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ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

SEPTEMBER 1991 **REV. 1**

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

EXECUTIVE SUMMARY
for the
Annual Site Environmental Report
for Calendar Year 1990

Revision 1

September 1991

Prepared by

MK-FERGUSON COMPANY
and
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7295 Highway 94 South
St. Charles, Missouri 63303

for the

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

EXECUTIVE SUMMARY

The Weldon Spring Site Remedial Action Project (WSSRAP) Annual Site Environmental Report for 1990 is the fifth in a series of annual reports produced by the 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, surface waters, and air quality through multiple pathways as well as monitoring for potential 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 areas and the Weldon Spring quarry area. Based upon the WSSRAP's consistent exercise of quality assurance measures, in the form of both standard operating procedures and quality control sample collection, the WSSRAP asserts that the data presented in the WSSRAP Annual Site Environmental Report for 1990 (ASER) accurately reflect the environmental conditions monitored at the WSS. This ASER presents narratives, summaries, and conclusions on environmental monitoring at the subject areas and surrounding vicinity properties for the entire 1990 monitoring year. The WSSRAP also initiated a quarterly data reporting mechanism in 1990. All routine monitoring data are tabulated and presented in quarterly reports, which allows for timely public review and avoids the delays associated with final 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 and international 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 ASER 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 nearly 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.

STATE AND FEDERAL REGULATIONS

The WSSRAP regulatory environment is multifaceted and complex. Therefore, the U.S. Department of Energy (DOE) and its Project Management Contractor (PMC), MK-Ferguson Company, have established complementary monitoring and reporting systems for responding to all applicable regulatory requirements. Modifications to improve these systems continue. The systems ensure compliance with legislation, regulations, and standards associated with the Clean Air Act; the Clean Water Act; the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA); the Resource Conservation and Recovery Act (RCRA); Superfund Amendments Reauthorization Act (SARA); and the Atomic Energy Act. These regulations and standards are enforced by the Environmental Protection Agency (EPA), the Missouri Department of Natural Resources (MDNR), and other Federal, State and local agencies.

SUMMARY AND CONCLUSIONS:

In 1990, the WSSRAP continued to adhere to its mission of environmental protection and site remediation. The DOE is pursuing the Weldon Spring Site Remedial Action Project as a coordinated effort among the DOE, the EPA, the MDNR, and others.

Comprehensive environmental monitoring data for 1990 show that emissions of radiological contamination from the WSS continue to decrease, and contaminant migration pathways and environmental variability are better understood.

The calculated total radiation dose to a hypothetical maximally exposed individual from the WSCP/WSRP was less than 1 mrem (0.01 mSv). The calculated total radiation dose from the WSQ to a maximally exposed individual was 3.9 mrem (0.055 Msv). The

calculated total radiation dose to a hypothetical maximally exposed individual for the vicinity properties was less than 1 mrem.

The collective dose equivalent estimate for 1990 is less than 0.018 person-rem for an estimated exposed population of 72,000 persons. Section 4.1.8 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 1990 were approximately $16.1 million. Remedial action at the WSS is presently slated to continue through the year 2000.

The 1990 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 59 monitoring wells. The monitoring network at the WSQ consists of 26 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 1990 groundwater analytical results for samples at the WSCP/RP/VP and the WSQ are consistent with previous monitoring. The analytical results for 1990 did

indicate uranium concentrations slightly above background levels over a larger area than indicated in previous years. Although these slightly higher levels are believed to be due in part to laboratory contamination, as evidenced by contamination of water blanks collected during the monitoring year, the WSSRAP will focus attention on the situation during the 1991 monitoring year.

SURFACE WATER

During 1990, 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 chloride, fluoride nitrate, sulfate and nitroaromatic compounds. All results were near or within their historical range of values. However, results also indicate that uranium continues to migrate from the site at relatively low levels in surface water and springs along known discharge pathways. Concentrations for both chemical and radiological parameters at the monitoring locations fluctuated due to seasonal and climatic effects.

An analysis for trends of uranium concentrations in surface water was performed for the site and the quarry area to compare with previous years' monitoring results. No trends were evident at the site other than fluctuations due to seasonal effects. The quarry area (Femme Osage Slough) indicated a possible trend; as uranium increased from 1987 to 1989, but then decreased during 1990 at most of the surface water locations. This is believed due to the effects of drought conditions on the concentrations in the slough during the 1988-89 period, followed by normal precipitation levels during 1990 which affected dilution.

EFFLUENT MONITORING (NPDES)

Surface water effluents from the WSS during 1990 were primarily due to precipitation runoff. The WSSRAP maintains discharge permits under the National Pollutant Discharge Elimination System (NPDES). During 1990, 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 requirements only under the permit. The sixth outfall (administration building's treated sanitary effluent) is subject to specific discharge limits.

During 1990, the five storm water outfalls maintained levels that corresponded with prior year values. Sampling was performed on three occasions when flows were not representative of normal storm water flows. These three sampling events were performed during water release which was not associated with precipitation. Some abnormal levels of monitored constituents were detected in the discharge associated with these events. Section 4.2.4 further explains the 1990 discharge history.

The sanitary wastewater outfall was monitored for comparison to effluent limitations for biochemical oxygen demand (BOD), total suspended solids (TSS), and fecal coliform. NPDES permit levels were exceeded twice in 1990 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 compliance limits.

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 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 levels above background.

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 guidelines of 3 pCi/l 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 stations around the WSCP, the WSRP, or at off-site stations.

The results from one station at the WSQ were statistically greater than background levels. During 1990, remediation activities at the quarry were in progress and engineering controls were in place to control dust. The calculated effective dose equivalent as a result of the above background results to a hypothetical maximally exposed individual was <1 mrem.

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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 data reported in the ASER have been collected from a growing complex of monitoring stations and a routine sampling program supplemented by the following:

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- Six National Pollutant Discharge Elimination System (NPDES) locations and over 25 surface water sampling locations.
- Twenty-two locations for measuring external gamma radiation.
- 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.

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1 INTRODUCTION

This report presents the findings of the environmental monitoring program conducted at the Weldon Spring site (WSS) in 1990. The report presents summary 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) Surplus Facilities Management Program (SFMP), 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 - 05/14/85). 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).

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 regarding the routine environmental monitoring program. It explains how the WSSRAP effluent monitoring program meets the requirements of the National Pollution Discharge Elimination System (NPDES) program and compares the measured contaminant levels to applicable standards. 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.

Environmental monitoring is the WSSRAP's most effective means by which to assess the impacts from the site. The data and evaluations contained in the report provide the summary of that monitoring for 1990. Section 4 reports results of the contaminant level measurements and compares the environmental levels of radioactivity and chemical contaminants released from the site with applicable standards. Quarterly data are presented in Appendix A.

In addition to the routine environmental monitoring conducted in 1990, a number of related activities and special studies were performed. These activities and studies are directly applicable to the assessment of the overall impact of site operations on the environment. Therefore, these activities are described and the results are discussed in Section 7.

Section 4 presents the results of calculations, based on the 1990 sampling results, of the maximum radiation dose to a hypothetical maximally exposed individual at the WSCP/WSRP and WSQ areas. Calculations of the doses to the general population in the vicinity of the WSS are also reported.

Appendix B contains trend analyses figures for groundwater wells. For definitions of selected terms used in this report, the reader may consult 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 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 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 located 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.

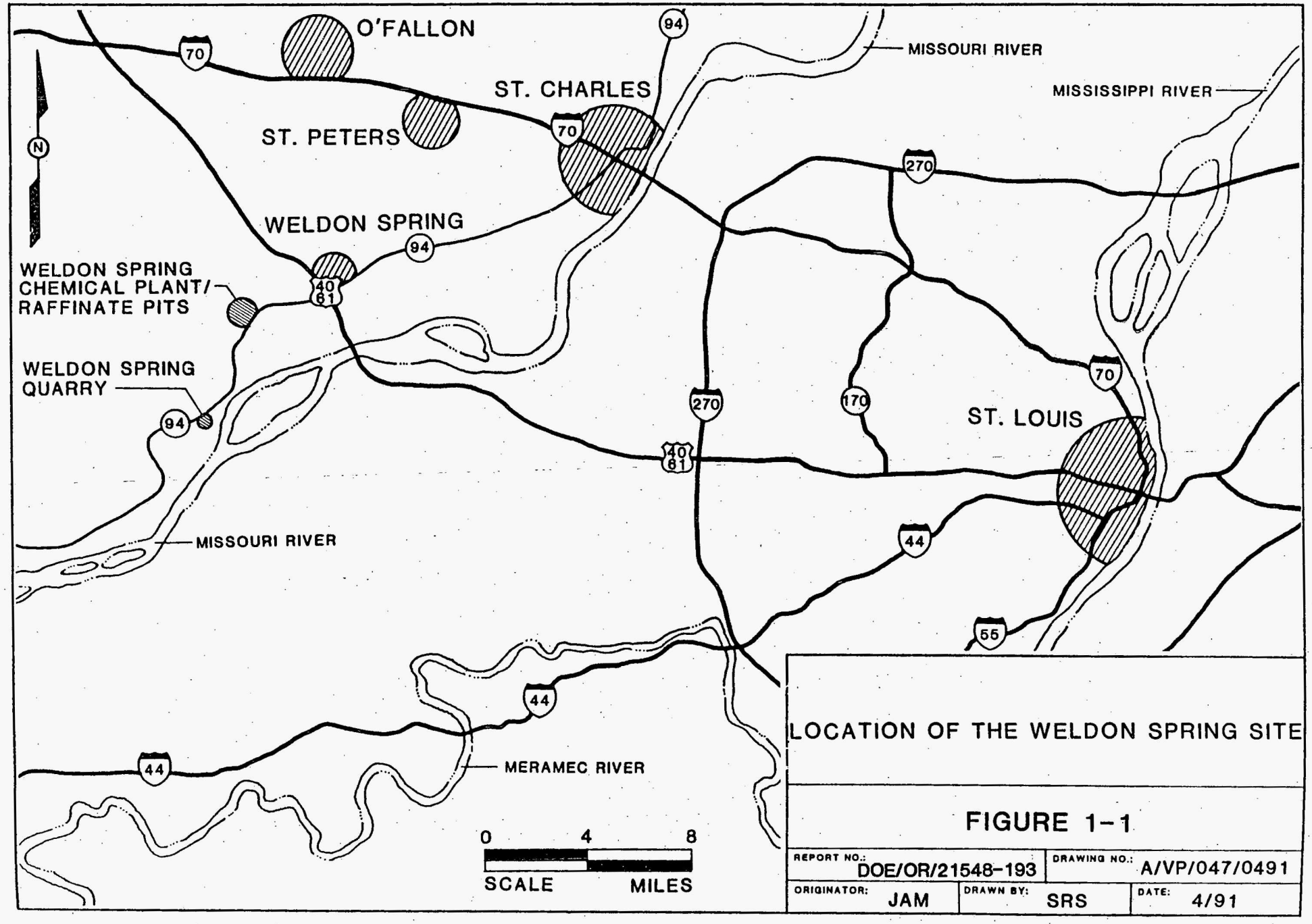
Uranium and thorium residues, waste materials, and contaminated rubble are stored at the WSS. In addition to environmental monitoring, engineering activities are being conducted to minimize the migration of contaminants from these facilities into surface water and groundwater.

Additional characterization activities have been conducted at the WSCP and WSRP during 1990. These activities provide information on the types and magnitudes of the contamination. The complete picture of characterization information has been presented in the Draft WSSRAP Remedial Investigation (RI) report issued to EPA in 1990 and scheduled for completion in 1991. This information will be used to evaluate the course of remedial actions.

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

Weldon Spring Raffinate Pits

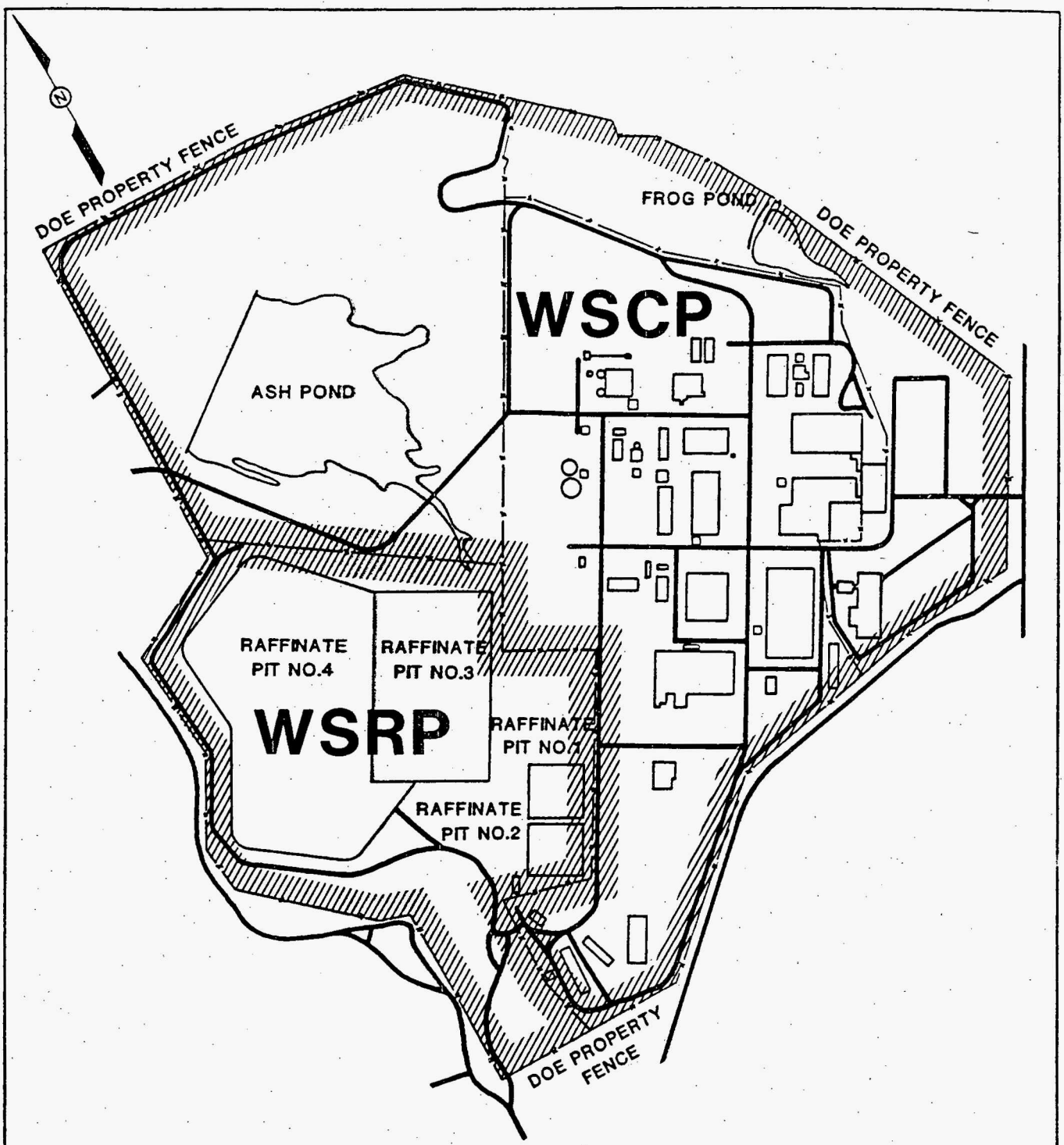
Figure 1-2 is map of the WSCP/WSRP area. The 20.7-ha (51-acre) area includes four pits that cover approximately 10.5 ha (26 acres). The raffinate pits were constructed by excavating into the existing clay soils and using the removed clay for construction of dikes. These pits contain radioactive residues (raffinates) from uranium and thorium processing



LOCATION OF THE WELDON SPRING SITE

FIGURE 1-1

REPORT NO.: DOE/OR/21548-193	DRAWING NO.: A/VP/047/0491	
ORIGINATOR: JAM	DRAWN BY: SRS	DATE: 4/91



SCALE 0 500 1000 FT
0 152.4 304.8 M

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

FIGURE 1-2

REPORT NO.: DOE/OR/21548-193		EXHIBIT NO.: A/CP/113/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91	

operations at the former Weldon Spring Uranium Feed Materials Plant (WSUFMP) which is now the WSCP.

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 1990 monitoring year, surface water covered the vast majority of the residues in the pits.

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, comprises 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. The data on these substances and their impacts to the environment will be detailed in the previously mentioned Remedial Investigation (RI) report.

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.

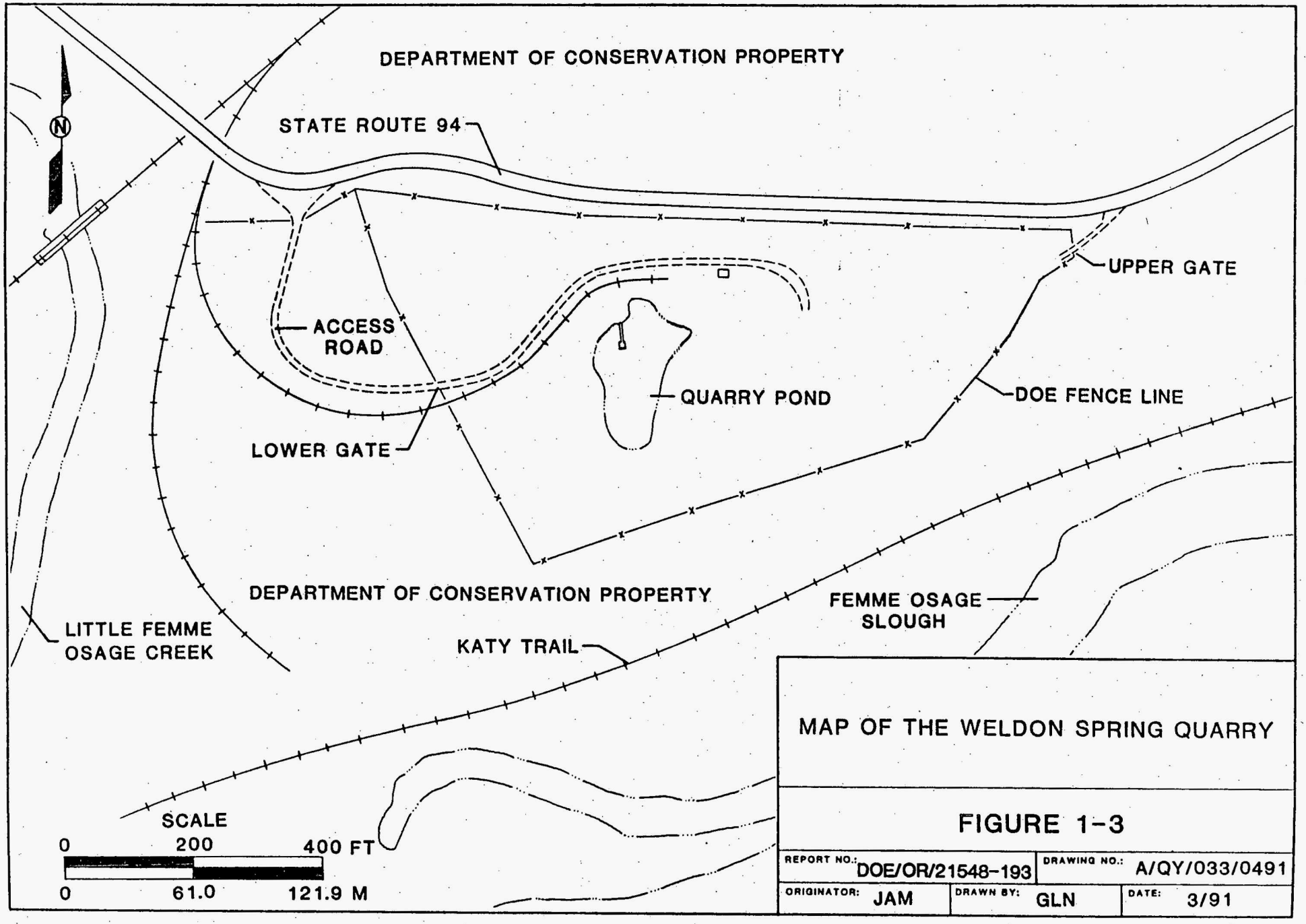
The only structures at the WSQ site are a small storage shed and a sampling platform in the pond area. Access to the site is restricted by a locked, 2.1-m (7-ft) high chain link fence. The amounts and types of wastes in the WSQ are summarized in the *Remedial Investigation Report for Quarry Bulk Wastes* (MKF and JEG 1989a).

1.2 Site History

The WSS has a complex history of production processes within its boundaries. Between 1941 and 1944, the U.S. Department of Army (DA) occupied the property (Weldon Spring Ordnance Works--WSOW) and located four of its 20 explosives production lines across the WSS area (the remaining 16 production lines were distributed across an adjacent property which is now referred to as the U.S. Army's Reserve Training Area, Weldon Spring, Missouri). The WSOW produced dinitrotoluene and trinitrotoluene (DNT and TNT) for the Allied Forces during World War II.

In 1955, 83 ha (205 acres) of the former ordnance works property was transferred to the U.S. Atomic Energy Commission (AEC) for construction of the WSUFMP. Until 1966, the AEC operated 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. The wastes generated from these operations were stored in four raffinate pits on the site property.

In 1958, the AEC acquired title to the WSQ from the DA. The WSQ had been used earlier by the DA for disposal of TNT-contaminated rubble during the operation of the



MAP OF THE WELDON SPRING QUARRY

FIGURE 1-3

REPORT NO.: DOE/OR/21548-193	DRAWING NO.: A/QY/033/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91

WSOW. The AEC used the WSQ as a disposal area for a small amount of thorium residue, but most of the material disposed of there consisted of uranium- and radium-contaminated building rubble and soils from the demolition of a uranium ore processing facility in St. Louis.

In February 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 WSSRAP was selected in February 1986. In July 1986, a DOE project office was established on site. The PMC, MK-Ferguson Company, 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 WSCP/WSRP was added to the NPL in March 1989.

Remedial investigations were conducted at the WSCP/WSRP area in 1988 and 1989. The 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 removal of exposed friable asbestos and overhead piping, PCB electrical equipment removal, power pole and wire removal, nonprocess-building demolition, Ash Pond isolation, and containerized chemical consolidation. Section 7.2 of this report details the interim response actions (IRAs) in process or completed during 1990.

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.

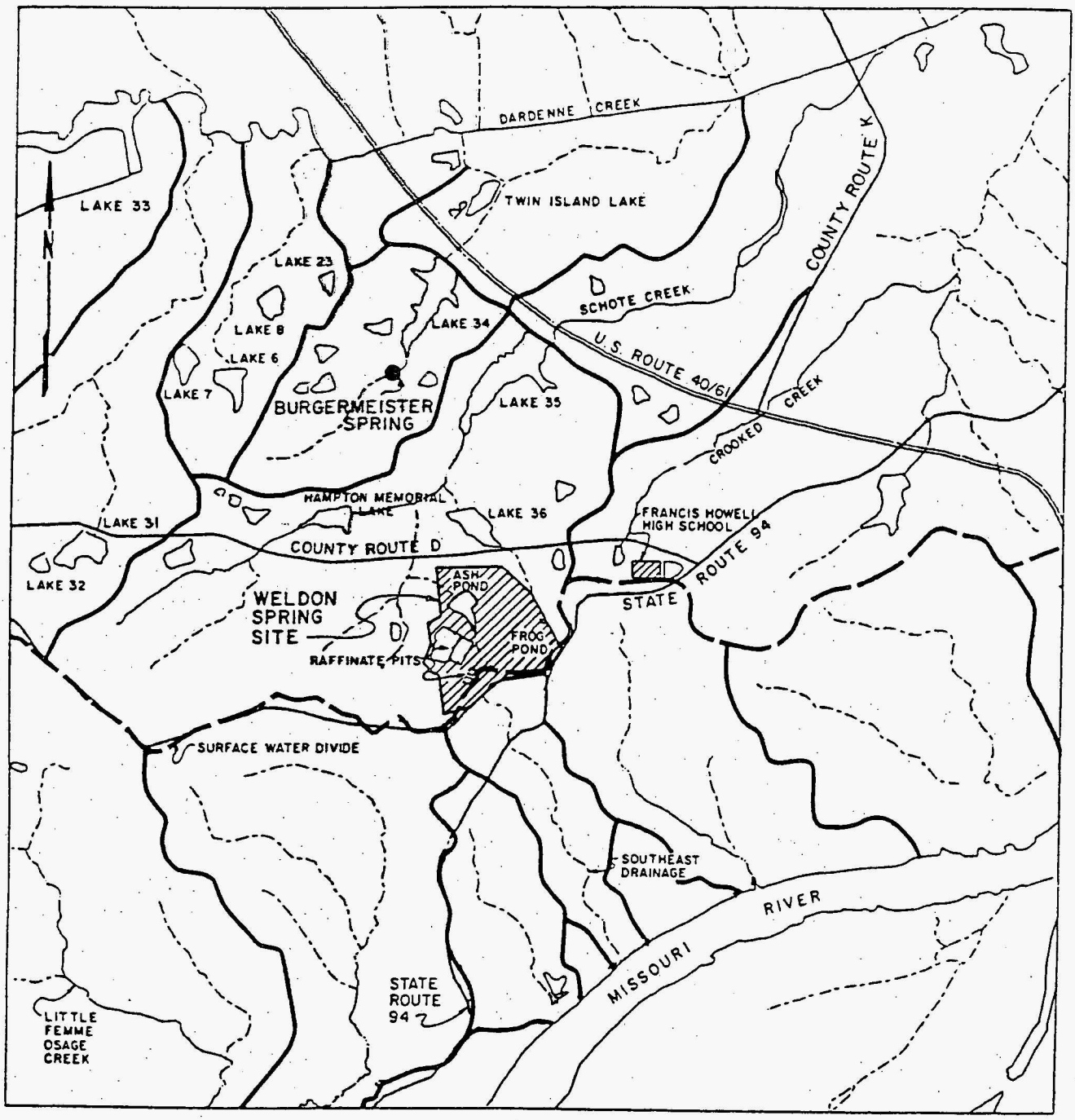
The residual contamination within the quarry confines can be characterized when the excavation is completed.

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 Army Reserve Training Area 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. 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 Weldon Spring 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/21548-193		EXHIBIT NO.: A/VP/068/0591	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 5/91	

2 COMPLIANCE SUMMARY

2.1 Compliance Status for 1990

The Department of Energy's Weldon Spring Site Remedial Action Project (WSSRAP) is subject to meeting or exceeding the regulatory requirements of Federal, State, and local laws and statutes. The WSSRAP maintains a permanent staff of compliance experts who monitor the progress and status of the project relative to the environmental laws. The following is a summary of applicable regulations and the WSSRAPs current compliance status.

2.1.1 Compliance Status

National Environmental Policy Act

The WSSRAP has successfully integrated the procedural and documentation requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) 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 sites' Remedial Investigation/Feasibility Study-Environmental Impact Statement (RI/FS-EIS). For example, Engineering Evaluation/Cost Analysis (EE/CA) and Remedial Investigation/ Feasibility Study (RI/FS) documents are adopted by the U.S. Department of Energy (DOE) as Environmental Assessments (EAs) and Environmental Impact Statements (EISs) and contain the required NEPA information. Proposed plans and actions are evaluated in terms of both NEPA and CERCLA. Actions falling under the categorical exclusion (CX) classification are submitted as such for approval. The WSSRAP submitted six categorical exclusions in 1990; four have been approved. The CX actions approved are: (1) the off-site removal of tributyl phosphate (TBP) to the Oak Ridge incinerator for destruction, (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, and (4) a variety of general plant projects, e.g., repaving the administration building parking lot. A memorandum-to-file was approved in September for a material staging area which will serve as a temporary storage area for debris resulting from building dismantlement at the chemical plant.

Comprehensive Environmental Response, Compensation, and Liability Act

The WSSRAP removal and remedial actions are performed under CERCLA (as amended by Superfund Amendments and Reauthorization Act [SARA]). The requirements of the following acts, laws, regulations, etc. may have Applicable or Relevant and Appropriate Requirements (ARARs) for the site.

Resource Conservation and Recovery Act

Hazardous waste at the Weldon Spring site (WSS) is managed as required by Resource Conservation Recovery Act (RCRA) (and substantive ARARs) and 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 for wastes generated during remedial activities. Phase II of the chemical consolidation is discussed in more detail in the Issues and Action Section. RCRA permits are not required at the WSS since the remediation is being performed in accordance with decisions reached under CERCLA. Section 121(e) of CERCLA states that no Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely on site.

Toxic Substances Control Act

PCBs are managed at the WSS under the requirements of the Toxic Substances Control Act (TSCA). Non-radiologically contaminated PCBs are scheduled for off-site disposal in 1991. More information is offered in the Issues and Actions Section.

Clean Air Act

The portion of the Clean Air Act (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 was approved by the Environmental Protection Agency (EPA), and is explained in more detail in the Issues and Actions Section.

Clean Water Act

Compliance under the Clean Water Act (CWA) consists of the two National Pollution Discharge Elimination System (NPDES) permits. Both effluent and erosion control monitoring is performed. NPDES permit limits were exceeded twice in 1990 at the administration building sanitary wastewater plant. Operational adjustments to the plant were made by the subcontractor, bringing levels to below permit 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 competent archaeologist was consulted for the quarry and the quarry haul road. The archaeologist found six sites in the quarry vicinity, that unless disturbed by newly planned activity, will need no mitigation. A preliminary investigation and surveillance was performed by the archaeologist on the haul road in 1990. The investigation will continue in 1991 before construction begins.

Endangered Species Act

The U.S. Fish and Wildlife Service (USFWS) has been consulted under Section 7(a) of the Endangered Species Act. An ecological assessment is being performed in conjunction with the Baseline Assessment. The Baseline Assessment will evaluate risks to human health and the environment in support of overall site waste management decisions. The ecological evaluation includes a review of threatened and endangered species present, or potentially present, in the area of the Weldon Spring site.

Consultation with USFWS regarding endangered species continued in 1990. The USFWS will be contacted in 1991 concerning the biological assessment requirement for the quarry haul road and the chemical plant. The Missouri Department of Conservation lists numerous threatened or endangered species for the county in which the WSS is located and will be consulted concerning the state's requirement for a biological assessment.

Executive Order 11988 Floodplain Management

The Engineering Evaluation/Cost Analysis Environmental Assessment (EE/CA-EA) for the proposed management of contaminated water at the Weldon Spring quarry contains a floodplain assessment that describes the impact of the floodplain as a result of construction activities at the quarry. The structure to be located in the floodplain is the effluent pond 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.

2.1.2 Issues and Actions

2.1.2.1 Ongoing Issues. An amended Federal Facilities Agreement (FFA) is being negotiated between the DOE and the EPA. The EPA transmitted the final draft of the FFA to DOE-Headquarters for approval. Any final issues will be negotiated during DOE review and the signature process.

In June 1988, electrical equipment was discovered on a concrete pad (Substation 411) outside of the WSS property boundaries. The equipment consisted of three transformers, a circuit breaker, three pole-mounted units and other electrical equipment that had remained in place since the closure of the chemical plant. One of the transformers contained 1,637 liters (360 gal) of oil contaminated with approximately 150 parts per million (ppm) of PCBs. One of the pole-mounted units contained 55 liters (12 gal) of oil contaminated with 1,100 ppm of PCBs. More discussion on Substation 411 is included in Section 7 of this report.

In August 1990, eight drums of PCB contaminated oil were generated by draining the transformers containing greater than 50 ppm of PCB. Two pole-mounted transformer units were placed in overpack containers. The containers have been stored in the RCRA/TSCA regulated building (Building 434) awaiting disposal. The containers will be disposed off site before August 1991.

Three compliance issues that were identified in 1990 still remain unresolved. They are described below.

Issue No. 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 on the Weldon Spring site. In addition, preliminary analyses indicate the TBP is also contaminated with mercury exceeding the regulatory level for Toxicity Characteristic, thereby making it a RCRA hazardous waste. On the site, there are also small amounts of radiologically contaminated PCB waste within electrical capacitors, and eight drums of PCB-contaminated soil suspected of radiological contamination.

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 for Issue No. 1: 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.

Efforts to send the TBP to the Oak Ridge Gaseous Diffusion Plant Incinerator for destruction continued during 1990. The incinerator was not operational during 1990.

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

Issue No. 2: Unknown abandoned wastes at the processing plant have not been chemically analyzed or placed in proper storage (40 CFR 264).

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 are being addressed by Phase II. Chemicals were found during both phases in tanks, sumps, process vessels, and in abandoned buildings. Phase I was completed in January 1989.

Corrective Action for Issue No. 2: After the containers which were accumulated and consolidated during Phase I were moved to the new RCRA storage area in Building 434, emphasis was directed to identifying, characterizing, and containerizing the remaining chemicals in accordance with the appropriate regulations. Activities included moving unknown chemicals to the site staging areas; and sampling, testing, and repackaging as necessary to meet the requirements of 40 CFR 264. As chemicals are properly packaged, they are placed in the RCRA storage facility in Building 434 pending final disposition.

Issue No. 3: Surpassing the Missouri State maximum permissible exposure limit for radon at the quarry (19 CSR 20 - 10.040)

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 for Issue No. 3: 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 Record of Decision (ROD).

2.1.2.2 Significant Accomplishments. In March 1990, Building 434 remodeling was completed for the storage of TSCA and RCRA wastes. The building meets storage requirements for RCRA and TSCA wastes and is inspected on a weekly basis.

The WSSRAP NEPA Compliance Officer (NCO) position was created in 1990 to review and ensure compliance with the requirements of NEPA. A procedure for ensuring early review of proposed activities was developed and has been implemented. Categorical exclusion determinations are being made for relevant subcontracts and projects to ensure compliance. NEPA EA and EIS documents are integrated with CERCLA EE/CA and RI/FS documents.

2.1.2.3 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 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 determine 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 Sections 4.1.6 and Appendix G. During calendar year 1990, no significant asbestos abatement activities were performed at the site.

2.1.2.4 Satisfaction of Reporting Requirements

2.1.2.4.1 Continuous Release Reporting. There have been no reportable quantity releases from the WSS not exempted as a Federally permitted release. Consequently, no continuous release reports have been submitted.

2.1.2.4.2 SARA Title III Report. For the 1990 calendar year, WSSRAP reported the following hazardous chemicals in the SARA Title III Annual Chemical Inventory Report: 15 drums of polychlorinated biphenyls (PCBs); two process tanks containing a solution of tributyl phosphate (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. WSSRAP is not a facility in the standard industrial classification and is therefore not required to submit the annual Toxic Release Inventory under Section 313 of SARA.

2.1.2.5 Audit Summary. The DOE from Oak Ridge National Laboratory (ORNL) conducted an environmental compliance audit at the Weldon Spring site in October 1990. Draft findings were subsequently submitted to the WSSRAP. In December 1990, a Corrective Action plan responding to the findings was submitted to ORNL.

Oak Ridge Operations (ORO) also conducted an appraisal of the environmental safety and health and quality assurance procedures at the site in October 1990. Findings were transmitted to the WSSRAP in December 1990. A response to the findings was submitted to ORO in January 1991.

The audits identified Major (Priority II) and Minor (Priority III) findings. The attached matrix gives the status of the Major findings. The Minor findings are addressed in the corrective action plan for each audit. No Significant (Priority I) findings are known and none were determined by audit.

2.1.3 Summary of Permits for 1990

The WSSRAP maintains the following permits:

2 NPDES permits (quarry and chemical plant).

1 Construction permit from the Missouri Department of Natural Resources (MDNR) for the quarry water treatment plant.

1 Driveway permit from the Missouri Highway and Transportation Department for the entrance at the quarry.

1 Floodplain Development permit from St. Charles County Planning and Zoning Commission.

TABLE 2-1 ORNL Audit October 1, 2, 3, 1990

REGULATION	ISSUE	CORRECTIVE ACTION	DATE IN COMPLIANCE
40 CFR 264.194	TBP tanks spill/overflow controls are inadequate.	No material has been added or taken from the tanks in 20 years. Openings and valves are closed and the tanks are less than 75% full to allow expansion. Tanks are inspected daily. Letter transmitted to MDNR 10/16/90 seeking concurrence.	OPEN
40 CFR 761.65(b)(i)ii	TBP tanks require roof and walls to prevent rain contact with PCB materials.	On 10/11/90 the TSCA branch of EPA Region VII was consulted. It was determined that roof and walls were not needed.	OPEN

082791

TABLE 2-2 ORO Audit October 15-19, 1990

REGULATION	ISSUE	CORRECTIVE ACTION (From Corrective Action Plan dated 1/91)	DATE IN COMPLIANCE
40 CFR 268.50	Land ban wastes stored beyond time limits.	WSSRAP does not concur because WSSRAP waste was stored prior to land ban (51 FR 40577).	OPEN
40 CFR 265.194	TBP tanks spill/overflow controls are inadequate.	See ORNL corrective action above.	OPEN
40 CFR 61, Subpart M	Areas of uncontained, possibly friable, asbestos materials were observed.	The major portion of uncontained asbestos from outdoor locations has been abated. The current schedule for remediation of uncontained ACM is appropriate for site remedial action priorities.	OPEN
29 CFR 1910.1001 29 CFR 1926.58 40 CFR 763.121	Asbestos containing materials not properly labelled.	Areas of ACM that cannot be labeled are posted with signs. Safety and health training and controlled access to the restricted areas meets the intent of the OSHA regulations.	OPEN
DOE Order 5400.1 40 CFR 262.41(a)(6)	Asbestos waste is not segregated by radiological contamination and non-radiological contamination.	WSSRAP does not concur. Regulation and order do not provide criteria for differentiating rad and non-rad contaminated asbestos	OPEN
40 CFR 262.41(a)6	Proper documentation for asbestos abatement action and waste disposal receipts is not being maintained.	WSSRAP will ensure documentation is provided in the future.	OPEN

082791

Archaeological and Historic Preservation Act

In March 1991, the WSSRAP consulting archaeologist further investigated the potential sites along the quarry haul road to determine whether mitigation will be necessary before construction of the road begins.

2.2 Compliance Status for the Period January 1 - April 15, 1991

Status remains unchanged under CERCLA, RCRA, TSCA, CWA, the Endangered Species Act, and Executive Order 11988.

NEPA

Approval of two categorical exclusions is anticipated in April 1991. The approval will allow construction of an annex to the administration building and construction of a composite building to house the new access control, warehouse, and lab space.

Clean Air Act (CAA)

Removal of asbestos from buildings and tanks at the chemical plant was initiated in February 1991. Under this activity, asbestos, and asbestos-containing material will be removed according to the NESHAP and OSHA regulations.

Archaeological and Historic Preservation Act

In March 1991, the WSSRAP consulting archaeologist further investigated the potential sites along the quarry haul road to determine whether mitigation will be necessary before construction of the road begins.

2.2.1 Current Issues and Actions

Beginning in February 1991, an asbestos abatement action was initiated. This project involved removal of friable and nonfriable asbestos materials from six non-process buildings, three outside insulated storage tanks, and several asbestos items stored in outside debris storage areas. The revised asbestos NESHAPs regulations, including the amended

notification requirements, were incorporated into the abatement project specifications. Friable asbestos wastes were containerized and transferred to Building 103 for interim on-site storage.

No other new issues or actions were initiated from January 1 to April 15, 1991.

2.2.2 Summary of Permits for 1991

The WSSRAP currently maintains the following permits:

2 NPDES permits (quarry and chemical plant).

1 Construction permit from Missouri Department of Natural Resources for the quarry water treatment plant (QWTP).

1 Application of renewal of construction permit for the QWTP.

1 Driveway permit from the Missouri Highway and Transportation Department for the entrance at the quarry.

1 Floodplain Development permit from St. Charles County Planning and Zoning Commission for construction of a portion of the equalization basins at the quarry.

3 ENVIRONMENTAL PROTECTION PROGRAM

3.1 Environmental Program Overview

The U.S. Department of Energy (DOE) has implemented a multifaceted environmental management approach at the Weldon Spring site (WSS) to meet the requirements of the National Environmental Policy Act (NEPA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The project is designed to reduce the health or safety threats to on-site workers and the public, mitigate actual or potential uncontrolled contaminant releases, provide for public participation through an active community relations program, and lead to timely initiation of remedial actions. The DOE approach for implementing remedial action at the Weldon Spring site consists of the following major elements:

- Site characterization.
- Risk evaluation.
- Preparation of Remedial Investigation/Feasibility Study (RI/FS) Environmental Impact Statement (EIS) consistent with both NEPA and CERCLA.
- Initiation and completion of interim response actions.
- Removal of quarry bulk wastes as a separate operable unit.
- Preparation of a separate RI/FS and baseline assessment for the quarry as a separate operable unit.
- Site remediation.

The difficulty in characterizing the wastes and environmental media at the quarry has led to the identification of the quarry as a separate operable unit. Quarry bulk waste will be removed and transported to the chemical plant site for temporary storage. This remedial action is addressed under a separate RI for quarry bulk wastes (MKF and JEG 1989a). The

quarry bulk waste will ultimately be disposed of with wastes from the chemical plant and the raffinate pits. Subsequent to the removal of the bulk wastes from the quarry, an RI/FS and baseline assessment for the quarry environs will be conducted. The results will be presented in separate documents which are consistent with the overall Weldon Spring Site Remedial Action Project (WSSRAP) objectives and CERCLA and NEPA requirements.

While the environmental documentation process and remedial action is ongoing, environmental monitoring has been and will continued to be performed to assess the impacts of remedial action on all affected media. Over the long term, this monitoring will document the effectiveness of remedial action. Environmental monitoring will also demonstrate, in the near term, the effectiveness of engineering controls on minimizing releases and exposures during remedial action. Currently, routine monitoring at the WSS provides baseline data prior to remedial action and documents releases and exposures to the public and the environment.

3.2 Site Programs to Ensure Quality

The WSSRAP maintains numerous on-site programs to ensure the quality of the work performed. These programs continually stress the project priorities of quality and environmental safety and health. Two programs include self-assessment and training maintenance and tracking. The following is a summary description of those programs exercised in 1990.

3.2.1 Self-Assessment Program

During 1990, development of a formal self-assessment program was initiated. Although a formal self-assessment program did not exist during 1990, project quality assurance personnel performed audits and surveillances covering essentially all quality-affecting aspects of the environmental monitoring program. Specifically, environmental protection, radiation protection, industrial hygiene, and environmental compliance activities were reviewed to assess procedural compliance. Environmental protection activities associated with sample collection and integrity were reviewed. Radiation protection procedures regarding worker protection and environmental monitoring activities and shipping of radioactive materials were evaluated. Asbestos and worker protection monitoring procedures were reviewed within the Industrial Hygiene group. Environmental Compliance

activities regarding the storage of hazardous waste, the shipping of regulated materials, and the NPDES program were reviewed.

Corrective action plans have been formulated for discrepancies identified in audits and are currently being implemented. Progress in the implementation of corrective actions is verified and tracked through the site-wide audit tracking system.

3.2.2 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 WSSRAP is evaluated and assigned training requirements based on job assignment. The department manager establishes a unique training matrix for each employee that includes documents, procedures, and on and 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 FY 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.

3.3 Waste Minimization/Pollution Prevention Program

The waste minimization/pollution prevention activities at the WSS have been combined and are described in the *Waste Minimization/Pollution Awareness Plan* (MKF and JEG 1990b). The waste minimization 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 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 sites employee participation program.

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 gal] drums to small vials) were collected, field analyzed, consolidated and placed in interim storage pending 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 1991a). The wastes will be stored in the on-site Resource Conservation Recovery Act (RCRA) storage facility, Building 434, until a final treatment or disposal option is available.

The on-site RCRA storage facility, Building 434, 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. The majority of wastes are contained in U.S. Department of Transportation (DOT) approved 209 liters (55 gal) drums and overpacks. The current containerized inventory includes 486 drums of hazardous material, 187 drums of asbestos containing material, 138 drums of RCRA regulated material, 43 drums of the Missouri Department of Natural Resources (MDNR) regulated material, 31 drums of Toxic Substance Control Act (TSCA) regulated material, 87 drums of other DOT hazardous material, and 550 drums of non-hazardous material. These drums are stored according to RCRA standards.

All wastes at the WSS are tracked using the Waste Inventory/Tracking System (WITS), a computer oriented 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 from its original location, a temporary location, or tracking a specific container. The disposal function is capable of providing information on the disposal of material from its original location, disposal from a temporary location, or disposal of a specific container. The report generation function is capable of producing reports based on the original inventory, remaining inventory, transferred inventory, disposed inventory, reportable quantities, and the tracking of a specific container, or type of waste.

3.5 Unusual Occurrence Reporting for Environmental Incidents

On September 20, 1990 an incident occurred within the chemical plant area in Building 406. During containerized chemical consolidation activities, incompatible substances, i.e., sodium metal bars and an aqueous caustic solution, were combined. The ensuing reaction resulted in the release of approximately 95 liters (25 gal) of caustic liquid

which was confined to the interior bermed portion of the building. Therefore, the release was not reportable under CERCLA and RCRA.

The released material was subsequently neutralized and recontainerized. No radioactive material was involved in the incident and only minor chemical burns were sustained by three employees working in the area. Corrective actions involved the implementation of a new safety oversight/management procedure that is designed to ensure communication of safety and health hazards and preventative measures at the working level. The incident was reported as an unusual occurrence under DOE Order 5000.3A.

3.6 Dam Safety Inspections

In early 1990, the PMC evaluated the dam safety requirements applicable to the WSSRAP. The PMC evaluated the raffinate pits, the Ash Pond dam, and the Ash Pond diversion structure against State and Federal regulations. It was determined that State requirements do not apply to Federally-owned structures or properties regulated by a dam safety program. Under Federal regulations, a dam or berm is regulated if it has a height of 7.6 m (25 ft) or greater as measured from the downstream toe to the maximum water storage elevation, and also if failure of the dam creates a significant downstream hazard.

It was determined that all four raffinate pits fall under Federal regulations. The berms of pits 3 and 4 meet the slope length regulations and the contamination in the pits poses a significant potential downstream hazard. Pits 1 and 2 also pose a significant potential downstream hazard. The PMC determined that the Ash Pond structures do not qualify as regulated dams.

Federal regulations require that all regulated structures be subjected to a standard inspection program. This program consists of surveillance on a regular basis, intermediate inspections on a yearly basis, and a formal inspection once every five years. An emergency inspection may also be performed if some significant damage occurs to the structure. An informal surveillance of the raffinate pit berms was performed on a monthly basis beginning in June of 1990. This schedule will continue through mid-1991 so that the baseline condition of the berms can be established. After this time, the informal surveillances will be performed on a quarterly basis.

4 ENVIRONMENTAL MONITORING PROGRAM INFORMATION

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 DOE Order 5400 series. The substances present as wastes on the site require monitoring for both radiological and non-radiological species. Although the programs are described separately in this report for information utility, the sampling and analysis programs for each are conducted simultaneously. The environmental monitoring programs and the analytical results, which represent the status of environmental impacts from site related contaminants, are described below.

4.1.1 Surface Water And Spring Monitoring

Surface water samples were collected and analyzed for radiological parameters from a total of 25 locations; 13 within or near the Weldon Spring Chemical Plant/Weldon Spring raffinate pits (WSCP/WSRP) and 12 near the quarry. A total of 10 springs were monitored both north and south of the WSCP/WSRP for radiological parameters. 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 not significant disturbance in radium or thorium contaminated soil materials during 1990, it is not expected that the discharge of those nuclides in surface water would differ significantly from previous years. Many of these locations have been sampled by the WSSRAP for four consecutive monitoring years and are considered to be the most representative for monitoring contaminants that may pose a risk to the public health or the environment.

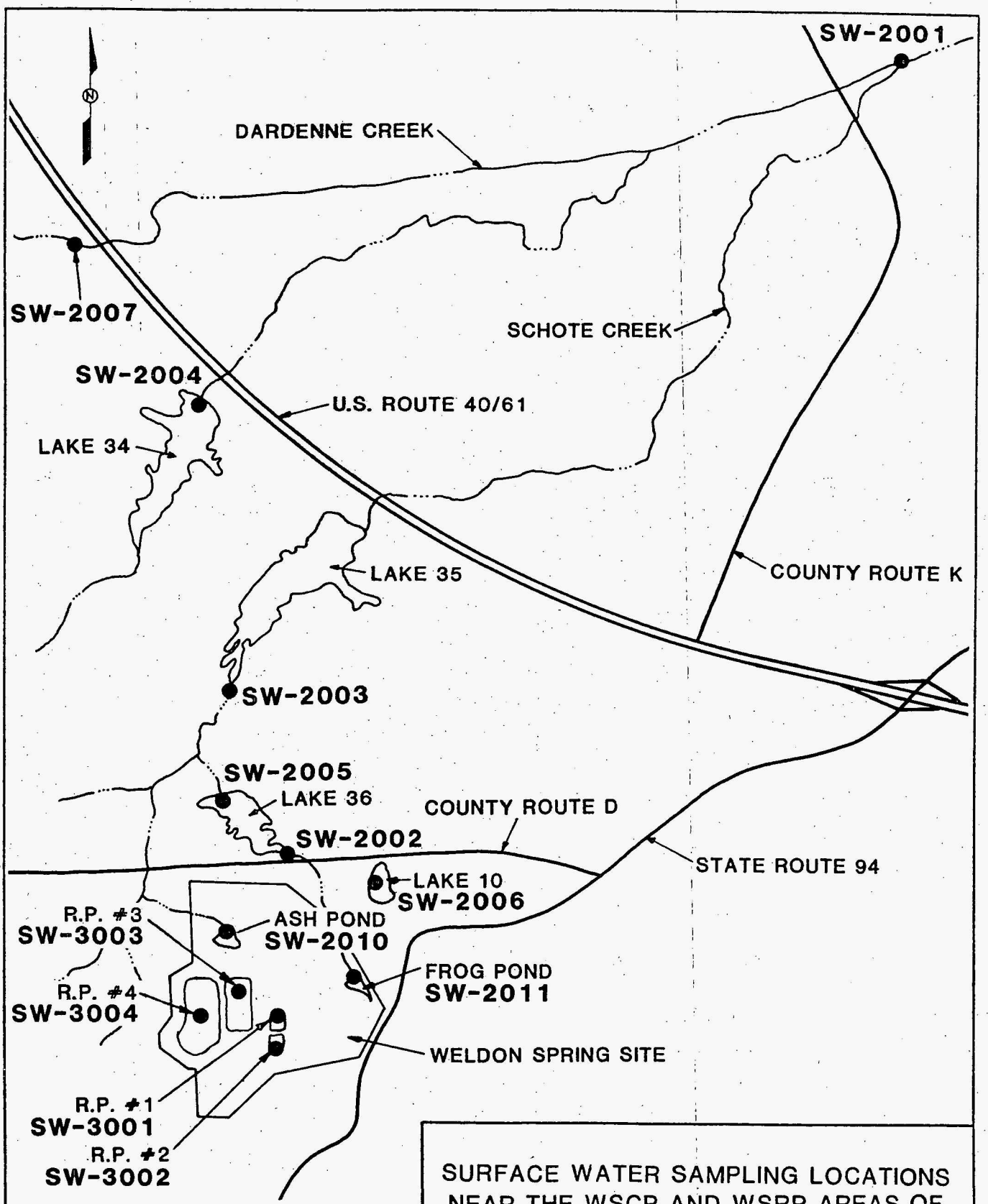
In an effort to maintain a current understanding of site-related contaminant concentrations in potentially affected surface water features, surface water samples were collected from five on-site and seven off-site locations. Locations SW-2007 and SW-2001 are upstream and downstream, respectively, of the surface water migration pathway from the

site. Locations SW-2002, SW-2003, SW-2004, SW-2005 and SW-2006 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 onsite. These locations are shown on Figure 4-1.

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 4-2.

The 12 surface water locations in Figures 4-3 and 4-4 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-1006 was renamed during the 1990 monitoring year as a groundwater monitoring location - GW-RAWW. Location SW-1008 monitors the ponded water 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.

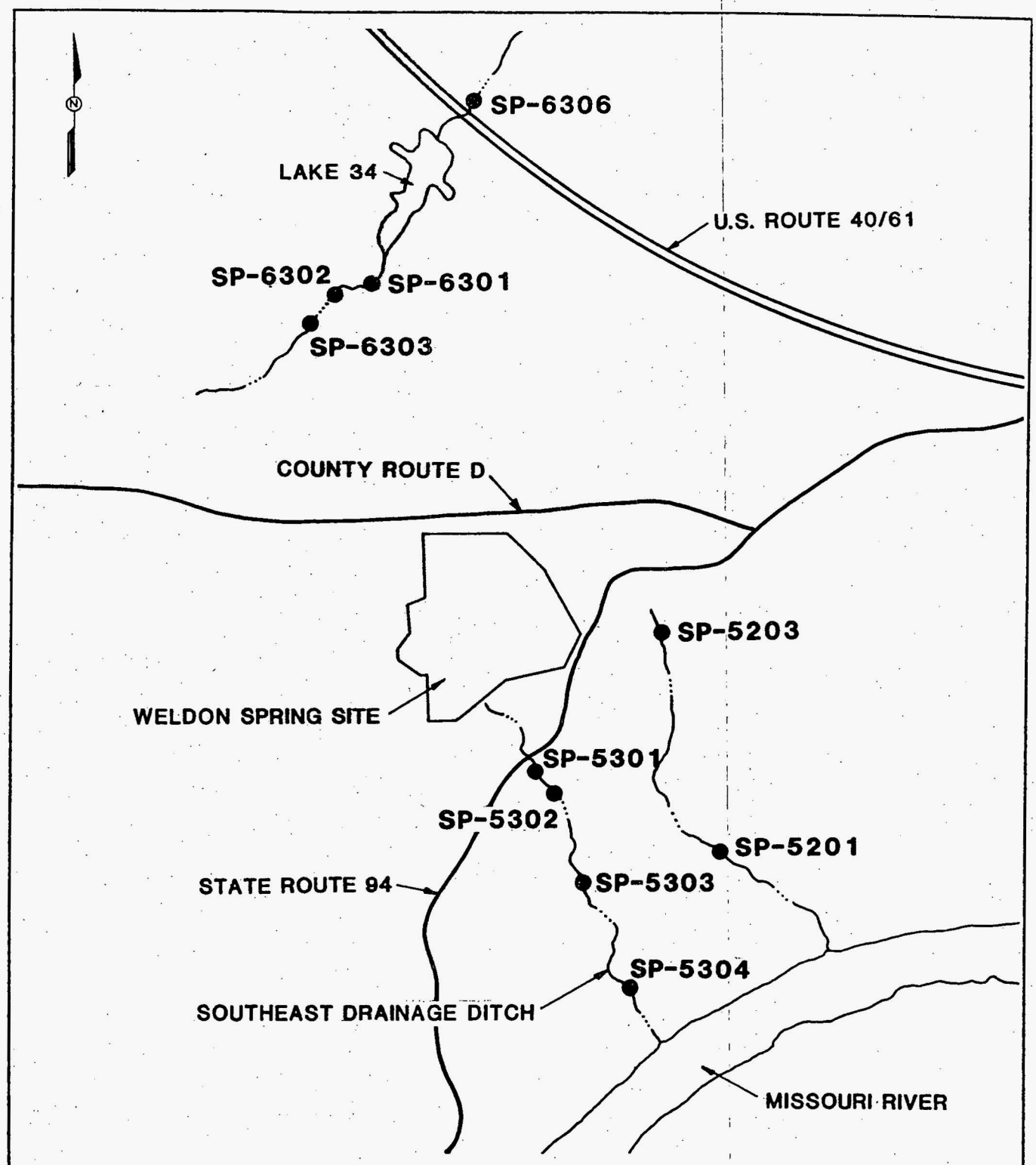
4.1.1.1 Weldon Spring Chemical Plant/Raffinate Pits. The average total uranium activities at off-site locations SW-2001, SW-2006, SW-2007, SP-5203, and SP-6303 were at background levels of less than 5 pCi/l (0.185 Bq/l) (see Tables 4-1 and 4-2 for annual averages). Off-site locations SW-2002, SW-2003, SW-2004, and SW-2005 ranged from a low of 7.34 pCi/l (0.27 Bq/l), or 1% of the derived concentration guideline (DCG) to a high of 190 pCi/l (7.03 Bq/l), or 32% of the DCG. These values were within their historical ranges as were all other off-site locations SP-5301, SP-5302, SP-5303, SP-5304, SP-5503, SP-6301, SP-6302, and SP-6306 which ranged from a low of 6.80 pCi/l (0.25 Bq/l), or 1% of the DCG, to a high of 592 pCi/l (21.9 Bq/l), or 99% of the DCG. The six on-site surface water



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

FIGURE 4-1

REPORT NO.: DOE/OR/21548-193		EXHIBIT NO.: A/VP/048/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91	



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

● - SAMPLE LOCATION

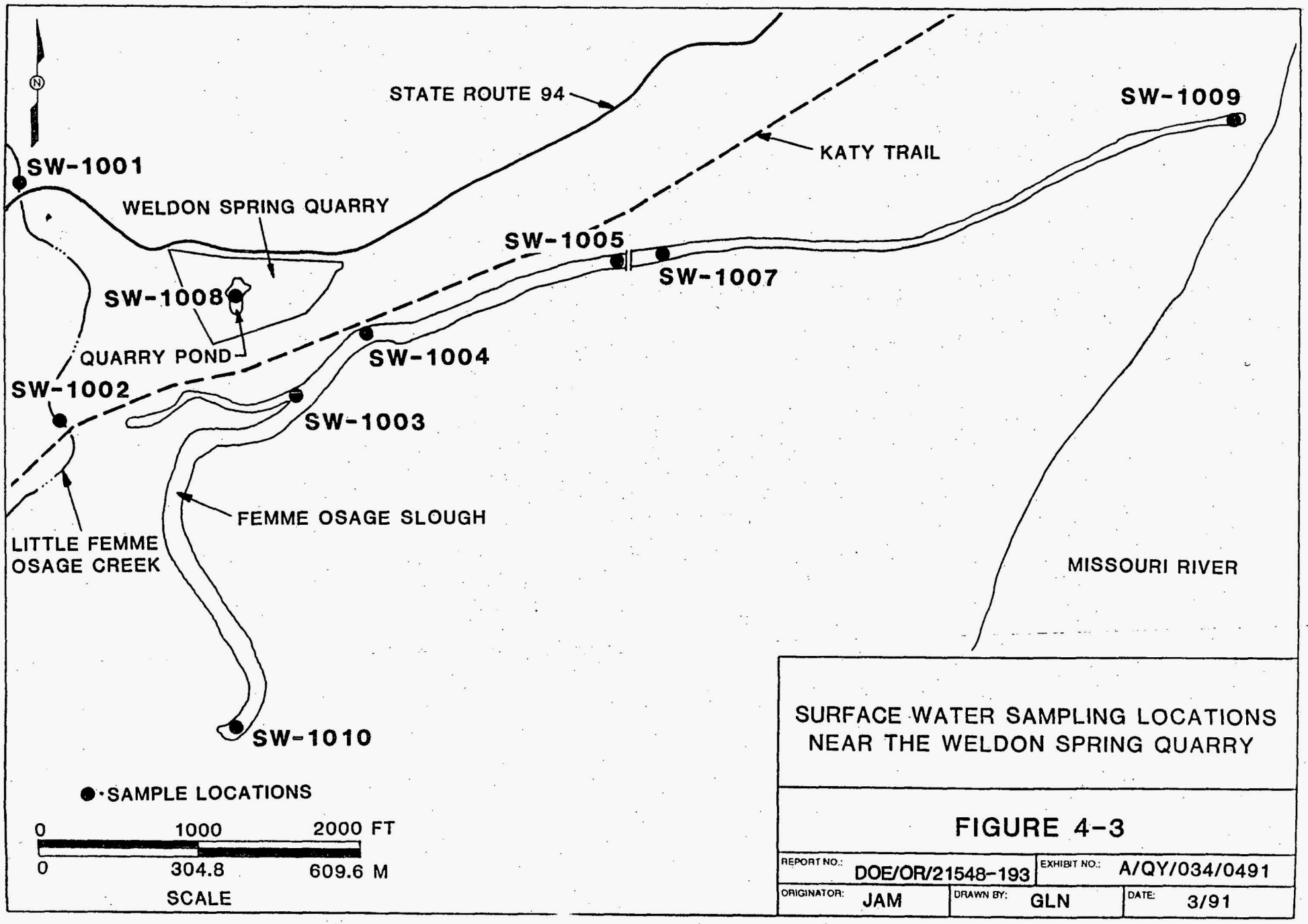
0 3200 6400 FT

0 975.4 1950.7 M

SCALE

FIGURE 4-2

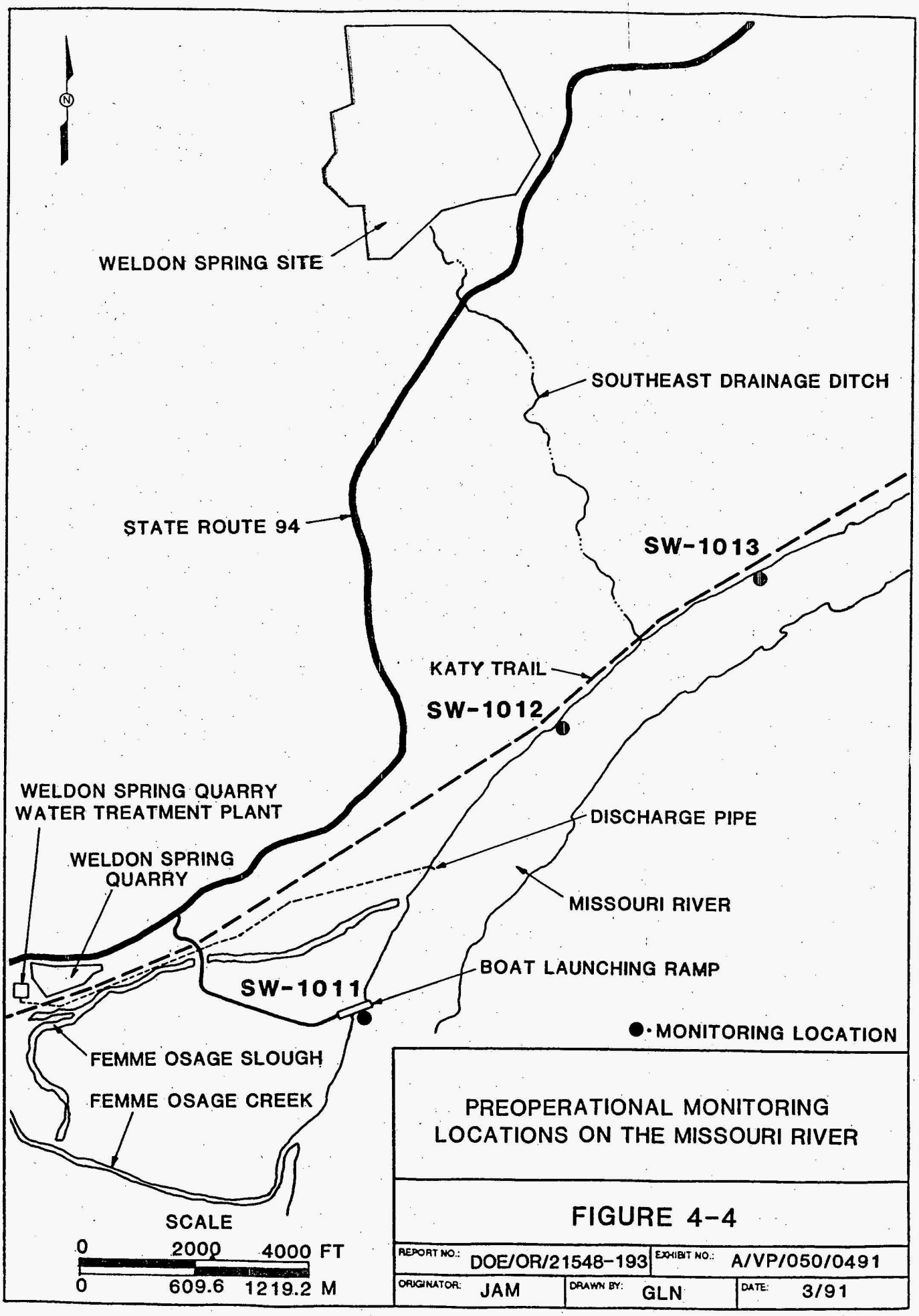
REPORT NO.: DOE/OR/21548-193		EXHIBIT NO.: A/VP/049/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91	



SURFACE WATER SAMPLING LOCATIONS
NEAR THE WELDON SPRING QUARRY

FIGURE 4-3

REPORT NO.: DOE/OR/21548-193		EXHIBIT NO.: A/QY/034/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91	



PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

FIGURE 4-4

REPORT NO.: DOE/OR/21548-193		EXHIBIT NO.: A/VP/050/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91	

TABLE 4-1 1990 Annual Average Uranium and Inorganic Anion Concentrations for Surface Water Near the WSCP/RP Area

WSSRAP ID	URANIUM (pCi/l) (0.68)*	@	CHLORIDE (mg/l) (0.25)*	@	FLUORIDE (mg/l) (0.25)*	@	NITRATE as N (mg/l) (0.1)*	@	SULFATE (mg/l) (1.0)*	@
SW-2001	4.9	(3/4)	NSF		NSF		NSF		NSF	
SW-2002	85.7	(4/4)	NSF		NSF		NSF		NSF	
SW-2003	14.7	(4/4)	NSF		NSF		NSF		NSF	
SW-2004	19.8	(4/4)	NSF		NSF		NSF		NSF	
SW-2005	16.5	(4/4)	NSF		NSF		NSF		NSF	
SW-2006	4.9	(3/4)	NSF		NSF		NSF		NSF	
SW-2007	4.5	(3/4)	NSF		NSF		NSF		NSF	
SW-2010	1792.0	(3/3)	NSF		NSF		NSF		NSF	
SW-2011	237.8	(4/4)	NSF		NSF		NSF		NSF	
SW-3001	292.4	(1/1)	27.9	(1/1)	0.3	(1/1)	464.0	(1/1)	318.0	(1/1)
SW-3002	1700.0	(1/1)	9.8	(1/1)	0.3	(1/1)	ND	(1/1)	415.0	(1/1)
SW-3003	1424.6	(2/2)	30.3	(1/1)	0.7	(1/1)	1900.0	(1/1)	695.0	(1/1)
SW-3004	1700.0	(1/1)	7.83	(1/1)	0.9	(1/1)	0.3	(1/1)	37.5	(1/1)

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

ND - Not Detected

NSF - Not Scheduled for Sampling

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.

* Detection limit

TABLE 4-2 1990 Annual Average Uranium and Inorganic Anion Results at Springs Near the WSCP/RP Area

WSSRAP ID	URANIUM (pCi/l) (0.68)*	@	CHLORIDE (mg/l) (0.25)*	@	FLUORIDE (mg/l) (0.25)*	@	NITRATE as N (mg/l) (0.1)*	@	SULFATE (mg/l) (1.0)*	@
SP-5203	1.7	(2/3)	NSF		NSF		NSF		NSF	
SP-5301	397.7	(4/4)	NSF		NSF		NSF		NSF	
SP-5302	368.9	(4/4)	NSF		NSF		NSF		NSF	
SP-5303	270.3	(4/4)	NSF		NSF		NSF		NSF	
SP-5304	119.3	(4/4)	NSF		NSF		NSF		NSF	
SP-5503	6.80	(1/1)	NSF		NSF		NSF		NSF	
SP-6301	56.6	(4/4)	32.0	(1/1)	ND	(0/1)	42.0	(1/1)	54.0	(1/1)
SP-6302	30.9	(2/2)	NSF		NSF		NSF		NSF	
SP-6303	4.1	(3/4)	NSF		NSF		NSF		NSF	
SP-6306	10.4	(3/3)	7.4	(1/1)	0.2	(1/1)	2.7	(1/1)	13.5	(1/1)

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

ND - Not Detected

NSF - Not Scheduled for Sampling

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.

* Detection limit

impoundments, the four raffinate pits, Ash Pond, and Frog Pond indicated a low of 170 pCi/l (6.29 Bq/l), or 28% of the DCG, to a high of 2,584 pCi/l (95.6 Bq/l), or 430% of the DCG. These levels are within their historical ranges.

No significant changes were observed between the average values measured in 1990 and 1989 at any of the 13 surface water or the 10 spring locations within or near the site. At the furthest downstream location, SW-2001 (the confluence of Schote and Dardenne creeks), the average of the quarterly measurements remained at background levels as in 1989, while the maximum value increased only slightly. No seasonal pattern was observed in the values.

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 concentrations (activity) of the 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 1990 at the raffinate pits only (see Table 4-3). Historically, no other monitoring locations have detected elevated levels of those species. The raffinate pits were sampled once in 1990 to maintain a baseline on the radioisotope levels. The radium and thorium values within the pits for 1990 were very similar to those of 1989.

4.1.1.2 Weldon Spring Quarry. The primary radionuclide of concern at the WSQ and surrounding area is total uranium, which was detected at levels ranging from 2.7 pCi/l (0.10 Bq/l) or less than 1% of the DCG within the Missouri River to a quarterly high of 3130 pCi/l (115.8 Bq/l) or 522% of the DCG in the quarry pond water within the access-controlled area. Refer to Table 4-4 for annual averages of uranium for sample locations near the quarry.

The quarry pond water was once again sampled quarterly for uranium. The average measured value was 2400.7 pCi/l (88.8 Bq/l) which is similar to but slightly higher than the average measured value of 1827 pCi/l (76.6 Bq/l) during 1989. The quarry pond poses little direct threat to the public health.

TABLE 4-3 1990 Radiological Results For Raffinate Pits (pCi/l)

WSSRAP ID	RADIUM-226	@	THORIUM-230	@	THORIUM-232	@
SW-3001	130.0	(1/1)	100.0	(1/1)	0.2	(1/1)
SW-3002	95.0	(1/1)	90.0	(1/1)	0.3	(1/1)
SW-3003	7.0	(1/1)	3.8	(1/1)	1.2	(1/1)
SW-3004	98.0	(1/1)	92.0	(1/1)	2.9	(1/1)

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were taken in 1990, two of which average 2.00 and the other two samples were ND.

Locations SW-1011 to SW-1013 are distributed along the north bank of the Missouri River to provide samples of river water for water quality testing in preparation for effluent discharge from the WSQ water treatment plant (WTP). The results of the measurements yielded annual average uranium activities for 1990 of 5.9 pCi/l (0.22 Bq/l) at SW-1013 (downstream), 5.7 pCi/l (0.21 Bq/l) at SW-1012, and 4.3 pCi/l 4.3 Bq/l) at SW-1011 (upstream). The error is $\pm$1.0 pCi/l (0.037 Bq/l). The highest quarterly measured uranium activity in the Missouri River was detected during the fourth quarter of 1990 at 9.52 pCi/l (0.35 Bq/l) or 2% of the DCG at SW-1013. These values fluctuate due to natural variations in the river water.

Uranium activities slightly above background were detected in the waters of the Little Femme Osage Creek both up and downstream of the quarry during the first quarter of 1990. Upstream (SW-1001) indicated 8.16 pCi/l and downstream (SW-1002) indicated 11.5 pCi/l. However, the later quarters for both locations were at background or non-detect. The higher uranium values for the first quarter were probably due to laboratory error as sampling blanks also contained uranium. The two locations will continue to be monitored.

The Femme Osage Slough, which is the former channel of the Femme Osage Creek prior to rerouting that stream course, is a nearly stagnant water body. The slough has been known to receive uranium contamination from the contaminated groundwater in the bedrock

TABLE 4-4 1990 Annual Average Uranium and Inorganic Anion Concentrations For Surface Water Near the WSQ

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	4.5	(3/4)	NSF		NSF		NSF		NSF	
SW-1002	6.8	(2/4)	NSF		NSF		NSF		NSF	
SW-1003	45.7	(4/4)	NSF		NSF		NSF		NSF	
SW-1004	47.6	(4/4)	NSF		NSF		NSF		NSF	
SW-1005	19.9	(4/4)	NSF		NSF		NSF		NSF	
SW-1007	17.2	(4/4)	NSF		NSF		NSF		NSF	
SW-1008	2400.7	(3/3)	12.1	(2/2)	0.9	(2/2)	ND	(2/2)	139.5	(2/2)
SW-1009	15.9	(3/3)	NSF		NSF		NSF		NSF	
SW-1010	34.4	(3/3)	NSF		NSF		NSF		NSF	
SW-1011	4.3	(3/3)	NSF		NSF		NSF		NSF	
SW-1012	5.7	(3/3)	NSF		NSF		NSF		NSF	
SW-1013	5.9	(3/3)	NSF		NSF		NSF		NSF	

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

ND - Not Detected

NSF - Not Scheduled For Sampling

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.

* Detection limit

082791

and alluvium to the north. In 1990, the uranium activities within the Slough ranged from a low of 8.84 pCi/l (0.33 Bq/l) or 1% of the DCG at SW-1009 to a high of 57.1 pCi/l (2.11 Bq/l) or 10% of the DCG at SW-1004. This is attributed to uranium contaminated groundwater discharging to the slough from the north side. The water level in the slough is managed by the Missouri Department of Conservation, whereby water is allowed to fill the slough during high river stage. The valve is closed at high stage and the water is retained in the slough. These fluctuating water levels are a mechanism for migration. All average uranium levels for the slough remained within their historical ranges.

According to the 1990 measurements, the quarry pond water did not contained Ra-226 or Ra-228 above the detection limit of 2 pCi/l (0.074 Bq/l), and Th-230 activities were measurable near the detection limit of 0.5 pCi/l (0.018 Bq/l) while Th-232 remained undetected. See Table 4-5. These values remain within their historical ranges.

4.1.2 Four Year Trend Analysis for Uranium in Surface Water

4.1.2.1 Weldon Spring Chemical Plant/Raffinate Pits. A four year trend analysis for uranium in surface water near the site was performed using surface water sampling locations SW-2001 through SW-2005 and SW-2007. Annual averages were used for the years 1987 through 1990. Refer to Figure 4-4A for a representation of this data.

The trend analysis does not portray an increase or decrease in uranium over a four-year period, but indicates fluctuations in concentrations that can be accounted for by natural dilution effects.

4.1.2.2 Weldon Spring Quarry. A four-year trend analysis for uranium in surface water near the quarry was performed using surface water sampling locations SW-1001 through SW-1005. Annual averages were once again used for the years 1987 through 1990 due to availability. Refer to Figure 4-4B for a representation of this data.

The trend analysis indicates fluctuations in uranium concentrations over a four-year period that can also be accounted for by natural dilution effects. However, it should be noted that surface water locations SW-1003 and SW-1004 do indicate a consistent trend of increasing from 1987 to 1989 and then decreasing during 1990. This pattern could be a

TABLE 4-5 1990 Annual Average Radiological Results For Surface Water in the WSQ (pCi/l)

WSSRAP ID	RADIUM-226	@	RADIUM-228	@	THORIUM-230	@	THORIUM-232	@
SW-1008	1.8	(3/3)	1.6	(1/1)	0.5	(2/3)	ND	(3/3)

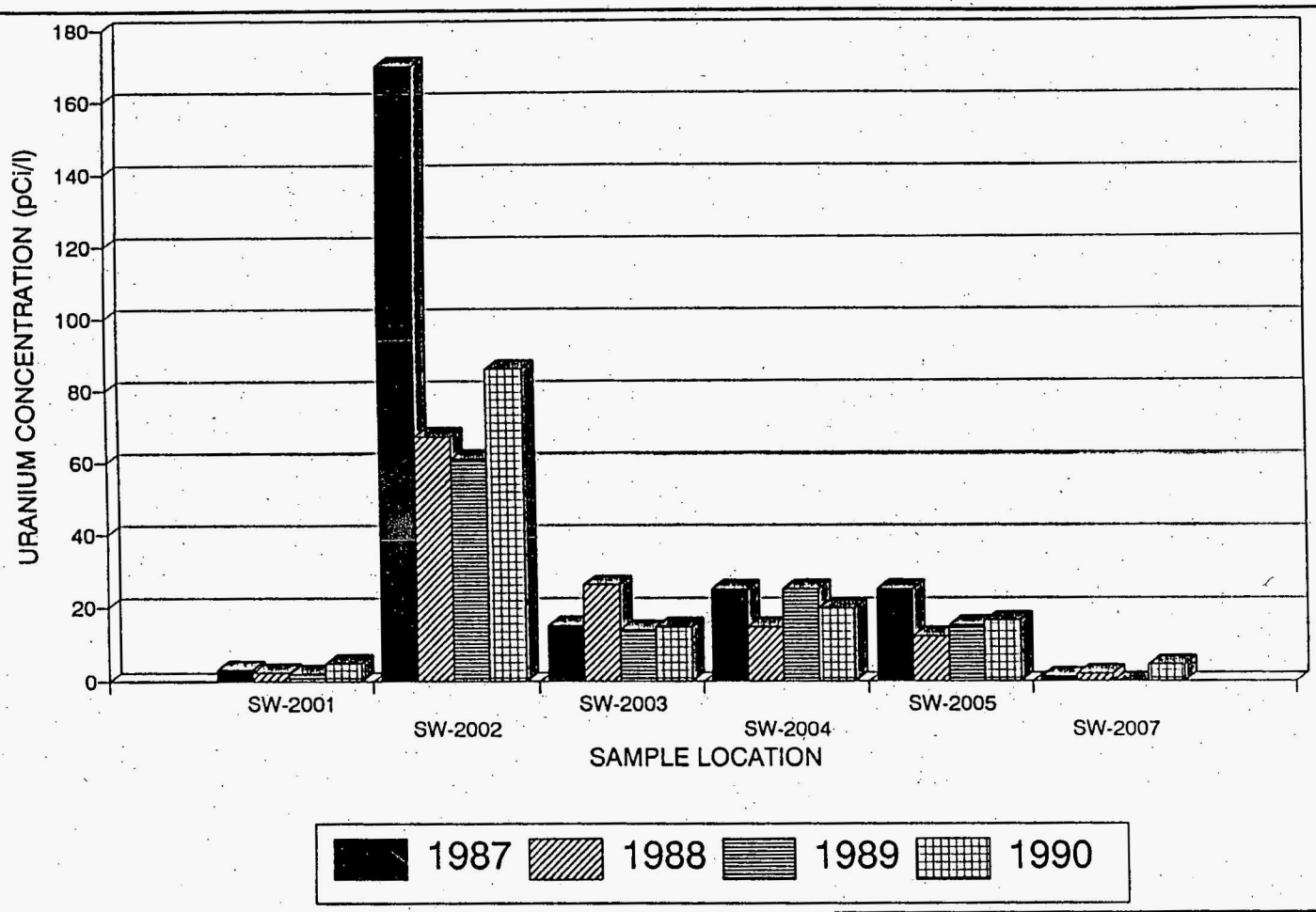
Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.
ND - Not Detected
@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.

result of the drought conditions that existed during 1988-1989 followed by an above normal amount of precipitation during 1990.

4.1.3 Groundwater Monitoring Radiological Results

All Weldon Spring Chemical Plant/raffinate pits/vicinity properties (WSCP/RP/VP) and WSQ monitoring wells were sampled during 1990 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 be more efficient by avoiding unnecessary or redundant sampling and analysis. Through these modifications, a high quality program to effectively assess the groundwater quality has been maintained.

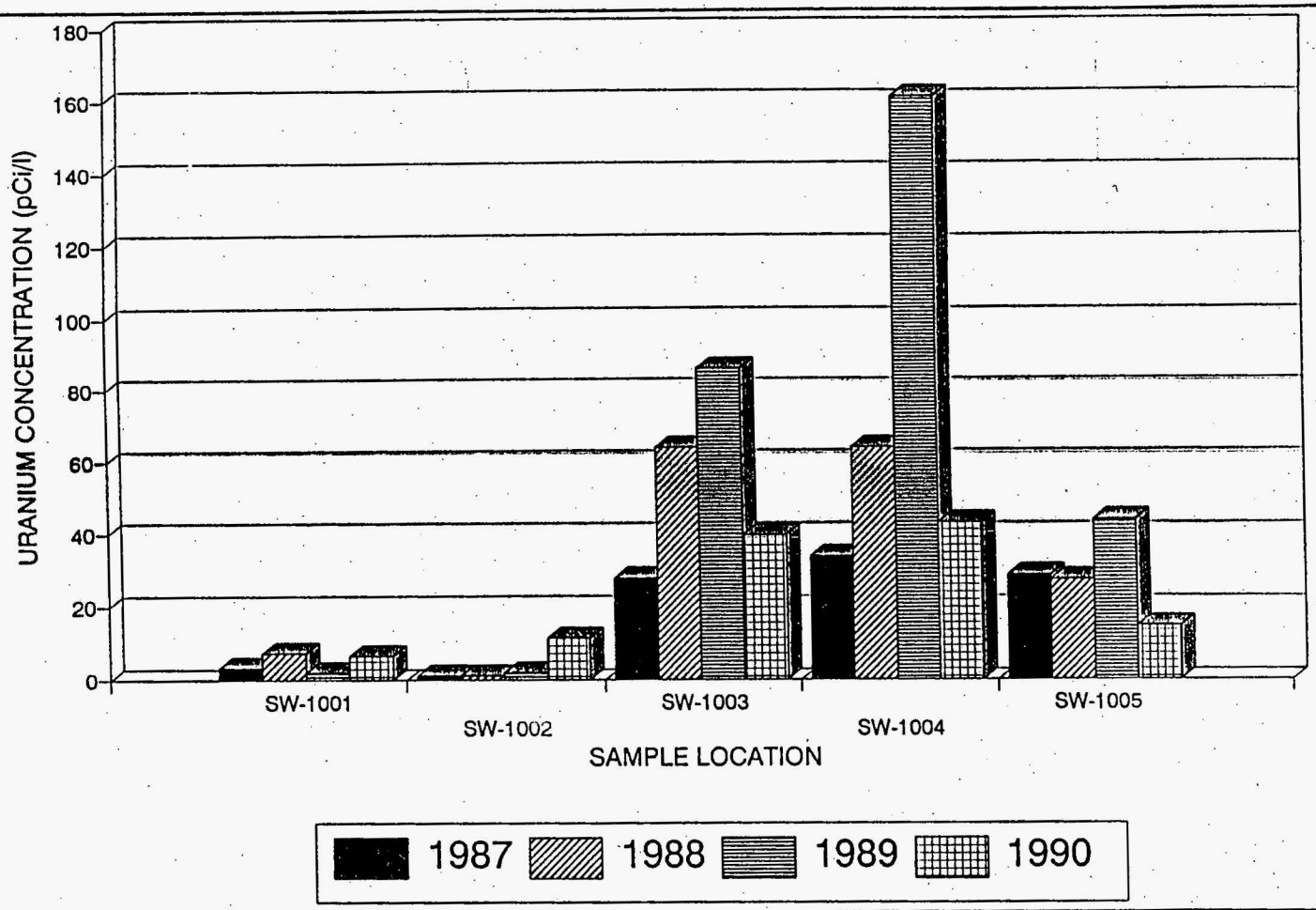
All wells sampled at the WSCP/RP/VPs and the WSQ were monitored at least semi-annually for total natural uranium. The St. Charles County pumping wells, the treated and untreated water from the St. Charles County Water Treatment Plant, and a select group of monitoring wells in the county wellfield were 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



FOUR YEAR TREND ANALYSIS FOR URANIUM IN SURFACE WATER NEAR THE SITE

FIGURE 4-4A

REPORT NO.:	DOE/OR/21548-193	EXHIBIT NO.:	A/PI/097/0591		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	5/91



FOUR YEAR TREND ANALYSIS FOR URANIUM IN SURFACE WATER NEAR THE QUARRY

FIGURE 4-4B

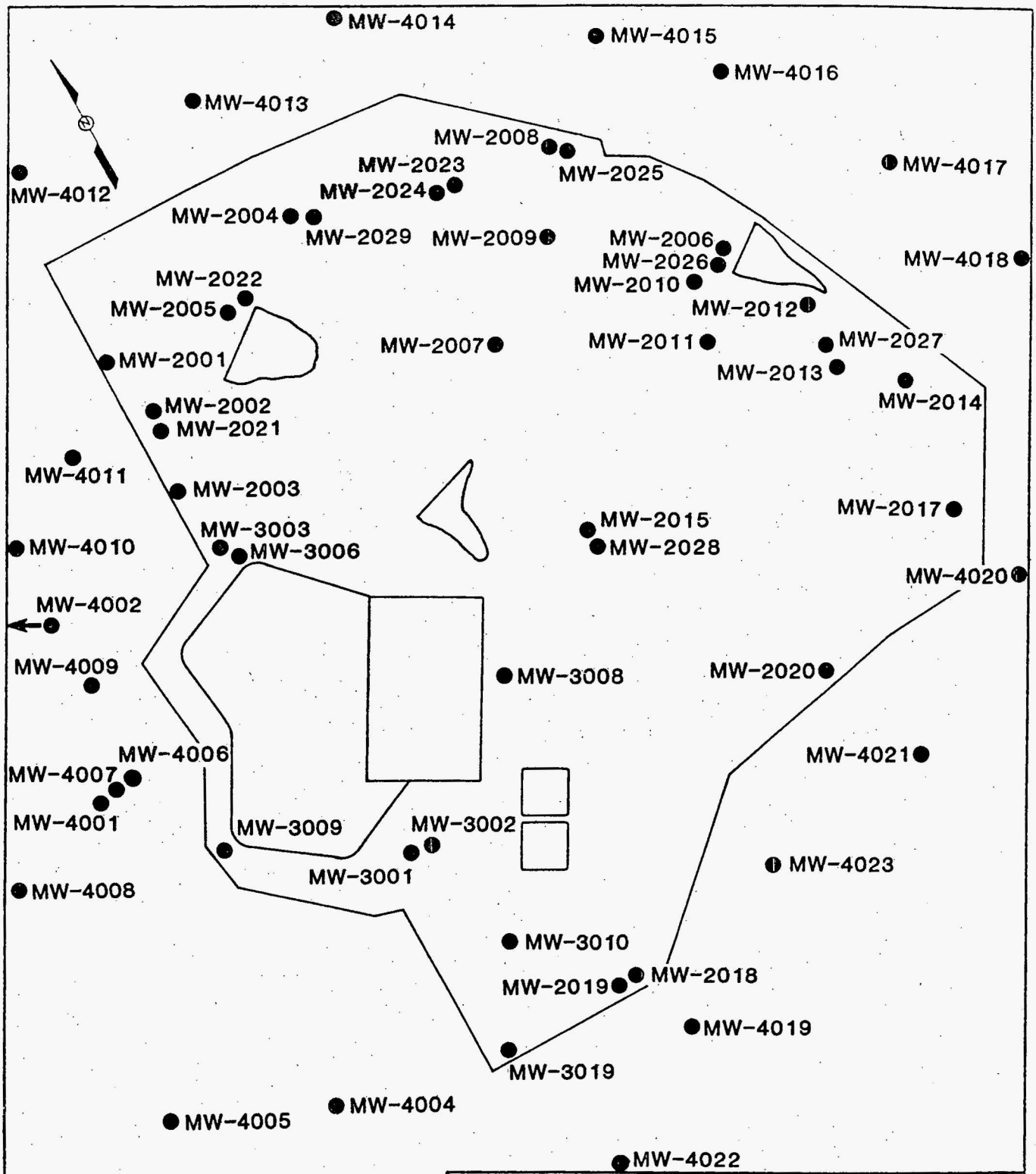
REPORT NO.:	DOE/OR/21548-193	EXHIBIT NO.:	A/PI/098/0591		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	5/91

migration originating from the WSQ. The protection of the wellfield is an issue of great sensitivity to the public, the U.S. Department of Energy (DOE), and other regulatory agencies.

Data tables for all laboratory analytical results of uranium analysis presented in this section contain annual average concentrations calculated from data generated during 1990 where more than one analysis was conducted. The values from the tables are compared to background concentrations and/or to Environmental Protection Agency (EPA) guidelines. The annual average concentration is stated in each column with a fraction in parentheses adjacent to that value. The numerator represents the number of samples used to calculate the annual concentration. The denominator represents the number of times that particular well was sampled during 1990. An "ND" 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 1990. If the analytical laboratory reported an "ND" for a particular parameter for a particular sampling event, the ND was not used to calculate the annual concentration. Quarterly results are presented in data tables in Appendix A. Where quarterly data points were not received from the analytical laboratory in time for inclusion in this report, the annual average was calculated based on available data. Where semi-annual data points might have been absent for calculation of annual average, sufficient historical data exists to verify the 1990 measured values.

4.1.3.1 Chemical Plant/Raffinate Pits. Groundwater at the WSCP/RP area became radiologically contaminated as a result of operations at the Weldon Spring Uranium Feed Materials Plant (WSUFMP) during the 1950s and 1960s. The *Water Quality Phase I Assessment Report* (MKF and JEG 1987) reported that: "groundwater near the raffinate pits contains elevated amounts of uranium and is a result of leaking raffinate pits and other sources." The Phase II Groundwater Quality Assessment Report (MKF and JEG 1989b), an expanded, comprehensive evaluation of groundwater quality at the WSCP/RP/VP area during the third quarter of 1988, is essentially in agreement with the Phase I report for radiological parameters.

The groundwater monitoring network consists of 59 wells; 28 at the WSCP, eight at the WSRP, and 23 at the WSVP. Figure 4-5 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. The wells are completed at a range of depths so that the entire



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

FIGURE 4-5

REPORT NO.: DOE/OR/21548-193		EXHIBIT NO.: A/CP/080/0391	
ORIGINATOR: TNA	DRAWN BY: GLN	DATE: 3/91	

uppermost aquifer is monitored. Detailed well construction information for individual wells is available in the 1990 *Environmental Monitoring Plan* (MKF and JEG 1990c). 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 1989b). the EPA has not yet established drinking water standards for uranium; however studies leading to proposed rulemaking are using uranium concentration in the 10 pCi/l to 40 pCi/l (0.37 Bq/l to 1.48 Bq/l) range (MKF and JEG 1989b).

Each groundwater monitoring well was sampled and analyzed for total natural uranium during 1990. Table 4-6 provides the annual concentrations.

Twenty-seven of the 59 groundwater monitoring wells have average total natural uranium concentrations below the upper bound for natural background. As Table 4-6 shows, 27 monitoring wells have annual average concentrations above background but below 10 pCi/l. Three wells, MW-3003, MW-4005 and MW-4020 have annual average concentrations in the 10 pCi/l to 40 pCi/l range. Monitoring wells MW-3008 and MW-3009 have the highest annual average concentrations, 231.2 pCi/l and 52.36 pCi/l (8.55 Bq/l and 1.94 Bq/l) respectively. Figure 4-6 highlights those wells with annual average total natural uranium concentrations above 10 pCi/l (the lowest proposed drinking water standard). These results show a larger area of groundwater uranium contamination than previous studies have indicated. This is believed to be due in part to the laboratory contamination discussed in Section 6.3.2.

4.1.3.2 Quarry. Groundwater near the WSQ has become radiologically contaminated as a result of contact with or migration from the radioactive substances present in the WSQ. Twenty-six DOE groundwater monitoring wells located at or near the WSQ were sampled and analyzed during 1990 to monitor for the presence of WSQ related contaminants. The St. Charles County 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 4-7 and 4-8 show the locations of the 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, upsection to and including the unconsolidated Quaternary-aged Missouri River alluvium. Samples from four monitoring wells (RMW series) screened in the Missouri River alluvium and owned by St. Charles County were also analyzed during 1990. During

TABLE 4-6 Summary of Averages for Inorganic Anions and Total Uranium in Groundwater Around the WSCP/RP Area

WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCi/l (0.68)*	@
MW-2001	57.0	(2/2)	4.71	(2/2)	6.3	(2/2)	1.27	(1/2)	ND	(0/2)
MW-2002	408.5	(2/2)	145.0	(2/2)	9.74	(2/2)	ND	(0/2)	3.4	(1/2)
MW-2003	266.00	(1/1)	232.00	(1/1)	12	(1/1)	0.09	(1/1)	1.17	(2/2)
MW-2004	0.74	(2/2)	5.13	(1/2)	1	(1/2)	0.16	(1/2)	2.31	(2/2)
MW-2005	240	(1/1)	19.34	(2/2)	3.3	(2/2)	0.19	(1/2)	4.05	(2/2)
MW-2006	5.99	(2/2)	34.95	(2/2)	176	(2/2)	ND	(0/2)	2.86	(2/2)
MW-2007	ND	(0/2)	14.55	(2/2)	ND	(0/2)	0.10	(1/2)	5.57	(2/2)
MW-2008	5.08	(2/2)	25.9	(2/2)	73.65	(2/2)	0.8	(1/2)	7.46	(2/2)
MW-2009	1.62	(2/2)	86.5	(2/2)	11.55	(2/2)	0.06	(1/2)	1.56	(2/2)
MW-2010	0.83	(2/2)	35.4	(2/2)	58.5	(2/2)	0.08	(1/2)	9.2	(2/2)
MW-2011	2.78	(1/1)	13	(1/1)	2.1	(1/1)	0.09	(1/1)	ND	(1/1)
MW-2012	0.38	(2/2)	65.9	(2/2)	37	(2/2)	0.05	(1/2)	ND	(1/2)
MW-2013	0.80	(3/3)	17.63	(3/3)	4.78	(3/3)	ND	(0/3)	2.47	(2/2)
MW-2014	1.66	(2/2)	84.6	(2/2)	26.4	(2/2)	0.07	(1/2)	2.04	(1/1)
MW-2015	0.28	(1/1)	104	(1/2)	1	(1/2)	0.15	(1/2)	4.66	(2/2)
MW-2017	2.92	(2/2)	426.5	(2/2)	7.95	(2/2)	0.19	(1/2)	3.98	(2/2)
MW-2018	0.52	(2/2)	17.26	(2/2)	12.63	(2/2)	0.27	(1/2)	5.75	(2/2)
MW-2019	2.41	(1/2)	33.1	(1/1)	2.38	(1/1)	0.2	(1/1)	4.08	(2/2)

TABLE 4-6 Summary of Data Averages for Inorganic Anions and Total Uranium in 1990 (Continued)

WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCi/l (0.68)*	@
MW-2020	0.89	(2/2)	155.5	(2/2)	16.9	(2/2)	0.24	(2/2)	7.48	(2/2)
MW-2021	ND	(0/2)	15.5	(2/2)	1.24	(2/2)	0.14	(2/2)	1.7	(2/2)
MW-2022	ND	(0/2)	14.8	(2/2)	1.74	(2/2)	0.16	(2/2)	1.36	(1/2)
MW-2023	0.08	(1/2)	21.45	(2/2)	1.62	(2/2)	0.24	(1/2)	7.15	(2/2)
MW-2024	ND	(0/2)	58.85	(2/2)	1.93	(2/2)	0.19	(2/2)	1.36	(1/2)
MW-2025	ND	(0/2)	19.35	(2/2)	1.73	(2/2)	0.19	(2/2)	0.7	(1/2)
MW-2026	ND	(0/2)	19.5	(2/2)	1.88	(2/2)	0.18	(1/2)	2.4	(2/2)
MW-2027	ND	(0/2)	12.9	(2/2)	3.11	(2/2)	0.22	(2/2)	2.04	(2/2)
MW-2028	ND	(0/2)	143.0	(2/2)	2.07	(2/2)	0.19	(2/2)	1.7	(2/2)
MW-2029	ND	(0/2)	27.95	(2/2)	2	(1/2)	0.17	(1/2)	3.48	(2/2)
MW-3001	537	(2/2)	24.5	(2/2)	12.25	(2/2)	0.16	(2/2)	1.03	(2/2)
MW-3002	ND	(0/2)	19.5	(2/2)	1.17	(2/2)	0.28	(2/2)	2.72	(2/2)
MW-3003	1280	(2/2)	88.6	(2/2)	6.9	(2/2)	0.18	(1/2)	15.5	(2/2)
MW-3006	ND	(0/2)	22.4	(2/2)	0.68	(1/2)	0.18	(1/2)	1.1	(2/2)
MW-3008	646	(1/1)	42.1	(1/1)	13.5	(1/1)	0.16	(1/1)	231.2	(1/1)
MW-3009	671	(2/2)	27.3	(1/1)	5.8	(1/1)	0.11	(1/1)	52.36	(2/2)
MW-3010	1.14	(2/2)	6.71	(2/2)	1.75	(2/2)	0.26	(2/2)	2.72	(1/2)
MW-3019	ND	(0/2)	26.74	(2/2)	2.95	(2/2)	0.31	(1/2)	9.5	(2/2)
MW-4001	30.15	(2/2)	62	(1/1)	3.91	(1/1)	0.11	(1/1)	0.84	(2/2)

TABLE 4-6 Summary of Data Averages for Inorganic Anions and Total Uranium in 1990 (Continued)

WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCi/l (0.68)*	@
MW-4002	3.01	(2/2)	27.4	(2/2)	11.9	(2/2)	0.11	(2/2)	0.7	(1/2)
MW-4003	0.68	(2/2)	32.2	(1/1)	5.7	(1/2)	0.17	(1/2)	3.4	(1/2)
MW-4004	0.70	(2/2)	25.95	(2/2)	2.97	(2/2)	0.33	(2/2)	8.16	(2/2)
MW-4005	1.27	(2/2)	23.25	(2/2)	5.11	(2/2)	0.32	(2/2)	15.64	(2/2)
MW-4006	14.1	(1/1)	29.45	(2/2)	1.8	(2/2)	0.15	(1/2)	1.34	(1/2)
MW-4007	0.14	(1/2)	18.25	(2/2)	1.43	(2/2)	0.46	(2/2)	3.74	(2/2)
MW-4008	ND	(0/2)	14.8	(2/2)	4.2	(1/2)	0.28	(2/2)	2.04	(2/2)
MW-4009	ND	(0/2)	17.45	(2/2)	1.1	(1/2)	0.33	(1/2)	6.93	(2/2)
MW-4010	0.12	(1/2)	24.85	(2/2)	2.56	(2/2)	0.26	(2/2)	4.76	(2/2)
MW-4011	16.8	(1/2)	37.2	(2/2)	5.75	(2/2)	0.29	(2/2)	6.46	(2/2)
MW-4012	0.13	(1/1)	30.7	(2/2)	2.5	(1/2)	0.32	(1/2)	4.13	(2/2)
MW-4013	51.4	(2/2)	44.4	(2/2)	6.14	(2/2)	ND	(0/2)	8.17	(2/2)
MW-4014	3.93	(2/2)	30.85	(2/2)	3.37	(2/2)	0.68	(2/2)	1.36	(2/2)
MW-4015	2.39	(2/2)	13.45	(2/2)	2.77	(2/2)	0.19	(2/2)	3.4	(2/2)
MW-4016	ND	(0/2)	7.15	(2/2)	1.5	(1/2)	0.21	(1/2)	3.7	(2/2)
MW-4017	0.43	(1/2)	8.65	(2/2)	1.4	(2/2)	0.15	(1/2)	1.59	(2/2)
MW-4018	0.94	(2/2)	8.25	(2/2)	6.2	(2/2)	0.11	(1/2)	2.4	(1/2)
MW-4019	0.23	(2/2)	7.35	(2/2)	1.3	(2/2)	0.4	(2/2)	4.8	(1/1)
MW-4020	0.05	(1/2)	105.7	(2/2)	5.8	(2/2)	0.19	(1/2)	16.66	(2/2)

TABLE 4-6 Summary of Data Averages for Inorganic Anions and Total Uranium in 1990 (Continued)

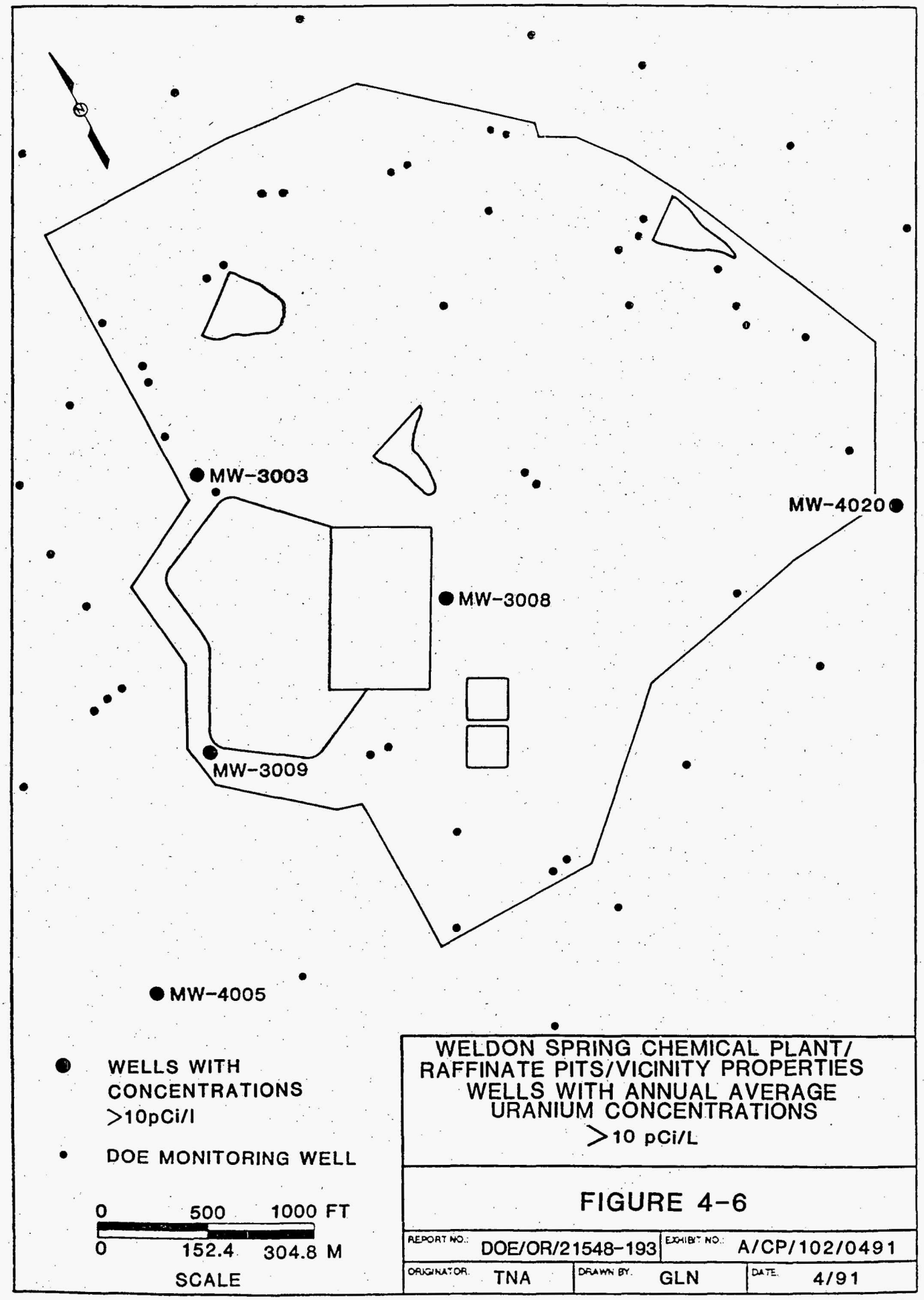
WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCI/l (0.68)*	@
MW-4021	0.12	(1/2)	265.0	(2/2)	1.55	(2/2)	0.17	(1/2)	6.56	(2/2)
MW-4022	0.05	(1/2)	29.55	(2/2)	4.45	(2/2)	0.39	(1/2)	6.61	(2/2)
MW-4023	6.07	(2/2)	90.5	(2/2)	14.15	(2/2)	0.25	(1/2)	4.415	(2/2)

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

ND - Not Detected

* - Detection limit

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.



WELDON SPRING CHEMICAL PLANT/
RAFFINATE PITS/VICINITY PROPERTIES
WELLS WITH ANNUAL AVERAGE
URANIUM CONCENTRATIONS
>10 pCi/L

FIGURE 4-6

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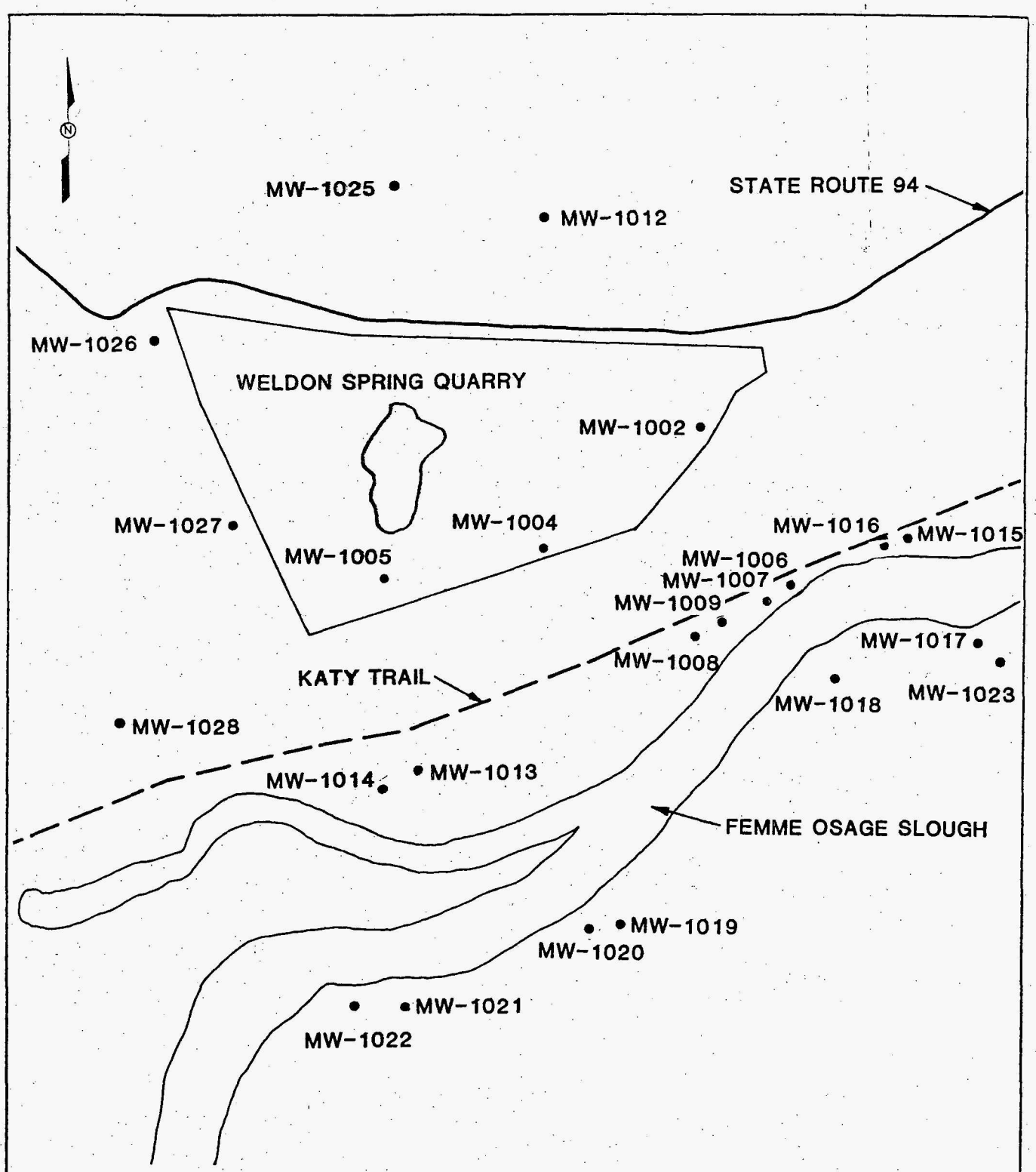


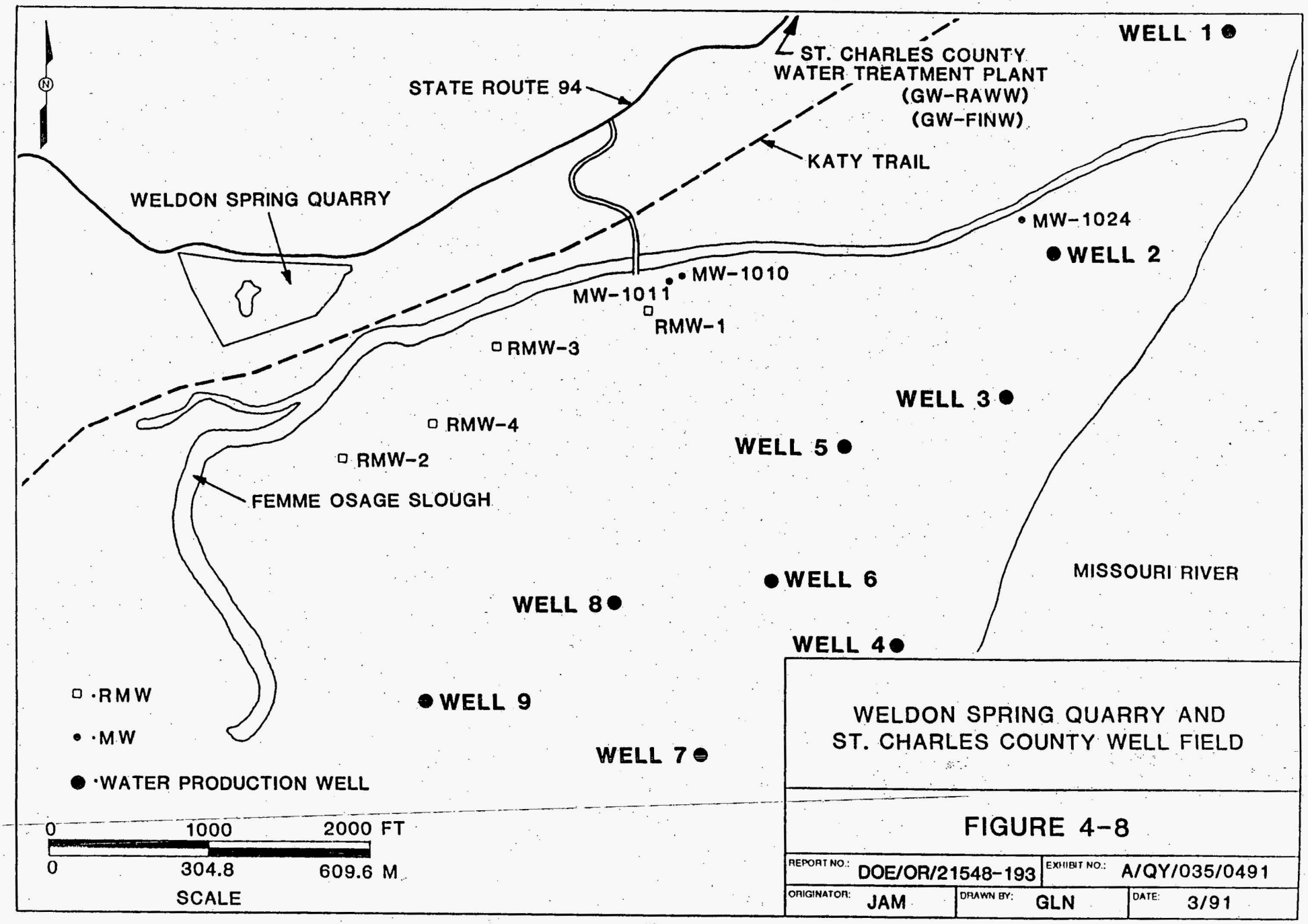
• · DOE MONITORING WELL

0 250 500 FT
0 76.2 152.4 M
SCALE

WELDON SPRING QUARRY AND
FEMME OSAGE SLOUGH
MONITORING WELL LOCATIONS

FIGURE 4-7

REPORT NO.: DOE/OR/21548-193		EXHIBIT NO.: A/QY/018/0391	
ORIGINATOR: TNA	DRAWN BY: GLN	DATE: 3/91	



WELDON SPRING QUARRY AND
ST. CHARLES COUNTY WELL FIELD

FIGURE 4-8

REPORT NO.: DOE/OR/21548-193		EXHIBIT NO.: A/QY/035/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91	

1988 and 1989, samples of groundwater were taken from a private water well which produces from the Missouri River alluvium and is located several miles upstream of the WSQ and St. Charles County wellfield. These samples were analyzed for a suite of parameters 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 the lower range for background in the Missouri River alluvium is approximately 4.2 pCi/l (0.19 Bq/l).

All groundwater sampling locations at the WSQ were sampled for total natural uranium during 1990. Table 4-7 presents the results of analyses performed on these samples. The average 1990 uranium results continue to show elevated levels in the bedrock adjacent to the quarry and the alluvium on the north side of the Femme Osage Slough. Figure 4-9 highlights the wells with concentrations above the lowest proposed drinking water standard of 10 pCi/l. One of the four samples collected from MW-1022 indicated a detectable level of uranium of 10.2 pCi/l. This measured value is attributed in part to be the result of the laboratory error discussed in Section 6.3.2 of this report. Two wells, RMW-2 and MW-1011, south of the slough exhibited annual uranium averages above background. However, the average concentrations from these wells, were still below the most restrictive proposed drinking water standard of 10 pCi/l.

Fifteen locations from the St. Charles county wellfield were sampled for gross alpha in 1990. Table 4-8 presents the results of analyses performed on these samples. These results are within a range that corresponds to the uranium values discussed earlier. These locations were also sampled once in 1990 for Th-230/Th-232, Ra-226/Ra-228 and gross beta. The results of these sample analyses are shown in Appendix A. The gross beta results are within the expected range to correspond with uranium and gross alpha values. No elevated values of thorium or radium were detected.

4.1.4 Radon Gas Monitoring

Radon is a naturally occurring radioactive gas in the uranium and thorium decay series. Rn-222 is formed by the natural radioactive decay of Ra-226 which is a decay product of U-238 found in soil and rock. Rn-220 (also referred to historically as thoron) is formed by the natural radioactive decay of Ra-224 which is a decay product of Th-232

TABLE 4-7 Summary of Averages for Inorganic Anions and Total Uranium in Groundwater Around the WSQ

WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCi/l (0.68)*	@
MW-1002	0.62	(2/2)	52.75	(2/2)	8.57	(2/2)	0.44	(2/2)	2.38	(2/2)
MW-1004	0.36	(2/2)	280.5	(2/2)	23.4	(2/2)	1.21	(2/2)	5167	(2/2)
MW-1005	ND	(0/2)	227.0	(2/2)	19.5	(2/2)	1.06	(2/2)	2481	(2/2)
MW-1006	0.76	(2/2)	529.0	(2/2)	32.55	(2/2)	0.32	(2/2)	3226	(2/2)
MW-1007	ND	(0/2)	31.75	(2/2)	72.15	(2/2)	0.44	(1/2)	100.3	(2/2)
MW-1008	0.12	(1/2)	308.5	(2/2)	24.4	(2/2)	0.38	(2/2)	5134	(2/2)
MW-1009	ND	(0/2)	308.0	(2/2)	25.5	(2/2)	0.27	(2/2)	5.44	(2/2)
MW-1010	ND	(0/2)	6.88	(1/2)	7.45	(2/2)	0.21	(1/2)	2.13	(2/2)
MW-1011	ND	(0/2)	18.83	(2/2)	11.55	(2/2)	0.28	(1/2)	9.57	(2/2)
MW-1012	1.44	(2/2)	54.35	(2/2)	7.03	(2/2)	0.46	(2/2)	2.04	(2/2)
MW-1013	ND	(0/2)	119.5	(2/2)	21.35	(2/2)	0.5	(2/2)	918	(2/2)
MW-1014	ND	(0/2)	113.25	(2/2)	24.2	(2/2)	0.46	(2/2)	816	(2/2)
MW-1015	1.14	(2/2)	333.0	(2/2)	27.2	(2/2)	0.35	(2/2)	574.6	(2/2)
MW-1016	0.68	(2/2)	212.5	(2/2)	16.65	(2/2)	0.31	(2/2)	173.2	(2/2)
MW-1017	ND	(0/4)	17.47	(4/4)	22.05	(4/4)	0.17	(2/4)	1.36	(2/4)
MW-1018	ND	(0/4)	59.55	(4/4)	19.2	(4/4)	0.23	(3/4)	6.12	(1/4)

TABLE 4-7 Summary of Data Averages for Inorganic Anions and Total Uranium in 1990 (Continued)

WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCi/l (0.68)*	@
MW-1019	ND	(0/4)	5.70	(2/4)	6.2	(4/4)	0.22	(3/4)	4.76	(2/3)
MW-1020	ND	(0/4)	23.5	(3/4)	10.91	(4/4)	0.3	(3/4)	3.27	(3/4)
MW-1021	ND	(0/4)	1.35	(2/4)	8.86	(4/4)	0.18	(3/4)	6.8	(1/4)
MW-1022	ND	(0/4)	3.93	(2/4)	8.56	(4/4)	0.21	(3/4)	10.2	(1/4)
MW-1023	ND	(0/3)	3.89	(2/3)	4.41	(4/4)	0.22	(2/3)	1.36	(1/4)
MW-1024	ND	(0/4)	5.46	(4/4)	10.3	(4/4)	0.28	(3/4)	1.36	(1/3)
MW-1025	ND	(0/2)	132.5	(2/2)	5.49	(2/2)	0.17	(1/2)	3.06	(2/2)
MW-1026	ND	(0/2)	1.81	(1/2)	2.98	(2/2)	0.19	(1/2)	ND	(0/2)
MW-1027	ND	(0/2)	135.0	(2/2)	14.4	(2/2)	0.28	(2/2)	618.9	(2/2)
MW-1028	0.06	(1/2)	58.8	(2/2)	10.24	(2/2)	0.28	(1/2)	6.46	(2/2)
MW-RMW1	ND	(0/4)	21.48	(4/4)	7.1	(4/4)	0.19	(2/4)	3.77	(3/4)
MW-RMW2	0.20	(1/4)	25.63	(4/4)	4.35	(4/4)	0.29	(3/4)	7.38	(4/4)
MW-RMW3	0.20	(1/4)	31.56	(4/4)	12.93	(4/4)	0.19	(2/4)	9.53	(2/4)
MW-RMW4	ND	(0/4)	16.45	(4/4)	7.58	(4/4)	0.24	(2/4)	3.46	(4/4)
MW-RAWW	ND	(0/1)	NSF		NSF		NSF		2.04	(2/4)
MW-FINW	ND	(0/1)	NSF		NSF		NSF		1.36	(1/4)

TABLE 4-7 Summary of Data Averages for Inorganic Anions and Total Uranium in 1990 (Continued)

WSSRAP LOCATION	NITRATE mg/l (0.1)*	@	SULFATE mg/l (1.0)*	@	CHLORIDE mg/l (0.25)*	@	FLUORIDE mg/l (0.25)*	@	URANIUM pCi/l (0.68)*	@
MW-PW02	ND	(0/2)	NSF		NSF		NSF		1.85	(2/4)
MW-PW03	ND	(0/1)	NSF		NSF		NSF		2.12	(2/3)
MW-PW04	ND	(0/2)	NSF		NSF		NSF		2.49	(3/4)
MW-PW05	ND	(0/1)	NSF		NSF		NSF		4.08	(1/3)
MW-PW06	ND	(0/2)	NSF		NSF		NSF		2.72	(2/4)
MW-PW07	ND	(0/2)	NSF		NSF		NSF		6.12	(2/4)
MW-PW08	ND	(0/2)	NSF		NSF		NSF		1.36	(1/4)
MW-PW09	ND	(0/2)	NSF		NSF		NSF		3.06	(2/4)

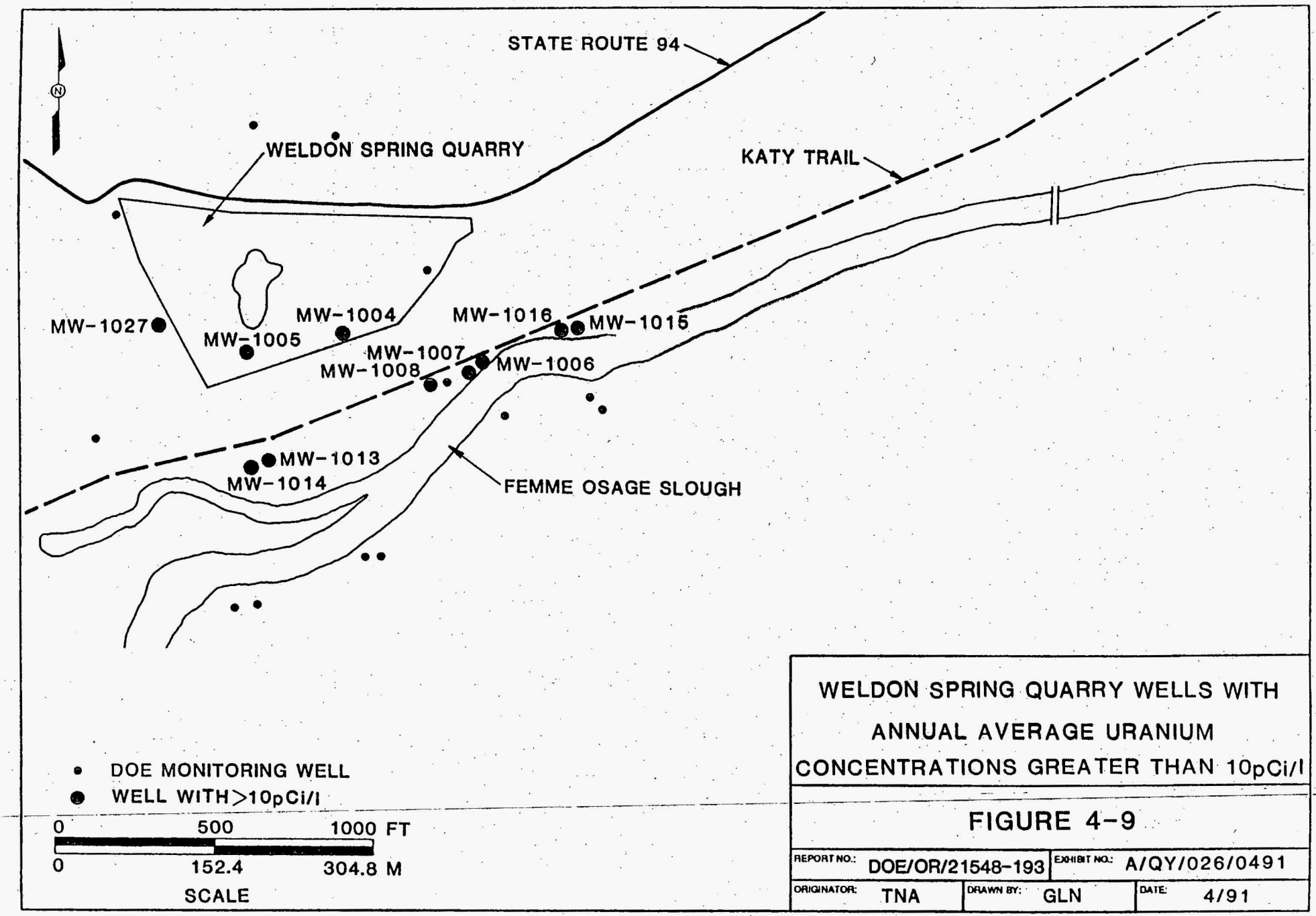
Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.

ND - Not Detected

* - Detection limit

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.

NSF - Not Scheduled For Sampling



WELDON SPRING QUARRY WELLS WITH ANNUAL AVERAGE URANIUM CONCENTRATIONS GREATER THAN 10pCi/l

FIGURE 4-9

REPORT NO.: DOE/OR/21548-193		EXHIBIT NO.: A/QY/026/0491	
ORIGINATOR: TNA	DRAWN BY: GLN	DATE: 4/91	

Table 4-8 Gross Alpha Data From St. Charles County Wellfield, 1990

WSSRAP LOCATION	Q190 pCi/l	Q290 pCi/l	Q390 pCi/l	Q490 pCi/l
MW-PWO2	2 +/- 5	2 +/- 3	< 4.9	0 +/- 3
MW-PWO3	NOL	3 +/- 3	< 4.5	2 +/- 3
MW-PWO4	4 +/- 6	0 +/- 3	< 4.8	1 +/- 3
MW-PWO5	6 +/- 6	2 +/- 3	NOL	0 +/- 3
MW-PWO6	2 +/- 6	3 +/- 4	< 5.5	1 +/- 4
MW-PWO7	1 +/- 7	-1 +/- 5	< 6.1	0 +/- 4
MW-PWO8	1 +/- 7	0 +/- 4	< 6.1	0 +/- 4
MW-PWO9	3 +/- 7	1 +/- 3	< 5.6	3 +/- 4
MW-RMW1	1 +/- 10	3 +/- 6	< 12.0	2 +/- 5
MW-RMW2	4 +/- 7	0 +/- 6	13.1 +/- 6	10 +/- 6
MW-RMW3	9 +/- 11	0 +/- 10	< 16.0	0 +/- 6
MW-RMW4	-3 +/- 8	2 +/- 4	< 14.0	4 +/- 6
MW-RAWW	4 +/- 4	2 +/- 3	< 8.4	2 +/- 3
MW-FINW	1 +/- 2	0 +/- 2	< 3.7	1 +/- 2
MW-1024	6 +/- 6	-2 +/- 4	< 6.3	1 +/- 5

NOL - Not on Line on Sample Date
MW-RAWW - Untreated Water From St. Charles County Water Treatment Plant
MW-FINW - Treated Water From St. Charles County Water Treatment Plant

found in soil and rock. A fraction of the radon diffuses into the atmosphere and accounts for natural background radon concentrations. Radon is also produced at the WSS as the Ra-226 and Ra-224 contained in the waste materials undergo decay.

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

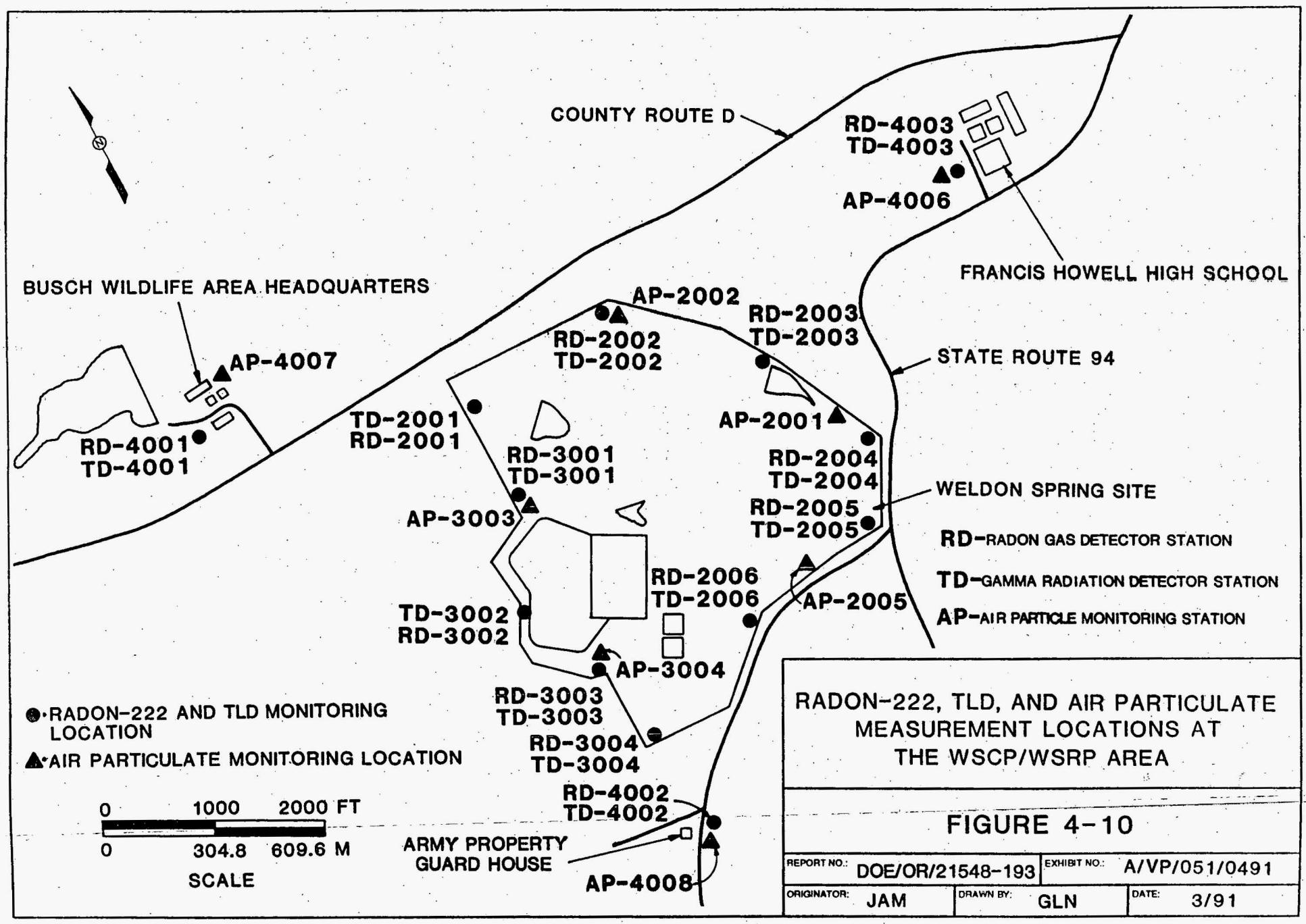
The emanating fraction is the portion of radon that escapes from soil particles into the pore spaces, which are the voids found in all soils regardless of density. Only the radon entering these pore spaces is available for release to the atmosphere.

Porosity is a measure of the amount of pore space or fraction of total volume occupied by the pore spaces. The higher the porosity the more pore spaces for the radon to move through.

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

The radon gas monitoring program uses a pair of radon detectors at each of 22 permanent monitoring locations; six locations are at the WSCP, six locations are at the WSQ, four locations are at the WSRP, and there are six off-site locations. Radon monitoring locations are identified with an "RD" prefix and are shown in Figures 4-10, 4-11, and 4-11A. On-site monitoring locations are spaced around the perimeter fences to ensure adequate detection of radon dissipating from the properties under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005 and RD-4006 were used to monitor background radon concentrations near the Weldon Spring site (WSS).

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


COUNTY ROUTE D
RD-4003
TD-4003
AP-4006
FRANCIS HOWELL HIGH SCHOOL
BUSCH WILDLIFE AREA HEADQUARTERS
AP-4007
RD-4001
TD-4001
AP-2002
RD-2002
TD-2002
RD-2003
TD-2003
STATE ROUTE 94
TD-2001
RD-2001
AP-2001
RD-3001
TD-3001
RD-2004
TD-2004
WELDON SPRING SITE
AP-3003
RD-2005
TD-2005
RD-2006
TD-2006
AP-2005
TD-3002
RD-3002
AP-3004
RD-3003
TD-3003
RD-3004
TD-3004
RD-4002
TD-4002
ARMY PROPERTY
GUARD HOUSE
AP-4008
RD-RADON GAS DETECTOR STATION
TD-GAMMA RADIATION DETECTOR STATION
AP-AIR PARTICLE MONITORING STATION
RADON-222 AND TLD MONITORING LOCATION
AIR PARTICULATE MONITORING LOCATION
0 1000 2000 FT
0 304.8 609.6 M
SCALE
RADON-222, TLD, AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSCP/WSRP AREA
FIGURE 4-10
REPORT NO.: DOE/OR/21548-193
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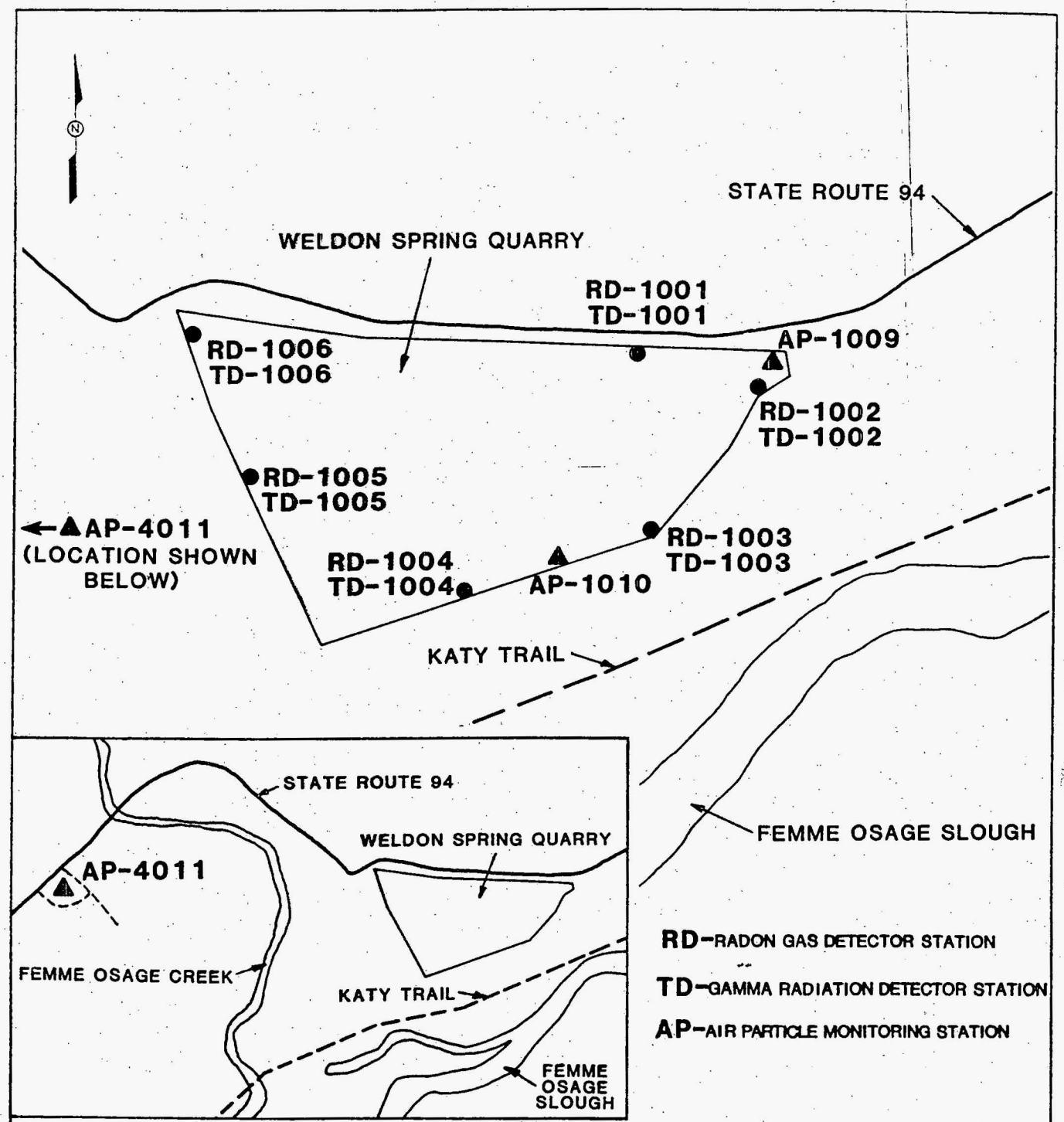
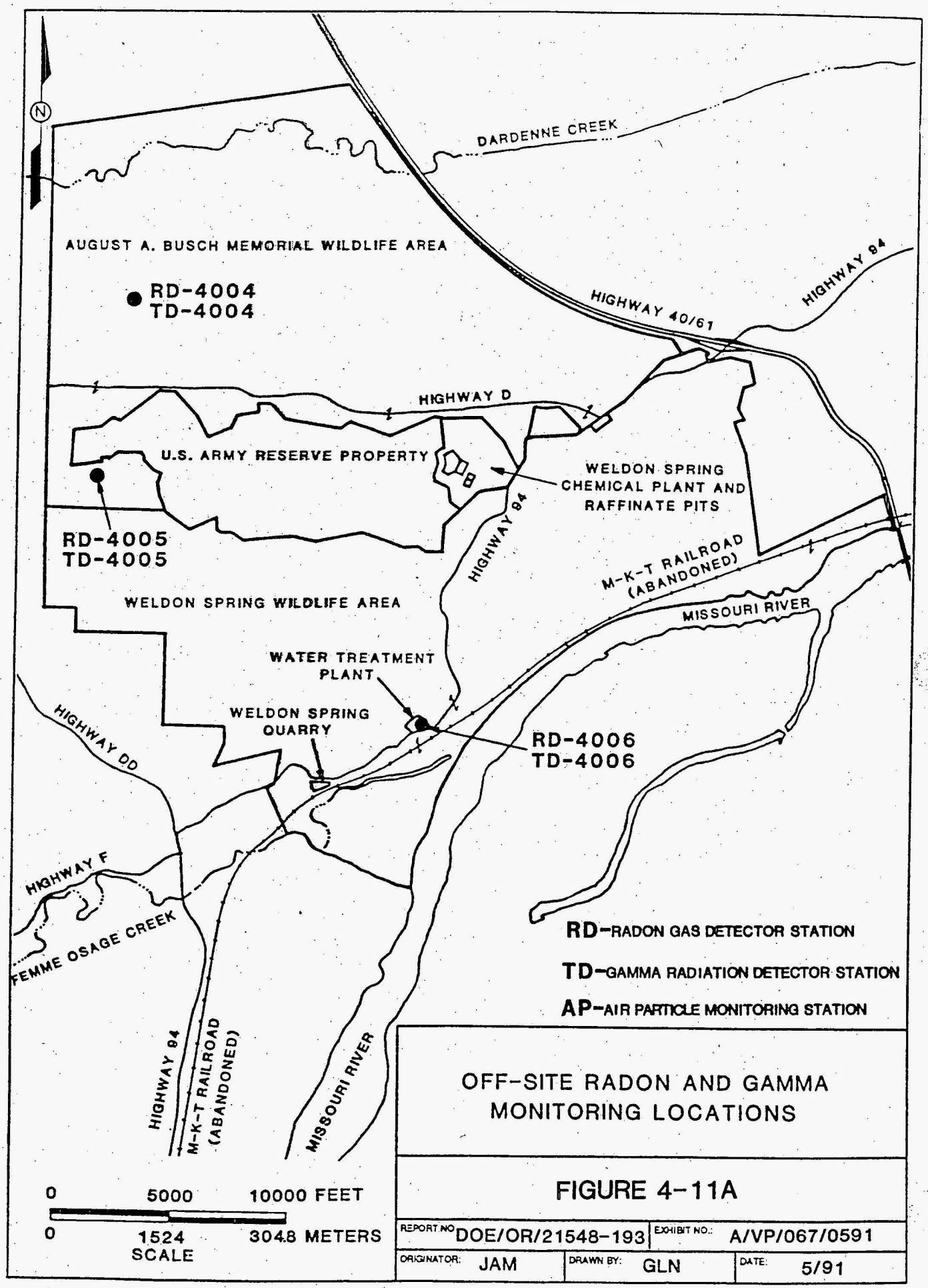
ORIGINATOR: JAM
DRAWN BY: GLN
DATE: 3/91



RADON-222, THERMO LUMINESCENT DOSIMETER (TLD) AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 4-11

REPORT NO.: DOE/OR/21548-193		EXHIBIT NO.: A/QY/036/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91	



OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

FIGURE 4-11A

REPORT NO. DOE/OR/21548-193		EXHIBIT NO.: A/VP/067/0591	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 5/91	

plastic cups and are mounted in an inverted fashion on posts. The detectors are exchanged at the beginning of each calendar quarter and are sent to a subcontract laboratory for analysis. The detectors were deployed in pairs to evaluate and reduce the natural uncertainties associated with this type of measurement.

Table 4-9 summarizes the quarterly and annual average radon concentrations detected at all WSS perimeter and off-site monitoring locations. Also contained in Table 4-9 is a comparison of the measured annual average concentration to the Derived Concentration Guideline for unrestricted areas of 3 pCi/l (111 Bq/m^3) as authorized by DOE Order 5400.5.

For each monitoring station, annual averages in Table 4-9 were calculated by finding the arithmetic average of the four quarterly values. The annual standard deviation was calculated by taking the square root of the sum of the squared quarterly standard deviations.

Ambient background concentrations were determined by calculating the arithmetic average of concentrations 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 plus Rn-220) in 1990 of 0.3 pCi/l (11.1 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. Only those monitoring locations that were statistically greater than background were compared to the Derived Concentration Guideline.

4.1.4.1 Chemical Plant/Raffinate Pits. Radon concentrations at the WSS perimeter and at the raffinate pit locations were lower in 1990 than in 1989. Abnormally high values were recorded in 1988 because of a regional drought. The 1988 drought reduced the moisture content of soils and radium-containing wastes, thus allowing a greater fraction of radon in the soil and waste voids to diffuse into the atmosphere. Lower radon concentrations were measured in 1989 and continued to decrease in 1990. The concentrations measured in 1990 are typical of values expected during years with normal precipitation levels.

TABLE 4-9 1990 Track Etch Radon 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 QUARTER pCi/l	ANNUAL AVERAGE (b) pCi/l	STD. DEV.	PERCENT OF DCG (b)(c)
WSQ							
RD-1001	1.1	1.4	2.4	1.1	1.5	0.3	40
RD-1002	1.4	2.1	3.1	1.7	2.1	0.4	60
RD-1003	1.0	0.5	1.0	1.0	0.9	0.3	20
RD-1004	0.3	0.4	0.8	0.4	0.5	0.2	
RD-1005	0.8	0.5	0.8	0.6	0.7	0.2	13
RD-1006	0.5	0.3	0.5	0.2	0.4	0.2	
WSCP							
RD-2001	0.4	0.3	0.5	0.2	0.4	0.2	
RD-2002	0.4	0.1	0.4	0.2	0.3	0.1	
RD-2003	0.4	0.1	0.7	0.3	0.4	0.2	
RD-2004	0.3	0.1	0.4	0.2	0.3	0.1	
RD-2005	0.5	0.1	0.4	0.2	0.3	0.1	
RD-2006	0.4	0.2	0.4	0.2	0.3	0.1	
WSRP							
RD-3001	0.3	0.1	0.5	0.1	0.3	0.1	
RD-3002	0.3	0.1	0.4	0.1	0.2	0.1	
RD-3003	0.5	0.1	0.5	0.1	0.3	0.1	
RD-3004	0.3	0.1	0.5	0.1	0.3	0.1	

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TABLE 4-9 1990 Track Etch Radon 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 QUARTER pCi/l	ANNUAL AVERAGE (b) pCi/l	STD. DEV.	PERCENT OF DCG (b)(c)
OFF SITE							
RD-4001*	0.3	0.1	0.7	0.1	0.3	0.1	
RD-4002	0.3	0.1	0.3	0.2	0.2	0.1	
RD-4003	0.3	0.1	0.3	0.2	0.2	0.1	
RD-4004*	0.3	0.1	0.7	0.3	0.4	0.2	
RD-4005*	0.5	0.1	0.3	-	0.3	0.1	
RD-4006*	0.3	0.1	0.5	0.1	0.3	0.1	

(a) Results include natural background.
(b) Percent of Derived Concentration Guideline (DCG) calculated by taking the annual average minus the average of the background stations divided by the DOE DCG for Rn-222 -3 pCi/l (100 Bq/M^3) (for annual average above background).
(c) Percent of guideline calculated only for stations that are statistically different from background.
* Denotes background station.
\- Denotes missing detector (vandalism).

4.1.4.2 Quarry. Only at the quarry were measured radon concentrations found to be statistically greater, at the 95% confidence level, than background radon concentrations. Radon concentrations found at the quarry are much greater than in concentrations measured at other WSS properties because the radium concentrations in quarry wastes are typically much greater than in other contaminated areas, and because 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). In conjunction with stable meteorological conditions, this tends to trap emanating radon within the quarry and raises 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). Third quarter results for station RD-1002 were above 3 pCi/l (111 Bq/m^3), but when averaged with the other three quarters the annual average concentration was less than 3 pCi/l. The concentrations at the quarry in 1990 were typical of years with normal precipitation.

4.1.4.3 Off-Site. Radon concentrations found at the off-site locations were lower in 1990 than in 1989. The concentration levels measured in 1990 were typical of years with normal precipitation.

4.1.5 Gamma Radiation Exposure Rate Monitoring Program and Results

Gamma rays are electromagnetic radiation emitted from the nucleus of atoms. The environment naturally contains radioactive substances which emit gamma radiation. Terrestrial radiation sources are natural radioactive elements in the environment found in soil and water. 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. Terrestrial and cosmic radiation fluctuates depending on the soil composition and elevation above sea level.

Gamma radiation is emitted by many radionuclides in the U-238 and Th-232 decay series. These radionuclides are found in above-background concentrations at the WSS properties. Therefore, gamma radiation is monitored at the WSS.

Spherical environmental thermoluminescent dosimeters (TLDs) were deployed at 22 monitoring stations to monitor exposure from gamma radiation at the WSS. The monitoring station locations are the same as the ambient radon monitoring locations.

Ten monitoring stations are located at the WSCP/WSRP along the perimeter fence (Figure 4-10), six monitoring stations are located along the WSQ perimeter fence (Figure 4-11) and six monitoring stations are located off-site (Figures 4-10 and 4-11). Monitoring stations TD-4001, TD-4004, TD-4005, and TD-4006 measure natural background at locations unaffected by the site.

The TLDs are composed of five lithium fluoride chips in a durable spherical polyethylene holder. The TLDs are exchanged quarterly.

To determine background levels of gamma radiation as measured with the TLDs, the gamma exposures at the four background monitoring stations were averaged. This yielded an average of 62 mrem/year (0.62 mSv/yr) with two standard deviations of 16.3 mrem/yr (0.163 mSv/yr).

Table 4-10 summarizes the quarterly and annual total 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 two standard deviations. The United Nations (UNSCEAR 1982) estimates the external annual effective dose equivalent from all naturally occurring radiation in "normal" parts of the world to be 30 mrem/yr (0.3 mSv/yr) from cosmic sources and 35 mrem/yr (0.35 mSv/yr) from terrestrial radiation for a total of 65 mrem/yr (0.65 mSv/yr). This correlates well with the results from the WSS background monitoring stations.

TLDs were missing at various monitoring stations during all four quarters. 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. Missing TLDs are indicated in Table 4-10 by a dash (-).

TABLE 4-10 Gamma Radiation Exposure Rate Monitoring Results for the WSCP/RP and WSQ Areas(a) (mrem/year)

LOCATION I.D.	FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER	ANNUAL TOTAL	2 ST DEV
QUARRY						
TD-1001	21	21	26	24	92	4
TD-1002	17	17	22	20	76	5
TD-1003	20	16	24	15	76	7
TD-1004	18	15	21	19	73	1
TD-1005[b]	18	17	--	21	75	4
TD-1006	15	14	21	19	69	5
CHEMICAL PLANT						
TD-2001	16	16	18	16	66	2
TD-2002	15	14	22	17	68	6
TD-2003	15	15	18	17	66	3
TD-2004	16	17	18	18	68	2
TD-2005	--	14	17	17	64	3
TD-2006	17	15	19	17	67	3
RAFFINATE PITS						
TD-3001[b]	--	16	20	19	73	4
TD-3002[b]	13	12	--	14	53	2
TD-3003	17	17	20	18	71	3
TD-3004[b]	12	13	18	--	57	5
OFF SITE						
TD-4001*	15	16	--	18	66	2
TD-4002	14	13	15	14	57	1
TD-4003	12	11	13	13	51	2
TD-4004*	14	16	20	18	69	4

TABLE 4-10 Gamma Radiation Exposure Rate Monitoring Results for the WSCP/RP and WSQ Areas(a) (mrem/year) (Continued)

LOCATION I.D.	FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER	ANNUAL TOTAL	2 ST DEV
TD-4005*(b)	12	–	–	–	48	0
TD-4006*	13	13	19	18	64	6

(a) Results include natural background.
(b) Year-to-date totals for locations where some quarterly data are unavailable were calculated using the average of the existing Quarterly data in place of the unavailable data.
* Denotes background station.
– Denotes a missing TLD.
To convert to mSv/yr, Divide by 100.

4.1.5.1 Chemical Plant/Raffinate Pits. At the WSCP/WSRP site perimeters, the annual exposures ranged from 53 mrem to 73 mrem (0.53 mSv to 0.73 mSv). There was no reason to suspect at the 95% confidence level, that any of the stations were greater than the background level.

4.1.5.2 Quarry. Two of the six monitoring stations at the quarry, TD-1001 and TD-1002 located on the north and east perimeter respectively, were statistically greater than background at the 95% confidence level. Station TD-1003 had the same annual total as TD–1002, but because it had a larger standard deviation it did not meet the statistically significant at 95% confidence level criteria. Permissible exposure level of 100 mrem (1.0 mSv) above background in unrestricted areas was not exceeded. Table 4-11 presents a comparison of the annual effective dose equivalent from external gamma radiation measured at TD-1001 and TD-1002, to the DOE 100 mrem/yr standard for all exposure modes as cited in DOE 5400.5. The percent of the DOE standard was calculated by subtracting the annual average background dose equivalent rate (62 mrem/year ± 16.3 mrem/year [0.62 ± 0.163 mSv/yr]) from the annual dose equivalent rate measured at stations TD-1001 and TD-1002 and then dividing by the 100 mrem/year (1.0 mSv/yr) DOE standard.

TABLE 4-11 Summary of TLD Monitoring Results of Stations That Exceeded Natural Background

STATION NUMBER	LOCATION	ANNUAL EXPOSURE (mrem/yr)	PERCENT OF DOE GUIDELINE[a]
TD-1001	WSQ North Perimeter	92	30
TD-1002	WSQ East Perimeter	76	8

(a) Percent of the DOE guideline is calculated by taking the annual exposure results minus the average background results divided by the DOE guideline of 100 mrem.

4.1.5.3 Off-Site. At the off-site locations the annual exposures ranged from 48 mrem to 69 mrem. Annual exposure at the Francis Howell High School was 51 mrem (0.51 mSv). At the U.S. Army Weldon Spring Training Area (WSTA) area the annual exposure was 57 mrem (0.57 mSv). At these two locations, the only off-site locations that are not background stations; there was no reason to suspect at the 95% confidence level, that the measured exposure levels were greater than background.

4.1.6 Radioactive Air Particulate Monitoring and Results

Radioactive air particulates are dust particles that carry radioactive contaminants. The main contributors to long-lived natural background radioactivity on dust particles are Po-210 and Pb-210 which are naturally occurring Rn-222 decay products. Surface soils also naturally contain radioactivity that becomes airborne and accounts, to a much lesser extent, for natural background concentrations of radioactive air particulates. Background concentrations of radioactive air particulates vary depending on soil moisture, wind, and geological conditions.

Many areas of the WSS properties contain elevated concentrations of radionuclides in the soil which could result in increased radioactive air 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.

Eleven air particulate samplers are used to monitor the WSS properties. Five of these (AP-2001, AP-2002, AP-3003, AP-3004, and AP-2005) are located around the WSCP

perimeter as shown on Figure 4-10. Two monitoring stations (AP-4006 and AP-4008) are located off-site at sensitive receptor locations, which are Francis Howell High School and the WSTA. The monitoring station (AP-4007), at the August A. Busch Wildlife Area (ABWA), is used to monitor background levels in the vicinity of the WSCP. The off-site monitoring stations are also shown on Figure 4-11A. Two monitors (AP-1009 and AP-1010) located at the quarry, and one monitor (AP-4011) located approximately 0.7 km (0.4 mi) west of the quarry are used to monitor levels in the vicinity of the quarry. The quarry monitoring stations are shown on Figure 4-11.

The sampling station near the ABWA headquarters is used as a WSCP/WSRP and WSQ background air monitoring station. 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 five air particulate samplers used at the WSCP, the two nearby off-site samplers, the background samplers at ABWA headquarters, and the three air particulate samplers used in and near the quarry are constant flow dual diaphragm units operating at a continuous total flow of 2.4 cu m/hr (85 ft^3/hour). 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 and filters are exchanged weekly.

The majority of the radionuclides present at the WSS and in the quarry waste are from the natural U-238 and Th-232 decay chains. Many of these radionuclides emit alpha particles during decay which pose the greatest hazard when deposited internally in the respiratory tract and lung. Therefore air particulate samples 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 standard zinc-sulfide alpha scintillation detector. The alpha counts per filter were converted to radioactivity per volume of air for that filter and reported in μCi/ml (Bq/m^3).

The annual average long-lived concentrations and the calculated standard deviations for the 11 air monitoring locations are summarized in Table 4-12. The annual average long-lived alpha concentration for each monitoring location was calculated by averaging the weekly air particulate analysis results, or the counting instrument's lower limit of detection (LLD), whichever was greater.

All of the monitoring stations exhibited some long-lived alpha weekly concentrations less than the LLD. The "<" sign in Table 4-12 indicates that the actual average is less than the calculated average. The cause for this was the use of LLD values in calculation of the annual average concentration. When a value was reported as less than the LLD, the LLD value was used in the calculation. The standard deviation for each of the monitoring locations was calculated using only analysis results that were above the LLD, because the weekly LLD values were nearly the same, and to have used them would have resulted in a low bias in the annual standard deviation.

The typical LLD at the WSCP/WSRP monitoring locations was approximately 7.5×10^{-16} μCi/ml (.03 mBq/m^3). The WSQ monitoring locations typically achieved an LLD of approximately 7.7×10^{-16} μCi/ml (.03 mBq/m^3). These LLDs are low enough to allow detection of Th-232, the radionuclide with the lowest derived concentration guideline (DCG) found at the WSS. The DCG for Th-232 is 7×10^{-15} μCi/ml (.26 mBq/m^3). The DOE provides DCGs for airborne contaminants which, if inhaled by a member of the public continuously for one year, would result in a committed effective dose equivalent of 100 mrem (1 mSv).

4.1.6.1 Chemical Plant/Raffinate Pits. There was no reason to suspect at the 95% confidence level, that the annual average long-lived gross alpha concentrations measured at WSCP/WSRP monitoring stations were greater than background station (AP-4007). This means that there were no statistically significant above background radioactive air particulates concentrations measured at the WSCP/WSRP perimeter during 1990.

TABLE 4-12 1990 Radioactive Air Particulate Results for the WSCP/RP and WSQ Areas

MONITOR IDENTIFICATION NUMBER	ANNUAL AVG. LONG-LIVED GROSS ALPHA CONCENTRATION ($X\ 10^{-15}$ μCi/ml)[b]	STANDARD DEVIATION	NUMBER OF VALUES ABOVE LLD[c]
AP-2001	<2.1	2.0	42
AP-2002	<2.5	8.6	45
AP-3003	<2.2	1.0	41
AP-3004	<2.3	1.2	43
AP-2005	<2.4	1.4	48
AP-4006	<2.2	1.0	39
AP-4007 (a)	<2.2	7.5	49
AP-4008	<2.4	1.5	47
AP-1009	<2.4	7.4	45
AP-1010	<2.7	8.0	43
AP-4011	<2.1	1.3	45

(a) Indicates background monitoring station.
(b) The lower limits of detection (LLD) range from 5.10E-16 μCi/ml to 1.09E-15 μCi/ml.
(c) LLD = Lower limit of detection.
< Indicates that LLD values were used to calculate the averages when reported values were less than the LLD.
To Convert μCi/ml To Bq/M^3 multiply by 3.7E10

4.1.6.2 Quarry. There are two airborne radioactive particulate monitoring stations along the WSQ perimeter. The long lived gross alpha activity measured at station AP-1009, located on the northeastern perimeter, was not statistically different at the 95% confidence level than the long lived gross alpha activity measured at the background station. The long lived gross alpha activity measured at Station AP-1010, located on the southern perimeter, was statistically different at the 95% confidence level than the long lived alpha activity measured at the background station. This is the first time that an annual average gross alpha concentration measured at any of the WSS air particulate monitoring stations has ever been statistically different at the 95% confidence level than the measured background concentration. During 1990, remediation activities at the quarry were in progress. Although engineering controls were in place to control dust, these activities could have resulted in the statistically significant above-background gross alpha activity measured at Station AP-1010. Although this was a statistically significant event, it would result in an effective dose

equivalent of less than 1 mrem to a hypothetical maximally exposed individual as is discussed in Section 4.1.8.2.

4.1.6.3 Off-Site. The annual average long-lived gross alpha concentrations at all off-site monitoring stations were not significantly different at the 95% confidence level than the long-lived background alpha activity measured at the background station during 1990. This is significant because it indicates that there are no releases from the WSQ or chemical plant that can be distinguished from background levels at these locations.

4.1.6.4 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). 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 using the CAP-88, AIRDOS-PC, or EPA COMPLY computer models for determining dose. The WSS monitoring 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 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 where the highest potential off-site concentrations of radionuclide other than radon are likely to occur during remediation of the WSS.

Tables 4-13 through 4-17 present the estimated effective dose equivalents (EDE) at each of the five designated critical receptor locations. The estimated EDEs at all critical receptor locations are less than 1 mrem (0.01 mSv). In order to determine EDEs, both the net airborne radionuclide concentrations (i.e., the airborne concentration at the critical receptor location less the background concentration) and the amount of time members of the public reside or abide at the critical receptor location must be known.

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 1990 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 gross radionuclide concentrations reported in Tables 4-13 through 4-17 are the averages of the results for the three aliquots. The net radionuclide concentrations equal the gross results minus the results reported for the WSS background monitoring station at the ABWA, which is designated as station AP-4007. The estimated EDE is then calculated by multiplying the net radionuclide concentrations in μCi/ml by an assumed breathing rate of 1.25 m^3/hr (44.14 ft^3/hr), the dose conversion factor in mrem/μCi as reported in *EPA Federal Guidance Report No. 11* (Eckerman et al. 1988) and the assumed exposure time at the specific critical receptor location. If the net concentration (gross minus background) was zero, or less than zero, then the net airborne concentration and the effective dose equivalent in Tables 4-13 through 4-17 was recorded as zero.

An EDE was 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 radionuclide concentrations, the exposure time stated in the NESHAPs compliance monitoring program, a breathing rate of 1.25 m^3/hr, and the radionuclide-specific dose conversions factors provided in EPA Federal Guidance Report No. 11 (Eckerman, et al. 1988). The EDEs calculated for all critical receptor locations are all less than 0.3 mrem as is shown in Tables 4-13 through 4-17. It is likely, however, that the airborne radionuclide concentrations measured at all critical receptor locations are all measurements

TABLE 4-13 Effective Dose Equivalent at Critical Receptor Location AP-2001

RADIONUCLIDE	GROSS ANALYSIS RESULTS (a) (pCi)	NET RESULTS(b) (GROSS -BKG.) (pCi)	NET AIRBORNE CONCENTRATION ($\mu Ci/m^3$)	DCF (c) (mrem/μ/Ci)	EDE[d] (mrem)
U-238	0.8	0.0	0	1.2E+05	0
U-234	0.7	-0.1	0	1.3E+05	0
U-235	<0.1	<0.0	0	0.2E+05	0
Ra-226	<0.7	<0.0	0	8.6E+03	0
Ra-228	5.3	-0.5	0	4.8E+03	0
Th-228	2.6	1.2	1.9E-10	3.4E+05	1.7E-01
Th-230	<1.5	<0.8	1.3E-10	3.3E+05	1.1E-01
Th-232	<0.4	<0.0	0	1.6E+06	0
				TOTAL EDE[d] =	1.1E-01

(a) Reported results are the average of three separate analysis on three sample aliquots.

(b) Net results obtained by subtracting results from the background station AP-4007.

(c) Dose conversion factors (DCF) were taken from the EPA Federal Guidance Report No. 11 (Eckerman et al. 1988).

(d) Effective Dose Equivalents (EDE). Exposure time assumed for this critical receptor location was 2,000 hours.

< Indicates that lower limit detection (LLD) values were used to calculate the average when reported values were less than the LLD.

TABLE 4-14 Effective Dose Equivalent at Critical Receptor Location AP-2005

RADIONUCLIDE	GROSS ANALYSIS RESULTS (a) (pCi)	NET RESULTS (b) (GROSS -BKG.) (pCi)	NET AIRBORNE CONCENTRATION ($\mu Ci/m^3$)	DCF (c) (mrem/μCi)	EDE (d) (mrem)
U-238	0.7	-0.1	0	1.2E+05	0
U-234	1.0	0.2	3.2E-11	1.3E+05	1.3E-02
U-235	<0.1	<0.0	0	1.2E+05	0
Ra-226	<0.5	<-0.2	0	8.6E+03	0
Ra-228	<9.3	<3.5	5.6E-10	4.8E+03	8.3E-03
Th-228	3.4	2.0	3.2E-10	3.4E+05	3.4E-01
Th-230	<0.8	<0.1	0	3.3E+05	0
Th-232	<0.6	<0.2	3.2E-11	1.6E+06	1.6E-01
				TOTAL EDE =	0.18

(a) Reported results are the average of three separate analysis performed on three sample aliquots.
(b) Net results obtained by subtracting results from the background station AP-4007.
(c) Dose conversion factors (DCF) were taken from the EPA Federal Guidance Report No. 11 (Eckerman et al. 1988)
(d) Effective Dose Equivalent (EDE). Exposure time assumed for the critical receptor location was 2,500 hours.

TABLE 4-15 Effective Dose Equivalent at Critical Receptor Location AP-4006

RADIONUCLIDE	GROSS ANALYSIS RESULTS(a) (pCi)	NET RESULTS(b) (GROSS -BKG.) (pCi)	NET AIRBORNE CONCENTRATION ($\mu Ci/m^3$)	DCF (c) (mrem/μCi)	EDE (d) (mrem)
U-238	0.5	-0.3	0	1.2E+05	0
U-234	0.7	-0.1	0	1.3E+05	0
U-235	<0.1	<0.0	0	1.2E+05	0
Ra-226	<0.6	<-0.1	0	8.6E+03	0
Ra-228	6.6	0.8	1.3E-10	4.8E+03	1.8E-03
Th-228	1.1	-0.3	0	3.4E+05	0
Th-230	<0.3	<-0.4	0	0.0E+00	0
Th-232	<0.3	<-0.1	0	1.6E+06	0
				TOTAL EDE =	1.8E-03

(a) Reported results are the average of three separate analysis performed on three sample aliquots.
(b) Net results obtained by subtracting results from the background station AP-4007.
(c) Dose conversion factors (DCF) were taken from the EPA Federal Guidance Report No. 11 (Eckerman et al. 1988).
(d) Effective Dose Equivalent (EDE). Exposure time assumed for this critical receptor location was 2,250 hours.

TABLE 4-16 Effective Dose Equivalent at Critical Receptor Location AP-4008

RADIONUCLIDE	GROSS ANALYSIS RESULTS (a) (pCi)	NET RESULTS (b) (GROSS -BKG.) (pCi)	NET AIRBORNE CONCENTRATION ($\mu Ci/m^3$)	DCF (c) (mrem/μCi)	EDE (d) (mrem)
U-238	0.5	-0.3	0	1.2E+05	0
U-234	0.5	-0.3	0	1.3E+05	0
U-235	<0.1	<0.0	0	1.2E+05	0
Ra-226	<0.6	<-0.1	0	8.6E+03	0
Ra-228	<4.1	<-1.7	0	4.8E+03	0
Th-228	<1.3	-0.1	0	3.4E+03	0
Th-230	<0.3	<-0.4	0	3.3E+05	0
Th-232	<0.3	<-0.1	0	1.6E+06	0
				TOTAL EDE =	0

(a) Reported results are the average of three separate analysis performed on three sample aliquots.
(b) Net results obtained by subtracting results from the background station AP-4007.
(c) Dose conversion factors (DCF) were taken from the EPA Federal Guidance Report No. 11 (Eckerman et al. 1988).
(d) Effective Dose Equivalents (EDE). Exposure time assumed for this critical receptor location was 2,000 hours.

TABLE 4-17 Effective Dose Equivalent at Critical Receptor Location AP-4011

RADIONUCLIDE	GROSS ANALYSIS RESULTS (a) (pCi)	NET RESULTS (b) (GROSS-BKG.) (pCi)	NET AIRBORNE CONCENTRATION ($\mu Ci/m^3$)	DCF (c) ($mrem/\mu Ci$)	EDE (d) (mrem)
U-238	0.6	-0.2	0	1.2E+05	0
U-234	0.6	-0.2	0	1.3E+05	0
U-235	<0.1	<0.0	0	1.2E+05	0
Ra-226	<0.5	<-0.2	0	8.6E+03	0
Ra-228	5.0	-0.8	0	4.8E+03	0
Th-230	<0.5	<-0.2	0	3.3E+05	0
Th-232	<0.5	<0.1	1.6E-11	1.6E+06	2.8E-01
				TOTAL EDE =	2.8E-01

(a) Reported results are the average of three separate analysis performed on three sample aliquots.
(b) Net results obtained by subtracting results from the background station AP-4007.
(c) Dose conversion factors (DCF) were taken from the EPA Federal Guidance Report No. 11 (Eckerman et al. 1988).
(d) Effective Dose Equivalent (EDE). Exposure time assumed for this critical receptor location was 8,736 hours.

of background concentrations. This is because, based on a T-test statistical comparison of airborne radionculide concentrations measured at the critical receptor locations versus concentrations measured at the background station, there is no reason to suspect, at the 95% confidence level, that there is a difference between the average of the concentration results measured at the background monitoring station and the average of the concentration results measured at any of the critical receptor locations other than at location AP-2005. The comparison of Th-228 analyses from stations AP-2005 and AP-4007 (background station) did not pass the statistical test at the 95% confidence level. The analysis results from station AP-2005 for Th-228 are probably an anomily because they are not supported by characterization data collected at the WSSRAP.

When Th-228 is detected uranium should also be detected. All site characterization data have indicated that whenever Ra-228 activity is present there are at least the same or greater U-238 activity concentrations. Th-228, a radioactive daughter product of Ra-228, has

a half-life of 1.9 years. At least 20 years have passed since the shutdown of the chemical plant, which is more than ample time for Th-228 to attain secular equilibrium with Ra-228. Therefore, whenever Ra-228 is present at the site, Th-228 should also be present at approximately the same activity level; and the U-238 activity should be equal to or greater than both Ra-228 and Th-228. However, analyses from station AP-2005 show that average gross Th-228 activity was almost five times higher than average gross U-238 activity. In addition, all uranium analyses from station AP-2005 passed the statistical test at the 95% confidence level. There is also 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.

There are five critical receptor locations surrounding 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. There are 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. Critical receptor AP-2005 is located near the WSSRAP administration building. There are approximately 150 workers at the administration building. The exposure time at this critical receptor location is 50 hr/wk, for 50 wk/yr, or 2,500 hr/yr. Critical receptor AP-4006 is located at the Francis Howell High School. There are approximately 1,800 students, faculty, and staff members at the high school. Faculty and staff generally spend more time at the school than do students. The exposure time for students, faculty and staff members at the high school is 45 hr/wk for 50 wk/yr at the school or 2,250 hr/yr. In addition, there is one employee who lives on the high school grounds; therefore, his exposure time is assumed to be continuous. This employee's exposure time is 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. Critical receptor AP-4011 is located approximately 0.7 km (0.4 mi) west of the quarry. There is a residence within 150 m (165 yd) of the critical receptor and directly in line with the quarry and critical receptor. The exposure time at the residence is continuous i.e., 8,760 hr/yr. Based on this exposure time and the radionuclide concentrations shown in Table 4-17, an effective dose equivalent of less than 1 mrem would be calculated for the residence.

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 receptor includes spikes, blanks, duplicates, and control charts. In addition, analytical data quality objectives have been established for precision and accuracy. Precision is determined by averaging the results of the three duplicate analyses. The results of the precision samples are considered acceptable if the standard deviation of duplicate analysis is within $\pm 50\%$ of the average for 85% of the duplicate data sets. Analytical precision is also calculated for U-238/U-234 for each composite sample. Precision results are acceptable if the standard deviation of U-238 and U-234 results for each composite sample falls within $\pm 50\%$ of the average for 85% of all samples analyzed. Accuracy objectives are that 85% of the results for spiked samples are within $\pm 50\%$ of the known values.

Except for spiked samples, data quality objectives were met in all cases. 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. All six composite thirds from the two U-238 spikes met the established criteria previously mentioned. However, four of the six Th-230 composite thirds did not meet established criteria for accuracy, so only 67% of all the spiked samples met accuracy criteria. Although accuracy for thorium spikes was not met, five of the six results were greater than the actual concentration and four of those were almost twice the actual concentration. This would indicate a probable high bias for Th-230 results. If Th-230 results are biased high, the effective dose equivalent calculation for Th-230 would also be high.

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. 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.

4.1.7 Unrestricted-Area Radiological Contamination Monitoring and Results

The WSS contains many areas of radiological contamination due to waste deposition and spillage during former uranium and thorium refining operations. Also, due to atmospheric releases of radioactivity during operations at the WSS, all structures and roads may have surficial contamination. The majority of the processing involved refining uranium, and thus uranium is the primary contaminant at the site.

Since 1986, the WSSRAP has employed an unrestricted-area monitoring program to ensure that radioactive materials are not migrating from the site (as a result of the remedial construction) to areas used by the general public.

This program includes radiological surveys of the WSSRAP administration building, laboratory, access control point for the site controlled area, WSSRAP trailers, subcontractor trailers, vehicles, site roadways, and a portion of the Katy Trail. Radiological surveys are usually performed monthly or at least quarterly. The surveys involve performing in situ measurements and collecting swipe samples.

In situ measurements are taken with a beta-gamma detector. Measurements are collected over a one-minute counting interval and then converted to disintegrations per minute per 100 cm^2 (dpm/100 cm^2) (dpm/15.5 $in.^2$). These measurements determine the total radioactivity; fixed plus removable.

Measurements of removable surficial contamination levels are made at each beta-gamma 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 one minute 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 $in.^2$).

For the purpose of this report, only the monitoring results for the WSSRAP roadways outside the controlled area and the Katy Trail are presented. These areas are discussed because they represent areas accessible to the public. All other monitoring results are on file at the WSSRAP. Performance of these surveys to date confirms that contaminated materials are not being carried into unrestricted areas.

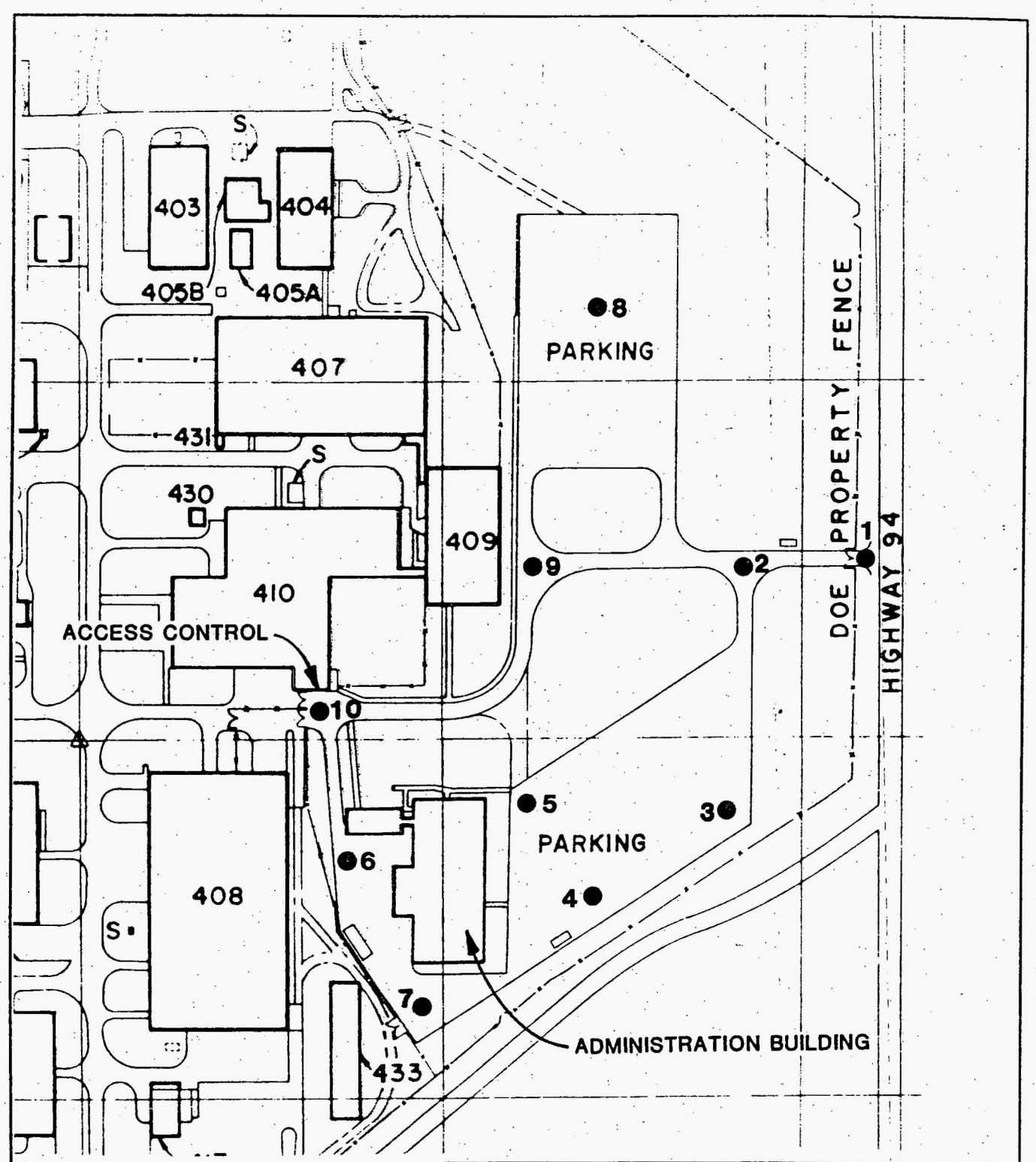
Figure 4-12 shows the monitoring locations for the roadways outside the controlled area. Table 4-18 lists the annual average beta-gamma and alpha monitoring results at each location. The "<" signs in the table indicate that some of the measurements at that location were less than the minimum detectable activity (MDA) of the instruments used. In such cases, the MDA of the instrument was used to calculate the annual average. Also included in the table are the associated standard deviations of the beta-gamma and alpha results. The standard deviation for each of the monitoring locations was calculated using only analysis results that were above the MDA, because the weekly MDS values were nearly the same, and to have used them would have resulted in a low basis in the standard deviation.

The results of the monitoring show that fixed contamination is present at a few locations, but only 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 Materials Plant (WSUFMP). Since monitoring began, there has been no increase in the removable contamination levels on the uncontrolled area roadways at the WSS.

The Katy Trail is shown on Figure 4-13. An approximate 1,130-m (1,243 yd) stretch of the trail is monitored due to its proximity to the WSQ and Femme Osage Slough. Beta/gamma measurements are taken at 10 locations along the trail. The section that is monitored is shaded in Figure 4-13. The 10 locations are varied each time so as to check for any mobile contamination over the entire length of the monitored portion of the trail.

Table 4-19 lists the average beta-gamma and alpha monitoring results for each location. The "<" signs in the table indicate that some of the measurements at that location were less than the MDA of the instrument used. In such cases, the MDAs of the instruments were used to calculate the annual average. The table also includes associated standard deviations of the beta-gamma and alpha results.

The results from all monitoring locations along the Katy Trail indicate background radionuclide concentration levels. A soil sample was taken at location No. 1 because this location had the highest average beta-gamma monitoring results. The analysis of this soil sample showed concentrations within the typical background concentrations ranges of U-238, Ra-226, Ra-228, and K-40. There is no evidence of radioactive material migrating from the



● · SURVEY LOCATIONS

0 200 400 FT

0 61.0 121.9 M

SCALE

ROAD SURVEY LOCATIONS

FIGURE 4-12

REPORT NO. DOE/OR/21548-193		EXHIBIT NO.: A/CP/121/0591	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 5/91	

TABLE 4-18 1990 Site Roads Periodic Survey Results

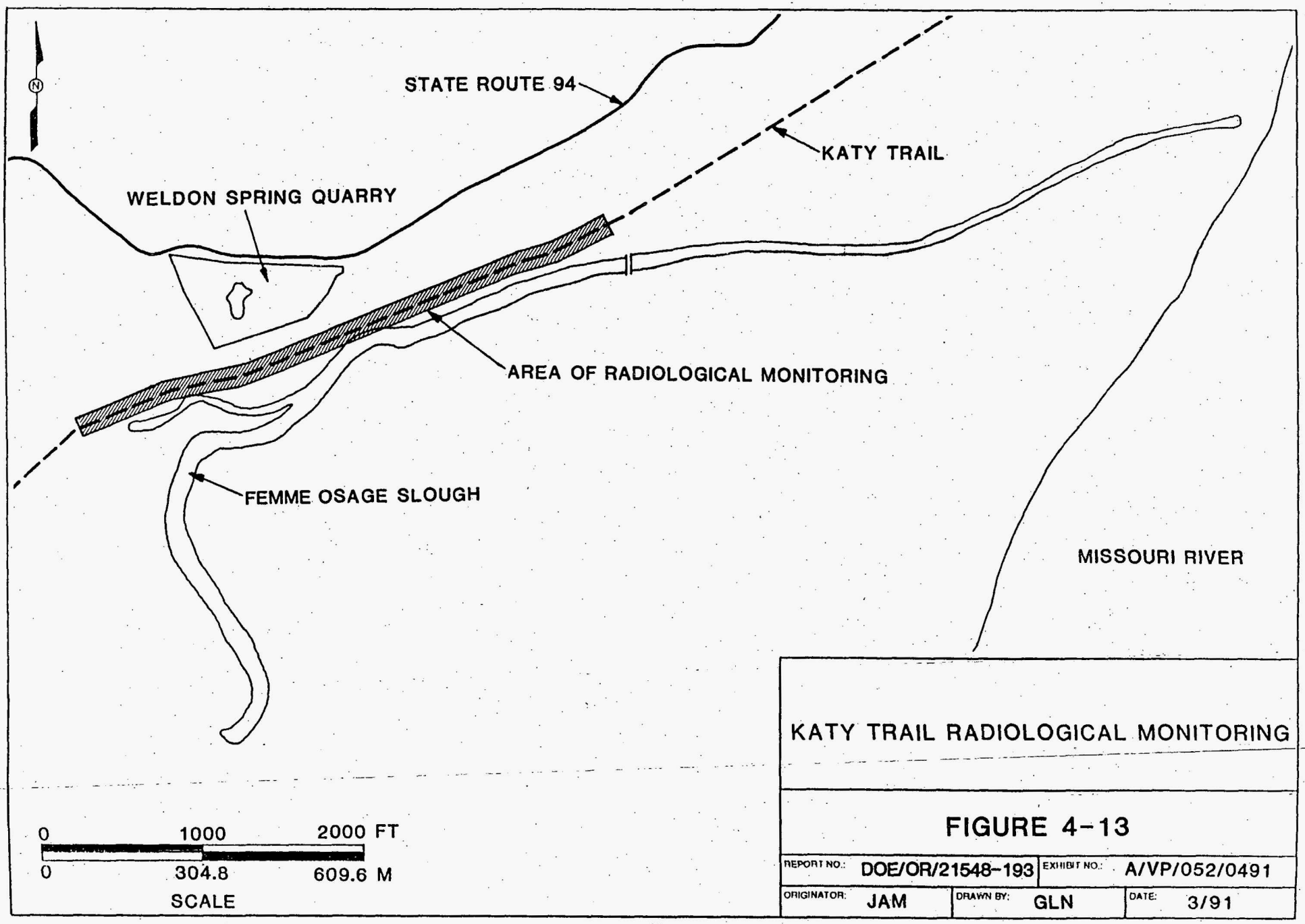
LOCATION I.D.	TOTAL BETA-GAMMA RESULTS ANNUAL AVERAGE[a][b] (dpm/100 cm^2)[b]	STANDARD DEVIATION	REMOVABLE ALPHA RESULTS ANNUAL AVERAGE[a][c] (dpm/100 cm^2)	STANDARD DEVIATION
1	752	356	<6	3.5
2	<621	161	<6	1.5
3	<650	390	<6	1.4
4	1333	474	<6	1.4
5	881	201	<6	3.2
6	<944	594	<6	4.2
7	2338	505	<6	1.4
8	2039	791	<6	2.1
9	1460	278	<6	2.5
10	810	201	<6	2.5

(a) Minimum detectable activities (MDA) ranged from 381 to 315 dpm/100 cm^2.
(b) Results given in disintegrations per minute per 100 square centimeter area.
(c) MDA ranged from 4 to 7 dpm/100 cm^2
< Indicates that some of the values used to calculate the annual average were the instruments minimum detectable activities, and that the actual averages would be lower than what is shown.

WSQ or the Femme Osage Slough area on to the Katy Trail, and thus, there is no identifiable probability of radiological contamination to users of the Katy Trail.

4.1.8 Radiological Exposure Assessments

In assessing the health effects of the radioactive materials present at the WSCP/WSRP, WSQ, and WSVP as required by DOE Order 5484.1; radiological exposure was evaluated for a maximally exposed individual at the WSCP/WSRP, the WSQ, the WSVP, and for the general population within 80 km (50 mi) of the WSS. 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 since the above-background airborne radioactive particulate concentrations, radon concentrations, and external gamma radiation measured during 1990 result in an estimated effective dose



KATY TRAIL RADIOLOGICAL MONITORING

FIGURE 4-13

REPORT NO.:	DOE/OR/21548-193	EXHIBIT NO.:	A/VP/052/0491		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	3/91

TABLE 4-19 1990 Katy Trail Periodic Radiological Survey Results

LOCATION I.D.	BETA-GAMMA RESULTS		ALPHA RESULTS	
	ANNUAL AVERAGE (DPM/100 CM^2)(a)(b)	STANDARD DEVIATION	ANNUAL AVERAGE (DPM/100 CM^2) (a)(c)	STANDARD DEVIATION
1	<760	335	<6	2.4
2	601	294	<6	1.2
3	562	214	<6	3.0
4	569	365	<6	3.5
5	<552	294	<6	2.7
6	<527	180	<6	1.3
7	652	319	<6	1.7
8	<674	336	<6	2.7
9	<525	174	<6	1.6
10	<493	106	<6	1.3

(a) Minimum detectable activities (MDA) ranged from 381 to 315 dpm/100 cm^2.
(b) Results given in disintegrations per minute per 100 square centimeter area.
(c) MDA ranged from 4 to 7 dpm/100 cm^2.
< Indicates that some of the values used to calculate the annual average were the instruments minimum detectable activities, and that the actual averages would be lower than what is shown.

equivalent of less than 3.9 mrem to a hypothetical maximally exposed individual as shown in Table 4-20 and discussed in this section.

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 4.1.8.1 through 4.1.8.4. A more detailed account of assumptions, parameters valves, and equations used to calculate effective dose equivalents is provided in Appendix G, Dose Assessment Calculations.

Individuals could be exposed to radioactivity from the WSS via five principal pathways: (1) direct external gamma radiation, (2) inhalation of radon, (3) inhalation of airborne radioactive dust particles, (4) ingestion of fish from nearby lakes that receive runoff from the WSS, and (5) ingestion of drinking water from sources contaminated with

TABLE 4-20 Estimated 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	TOTAL EDE	PERCENT OF EPA[(a)] STANDARD	PERCENT OF DOE[(b)] GUIDELINE
Radiation dose to a maximally exposed individual	0.006 mrem	0.55 mrem	3.3 mrem	3.9 mrem	0.06	3.9
Radiation collective population dose	0.0002 person-rem	0.004 person.rem	0.055 person-rem	0.059 person-rem	N/A	N/A

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

(b) The DOE guideline limits effective dose equivalents from plant emissions to 100 mrem annually. The WSSRAPs total effective dose equivalent was compared to the DOE guideline.

radionuclides from the WSS. All five pathways were included for the hypothetical maximally exposed individual. Pathway 4 was not considered in the population dose assessments because it is not reasonable or realistic to expect all members of a population to eat fish from bodies of water that receive runoff from the WSS. Pathway 5 was not considered in the population dose estimate because none of the surface water or groundwater voids that receive runoff or recharge from the WSS are used as drinking water sources. An evaluation of radiological exposures from these lakes when they are used for recreational purposes was included to ensure that the assessment would be thorough.

Although radiation doses can be calculated or measured for individuals, it is not practical to predict the health risk to a single individual. Estimates of health risks related to radiation doses 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 effective dose equivalent (EDE). 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 (CEDE) in units of person-rems (person-sieverts). Table 4-20 reports 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, 3.8 mrem, and <1 mrem (<0.01 mSv, 0.038 mSv, and <0.01 mSv) respectively. The highest of these three results was included in Table 4-20. 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 4-20, 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 annually for airborne emissions other than radon. It is not clear whether the emission standards in 40 CFR 61 subpart H are meant to apply to fugitive emissions from a site being remediated according to CERCLA. DOE is attempting to clarify this through a draft Memorandum of Understanding (MOU) with EPA. Until this issue is resolved, exposures due to fugitive emissions from area sources will be compared to the standards in 40 CFR 61 subpart H.

4.1.8.1 Radiation Dose From the WSCP/WSRP to a Hypothetical Maximally Exposed Individual. This section provides an 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 particle inhalation, and radon daughter inhalation assume a realistic less than 100% residence time. The amount of fish obtained and ingested from lakes receiving effluent from the WSCP/WSRP is assumed to be the average consumption rate per year according to U.S. Environmental Protection Agency statistics (Eckerman et al. 1988). None of these bodies of water are used as sources of drinking water. However, an evaluation of this pathway is included on the assumption that people could conceivably drink from them.

Direct gamma exposure rates were determined by means of TLD monitoring stations at the WSTA, the Missouri State Highway Department facility, and the ABWA. Continuous air samplers measured airborne radioactive particulates at these three locations, and radon exposures were measured via alpha track-etch detectors. There is no reason to suspect (with 95% confidence) that gamma exposure rates, airborne radioactive particulate concentrations, and radon gas concentrations exceed natural background; therefore, the effective dose equivalent to a hypothetical individual receiving the maximum reasonable exposure from these three pathways is not measurable above normal background exposure.

Three off-site bodies of water (Busch Lakes 34, 35, and 36) receive runoff from drainage originating at the WSCP/WSRP site. All three lakes are used for fishing and boating. In 1990, a bio-uptake investigation was conducted in order to determine the possible exposure of humans to chemical and radioactive contamination from 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 were collected from the lakes which included bass, catfish, sunfish, and crappie. 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 0.001 pCi/g, 0.005 pCi/g, and 0.018 pCi/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 less than 1 mrem (0.01 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. Swimming can result in the ingestion of 0.05 liters/hr (0.05 qt/hr) on average (EPA 1988). Assuming that the individual swims in Lake 36, which has the highest average surface water concentration (51 pCi/l, or 1,887 Bq/m^3) for 12 hr/yr based on swimming 1 hr/wk during the summer or approximately

three months and using EPA dose conversion factors (Eckerman et al. 1988), the calculated dose would be less than 1 mrem (0.01 mSv).

It is also possible for an individual to ingest lake sediments during visits to the lakes. It is assumed the hypothetical individual would spend an average of approximately 2 day/yr at the lakes consuming 200 mg/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 below 1 mrem (0.01 mSv).

A maximally exposed individual would therefore receive a total effective dose equivalent of less than 1 mrem (0.01 mSv) from direct gamma exposure, inhalation of airborne dust particles, inhalation of radon daughters, ingestion of water and sediment, and ingestion of fish from contaminated waters.

4.1.8.2 Radiation Dose From the WSQ to a Hypothetical Maximally Exposed Individual. This section discusses the estimated committed effective dose equivalent of 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 exposure, airborne radioactive particulate concentrations, and radon daughter inhalation assume a realistic less than 100% residence time. Access to the quarry is controlled by a barbed wire fence; thus fishing, swimming, and drinking water from the quarry pond need not be evaluated.

In order to estimate the effective dose equivalent received via the inhalation pathway, a breathing rate must be assumed. The breathing rate assumed for all inhalation pathway calculations is 1.25 m^3/hr (Cember 1983). All effective dose equivalent conversion factors were determined from the EPA Federal Guidance Report No. 11 (Eckerman et al. 1988).

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 1989), 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 environmental TLD 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 (30 μrem/hr at TD-1001), the calculated dose equivalent would be less than 1 mrem (0.01 mSv).

Analysis of long-lived gross alpha activity from airborne radioactive particulate data from 1990 indicated that results from monitoring station AP-1010 on the quarry southern perimeter were significantly different than background at the 95% confidence level. The net average airborne long-lived gross alpha concentration at station AP-1010 (i.e., the concentration measured at AP-1010 less the background concentration measured at the Busch Wildlife Area) was 4.6 E-16 μCi/ml. This net airborne gross alpha concentration was proportioned among uranium, radium, and thorium isotopes according to the average radionuclide concentration results measured in the surface (0 m to 0.15 m) wastes within the WSQ and reported in the Remedial Investigation for the Quarry Bulk Waste (MKF and JEG 1989a). Using this assumption, the measured concentration would result in an estimated effective dose equivalent of less than 1 mrem (0.01 mSv).

The risk associated with Rn-222 is due primarily to inhalation of its short-lived daughter products. Data from the three alpha track-etch radon monitoring stations closest to State Route 94 were used to evaluate the dose by inhalation of radon daughters for the hypothetical individual. The highest average measured radon gas concentration at these monitoring stations was 1.8 pCi/l (67 Bq/m^3) above normal background. Assuming a 50% equilibrium between radon gas and its daughters and 1.25 rem/working level month (WLM) (12 mSv/WLM) effective dose equivalent conversion factor derived from EPA guidance (Eckerman et al. 1988), the estimated effective dose equivalent from inhalation of radon daughters is 3.3 mrem (0.033 mSv).

The dose to the hypothetical maximally exposed individual from the three pathways discussed above consists of a total of 3.8 mrem (0.038 mSv) from direct gamma exposure, inhalation of radon daughters and inhalation of radioactive air particulates.

4.1.8.3 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 Refuge); therefore, all direct gamma exposure calculations assume a realistic less than 100% time of residence. The slough is not suspected of having airborne radioactive particulate concentrations and radon daughter 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 1988). 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. The 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 2.5 μrem/hr in excess of natural background, the calculated dose equivalent would be less than 1 mrem (0.01 mSv).

As part of the bio-uptake study, fish samples were collected and analyzed for total uranium, Th-230, Th-232, and Ra-226. All results were below detection limits. 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. Assuming that the uranium concentration in fish is equal to the detection limit achieved during tissue analysis, the fish tissue concentration is 0.01 pCi/g (0.27 mBq/g). Using the average annual consumption rate of 6.5 g/day (0.23 oz/day) (EPA 1988), the calculated effective dose equivalent to the maximally exposed

individual from ingestion of fish living in contaminated waters would be less than 1 mrem (0.01 mSv).

The dose to the maximally exposed individual from the two pathways discussed above consists of a total of less than 1 mrem (0.01 mSv) from direct gamma exposure and consumption of fish tissue.

4.1.8.4 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 1990 is less than 0.059 person-rem. The estimated exposed population is 72,000 persons. 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 and WSQ perimeter monitoring stations. None of the analytical results from critical receptor monitoring stations were significantly different than 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 than 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 airborne radioactive particulate and 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 yd) south of the quarry at its closest point and about 25 m (27.5 yd) below the southern quarry rim. It parallels the southern rim for approximately 260 m (286 yd). The Katy Trail was chosen as the only potential exposure point location because only at the quarry were statistically significant above background radon and air particulate concentrations measured. The estimated number of people using the Katy Trail annually is 72,000, which was derived from an estimate provided by the Missouri State Parks Department in February 1991, (Maher 1991). Results from monitoring stations at other potentially affected populations near the WSQ (e.g., monitoring stations AP-4011 and RD-4006) are not significantly different than background levels. Figure 4-11 shows the locations of all WSQ perimeter monitoring stations as well as the Katy Trail.

The Katy Trail was chosen as the only potential exposure point location; because only at the WSQ were measured concentrations found to be statistically different at the 95% confidence level than the measured background concentrations for radon, external gamma radiation, and airborne radioactive particulates. Results at all non-WSQ monitoring locations, including the designated critical receptor locations, were not statistically different than the measured background concentrations at the 95% confidence level. Since measured concentrations at all monitoring locations other than the WSQ monitoring stations were not significantly different than background, and the monitoring network includes a monitoring station at every public receptor location within 2.5 km (1.5 mi) of the site, there were no other potential public exposure points during 1990.

The collective effective dose equivalent estimate was determined by calculation of conservatively-estimated airborne particulate and radon gas concentrations at the Katy Trail and an assumed exposure time of 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 breathing rate used in calculation of effective dose equivalent via the inhalation pathway was 1.25 m^3/hr (Cember 1983) and the dose equivalent conversion factors were obtained from EPA Federal Guidance Report No. 11 (Eckerman et al. 1988). Airborne radioactive particulate and radon concentrations at the WSQ were estimated using a Gaussian atmospheric dispersion model modified to predict concentrations close to an area source (DOE 1986). External gamma radiation is estimated using the inverse square law modified for an area source (Cember 1983). 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. It is not realistic to expect that a significant number of persons living within 80 km (50 mi) of the site consume fish or game affective by the WSS; hence this is not a significant exposure pathway (see Section 4.1.8.1).

The above-background airborne particulate and radon gas concentration estimates at the Katy Trail were 1.7E-16 μCi/ml and 0.26 pCi/l respectively. The above-background external gamma dose equivalent rate estimate is 7.7E-4 mrem/hr.

The resultant concentration estimates at the Katy Trail exposure point are conservative, because the model used to estimate concentrations at the trail assumes that the wind direction toward the trail remains continuous. Since the wind direction is variable, the true average concentrations of airborne particulates and radon gas at the exposure point would be lower than predicted by the model. More realistic wind direction estimates were not included in the model, because increasing the model complexity was not warranted based on the extremely low collective population dose estimate obtained by the conservative model used (DOE Order 5400.5).

4.1.8.5. Five Year Trend Analysis of Radon Gas. Track etch radon detector results from the last five years are represented graphically in Figure 4-14. The graph represents the

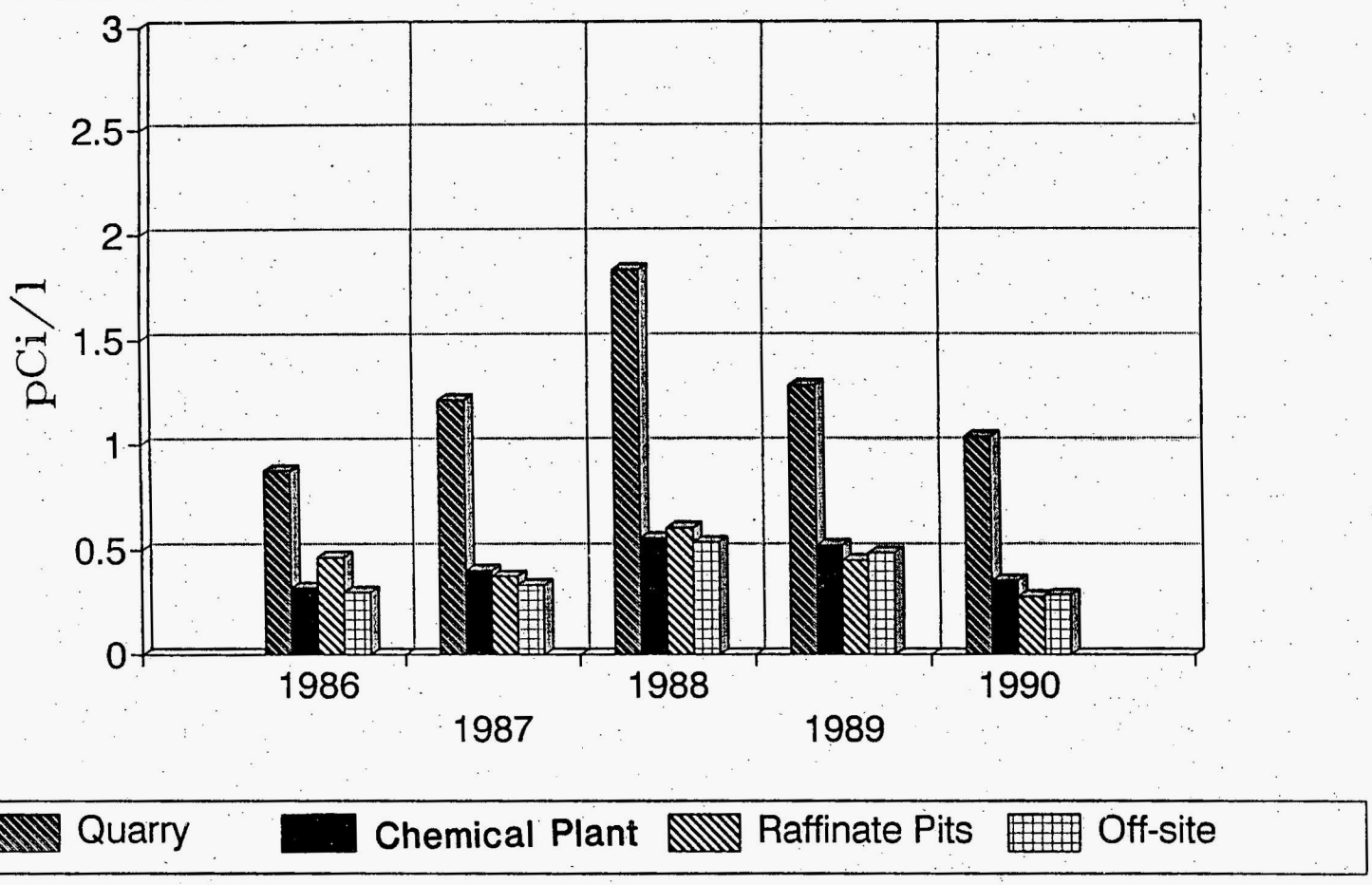
yearly averages of results from the monitoring stations at the quarry, chemical plant, raffinate pits, and off-site locations. The results shown include natural background.

The graph shows a definite increase and decrease in radon concentrations centered around 1988. This is due to the regional drought which occurred during this time period. The drought reduced the moisture content of the soil and the low moisture content allowed a greater fraction of the radon in the voids to diffuse into the atmosphere.

The quarry annual average concentrations, which are higher than other locations, also had greater increases in radon concentrations in proportion to the other locations. This is due to the higher concentrations of uranium and thorium at the quarry. Radon is a naturally occurring radionuclide in the uranium and thorium decay series.

4.1.8.6. Five Year Trend TLD. Gamma radiation exposure monitoring results from the last five years are represented graphically in Figure 4-15. 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.

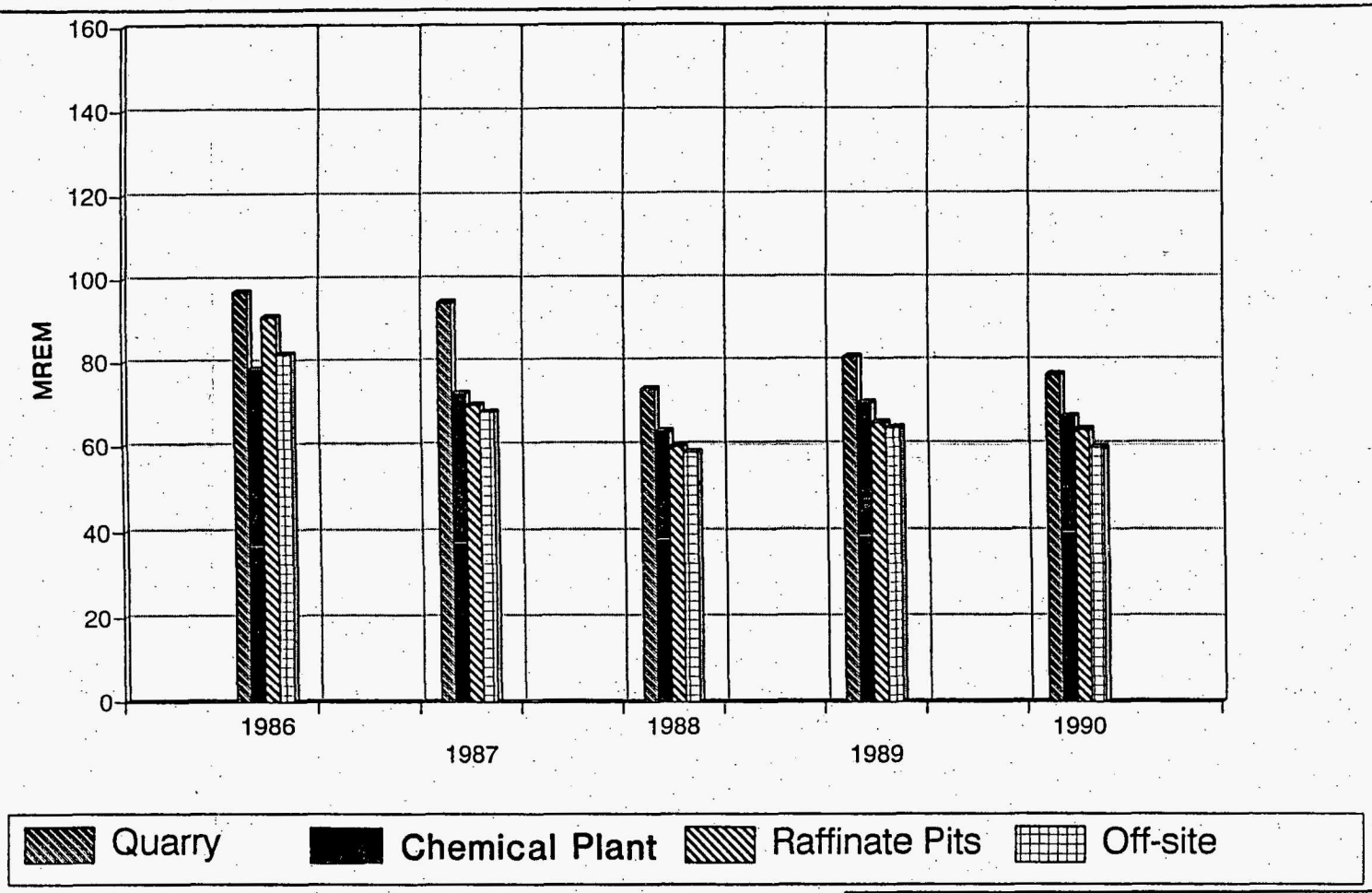
As shown in the graph, there is a difference of approximately 20 mrem between 1986 and 1987 data, and 1988-1990 data. The 20 mrem change between the two time periods can not be explained by changes in the radionuclide inventory, since the radionculide inventory at the WSSRAP has not significantly changed since 1986. The control thermoluminescent dosimeter (TLD) results reported in 1986 and 1987 were also approximately 20 mrem higher than the control TLD results reported in 1988 through 1990. 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. The subcontract laboratory that provides and analyzes the TLDs was contacted and indicated that a probable cause for the change between 1987 and 1988 could be due to improvements, based on additional testing and research, in the calculation of effective dose equivalents measured by the environmental TLDs. 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 1990, there is not an increasing trend in the effective dose equivalents resulting from gamma exposure.



TRACK ETCH RADON RESULTS

FIGURE 4-14

REPORT NO.:	DOE/OR/21548-193	EXHIBIT NO.:	A/PI/088/0591		
ORIGINATOR:	JAM	DRAWN BY:	GLN	DATE:	5/91



ENVIRONMENTAL TLD RESULTS

FIGURE 4-15

REPORT NO.:	DOE/OR/21548-193	EXHIBIT NO.:	A/PI/089/0591		
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4.1.9 Radiological Release Estimates

During 1990 air particulate monitoring station AP-1010, located at the rim of the quarry, was the only location which had results that were statistically above background. An average of 4.6E-16 pCi/ml above background gross alpha results were obtained at station AP-1010. Using this concentration and a box model, calculations showed that 1.08E-5 Ci of gross alpha activity was released form the quarry perimeter. Assuming that the ratios of the various nuclides on filter are the same as those for surface soils reported in the remedial investigations for quarry bulk waste report (MKF and JEG 1989), the calculated amounts of the radionuclides range from 5.8 pCi to 0.3 pCi. Based on the reported activity of uranium that was released, and a specific activity of 3.3E-5 pCi/g, a total of 8.9 grams of uranium were released from the quarry perimeter. The results of the calculated quantities of radioactive materials are shown in Table 4-20A.

Intermittent surface water runoff also transported uranium (in the natural distribution) from the site area during 1990 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 (see Section 4.2.4). Table 4-28 shows the discharge of natural uranium from the NPDES outfalls. Based upon those estimated total activities, and since the uranium on the site maintains a natural distribution of the isotopes, the estimated activity by isotope is calculated and is shown in Table 4-20A. Other radionuclides were not measured in surface water during 1990.

4.2 Non-Radiological Monitoring Program Information

4.2.1 Surface Water and Spring Monitoring

The environmental monitoring program for chemical constituents in surface water and springs for 1990 include 10 locations, nine of which were within or near the site and the other location was located within the quarry sump. The four surface water locations within the four on-site raffinate pits (SW-3001 through SW-3004), were monitored annually for inorganic anions. The five spring locations, SP-5201, SP-6301, SP-6302, SP-6303, and

TABLE 4-20A Radionuclide Emissions to the Environment

RADIONUCLIDE	ACTIVITY OF RADIONUCLIDE RELEASED TO AIR (Ci)	ACTIVITY OF RADIONUCLIDE RELEASED TO WATER	HALF-LIFE (yrs)
U-238	2.89E-6	1.8E-2	4.47E9
U-235	1.34E-7	8.0E-4	7.04E8
U-234	2.89E-6	1.8E-2	2.45E5
Th-232	3.24E-7	—	1.40E10
Th-230	2.49E-6	—	7.54E4
Ra-228	3.24E-7	—	5.76
Ra-226	1.76E-6	—	1,600
Rn-222	16.4	—	3.82 days

SP–6306 located off-site were monitored for nitroaromatics either semiannually or quarterly and two of the same springs, SP-6301 and SP-6306, were monitored annually for inorganic anions. The surface water monitoring location within the quarry, the quarry pond (SW–1008), was sampled quarterly for inorganic anions and nitroaromatics.

4.2.1.1 Inorganic Anion Analyses in Surface Water at the WSCP. The inorganic anions of interest included chloride, fluoride, nitrate, and sulfate. The following text details the results and implications of the anion analyses. Annual averages of these analytical results are presented in Tables 4-1 and 4-2.

The average chloride levels measured in the two off-site surface water locations ranged from 7.4 mg/l at SP-6306 to 32.0 mg/l at SP-6301. These values are within their historical range. These results indicate that the chloride levels off-site do not pose a threat to public health or safety as the secondary standard for chloride is 250 mg/l. No standards exist for protection of aquatic life or biota. The average chloride levels located onsite ranged from 7.83 mg/l to 30.3 mg/l within the raffinate pits. These values are also within their historical ranges.

The measured average fluoride concentrations at the off-site sampling locations remained below 0.2 mg/l. The highest concentration measured in the raffinate pits was 0.9 mg/l which remains well within the EPA's maximum contaminant level (MCL) of 4 mg/l

for fluoride. Fluoride does not constitute a major contamination problem at the WSCP/WSRP.

Off-site concentrations of nitrate (as N) ranged from 2.7 mg/l at SP-6306 to 42.0 mg/l at SP-6301, (Burgermeister Spring). The level at Burgermeister Spring is below its historical range. However, the nitrate levels reinforce the conclusion that contaminated groundwater is apparently contributing to the elevated nitrate levels in the Burgermeister Spring. The levels of nitrate (as N) that are present in Burgermeister Spring are above the drinking water standard of 10 mg/l; however, these nitrate levels constitute no particular threat to human health or the environment as the water is not used domestically, but they do provide valuable information on the mechanics of contaminant migration from the WSS. Nitrate levels within the raffinate pits remained within their historical ranges also. Nitrate values ranged from a low of ND in SW-3002 to a high of 1900 mg/l in SW-3003 (see Table 4-1).

The off-site sulfate measurements made as part of the surface water monitoring program yielded levels ranging between 13.5 mg/l at SP-6306 and 54.0 mg/l at SP-6301. The sulfate value of 54 mg/l at Burgermeister Spring remains within its historical range and possibly suggests a component of sulfate contaminated groundwater discharging at that point. The measured level is well below the EPA's secondary drinking water standard of 250 mg/l for sulfate.

Sulfate levels within the raffinate pits remained within their historical range with a low of 37.5 mg/l at SW-3004 and a high of 695.0 mg/l at SW-3003.

4.2.1.2 Nitroaromatic Compound Monitoring - WSCP/RP Surface Water. The monitoring program for nitroaromatic compounds in 1990 involved quarterly and semi-annual sampling at five off-site locations, SP-5201, SP-6301, SP-6302, SP-6303 and SP-6306. Table 4-21 shows the levels of nitroaromatic compounds detected in those springs. No routine monitoring for nitroaromatic compounds was performed during 1990 at the raffinate pit locations (SW-3001 through SW-3004).

The monitoring results confirm what has been detected historically at the off-site monitoring locations. Total nitroaromatics were detected at levels above the detection limits to a high of 0.8 µg/l at Burgermeister Spring. Positive results were also indicated at SP-5201,

TABLE 4-21 1990 Annual Average Nitroaromatic Concentrations (ug/l) in Springs

WSSRAP ID	1,3,5-TRINITROBENZENE	@	1,3-DINITROBENZENE	@	2,4,6-TNT	@	2,4-DNT	@	2,6-DNT	@	NITROBENZENE	@	NITROTOLUENE	@
SP-5201	1.1	(1/2)	ND	(0/2)	8.4	(2/2)	ND	(0/2)	0.4	(2/2)	ND	(0/2)	NSF	
SP-6301	0.02	(1/2)	ND	(0/2)	0.5	(2/2)	0.8	(2/2)	0.4	(2/2)	ND	(0/2)	ND	(0/1)
SP-6302	ND	(0/2)	ND	(0/2)	0.1	(2/2)	0.7	(2/2)	0.3	(2/2)	ND	(0/2)	NSF	
SP-6303	ND	(0/2)	ND	(0/2)	0.2	(1/2)	0.06	(1/2)	0.4	(2/2)	ND	(0/2)	NSF	
SP-6306	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	NSF	

Average is calculated using non-ND results. An ND is reported in this table only if all samples from that location had ND reported.
ND - Not Detected
NSF - Not Scheduled For Sampling
@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were taken in 1990, two of which average 2.00 and the other two samples were ND.

downstream of a known source of this contamination known as the Department of Army Burn Area No. 1.

4.2.2 Weldon Spring Quarry Surface Water Monitoring

4.2.2.1 Inorganic Anions Results. Inorganic anions were analyzed on a quarterly basis on samples from the quarry pond. The inorganic anions category includes chlorides, fluorides, nitrates, and sulfates. The results of the analyses are presented for each parameter below. Table 4-4 shows the annual averages for each parameter measured.

The highest measured chloride value detected in the quarry sump was 12.4 mg/l with an annual average of 12.1 mg/l. The levels measured in 1990 at SW-1008 have remained very nearly the same compared to historical values. The relatively slight variations can be accounted for by natural dilution effects.

Fluoride levels also remained within their historical range at SW-1008. The annual average for fluoride at SW-1008 was 0.9 mg/l.

The nitrate levels for SW-1008 remained below the detection limit for 1990.

The sulfate measurements ranged from 118 mg/l to 161 mg/l with an average value of 139.5 mg/l at SW-1008. This level is the same as historical values at this location. All measured levels remained well below the EPA's secondary drinking water standard for sulfate of 250 mg/l.

4.2.2.2 Results for Nitroaromatics Analyses in WSQ Surface Water. The quarry pond SW-1008 was sampled quarterly for nitroaromatic compounds. The total quantified concentrations of all six compounds ranged from 1.8 ug/l during the first quarter to 16.2 ug/l during the fourth quarter. Table 4-22 shows those measured values. 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.

TABLE 4-22 1990 Annual Average Nitroaromatic Concentrations (ug/l) For Surface Water Near the WSQ

WSSRAP ID	1,3,5-TRINITROBENZENE	@	1,3-DINITROBENZENE	@	2,4,6-TNT	@	2,4-DNT	@	2,6-DNT	@	NITROBENZENE	@
SW-1008	0.08	(1/3)	ND	(0/3)	4.73	(3/3)	1.71	(3/3)	0.48	(3/3)	ND	(0/3)

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

ND - Not Detected

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicated that four samples were taken in 1990, two of which average 2.00 and the other two samples were ND.

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4.2.3 Groundwater Monitoring Non-Radiological Results

All WSCP/RP/VP and WSQ monitoring wells were sampled during 1990 for nitroaromatics, nitrate, sulfate, chloride, and fluoride. These parameters are sampled with the same frequency and same monitoring program as uranium described in Section 4.1.3 of this report. The St. Charles County pumping wells, treated and untreated water from the St. Charles County Water Treatment Plant, and a select group of monitoring wells in the county wellfield were monitored quarterly for arsenic and barium. These same locations at the wellfield were sampled once in 1990 for volatile and semi-volatile organics, pesticides\polychlorinated biphenyls (PCBs), mercury, lead, and cadmium.

Data tables for all laboratory analytical results presented in this section contain annual concentrations calculated in the same format as the uranium table of Section 4.1.3.1 of this report.

4.2.3.1 Chemical Plant/Raffinate Pits. Groundwater at the WSCP/RP area became contaminated as a result of the Weldon Spring Ordnance Works (WSOW) operations during World War II and operations at the WSUFMP during the 1950s and 1960s. The *Phase I Water Quality Assessment Report* (MKF and JEG 1987) reported: "nitroaromatic compounds are present at low to high levels over much of the site; and relatively widespread nitrate and sulfate contamination problems are the result of leaking raffinate pits and other sources." The *Phase II Groundwater Quality Assessment Report* (MKF and JEG 1989b), an expanded comprehensive evaluation of groundwater quality at the WSCP/RP/VP area during the third quarter of 1988, is essentially in agreement with the Phase I report. Two notable exceptions are that the nitrate plume has been more clearly defined and that the original sulfate plume reported in the *Phase I Water Quality Assessment* is actually several isolated plumes, and its source is not exclusively the raffinate pits. These exceptions were detected as a result of additional monitoring well installations.

The groundwater monitoring network is described in Section 4.1.3.1 of this report. Figure 4-5 shows the location of individual wells at the WSCP/RP/VP area.

4.2.3.1.1 Analytical Results for Nitroaromatic Compounds - WSCP/RP Groundwater. No primary or secondary drinking water standards have been promulgated for any of the six nitroaromatic compounds of interest at the WSCP/RP/VP area. However, standards set by

the Clean Water Act-Federal Ambient Water Quality Criteria may be utilized as a reference for discussion. The criteria for 2,4-DNT is 0.11 μg/l based on a lifetime 10^{-6} cancer risk. For nitrobenzene, the criteria is 30 μg/l based on toxicity. Both 2,4-DNT and 2,6-DNT are suspected carcinogens. Nitroaromatic compounds are not naturally occurring; therefore any concentration detected indicates contamination of the groundwater system.

Each groundwater monitoring well was sampled and analyzed for nitroaromatic compounds during 1990. Table 4-23 summarizes the results of these analyses. Nitroaromatic compounds were not detected in 34 monitoring wells. Eighteen wells exhibited cumulative annual average concentrations of nitroaromatic compounds above detection limits, but below 10 μg/l. Seven wells exhibited annual average concentrations greater than 10 μg/l. They are MW-2006, MW-2011, MW-2012, MW-2013, MW-4001, MW-4006 and MW-4013. Figure 4-16 highlights wells with detected annual concentrations.

All 25 of the wells with detected concentrations of nitroaromatics exhibited concentrations of one or both of the suspected carcinogens 2,4-DNT and 2,6-DNT. Ten groundwater monitoring wells--MW-2009, MW-2010, MW-2011, MW-2012, MW-2013, MW-2014, MW-3001, MW-3009, MW-4001 and MW-4013--exhibited annual concentrations of 2,4-DNT above the ambient water quality criteria (0.11 μg/l). No detectable concentrations of nitrobenzene were observed in 1990. Overall the nitroaromatic results are consistent with past environmental monitoring and characterization studies.

4.2.3.1.2 Analytical Results for Inorganic Anions - WSCP/RP Groundwater. All groundwater monitoring wells at the WSCP/RP/VP were sampled for nitrate, sulfate, chloride, and fluoride in 1990. Table 4-6 shows the annual average concentrations of these inorganic anions.

The standard issued in the Safe Drinking Water Act for nitrate (as nitrogen) is 10 mg/l. Background concentrations are below 3.26 mg/l (MKF and JEG 1989a). During 1990, concentrations exceeding background occurred in 16 groundwater monitoring wells. The range of values for these wells is 3.93 mg/l in MW-4014 to 1280 mg/l in MW-3003. Figure 4-17 highlights wells with nitrate values above the EPAs drinking water standard of 10 mg/l. Although values from individual wells have fluctuated somewhat from previous

TABLE 4-23 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Chemical Plant/Raffinate Pits

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-2001	0.032	(1/2)@	ND	(0/2)	ND	(0/2)	0.106	(2/2)	0.054	(2/2)	ND	(0/2)	0.192
MW-2002	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.077	(2/2)	0.415	(2/2)	ND	(0/2)	0.492
MW-2003	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.029	(2/2)	1.4	(2/2)	ND	(0/2)	1.429
MW-2004	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2005	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.08	(2/2)	0.06	(2/2)	ND	(0/2)	0.140
MW-2006	11.5	(2/2)	0.14	(1/2)	0.039	(1/2)	0.06	(1/2)	1.5	(2/2)	ND	(0/2)	13.239
MW-2007	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2008	6.455	(2/2)	0.14	(1/2)	0.036	(1/2)	ND	(0/2)	1.16	(2/2)	ND	(0/2)	7.791
MW-2009	ND	(0/2)	0.5	(1/2)	ND	(0/2)	0.74	(1/2)	0.425	(2/2)	ND	(0/2)	1.665
MW-2010	0.25	(2/2)	0.155	(2/2)	0.455	(2/2)	0.491	(2/2)	0.875	(2/2)	ND	(0/2)	2.226
MW-2011	0.19	(1/1)	0.48	(1/1)	0.06	(1/1)	14	(1/1)	2.2	(1/1)	ND	(0/1)	16.930
MW-2012	4.35	(2/2)	0.29	(1/2)	1.17	(2/2)	4.3	(1/2)	1.65	(2/2)	ND	(0/2)	11.760
MW-2013	6.7	(2/3)	ND	(3/3)	1.9	(2/3)	2.97	(2/3)	21	(2/3)	ND	(0/3)	32.570
MW-2014	4	(1/2)	0.14	(1/2)	0.03	(0/2)	2.2	(1/2)	1.2	(1/2)	ND	(0/2)	7.570
MW-2015	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2017	0.074	(1/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	1.2	(1/2)	ND	(0/2)	1.274
MW-2018	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2019	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND

TABLE 4-23 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Chemical Plant/Raffinate Pits (Continued)

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-2020	ND	(0/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)	ND
MW-2021	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2022	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2023	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2024	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2025	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2026	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2027	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2028	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-2029	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(2/2)	ND
MW-3001	0.115	(2/3)	ND	(0/3)	ND	(0/3)	0.52	(2/3)	0.185	(2/3)	ND	(0/2)	0.820
MW-3002	ND	(0/1)	ND	(0/2)	ND	(0/2)	ND	(0/1)	ND	(0/1)	ND	(0/2)	ND
MW-3003	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.034	(1/2)	0.073	(1/2)	ND	(0/2)	0.107
MW-3006	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.06	(1/2)	0.11	(1/2)	ND	(0/2)	0.170
MW-3008	ND	(0/1)	ND	(0/1)	ND	(0/1)	0.08	(1/1)	0.04	(1/1)	ND	(0/1)	0.120
MW-3009	0.235	(2/2)	ND	(0/2)	ND	(0/2)	0.14	(2/2)	0.1	(2/2)	ND	(0/2)	0.475

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TABLE 4-23 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Chemical Plant/Raffinate Pits (Continued)

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-3010	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-3019	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4001	59	(2/2)	ND	(0/2)	1.95	(2/2)	3.05	(2/2)	3.15	(2/2)	ND	(0/2)	67.150
MW-4002	0.235	(2/2)	ND	(0/2)	1.05	(2/2)	ND	(0/2)	0.345	(0/2)	ND	(0/2)	1.630
MW-4003	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4004	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4005	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4006	19.5	(2/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	4.05	(2/2)	ND	(0/2)	23.550
MW-4007	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4008	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4009	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4010	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4011	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4012	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4013	38.5	(2/2)	ND	(0/2)	0.075	(2/2)	0.22	(2/2)	1.4	(2/2)	ND	(0/2)	40.195
MW-4014	0.465	(2/2)	ND	(0/2)	0.06	(0/2)	ND	(0/2)	0.085	(2/2)	ND	(0/2)	0.610

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TABLE 4-23 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Chemical Plant/Raffinate Pits (Continued)

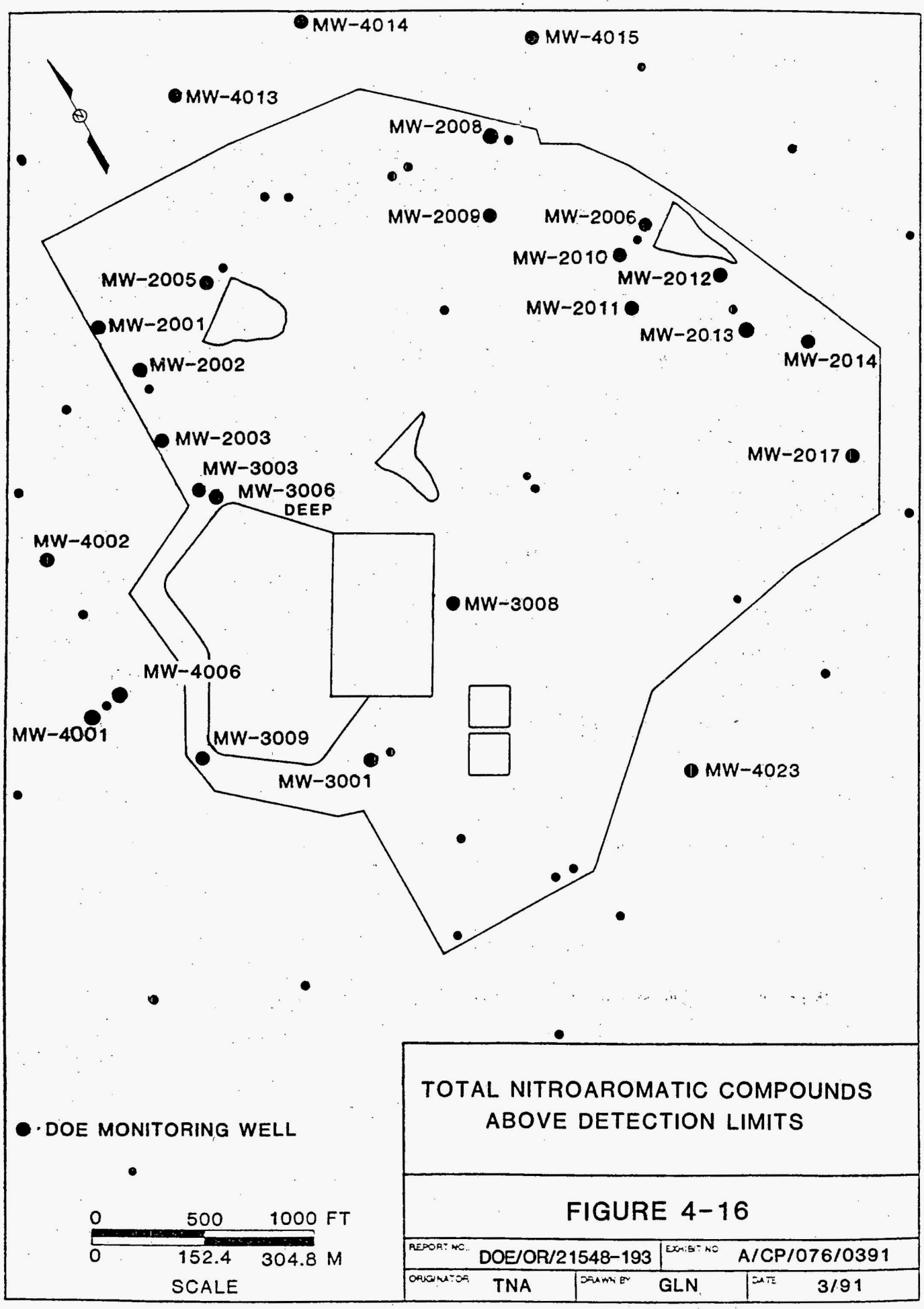
WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-4015	0.32	(2/2)	ND	(0/2)	ND	(0/2)	0.05	(1/2)	2	(2/2)	ND	(0/2)	2.370
MW-4016	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4017	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4018	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4019	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4020	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4021	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4022	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-4023	0.09	(2/2)	ND	(0/2)	ND	(0/2)	0.068	(2/2)	0.024	(2/2)	ND	(0/2)	0.182

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

ND - Not Detected

* - Detection limit

@ - The numerator is number of samples with detectable concentrations upon which the average is based and the denominator is the number of times the location was sampled during 1990. For example, 2.00 2/4) indicates that four samples were collected in 1990, two of which average 2.00 and the other two samples were ND.



TOTAL NITROAROMATIC COMPOUNDS ABOVE DETECTION LIMITS

FIGURE 4-16

REPORT NO. DOE/OR/21548-193		EXHIBIT NO A/CP/076/0391	
ORIGINATOR TNA	DRAWN BY GLN	DATE 3/91	

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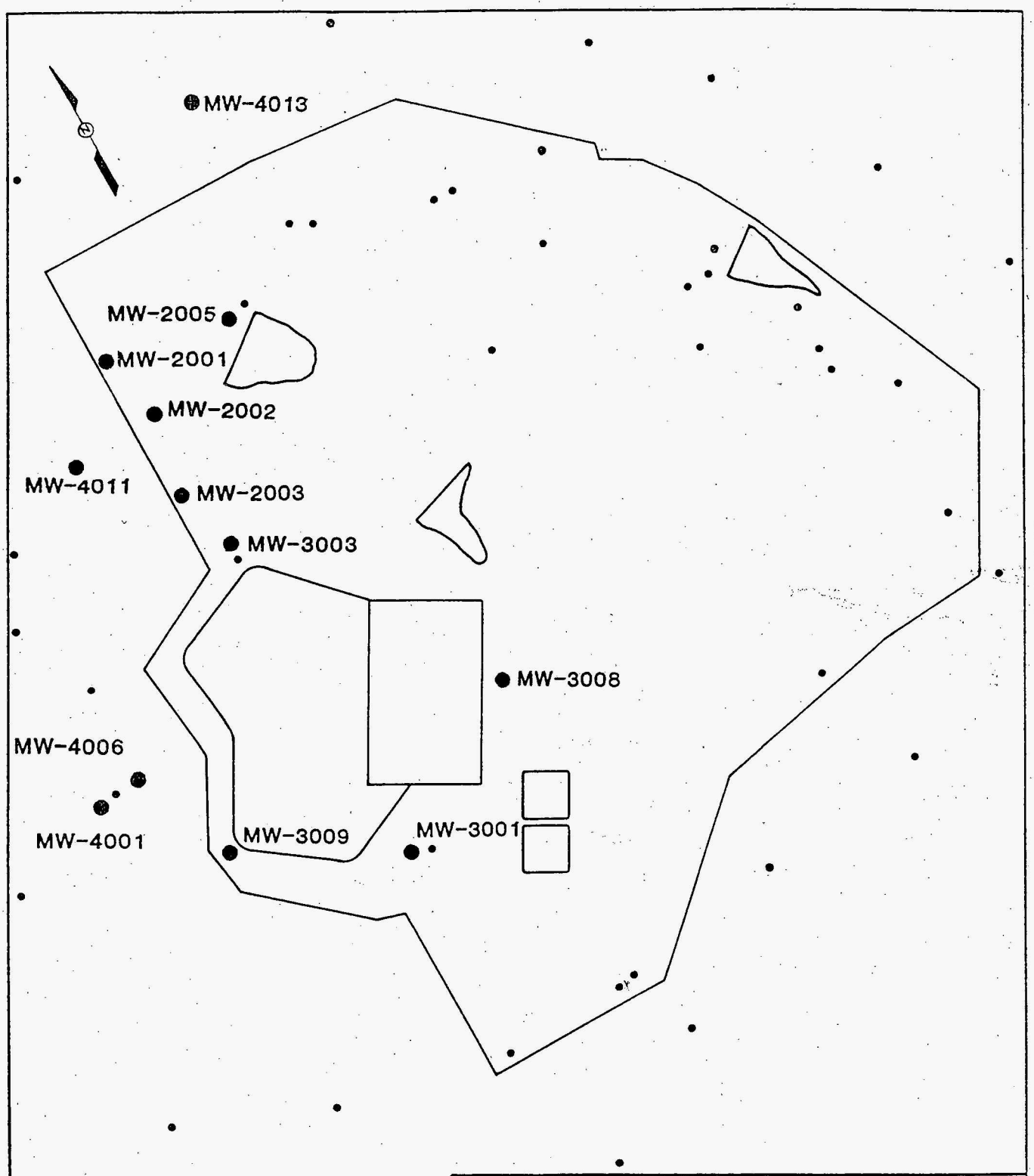


● WELLS WITH CONCENTRATIONS >10mg/l

• DOE MONITORING WELL

0 500 1000 FT
0 152.4 304.8 M
SCALE

ANNUAL AVERAGE NITRATE CONCENTRATIONS ABOVE 10mg/L

FIGURE 4-17

REPORT NO. DOE/OR/21548-193		EXHIBIT NO. A/CP/104/0491	
ORIGINATOR TNA	DRAWN BY GLN	DATE 4/91	

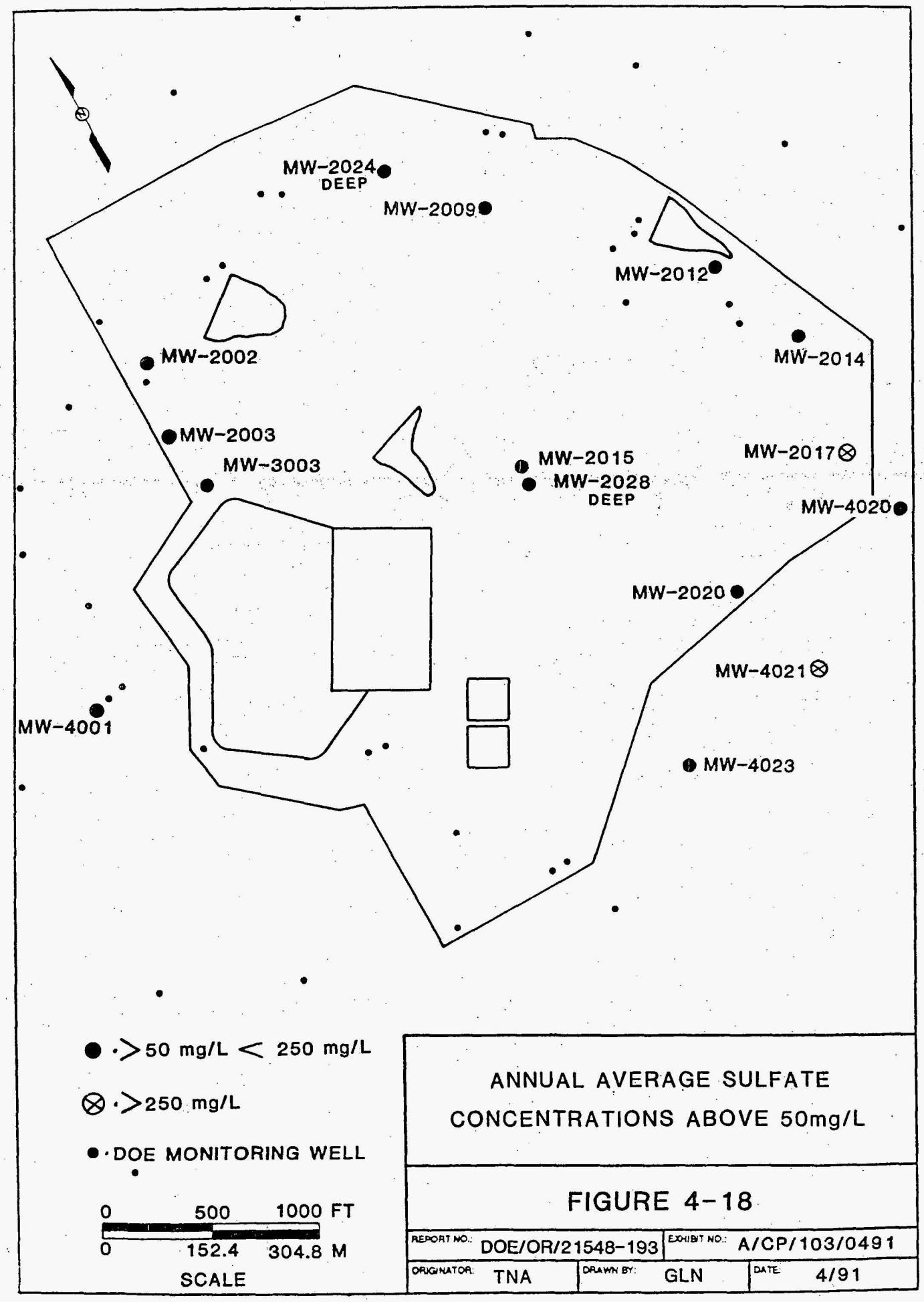
monitoring and characterizations, the groundwater scenario for nitrate contamination at the WSCP/RP/VP remains unchanged.

The upper bound of natural background sulfate concentrations in the aquifer at the WSCP/RP/VP was determined to be 50 mg/l (MKF and JEG 1989b). The EPA secondary drinking water standard for sulfate is 250 mg/l. Monitoring wells MW-2017 and MW-4021 exhibited average sulfate concentrations above the drinking water standard in 1990. Thirteen monitoring wells exhibited average sulfate concentrations between the upper bound of background and the drinking water standard. Figure 4-18 highlights monitoring wells with average sulfate concentrations above the upper bound of background. The *Phase II Groundwater Quality Assessment* (MKF and JEG 1989b) established that former WSOW processes were the primary source of these areas of sulfate contamination.

The upper limit of background for chloride in groundwater at the WSCP/RP/VP area is 22 mg/l (MKF and JEG 1989b). The EPA secondary drinking water standard for chloride is 250 mg/l. Five wells--MW-2006, MW-2008, MW-2010, MW-2012 and MW-2014--exhibited annual average chloride concentrations above the upper bound of background, but below the secondary drinking water standard in 1990. All five of these wells are located adjacent to a surface water drainage that drains a salt (sodium chloride) depot of the Missouri Highway Department off Highway 94. All of these wells have exhibited elevated chloride concentrations in the past.

Background concentrations for fluoride in groundwater are below 1 mg/l. The maximum contaminant level (MCL) for fluoride is 4.0 mg/l. One groundwater monitoring well, MW-2001 exhibited a fluoride concentration of 1.27 mg/l for the first sample of 1990 and was not detected in the second sample. No other monitoring wells exceeded background concentrations in 1990. This is consistent with previous monitoring results.

4.2.3.2 Non-Radiological Monitoring Results for WSQ Groundwater. Groundwater near the WSQ has become contaminated as a result of contact with or migration from the hazardous substances present in the WSQ. The monitoring well network for the WSQ is described in Section 4.1.3.2 of this report. The analytical results for non-radiological substances in groundwater at the WSQ are discussed in the following sections.



ANNUAL AVERAGE SULFATE CONCENTRATIONS ABOVE 50mg/L

FIGURE 4-18

REPORT NO.: DOE/OR/21548-193		EXHIBIT NO.: A/CP/103/0491	
ORIGINATOR: TNA	DRAWN BY: GLN	DATE: 4/91	

4.2.3.2.1 Analytical Results for Nitroaromatic Compounds - WSQ Groundwater. During 1990, samples from all WSQ wells were analyzed for nitroaromatic compounds. Ten monitoring wells yielded detectable concentrations of at least one of the six nitroaromatic compounds analyzed. The analytical results are presented in Table 4-24. The 10 wells yielding detectable concentrations are all 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 environmental monitoring and characterization. The one exception is MW-1002 which indicated no detectable levels of nitroaromatic compounds in 1989 (MKF and JEG 1989b), but did average 47.97 µg/l total nitroaromatics in 1990. This well has, however, indicated detectable concentrations of nitroaromatics before 1989.

4.2.3.2.2 Analytical Results for Inorganic Anions - WSQ Groundwater. All monitoring wells in the WSQ area were sampled for nitrate, sulfate, chloride and fluoride in 1990. Table 4-7 displays the annual averages for these inorganic anions.

Groundwater samples collected at the WSQ area in 1990 continued to indicate no notable groundwater contamination by nitrate. The highest annual average observed was at MW-1012, which is adjacent to the WSQ. This level was 1.44 mg/l. Nitrate does not constitute a particular threat to the groundwater system near the WSQ.

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. The highest 1990 sulfate average value of 529 mg/l was measured in MW-1006. Wells to the south of the slough continue to remain at background concentration levels. Groundwater samples collected in 1988 and 1989 from the upgradient background well referenced in Section 4.1.3.2 indicate a background level of 95 mg/l for sulfate in the alluvial groundwater.

Groundwater samples collected for chloride analysis in 1990 continue to agree with previous environmental monitoring and characterizations. The upper limit for background chloride levels in the bedrock aquifer near the WSCP/RP/VP was established at 22 mg/l in the WSSRAP's *1988 Environmental Monitoring Report* (MKF and JEG 1988). Data from the Missouri River alluvial water samples indicate that the background for the alluvium is

TABLE 4-24 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Quarry

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-1002	36	(2/2)@	0.27	(1/2)	8.2	(2/2)	ND	(0/2)	3.5	(2/2)	ND	(0/2)	47.97
MW-1004	0.5	(2/2)	ND	(0/2)	3.05	(2/2)	0.84	(2/2)	2.8	(2/2)	ND	(0/2)	7.19
MW-1005	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.16	(1/2)	0.071	(2/2)	ND	(0/2)	0.231
MW-1006	62.8	(2/2)	0.19	(1/2)	13.45	(2/2)	0.16	(1/2)	6	(2/2)	ND	(0/2)	82.60
MW-1007	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1008	ND	(0/2)	0.14	(1/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.14
MW-1009	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1010	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1011	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1012	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1013	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.038	(1/2)	ND	(0/2)	ND	(0/2)	0.038
MW-1014	ND	(0/2)	ND	(0/2)	ND	(0/2)	0.066	(2/2)	0.02	(1/2)	ND	(0/2)	0.086
MW-1015	14.45	(2/2)	0.22	(1/2)	6.515	(2/2)	0.36	(1/2)	0.465	(2/2)	ND	(0/2)	22.010

TABLE 4-24 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Quarry (Continued)

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-1016	0.37	(2/2)	0.43	(2/2)	0.425	(2/2)	ND	(0/2)	0.07	(1/2)	ND	(0/2)	1.295
MW-1017	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1018	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1019	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1020	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1021	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1022	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1023	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND
MW-1024	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-1025	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1026	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND
MW-1027	0.13	(1/2)	ND	(0/2)	15.2	(2/2)	25	(2/2)	11.85	(2/2)	ND	(0/2)	52.180
MW-1028	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND	(0/2)	ND

[illegible] for Nitroaromatic Compounds - WSQ Groundwater. [illegible] wells were analyzed for nitroaromatic compounds. Ten [illegible] concentrations of at least one of the six nitroaromatic [illegible] are presented in Table 4-[illegible]. The 10 wells [illegible] south of the Femme Osage Slough. No [illegible] the Femme Osage Slough exhibited detectable [illegible] compounds. Overall the nitroaromatic results are consistent [illegible] characterization. The only exception is MW-[illegible] [illegible] levels of nitroaromatic [illegible] pounds in 1989 [illegible] average 47.97 µg/l total nitro[illegible] in 1990. This will [illegible] concentrations of nitroaromatics before 1989.

[illegible] for Inorganic Anions - WSQ Groundwater. All [illegible] sampled for nitrate, sulfate, chloride and fluoride [illegible] averages for these inorganic anions.

[illegible] the WSQ area in 1990 continued to indicate no [illegible] nitrate. The highest annual average observed was [illegible] WSQ. This level was 1.44 mg/l. Nitrate does not [illegible] to the groundwater system near the WSQ.

[illegible] of sulfate co[illegible]ation to the surface water in the [illegible] groundwater s[illegible]ng the quarry. Sulfate levels in [illegible] quarry and in the [illegible] north of the Femme O[illegible] [illegible] of migration from the quarry. The highest [illegible] [illegible] in MW-1008. Wells to the south of [illegible] concentration levels. Groundwater samples [illegible] from the upgradient background well referenced in [illegible] levels of 95 mg/l for sulfate in the alluvial groundwater.

[illegible] chloride analysis in 1990 continue to agree with [illegible] observations. The upper limit for background [illegible] SCV/RP/VF was established at 22 mg/l in [illegible] *Report* (MKF and JEG 1988). Data from the [illegible] indicate that the background for the alluvium is

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TABLE 4-24 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Quarry (Continued)

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-RMW1	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-RMW2	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-RMW3	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-RMW4	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-RAWW	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-FINW	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-PW02	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-PW03	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND
MW-PW04	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-PW05	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND	(0/3)	ND
MW-PW06	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-PW07	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND
MW-PW08	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND

TABLE 4-24 Summary of 1990 Data Averages for Nitroaromatic Compounds, Weldon Spring Quarry (Continued)

WSSRAP ID	1,3,5-TNB µg/l (0.01)*	@	1,3-DNB µg/l (0.13)*	@	2,4,6-TNT µg/l (0.17)*	@	2,4-DNT µg/l (0.05)*	@	2,6-DNT µg/l (0.17)*	@	NITRO-BENZENE µg/l (0.2)*	@	TOTAL NITRO-AROMATICS µg/l
MW-PW09	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND	(0/4)	ND

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

ND - Not Detected

@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were taken in 1990, two of which average 2.00 and the other two samples were ND.

* - Detection limit

similar. The quarry sump shows an annual average concentration of 12.1 mg/l chloride. Based upon the comparison with background, chloride levels appear to be slightly elevated north of the Femme Osage Slough. The elevated chloride levels remain well below the EPA secondary drinking water standard of 250 mg/l. The highest level of chloride measured south of the Femme Osage Slough was 22.05 mg/l. Chloride does not constitute a threat to the groundwater system near the WSQ.

Fluoride levels ranged from 0.17 mg/l to 1.21 mg/l in the groundwater near the WSQ. These levels do not exceed the EPA's maximum contaminant level of 4.0 mg/l.

4.2.3.2.3 Analytical Results for Metals - WSQ Groundwater. Samples were collected for arsenic, barium, cadmium, lead, and mercury in 1990 at the St. Charles County pumping wells and the treated and untreated water from the St. Charles County Water Treatment Plant. These metals have been detected in previous samples of the quarry bulk waste. Arsenic and barium samples were also retrieved from the St. Charles County RMW series monitoring wells and monitoring well MW-1024. The results of analyses for these samples are shown in Table 4-25. The WSQ does not appear to influence metals concentrations in the well field area. Uranium is the primary indicator for WSQ contaminant migration.

4.2.3.2.4 Analytical Results for Organics - WSQ Groundwater. 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 1990 for PCBs, pesticides, and volatile and semi-volatile organics. No PCBs, pesticides, or semi-volatiles were detected in sample analyses. Low levels of acetone were detected in two samples and a low level of xylene was detected in one sample. Low levels of these compounds were also detected in quality control laboratory blanks. Due to this, the levels are believed to be a result of lab contamination. Laboratory analysis also indicated low levels of three trihalomethanes (chloroform, bromodichloromethane and dibromochloromethane) in the treated water from the water treatment plant. However, the summed concentrations of the three compounds are less than 100 ug/l, which is the maximum contaminant level from the Safe Drinking Water Act for the sum of all four trihalomethanes that may occur in drinking water. The compounds are believed to be a result of the natural organics in the groundwater reacting with the chlorine in the water treatment process.

Table 4-25 Metals Data Averages From St. Charles County Wellfield, 1990

WSSRAP ID	ARSENIC µg/l (10.0)*	@	BARIUM µg/l (200)*	@	CADMIUM µg/l (5.0)*	@	LEAD µg/l (5.0)*	@	MERCURY µg/l (0.2)*	@
MW-PW02	ND	(0/1)	287	(1/1)	ND	(0/1)	6.1	(1/1)	ND	(0/1)
MW-PW03	NOL		NOL		NOL		NOL		NOL	
MW-PW04	ND	(0/1)	266	(1/1)	ND	(0/1)	4.4	(1/1)	ND	(0/1)
MW-PW05	ND	(0/1)	275	(1/1)	ND	(0/1)	5	(1/1)	ND	(0/1)
MW-PW06	ND	(0/1)	310	(1/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)
MW-PW07	ND	(0/1)	397	(1/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)
MW-PW08	ND	(0/1)	382	(1/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)
MW-PW09	ND	(0/1)	389	(1/1)	ND	(0/1)	ND	(0/1)	ND	(0/1)
MW-RMW1	6.6	(2/4)	427	(4/4)	NSF		NSF		NSF	
MW-RMW2	21.3	(4/4)	202	(4/4)	NSF		NSF		NSF	
MW-RMW3	41.3	(4/4)	498	(4/4)	NSF		NSF		NSF	
MW-RMW4	40	(3/4)	194	(4/4)	NSF		NSF		NSF	
MW-RAWW	6.4	(1/4)	337	(4/4)	ND	(0/1)	ND	(0/1)	ND	(0/1)
MW-FINW	ND	(0/4)	286	(4/4)	ND	(0/1)	5.4	(1/1)	ND	(0/1)
MW-1024	8	(1/4)	316	(4/4)	NSF		NSF		NSF	

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

ND - Not Detected
NOL - Well Not on Line or Sample Date
NSF - Not Scheduled For Sampling
* - Detection limit
@ - Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1990. For example, 2.00 (2/4) indicates that four samples were taken in 1990, two of which average 2.00 and the other two samples were ND.

4.2.4 Effluent Monitoring Results

Surface water and effluent samples were collected and analyzed in compliance with the Weldon Spring Site National Pollutant Discharge Elimination System (NPDES) permit. This permit (Number MO-0107701) was issued in November 1988, and addresses storm water and wastewater discharges. Six discharge points or outfalls are included in this permit and are shown on Figure 4-19. Outfalls NP-0001 through NP-0005 represent surface water discharge and NP-0006 represents the treated effluent discharge associated with the administration building sanitary wastewater treatment plant. 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 4-26.

Annual averages of analytical results for the storm water locations are presented in Table 4-27. This table presents an annual summary of the individual sampling events. Tables indicating analytical results for the individual NPDES sampling events may be found in Appendix A.

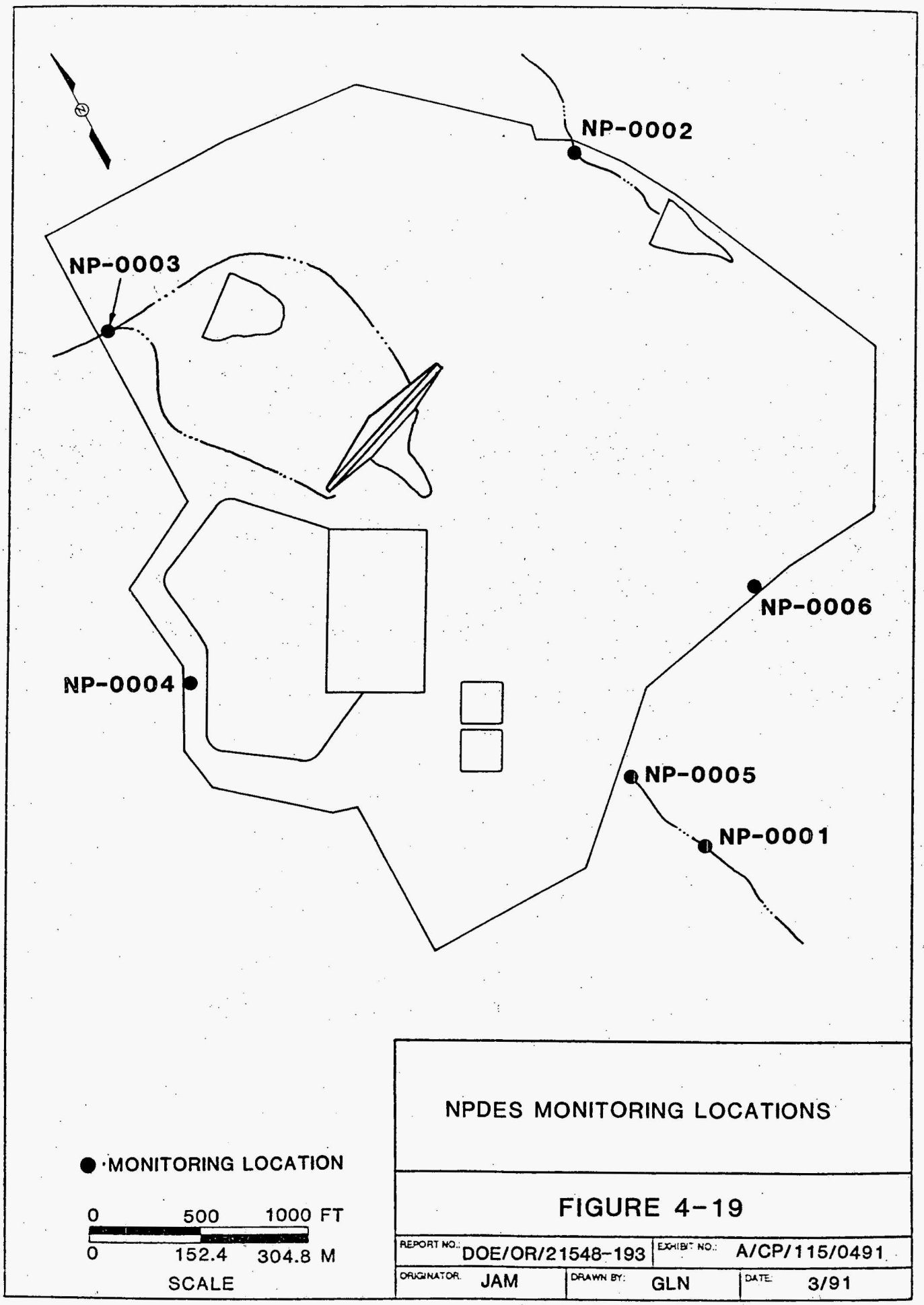
In general, all values correspond well with prior year values. On three occasions sampling was performed when flows were not representative of normal storm water flows. These three sampling events were performed during water release which was not associated with precipitation:

March 1: Samples collected at NP-0003 in conjunction with a release of water from Ash Pond retention basin.

May 8: Samples collected at NP-0003 in conjunction with a release of water from the Ash Pond retention basin.

September 27: Samples collected at NP-0001, NP-0002, and NP-0005 in conjunction with flow testing in the Frog Pond and Southeast drainages.

During the March 1 release, above average concentrations of gross alpha, uranium, settleable solids and nitrate were observed. These values are within the expected range with the exception of nitrate. An intermittent nitrate source has been observed in this drainage



NPDES MONITORING LOCATIONS

FIGURE 4-19

REPORT NO.: DOE/OR/21548-193		EXHIBIT NO.: A/CP/115/0491	
ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 3/91	

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TABLE 4-26 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	-
Total Suspended Solids*F	Q	M	M	Q	M	Q
Nitrate *	Q	M	M	Q	M	-
Uranium*	Q	M	M	Q	M	-
Lithium*	Q	M	M	Q	M	-
Gross Alpha*	Q	M	M	Q	M	-
pH*	Q	M	M	Q	M	Q
BOD F	-	-	-	-	-	Q
Fecal Coliforms F	-	-	-	-	-	Q

* - Monitoring requirements only; no discharge limits
F - Limits set for Outfall NP-0006
Q - Quarterly sampling
M - Monthly sampling

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TABLE 4-27 1990 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	FLOW GPD
NP-0001	6	6.98	413.4	398.8	1.290	0.0139	4.6	<0.1	38,880
NP-0002	12	6.84	139.47	147.24	0.678	0.0100	91.42	<0.1	393,053
NP-0003	13	6.77	89.45	81.95	95.310	ND	33.45	<0.1	296,494
NP-0004	4	6.91	7.59	8.35	0.290	ND	22.75	<0.1	2,550
NP-0005	12	6.76	364.45	373.68	3.350	*0.0256	12.36	<0.1	158,172

* This was the only sample above detection limits out of 12 total samples.

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in the past. Values from the May 8 discharge were within expected ranges. Values from the September 27 sampling were slightly lower than normal, with the exception of lithium at NP-0005. This was the only sampling event in 1990 when lithium was detected at NP-0005 and the lithium levels at NP-0001 and NP-0002 were highest in samples obtained on this date.

4.2.4.1 Radiological Analysis. Annual average uranium levels ranged from 7.59 pCi/l (0.281 Bq/l), about 1% of the DCG at the minimum concentration discharge point (NP-0004) to 413.4 pCi/l (15.3 Bq/l), about 75% of the DCG at the maximum concentration discharge point (NP-0001) (Table 4-27). The highest average uranium concentration was measured at the off-site discharge of the abandoned sanitary and process sewer outfall (NP-0001). Uranium concentrations measured at NP-0001 ranged from 197 to 952 pCi/l (7.29 to 35.22 Bq/l) during 1990. Flows from the process and sanitary sewer outfall (NP-0001) combine with surface runoff from the southeast drainage easement. Uranium concentrations measured at NP-0005 exhibited similar levels with an annual average of 364.45 pCi/l (13.48 Bq/l), 66% of the DCG, and a range of 17.7 to 1020 pCi/l (0.65 to 37.74 Bq/l).

Frog Pond's off-site discharge (NP-0002) exhibited an annual average uranium concentration of 139.47 pCi/l (5.16 Bq/l), 25% of the DCG. Individual monthly measurements ranged from 10.2 to 367.2 pCi/l (0.38 to 13.59 Bq/l).

Off-site runoff from the area of raffinate pit No. 4 (NP-0004) exhibited an annual average uranium concentration of 7.59 pCi/l (0.281 Bq/l), 1 % of the DCG with a range of individual measurements from 4.2 to 10.9 pCi/l (0.16 to 0.40 Bq/l).

Runoff from the Ash Pond drainage (NP-0003) exhibited an annual average uranium concentration of 89.45 pCi/l (3.31 Bq/l). This continues a downward trend in uranium concentration at this outfall. The 1988 annual average at NP-0003 was 1178 pCi/l (43.59 Bq/l). The 1989 annual average of 280 pCi/l (10.36 Bq/l) signaled the start of the downward trend in uranium concentrations, primarily due to the completion of the Ash Pond diversion project. This project provided for diversion of surface water around the south dump and the Ash Pond areas.

Annual average gross alpha levels generally followed the same pattern as the natural uranium results. This correlation between the average uranium and gross alpha values indicates that the majority of all off-site radionuclide release in surface water is in the form of soluble uranium.

Estimated quantities of total uranium released off site through surface water are presented in Table 4-28. 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 upper bound estimate of the total uranium released can be calculated. These results are consistent with values from 1989 with the exception of NP-0003 which was lower in 1990.

4.2.4.2 Physical/Chemical Analysis. Physical analysis (settleable solids and suspended solids) and chemical analysis (nitrate, pH, and lithium) were also performed on NPDES samples in 1990. The 1990 values generally correspond to 1989 values for the majority of parameters.

Settleable solids analyses of all outfalls averaged <0.1 ml/l in 1990. All outfalls exhibited at least one sample equal to 0.1 ml/l, with the following exceptions: all samples from NP-0004 were <0.1 ml/l and two samples from NP-0003 were equal to 0.1 ml/l.

Suspended solids analyses were comparable to prior data. Annual average values ranged from 4.6 mg/l at NP-0001 to 91.42 mg/l at NP-0002. Higher values of suspended solids were present at NP-0002 in July and August due to an accumulation of silt immediately above the outfall structure. Following removal of this sediment, measured values dropped and remained much lower.

Nitrate values were lower in 1990 compared to 1989 in all outfalls except NP-0003. Annual average values ranged from 0.290 mg/l at NP-0004 to 95.31 at NP-0003. The higher values at NP-0003 were present due to the single high value reported for March 1 during release from the Ash Pond retention basin, as mentioned previously.

Lithium values were slightly higher in 1990 compared to 1989. Annual average values ranged from ND (not detected) at NP-0003 and NP-0004 to 0.0256 mg/l at NP-0005. A

TABLE 4-28 1990 Estimated Annual Release of Natural Uranium from NPDES Outfalls

OUTFALL LOCATION*	DRAINAGE AREA (ACRES)	PERCENT OF PRECIPITATION AS RUNOFF**	AVERAGE CONCENTRATION (pCi/l)	UPPER BOUND TOTAL VOLUME (Mgal/yr)	UPPER BOUND TOTAL URANIUM (Ci/yr)	UPPER BOUND TOTAL URANIUM (kg/yr)
NP-0001 & NP-0005	20.2	60%	388.93	12.8	0.019	27.78
NP-0002	39.1	65%	139.47	26.9	0.014	20.87
NP-0003	60.1	20%	89.45	12.7	0.004	6.32
NP-0004	5.6	50%	7.59	3.0	0.00009	0.13
TOTALS =					0.0371	55.10

* See Figure 4-19 for Outfall Locations

** Estimated

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limited number of samples from NP-0001 and NP-0002 contained lithium values slightly above the detection limit. The highest lithium value (at NP-0005) was present in a sample obtained during flow testing on September 27. As discussed previously, this flow was not representative of normal storm water flows.

4.2.4.3 Sanitary Wastewater. Outfall NP-0006 is the discharge for the site administration building wastewater treatment facility. The NPDES permit contains effluent limitations on biochemical oxygen demand (BOD), total suspended solids (TSS), and fecal coliform at this outfall. These limits are 10 mg/l BOD, 15 mg/l TSS, and 400 colonies/100 ml (fecal coliform). Samples were analyzed quarterly for these parameters by the Subcontractor operating this facility. A table illustrating all of these results is presented in Appendix A. NPDES permit limits were exceeded twice in 1990 at this outfall. The BOD value of April 12 was 13.8 mg/l. Operational adjustments to the plant were performed by the Subcontractor, and BOD levels returned to below permit limits. The fecal coliform value for December 5 was 7000 colonies/100 ml. This was due to removal of additional chlorine in the chlorine contact chamber by the Subcontractor. This was done at the direction of Missouri Department of Natural Resources (MDNR), due to a concern that excess residual chlorine might be present in the effluent. The Subcontractor has since replaced this additional chlorine in a more acceptable location resulting in a return to compliance for fecal coliform levels, while maintaining a minimal level of residual chlorine.

4.2.4.4 Erosion Control Monitoring. Sampling was conducted in the Little Femme Osage Creek, near the Weldon Spring quarry to assess erosion control measures associated with construction of the quarry staging area and water treatment plant facilities. Although the treatment plant has not yet been constructed, the NPDES permit for this discharge (MO-0108987), requires that all runoff from construction and material storage areas remain within the following limits.

Total Suspended Solids: Less than 50.0 mg/l (standard units)
pH: greater than 6.0 and less than 9.0

Samples were collected from SW-1001 and SW-1002 during rainfall events (see Figure 4-3). SW-1001 is located upstream of the quarry staging area and represents normally occurring concentrations in this drainage. SW-1002 is located immediately downstream of the quarry staging area. Water quality impacts from quarry staging area

construction are assessed by comparing values from these two locations. Results from these samples were as follows:

DATE	SW-1001		SW-1002	
	TOTAL SUSPENDED SOLIDS	pH	TOTAL SUSPENDED SOLIDS	pH
08/29/90	1.6	6.90	<0.1	7.17
10/10/90	6.0	7.32	7.0	7.32
11/05/90	7.0	6.74	7.0	6.66

These results indicate compliance with permit requirements.

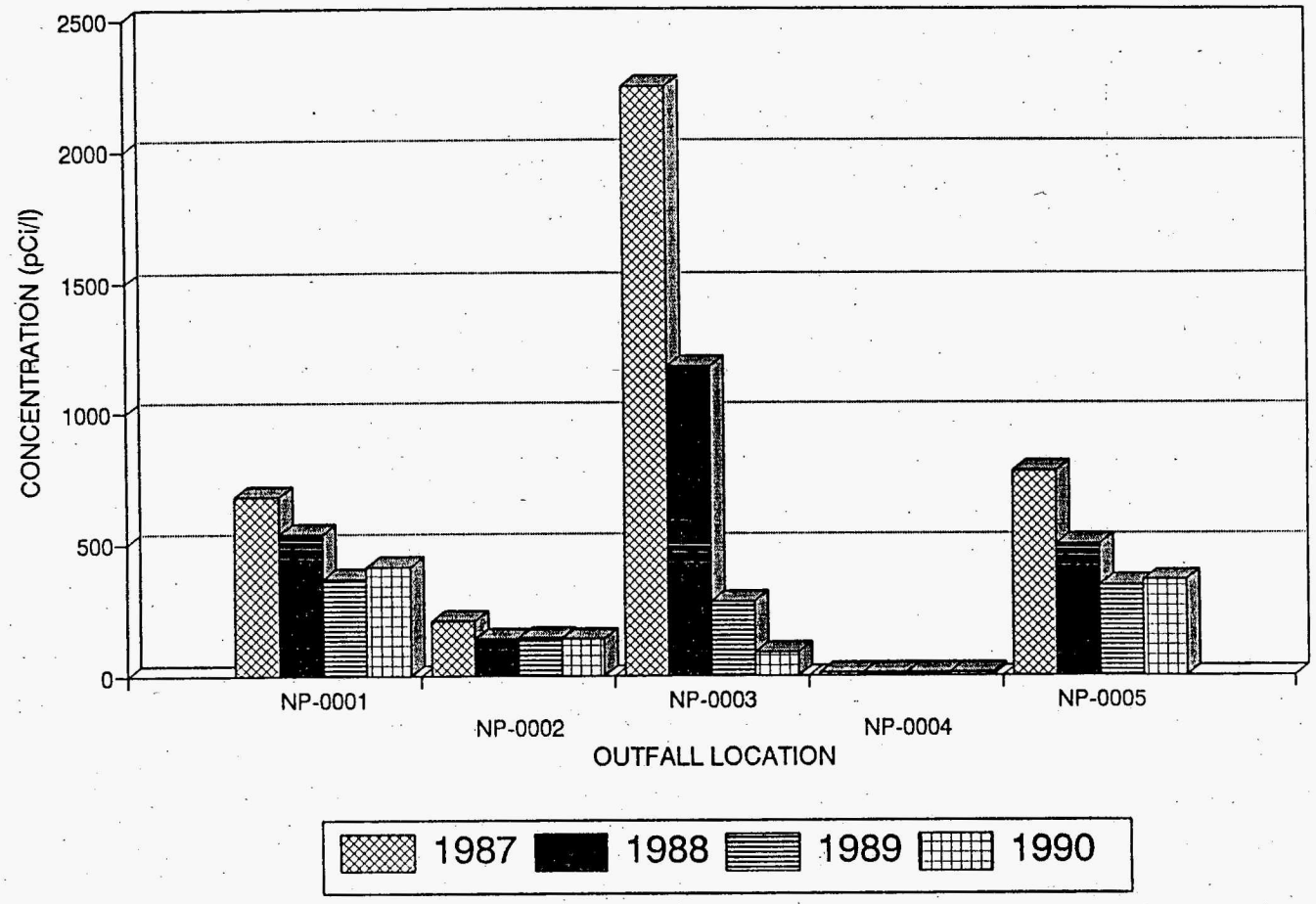
4.2.4.5 Uranium Trend Analysis. Annual average uranium concentrations in NPDES Outfalls from 1987 through 1990 are presented in Table 4-29. Uranium trends in NPDES Outfalls are shown in Figure 4-20. Uranium concentrations show an overall decline for the past four years with the exceptions of NP-0001 and NP-0005 which show a slight increase in 1990. All average values for both 1989 and 1990 are below the DCG of 600 pCi/l (22.2 Bq/l). The most dramatic decrease during this period was at NP-0003, the Ash Pond outfall. The Ash Pond diversion project is an interim response action that was completed in early 1989. This project provided surface water diversion around the south dump and Ash Pond areas and resulted in a subsequent decrease in uranium levels.

Comparison of values between Outfall locations indicates the following:

Uranium concentrations at NP-0004 remain extremely low indicating no significant contaminant migration in this area.

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.

Outfall NP-0003 has shown a dramatic decrease in uranium concentrations due to effective surface water management.



TRENDS OF ANNUAL AVERAGE
URANIUM VALUES
FOR NPDES OUTFALLS

FIGURE 4-20

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TABLE 4-29 Annual Average Uranium Values at NPDES Outfalls 1987-1990

URANIUM VALUES pCi/l				
OUTFALL LOCATION	1987	1988	1989	1990
NP-0001	680	539	368	413
NP-0002	210	141	145	139
NP-0003	2240	1178	280	89
NP-0004	9.5	6.2	6.5	7.6
NP-0005	780	497	347	364

Currently, the highest values of uranium release in surface water occur in the southeast drainage (from Outfalls NP-0001 and NP-0005).

4.2.5 Airborne Asbestos Monitoring

During the first and second quarters of 1990, asbestos was monitored at five site perimeter stations and at the off-site monitoring station located at Francis Howell High School (FHHS) (Figure 4-10). Samples were typically collected once per week. Each sample was collected over a 7 hr to 8 hr sampling period, during normal site working hours. During the subject period, no asbestos abatement operations were conducted at the site. On the basis of the air monitoring results obtained from the site perimeter and off-site asbestos monitoring stations for the period from April 1988 through May 1990, in which no significant trends or findings were observed, site perimeter and off-site asbestos monitoring for the third and fourth quarters was discontinued. Routine asbestos monitoring at the FHHS and site perimeter stations will resume whenever on-site asbestos abatement operations are underway.

All samples were analyzed by Phase Contrast Microscopy (PCM). This method provides a measurement of total airborne concentration for fibers having size and shape characteristics typical of asbestos fibers. PCM methodology does not distinguish between airborne asbestos fibers and non-asbestos fibers having similar morphology. One sample, collected at the FHHS on May 18, was analyzed by Transmission Electron Microscopy

(TEM) which is capable of positively identifying asbestos fibers. No asbestos fibers were detected in the TEM sample.

The results of the PCM analyses for the air samples collected at the site perimeter and off-site monitoring stations are provided in Table 4-30. The average fiber concentration for the 28 site perimeter samples was 0.002 f/cc. The average concentration for the 18 FHHS samples was < 0.001 f/cc.

Table 4-30 Asbestos Monitoring Summary Calendar Quarter 1 and 2, 1990

SAMPLING LOCATIONS[a]	CONCENTRATION RANGE MIN. (FIBERS/CC)	CONCENTRATION RANGE MAX. (FIBERS/CC)	AVERAGE (FIBERS/CC)[b]	NO. OF SAMPLES REPORTED AS BELOW DETECTION LIMIT	TOTAL NUMBER OF SAMPLES COLLECTED
AP-2001	<0.001	<0.001	<0.001	4	5
AP-2002	<0.001	0.007	0.003	3	4
AP-2005	<0.001	0.002	0.001	9	11
AP-3003	<0.001	0.009	0.002	5	6
AP-3004	<0.001	<0.001	<0.001	2	2
AP-4006	<0.001	<0.001	<0.001	18	18

(a) See Figure 2-7 for monitoring station locations.

(b) For those samples with fiber concentrations less than the limit of detection, the limit of detection was used to calculate the overall average fiber concentration for each sampling location.

Routine area and employee exposure monitoring were conducted throughout 1990. This monitoring was conducted in the vicinity or in the breathing zones of site personnel engaged in asbestos related activities or other activities for which there were potential asbestos exposures. The results of the PCM analysis for the area and employee exposure monitoring are provided in Table 4-31. The average fiber concentration for the seven area

TABLE 4-31 Area and Worker Asbestos Exposure Monitoring Summary Calendar Year 1990

SAMPLE TYPE	CONCENTRATION RANGE (fibers/cc)	AVERAGE (fibers/cc) [a]	NO. OF SAMPLES REPORTED AS BELOW DETECTION LIMIT	TOTAL NO. OF SAMPLES COLLECTED
Area	<0.002 - 0.006	.009	4	7
Worker Exposure	<0.003 - 0.069 [b]	.013	4	9

(a) For those samples with fiber concentrations less than the limit of detection, the limit of detection was used to calculate the overall average fiber concentration for each sample type.

(b) Concentrations represent 8-hr time weighted average exposures.

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samples was 0.009 f/cc. The air sample results for the employee exposure monitoring indicate that worker exposures were less than the Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELS). OSHA's PEL for an 8-hr time weighted average (TWA) is 0.2 f/cc and for a 30-min excursion limit is 1 f/cc.

4.2.6 Meteorological Monitoring

In 1990, the WSSRAP installed a new meteorological tower and associated equipment capable of monitoring current weather data and recording the data for later use. Located near the main entrance to the chemical plant site, the meteorological station monitors the following parameters: wind speed, wind direction, temperature, barometric pressure, and precipitation. The intended uses of the meteorological system include:

1. Correlation with background fluctuations of naturally occurring radionuclides in ambient air measured at nearby locations.

2. Real time data read out of the meteorological variables influencing the dispersion of potentially released airborne materials.

3. Post incident data review to potentially explain source and receptor results.

The WSSRAP meteorological monitoring system produces data that can be used in routine dispersion modeling to predict impacts from site operations and as input to emergency response atmospheric models used in the event of accidental releases from the site.

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5 GROUNDWATER PROTECTION PROGRAM

5.1 Groundwater Protection Program Management Plan

The Weldon Spring Site Remedial Action Project (WSSRAP) Groundwater Protection Program (GWPP) began in 1981 when the U.S. Department of Energy (DOE) appointed Bechtel National, Inc. (BNI) as the custodial contractor, responsible for installing the first groundwater monitoring wells and investigating water quality beneath the Weldon Spring site (WSS). Since the establishment of the WSSRAP in 1986, the current Project Management Contractor (PMC) has had an informal organization in place devoted to the protection, investigation, and remediation of the groundwater system at the WSS. The purpose of the WSSRAP GWPP Management Plan is to formalize and structure the program both for internal consistency and ease of external review. The formal plan developed in 1990 meets the requirements for a Groundwater Protection Management Program and Groundwater Monitoring Plans as described in DOE Order 5400.1. The scope of the plan is as follows:

- To define the purpose, policies, and objectives of the WSSRAP 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 separate quality assurance [QA] plan that meets Nuclear Quality Assurance (NQA-1) requirements has been developed for the project.)
- To provide the most effective overall management possible for the GWPP.

5.1.1 History of Groundwater Protection Program Activities

A large number of wells, piezometers, and borings have been installed at the WSS for groundwater monitoring, aquifer testing, geologic characterization, and geotechnical studies. The current monitoring well network includes wells constructed to support the

current Remedial Investigation/Feasibility Study-Environmental Impact Statement (RI/FS-EIS) studies and wells installed for routine monitoring.

The following well designations are currently used at the WSS. Monitoring wells with 1000 series numbers are located at or near the 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 near the WSCP/WSRP.

Monitoring wells constructed at the WSS have been drilled, installed, and developed generally in accordance with accepted procedures as discussed in the U.S. Environmental Protection Agency (EPA) Resource Conservation and Recovery Act (RCRA) *Groundwater Monitoring Technical Enforcement Guidance Document* (EPA 1986). Standard operating procedures have been developed for WSSRAP based on these EPA guidelines.

5.1.2 Application of the GWPP Management Plan

The WSSRAP GWPP Management Plan is a management tool for the formalization of the DOE groundwater protection and management policies at the WSS. The Management Plan establishes criteria for the performance of groundwater management practices at the WSSRAP. Functionally, it serves the DOE, the PMC, and the public by establishing the groundwater protection and management criteria for the project. Annual review and appropriate updates to the plan also ensure that the plan remains up to date.

5.1.3 Plugging and Abandonment Requirements

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 the Groundwater Protection Program Management Plan (GWPPMP).

Project Structure and Lines of Authority

Since all monitoring wells are used by, and are under the authority of, the PMC Environmental Safety and Health (ES&H) Department, this department will approve the plugging and abandonment (P&A) process. The process will proceed as follows:

- The ES&H Department will authorize removing a well from service. The ES&H Department will notify the Construction Management and Operations (CM&O) and Engineering departments to begin their respective tasks.

- The Engineering Department will prepare a specification, subject to approval by the ES&H Department, and a request for bids to subcontract for the work will be issued by the Procurement Department.

- The CM&O and ES&H departments will oversee the Subcontractor's work.

- The ES&H and QA Departments may also choose to perform quality-related supervision of the P&A activities.

Well Plugging Criteria

The WSSRAP has developed a standard operating procedure (SOP) for the ES&H Department (ES&H Procedure 4.4.4s) for the abandonment of all subsurface monitoring devices, including wells. Wells will be plugged in accordance with all applicable State and Federal regulations and requirements. Currently, the State of Missouri has some formal requirements for P&A; however, the regulations do not specify how technical specifications should be written. The Missouri Code of State Regulations (10 CSR 23-3.02) requires that wells be plugged to prevent the vertical migration of pollutants. These regulations will be reviewed prior to the preparation of each P&A specification to ensure, at a minimum, that the State regulations and reporting requirements are met.

The WSSRAP will take greater precautions than required by the State regulations when plugging wells. As a standard practice, the WSSRAP will remove the well casing, filter pack, and drilling debris from the borehole and grout the hole using a tremie method.

5.2 Groundwater Contaminant Trend Analysis

Appendix B presents graphs of annual average concentrations of total nitroaromatics, total natural uranium, nitrate (as N) and sulfate for the years 1987 through 1990. Some of the monitoring wells were installed during this time. Accordingly, not all of the locations list four years of data. The monitoring wells are grouped primarily by concentration, due to the wide range of concentrations. The annual average concentrations are calculated in the same format as described in Sections 4.1.2 and 4.2.2.

Overall, the data for nitroaromatics show consistency with the exception of 1988 when a problem with laboratory contamination and error biased some results. The largest discrepancy evident is a reduction by one order of magnitude at location MW-2013.

As the graphs illustrate, (see Figure 4-20) the uranium concentrations show an overall increase in 1990. As discussed in Section 6.3, many distilled water blanks showed detectable levels of uranium in 1990, indicating laboratory contamination.

There appears to be a gradual increase in nitrate concentrations for certain wells adjacent to the raffinate pits. The nitrate levels for monitoring wells MW-1002, MW-1004, MW-1005, and MW-1014 show consistency for the years 1988 through 1990. The 1987 concentrations for these wells are believed to be in error due to laboratory contamination or sample handling.

Due to the widespread areas of sulfate contamination at the Weldon Spring Chemical Plant/raffinate pits/vicinity property (WSCP/RP/VP) and the WSQ, the graphs illustrate some fluctuations for the four years in certain monitoring wells. There appears to be some concentration error involved for certain wells in 1987. This is believed to be related to the nitrate concentration errors from the same year.

6 QUALITY ASSURANCE PROGRAM INFORMATION

The Weldon Spring Site Remedial Action Project (WSSRAP) Quality Assurance Program Plan (QAPP) establishes the quality program for those activities performed by the Project Management Contractor (PMC) during the WSSRAP. The QAPP requires compliance with the criteria of ANSI/ASME NQA-1 1986; the U.S. Department of Energy (DOE) Order 5700.6B, as required by the PMC; the DOE contract document DE-AC05-86OR21548; and the MK-Environmental Services NQA-1 Quality Assurance Manual. The purpose of the QAPP is to assure compliance with these documents.

All criteria of NQA-1 are applicable to the WSSRAP. The MK-Environmental Services NQA-1 Quality Assurance program provides guidance for the development of requisites to implement quality at the WSSRAP. The QAPP, however, does not address all criteria. Only criteria that describe quality assurance departmental actions are described. QA Audits, QA Surveillances, and the WSSRAP Self-Assessment program ensure compliance with criteria not addressed in the QAPP.

Certain environmental compliance issues are addressed in the WSSRAP Remedial Investigation Quality Assurance Program Plan (RIQAPP). The RIQAPP addresses the specific EPA/QAMS 005-80 Quality Assurance requirements for the characterization of the WSSRAP. The RIQAPP does not supersede the project QAPP, but rather it expands on specific requirements.

This chapter includes a discussion of the data administration and validation program in Section 6.1, the external audits and audit tracking system in Section 6.2, and the quality assurance sample results in Section 6.3.

6.1 Data Administration and Data Quality

The WSSRAP quality assurance (QA) program for environmental data has numerous initiatives within each aspect of data collection, evaluation, and reporting. The *Environmental Data Administration Plan* (EDAP), (MKF and JEG 1991b) a specific program-level plan, provides the foundation for collecting, verifying, validating, and interpreting data. The EDAP provides site-specific guidance for managing data and associated documentation, and establishes general data quality goals. This plan also includes

guidance on sampling plan preparation, data verification, validation requirements, database administration, and data archival.

All WSSRAP environmental surveillance and effluent monitoring activities required by permits and DOE Orders are performed as detailed in the *Environmental Monitoring Plan* (MKF and JEG 1990c) which describes sampling methods, locations, rationale, and quality control measures.

Site specific procedures have been developed for all aspects of sample collection and handling. These procedures were developed from EPA and other relevant guidance documents. They are reviewed annually and revised as necessary. Sampling personnel are trained in appropriate procedures prior to sample collection. All procedure training is documented and tracked so that personnel are retrained as procedures are revised. Variances or field modifications to procedures are noted in field notebooks and on sampling forms.

Quality control samples are collected to assess location variability, the effects of sample matrix on analytical procedures, laboratory precision, and the effects of sampling methods and shipping on analytical results. Chain of custody documentation is maintained for all samples from sample collection through shipment to the analytical laboratory. Completed chain of custody records are maintained at the WSSRAP as QA records.

Laboratories analyzing the WSSRAP samples are required to use standard methods and to have a quality assurance program. These quality assurance programs are reviewed and approved by the project's Quality Assurance Department prior to commencement of analyses. Laboratories are also required to comply with standardized reporting requirements, thus simplifying data verification, validation, and interpretation. Laboratories are routinely audited to assure compliance with their QA programs and appropriate analytical procedures.

All data received from analytical laboratories are subjected to data verification. The data verification process is detailed in ES&H Procedure 4.9.1 and consists of a preliminary review of the quality-impacting aspects of sampling, analysis, and reporting. Data verification includes reviewing field sampling documentation, sample preservation, chain of custody, analytical holding times, and a comparison of electronic versus hard copy reporting.

Data verification assures that all data are received for every sample submitted for analyses and includes a preliminary review by the data users. The verification process also ensures that any discrepancies noted have been addressed and that the resultant changes are documented.

Data validation is performed independent of the analytical laboratory. Data validation consists of two primary functions. First, the analytical process is reviewed and the quality of the data is documented. This consists of reviewing all records related to sample integrity, sample preparation, and the analytical measurement systems. Second, the data are compared to the method-specific criteria and site-specific data quality requirements. This ensures that data quality is evaluated based on the end use of the data. At the WSSRAP, approximately 10% of all analytical data is validated according to site-specific procedures. Approximately 5% is evaluated on a random basis to provide coverage across all data sets. The other 5% is selected from critical data. The 10% validation actually reviews a large portion of the analytical lots, effectively validating a much larger percentage of the data base. This is accomplished by reviewing information affecting data quality, such as instrument calibration, which is the same for all samples in an analytical lot.

The useability of the data is established by data validation. The final step involves comparing results to the method criteria and data quality requirements. Qualifiers are attached to data records that have been validated. This allows data users to assess the quality of the data being used without requiring a detailed knowledge of the analytical processes. The data validation process is detailed in Engineering Procedure ENG-9.

The result of these programs and procedures is that analytical data quality is known and documented. The data presented in this report have been verified and a percentage have been validated. Additional information regarding data quality is available in the *Chemical Plant Site Remedial Investigation/Feasibility Study Data Validation Report* (MKF and JEG 1991c).

6.2 Quality Assurance Audits and Audit Tracking System

In 1990, WSS operations were reviewed during seven audits by outside entities. Four of these audits directly evaluated environmental aspects of the project. These audits evaluated the topics, and were performed by the organizations listed below.

Scope of Audit	Auditing Organization
Management Appraisal of ES&H and Quality Assurance	DOE - Oak Ridge Operations
Waste Management and Regulatory Compliance	Oak Ridge National Laboratories
ES&H and QA Appraisal	DOE - Oak Ridge Operations
Quality Assurance Project Plan Compliance	M-K Environmental Services Quality Assurance

Each audit resulted in an audit report which detailed findings and proficiencies. A response was prepared and corrective actions were 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 and verification by both internal and external entities. The majority of findings in these audits relate to problems that only remedial action can solve (such as storage of polychlorinated biphenyls (PCBs) beyond the one-year limit), or relate to best management practices (which can be resolved through upgrading existing systems or by developing or revising procedures). The status of all audits is routinely reviewed by project management and QA personnel to ensure that progress is being made and that adequate resources are applied to correcting problems.

6.3 Quality Control Data Summary

Quality control samples were collected during all phases of the routine environmental monitoring program at the WSS. In some programs such as the external gamma and radon monitoring, the results are directly incorporated into the discussion of the data.

Groundwater, surface water, spring and National Pollution Discharge Elimination System (NPDES) monitoring, quality control sample results are discussed in this chapter. These 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. Quality control data has been reviewed to evaluate impacts on the conclusions and interpretations presented in this report. The detection of uranium in water and bottle blanks, and field blanks has not impacted the dose calculations discussed in this report.

The WSSRAP did not participate in the DOE interlab comparison program in 1990. Participation will be implemented during 1991 for subcontract laboratory samples that were analyzed. The WSSRAP did collect quality control samples that were analyzed by numerous laboratories. The results of this program are discussed in Section 6.3.4.

6.3.1 Trip Blanks

Trip blank samples were collected to assess the impacts of sample shipping on analytical results. Trip blanks are sent with each shipment of samples to be analyzed for volatile organic compounds. During 1990, six trip blank samples were analyzed for volatile organic compounds. Analysis of these samples detected only low concentrations of acetone, methylene chloride, and toluene. These compounds were also detected in laboratory blanks, indicating that lab contamination is the source of these compounds.

6.3.2 Water and Bottle Blanks

Water and bottle blank samples are collected to evaluate the cleanliness of sampling containers and the purity of distilled water used to decontaminate nondedicated sampling equipment. These samples also serve as additional laboratory blanks. Eleven water and bottle blank samples were collected during 1990. These samples were analyzed for combinations of the following parameters: inorganic anions, uranium, gross alpha, and nitroaromatic compounds. These samples detected low concentrations (near the detection limit) for chloride (1 of 5 samples), fluoride (1 of 5 samples), sulfate (3 of 5 samples) and uranium (6 of 6 samples). The detection of uranium is particularly significant due to the concentrations detected. Uranium concentrations in these samples ranged from less than 1 pCi/l to 4.8 pCi/l (0.037 Bq/l to 0.177 Bq/l). As a result of these analyses, the uranium results (in water samples) presented in Section 4 are likely biased high, up to approximately

5 pCi/l (0.185 Bq/l). In many areas, this slight bias may not be significant. However, in surface water and groundwater at the Weldon Spring Chemical Plant/raffinate pits (WSCP/WSRP), this bias may have artificially increased concerns regarding elevated uranium levels.

6.3.3 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. Seven field blank samples were collected during 1990. Field blank results must be used in conjunction with water and bottle blank sample results to accurately assess any impacts associated with actual sample collection. Field blank sample results correlated with water and bottle blanks sample results, indicating either bottle or laboratory contamination as the source for biased results for uranium and sulfate analyses. Uranium concentrations in field blanks ranged from less than 1 pCi/l to 5.4 pCi/l (0.037 Bq/l to 0.199 Bq/l), supporting the conclusions reached in Section 6.3.2.

6.3.4 Duplicate Sample Results

Two types of duplicate samples were collected and analyzed during 1990 for groundwater, surface water, spring, and NPDES samples. The first duplicate type is blind duplicate samples which were collected at the same time and in the same manner as regular samples, given a unique sample number, and analyzed by the laboratory analyzing the regular sample. The second duplicate type is replicate samples which are collected at the same time and in the same manner as the original sample and analyzed by a different laboratory.

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 most frequently analyzed for uranium, nitroaromatic compounds, and inorganic anions. The number of duplicate samples analyzed by analytical parameter is presented in Table 6-1. Overall, the duplicate and replicate analyses indicated good agreement between the original and duplicate samples.

TABLE 6-1 Duplicate Sample Summary for Water Samples

PARAMETER	NUMBER OF DUPLICATE SAMPLES
1,3,5-Trinitrobenzene	25
1,3-Dinitrobenzene	25
Nitrobenzene	25
2,4,6-Trinitrotoluene	25
2,4-Dintrotoluene	25
2,6-Dinitrotoluene	25
Nitrate	26
Sulfate	24
Fluoride	25
Chloride	25
Uranium	28

7 SPECIAL STUDIES AND REMEDIAL ACTIVITIES

7.1 Characterization Special Studies

7.1.1 Haul Route Characterization

A haul road is planned for transportation of quarry bulk wastes from the Weldon Spring quarry (WSQ) to the Weldon Spring Chemical Plant (WSCP). This road will traverse an abandoned railroad grade and parallel Highway 94 when deviating from the railroad grade. The majority of this route crosses portions of the Weldon Spring Wildlife Area (owned by the Missouri Department of Conservation [MDOC]). Chemical and radiological characterization efforts were performed along this route in 1990 to assess waste management requirements for excavated materials and personnel exposure during construction of the road.

Chemical sampling included soil sampling in the marshalling yard (near the WSCP) and soil sampling near two abandoned drum locations adjacent to the railroad grade. The most intensive sampling was performed in the marshalling yard since this area presented the highest potential for contamination due to additional railcar operations and documentation of potential contaminant sources in this area. Soil samples were analyzed for volatile organics, semi-volatile organics, pesticides and polychlorinated biphenyls (PCBs), hazardous substance list metals, and nitroaromatic compounds. Samples from the marshalling yard indicated detectable levels of nitroaromatics in one grab sample and in one composite sample. PCBs were found at levels just above the detection limit near an abandoned transformer station. Metals concentrations were at or near background levels. No contaminants were found above background levels near the two abandoned drum locations. Chemical characterization did not indicate any contaminant levels which would require the use of special personnel protection equipment or present waste management concerns during construction of the haul road. The chemical results on wastes in the marshalling yard area will be given to the Department of the Army to support their remedial action decision on the Weldon Spring Training Area (WSTA).

Radiological characterization was performed along the entire railroad grade from the WSQ up to and including the marshalling yard. The characterization included: total beta-gamma radiation measurement and loose alpha contamination measurement surveys, and collection of physical samples from railroad ties, soil, and rail. Total beta-gamma

measurements and loose alpha contamination measurement surveys were performed to determine the levels of contamination present. Physical samples were collected to determine which radionuclides were present. Radiological characterization results indicated that all materials surveyed were within the release criteria established in the *Radiological Survey and Release Plan for the Quarry Haul Road* (MKF and JEG 1990e). Additional surveying of areas on the rails and ties that are inaccessible at this time (e.g., bottoms of rails), will be completed before any materials can be released for unrestricted use.

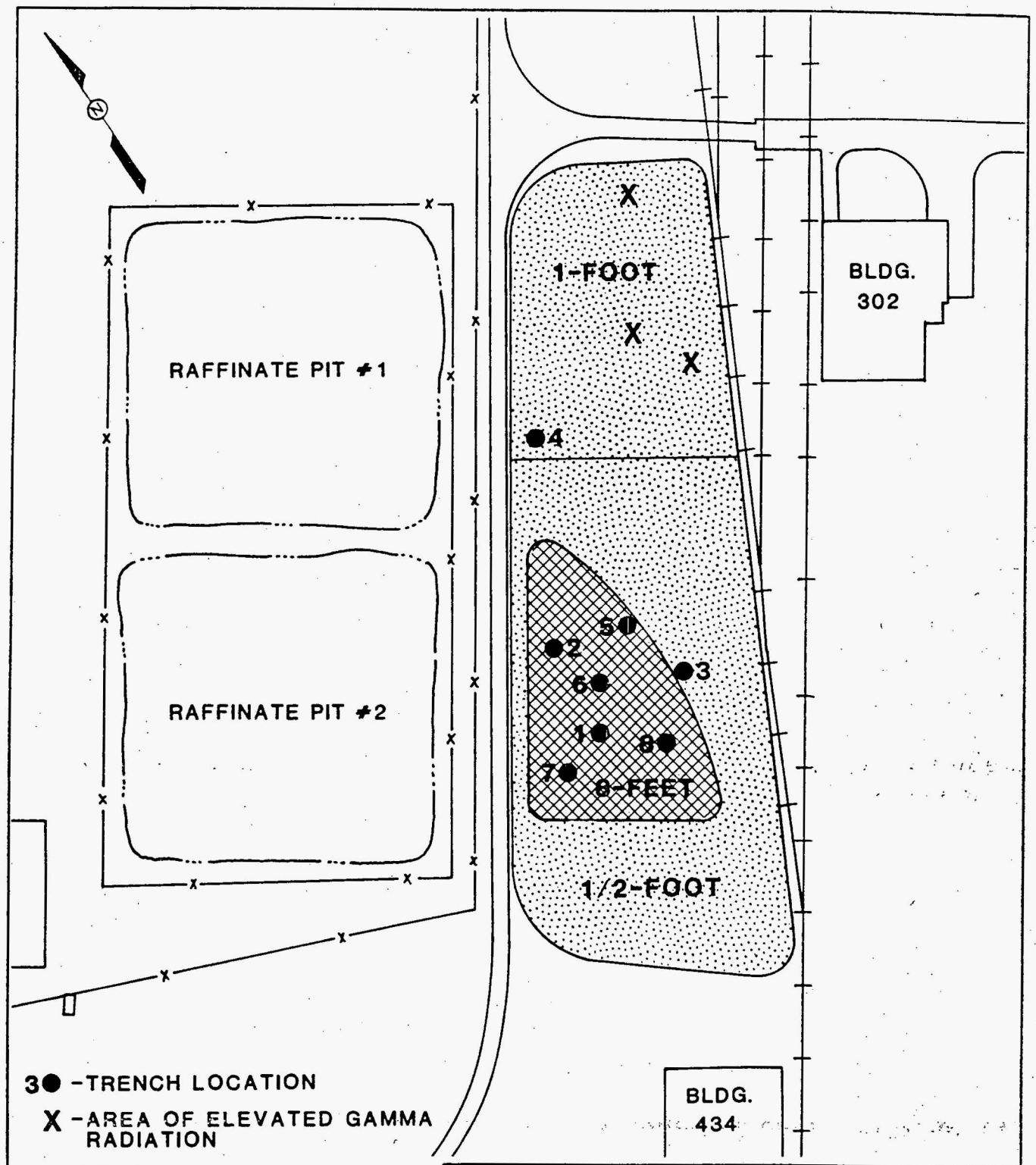
7.1.2 Aquatic Sampling

Fish and turtle specimens were collected during the 1990 calendar year to assess bio-uptake in aquatic habitats. In May 1990, a fish survey was performed in conjunction with MDOC in the Busch Wildlife area. Lakes 34 and 35 were sampled using electroshocking methods. Channel and bullhead catfish, sunfish (redear, green and bluegill) and largemouth bass were collected from Lake 34. The same three species were also collected in Lake 35, along with black crappie and white crappie. Fish samples which included (fillets, cakes, and the entire fish) were analyzed for isotopic uranium. The data results showed a range of concentrations from below the detection limit of .001 pCi/g to 0.349 pCi/g (0.000037 Bq/g to 0.0129 Bq/g). The whole fish samples from Lakes 34 and 35 showed the highest uranium concentrations.

On May 16, 1990, a snapping turtle was captured from the raffinate pit area. The turtle was analyzed to determine bioaccumulation of U-238, isotopic thorium, and isotopic radium. Four samples; skin, muscle tissue, bones, and internal organs were analyzed separately for each of the isotopes. Data results ranged from <.001 pCi/g (<0.000037 Bq/g) for Th-232 in muscle tissues and organs to 7.17 pCi/g (0.265 Bq/g) for Th-228 in the bone sample. A report is being prepared that will present the data and further discuss the findings of this study.

7.1.3 Southeast Drainage Sampling

The Southeast Drainage Flow Study was initiated during 1990 as a three-step investigation to determine the impacts of contaminated sediments on relatively uncontaminated stream flow. Steps one and two were performed in the autumn of 1990 at flow rates of 100 gal/min (gpm) (378.5 liters/min) and 200 gpm (757 liters/min). Step three



BURIED BRICK TRENCHING AREA

FIGURE 7-1

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ORIGINATOR: JAM	DRAWN BY: GLN	DATE: 4/91	

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is consistent with site characterization results for this area. The average U-238 concentration in this area, based on site characterization performed in 1987, is approximately 20 pCi/g (0.74 Bq/g). Trench No. 4 exhibited unexpected results. This trench was out of the suspected debris area, and no debris other than gravel was encountered. However, the composite soil sample collected from this location contained 125 pCi/g (4.625 Bq/g) of U-238. This is much higher than the 20 pCi/g (0.74 Bq/g) average found during site characterization. A more thorough discussion and presentation of the data are included in the completion report being prepared by the Project Management Contractor (PMC).

7.1.6 Transformer 411 Characterization

Number 411 Electrical Substation is located on Department of Conservation property south of the Weldon Spring Chemical Plant (WSCP). The objective of the characterization effort was to supply the data necessary to prepare a subcontract package for the removal of all transformers and dielectric fluids contained at Substation 411.

Actual sampling of Substation 411 was performed on April 23 and 24, 1990. This included soil sampling throughout the area and collection of dielectric fluid (oil) samples from each transformer. A sampling plan was developed prior to sampling which contained detailed information on sampling locations, equipment, techniques, and personal protective equipment to be used during the sampling effort.

Two pole mounted transformers located within Substation 411 could not be sampled in April due to safety concerns. On June 14, 1990, a subcontractor was employed to disconnect and remove the transformers from their respective poles and place them on the substation concrete pad. The transformers were sampled on June 20, 1990, using the prescribed sampling techniques.

The results of the sampling were as follows: the oils in the transformers were determined to contain background levels of uranium; the oils contained varying levels of PCBs ranging from 6.1 ppm to 1,100 ppm of PCB (Arochlor 1260); the transformers were drained and rinsed as required by 40 CFR 761.60(b)(1)(i)B.

The soils surrounding the substation were sampled for Hazardous Substance List (HSL) metals, nitroaromatics, and PCBs. Metal levels were within the range of background.

Two soil samples showed low levels of nitrobenzene. Two samples showed detectable levels of PCBs, although both were below the 10 ppm clean-up criteria in 40 CFR 761.125(c)(4). Further detail on this investigation is available in the completion report for this effort (MKF and JEG 1990d).

7.2 Interim Response Actions

7.2.1 Quarry Water Treatment Plant Soil Remediation

The quarry construction staging area (QCSA) is an area adjacent to the WSQ to be used for placement of a quarry water treatment system to support the treatment of contaminated water from the quarry pond and subsequent removal of bulk wastes from the quarry.

The planned QCSA is to include an equalization basin, two effluent ponds, roads, parking areas, and infrastructure along with a water treatment plant. Before work could begin on the QCSA, contamination due to spills from haul trucks and railroad cars bringing wastes into quarry during past disposal operations had to be characterized.

Prior to radiological characterization, background gamma radiation levels and soil radionuclide concentrations were measured in the vicinity of the WSQ. The background locations were selected in areas unaffected by previous operations at the Weldon Spring site. Soil samples were collected in these background areas to a depth of 15.24 cm (6 in). All soil samples were analyzed for U-238, Ra-226 and Th-232 via high-purity germanium (HpGe) gamma spectroscopy.

Using background gamma radiation levels and soil radionuclide concentrations as a guide, initial characterization of the QCSA was performed. Systematic soil sampling was performed within the QCSA. Sample locations were established approximately every 68 m (200 ft) along the Little Femme Osage Creek, the quarry access road, and the abandoned railroad tracks and spurs. Seventeen sample locations were established and 20 soil samples were collected. These soil samples were taken to determine whether radioactive contamination occurs in these areas and, if necessary, to guide further sampling. Further information concerning the QCSA initial characterization may be found in the *Radiological*

and Chemical Characterization Report For The Planned Quarry Construction Staging Area and Water Treatment Plant, (MKF and JEG 1989d).

The areal extent of contamination was determined after the initial characterization was performed and contaminated areas were identified. This was done to determine explicit perimeter boundaries (depth and area) of the contaminated zones determined in the initial characterization. Previously determined background radiation and background radionuclide concentrations were used in this phase of characterization.

Thirty-four sample grids bordering the perimeters of the contaminated Zones 1, 2, and 3, previously identified in the initial characterization were established, and total of 36 composite soil samples were collected. Figure 7-2 displays these zones.

As a result of this characterization, the perimeters of the extent of contamination were unchanged from those previously determined by initial characterization. The single exception was one sample grid which had results for Th-230 of 6.9 pCi/g (0.255 Bq/g). This area was added to those which required remediation.

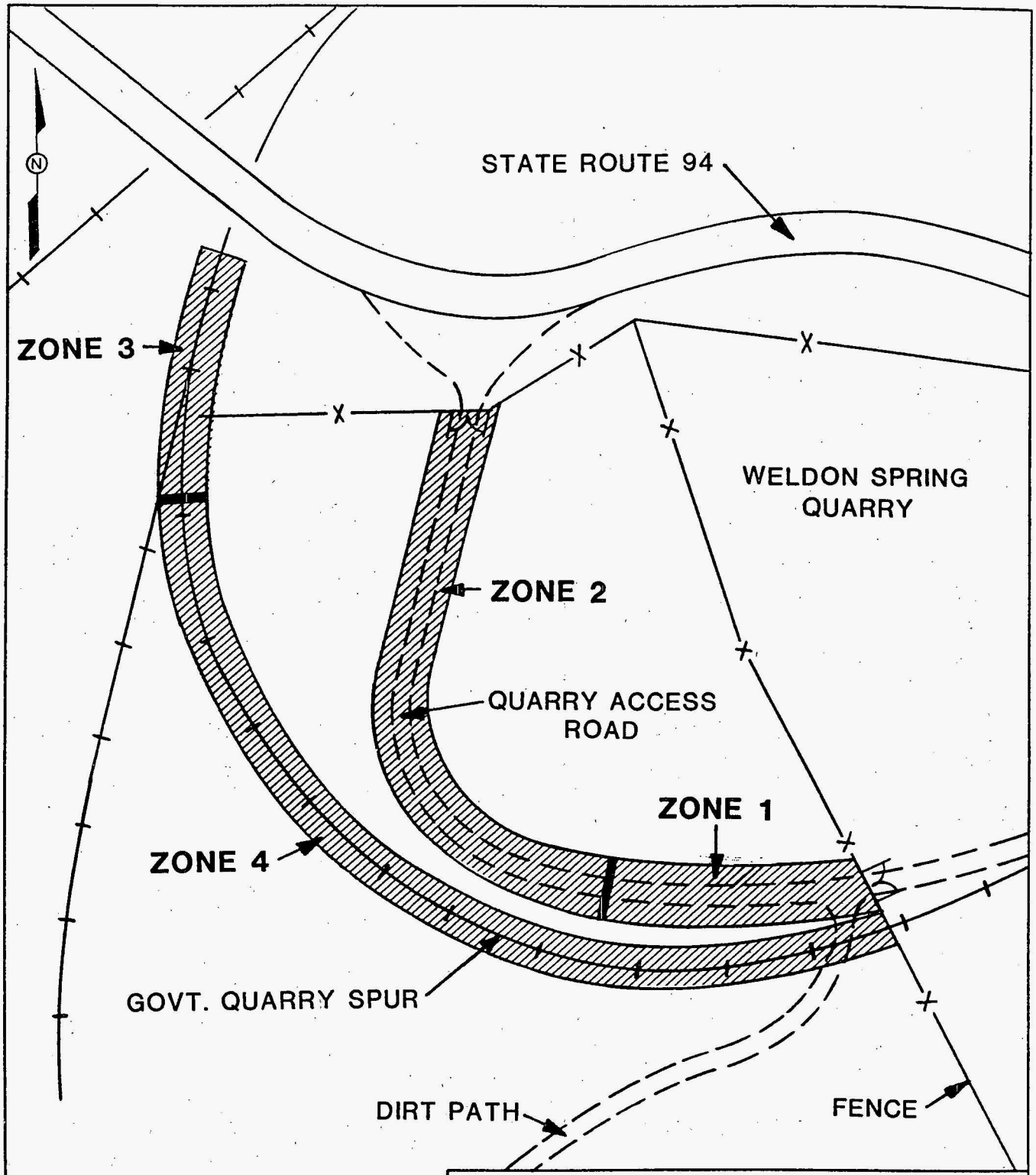
After contaminated zone perimeters were established through initial and areal extent characterization, remediation was performed by excavating with a backhoe and dumptruck. The excavated soil was placed in a soils staging area within the fenced inner quarry area.

Characterization to confirm the completion of remediation was performed immediately following excavation of each area. After each area was remediated, a walk-over scan of the exposed surface was performed. Walk-over scans after remediation revealed background levels of contamination.

Soil was sampled in each area after the walk-over scans were performed. All verification samples taken after remediation revealed concentrations of Th-230, U-238, Ra-226, and Ra-228 below criteria established for this project.

7.2.2 Containerized Chemical Consolidation

As reported in the 1989 *Annual Site Environmental Report* (MKF and JEG 1989c) the containerized chemical consolidation program continued to identify, characterize, consolidate,



- CONTAMINATED AREA

0 100 200 FT

0 30.5 61.0 M

SCALE

WELDON SPRING QUARRY
SOIL REMEDIATION
CONTAMINATED ZONES

FIGURE 7-2

REPORT NO.: DOE/OR/21548-193		EXHIBIT NO.: A/QY/048/0691	
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repackage and temporarily store chemical wastes which were located throughout the chemical plant. Approximately 6,000 containers (bottles, jars, barrels, etc.) have been repackaged and placed into storage. Work has begun on characterizing the process piping, sumps, tanks, and vessels which occur throughout the site. Upon completion, the results of this program will be described in a characterization report.

8 REFERENCES

Argonne National Laboratory, 1989. *Draft Baseline Risk Evaluation for Bulk Wastes at the Weldon Spring Quarry*, Weldon Spring, Missouri. DOE/OR/21548-065. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. February.

Bechtel National, Inc., 1984. *Radiological Survey Report for the Weldon Spring Raffinate Pits Site*, DOE/OR/20722-7 (DE84015853). Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. August.

Bechtel National, Inc. 1987. *Hydrogeologic Characterization Report for Weldon Spring Chemical Plant*, Weldon Spring, Missouri. DOE/OR/20722-137. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. July.

BIER, see committee on the Biological Effects of Ionizing Radiations Board on Radiation Effects Research Commission on Life Sciences National Research Council.

Committee on the Biological Effects of Ionizing Radiation Board on Radiation Effects Research commission on Life Sciences. National Research Council, 1988. BEIR IV. National Academic Press. Washington, D.C.

Cember, H. 1983. *Introduction to Health Physics*, Second Edition. Northwest University. Pergamon Press, New York, Oxford, Toronto, Sydney, Paris and Frankfort.

DOE, see U.S. Department of Energy.

Eckerman, K.F., A.B. Wolbarst, and A.C.B. Richardson, 1988. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion: Derived Guides for Control of Occupational Exposure and Exposure-to-Dose conversion Factors for General Application, Based on the 1987 Federal Radiation Protection Guidance, Federal Guidance Report No. 11.* U.S. Environmental Protection Agency, Office of Radiation Programs, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

EPA, see U.S. Environmental Protection Agency.

Ficker, C.F., 1981. Environmental Monitoring Program for DOE Weldon Spring, Missouri Site, NCLO-009EV (Special) UC-70A. Prepared for the U.S. Department of Energy, Remedial Action Program Office, Surplus Facilities Management Program, by National Lead Company of Ohio. Cincinnati. August.

ICRP, see International Commission on Radiological Protection.

International Commission on Radiological Protection, 1977. Recommendations of the International Commission on Radiological Protection. Publication No. 26. Pergamon Press, New York. (Adopted January 17, 1977).

International Commission on Radiological Protection, 1979. Limits on the Intake of Radionuclides By Workers, Part 1. Publication No. 30. Pergamon Press, New York. August.

Maher, S., 1991. Telecon to G. Valette from S. Maher regarding usage of the Katy Trail. Weldon Spring Remedial Action Project. St. Charles, Missouri.

MKF and JEG, see MK-Ferguson Company and Jacobs Engineering Group.

MK-Ferguson Company and Jacobs Engineering Group, 1987. *Water Quality Phase I Assessment Report*, Revision 0. DOE/OR/21548-003. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. December.

MK-Ferguson Company and Jacobs Engineering Group, 1988. *Annual Environmental Monitoring Report 1988*. Revision 0. DOE/OR/21548-079. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. June.

MK-Ferguson Company and Jacobs Engineering Group, 1989a. *Remedial Investigation for Quarry Bulk Wastes*. DOE/OR/21548-066. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. December.

MK-Ferguson Company and Jacobs Engineering Group, 1989b. *Phase II Groundwater Quality Assessment for the Weldon Spring Site, Chemical Plant, Raffinate Pits, and Surrounding Vicinity Properties*. DOE/OR/21548-078. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. August.

MK-Ferguson Company and Jacobs Engineering Group, 1989c. *Annual Site Environmental Report 1989*, Revision 1. DOE/OR/21548-129. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. November.

MK-Ferguson Company and Jacobs Engineering Group, 1989d. *Radiological and Chemical Characterization Report for the Planned Quarry Construction Staging Area and Water Treatment Plant*, Revision 1. DOE/OR/21548-046. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. March.

MK-Ferguson Company and Jacobs Engineering Group, 1990a. *Plan for Monitoring Radionuclide Emissions Other than Radon at the Weldon Spring Site Critical Receptors*, Revision 0. DOE/OR/21548-127. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. May.

MK-Ferguson Company and Jacobs Engineering Group, 1990b. *Waste Minimization/Pollution Prevention Awareness Plan*, Revision 0. DOE/OR/21548-124. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. May.

MK-Ferguson Company and Jacobs Engineering Group, 1990c. *Environmental Monitoring Plan*, Revision 1. DOE/OR/21548-103. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. January.

MK-Ferguson Company and Jacobs Engineering Group, 1990d. *Screening Level Characterization of Electrical Substation 411*. Revision 0. DOE/OR/21548-154. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. November.

MK-Ferguson Company and Jacobs Engineering Group, 1990e. *Radiological Survey and Release Plan for Railroad Tracks Being Removed for the National Museum of Transport*. DOE/OR/21548-115. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. April.

MK-Ferguson Company and Jacobs Engineering Group, 1991a. *Waste Analysis Plan for the Weldon Spring Site Remedial Action Project*, Revision 2. DOE/OR/21548-128. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. February.

MK-Ferguson Company and Jacobs Engineering Group, 1991b. *Environmental Data Administration Plan*, Revision 1. DOE/OR/21548-119. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. April.

MK-Ferguson Company and Jacobs Engineering Group, 1991c. *Chemical Plant Site Remedial Investigation/Feasibility Study Data Validation Report*, Revision A. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. January.

Peterson, J.M., M.M. MacDonell, L.A. Haroun, F.K. Nowaly, W.C. Knight, and G.F. Vajda, 1988. *Work Plan for the Remedial Investigation/Feasibility Study-Environmental Impact Statement for the Weldon Spring Site, Weldon Spring, Missouri*. DOE/OR/21548-033. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, by Argonne National Laboratory, Energy and Environmental Systems Division. August.

United Nations Scientific Committee on the Effects of Atomic Radiation, 1982. 37th Session, Suppl. No. 45 (A/37/45). United Nations, New York.

United States Department of Energy, 1986. *Grand Junction Final Environmental Impact Statement*, DOE/EIS-0126-F. Remedial Action at the Former Climax Uranium Company Uranium Mill Site. Grand Junction, Colorado. December.

U.S. Department of Energy, 1988. *Internal Dose Conversion Factors for Calculation of Dose to the Public*. DOE/EH-0071.

U.S. Environmental Protection Agency, 1980. *Prescribed Procedures for Measurement of Radioactivity in Drinking Water.* EPA-600/4-80-032. Cincinnati, Ohio. August.

U.S. Environmental Protection Agency, 1986. *RCRA Groundwater Monitoring Technical Enforcement Guidance Document.* OSWER-9950. September.

U.S. Environmental Protection Agency, 1988. *Superfund Exposure Assessment Manual.* OSWER Directive 9285.5-1.

DOE ORDERS

DOE Order 5000.3A *Occurrence Reporting and Processing of Information.*

DOE Order 5400.1 *General Environmental Protection Program.*

DOE Order 5400.4 *Comprehensive Environmental Response, Compensation, and Liability Act Requirements.*

DOE Order 5484.1 *Environmental Protection, Safety, and Health Protection Information Reporting Requirements.*

DOE Order 5400.5 *Radiation Protection for the Public and the Environment.*

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

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

40 CFR 761.65(a) Polychlorinated biphenyls (PCBs) manufacturing, processing distribution in commerce, and use prohibitions.

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

19 CSR 20-10.040 - Maximum Permissible Exposure Limits

APPENDIX A
QUARTERLY MONITORING DATA FOR WATER MEDIA

Appendix A contains all of the measured valves that were used to calculate the annual averages reported in the preceding text. Although the quarterly and annual sampling schedules varied by media and location, all data in the appendix are tabulated by the quarter during which they were collected.

Consequently, this format represents differing numbers of data points per location based on the sampling schedule of each location.

The data are organized by media beginning with groundwater, followed by springs, and then surface water. Data within each section are arranged by analytical category as follows: nitraromatics, inorganic anions, and radiological species.

1,3,5-TRINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	20.0			52.0	µg/l
GW-1004	0.21			0.79	µg/l
GW-1005	ND			ND	µg/l
GW-1006	5.60			120	µg/l
GW-1007	ND			ND	µg/l
GW-1008		ND		ND	µg/l
GW-1009	ND			ND	µg/l
GW-1010	ND		ND		µg/l
GW-1011	ND		ND		µg/l
GW-1012	ND			ND	µg/l
GW-1013	ND			ND	µg/l
GW-1014	ND			ND	µg/l
GW-1015	17.9			11.0	µg/l
GW-1016	0.26			0.48	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	0.00	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	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-1025		ND		ND	µg/l
GW-1026		ND		ND	µg/l
GW-1027	ND			0.13	µg/l
GW-1028	ND			ND	µg/l
GW-2001		ND	.032		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		12.0	11.0		µg/l
GW-2007		ND	ND		µg/l
GW-2008		12.0	0.91		µg/l
GW-2009		ND	ND		µg/l
GW-2010		0.26	0.24		µg/l
GW-2011		0.19			µg/l
GW-2012		5.20	3.50		µg/l
GW-2013	7.50		5.90	ND	µg/l
GW-2014		4.00		ND	µg/l
GW-2015		ND	ND		µg/l
GW-2017		ND	.074		µg/l
GW-2018		ND		ND	µg/l
GW-2019		ND		ND	µg/l
GW-2020		ND			µg/l

1,3,5-TRINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
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-3001		0.09	0.14	ND	µg/l
GW-3002		ND			µg/l
GW-3003		ND	ND		µg/l
GW-3006		ND	ND		µg/l
GW-3008		ND			µg/l
GW-3009		0.36		0.11	µg/l
GW-3010		ND		ND	µg/l
GW-3019		ND	ND		µg/l
GW-4001		60.0	58.000		µg/l
GW-4002		0.20	0.27		µg/l
GW-4003		ND	ND		µg/l
GW-4004	ND			ND	µg/l
GW-4005	ND			ND	µg/l
GW-4006		22.0	17.000		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		43.0		34.0	µg/l
GW-4014		0.45		0.48	µg/l
GW-4015		0.48		0.16	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		ND		µg/l
GW-4023	0.08		0.100		µg/l
GW-FINN		ND			µg/l
GW-FINW	ND		ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03		ND	ND	ND	µg/l

1,3,5-TRINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND		ND	µg/l
GW-PW06	ND	ND	ND	ND	µg/l
GW-PW07	ND	ND	ND	ND	µg/l
GW-PW08	ND	ND	ND	ND	µg/l
GW-PW09	ND	ND	ND	ND	µg/l
GW-RAWW	ND	ND	ND	ND	µg/l
GW-RMW1	ND	ND	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
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	ND			0.27	µg/l
GW-1004	ND			ND	µg/l
GW-1005	ND			ND	µg/l
GW-1006	ND			0.19	µg/l
GW-1007	ND			ND	µg/l
GW-1008		ND		0.14	µg/l
GW-1009	ND			ND	µg/l
GW-1010	ND		ND		µg/l
GW-1011	ND		ND		µg/l
GW-1012	ND			ND	µg/l
GW-1013	ND			ND	µg/l
GW-1014	ND			ND	µg/l
GW-1015	ND			0.22	µg/l
GW-1016	0.66			0.20	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	0.00	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	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-1025		ND		ND	µg/l
GW-1026		ND		ND	µg/l
GW-1027	ND			ND	µg/l
GW-1028	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		0.14	ND		µg/l
GW-2007		ND	ND		µg/l
GW-2008		0.14	ND		µg/l
GW-2009		0.50	ND		µg/l
GW-2010		0.11	0.20		µg/l
GW-2011		0.48			µg/l
GW-2012		0.29	ND		µg/l
GW-2013	ND		ND	ND	µg/l
GW-2014		0.14		ND	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			µg/l
GW-2021		ND		ND	µg/l

1,3-DINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
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-3001		ND	ND	ND	µg/l
GW-3002		ND			µg/l
GW-3003		ND	ND		µg/l
GW-3006		ND	ND		µg/l
GW-3008		ND			µg/l
GW-3009		ND		ND	µg/l
GW-3010		ND		ND	µg/l
GW-3019		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	µg/l
GW-4006		ND	ND		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		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		ND		µg/l
GW-4023	ND		ND		µg/l
GW-FINN		ND			µg/l
GW-FINW	ND		ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03		ND	ND	ND	µg/l

1,3-DINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND		ND	µg/l
GW-PW06	ND	ND	ND	ND	µg/l
GW-PW07	ND	ND	ND	ND	µg/l
GW-PW08	ND	ND	ND	ND	µg/l
GW-PW09	ND	ND	ND	ND	µg/l
GW-RAWW	ND	ND	ND	ND	µg/l
GW-RMW1	ND	ND	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

2,4,6-TNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	6.40			10.0	µg/l
GW-1004	1.90			4.20	µg/l
GW-1005	ND			ND	µg/l
GW-1006	8.90			18.0	µg/l
GW-1007	ND			ND	µg/l
GW-1008		ND		ND	µg/l
GW-1009	ND			ND	µg/l
GW-1010	ND		ND		µg/l
GW-1011	ND		ND		µg/l
GW-1012	ND			ND	µg/l
GW-1013	ND			ND	µg/l
GW-1014	ND			ND	µg/l
GW-1015	8.13			4.9	µg/l
GW-1016	0.57			0.28	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	0.00	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	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-1025		ND		ND	µg/l
GW-1026		ND		ND	µg/l
GW-1027	2.40			28.0	µg/l
GW-1028	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	0.039		µg/l
GW-2007		ND	ND		µg/l
GW-2008		ND	0.036		µg/l
GW-2009		ND	ND		µg/l
GW-2010		0.36	0.55		µg/l
GW-2011		0.06			µg/l
GW-2012		1.60	0.74		µg/l
GW-2013	2.60		1.20	ND	µg/l
GW-2014		0.03		ND	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			µg/l
GW-2021		ND		ND	µg/l

2,4,6-TNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
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-3001		ND	ND	ND	µg/l
GW-3002		ND			µg/l
GW-3003		ND	ND		µg/l
GW-3006		ND	ND		µg/l
GW-3008		ND			µg/l
GW-3009		ND		ND	µg/l
GW-3010		ND		ND	µg/l
GW-3019		ND	ND		µg/l
GW-4001		1.90	2.000		µg/l
GW-4002		1.90	0.20		µg/l
GW-4003		ND	ND		µg/l
GW-4004	ND			ND	µg/l
GW-4005	ND			ND	µg/l
GW-4006		ND	ND		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		0.08		0.07	µg/l
GW-4014		0.06		0.06	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		ND		µg/l
GW-4023	ND		ND		µg/l
GW-FINN		ND			µg/l
GW-FINW	ND		ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03		ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND		ND	µg/l

2,4,6-TNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW06	ND	ND	ND	ND	µg/l
GW-PW07	ND	ND	ND	ND	µg/l
GW-PW08	ND	ND	ND	ND	µg/l
GW-PW09	ND	ND	ND	ND	µg/l
GW-RAWW	ND	ND	ND	ND	µg/l
GW-RMW1	ND	ND	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

2,4-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	ND			ND	µg/l
GW-1004	0.08			1.60	µg/l
GW-1005	ND			0.16	µg/l
GW-1006	ND			0.16	µg/l
GW-1007	ND			ND	µg/l
GW-1008		ND		ND	µg/l
GW-1009	ND			ND	µg/l
GW-1010	ND		ND		µg/l
GW-1011	ND		ND		µg/l
GW-1012	ND			ND	µg/l
GW-1013	ND			0.038	µg/l
GW-1014	0.10			0.031	µg/l
GW-1015	0.36			ND	µg/l
GW-1016	ND			ND	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	0.00	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	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-1025		ND		ND	µg/l
GW-1026		ND		ND	µg/l
GW-1027	38.0			12.0	µg/l
GW-1028	ND			ND	µg/l
GW-2001		0.14	.071		µg/l
GW-2002		0.07		0.083	µg/l
GW-2003		0.30	0.28		µg/l
GW-2004		ND	ND		µg/l
GW-2005		0.08	.079		µg/l
GW-2006		0.06	ND		µg/l
GW-2007		ND	ND		µg/l
GW-2008		ND	ND		µg/l
GW-2009		0.74	ND		µg/l
GW-2010		0.95	0.032		µg/l
GW-2011		14.0			µg/l
GW-2012		4.30	ND		µg/l
GW-2013	5.40		0.54	ND	µg/l
GW-2014		2.20		ND	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			µg/l
GW-2021		ND		ND	µg/l

2,4-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
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-3001		0.38	0.66	ND	µg/l
GW-3002		ND			µg/l
GW-3003		ND	.034		µg/l
GW-3006		0.06	ND		µg/l
GW-3008		0.08			µg/l
GW-3009		0.17		0.11	µg/l
GW-3010		ND		ND	µg/l
GW-3019		ND	ND		µg/l
GW-4001		3.00	3.100		µg/l
GW-4002		ND	ND		µg/l
GW-4003		ND	ND		µg/l
GW-4004	ND			ND	µg/l
GW-4005	ND			ND	µg/l
GW-4006		ND	ND		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		0.40		0.04	µg/l
GW-4014		ND		ND	µg/l
GW-4015		ND		0.05	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		ND		µg/l
GW-4023	0.06		0.075		µg/l
GW-FINN		ND			µg/l
GW-FINW	ND		ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03		ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND		ND	µg/l

2,4-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW06	ND	ND	ND	ND	µg/l
GW-PW07	ND	ND	ND	ND	µg/l
GW-PW08	ND	ND	ND	ND	µg/l
GW-PW09	ND	ND	ND	ND	µg/l
GW-RAWW	ND	ND	ND	ND	µg/l
GW-RMW1	ND	ND	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

2,6-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	2.60			4.40	µg/l
GW-1004	1.80			3.80	µg/l
GW-1005	0.08			0.062	µg/l
GW-1006	4.60			7.40	µg/l
GW-1007	ND			ND	µg/l
GW-1008		ND		ND	µg/l
GW-1009	ND			ND	µg/l
GW-1010	ND		ND		µg/l
GW-1011	ND		ND		µg/l
GW-1012	ND			ND	µg/l
GW-1013	ND			ND	µg/l
GW-1014	0.02			ND	µg/l
GW-1015	0.37			0.56	µg/l
GW-1016	ND			0.070	µg/l
GW-1017	ND	ND	ND	ND	µg/l
GW-1018	ND	ND	ND	ND	µg/l
GW-1019	ND	ND	0.00	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	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-1025		ND		ND	µg/l
GW-1026		ND		ND	µg/l
GW-1027	17.0			6.70	µg/l
GW-1028	ND			ND	µg/l
GW-2001		0.06	.048		µg/l
GW-2002		0.34		0.49	µg/l
GW-2003		1.60	1.20		µg/l
GW-2004		ND	ND		µg/l
GW-2005		0.07	.050		µg/l
GW-2006		1.40	1.60		µg/l
GW-2007		ND	ND		µg/l
GW-2008		1.60	0.72		µg/l
GW-2009		0.50	0.35		µg/l
GW-2010		1.00	0.75		µg/l
GW-2011		2.20			µg/l
GW-2012		1.90	1.40		µg/l
GW-2013	29.0		13.0	ND	µg/l
GW-2014		1.20		ND	µg/l
GW-2015		ND	ND		µg/l
GW-2017		ND	1.20		µg/l
GW-2018		ND		ND	µg/l
GW-2019		ND		ND	µg/l
GW-2020		ND			µg/l
GW-2021		ND		ND	µg/l

2,6-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
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-3001		0.17	0.20	ND	µg/l
GW-3002		ND			µg/l
GW-3003		ND	.073		µg/l
GW-3006		0.11	ND		µg/l
GW-3008		0.04			µg/l
GW-3009		0.14		0.06	µg/l
GW-3010		ND		ND	µg/l
GW-3019		ND	ND		µg/l
GW-4001		3.20	3.100		µg/l
GW-4002		0.56	0.13		µg/l
GW-4003		ND	ND		µg/l
GW-4004	ND			ND	µg/l
GW-4005	ND			ND	µg/l
GW-4006		4.60	3.500		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		1.50		1.30	µg/l
GW-4014		0.05		0.12	µg/l
GW-4015		1.80		2.20	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		ND		µg/l
GW-4023	0.02		0.028		µg/l
GW-FINN		ND			µg/l
GW-FINW	ND		ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03		ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND		ND	µg/l

2,6-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW06	ND	ND	ND	ND	µg/l
GW-PW07	ND	ND	ND	ND	µg/l
GW-PW08	ND	ND	ND	ND	µg/l
GW-PW09	ND	ND	ND	ND	µg/l
GW-RAWW	ND	ND	ND	ND	µg/l
GW-RMW1	ND	ND	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

NITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	ND			ND	µg/l
GW-1004	ND			ND	µg/l
GW-1005	ND			ND	µg/l
GW-1006	ND			ND	µg/l
GW-1007	ND			ND	µg/l
GW-1008		ND		ND	µg/l
GW-1009	ND			ND	µg/l
GW-1010	ND		ND		µg/l
GW-1011	ND		ND		µg/l
GW-1012	ND			ND	µg/l
GW-1013	ND			ND	µg/l
GW-1014	ND			ND	µg/l
GW-1015	ND			ND	µg/l
GW-1016	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	µg/l
GW-1024	ND	ND	ND	ND	µg/l
GW-1025		ND		ND	µg/l
GW-1026		ND		ND	µg/l
GW-1027	ND			ND	µg/l
GW-1028	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			µg/l
GW-2012		ND	ND		µg/l
GW-2013	ND		ND	ND	µg/l
GW-2014		ND		ND	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			µg/l
GW-2021		ND		ND	µg/l

NITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
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-3001		ND	ND	ND	µg/l
GW-3002		ND			µg/l
GW-3003		ND	ND		µg/l
GW-3006		ND	ND		µg/l
GW-3008		ND			µg/l
GW-3009		ND		ND	µg/l
GW-3010		ND		ND	µg/l
GW-3019		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	µg/l
GW-4006		ND	ND		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		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		ND		µg/l
GW-4023	ND		ND		µg/l
GW-FINN		ND			µg/l
GW-FINW	ND		ND	ND	µg/l
GW-PW02	ND	ND	ND	ND	µg/l
GW-PW03		ND	ND	ND	µg/l
GW-PW04	ND	ND	ND	ND	µg/l
GW-PW05	ND	ND		ND	µg/l

NITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW06	ND	ND	ND	ND	µg/l
GW-PW07	ND	ND	ND	ND	µg/l
GW-PW08	ND	ND	ND	ND	µg/l
GW-PW09	ND	ND	ND	ND	µg/l
GW-RAWW	ND	ND	ND	ND	µg/l
GW-RMW1	ND	ND	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

CHLORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	7.70			9.44	mg/l
GW-1004	19.0			27.8	mg/l
GW-1005	13.8			25.2	mg/l
GW-1006	28.1			37.0	mg/l
GW-1007	79.8			64.5	mg/l
GW-1008		24.80		24.0	mg/l
GW-1009	25.5			25.5	mg/l
GW-1010	9.50		5.40		mg/l
GW-1011	13.7		9.40		mg/l
GW-1012	6.00			8.06	mg/l
GW-1013	22.2			20.5	mg/l
GW-1014	25.4			23.0	mg/l
GW-1015	25.4			29.0	mg/l
GW-1016	14.3			19.0	mg/l
GW-1017	27.3	23.0	19.0	18.9	mg/l
GW-1018	25.0	23.30	5.90	22.6	mg/l
GW-1019	5.50	6.90	6.10	6.30	mg/l
GW-1020	13.5	11.5	9.20	9.44	mg/l
GW-1021	3.00	11.00	12.0	9.44	mg/l
GW-1022	9.80	9.000	6.00	9.44	mg/l
GW-1023	2.50	5.50	4.40	5.25	mg/l
GW-1024	10.2	10.4	8.90	11.7	mg/l
GW-1025		5.500		5.48	mg/l
GW-1026		4.00		1.96	mg/l
GW-1027	14.000			14.8	mg/l
GW-1028	11.6			8.88	mg/l
GW-2001		9.00	3.60		mg/l
GW-2002		9.50		9.97	mg/l
GW-2003		12.0			mg/l
GW-2004		1.00	ND		mg/l
GW-2005		3.80	2.80		mg/l
GW-2006		279	73.0		mg/l
GW-2007		ND	ND		mg/l
GW-2008		93.3	54.0		mg/l
GW-2009		14.5	8.60		mg/l
GW-2010		49.0	68		mg/l
GW-2011		2.10			mg/l
GW-2012		62.0	12.0		mg/l
GW-2013	6.500		3.40	4.44	mg/l
GW-2014		26.5		26.3	mg/l
GW-2015		1.00	ND		mg/l
GW-2017		13.9	2.00		mg/l
GW-2018		17.9		7.35	mg/l
GW-2019		2.38			mg/l
GW-2020		16.6		17.2	mg/l
GW-2021		1.43		1.05	mg/l

CHLORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2022		1.90		1.57	mg/l
GW-2023		1.90		1.34	mg/l
GW-2024		2.00		1.86	mg/l
GW-2025		2.40		1.05	mg/l
GW-2026		2.00		1.76	mg/l
GW-2027		5.00		1.21	mg/l
GW-2028		2.48		1.65	mg/l
GW-2029		2.00	ND		mg/l
GW-3001		12.9	11.6		mg/l
GW-3002		1.43		0.91	mg/l
GW-3003		12.4	1.40		mg/l
GW-3006		ND	0.68		mg/l
GW-3008		13.5			mg/l
GW-3009		5.80			mg/l
GW-3010		1.50		2.00	mg/l
GW-3019		5.000	0.89		mg/l
GW-4001		3.910			mg/l
GW-4002		3.80	20.0		mg/l
GW-4003		5.70	ND		mg/l
GW-4004	2.32			3.62	mg/l
GW-4005	5.50			4.72	mg/l
GW-4006		2.00	1.60		mg/l
GW-4007		1.500		1.35	mg/l
GW-4008		ND		4.20	mg/l
GW-4009	ND		1.10		mg/l
GW-4010	2.50			2.62	mg/l
GW-4011		4.00		7.50	mg/l
GW-4012	2.500		ND		mg/l
GW-4013		6.50		5.78	mg/l
GW-4014		2.500		4.24	mg/l
GW-4015		2.85		2.69	mg/l
GW-4016		1.50	ND		mg/l
GW-4017		1.50	1.30		mg/l
GW-4018		5.50	6.90		mg/l
GW-4019	1.00			1.60	mg/l
GW-4020		5.70		5.89	mg/l
GW-4021	1.00		2.10		mg/l
GW-4022	6.500		2.40		mg/l
GW-4023	16.3		12.0		mg/l
GW-PW02			15.0		mg/l
GW-PW03			18.0		mg/l
GW-PW04			17.0		mg/l
GW-PW06			17.0		mg/l
GW-PW07			2.9		mg/l
GW-PW08			4.20		mg/l

CHLORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW09			4.80		mg/l
GW-RMW1	6.80	6.95	6.90	7.75	mg/l
GW-RMW2	7.20	3.86	2.1	4.24	mg/l
GW-RMW3	14.6	15.9	9.00	12.2	mg/l
GW-RMW4	11.2	3.50	5.40	10.2	mg/l

FLUORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	0.463			0.41	mg/l
GW-1004	1.18			1.23	mg/l
GW-1005	1.090			1.02	mg/l
GW-1006	0.273			0.36	mg/l
GW-1007	ND			0.44	mg/l
GW-1008		0.256		0.50	mg/l
GW-1009	0.189			0.35	mg/l
GW-1010	0.205		ND		mg/l
GW-1011	0.284		ND		mg/l
GW-1012	0.482			0.43	mg/l
GW-1013	0.482			0.51	mg/l
GW-1014	0.427			0.50	mg/l
GW-1015	0.321			0.38	mg/l
GW-1016	0.262			0.36	mg/l
GW-1017	ND	0.096	ND	0.24	mg/l
GW-1018	0.229	0.212	ND	0.25	mg/l
GW-1019	0.281	0.188	ND	0.20	mg/l
GW-1020	0.331	0.281	ND	0.28	mg/l
GW-1021	0.215	0.109	ND	0.23	mg/l
GW-1022	0.292	0.137	ND	0.20	mg/l
GW-1023		0.171	ND	0.27	mg/l
GW-1024	0.229	0.250	ND	0.35	mg/l
GW-1025		0.168		ND	mg/l
GW-1026		0.191		ND	mg/l
GW-1027	0.200			0.36	mg/l
GW-1028	0.282			ND	mg/l
GW-2001		1.270	ND		mg/l
GW-2002		ND		ND	mg/l
GW-2003		0.086			mg/l
GW-2004		0.160	ND		mg/l
GW-2005		0.190	ND		mg/l
GW-2006		ND	ND		mg/l
GW-2007		0.098	ND		mg/l
GW-2008		0.080	ND		mg/l
GW-2009		0.056	ND		mg/l
GW-2010		0.083	ND		mg/l
GW-2011		0.090			mg/l
GW-2012		0.051	ND		mg/l
GW-2013	ND		ND	ND	mg/l
GW-2014		0.070		ND	mg/l
GW-2015		0.150	ND		mg/l
GW-2017		0.191	ND		mg/l
GW-2018		0.230		0.31	mg/l
GW-2019		0.201			mg/l
GW-2020		0.186		0.30	mg/l
GW-2021		0.146		0.13	mg/l

FLUORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2022		0.178		0.14	mg/l
GW-2023		0.236		ND	mg/l
GW-2024		0.222		0.15	mg/l
GW-2025		0.191		0.18	mg/l
GW-2026		0.180		ND	mg/l
GW-2027		0.138		0.31	mg/l
GW-2028		0.158		0.22	mg/l
GW-2029		0.173	ND		mg/l
GW-3001		0.152	0.167		mg/l
GW-3002		0.186		0.37	mg/l
GW-3003		0.180	ND		mg/l
GW-3006		0.180	ND		mg/l
GW-3008		0.163			mg/l
GW-3009		0.105			mg/l
GW-3010		0.209		0.32	mg/l
GW-3019		0.314	ND		mg/l
GW-4001		0.111			mg/l
GW-4002		0.098	.121		mg/l
GW-4003		0.173	ND		mg/l
GW-4004	0.215			0.45	mg/l
GW-4005	0.327			0.32	mg/l
GW-4006		0.148	ND		mg/l
GW-4007		0.495		0.42	mg/l
GW-4008		0.275		0.28	mg/l
GW-4009	0.327		ND		mg/l
GW-4010	0.241			0.27	mg/l
GW-4011		0.231		0.35	mg/l
GW-4012	0.321		ND		mg/l
GW-4013		ND		ND	mg/l
GW-4014		0.191		1.17	mg/l
GW-4015		0.110		0.26	mg/l
GW-4016		0.212	ND		mg/l
GW-4017		0.148	ND		mg/l
GW-4018		0.105	ND		mg/l
GW-4019	0.444			0.35	mg/l
GW-4020		0.186		ND	mg/l
GW-4021	0.167		ND		mg/l
GW-4022	0.393		ND		mg/l
GW-4023	0.250		ND		mg/l
GW-PW02			ND		mg/l
GW-PW03			ND		mg/l
GW-PW04			ND		mg/l
GW-PW06			ND		mg/l
GW-PW07			ND		mg/l
GW-PW08			ND		mg/l

FLUORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW09			ND		mg/l
GW-RMW1	0.195	0.180	ND	ND	mg/l
GW-RMW2	0.259	0.246	ND	0.35	mg/l
GW-RMW3	0.195	0.186	ND	ND	mg/l
GW-RMW4	ND	0.200	ND	0.27	mg/l

NITRATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	0.557			0.68	mg/l
GW-1004	0.093			0.629	mg/l
GW-1005	ND			ND	mg/l
GW-1006	0.197			1.33	mg/l
GW-1007	ND			ND	mg/l
GW-1008		0.116		ND	mg/l
GW-1009	ND			ND	mg/l
GW-1010	ND		ND		mg/l
GW-1011	ND		ND		mg/l
GW-1012	1.58			1.29	mg/l
GW-1013	ND			ND	mg/l
GW-1014	ND			ND	mg/l
GW-1015	0.349			1.93	mg/l
GW-1016	0.071			1.29	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	ND	mg/l
GW-1022	ND	ND	ND	ND	mg/l
GW-1023		ND	ND	ND	mg/l
GW-1024	ND	ND	ND	ND	mg/l
GW-1025		ND		ND	mg/l
GW-1026		ND		ND	mg/l
GW-1027	ND			ND	mg/l
GW-1028	0.06			ND	mg/l
GW-2001		100	14.0		mg/l
GW-2002		493		324	mg/l
GW-2003		266			mg/l
GW-2004		0.61	0.86		mg/l
GW-2005		11900	240		mg/l
GW-2006		5.79	6.20		mg/l
GW-2007		ND	ND		mg/l
GW-2008		2.76	7.40		mg/l
GW-2009		1.73	1.50		mg/l
GW-2010		0.797	0.86		mg/l
GW-2011		2.780			mg/l
GW-2012		0.38	0.38		mg/l
GW-2013	0.954		0.70	0.74	mg/l
GW-2014		1.320		1.99	mg/l
GW-2015		0.28			mg/l
GW-2017		1.23	4.60		mg/l
GW-2018		0.48		0.56	mg/l
GW-2019		ND		2.41	mg/l
GW-2020		0.67		1.11	mg/l
GW-2021		ND		ND	mg/l

NITRATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2022		ND		ND	mg/l
GW-2023		0.08		ND	mg/l
GW-2024		ND		ND	mg/l
GW-2025		ND		ND	mg/l
GW-2026		ND		ND	mg/l
GW-2027		ND		ND	mg/l
GW-2028		ND		ND	mg/l
GW-2029		ND	ND		mg/l
GW-3001		670	404		mg/l
GW-3002		ND		ND	mg/l
GW-3003		2200	360		mg/l
GW-3006		ND	ND		mg/l
GW-3008		646			mg/l
GW-3009		1340		2.09	mg/l
GW-3010		1.08		1.19	mg/l
GW-3019		ND	ND		mg/l
GW-4001		32.300	28.0		mg/l
GW-4002		2.70	3.32		mg/l
GW-4003		0.59	0.76		mg/l
GW-4004	0.72			0.67	mg/l
GW-4005	0.98			1.55	mg/l
GW-4006		14.1			mg/l
GW-4007		0.140		ND	mg/l
GW-4008		ND		ND	mg/l
GW-4009	ND		ND		mg/l
GW-4010	0.12			ND	mg/l
GW-4011		ND		16.8	mg/l
GW-4012	0.130				mg/l
GW-4013		11.8		91.0	mg/l
GW-4014		7.70		0.15	mg/l
GW-4015		2.04		2.74	mg/l
GW-4016		ND	ND		mg/l
GW-4017		ND	0.43		mg/l
GW-4018		0.081	1.80		mg/l
GW-4019	0.177			0.28	mg/l
GW-4020		0.05		ND	mg/l
GW-4021	ND		0.12		mg/l
GW-4022	0.054		ND		mg/l
GW-4023	7.33		4.80		mg/l
GW-FINW	ND				mg/l
GW-PW02	ND		ND		mg/l
GW-PW03			ND		mg/l
GW-PW04	ND		ND		mg/l
GW-PW05	ND				mg/l
GW-PW06	ND		ND		mg/l

NITRATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW07	ND		ND		mg/l
GW-PW08	ND		ND		mg/l
GW-PW09	ND		ND		mg/l
GW-RAWW	ND				mg/l
GW-RMW1	ND	ND	ND	ND	mg/l
GW-RMW2	0.20	ND	ND	ND	mg/l
GW-RMW3	0.20	ND	ND	ND	mg/l
GW-RMW4	ND	ND	ND	ND	mg/l

SULFATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	50.5			55.0	mg/l
GW-1004	231			330	mg/l
GW-1005	186			268	mg/l
GW-1006	383			675	mg/l
GW-1007	34.7			28.8	mg/l
GW-1008		266		351	mg/l
GW-1009	348			268	mg/l
GW-1010	6.88		ND		mg/l
GW-1011	3.66		34.0		mg/l
GW-1012	72.5			36.2	mg/l
GW-1013	119			120	mg/l
GW-1014	92.5			134	mg/l
GW-1015	192			474	mg/l
GW-1016	196			229	mg/l
GW-1017	14.0	39.2	14.0	2.68	mg/l
GW-1018	71.0	41.2	21.0	105	mg/l
GW-1019	6.90	ND	ND	4.50	mg/l
GW-1020	ND	25.3	20.0	25.2	mg/l
GW-1021	1.10	ND	1.60	ND	mg/l
GW-1022	5.90	ND	ND	1.95	mg/l
GW-1023		ND	4.00	3.77	mg/l
GW-1024	1.70	3.64	5.50	11.0	mg/l
GW-1025		131		134	mg/l
GW-1026		1.81		ND	mg/l
GW-1027	114			156	mg/l
GW-1028	67.5			50.1	mg/l
GW-2001		4.72	4.70		mg/l
GW-2002		147		143	mg/l
GW-2003		232			mg/l
GW-2004		5.13	ND		mg/l
GW-2005		8.68	30.0		mg/l
GW-2006		36.9	33.0		mg/l
GW-2007		15.1	14.0		mg/l
GW-2008		34.8	17.0		mg/l
GW-2009		128	45.0		mg/l
GW-2010		29.8	41.0		mg/l
GW-2011		13.0			mg/l
GW-2012		86.8	45.0		mg/l
GW-2013	22.7		16.0	14.2	mg/l
GW-2014		130		39.2	mg/l
GW-2015		104	ND		mg/l
GW-2017		840	13.0		mg/l
GW-2018		25.3		9.22	mg/l
GW-2019		33.1			mg/l
GW-2020		168		143	mg/l
GW-2021		17.1		13.9	mg/l

SULFATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2022		14.9		14.7	mg/l
GW-2023		24.5		18.4	mg/l
GW-2024		88.0		29.7	mg/l
GW-2025		22.9		15.8	mg/l
GW-2026		23.8		15.2	mg/l
GW-2027		12.6		13.2	mg/l
GW-2028		143		143	mg/l
GW-2029		30.9	25.0		mg/l
GW-3001		24.2	24.8		mg/l
GW-3002		21.1		17.9	mg/l
GW-3003		174	3.20		mg/l
GW-3006		23.8	21.0		mg/l
GW-3008		42.1			mg/l
GW-3009		27.3			mg/l
GW-3010		7.35		6.07	mg/l
GW-3019		6.47	47.0		mg/l
GW-4001		62.0			mg/l
GW-4002		37.2		17.6	mg/l
GW-4003		32.2	350		mg/l
GW-4004	25.1			26.8	mg/l
GW-4005	20.9			25.6	mg/l
GW-4006		31.9	27.0		mg/l
GW-4007		22.4		14.1	mg/l
GW-4008		13.8		15.8	mg/l
GW-4009	17.9		17.0		mg/l
GW-4010	25.9			23.8	mg/l
GW-4011		36.2		38.2	mg/l
GW-4012	57.5		3.90		mg/l
GW-4013		44.400		44.4	mg/l
GW-4014		31.900		29.8	mg/l
GW-4015		15.2		11.7	mg/l
GW-4016		11.8	2.50		mg/l
GW-4017		10.5	6.80		mg/l
GW-4018		9.70	6.80		mg/l
GW-4019	8.02			6.68	mg/l
GW-4020		126		85.4	mg/l
GW-4021	270		260		mg/l
GW-4022	57.5		1.60		mg/l
GW-4023	103		78.0		mg/l
GW-PW02			94.0		mg/l
GW-PW03			130		mg/l
GW-PW04			110		mg/l
GW-PW06			110		mg/l
GW-PW07			22.0		mg/l
GW-PW08			40.0		mg/l

SULFATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW09			53.0		mg/l
GW-RMW1	12.6	20.8	29.0	23.5	mg/l
GW-RMW2	18.7	25.0	32.0	26.8	mg/l
GW-RMW3	16.7	12.0	36.0	61.6	mg/l
GW-RMW4	7.50	29.8	10.0	18.5	mg/l

GROSS ALPHA
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1024	6.00		ND	1.00	pCi/l
GW-FINN		ND			pCi/l
GW-FINW	1.00		ND	1.00	pCi/l
GW-PW02	2.00	2.00	ND	ND	pCi/l
GW-PW03		3.00	ND	2.00	pCi/l
GW-PW04	4.00	ND	ND	1.00	pCi/l
GW-PW05	6.00	2.00		ND	pCi/l
GW-PW06	2.00	3.00	ND	1.00	pCi/l
GW-PW07	1.00	ND	ND	ND	pCi/l
GW-PW08	1.00	ND	ND	ND	pCi/l
GW-PW09	3.00	1.00	ND	3.00	pCi/l
GW-RAWW	4.00	2.00	ND	2.00	pCi/l
GW-RMW1	1.00		ND	2.00	pCi/l
GW-RMW2	4.00	ND	13.1	10.0	pCi/l
GW-RMW3	9.00	ND	ND	ND	pCi/l
GW-RMW4	ND		ND	4.00	pCi/l

GROSS BETA
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1024	1.00				pCi/l
GW-FINW	4.00				pCi/l
GW-PW02	6.00		5.38		pCi/l
GW-PW03			5.52		pCi/l
GW-PW04	5.00		4.64		pCi/l
GW-PW05	2.00				pCi/l
GW-PW06	2.00		5.71		pCi/l
GW-PW07	1.00		5.53		pCi/l
GW-PW08	3.00		7.43		pCi/l
GW-PW09	ND		6.50		pCi/l
GW-RAWW	7.00				pCi/l
GW-RMW1	7.00				pCi/l
GW-RMW2	2.00		7.63		pCi/l
GW-RMW3	ND				pCi/l
GW-RMW4	ND				pCi/l

RADIUM-226
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1024	0.30				pCi/l
GW-4015		0.10			pCi/l
GW-4020		ND			pCi/l
GW-FINW	ND				pCi/l
GW-PW02	0.40				pCi/l
GW-PW04	0.30				pCi/l
GW-PW05	0.60				pCi/l
GW-PW06	0.40				pCi/l
GW-PW07	4.00				pCi/l
GW-PW08	0.60				pCi/l
GW-PW09	0.40				pCi/l
GW-RAWW	0.50				pCi/l
GW-RMW1	0.20				pCi/l
GW-RMW2	0.60				pCi/l
GW-RMW3	0.40				pCi/l
GW-RMW4	0.10				pCi/l

RADIUM-228
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1024	ND				pCi/l
GW-4015		ND			pCi/l
GW-4020		0.70			pCi/l
GW-FINW	0.90				pCi/l
GW-PW02	0.40				pCi/l
GW-PW04	ND				pCi/l
GW-PW05	0.10				pCi/l
GW-PW06	0.90				pCi/l
GW-PW07	0.30				pCi/l
GW-PW08	1.60				pCi/l
GW-PW09	1.30				pCi/l
GW-RAWW	0.70				pCi/l
GW-RMW1	1.20				pCi/l
GW-RMW2	ND				pCi/l
GW-RMW3	0.90				pCi/l
GW-RMW4	ND				pCi/l

THORIUM-230
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1024	ND				pCi/l
GW-4015		ND			pCi/l
GW-4020		0.70			pCi/l
GW-FINW	ND				pCi/l
GW-PW02	ND				pCi/l
GW-PW04	0.30				pCi/l
GW-PW05	ND				pCi/l
GW-PW06	ND				pCi/l
GW-PW07	ND				pCi/l
GW-PW08	0.80				pCi/l
GW-PW09	0.50				pCi/l
GW-RAWW	0.10				pCi/l
GW-RMW1	ND				pCi/l
GW-RMW2	ND				pCi/l
GW-RMW3	0.50				pCi/l
GW-RMW4	0.40				pCi/l

THORIUM-232
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1024	ND				pCi/l
GW-4015		ND			pCi/l
GW-4020		ND			pCi/l
GW-FINW	ND				pCi/l
GW-PW02	0.10				pCi/l
GW-PW04	ND				pCi/l
GW-PW05	ND				pCi/l
GW-PW06	ND				pCi/l
GW-PW07	ND				pCi/l
GW-PW08	0.20				pCi/l
GW-PW09	0.10				pCi/l
GW-RAWW	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

URANIUM, TOTAL
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-1002	4.08			0.68	pCi/l
GW-1004	4350			5984	pCi/l
GW-1005	1970			2992	pCi/l
GW-1006	3120			3332	pCi/l
GW-1007	23.8			176.8	pCi/l
GW-1008		6732		3536	pCi/l
GW-1009	2.72			8.16	pCi/l
GW-1010	4.08		0.17		pCi/l
GW-1011	12.2		6.94		pCi/l
GW-1012	2.04			2.04	pCi/l
GW-1013	884			952	pCi/l
GW-1014	680			952	pCi/l
GW-1015	510			639.2	pCi/l
GW-1016	156			190.4	pCi/l
GW-1017	ND		ND	1.36	pCi/l
GW-1018	6.12	ND	ND	ND	pCi/l
GW-1019	4.08			ND	pCi/l
GW-1020	6.12		0.28	3.40	pCi/l
GW-1021			ND	ND	pCi/l
GW-1022			ND	ND	pCi/l
GW-1023	ND		ND	1.36	pCi/l
GW-1024	1.36		ND	ND	pCi/l
GW-1025				1.36	pCi/l
GW-1026				ND	pCi/l
GW-1027				652.8	pCi/l
GW-1028	5.44			7.48	pCi/l
GW-2001			ND		pCi/l
GW-2002		3.40		ND	pCi/l
GW-2003		0.68	1.65		pCi/l
GW-2004			1.87		pCi/l
GW-2006			2.96		pCi/l
GW-2007		4.76	6.37		pCi/l
GW-2008			12.2		pCi/l
GW-2009		2.04	1.07		pCi/l
GW-2010		1.70			pCi/l
GW-2011		ND			pCi/l
GW-2012		ND	ND		pCi/l
GW-2013			0.85	ND	pCi/l
GW-2014		2.04		ND	pCi/l
GW-2015		6.80	2.51		pCi/l
GW-2017			0.48		pCi/l
GW-2018				2.72	pCi/l
GW-2019		3.40		4.76	pCi/l
GW-2020		9.52		5.44	pCi/l
GW-2021		2.04		1.36	pCi/l
GW-2022		ND		1.36	pCi/l

URANIUM, TOTAL
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2023		3.40		10.9	pCi/l
GW-2024		ND		1.36	pCi/l
GW-2025				ND	pCi/l
GW-2026				0.68	pCi/l
GW-2027		2.72		1.36	pCi/l
GW-2028		1.36		2.04	pCi/l
GW-2029			5.58		pCi/l
GW-3001		1.36	0.68		pCi/l
GW-3002		2.04		3.40	pCi/l
GW-3003			20.1		pCi/l
GW-3006			0.42		pCi/l
GW-3008		231.2			pCi/l
GW-3009		29.92		74.8	pCi/l
GW-3010		2.722		ND	pCi/l
GW-3019			6.67		pCi/l
GW-4001		0.68	0.99		pCi/l
GW-4002			ND		pCi/l
GW-4003			ND		pCi/l
GW-4004				2.72	pCi/l
GW-4005				24.48	pCi/l
GW-4006		ND	1.34		pCi/l
GW-4007		2.04		5.44	pCi/l
GW-4008		2.72		1.36	pCi/l
GW-4009			3.65		pCi/l
GW-4010	1.36			8.16	pCi/l
GW-4011		9.52		3.40	pCi/l
GW-4012			3.50		pCi/l
GW-4013				14.3	pCi/l
GW-4014				1.36	pCi/l
GW-4015		3.40		3.40	pCi/l
GW-4016			5.372		pCi/l
GW-4017			1.135		pCi/l
GW-4018			0.69		pCi/l
GW-4020		13.6		19.72	pCi/l
GW-4021			7.68		pCi/l
GW-4022			4.42		pCi/l
GW-4023			2.03		pCi/l
GW-FINN		1.36			pCi/l
GW-FINW	ND		ND	ND	pCi/l
GW-PW02	2.72	ND	0.97	ND	pCi/l
GW-PW03		ND	0.84	3.40	pCi/l
GW-PW04	4.08	1.36	ND	2.04	pCi/l
GW-PW05	4.08	ND		ND	pCi/l
GW-PW06	3.40	2.04	ND	ND	pCi/l
GW-PW07	8.16	4.08	ND	ND	pCi/l

URANIUM, TOTAL
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE (Continued)

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-PW08	1.36	ND	ND	ND	pCi/l
GW-PW09	4.76	1.36	ND	ND	pCi/l
GW-RAWW	1.36	ND	ND	2.72	pCi/l
GW-RMW1	8.84		1.14	1.36	pCi/l
GW-RMW2	10.2	7.48	7.07	4.76	pCi/l
GW-RMW3	8.16	10.88	ND	ND	pCi/l
GW-RMW4	6.12		2.29	3.40	pCi/l

URANIUM-234
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2005			2.27		pCi/l
GW-2010			13.0		pCi/l

URANIUM-235
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2005			ND		pCi/l
GW-2010			1.09		pCi/l

URANIUM-238
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
GW-2005			3.71		pCi/l
GW-2010			10.4		pCi/l

1,3,5-TRINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5201	1.10		ND		µg/l
SP-5304				ND	µg/l
SP-6301	ND		0.02		µg/l
SP-6302	ND	ND			µg/l
SP-6303	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l

1,3-DINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5201	ND		ND		µg/l
SP-5304				ND	µg/l
SP-6301	ND		0.00		µg/l
SP-6302	ND	ND			µg/l
SP-6303	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l

2,4,6-TNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5201	15.0		1.80		µg/l
SP-5304				0.44	µg/l
SP-6301	0.05		0.97		µg/l
SP-6302	0.11	0.04			µg/l
SP-6303	ND		0.24		µg/l
SP-6306	ND	ND	ND	ND	µg/l

2,4-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5201	ND		ND		µg/l
SP-5304				0.098	µg/l
SP-6301	1.44		0.22		µg/l
SP-6302	1.42	0.03			µg/l
SP-6303	ND		0.056		µg/l
SP-6306	ND	ND	ND	ND	µg/l

2,6-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5201	0.34		0.49		µg/l
SP-5304				0.14	µg/l
SP-6301	0.58		0.24		µg/l
SP-6302	0.53	0.13			µg/l
SP-6303	0.21		0.66		µg/l
SP-6306	ND	ND	ND	ND	µg/l

NITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5201	ND		ND		µg/l
SP-5302	ND				µg/l
SP-5304				ND	µg/l
SP-6301	ND		0.00		µg/l
SP-6302	ND	ND			µg/l
SP-6303	ND		ND		µg/l
SP-6306	ND	ND	ND	ND	µg/l

CHLORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-6301			32.0		mg/l
SP-6306	7.40				mg/l

FLUORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-6301			ND		mg/l
SP-6306	231				µg/l

NITRATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-6301			42.0		mg/l
SP-6306	2.70				mg/l

SULFATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-6301			54.0		mg/l
SP-6306	13.5				mg/l

URANIUM, TOTAL
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SP-5203	2.04	ND		1.36	pCi/l
SP-5301	503	285	211	592	pCi/l
SP-5302	435	238	258	544	pCi/l
SP-5303	265	170	272	374	pCi/l
SP-5304	142	39.4	74.8	221.00	pCi/l
SP-5503	6.80				pCi/l
SP-6301	55.0	13.6	55.8	102	pCi/l
SP-6302	51.6	10.2			pCi/l
SP-6303	5.44	2.72	4.08	ND	pCi/l
SP-6306	12.9	10.2		8.16	pCi/l

1,3,5-TRINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	ND	0.08		ND	µg/l
SW-3201				ND	µg/l
SW-3301				ND	µg/l
SW-3302				ND	µg/l
SW-3401				ND	µg/l
SW-3402				ND	µg/l
SW-5311				ND	µg/l

1,3-DINITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	ND	ND		ND	µg/l
SW-3201				ND	µg/l
SW-3301				ND	µg/l
SW-3302				ND	µg/l
SW-3401				ND	µg/l
SW-3402				ND	µg/l
SW-5311				ND	µg/l

2,4,6-TNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	0.18	2.00		12.0	µg/l
SW-3201				ND	µg/l
SW-3301				ND	µg/l
SW-3302				ND	µg/l
SW-3401				ND	µg/l
SW-3402				ND	µg/l
SW-5311				ND	µg/l

2,4-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	1.50	0.63		3.00	µg/l
SW-3201				ND	µg/l
SW-3301				ND	µg/l
SW-3302				ND	µg/l
SW-3401				ND	µg/l
SW-3402				ND	µg/l
SW-5311				ND	µg/l

2,6-DNT
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	0.12	0.12		1.20	µg/l
SW-3201				ND	µg/l
SW-3301				ND	µg/l
SW-3302				ND	µg/l
SW-3401				ND	µg/l
SW-3402				ND	µg/l
SW-5311				0.057	µg/l

NITROBENZENE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	ND	ND		ND	µg/l
SW-3201				ND	µg/l
SW-3301				ND	µg/l
SW-3302				ND	µg/l
SW-3401				ND	µg/l
SW-3402				ND	µg/l
SW-5311				ND	µg/l

CHLORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	12.4	11.7			mg/l
SW-3001		27.9			mg/l
SW-3002		9.80			mg/l
SW-3003		30.3			mg/l
SW-3004		7.83			mg/l
SW-3101				44.6	mg/l
SW-3201				10.1	mg/l
SW-3301				29.8	mg/l
SW-3302				29.1	mg/l
SW-3401				7.50	mg/l
SW-3402				10.0	mg/l

FLUORIDE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	0.79	0.97			mg/l
SW-3001		0.30			mg/l
SW-3002		0.31			mg/l
SW-3003		0.66			mg/l
SW-3004		0.87			mg/l
SW-3101				4.65	mg/l
SW-3201				3.63	mg/l
SW-3301				8.75	mg/l
SW-3302				ND	mg/l
SW-3401				10.2	mg/l
SW-3402				13.7	mg/l

NITRATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	ND	ND			mg/l
SW-3001		464			mg/l
SW-3002		ND			mg/l
SW-3003		1900			mg/l
SW-3004		0.28			mg/l
SW-3201				ND	mg/l
SW-3301				1000	mg/l
SW-3302				1100	mg/l
SW-3401				ND	mg/l
SW-3402				ND	mg/l

SULFATE
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	118	161			mg/l
SW-3001		318			mg/l
SW-3002		415			mg/l
SW-3003		695			mg/l
SW-3004		37.5			mg/l
SW-3101				333	mg/l
SW-3201				978	mg/l
SW-3301				735	mg/l
SW-3302				765	mg/l
SW-3401				76.0	mg/l
SW-3402				79.1	mg/l

GROSS ALPHA
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-3401				2900	pCi/l
SW-3402				3000	pCi/l

GROSS BETA
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-3401				950	pCi/l
SW-3402				990	pCi/l

RADIUM-226
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	1.20	2.9		1.30	pCi/l
SW-3001		130.000			pCi/l
SW-3002		95.000			pCi/l
SW-3003		7.000			pCi/l
SW-3004		98.000			pCi/l
SW-3401				5.60	pCi/l
SW-3402				6.00	pCi/l
SW-5305				0.50	pCi/l
SW-5311				1.1	pCi/l

RADIUM-228
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008				1.60	pCi/l
SW-3401				15.0	pCi/l
SW-3402				15.0	pCi/l
SW-5305				0.30	pCi/l
SW-5311				ND	pCi/l

THORIUM-228
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-3401				1.20	pCi/l
SW-3402				1.30	pCi/l

THORIUM-230
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	ND	0.20		0.70	pCi/l
SW-3001		100.000			pCi/l
SW-3002		90.000			pCi/l
SW-3003		3.800			pCi/l
SW-3004		92.000			pCi/l
SW-3401				2.00	pCi/l
SW-3402				3.30	pCi/l
SW-5305				0.05	pCi/l
SW-5311				ND	pCi/l

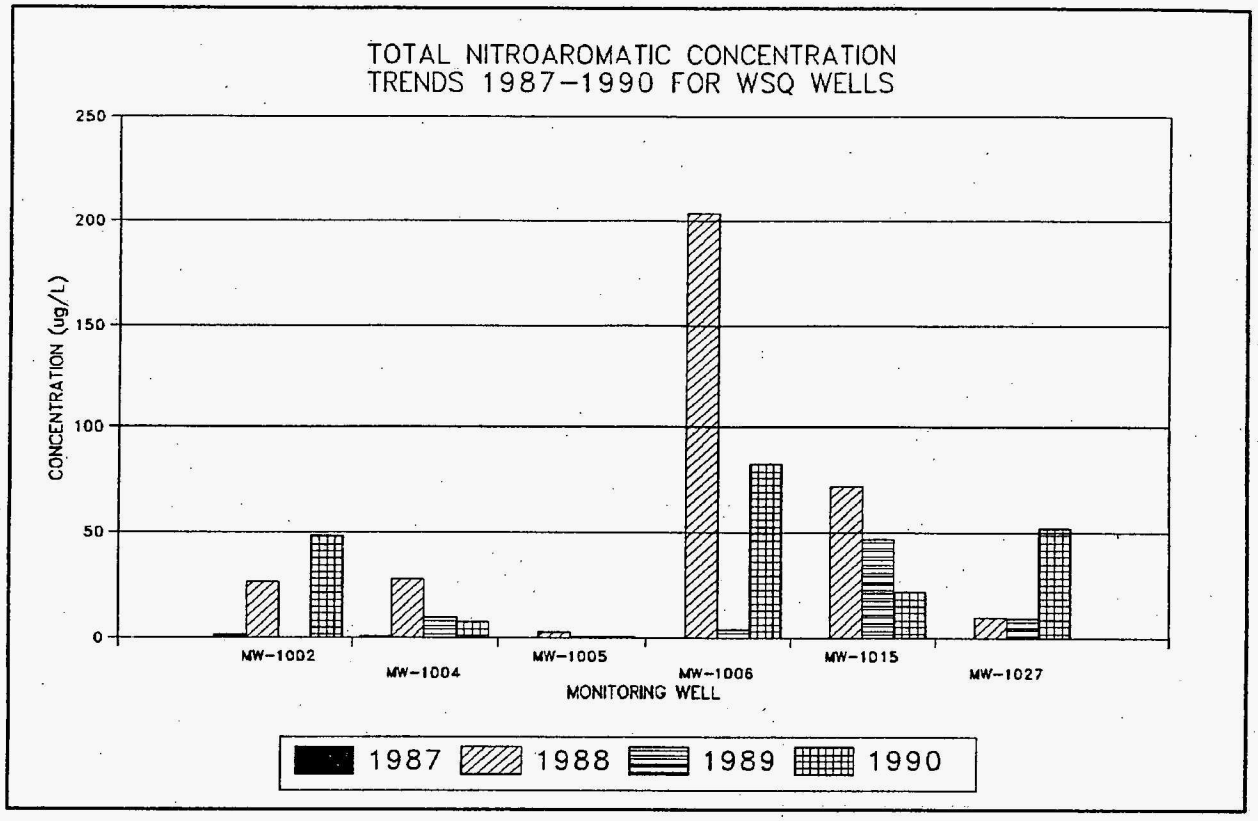
THORIUM-232
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

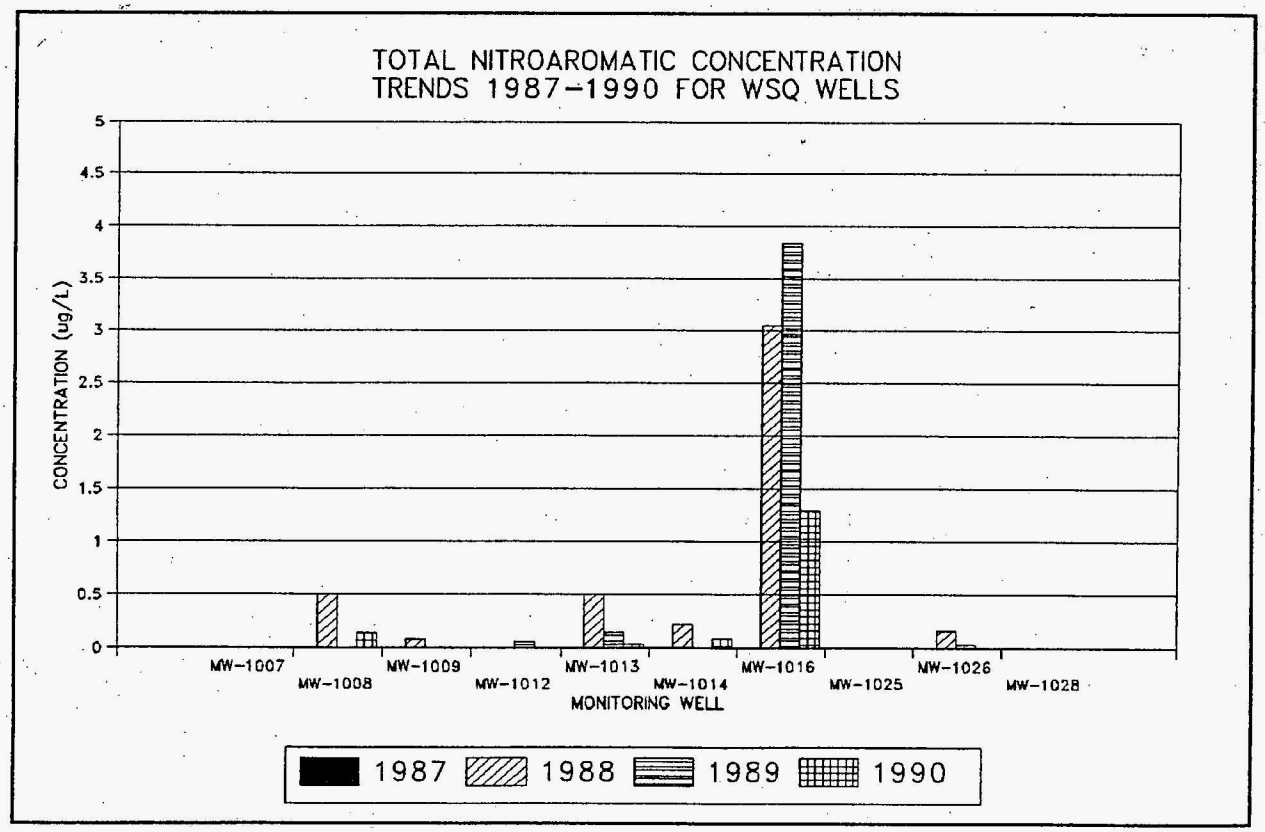
WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1008	ND	ND		ND	pCi/l
SW-3001		0.200			pCi/l
SW-3002		0.300			pCi/l
SW-3003		1.200			pCi/l
SW-3004		2.900			pCi/l
SW-3401				0.20	pCi/l
SW-3402				0.50	pCi/l
SW-5305				0.00	pCi/l
SW-5311				ND	pCi/l

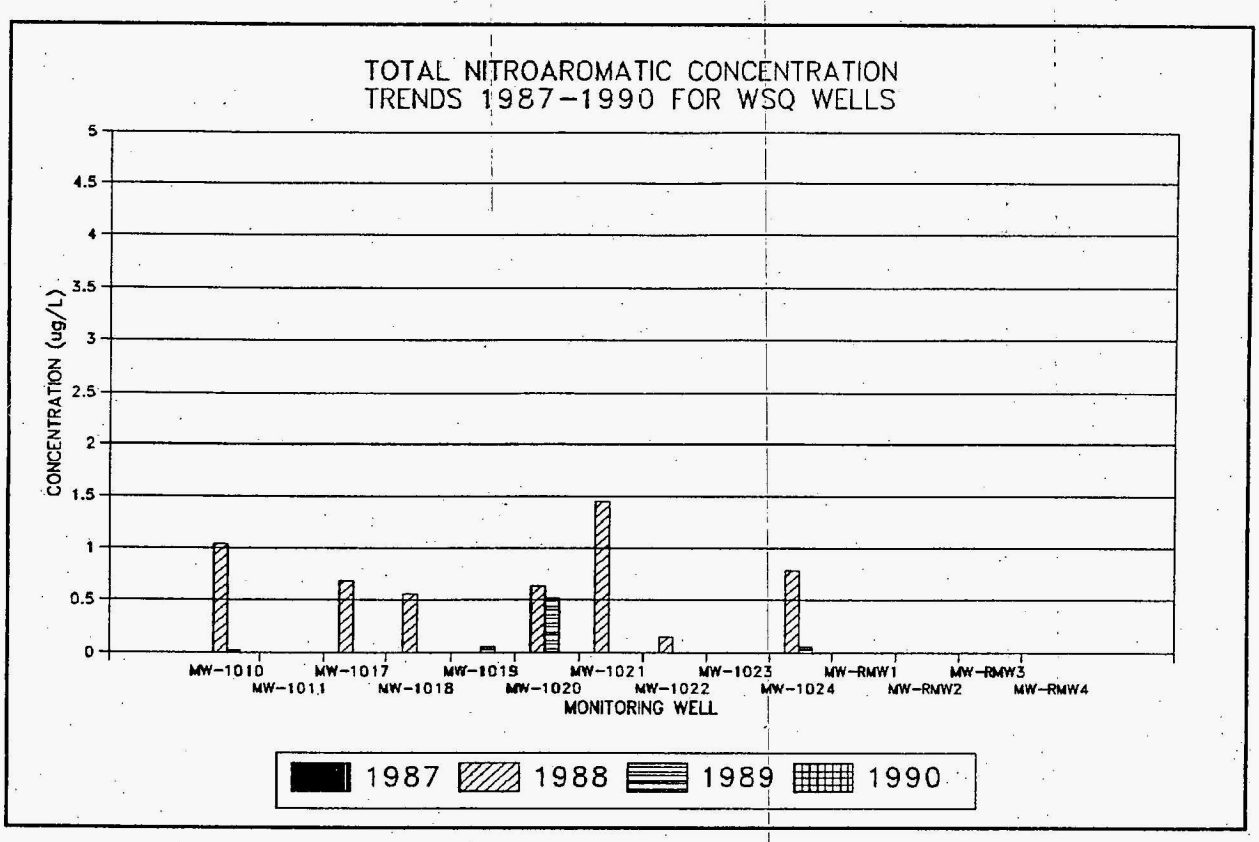
URANIUM, TOTAL
1990 QUARTERLY DATA FOR THE WELDON SPRING SITE

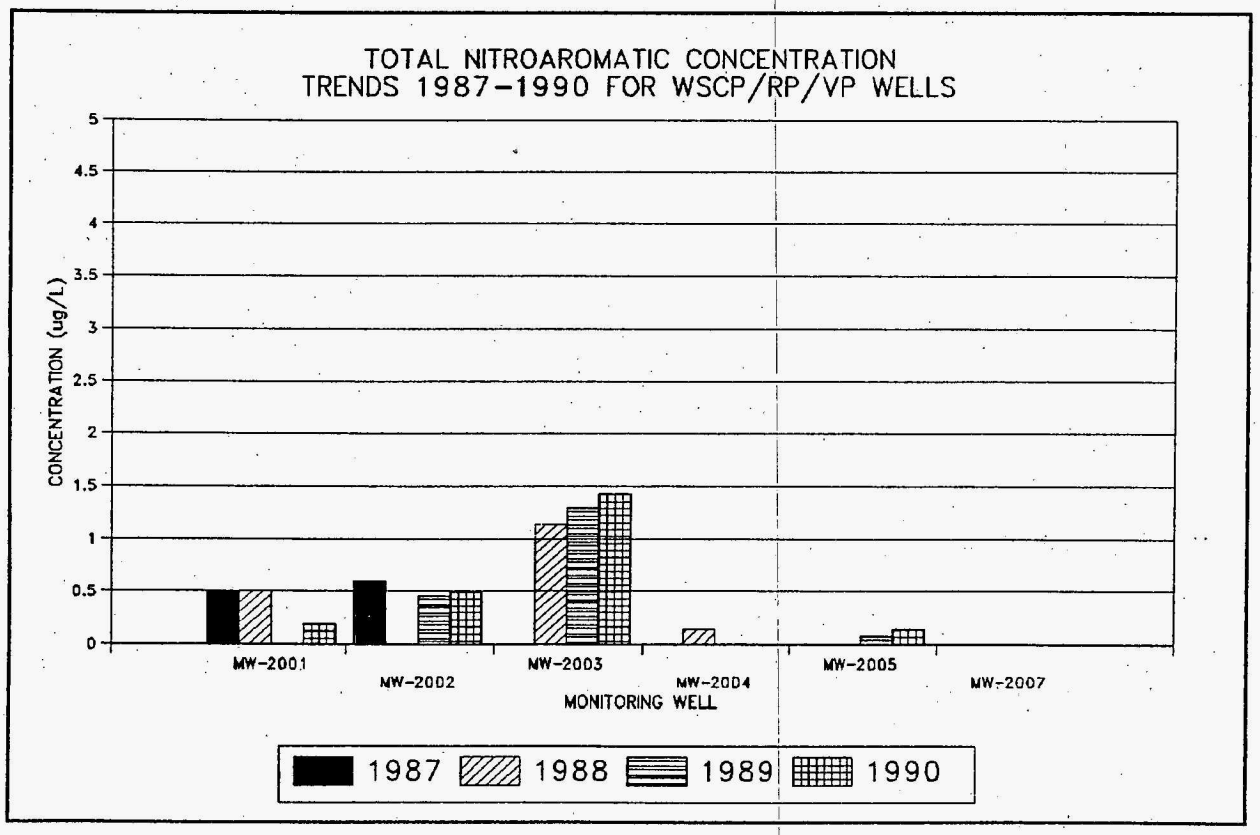
WSSRAP ID	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	UNITS
SW-1001	8.16	4.76		ND	pCi/l
SW-1002	11.5	ND		ND	pCi/l
SW-1003	38.1	22.4		58.5	pCi/l
SW-1004	34.6	37.4		57.1	pCi/l
SW-1005	18.3	12.2		13.6	pCi/l
SW-1007	17.0	10.2		19.0	pCi/l
SW-1008	1770	2312		3130	pCi/l
SW-1009	17.7	8.84		21.1	pCi/l
SW-1010	41.4	20.4		41.5	pCi/l
SW-1011	6.12	2.72		4.08	pCi/l
SW-1012	4.08	5.44		7.48	pCi/l
SW-1013	5.40	2.72		9.52	pCi/l
SW-2001	8.16	4.76	1.90	ND	pCi/l
SW-2002	190	39.4	11.3	102	pCi/l
SW-2003	24.4	14.9	7.34	12.24	pCi/l
SW-2004	29.2	23.8	12.7	13.6	pCi/l
SW-2005	18.3	18.3	13.0	16.32	pCi/l
SW-2006	12.9	1.36	0.37	ND	pCi/l
SW-2007	8.20	ND	0.55	4.76	pCi/l
SW-2010	2510	1156	1710		pCi/l
SW-2011	258	299.2	224	170	pCi/l
SW-2013			ND		pCi/l
SW-3001		292			pCi/l
SW-3002		1700			pCi/l
SW-3003		2584		265.20	pCi/l
SW-3004		1700			pCi/l
SW-3401				2180	pCi/l
SW-3402				2180	pCi/l
SW-4019				4.76	pCi/l

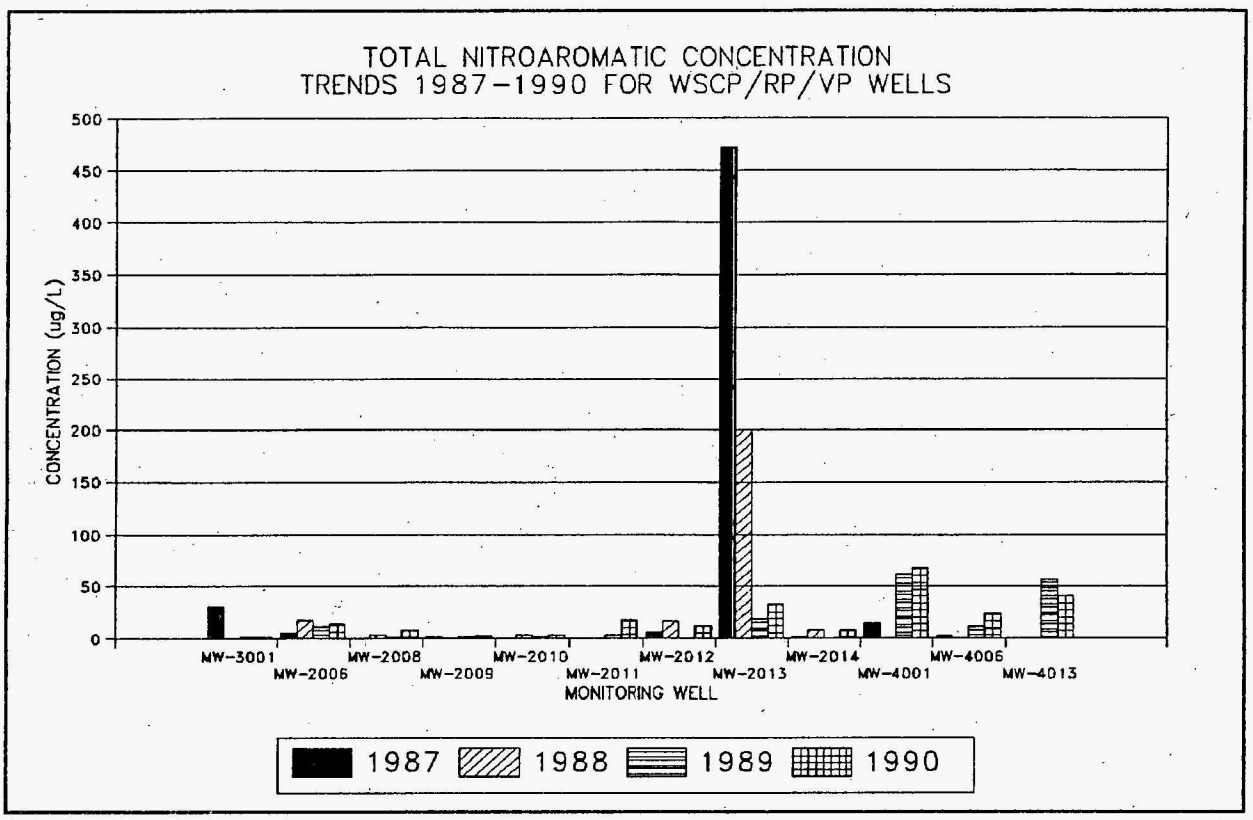
APPENDIX B
TREND ANALYSIS FIGURES

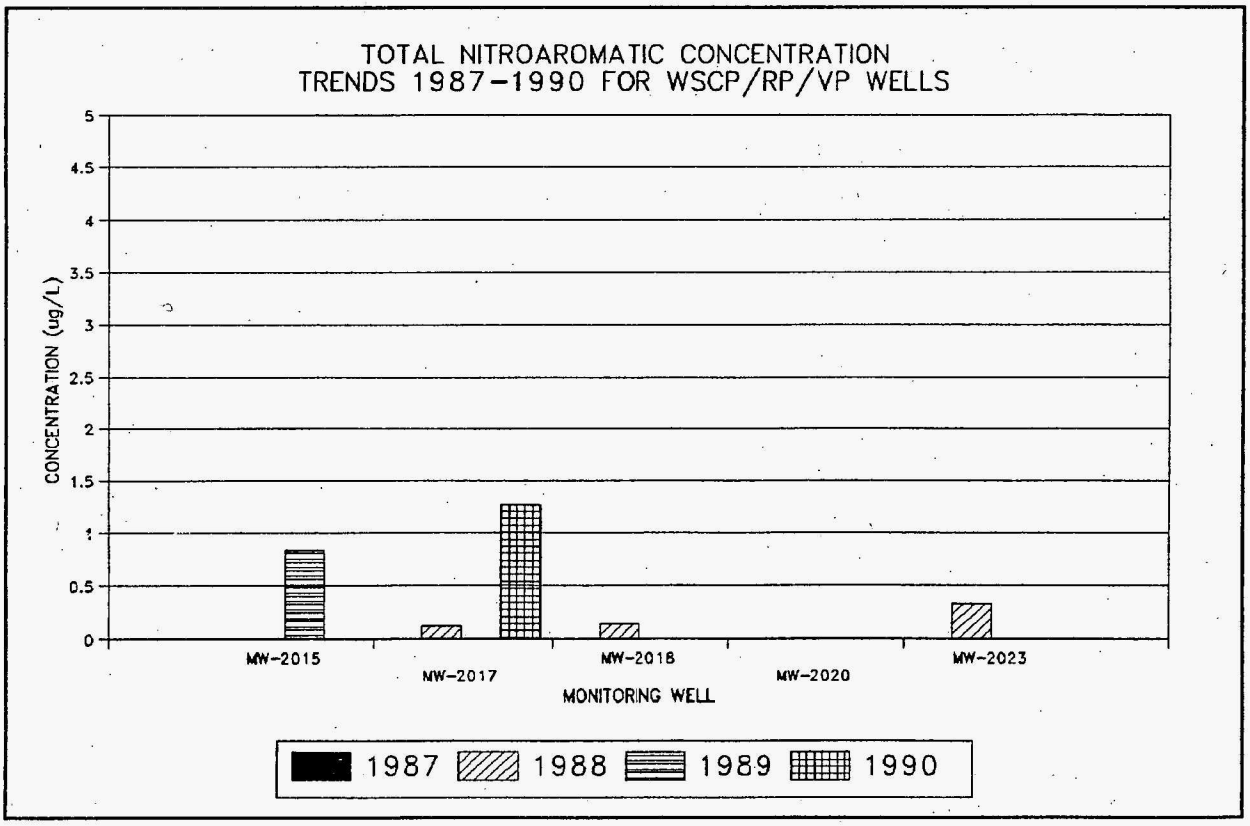

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSQ WELLS
CONCENTRATION (ug/L)
250
200
150
100
50
0
MW-1002
MW-1004
MW-1005
MW-1006
MW-1015
MW-1027
MONITORING WELL
1987
1988
1989
1990

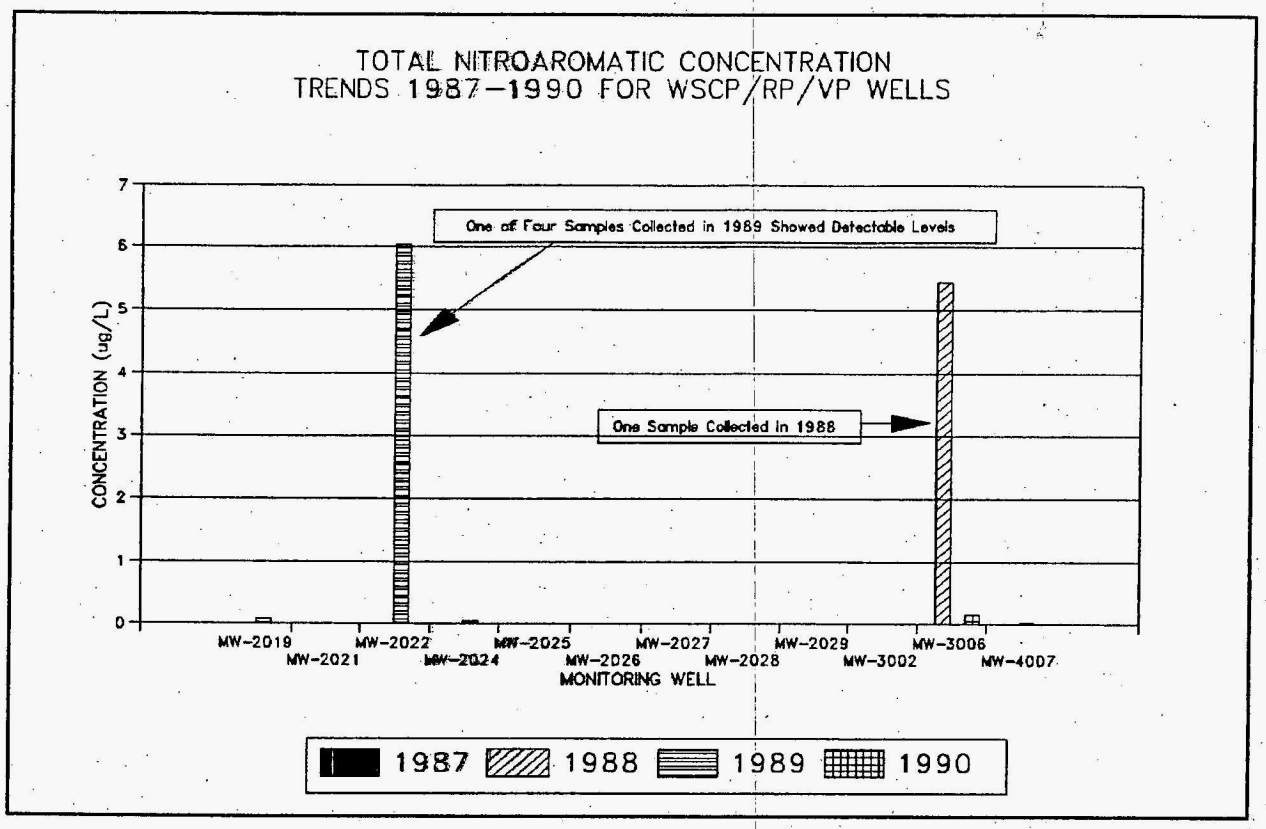

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSQ WELLS
CONCENTRATION (ug/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
MW-1007
MW-1008
MW-1009
MW-1012
MW-1013
MW-1014
MW-1016
MW-1025
MW-1026
MW-1028
MONITORING WELL
1987
1988
1989
1990

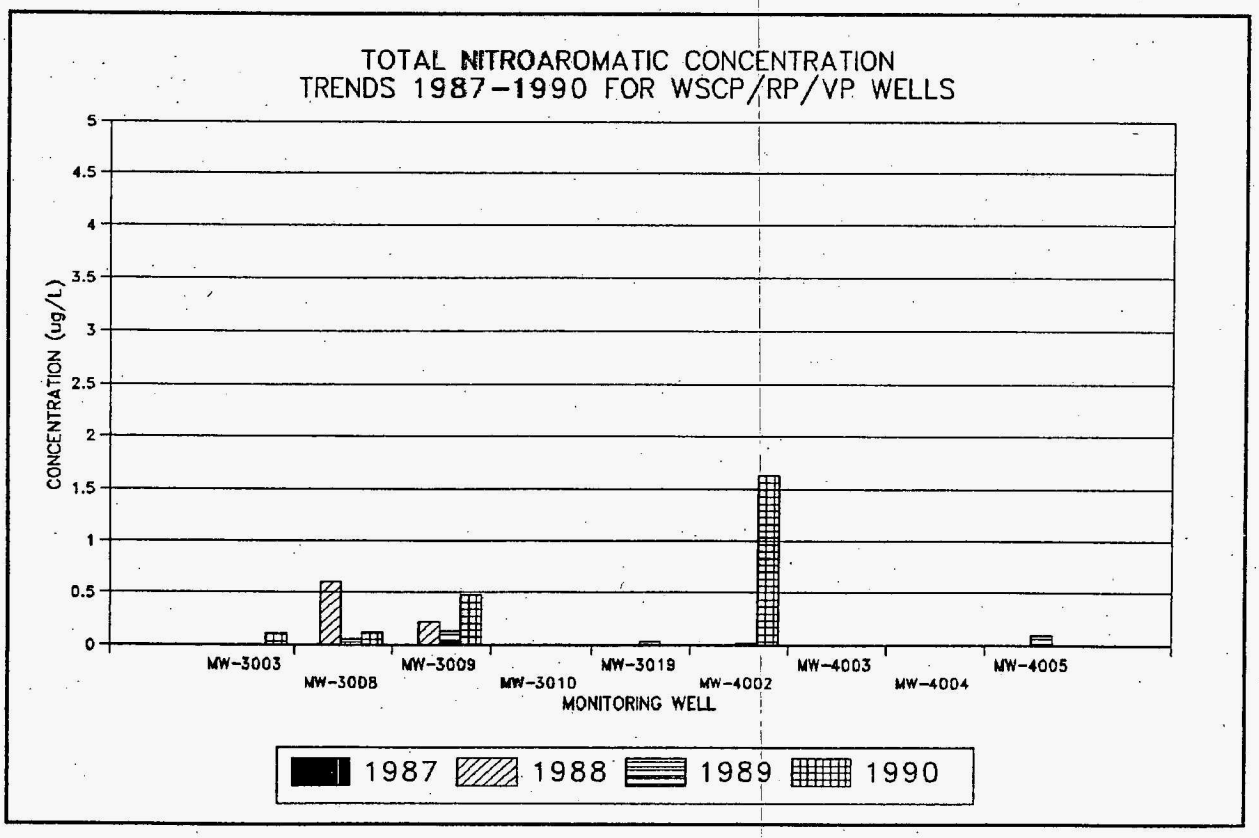

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSQ WELLS
CONCENTRATION (ug/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
MW-1010
MW-1011
MW-1017
MW-1018
MW-1019
MW-1020
MW-1021
MW-1022
MW-1023
MW-1024
MW-RMW1
MW-RMW2
MW-RMW3
MW-RMW4
MONITORING WELL
1987
1988
1989
1990

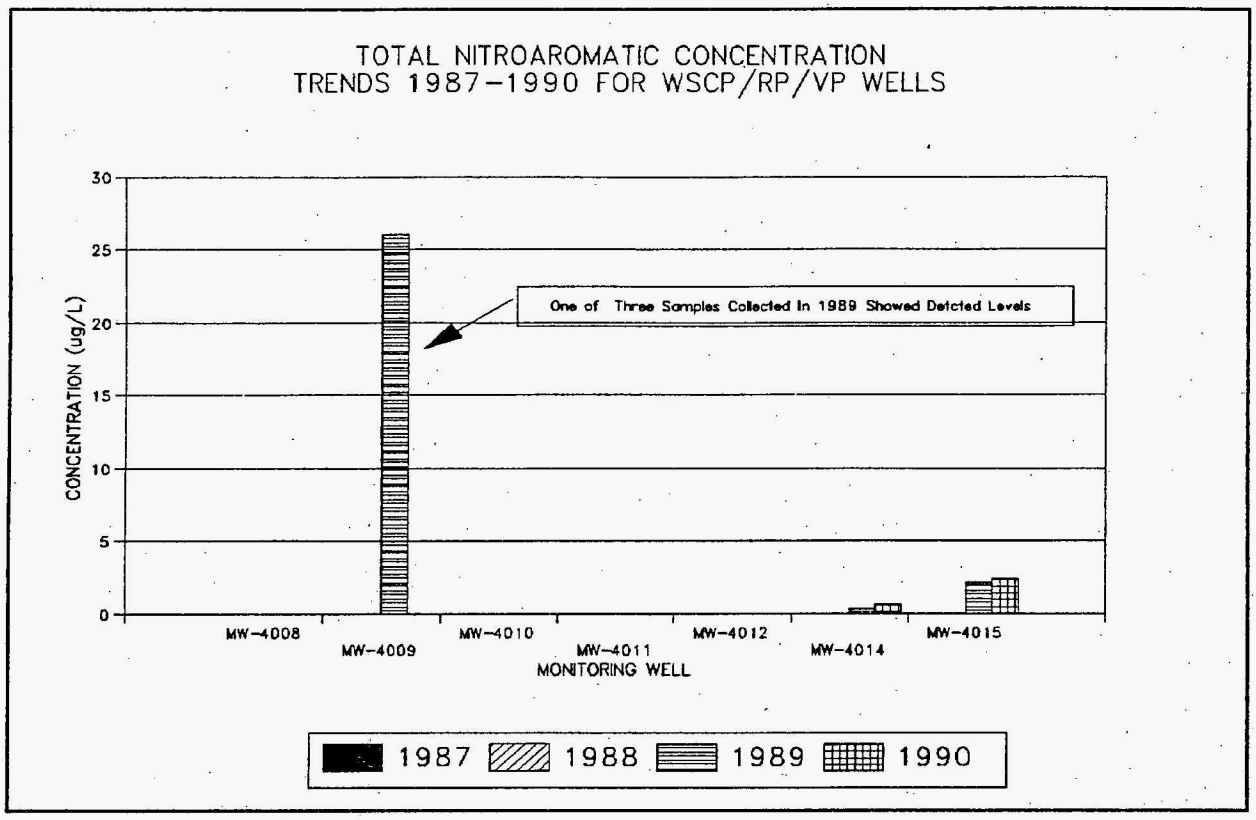

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSCP/RP/VP WELLS
CONCENTRATION (ug/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
MW-2001
MW-2002
MW-2003
MW-2004
MW-2005
MW-2007
MONITORING WELL
1987
1988
1989
1990

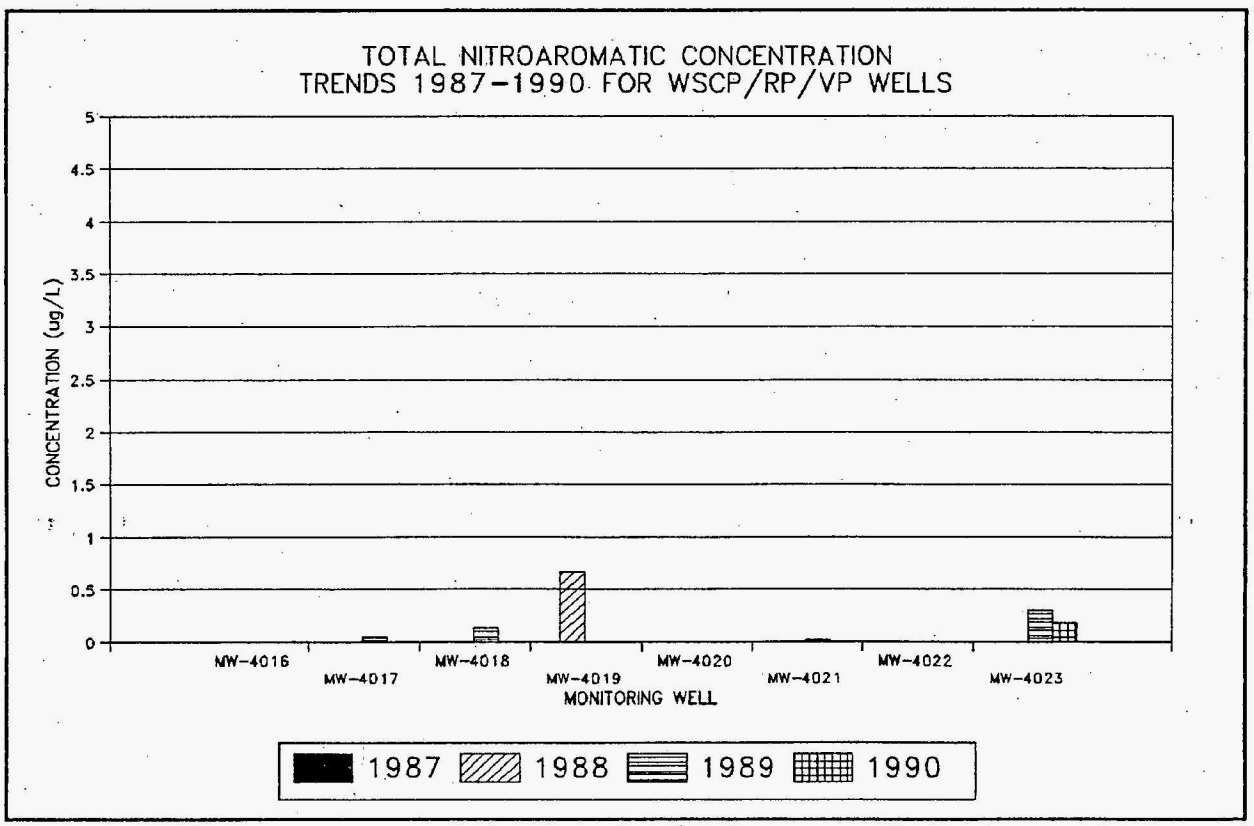

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSCP/RP/VP WELLS
CONCENTRATION (ug/L)
500
450
400
350
300
250
200
150
100
50
0
MW-3001
MW-2006
MW-2008
MW-2009
MW-2010
MW-2011
MW-2012
MW-2013
MW-2014
MW-4001
MW-4006
MW-4013
MONITORING WELL
1987
1988
1989
1990

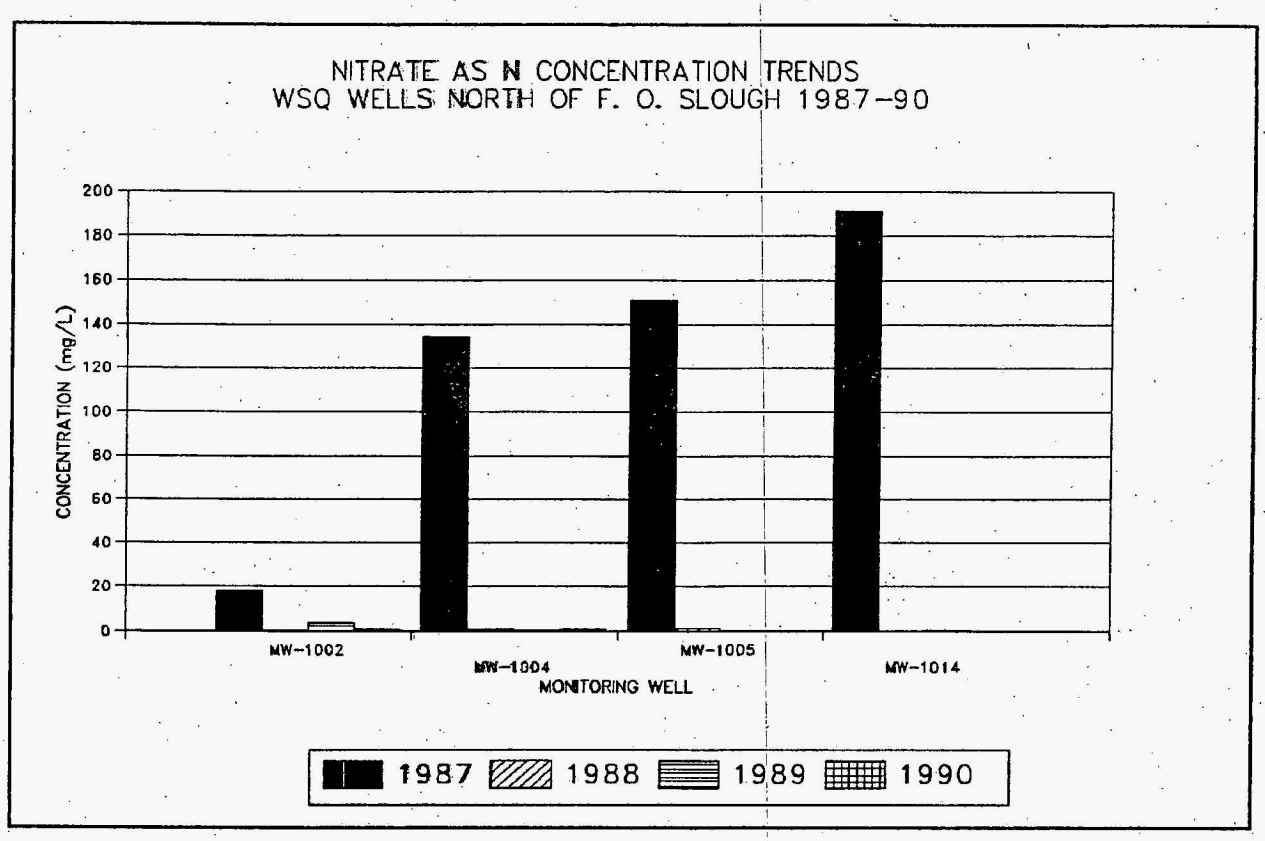

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSCP/RP/VP WELLS
CONCENTRATION (ug/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
MW-2015
MW-2017
MW-2018
MW-2020
MW-2023
MONITORING WELL
1987
1988
1989
1990

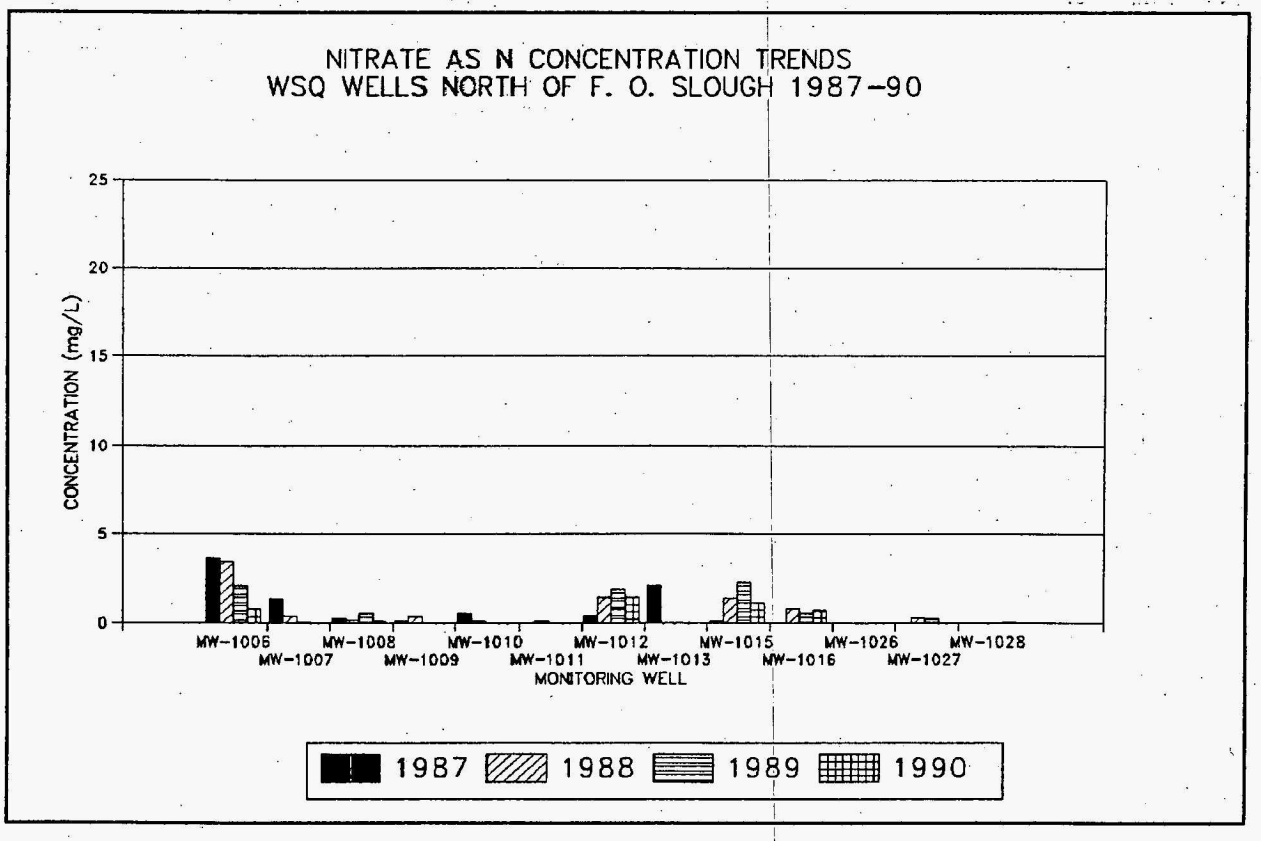

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSCP/RP/VP WELLS
One of Four Samples Collected in 1989 Showed Detectable Levels
One Sample Collected in 1988
CONCENTRATION (ug/L)
0
1
2
3
4
5
6
7
MW-2019
MW-2021
MW-2022
MW-2024
MW-2025
MW-2026
MW-2027
MW-2028
MW-2029
MW-3002
MW-3006
MW-4007
MONITORING WELL
1987
1988
1989
1990

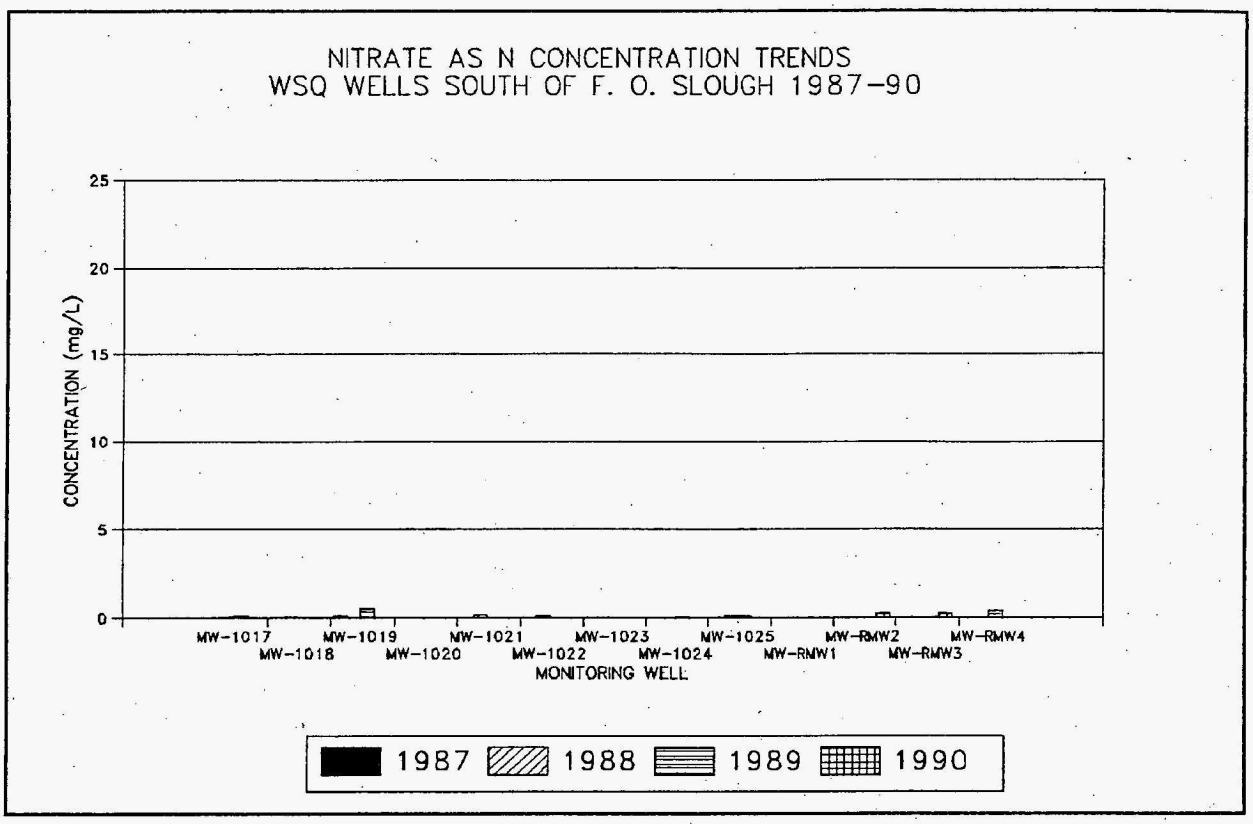

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSCP/RP/VP WELLS
CONCENTRATION (ug/L)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
MW-3003
MW-3008
MW-3009
MW-3010
MW-3019
MW-4002
MW-4003
MW-4004
MW-4005
MONITORING WELL
1987
1988
1989
1990

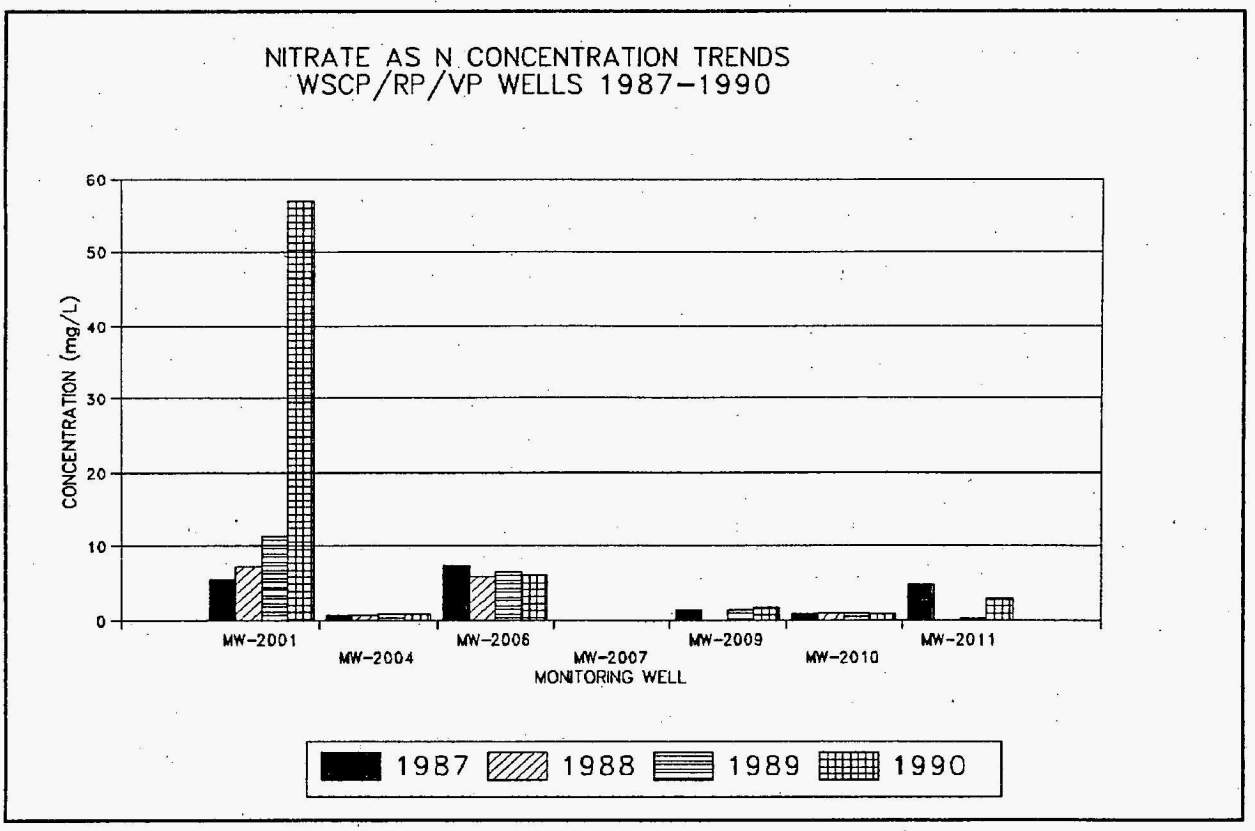

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSCP/RP/VP WELLS
CONCENTRATION (ug/L)
30
25
20
15
10
5
0
One of Three Samples Collected In 1989 Showed Detected Levels
MW-4008
MW-4009
MW-4010
MW-4011
MW-4012
MW-4014
MW-4015
MONITORING WELL
1987
1988
1989
1990

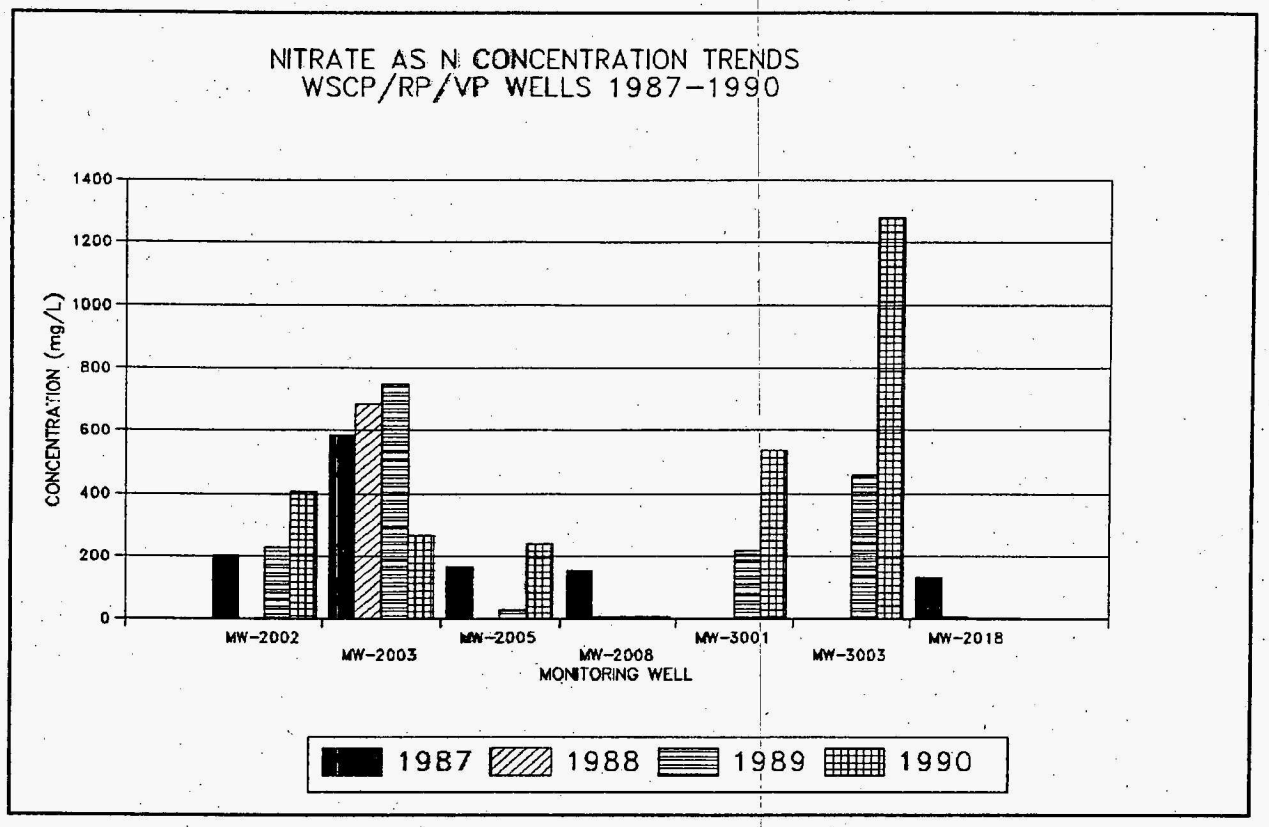

TOTAL NITROAROMATIC CONCENTRATION
TRENDS 1987-1990 FOR WSCP/RP/VP WELLS
CONCENTRATION (ug/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
MW-4016
MW-4017
MW-4018
MW-4019
MW-4020
MW-4021
MW-4022
MW-4023
MONITORING WELL
1987
1988
1989
1990

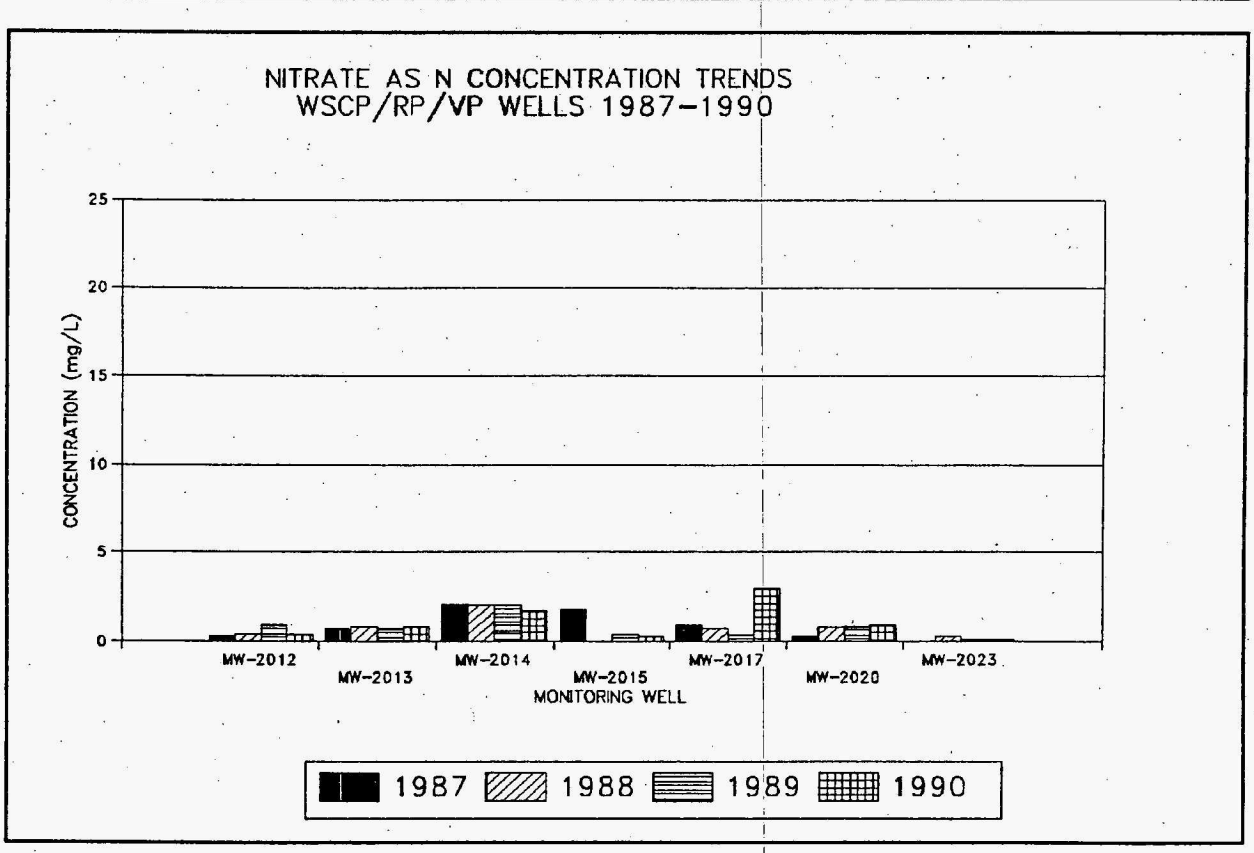

NITRATE AS N CONCENTRATION TRENDS
WSQ WELLS NORTH OF F. O. SLOUGH 1987-90
CONCENTRATION (mg/L)
200
180
160
140
120
100
80
60
40
20
0
MW-1002
MW-1004
MW-1005
MW-1014
MONITORING WELL
1987
1988
1989
1990

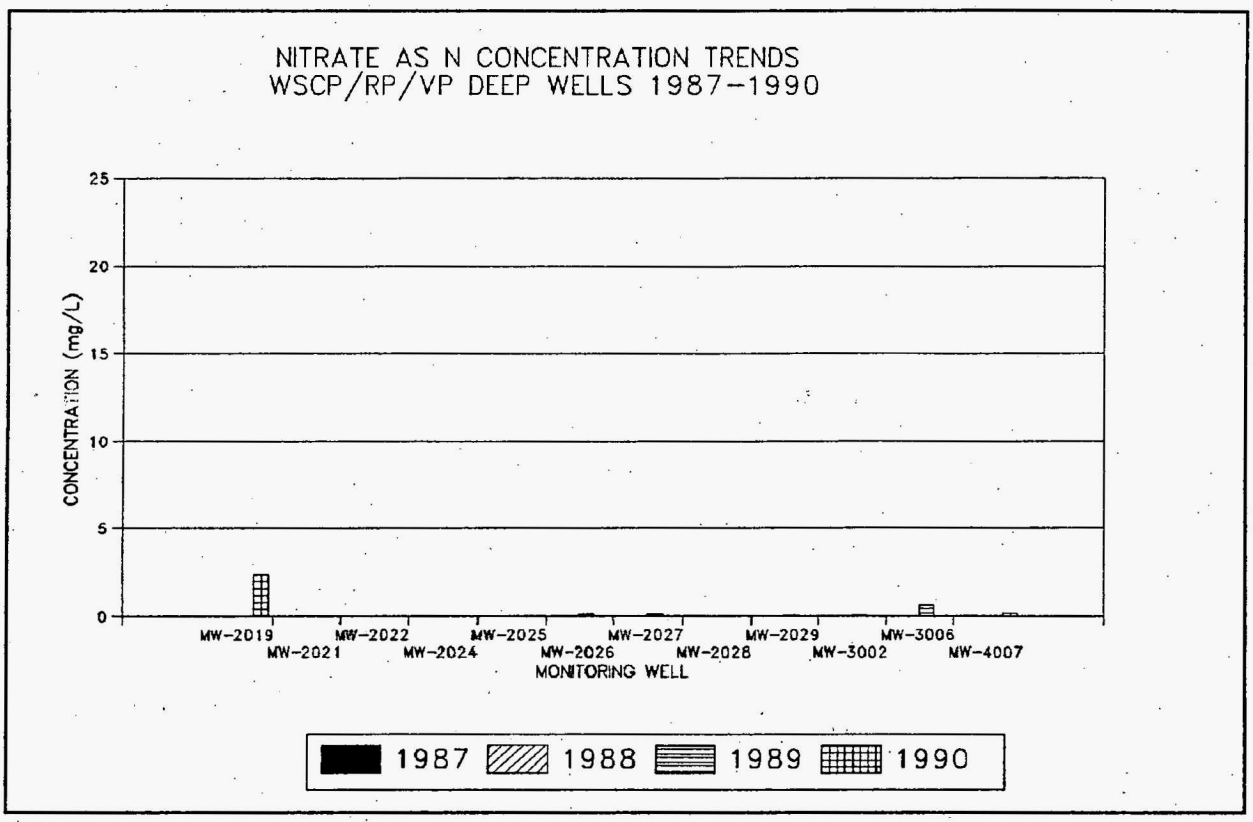

NITRATE AS N CONCENTRATION TRENDS
WSQ WELLS NORTH OF F. O. SLOUGH 1987-90
CONCENTRATION (mg/L)
25
20
15
10
5
0
MW-1006
MW-1007
MW-1008
MW-1009
MW-1010
MW-1011
MW-1012
MW-1013
MW-1015
MW-1016
MW-1026
MW-1027
MW-1028
MONITORING WELL
1987
1988
1989
1990

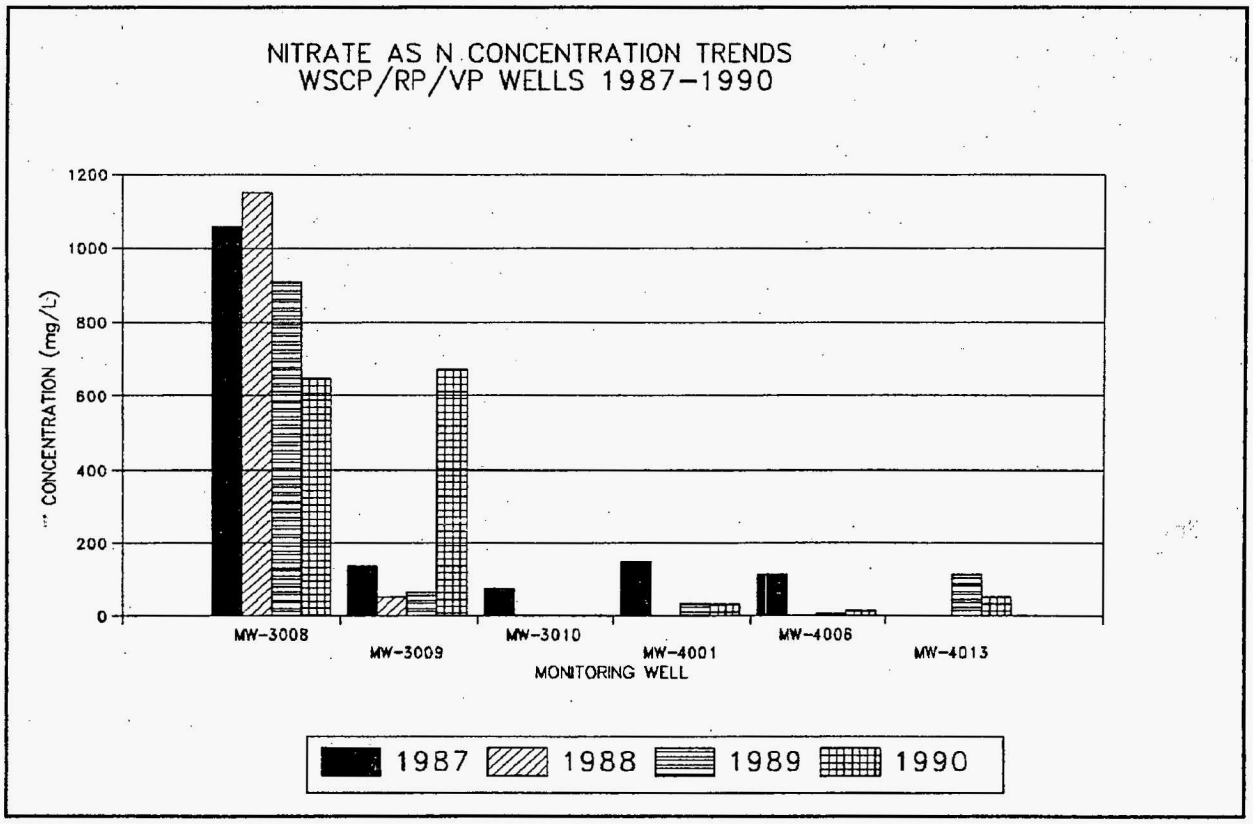

NITRATE AS N CONCENTRATION TRENDS
WSQ WELLS SOUTH OF F. O. SLOUGH 1987-90
CONCENTRATION (mg/L)
25
20
15
10
5
0
MW-1017
MW-1018
MW-1019
MW-1020
MW-1021
MW-1022
MW-1023
MW-1024
MW-1025
MW-RMW1
MW-RMW2
MW-RMW3
MW-RMW4
MONITORING WELL
1987
1988
1989
1990

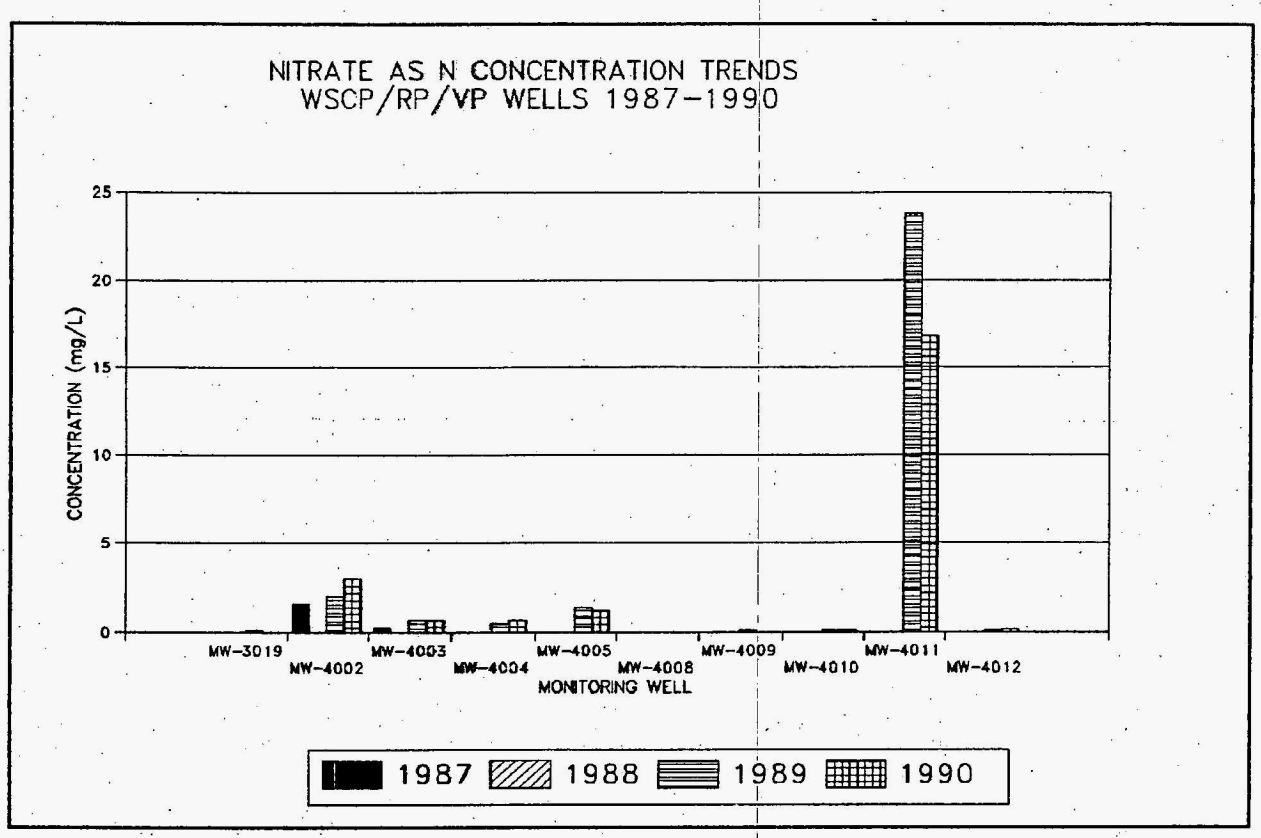

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP WELLS 1987-1990
CONCENTRATION (mg/L)
60
50
40
30
20
10
0
MW-2001
MW-2004
MW-2006
MW-2007
MW-2009
MW-2010
MW-2011
MONITORING WELL
1987
1988
1989
1990

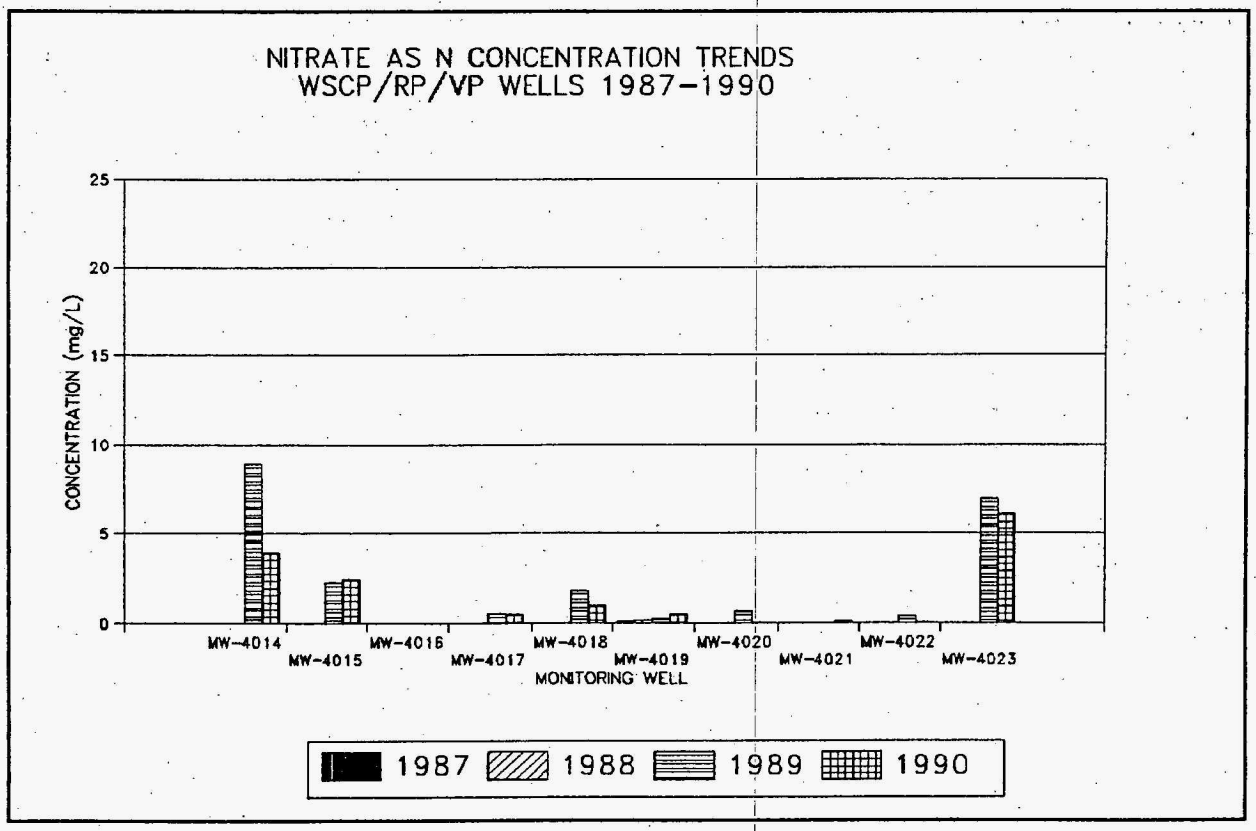

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP WELLS 1987-1990
CONCENTRATION (mg/L)
1400
1200
1000
800
600
400
200
0
MW-2002
MW-2003
MW-2005
MW-2008
MW-3001
MW-3003
MW-2018
MONITORING WELL
1987
1988
1989
1990

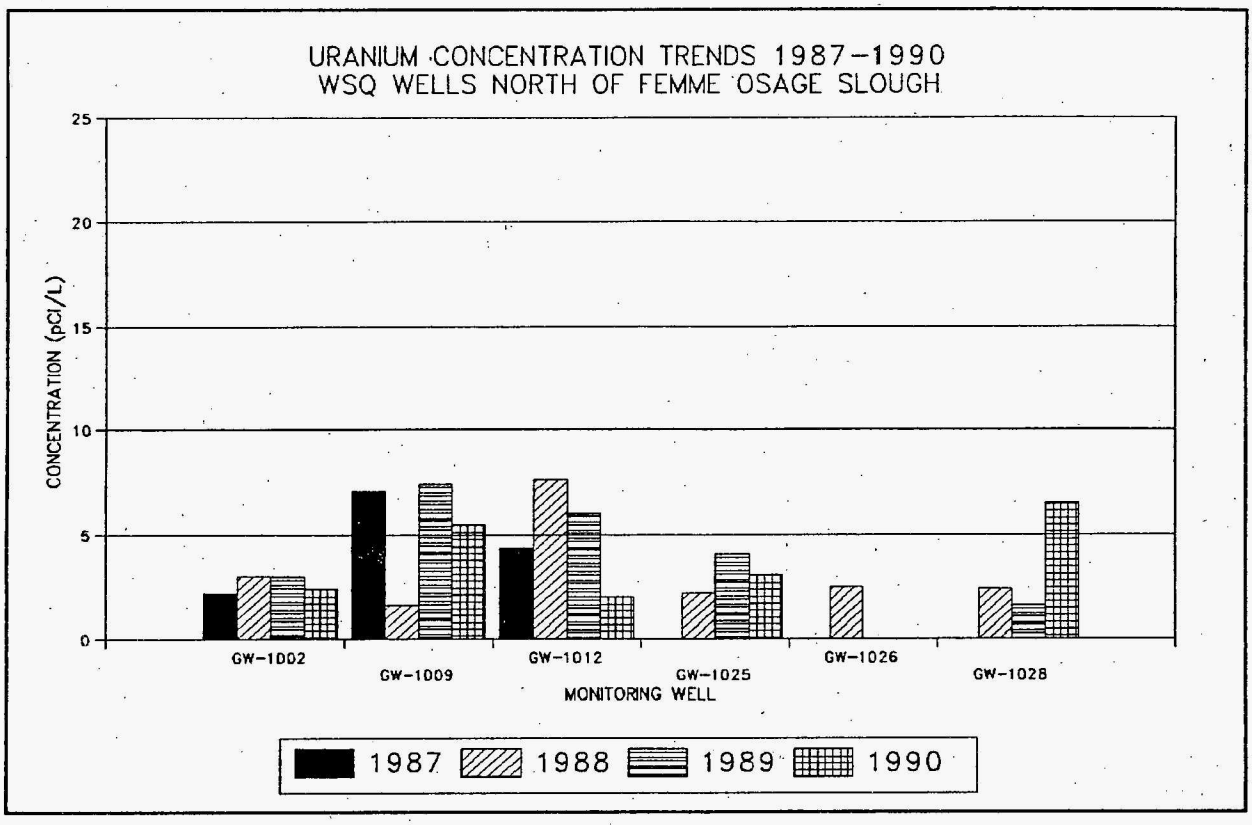

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP WELLS 1987-1990
CONCENTRATION (mg/L)
25
20
15
10
5
0
MW-2012
MW-2013
MW-2014
MW-2015
MW-2017
MW-2020
MW-2023
MONITORING WELL
1987
1988
1989
1990

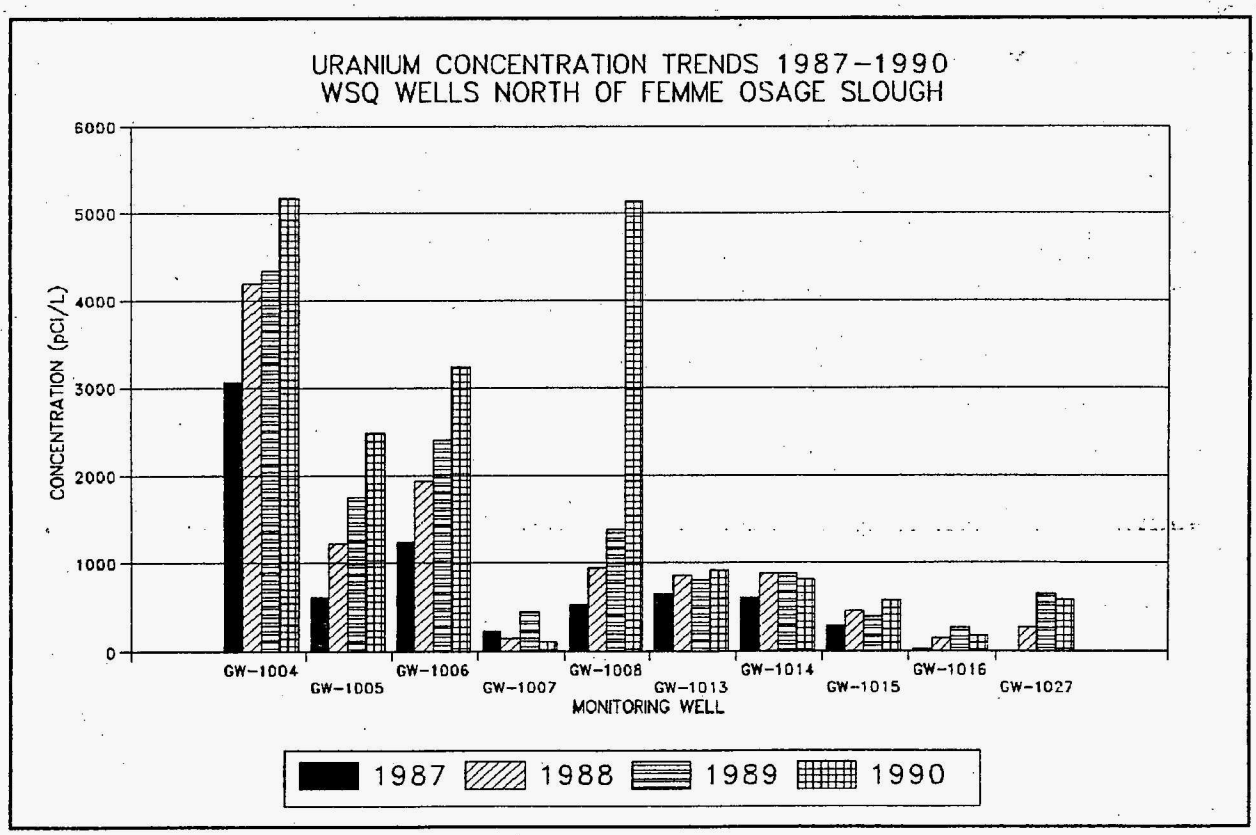

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP DEEP WELLS 1987-1990
CONCENTRATION (mg/L)
25
20
15
10
5
0
MW-2019
MW-2021
MW-2022
MW-2024
MW-2025
MW-2026
MW-2027
MW-2028
MW-2029
MW-3002
MW-3006
MW-4007
MONITORING WELL
1987
1988
1989
1990

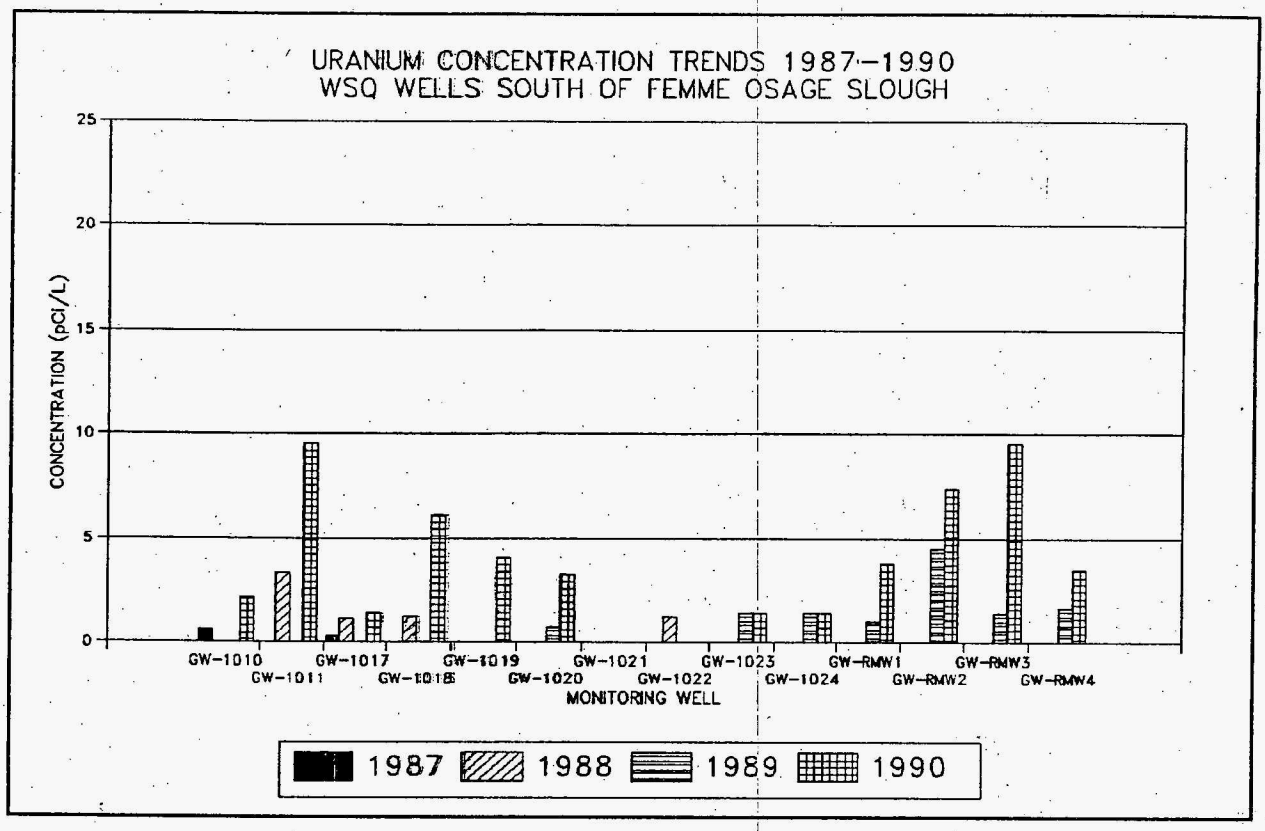

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP WELLS 1987-1990
CONCENTRATION (mg/L)
1200
1000
800
600
400
200
0
MW-3008
MW-3009
MW-3010
MW-4001
MW-4006
MW-4013
MONITORING WELL
1987
1988
1989
1990

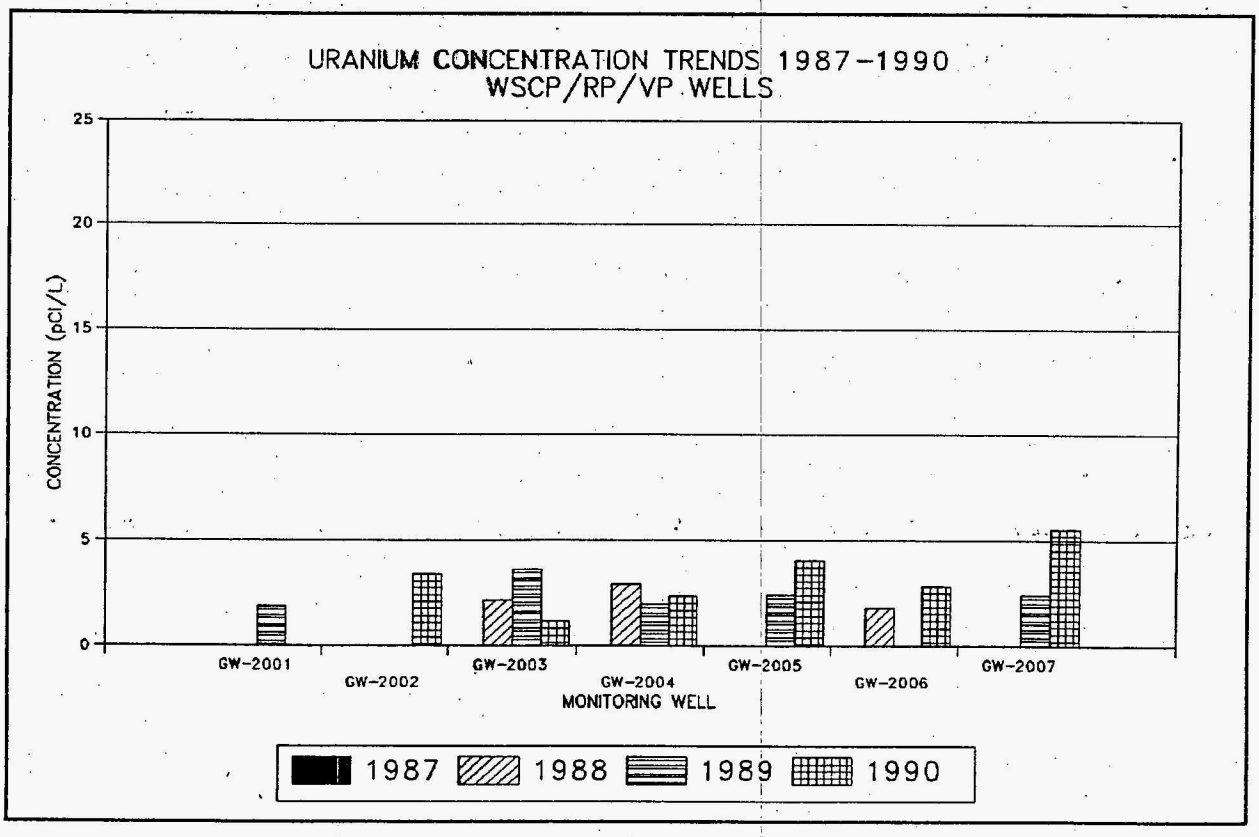

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP WELLS 1987-1990
CONCENTRATION (mg/L)
25
20
15
10
5
0
MW-3019
MW-4002
MW-4003
MW-4004
MW-4005
MW-4008
MW-4009
MW-4010
MW-4011
MW-4012
MONITORING WELL
1987
1988
1989
1990

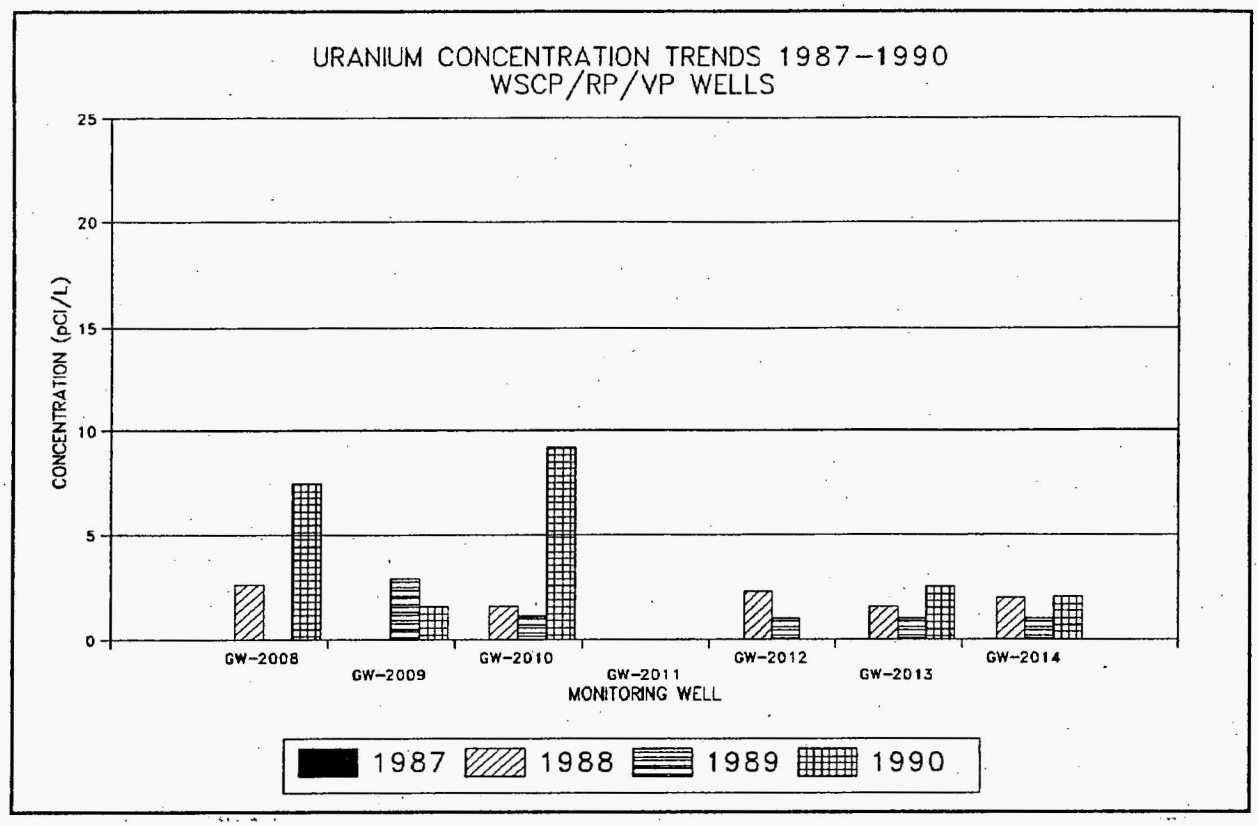

NITRATE AS N CONCENTRATION TRENDS
WSCP/RP/VP WELLS 1987-1990
CONCENTRATION (mg/L)
25
20
15
10
5
0
MW-4014
MW-4015
MW-4016
MW-4017
MW-4018
MW-4019
MW-4020
MW-4021
MW-4022
MW-4023
MONITORING WELL
1987
1988
1989
1990

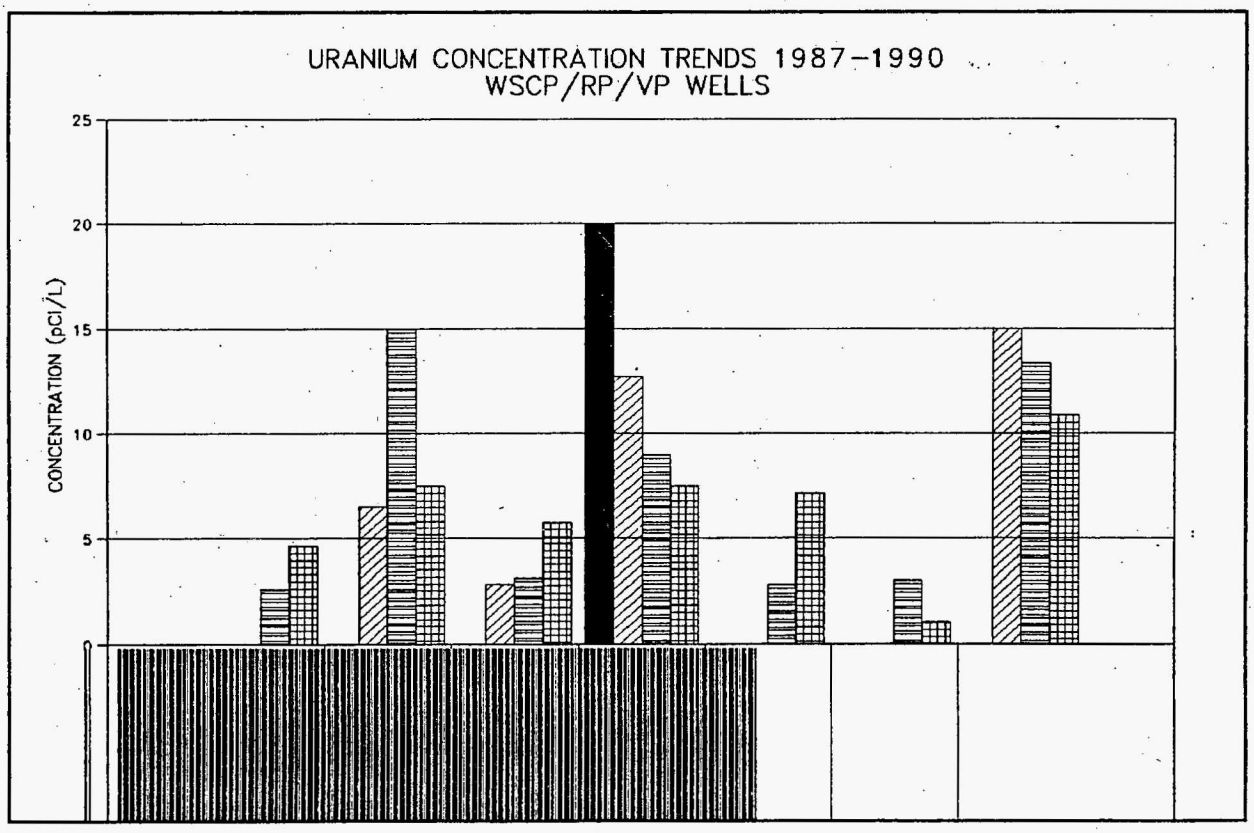

URANIUM CONCENTRATION TRENDS 1987-1990
WSQ WELLS NORTH OF FEMME OSAGE SLOUGH
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-1002
GW-1009
GW-1012
GW-1025
GW-1026
GW-1028
MONITORING WELL
1987
1988
1989
1990

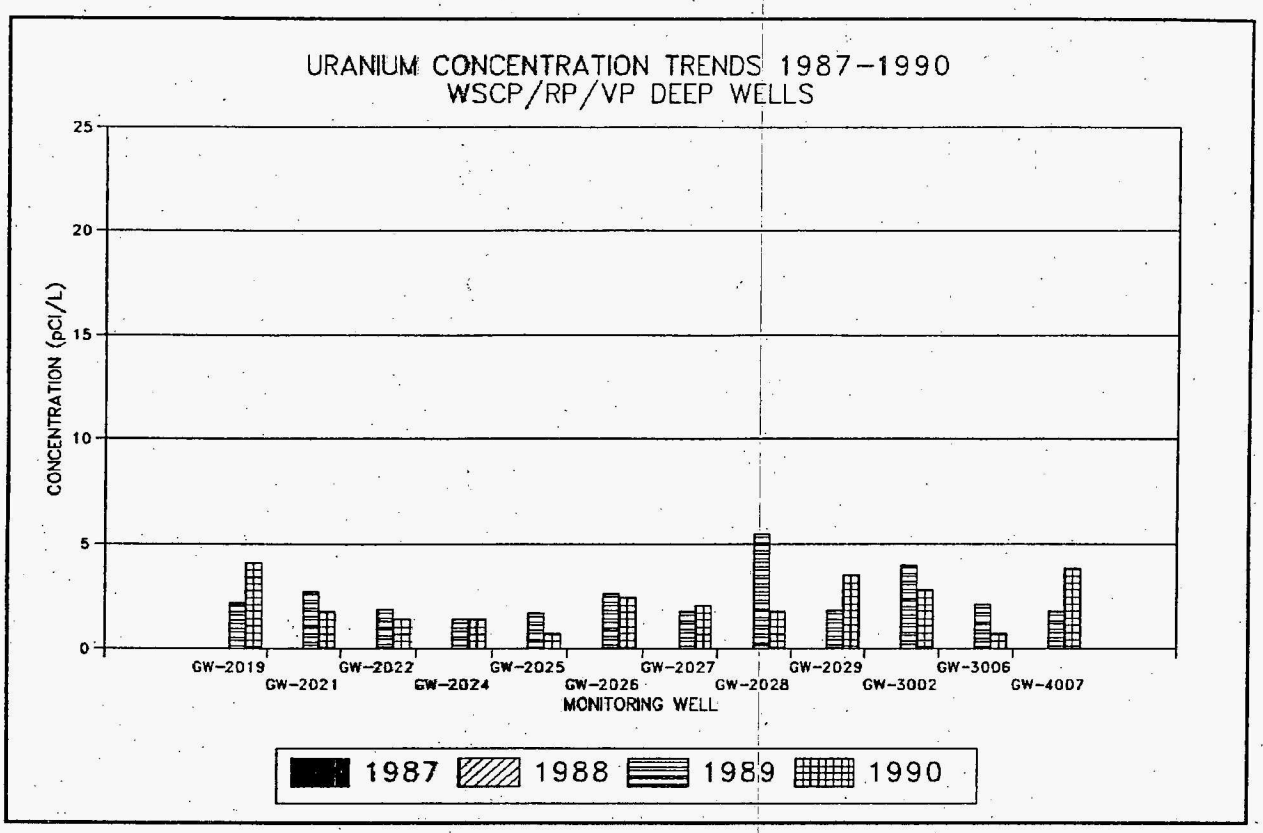

URANIUM CONCENTRATION TRENDS 1987-1990
WSQ WELLS NORTH OF FEMME OSAGE SLOUGH
CONCENTRATION (pCi/L)
6000
5000
4000
3000
2000
1000
0
GW-1004
GW-1005
GW-1006
GW-1007
GW-1008
GW-1013
GW-1014
GW-1015
GW-1016
GW-1027
MONITORING WELL
1987
1988
1989
1990

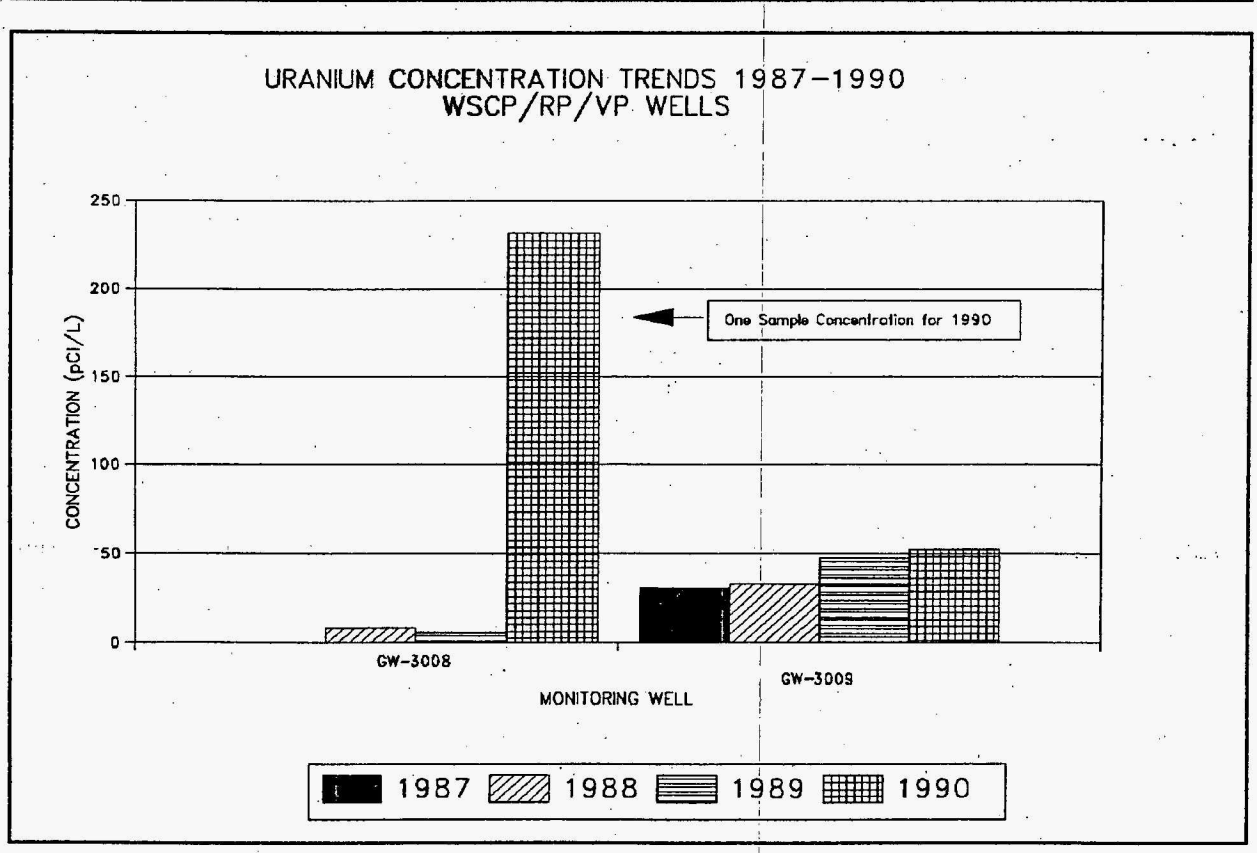

URANIUM CONCENTRATION TRENDS 1987-1990
WSQ WELLS SOUTH OF FEMME OSAGE SLOUGH
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-1010
GW-1011
GW-1017
GW-1018
GW-1019
GW-1020
GW-1021
GW-1022
GW-1023
GW-1024
GW-RMW1
GW-RMW2
GW-RMW3
GW-RMW4
MONITORING WELL
1987
1988
1989
1990

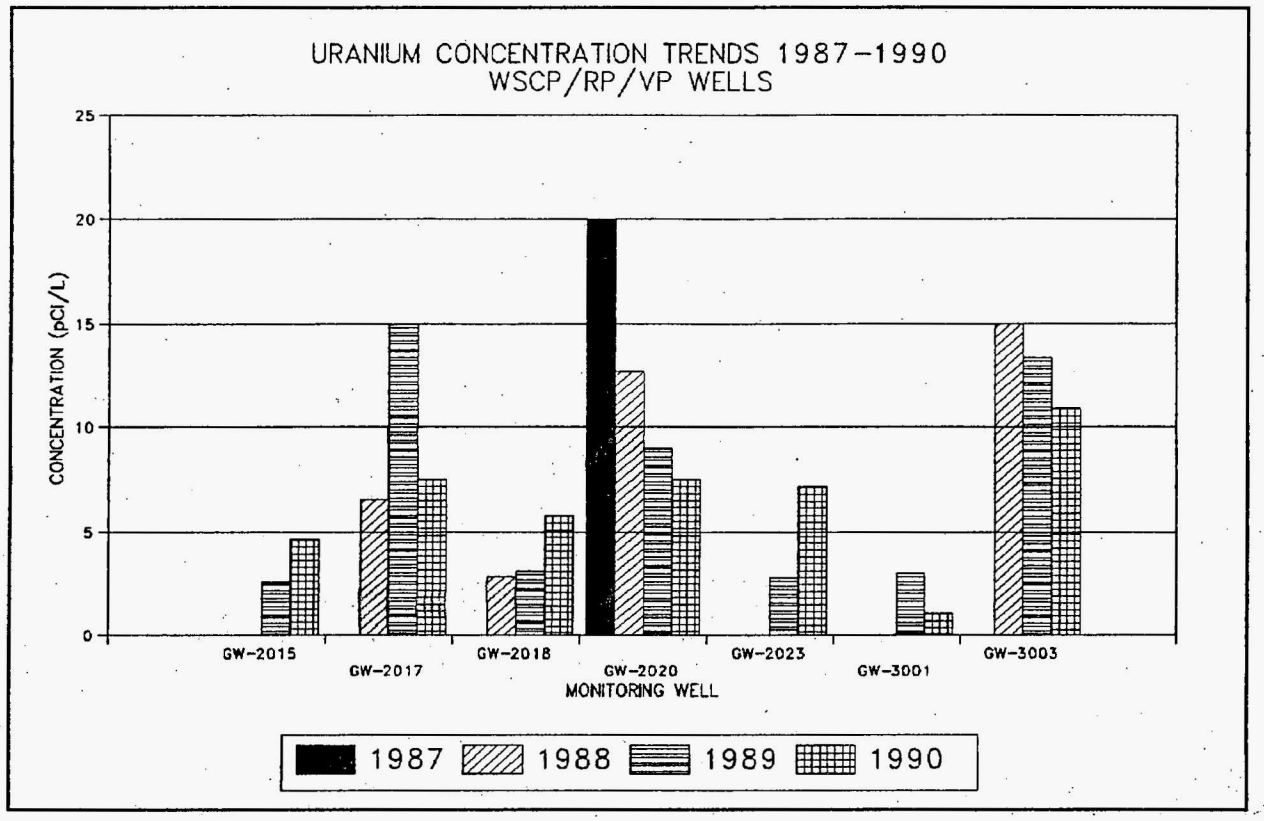

URANIUM CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-2001
GW-2002
GW-2003
GW-2004
GW-2005
GW-2006
GW-2007
MONITORING WELL
1987
1988
1989
1990

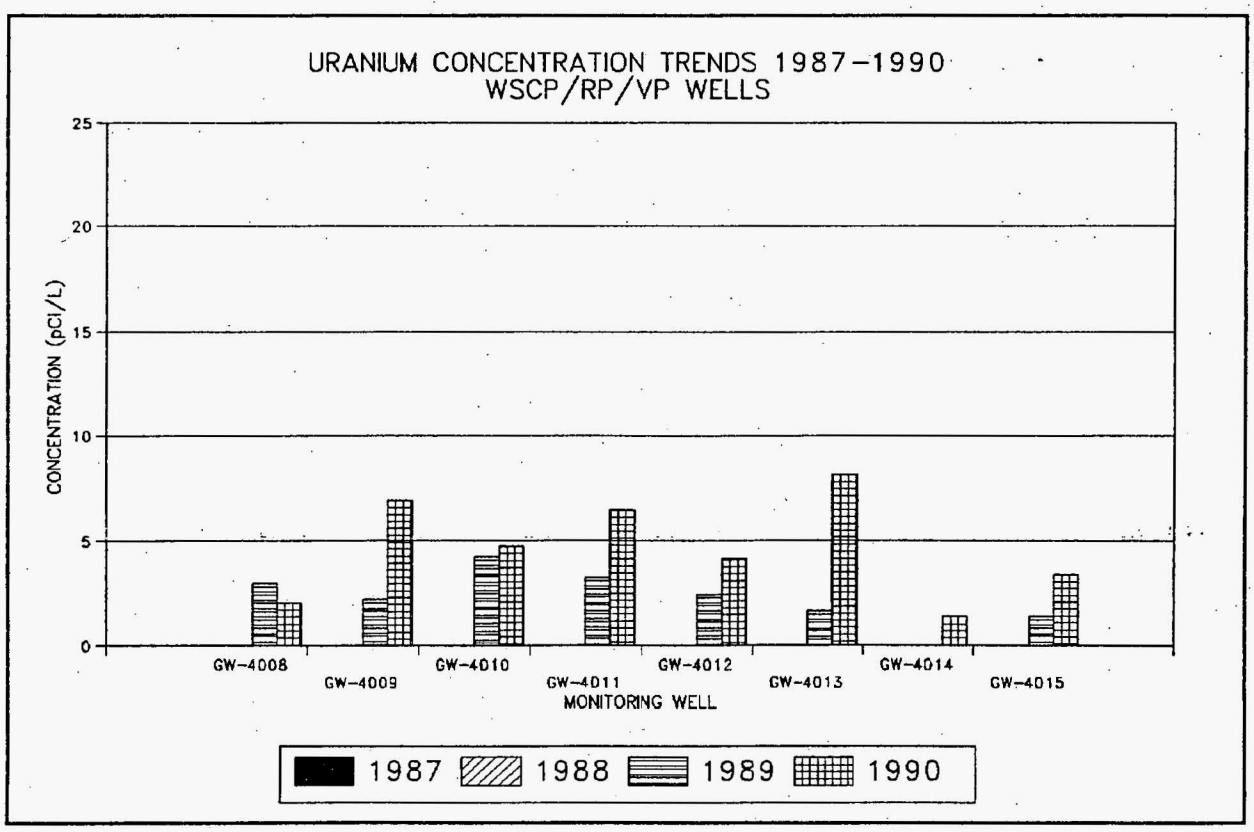

URANIUM CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-2008
GW-2009
GW-2010
GW-2011
GW-2012
GW-2013
GW-2014
MONITORING WELL
1987
1988
1989
1990

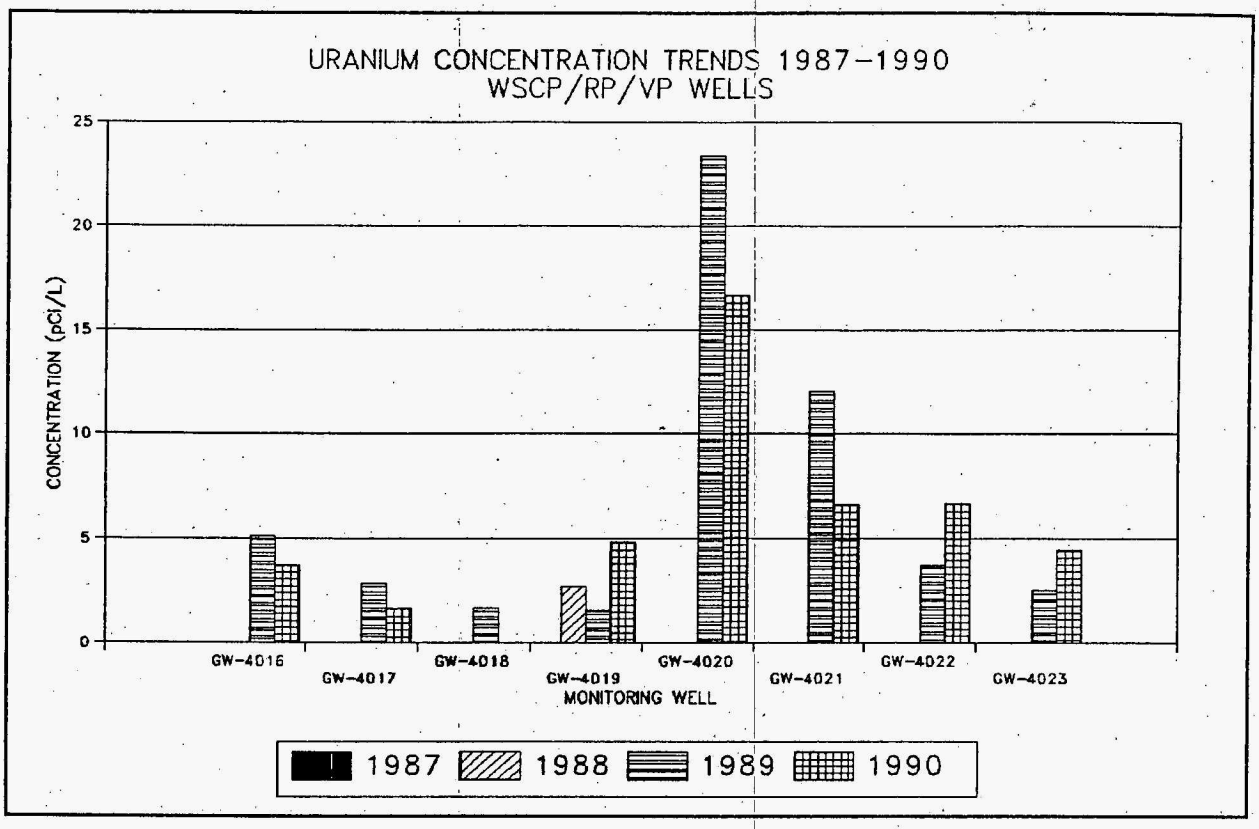

URANIUM CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
25
20
15
10
5
0

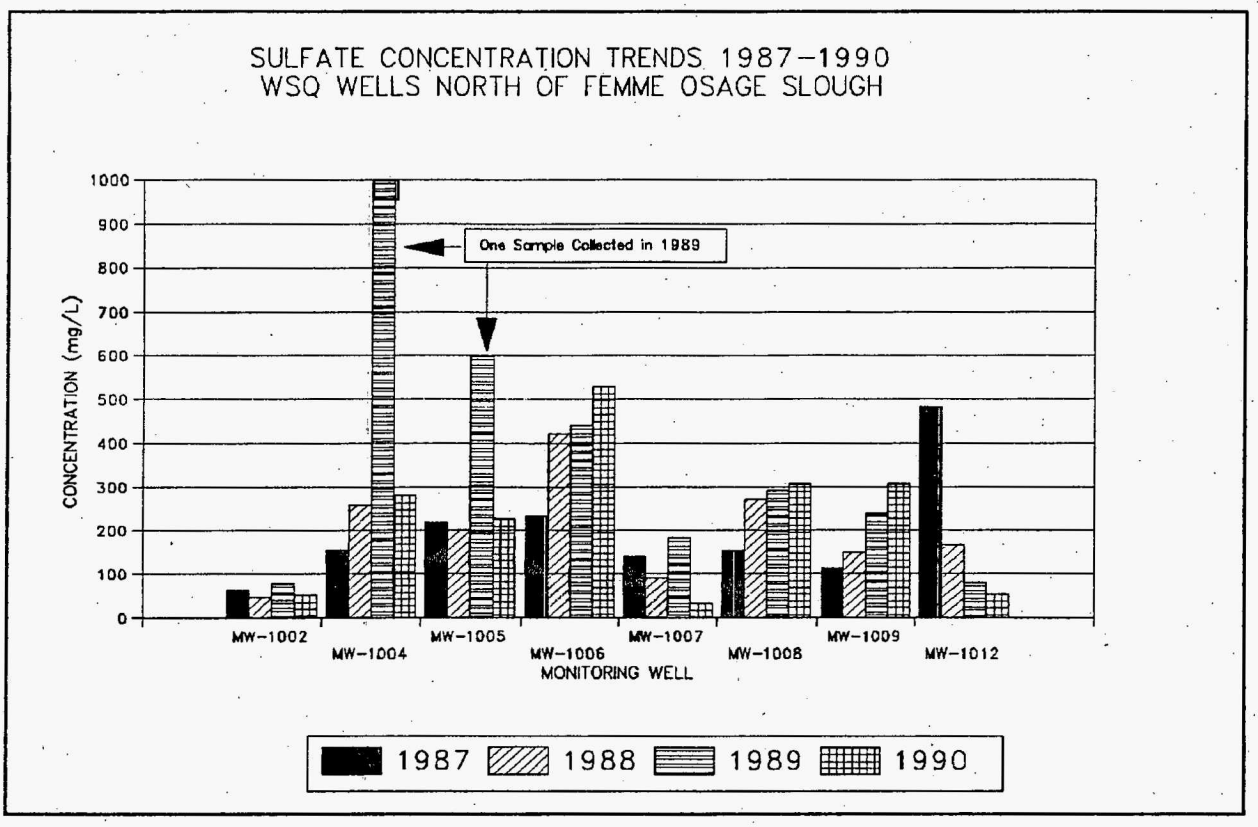

URANIUM CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP DEEP WELLS
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-2019
GW-2021
GW-2022
GW-2024
GW-2025
GW-2026
GW-2027
GW-2028
GW-2029
GW-3002
GW-3006
GW-4007
MONITORING WELL
1987
1988
1989
1990

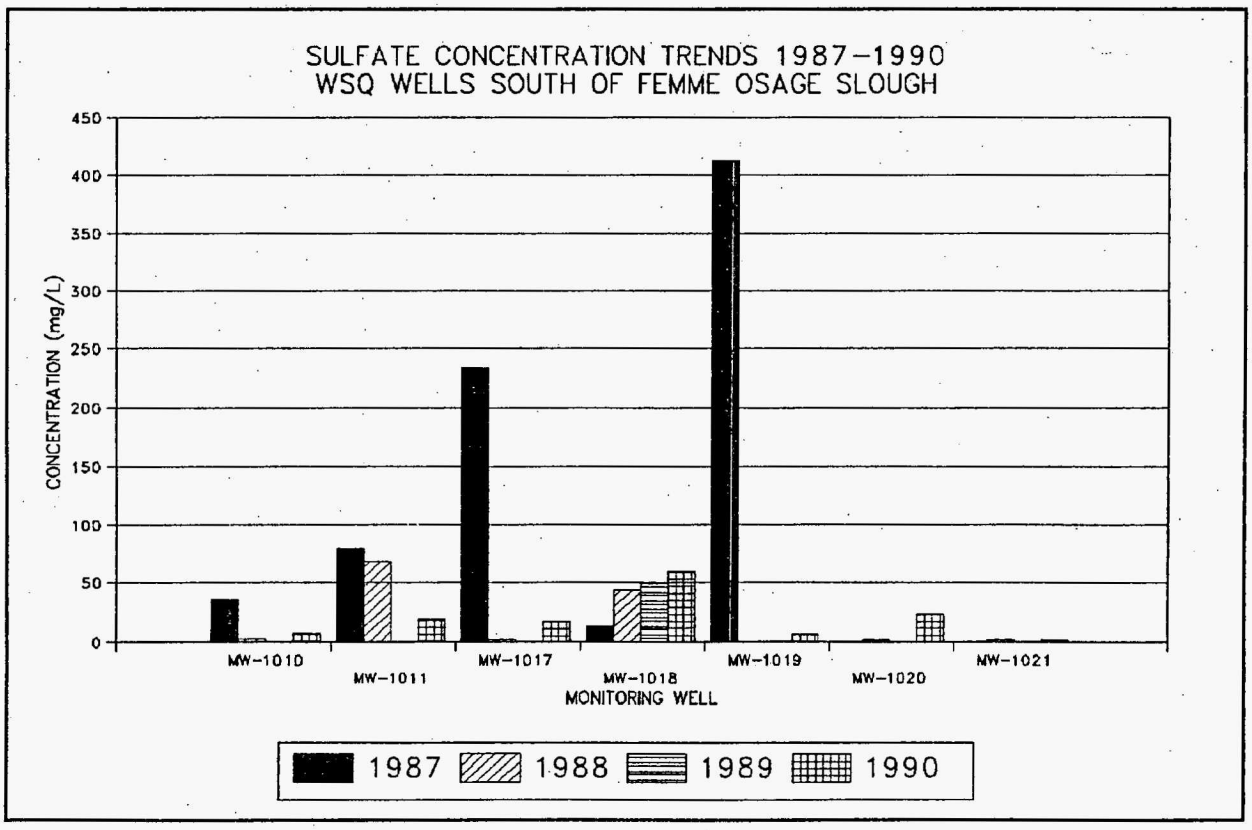

URANIUM CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
250
200
150
100
50
0
One Sample Concentration for 1990
GW-3008
GW-3009
MONITORING WELL
1987
1988
1989
1990

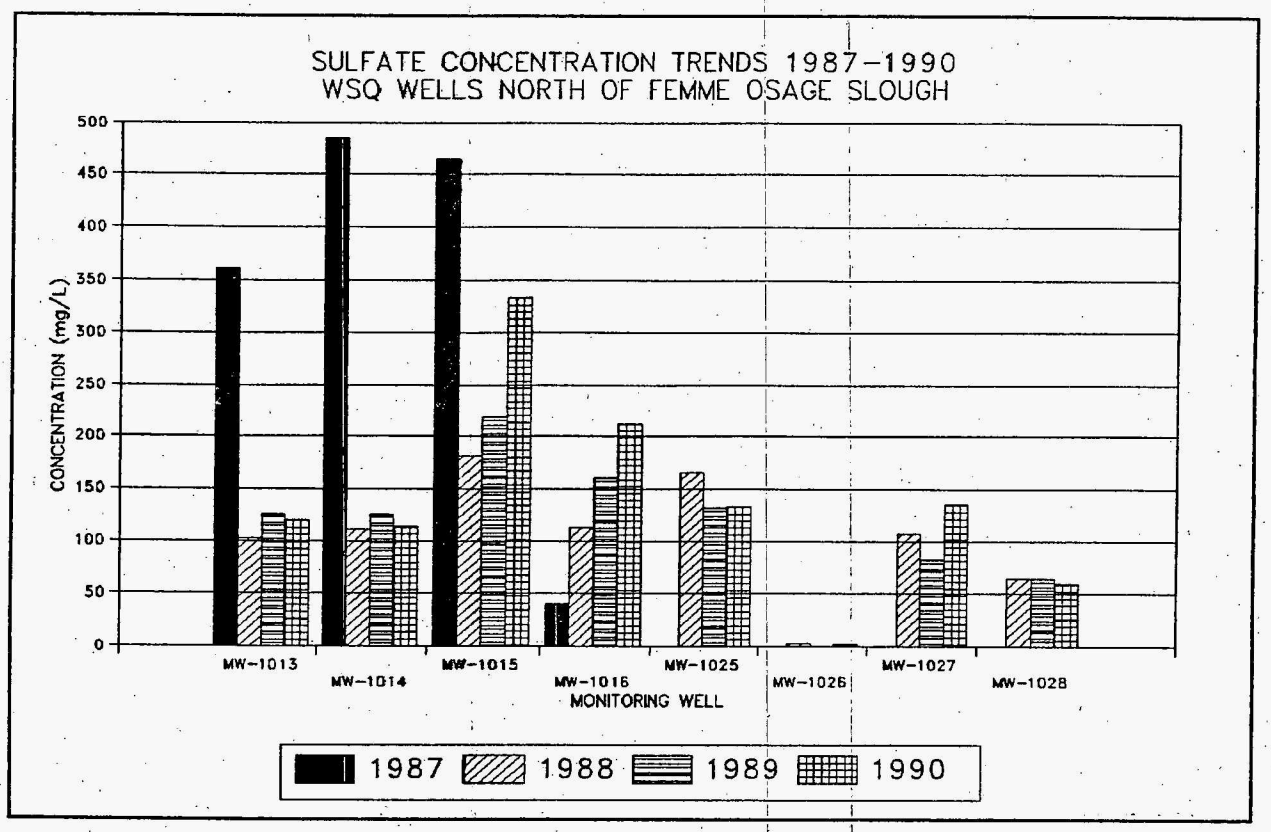

URANIUM CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-2015
GW-2017
GW-2018
GW-2020
GW-2023
GW-3001
GW-3003
MONITORING WELL
1987
1988
1989
1990

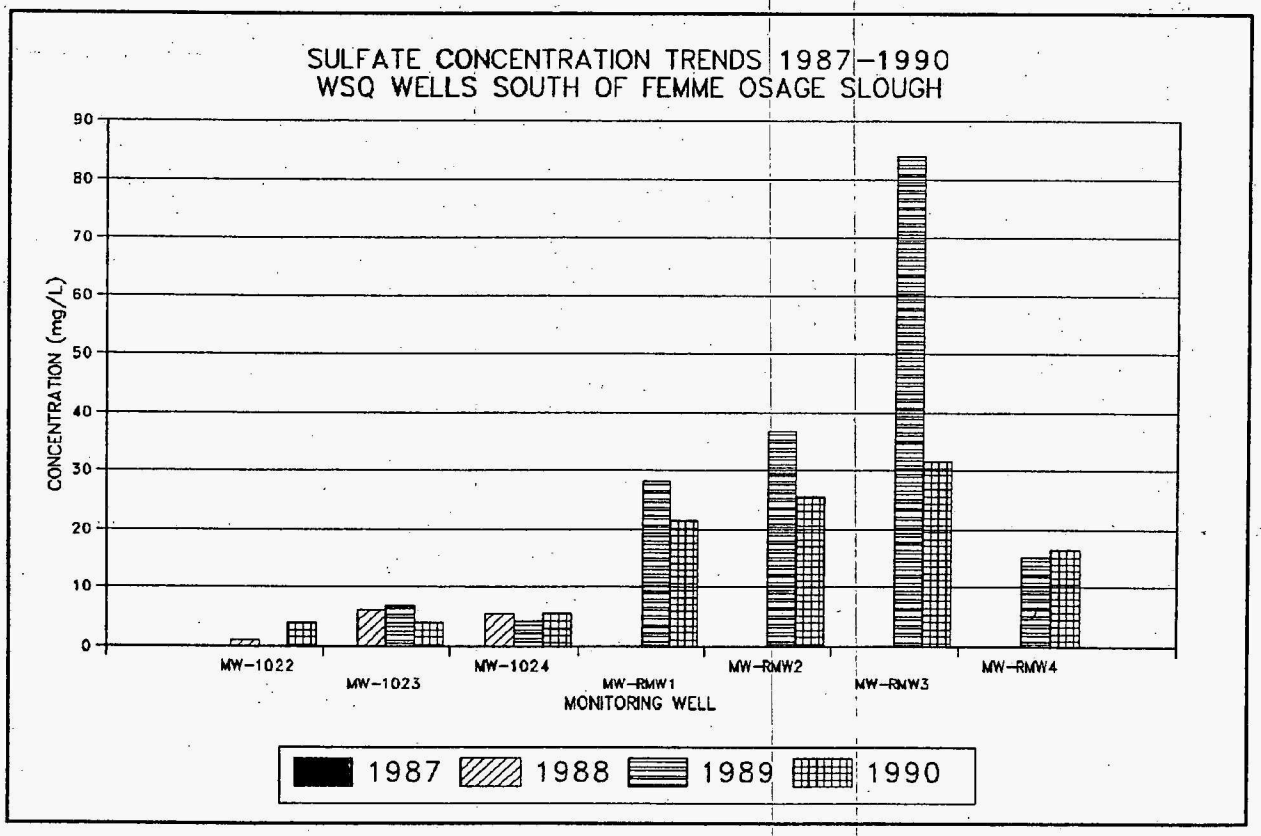

URANIUM CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-4008
GW-4009
GW-4010
GW-4011
GW-4012
GW-4013
GW-4014
GW-4015
MONITORING WELL
1987
1988
1989
1990

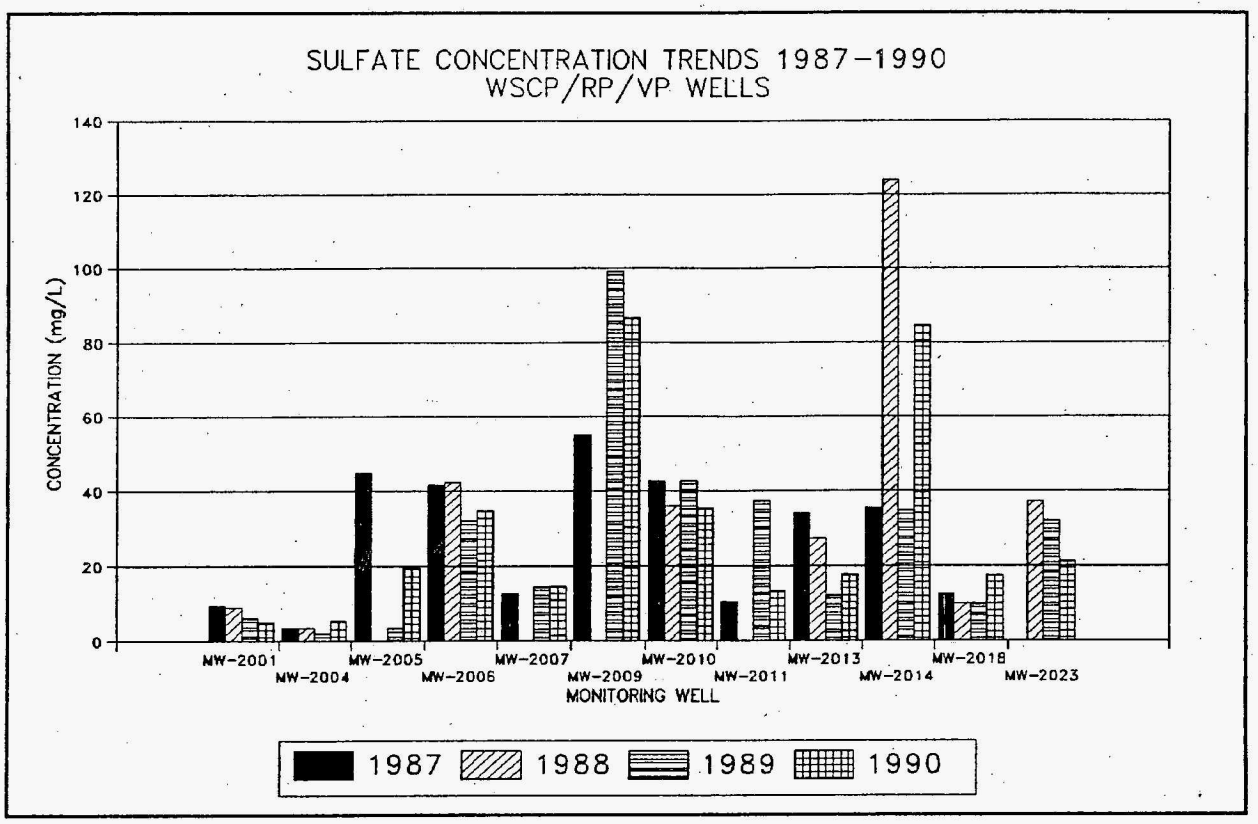

URANIUM CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (pCi/L)
25
20
15
10
5
0
GW-4016
GW-4017
GW-4018
GW-4019
GW-4020
GW-4021
GW-4022
GW-4023
MONITORING WELL
1987
1988
1989
1990

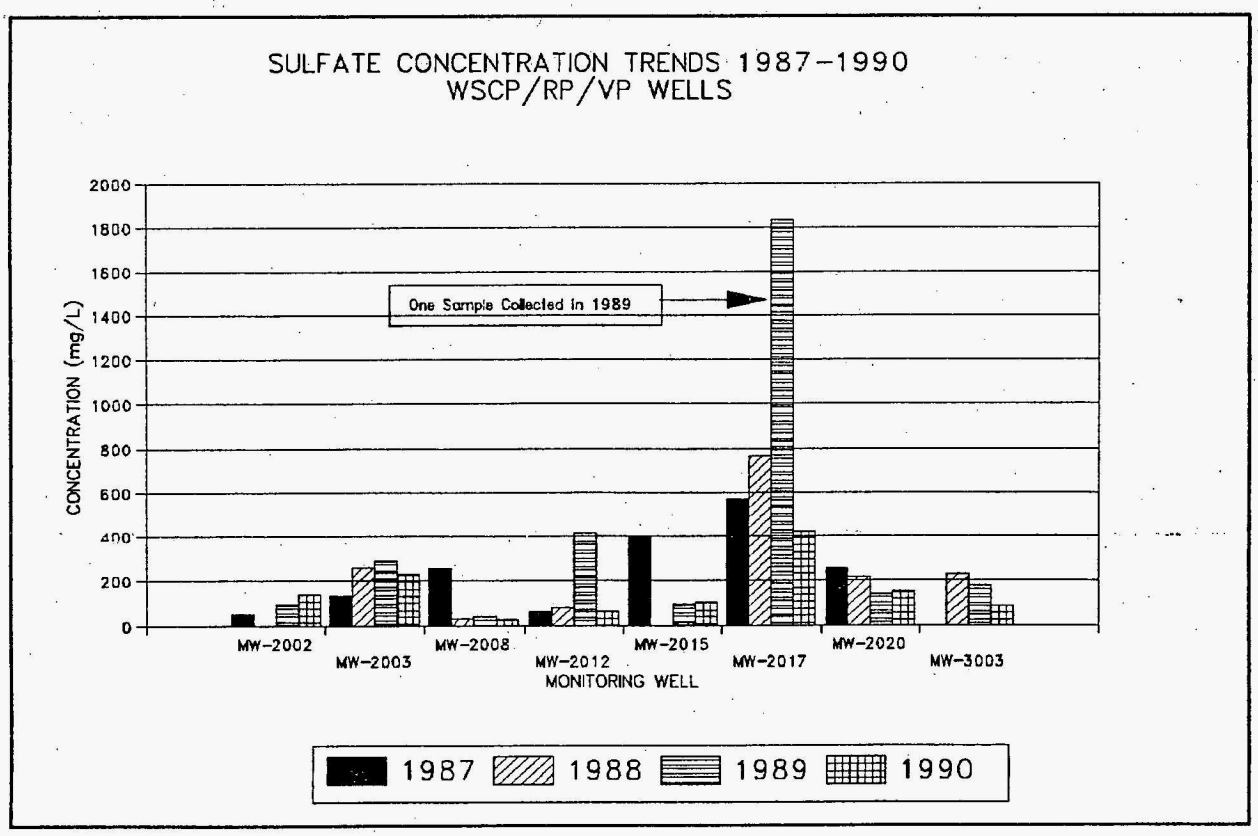

SULFATE CONCENTRATION TRENDS 1987-1990
WSQ WELLS NORTH OF FEMME OSAGE SLOUGH
CONCENTRATION (mg/L)
1000
900
800
700
600
500
400
300
200
100
0
One Sample Collected in 1989
MW-1002
MW-1004
MW-1005
MW-1006
MW-1007
MW-1008
MW-1009
MW-1012
MONITORING WELL
1987
1988
1989
1990

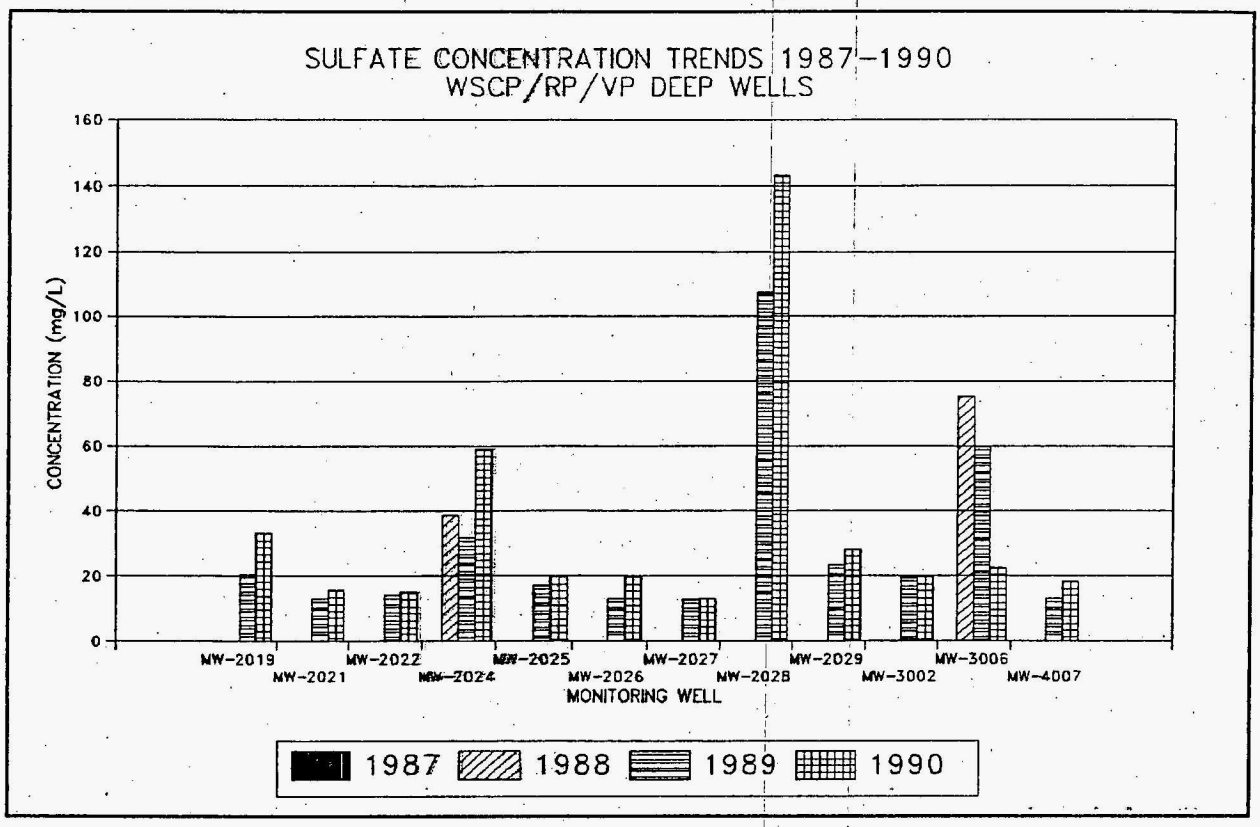

SULFATE CONCENTRATION TRENDS 1987-1990
WSQ WELLS SOUTH OF FEMME OSAGE SLOUGH
CONCENTRATION (mg/L)
450
400
350
300
250
200
150
100
50
0
MW-1010
MW-1011
MW-1017
MW-1018
MW-1019
MW-1020
MW-1021
MONITORING WELL
1987
1988
1989
1990

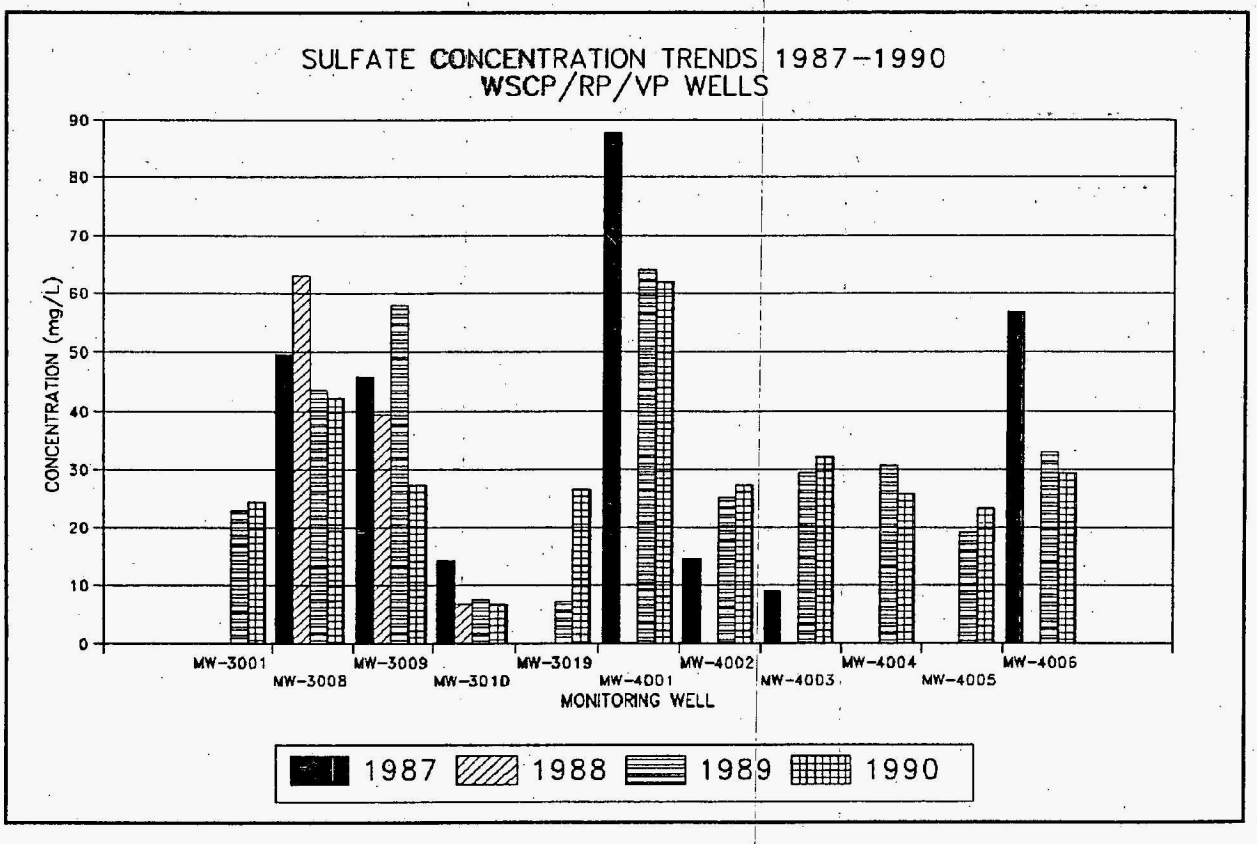

SULFATE CONCENTRATION TRENDS 1987-1990
WSQ WELLS NORTH OF FEMME OSAGE SLOUGH
CONCENTRATION (mg/L)
500
450
400
350
300
250
200
150
100
50
0
MW-1013
MW-1014
MW-1015
MW-1016
MW-1025
MW-1026
MW-1027
MW-1028
MONITORING WELL
1987
1988
1989
1990

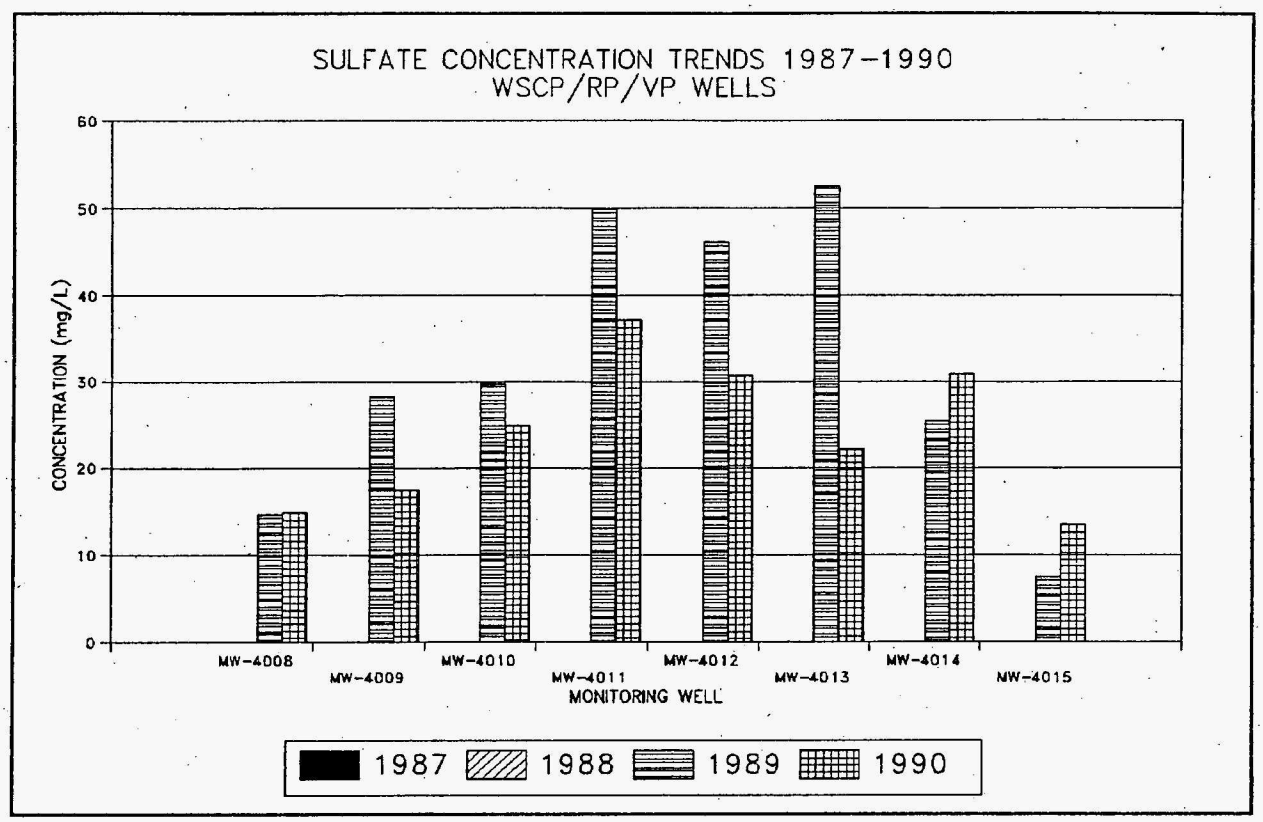

SULFATE CONCENTRATION TRENDS 1987-1990
WSQ WELLS SOUTH OF FEMME OSAGE SLOUGH
CONCENTRATION (mg/L)
90
80
70
60
50
40
30
20
10
0
MW-1022
MW-1023
MW-1024
MW-RMW1
MW-RMW2
MW-RMW3
MW-RMW4
MONITORING WELL
1987
1988
1989
1990

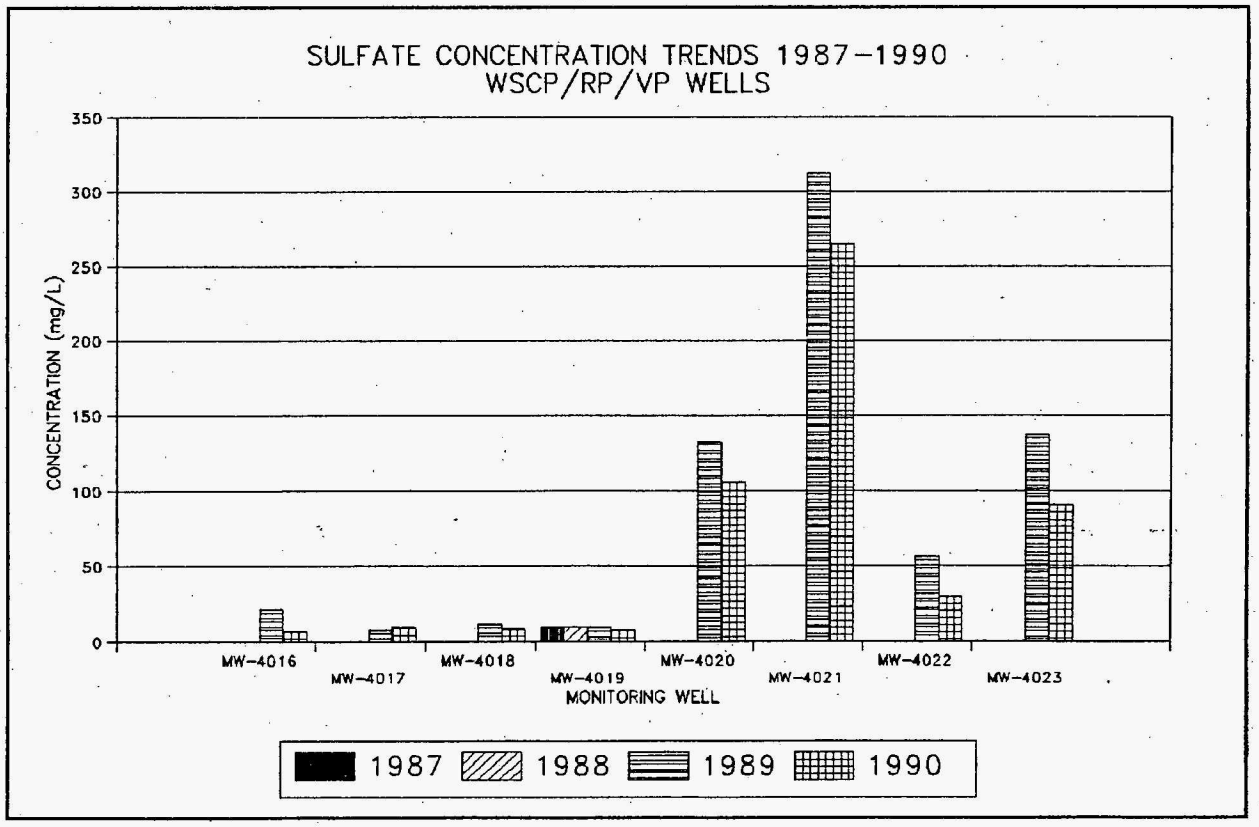

SULFATE CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (mg/L)
140
120
100
80
60
40
20
0
MW-2001
MW-2004
MW-2005
MW-2006
MW-2007
MW-2009
MW-2010
MW-2011
MW-2013
MW-2014
MW-2018
MW-2023
MONITORING WELL
1987
1988
1989
1990


SULFATE CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (mg/L)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
One Sample Collected in 1989
MW-2002
MW-2003
MW-2008
MW-2012
MW-2015
MW-2017
MW-2020
MW-3003
MONITORING WELL
1987
1988
1989
1990


SULFATE CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP DEEP WELLS
CONCENTRATION (mg/L)
0
20
40
60
80
100
120
140
160
MW-2019
MW-2021
MW-2022
MW-2024
MW-2025
MW-2026
MW-2027
MW-2028
MW-2029
MW-3002
MW-3006
MW-4007
MONITORING WELL
1987
1988
1989
1990


SULFATE CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (mg/L)
0
10
20
30
40
50
60
70
80
90
MW-3001
MW-3008
MW-3009
MW-3010
MW-3019
MW-4001
MW-4002
MW-4003
MW-4004
MW-4005
MW-4006
MONITORING WELL
1987
1988
1989
1990


SULFATE CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (mg/L)
0
10
20
30
40
50
60
MW-4008
MW-4009
MW-4010
MW-4011
MW-4012
MW-4013
MW-4014
MW-4015
MONITORING WELL
1987
1988
1989
1990


SULFATE CONCENTRATION TRENDS 1987-1990
WSCP/RP/VP WELLS
CONCENTRATION (mg/L)
0
50
100
150
200
250
300
350
MW-4016
MW-4017
MW-4018
MW-4019
MW-4020
MW-4021
MW-4022
MW-4023
MONITORING WELL
1987
1988
1989
1990

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 radon-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.

APPENDIX D
ACRONYMS AND ABREVIATIONS

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APPENDIX D
ACRONYMS AND ABBREVIATIONS

ABWA	August A. Busch Memorial Wildlife Area
AEC	Atomic Energy Commission
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	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
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

APPENDIX E
ENVIRONMENTAL GUIDELINES

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. DOSE LIMITS

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.

B. DERIVED CONCENTRATION GUIDES (DCG)

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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.

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 <u>or</u> 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.

	Drinking Water		Inhaled Air	
Radionuclide	μCi/mL	Bq/mL	μCi/mL	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. <u>RADON</u>

DCGs for radon (Rn-220) are being assessed by DOE. Until the review has been completed and new valves issued, the valve of 3.E-09 μCi/ml stated in DOE Order 5400.5 shall be used from 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

Drinking water standards are presented only for comparison purposes. These should not necessarily be construed as 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

* Primary maximum contaminant level
** Secondary maximum contaminant level
NS - No Drinking Water Standard

APPENDIX F
CONVERSION FACTORS

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CONVERSION FACTORS

1 millisievert (mSv)	=	100 mrem
1 milliroentgen (mR)	=	1 mrem (for gamma radiation)
1 Curie (Ci)	=	3.7×10^{10}dps (disintegrations/sec)
1 Bequerel (Bq)	=	1 disintegration per second
1 M^3	=	1000 litres
1 Bq/M^3	=	3.7×10^{-2} pCi/M^3
1 Bq/l	=	3.7×10^{-2} pCi/l
1 Bq/kg	=	3.7×10^{-2} pCi/kg
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

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A. Dose from the WSCP/WSRP to a maximally exposed individual.

1. Inhalation 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:

a. fish - assume a 6.5 g/d fresh water fish consumption rate (EPA 1988) from Lake 36 (highest average uranium concentration in fish of all lakes receiving runoff from the WSS).

b. water - assume a 0.05 liter/hr swimming ingestion rate (EPA 1988) for 1hr/wk for 12 wks, total of 0.6 liters. Assume water has uranium concentrations as detected in Lake 36 (highest uranium in water concentrations of all lakes receiving runoff from the WSS).

c. sediment - assume a 200 mg/day ingestion rate for 2 days/yr for a total of 400 mg of sediment. Assume sediment has uranium concentrations as detected in Lake 34 (highest uranium concentration of all lakes receiving runoff from the WSS).

EDE (ingestion) = annual fish consumption x isotopic uranium concentration x isotopic DCF(1) + annual water consumption x uranium concentration x uranium DCF(2) + annual sediment concentration x uranium concentration x uranium DCF(2)

EDE (ingestion) = 0.0246 mrem

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(1) Isotopic Dose Converstion Factor (DCF) was the greater of the two DCFs reported for each uranium isotope as reported in Table 2.2 of Eckerman et al. (1988).

(2) Uranium DCF was obtained from DOE (1988). DOE DCF guidance was used for water and sediment consumption to be consistent with the exposure scenario used in the 1989 Annual Site Environmental Report.

B. Dose from the WSQ to a maximally exposed individual.

1. Inhalation pathway:

a. Airborne radioactive particulate - assume that the net concentration measured at AP-1010 (4.6E-16 μCi/ml) had the same ratio of radionuclides in the radionuclide inventory of the quarry surface soils, as reported in the quarry remedial investigation report (MKF and JEG 1989b) Activity ratios are given in Section D of this appendix. Assume an annual residence time of 50 hrs (Section 4.1.8.2). Assume a breathing rate of 1.25 m^3/hr (Cember 1983).

b. Radon gas - assume the concentration at State Route 94 is equal to the measured net concentration RD-1002 1.8 pCi/l. Assume an annual residence time of 50 hrs (Section 4.1.8.2). Assume that the working level ratio for Rn-222 was 50%.

EDE (inhalation) = net radon concentration x breathing rate x exposure time x dose conversion factor + net isotopic airborne particulate concentration x breathing rate x exposure time x isotopic DCF[1].

EDE (inhalation) = 3.306 mrem

2. External gamma radiation pathway: assume that the net gamma exposure at State Route 94 was the same as measured at monitoring station TD-1001 (0.003 mrem/hr), (the highest rate measured at the quarry). Assumed that the annual residence time was 50 hrs (Section 4.1.8.2).

EDE = Exposure rate x exposure time
EDE (gamma) = 0.15 mrem

(1) Dose Conversion Factors (DCF) were obtained from the EPA (Eckerman et al. 1988).

3. Ingestion pathway: because the quarry is controlled by an 2.4 m (8 ft) high barbed wire fence; fishing, swimming, and drinking water at the quarry does not constitute a realistic scenario.

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 4.1.8.3), and thus there should be no effective dose 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 4.1.8.3). In addition the measured net gama exposure rate of 2.5 μR/hr was used to calculate the effective dose equivalent.

EDE = Exposure time x exposure rate
EDE = 0.5 mrem

3. Ingestion pathway:

Fish - assume a 6.5 g/day fresh water fish consumption rate (EPA 1988) from the slough. Assumed that the uranium concentration in fish is equal to the detection limit achieved during analysis (Section 4.1.8.3).

EDE = Fish consumption x uranium concentration x DCF[1]
EDE = 0.006 mrem

(1) Dose Conversion Factor (DCF) is from DOE guidance to be oonsistent with the exposure scenario used in the 1989 Annual Site Environmental Report.

D. Collective Population Dose Estimate

<u>Exposure Points</u> - 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. The first three pathways will be addressed for the collective population dose estimate. Exposure to above-background radionuclide concentrations in food or water will not be addressed since it is not reasonable to assume that a majority of the population eats fish from bodies of water that receive runoff from the WSS, and because no surface water or groundwater bodies that receive runoff or recharge from the WSS 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 for airborne radioactive particulate concentrations, radon concentrations, and external gamma radiation. The only potential receptors near the WSQ perimeter are people using the Katy Trail, a recreational 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 72,000 persons, which is derived from a one-calendar-quarter estimate made by the Missouri State Parks Department (Maher 1991). 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.

Although the Katy Trail was chosen as an exposure point, and a collective population dose estimate was calculated for persons using the trail, this does not mean that measurable exposures did in fact occur there. Implicit in the following radioactive air particulate and radon gas concentration calculations is the conservative assumption that the wind is blowing from the WSQ towards the Katy Trail 100% of the time. This is definitely not the case; therefore, these calculations overestimate the maximum above-background average airborne radioactive particulate and radon concentrations which could have occurred at the trail.

Models

In order to estimate airborne radioactive particulate and radon concentrations at the Katy Trail, the above-background results measured at the WSQ perimeter were incorporated into a box model. A box model predicts a radon or airborne radioactive particulate release rate in pCi/s by multiplying the measured net airborne radioactive particulate 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 radioactive particulate and radon release rates because: (1) in the case of airborne radioactive particulates the net measured gross alpha concentration (i.e., the concentration measured at quarry monitoring station AP-1010 less the background concentration measured at station AP-4007) is an extremely small 4.6E-16μCi/ml, and (2) in the case of both the airborne particulate and radon concentrations, the effective dose equivalent and population doses are low as indicated by the calculation results.

Once airborne radioactive particulate and radon release rates are obtained using the box model, fluxes are calculated by dividing the release rates by the surface area of the quarry. Once estimated airborne radioactive particulate and radon fluxes are calculated, estimated concentrations at the Katy Trail are calculated using the Gaussian atmospheric dispersion model modified to predict concentrations close to an area source (DOE 1986).

The modified Gaussian dispersion model can predict airborne concentrations at distances as close as 50 m (55 yd) from the edge of the area source, therfore this minimum distance was chosen as the distance between the quarry rim and the Katy Trail for the purposes of the model. This 50 m (55 yd) distance is comparable to the 45 m (50 yd) minimum distance between the quarry rim and the trail.

The net annual average radon concentration at the WSQ is 0.7 pCi/l and is calculated by averaging the results from stations RD-1001 through RD-1006 less the average background result of 0.3 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

   b. Flux (Ø) = Release rate; where quarry floor area = 3.6 ha (9 acre) quarry floor area (MKF and JEG 1989b)

      = 14 pCi/m^2/s

2. Modified Gaussin Dispersion Model (DOE 1986)

   Model inputs include source diameter (D), distance from source edge to receptor (d), and atmospheric stability class. Given 3.6 ha (9-acre) quarry floor area and using $A = \pi r^2$, effective diameter of quarry is D = 215 m (237 yd). Assume d = 50 m (55 yd) (minimum distance for input into model) and atmospheric stability Class D.

Given the input parameters, the model predicts values for $(X\mu/\phi)$[1]

$(X\mu/\phi)$ for D = 215 m (237 yd) is found by interpolation to be 36.63

$$\frac{X\mu}{\phi} = 36.63$$

$$X = 36.63 \times \frac{\phi}{\mu} = 0.26 pCi/l$$

3. Estimated Effective Dose Equivalent (EDE) = radon concentration x working level ratio x exposure time x DCF[2]

EDE (from radon) = 7.6E-7 rem

4. Population Dose Estimate from radon = 72,000 persons x 7.6E-7 mrem = 0.055 person rem

5. Population dose estimate due to airborne radioactive particulates

The same box model and modified Gaussion dispersion model are applicable to predict the airborne radioactive particulate concentration. The difference is that the net measured annual average long-lived gross alpha concentration of 4.6E-16 μCi/ml (Section 4.1.8.2) is substituted for the net annual average radon concentration.

---

(1) X = predicted concentration at receptor location. For atmospheric stability Class D and d = 50 m (55 yd) the following $X\mu/\phi$ values are predicated:

Source Diameter(m)	$(X\mu/\phi)$
200 (220 yd)	35.39
300 (330 yd)	43.66

(2) Radon concentration = 0.26 pCi/l
Working level ratio = 0.50 (assumed)
Exposure time = 0.08 hr = 5 min
Dose conversion factor = 1.25 rem/working level month (Eckerman et al. 1988)

Using the same calculation and parameter values used to estimate the radon concentration:

Release Rate = 3.4E-7 μCi/s

Flux (ϕ) = 9.3E-12 μCi/m^2/s

$$\frac{X\mu}{\phi} = 36.63$$

$$X = 36.63 \; x \; \frac{\phi}{\mu}$$

$$= 36.63 \; x \; \frac{9.3E-12 \; \mu Ci/m^2 \cdot s}{2 \; m/s}$$

X = 1.7E-16 μCi/ml

To estimate radionuclide concentrations contributing to the long-lived gross alpha concentration, 1.7E-16 μCi/ml is proportioned among radium, thorium, and uranium isotopes according to average radionuclide concentrations in quarry surface (0 to 0.15 m) soils as reported in Table 4.6 of MKF and JEG 1989b. Additionally, U-238, U-234 and U-235 isotopes were assumed to be in their natural equilibrium state as were Ra-228 and Th-232. This results in the following percent of total activity and estimated airborne radionuclide concentrations:

RADIONUCLIDE	PERCENT OF TOTAL ACTIVITY	RADIONUCLIDE AIRBORNE CONCENTRATION μCi/ml
U-234	26.8	4.6E-17
U-235	1.2	2.03-18
U-238	26.8	4.6E-17
Ra-226	16.1	2.7E-17
Ra-228	3.0	5.1E-18
Th-230	23.1	3.9E-17
Th-232	3.0	5.1E-18

EDE = airborne radionuclide concentration x breathing rate x exposure time x radionuclide DCF(1)

EDE (airborne radioactive particulates) = 3.3E-6 mrem

$$\textit{Population dose estimate airborne particulates} = 72{,}000 \textit{ persons } x\ 3.3E\text{-}6 \textit{ mrem } x \left(\frac{rem}{10^3 mrem}\right)$$

= 0.0002 person rem

6. Population dose estimate due to external gamma radiation

Model the quarry as a circular area source of diameter D = 215 m (same as for previous estimates) and use the following formula for ratio of external gamma dose equivalent rates at two points near a circular planar source.

(1) Breathing rate = 1.25 m^3/h (Cember 1983)
Exposure time = 0.08 h
Radionuclide DCFs are as reported in Table 4-13

$$\frac{H_1}{H_2} = \frac{\ln[(R^2+h_1^2)/h_1^2]}{\ln[(R^2+h_2^2)/h_2^2]} \qquad (Cember 1983)$$

H_1	=	Average above-background dose equivalent rate at the quarry rim = 14.8 mrem/yr
H_2	=	Estimated dose equivalent rate at Katy Trail
R	=	D/2 = 108 m
h_1	=	Distance from quarry center to southern rim = 58 m (64 yd)
h_2	=	h_1 + distance from quarry's southern rim to Katy Trail = 109 m (120 yd)

H_2 = 7.7E-4 mrem/hr

$$\textit{Population Dose Estimate} = 72{,}000 \textit{ persons } x\ 7.74E{-}4\ \frac{mrem}{h}\ x\ 0.08h\ x \left(\frac{rem}{10^3\ mrem}\right)$$

= 0.004 person rem

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