/QY/041/0592	
ORIGINATOR: RCC	DRAWN BY: SRS	DATE: 5/92	



ANNUAL AVERAGE SULFATE CONCENTRATIONS IN ALLUVIAL MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE I-7

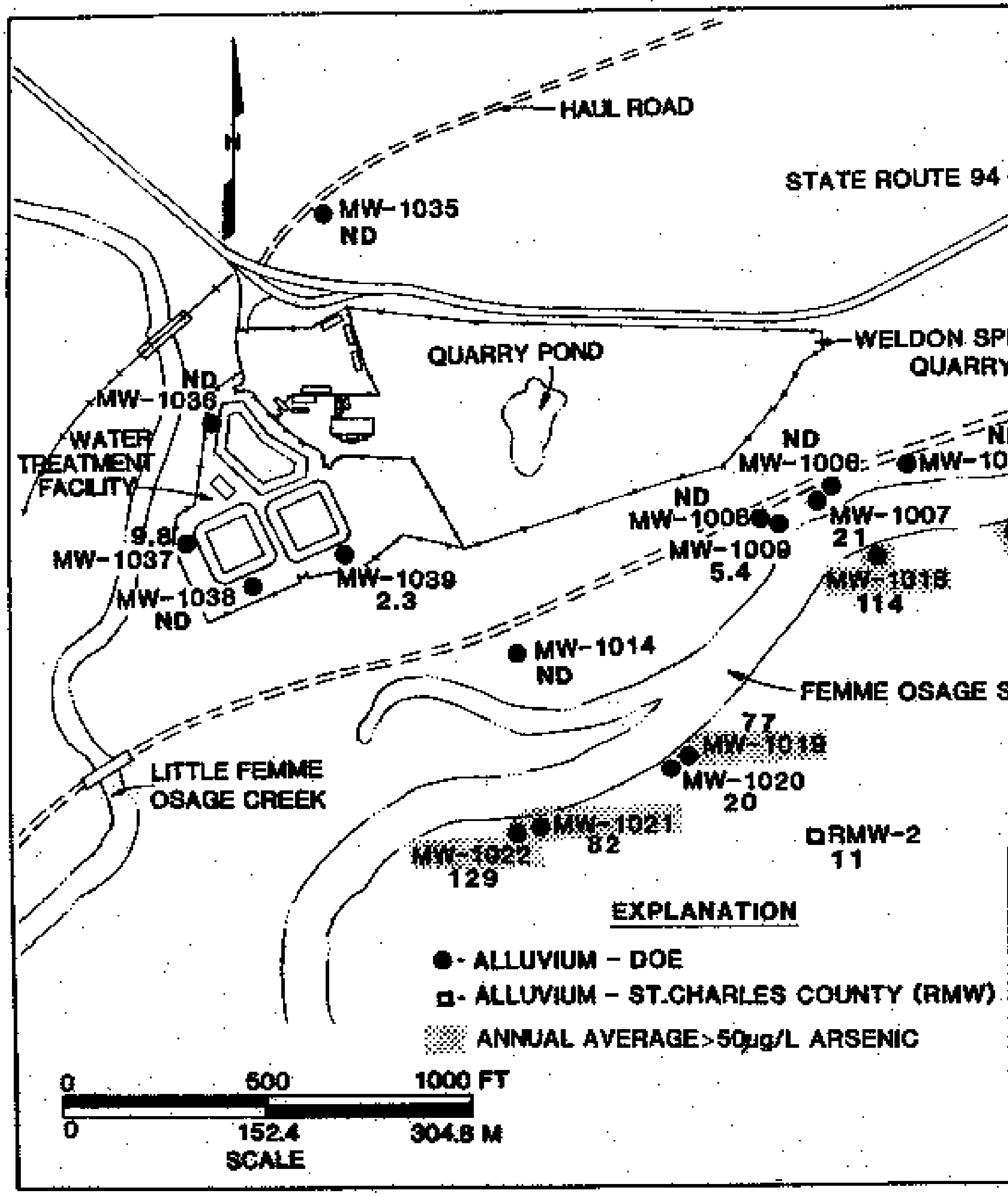
REPORT NO.: DOE/OR/21548-283		EXHIBIT NO.: A/QY/042/0592	
ORIGINATOR: RCC	DRAWN BY: SRS	DATE: 5/92	



ANNUAL AVERAGE SULFATE CONCENTRATIONS IN BEDROCK MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE I-8

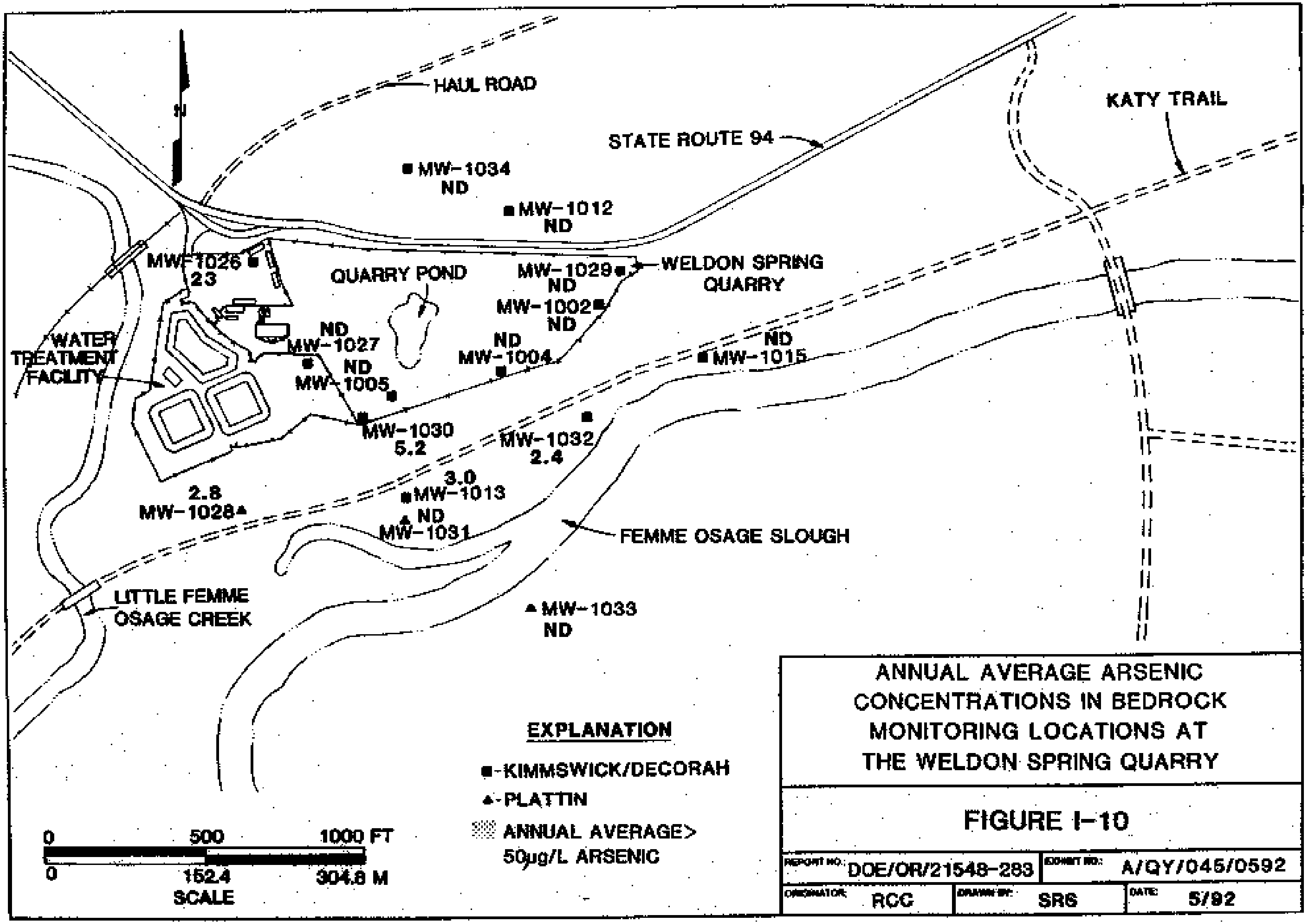
REPORT NO:	DOE/OR/21548-283		EXHIBIT NO:	A/QY/043/0592	
ORIGINATOR: RCC		DRAWN BY: SRS		DATE: 5/92	



ANNUAL AVERAGE ARSENIC CONCENTRATIONS IN ALLUVIAL MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE I-9

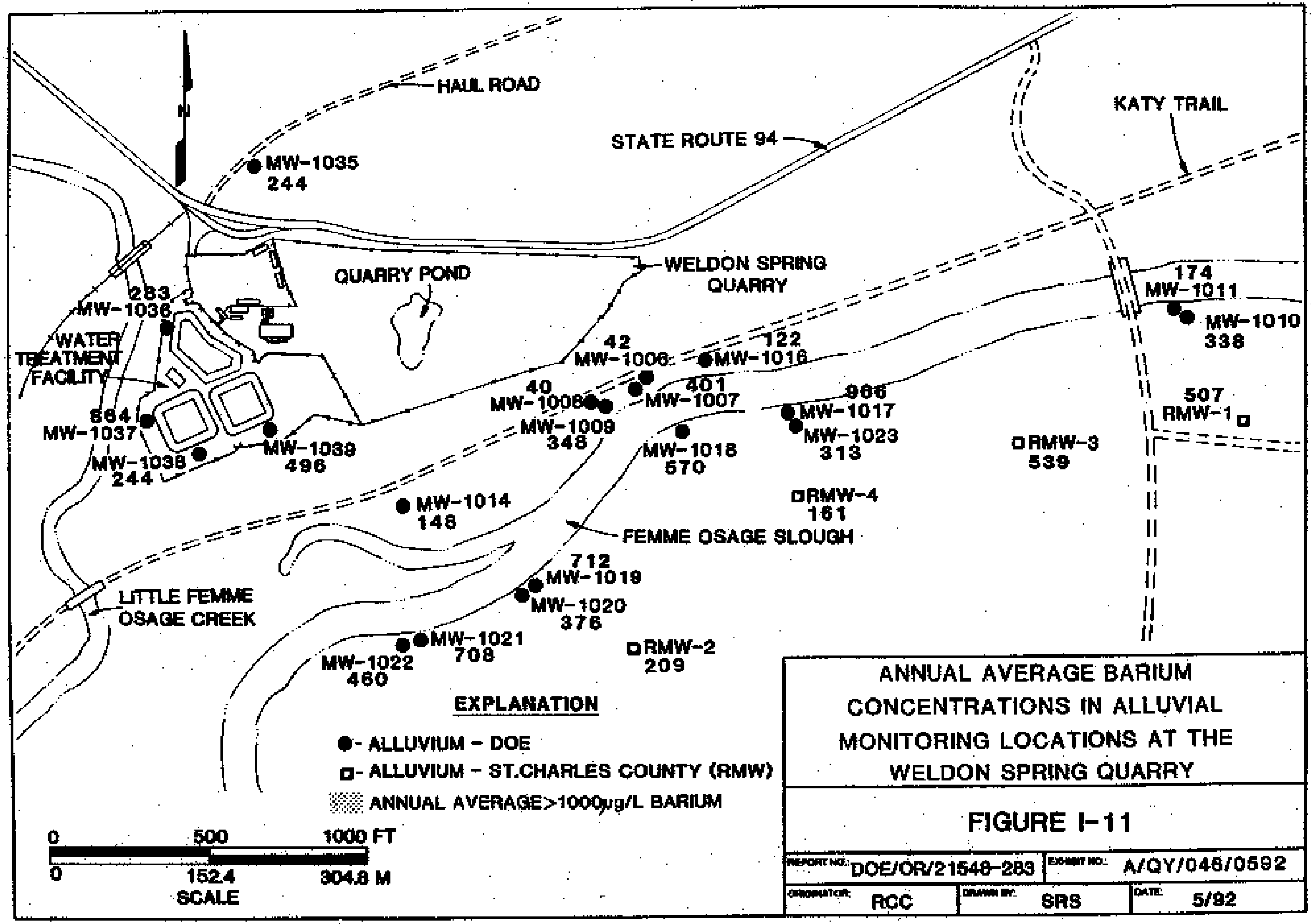
REPORT NO.: DOE/OR/21548-283		EXHIBIT NO.: A/QY/044/0592	
ORIGINATOR: RCC	DRAWN BY: SRS	DATE: 5/92	



ANNUAL AVERAGE ARSENIC CONCENTRATIONS IN BEDROCK MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE I-10

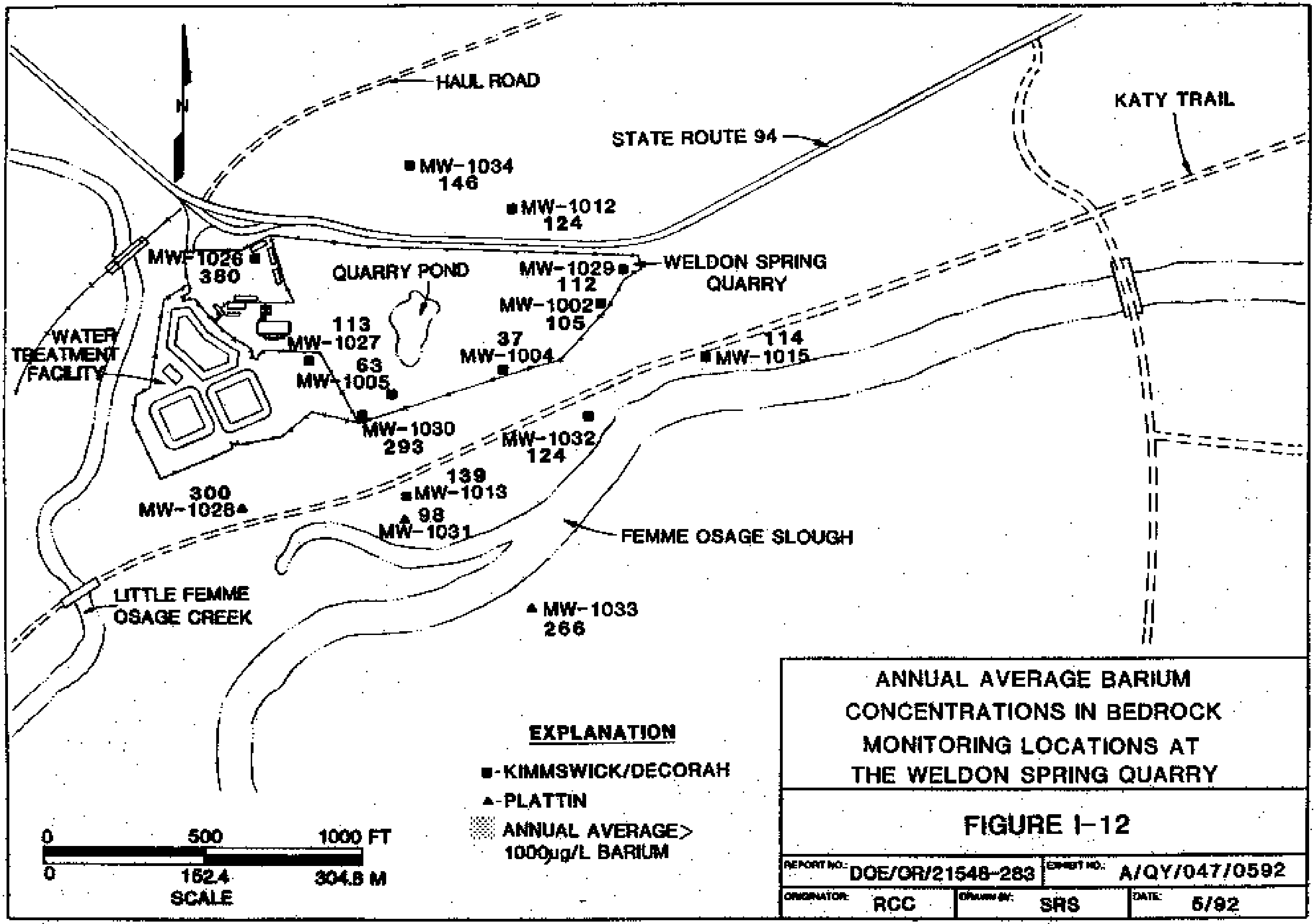
REPORT NO: DOE/OR/21548-283	EXHIBIT NO: A/QY/045/0592	
ORIGINATOR: RCC	DRAWN BY: SRS	DATE: 5/92



ANNUAL AVERAGE BARIUM CONCENTRATIONS IN ALLUVIAL MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE I-11

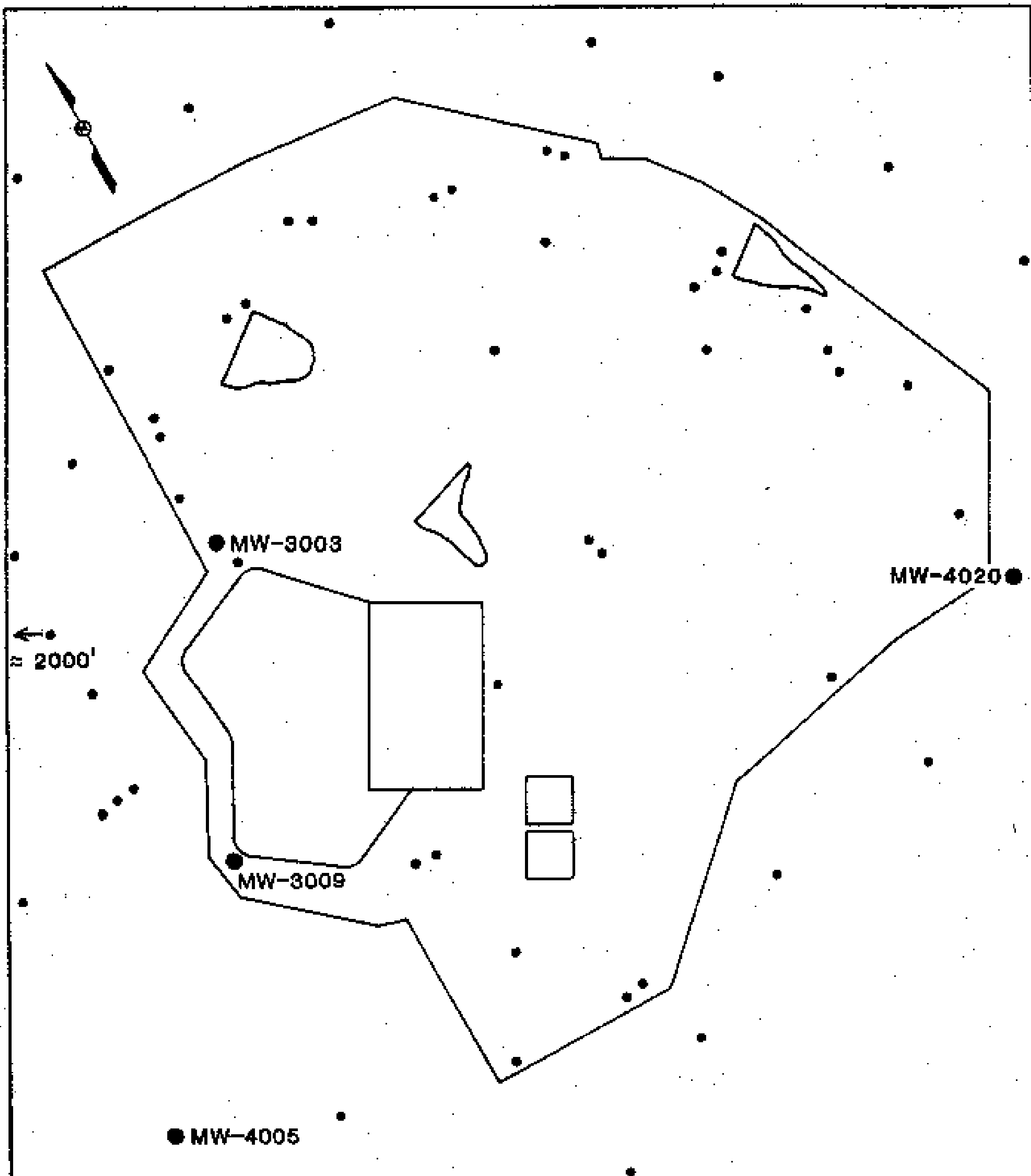
REPORT NO.: DOE/OR/21548-283		EXHIBIT NO.: A/QY/046/0592	
ORIGINATOR: RCC	DRAWN BY: SRS	DATE: 5/92	



ANNUAL AVERAGE BARIUM CONCENTRATIONS IN BEDROCK MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE I-12

REPORT NO.: DOE/OR/21548-283	EXHIBIT NO.: A/QY/047/0592	
ORIGINATOR: RCC	DRAWN BY: SRS	DATE: 5/92



● WELLS WITH CONCENTRATIONS >14pCi/l

• DOE MONITORING WELL

0 600 1000 FT

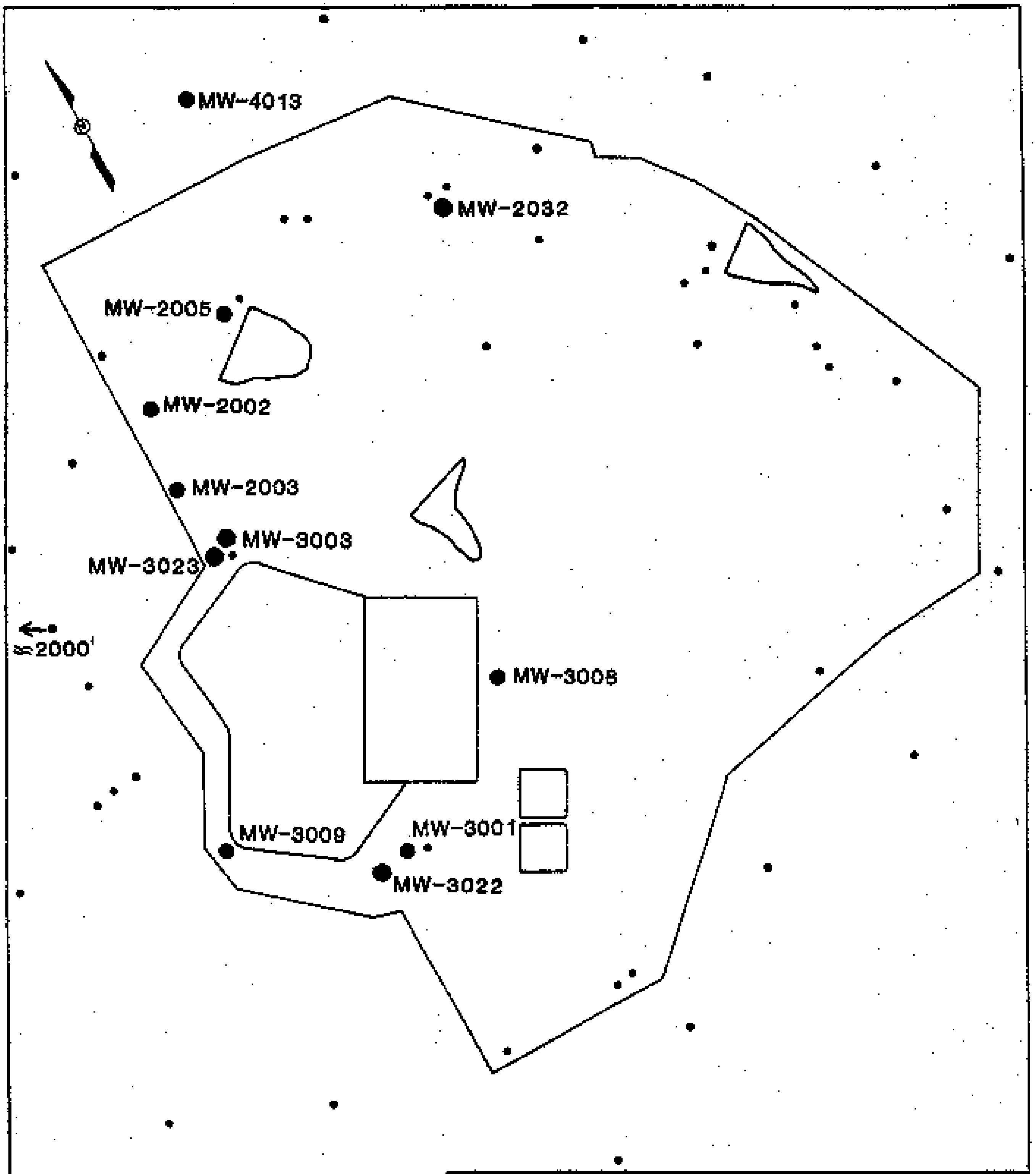
0 152.4 304.8 M

SCALE

WELDON SPRING CHEMICAL PLANT/ RAFFINATE PITS/VICINITY PROPERTIES WELLS WITH ANNUAL AVERAGE URANIUM CONCENTRATIONS >14pCi/L (20 μg/L EQUIVALENT)

FIGURE I-13

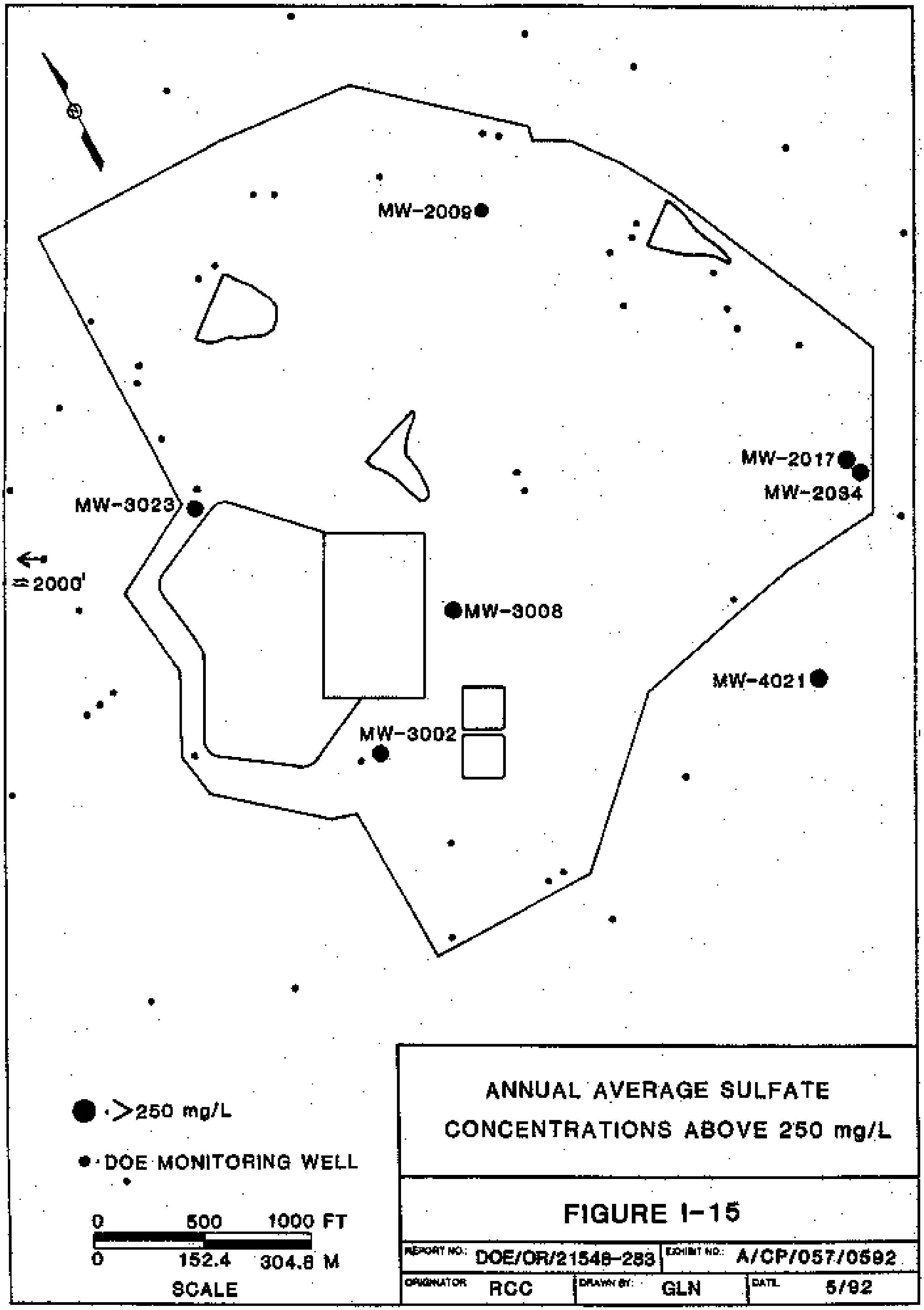
REPORT NO. DOE/OR/21548-283		EXHIBIT NO. A/CP/054/0592	
ORIGINATOR RCC	DRAWN BY GLN	DATE 5/92	



ANNUAL AVERAGE NITRATE CONCENTRATIONS (AS NITROGEN) ABOVE 10 mg/L

FIGURE I-14

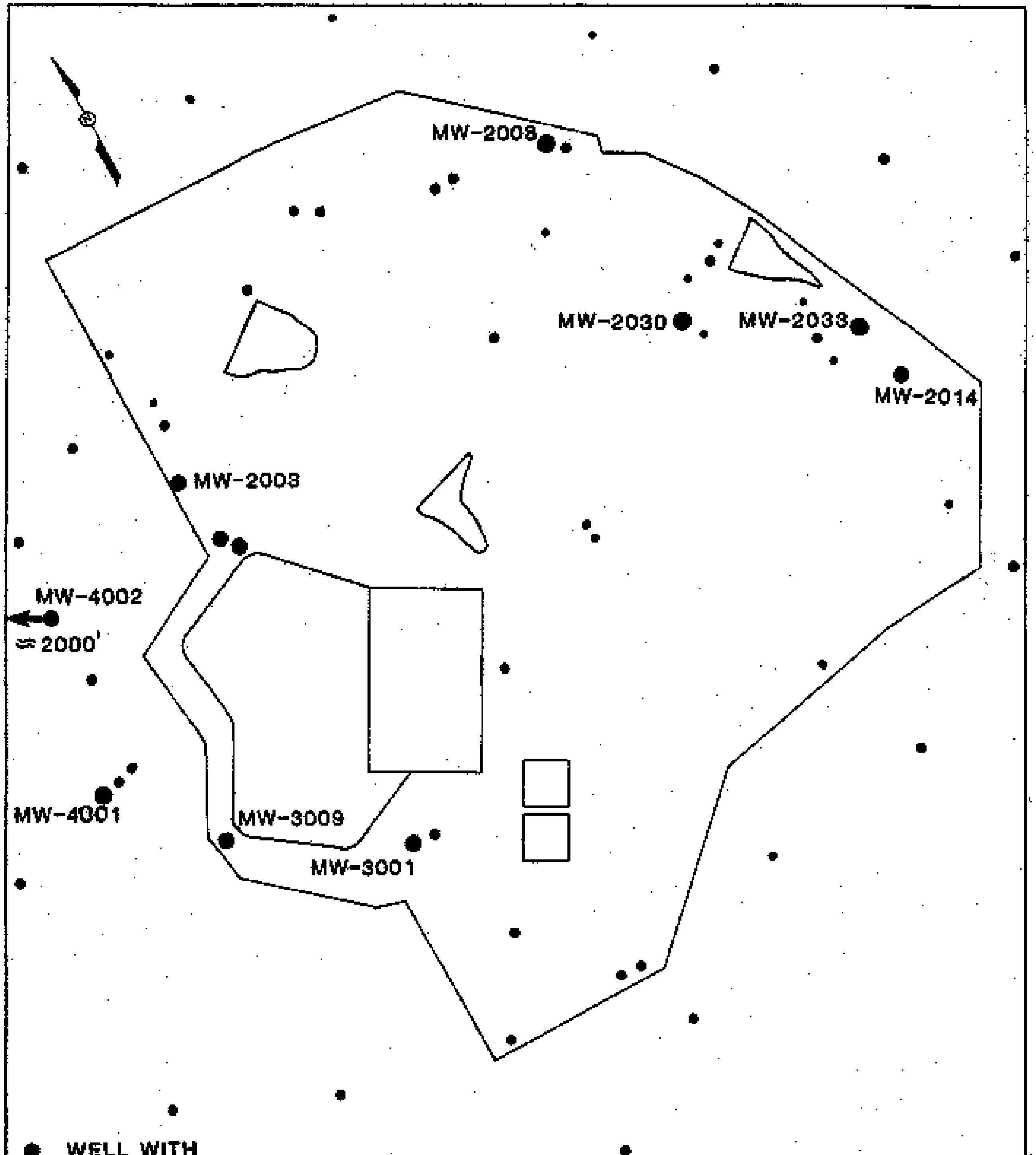
REPORT NO. DOE/OR/21548-283		EXHIBIT NO: A/CP/056/0592	
ORIGINATOR RCC	DRAWN BY GLN	DATE 5/92	



ANNUAL AVERAGE SULFATE CONCENTRATIONS ABOVE 250 mg/L

FIGURE I-15

REPORT NO.: DOE/OR/21548-283	EXHIBIT NO.: A/CP/057/0592	
ORIGINATOR: RCC	DRAWN BY: GLN	DATE: 5/92



ANNUAL AVERAGE 2,4-DNT CONCENTRATIONS ABOVE 0.11ug/L

FIGURE I-16

REPORT NO. DOE/OR/21548-283	EXHIBIT NO. A/CP/055/0592	
ORIGINATOR RCC	DRAWN BY GLN	DATE 5/92

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