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ANNUAL SITE ENVIRONMENTAL REPORT 1989

For the
Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

Prepared by MK-Ferguson Company and Jacobs Engineering Group

NOVEMBER 1990 REV. 1

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

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November 1990

Prepared by

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and
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Prepared for

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

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ABSTRACT

Environmental monitoring continued at the Weldon Spring Site in 1989. Numerous exposure pathways were monitored in 1989, including groundwater, surface water, and air. Analytical parameters included radionuclides, nitroaromatic compounds, inorganic anions, and direct gamma exposure. The results are being used to calculate exposure doses (where applicable) so the impact of the site on potentially exposed populations can be assessed.

Off-site exposures did not dramatically increase in 1989 over exposures calculated in previous years. Contaminated groundwater did not affect private water supplies or the St. Charles County Well Field. Surface water containing elevated uranium activity continued to impact the Femme Osage Slough and several lakes in the August A. Busch Memorial Wildlife Area. Elevated radon exposures at the Weldon Spring Quarry continued in 1989 due to the unusually dry conditions. Off-site gamma, radon and air particulate exposures remained indistinguishable from background. Off-site monitoring demonstrated that exposure at the Francis Howell High School, the Busch Wildlife Area Headquarters, and the Weldon Spring Training Area is indistinguishable from background levels. No spills occurred at the Weldon Spring Site in 1989.

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1 INTRODUCTION

This report presents the findings of the environmental monitoring program conducted at the Weldon Spring Site (WSS) in 1989. Annual environmental monitoring reports have been prepared for this site (or portions thereof) since 1981. The WSS is part of the 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 hectares (ha) (51, 166, and 9 acres), respectively. The WSRP and WSCP areas are contiguous. The WSQ is approximately 6.4 kilometers (km) (4 miles) to the south-southwest.

When custody of the WSCP was transferred in 1985 from the 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 mission under SFMP, the WSSRAP will eliminate potential hazards to the public and the environment and make surplus real property available for other uses.

During the years 1981 through 1985, the WSRP and WSQ were under DOE caretaker status. The WSCP was controlled by the DA. The DOE conducted environmental monitoring programs during this period to identify changes (if any) in the radiological levels in and around the WSRP and WSQ. The DA did not collect environmental monitoring data in and around the WSCP. When the WSCP was transferred to the DOE in 1985, the DOE began revision of the overall Environmental Monitoring Program to more

adequately determine the levels of contamination in and around the WSCP, WSRP, and the WSQ. A description of the WSS environmental monitoring program for 1989 is provided in Section 1.4 of this report.

DOE Order 5400.1 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. The only permit in effect at the WSS in 1989 was the National Pollutant Discharge Elimination System (NPDES) - Storm Water Runoff Permit Number MO-0107701. Compliance with this permit is discussed in Section 2.2.1 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 environmental monitoring program meets the requirements of the 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 1989. Section 2 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 is presented in Appendix A.

In addition to the routine environmental monitoring conducted in 1989, 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 3.

Section 4 presents the results of calculations, based on the 1989 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.

For definitions of selected terms used in this report, the reader may consult Appendix B. 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 C. Appendix D contains a description of the quality assurance methods that are applied to sampling and analysis activities in this monitoring program. Appendix E presents a discussion of the environmental guidelines that apply to the monitoring program. Appendix F provides a useful conversion table, and Appendix G 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 1989. These activities provide information on the types and magnitudes of the contamination. The complete picture of characterization information will be

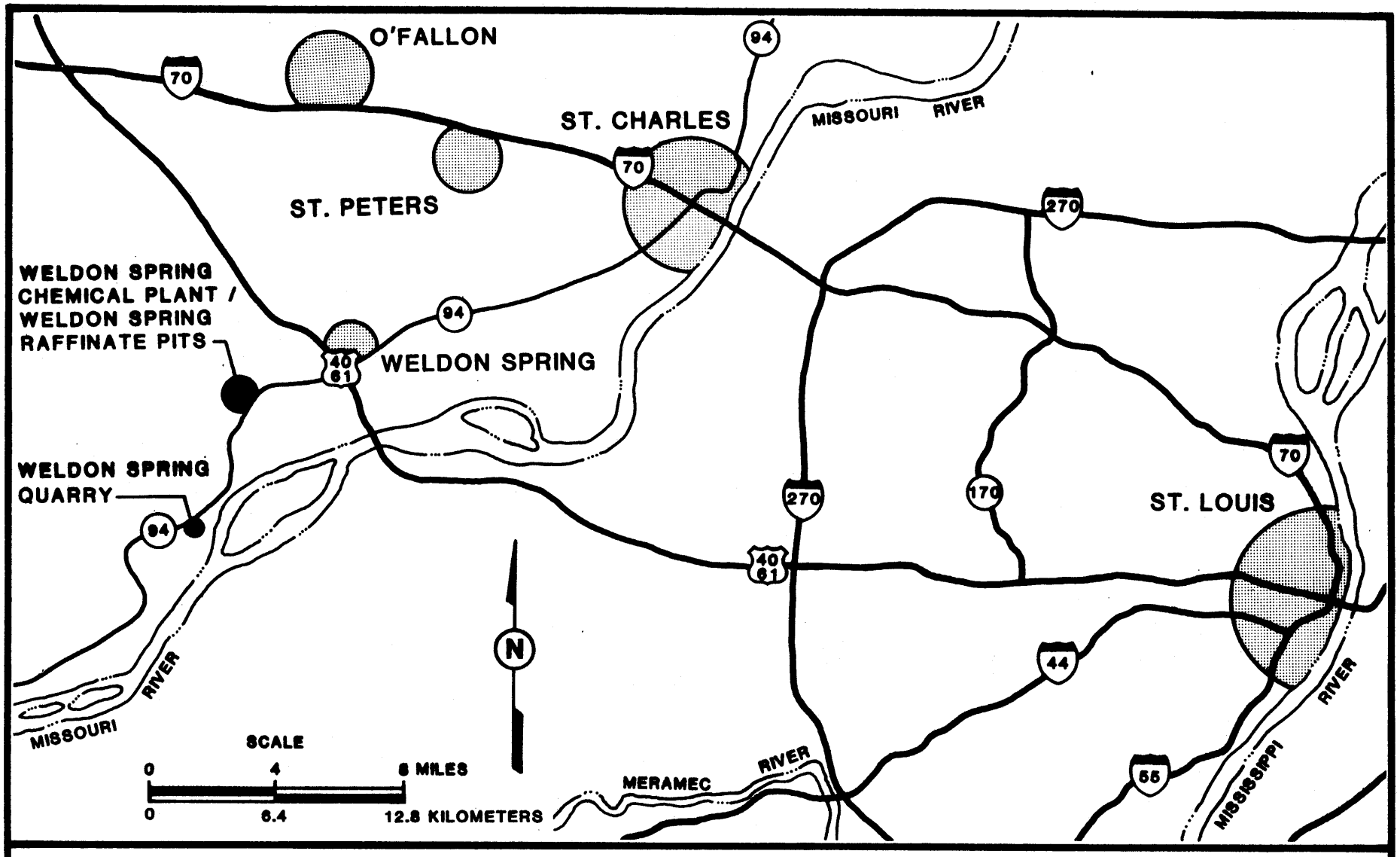


FIGURE 1-1

LOCATION OF THE WELDON SPRING SITE

presented in a Remedial Investigation (RI) report scheduled to be completed in 1990 and 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 an aerial view of the WSRP area with part of the WSCP in the background. The 20.7-ha (51-acre) area includes four pits that cover approximately 10.5 ha (26 ac) (see Figure 1-3). The raffinate pits were constructed by excavating into the existing clay soils and using the removed clay for construction of dikes. These pits contain radioactive residues (raffinates) from uranium and thorium processing operations at the former Weldon Spring Uranium Feed Materials Plant (WSUFMP) which is now the WSCP.

Access to the area is controlled by a 2.1-meter (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 1989 monitoring year, surface water covered the vast majority of the residues in the pits.

Weldon Spring Chemical Plant

The 67.2-ha (166-ac) WSCP is located to the north and east of the WSRP area (Figure 1-3). The WSCP, which operated as the Weldon Spring Uranium Feed Materials Plant until 1966, comprises 13 major buildings and 27 smaller buildings. Of the former, five

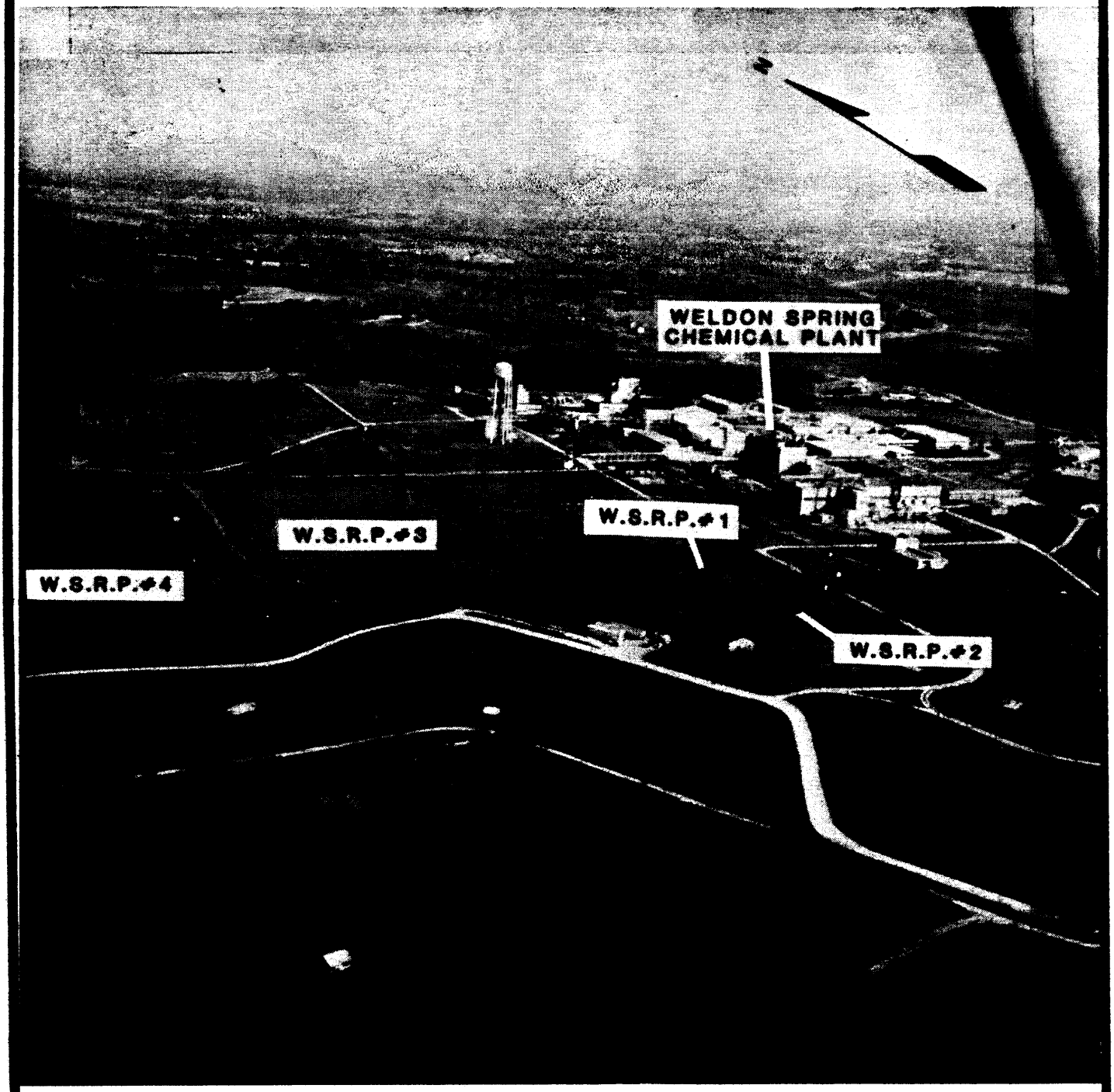


FIGURE 1-2

AERIAL PHOTOGRAPH OF THE WSRP AREA

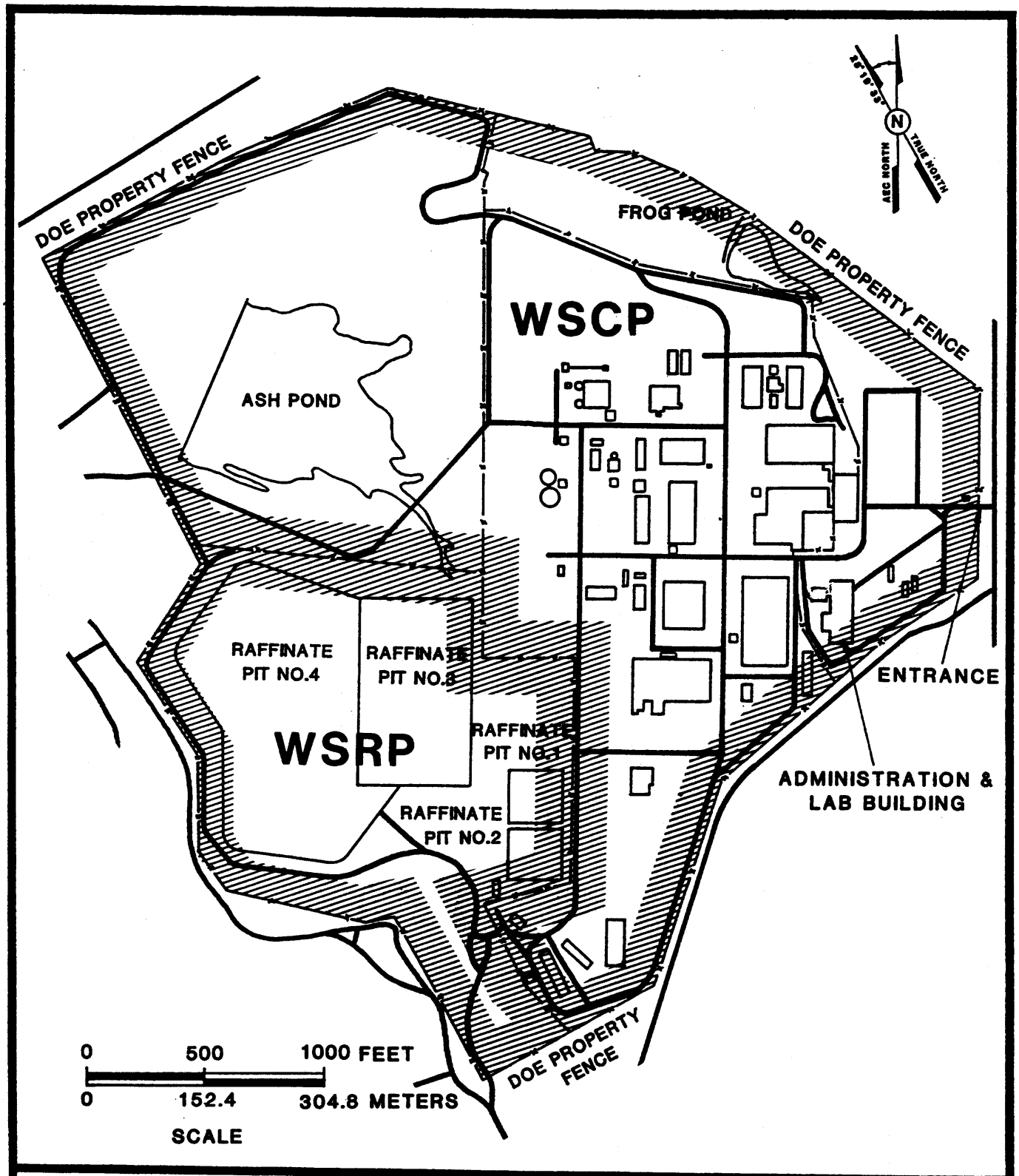


FIGURE 1-3

MAP OF THE WSCP & WSRP

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 hours per 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. These drainageways are more thoroughly discussed in Sections 1.3 and 2.2.

Small quantities of 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), dinitrotoluene, 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 RI report.

Weldon Spring Quarry

The WSQ, an abandoned 3.6-ha (9-ac) limestone quarry, is located approximately 6.4 km (4 mi) south-southwest of the WSRP/WSCP area. Figure 1-4 is an aerial photograph of the WSQ. As shown in Figure 1-5, the WSQ is accessible at both the upper and lower levels from Missouri State Route 94. An unused

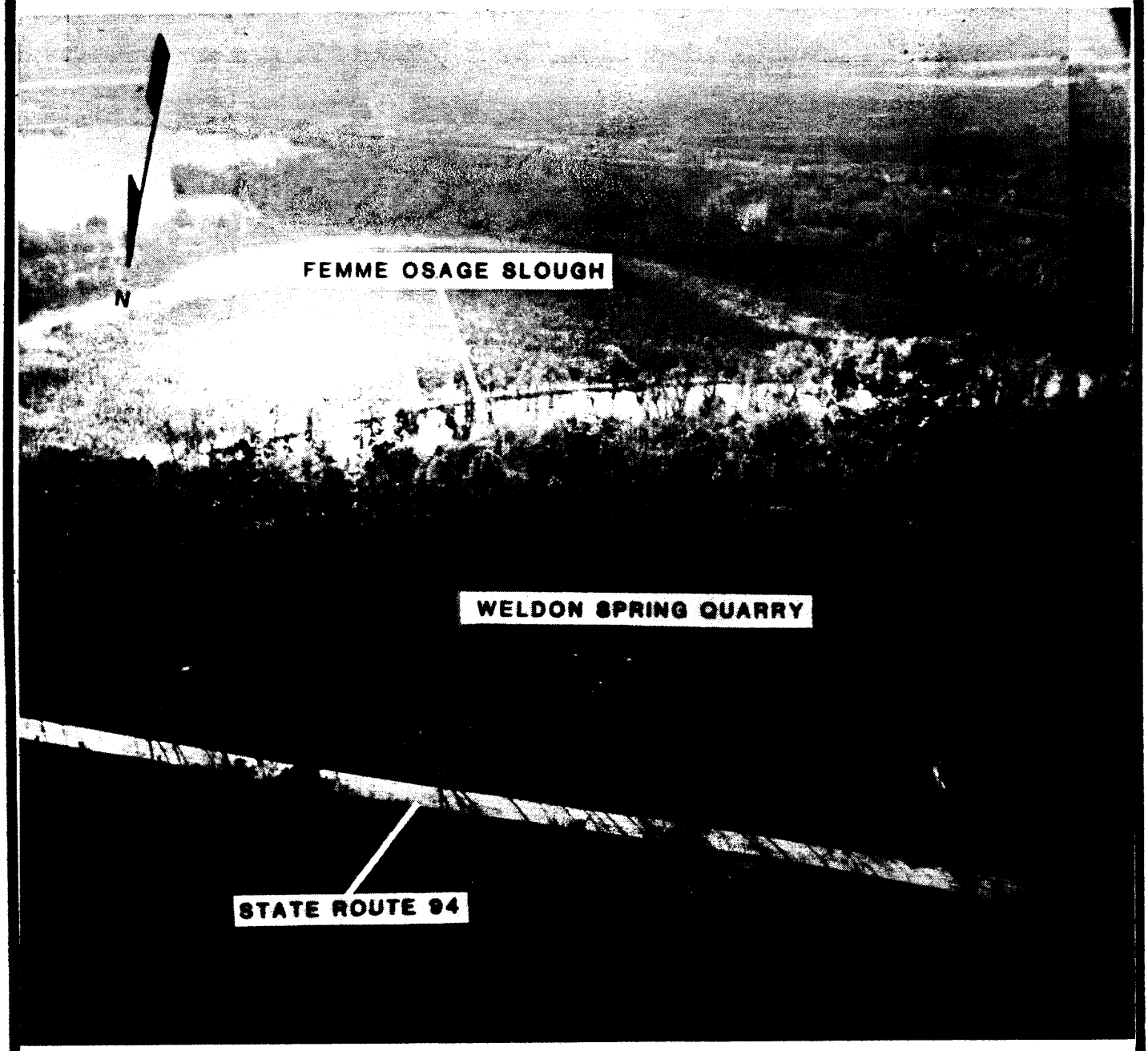


FIGURE 1-4

AERIAL PHOTOGRAPH OF THE WSQ

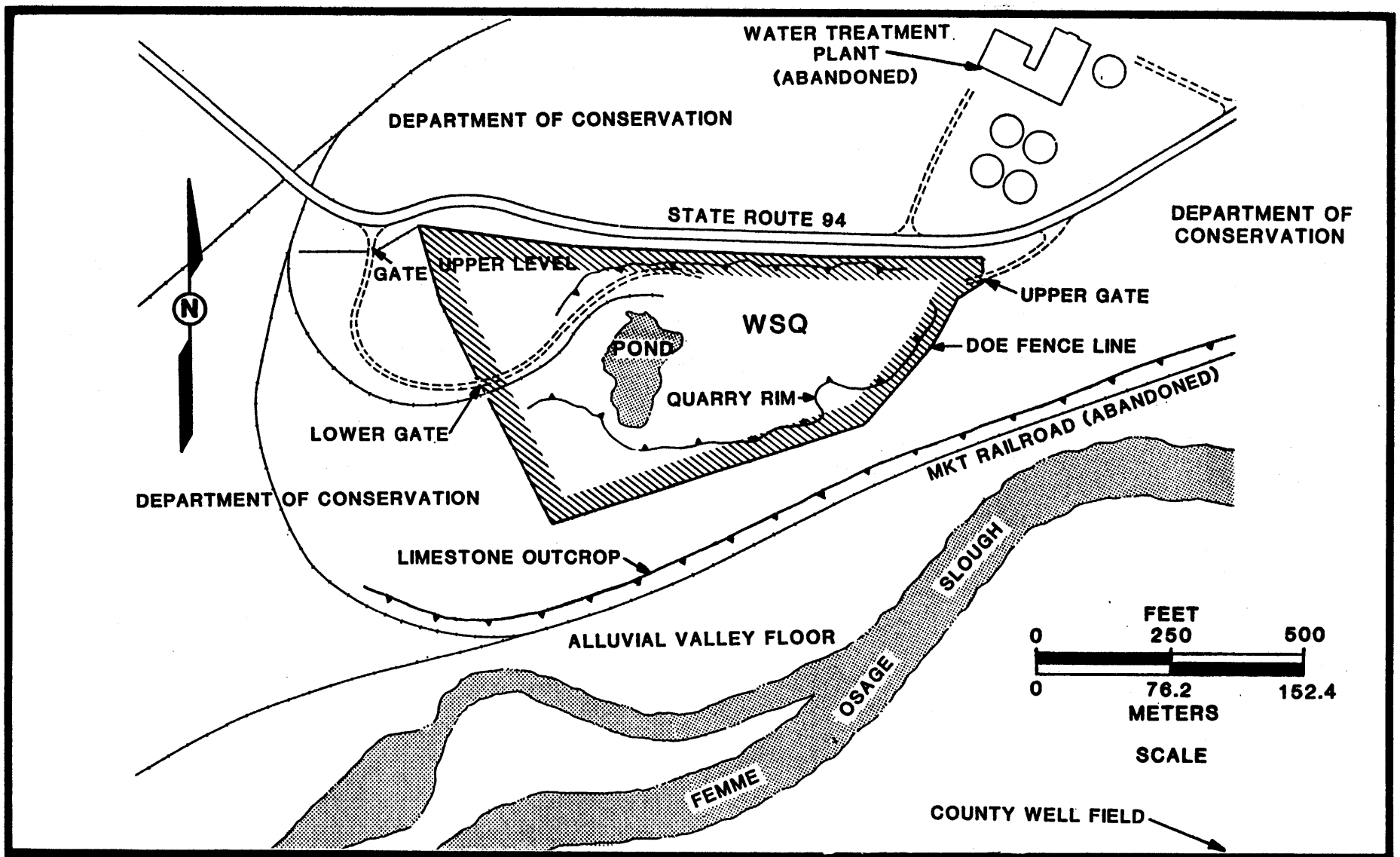


FIGURE 1-5

MAP OF THE WSQ

railroad spur enters the site at the lower level and extends approximately one-third of the way into the WSQ. 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 ac). The pond contains approximately 12 million liters (3 million gallons) 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, 1989b).

1.2 Site History

The WSS has a complex history of production processes within its boundaries. Between 1941 and 1944, the 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 Weldon Spring Training Area). The WSOW produced dinitrotoluene and trinitrotoluene (DNT and TNT) for the Allied Forces during World War II.

In 1955, 83 ha (205 ac) of the former ordnance works property was transferred to the Atomic Energy Commission (AEC) for construction of the Weldon Spring Uranium Feed Materials Plant (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 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 Weldon Spring Site Remedial Action Project (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, power pole and wire removal, nonprocess-building demolition, Ash Pond isolation, and containerized chemical consolidation. Section 3.2 of this report details the interim response actions (IRAs) in process or completed during 1989.

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 as of autumn of 1987. In 1989, the environmental documentation process necessary to begin the excavation of the bulk waste from the WSQ was 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 Remedial Investigation reports for the WSQ and the WSCP/WSRP prepared by and available from 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 RI/FS-EIS Work Plan for the WSS (MKF and JEG, 1988a). 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 to 9 m (3 to 30 ft) thick.

Burlington-Keokuk cherty limestone is the first bedrock unit and the first aquifer underlying the WSCP/WSRP. Bedrock topography varies in elevation from about 178.3 m (585 ft) National Geodesic Vertical Datum (NGVD) to 193 m (635 ft) NGVD.

The Burlington-Keokuk limestone is vertically fractured with two primary joint sets trending between N30°E and N72°E and between N30°W and N65°W (Roberts, 1951) and is susceptible to natural solution processes. Burlington-Keokuk solution features normally develop along fractures and bedding planes. Most solution features are small (up to several centimeters wide) and may or may not be clay filled.

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 combines 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. Dardenne Creek, portions of Schote Creek, and lakes on the August A. Busch Memorial Wildlife Area 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.

Sediments along the Missouri River vary from clays and silts through sands, gravels, cobbles, and boulders. The maximum alluvium thickness near the WSQ is approximately 30 m (100 ft). The alluvium "pinches out" at the base of the bedrock bluffs along the now-abandoned Missouri-Kansas-Texas (MKT) rail line. The alluvium thickness increases dramatically as distance from the Missouri River valley wall increases and then levels out.

Approximately 210 m (700 ft) to the south of the WSQ, toward the Missouri River, lies a 2.4 km (1.5 mi) section of the original Femme Osage Creek that was dammed at both ends between 1960 and 1963 by the University of Missouri. This section is now called the Femme Osage Slough. Southwest of the slough lies the area of floodplain alluvium from which St. Charles County draws its drinking water. Eight production wells are in this area, of which only five usually operate at one time. Average production from the well field is about 40 million liters (10 million gallons) per day.

Figure 1-6 shows silts and clays with minor amounts of sand as the primary sediments between the bluff and the Femme Osage Slough. The water-producing sands and gravels, 15 to 20 m (50 to 60 ft) thick, appear to pinch out southeast of the slough near the WSQ.

The WSQ bedrock consists of three distinct Ordovician formations. In descending order, they are the Kimmswick Formation, the Decorah Formation, and the Plattin Formation. The Bushberg Formation (the lowermost Mississippian formation in the area of the WSS) overlies the Kimmswick Formation to the north, west, and east of the WSQ at higher elevations but is not present at the WSQ.

With the exception of the Missouri River floodplain to the south, the topography of the WSQ area is rugged. Surface drainage in the area flows to the Missouri River, 1.6 km (1 mi) to the east, through the Femme Osage Creek and Little Femme Osage Creek (Figure 1-7).

Groundwater Occurrence

Groundwater in the vicinity of the WSRP and WSCP areas occurs in two separate zones: perched lenses and the underlying bedrock. Perched groundwater is present in small, isolated deposits of coarse-grained glacial drift.

A groundwater divide at the WSCP/WSRP trends roughly northeast to southwest through the eastern portion of the plant. Groundwater in the Burlington-Keokuk Formation flows to the northwest and to the southeast on opposite sides of the divide. Groundwater contamination sources include the raffinate pits, Ash and Frog ponds, and losing streams draining the site. The

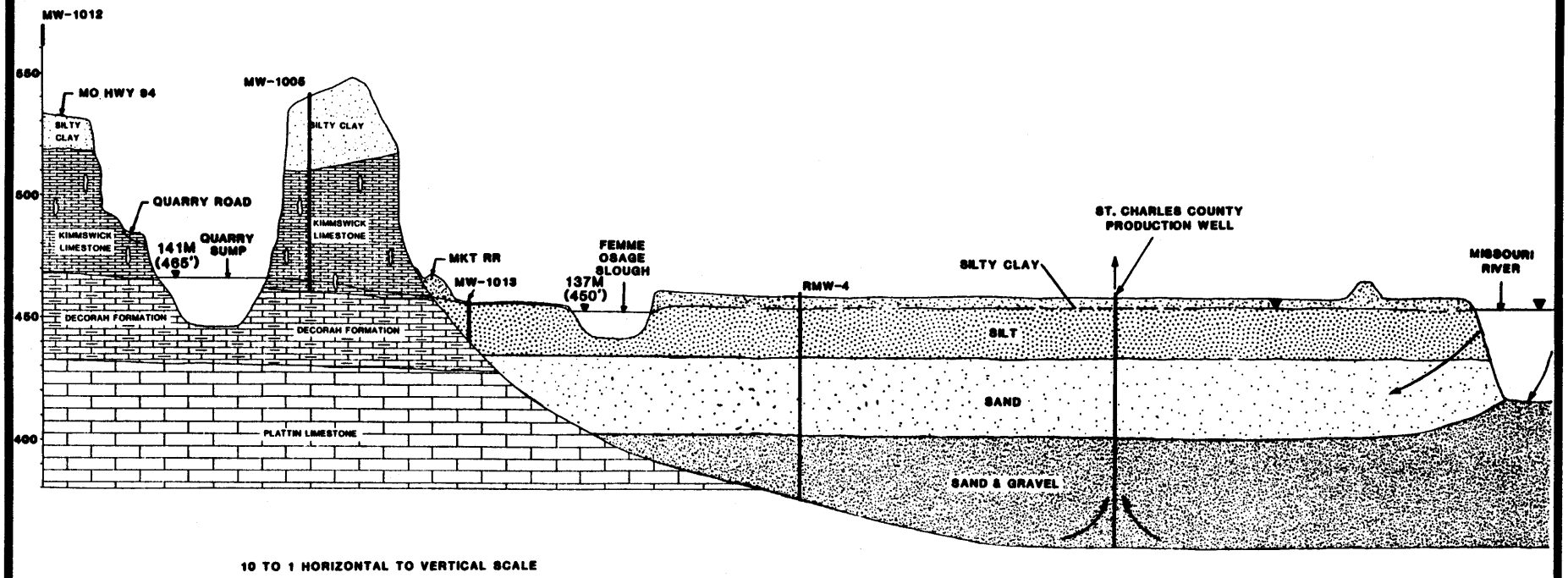


FIGURE 1-6

TYPICAL HYDRO-GEOLOGIC CROSS-SECTION OF WSQ AREA

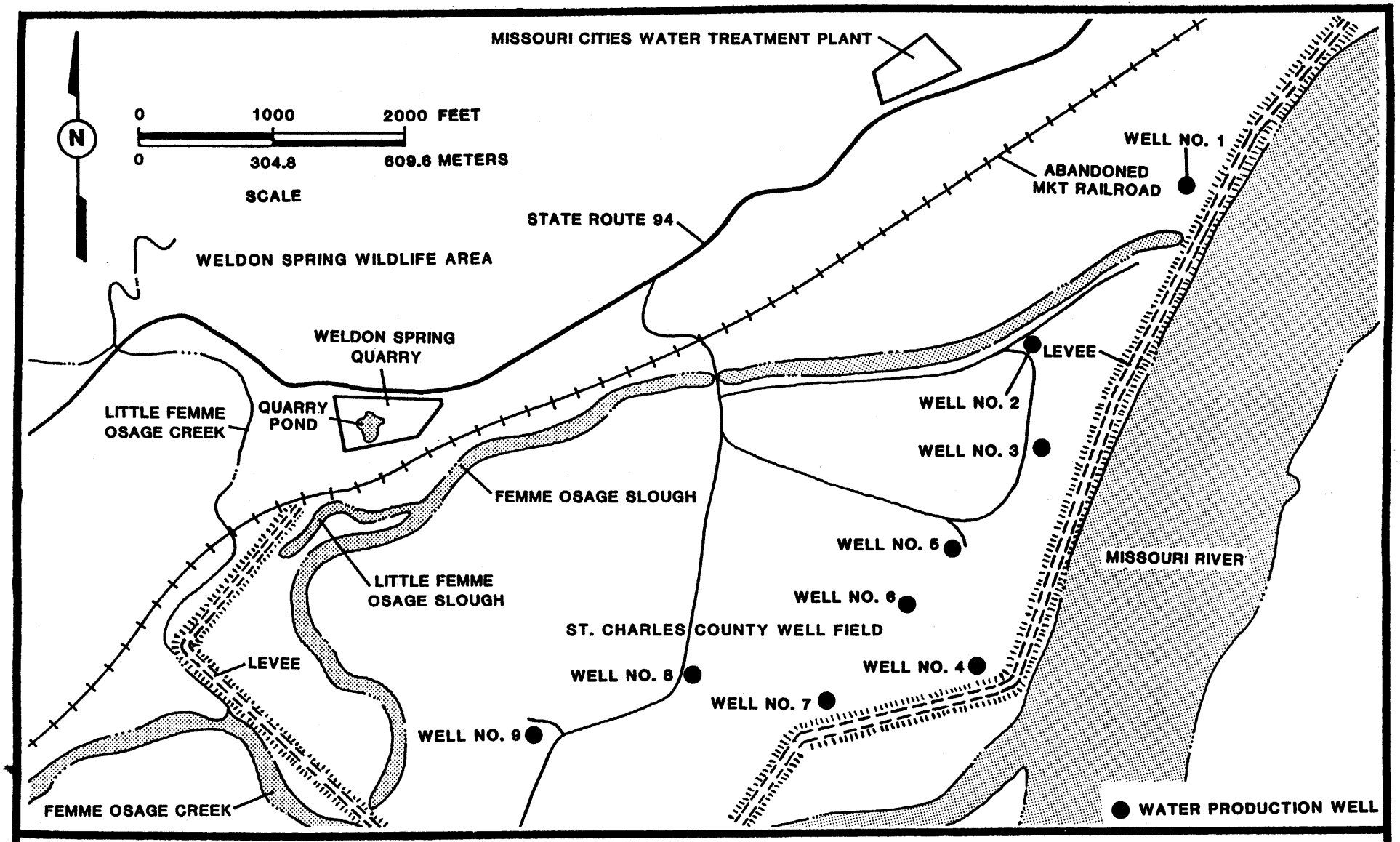


FIGURE 1-7

WELDON SPRING QUARRY & ST. CHARLES COUNTY WELL FIELD

Burlington-Keokuk Formation is not a heavily utilized aquifer, but private wells do supply households in rural areas. No private wells are currently utilized in the Burlington-Keokuk Formation within 2 km (1.25 mi) of the WSCP/WSRP.

Groundwater in the WSQ vicinity occurs both in bedrock and Missouri River alluvium (Figure 1-6). Groundwater flow near the WSQ is influenced by the Missouri River and pumpage from the St. Charles County well field, and varies with river stages and pumping rates. These production wells are controlled and monitored under public drinking water regulations. No additional active water supply wells are completed in the alluvial aquifer near the WSQ.

Local Climate Summary

The climate in the WSS area is continental, with moderately cold winters and warm summers. Alternating warm/cold, wet/dry air masses converge and pass eastward through the area almost daily. Normal annual precipitation in the area is approximately 85 centimeters (cm) (39 in.), with the heaviest rainfall occurring in spring and early summer. The total measured precipitation at the WSCP in 1989 was 72 cm (28.5 in.). The average temperature is 13° C (56° F). Prevailing winds in the vicinity of the WSS are from the south during the summer and fall. Wind speeds during these months average 13.9 km/h (8.7 mph). Winds during the winter months are from the northwest and west-northwest, averaging 17.6 km/h (11 mph) (GRC, 1985).

1.4 Summary of 1989 Environmental Monitoirng Activities

The 1989 Environmental Monitoring Program was carried out in order to identify, characterize and monitor release pathways for

both radiological and chemical constituents. Following the extensive characterization efforts conducted in 1988 as part of the remedial investigations of the site, an expanded quarterly monitoring program was instituted to collect additional data to allow for evaluation of seasonal or time based trends in contaminant concentrations. Groundwater sampling locations were added to the previous year's monitoring program to include the extended monitoring well network.

The surface water monitoring program was modified to include three additional locations on the Missouri River, one location at the west end of the Femme Osage Slough and additional on-site surface water bodies. Samples were collected quarterly at each location.

The program is dynamic, changing to meet the monitoring needs of the site as new physical and analytical data are assimilated and as release pathways are better understood. These release pathways include groundwater (via subsurface migration), surface water (via storm-water runoff), and air.

In 1989, 91 monitoring wells were sampled, compared with 50 wells sampled in 1988. This includes 59 wells installed at the chemical plant and raffinate pits, and 32 wells at the WSQ.

Surface water samples were collected from a total of 45 locations where measurable impacts from drainage originating at the Weldon Spring Site might be detected. These samples include 39 quarterly sampling locations and samples of storm water runoff from the six permitted outfalls at the WSCP and WSRP as required by the National Pollutant Discharge Elimination System (NPDES) Permit (storm water) for the Weldon Spring Site. The 39

quarterly sampling locations include 13 around the WSQ and 26 around the WSCP and WSRP.

A total of 22 locations were monitored quarterly for radon gas and external gamma exposure. Duplicate radon gas detectors were installed at each location to improve the precision and accuracy of the measurements. Four additional off-site monitoring locations were used to determine annual average background gamma exposure rates and radon concentrations near the WSSRAP.

Air particulate sampling for radiological parameters at the site perimeter continued on a weekly basis through 1989. Two new sampling stations were installed at the WSQ perimeter. A third station was installed one-half mile west (up prevailing wind direction) to provide background measurements. The air was monitored at these locations to establish ambient baseline data and to monitor for potential off-site releases. Data from this program will also be used to assess the effectiveness of engineering controls at the site during future remedial action activities.

1.5 Compliance Summary

The PMC is responsible for the management of hazardous waste at WSSRAP including the characterization, consolidation, inventory, storage, transportation, and disposal of hazardous and other wastes that remained on-site after closure of the WSUFMP and for wastes generated during remedial action activities. All WSSRAP waste management activities are performed in accordance with the Resource Conservation and Recovery Act and the Toxic Substances Control Act (RCRA and TSCA), as well as Occupational Safety and Health Act, (OSHA), Department of Transportation (DOT)

and Missouri regulations concerning the storage, labeling, transport and disposal of hazardous materials, and DOE Order 5820.2A, Radioactive Waste Management.

Compliance issues were determined through continuing internal evaluation and a series of audits conducted by the DOE and the PMC. These issues, their resolution and status are presented in Table 1-1 and the open issues explained in more detail in the text. Those issues identified as closed in Table 1-1 are considered closed by the PMC/DOE WSSRAP Office. Only four of 19 compliance issues remain open at this time. These issues should be resolved in 1990; they are described in the following subsections.

1.5.1 Improper Storage of PCB Contaminated Materials (40 CFR 761.65)

Issue: All non-radiologically contaminated PCB articles have previously been removed and appropriately disposed of by off-site treatment, storage, and disposal facilities. Except for the capacitors in Building 301, the remaining PCB-contaminated equipment has been placed in proper storage, labelled, and inspected weekly. The capacitors in Building 301 are stored in a cabinet and offer minimal threat of release.

Corrective Action: The capacitors are labelled and inspected monthly, and are scheduled for removal during the first half of 1990 through the ongoing chemical containerization interim response action at WSSRAP (Section 3.2.5).

TABLE 1-1 Regulatory Compliance Summary

Issue	Regulation	Resolution/Date	Status
Inadequate separation of wastes	40 CFR 264.177(o)	Proper storage in Bldg 434 - 04/90	Closed
Run-on into waste storage area	40 CFR 264.175(b)(4)	Proper storage in Bldg 434 - 04/90	Closed
Inadequate aisle space	40 CFR 264.35	Proper storage in Bldg 434 - 04/90	Closed
Inadequate characterization of wastes	40 CFR 264.13(a)(1)	Wastes are being characterized - 05/90	Closed
Waste Analysis Plan inadequately describes methods	40 CFR 264.13(a)	Waste Analysis Plan revised - 05/90	Closed
Inadequate inspection records	40 CFR 264.15(d)	Procedure revised 11/89	Closed
Contingency Plan did not address emergencies	40 CFR 264.52	Plan revised 04/90	Closed
Improper storage of PCB contaminated RCRA liquid	40 CFR 761.65	Containment Structure built 11/89	Closed
Improper storage of PCB contaminated materials	40 CFR 761.65	Routine inspection/ labelling-Removal planned for 1990	Open
Storage of PCB contaminated material in excess of 1 year	40 CFR 761.61a	Removal scheduled for 1990	Open
Annual PCB Report not completed by July 1	40 CFR 761.180	Report submitted 11/89	Closed
PCB items not inspected every 30 days	40 CFR 761.65(c)(5)	Inspections performed 09/89	Closed
PCB items not properly labelled	40 CFR 761	Items properly labelled	Closed
Radionuclide emission monitoring not confirmed by EPA as suitable for NESHAP	40 CFR 61.93	Under discussion with EPA	Open
Inadequate water supply for RCRA storage	40 CFR 264.32(d)	Sprinkler system in Building 434	Closed

TABLE 1-1 Regulatory Compliance Summary (Continued)

Issue	Regulation	Resolution/Date	Status
Receipt of improper radiological shipment	49 CFR 172.20, .300, .400, 173.400	Vehicle surveyed; no contamination	Closed
Offsite release of radionuclide	Clean Water Act (CWA) Section 311(b)(1)	CWA satisfied. Ongoing remedial action (Ash Pond Diversion 05/89)	Closed
Offsite release of nitroaromatic compounds	Clean Water Act Section 311(b)(1)	CWA satisfied. Ongoing remedial action	Closed
Storage of PCB and land ban wastes beyond 1 year	40 CFR 761.65(a) and 268.50(a)	Destruction scheduled for 1990	Open

1.5.2 Storage of PCB Contaminated Material in Excess of the One Year Limit (40 CFR 761.61a)

Issue: Remaining PCB capacitors and equipment have been stored for more than one year. These items remained from WSUFMP operation and were recently identified and characterized.

Corrective Action: All PCB contaminated capacitors and equipment currently in temporary storage are properly labelled and inspected weekly. They are scheduled to be radioactively decontaminated and removed during the first half of 1990 as a part of the chemical containerization interim response action.

1.5.3 Storage of PCB and Land Ban Wastes Beyond the One Year Storage Requirement (40 CFR 761.65(a) and 40 CFR 268.50(a))

Issue: There are approximately 7,400 gallons of tributyl phosphate (TBP) stored at WSSRAP which is RCRA and TSCA regulated as well as being contaminated with radionuclides. The TBP remains stored in the same two tanks it was placed in during the late 1960s.

Corrective Action: WSSRAP is addressing this issue in three ways. The primary effort involves dialogue with the Oak Ridge Gaseous Diffusion Plant (ORGDP) to have the TBP prioritized for destruction by their permitted incinerator. In October, the WSSRAP resampled the material to verify that it meets ORGDP's analytical acceptance criteria, and the results were forwarded to ORGDP in eary 1990.

Another approach has been to reply to an ORO request for input seeking a nationwide extension for storage of

radiologically contaminated land ban waste. Also a request to EPA Region VII for a variance from the storage requirements for radiologically contaminated land ban and PCB wastes was submitted in eary 1990.

1.5.4 Radionuclide Emissions Monitoring that is Currently Conducted at Weldon Spring Does Not Meet the Requirement for the Radionuclide NESHAPS (40 CFR 61.93)

Issue: The WSSRAP is currently using an environmental monitoring network which monitors the source (the entire WSS). However, the WSSRAP is not in strict compliance with NESHAPS requirements since it does not measure "annual air concentration where a maximally exposed individual resides."

Corrective Action: On March 18, 1989, WSSRAP personnel met with EPA Region VII personnel to outline the off-site Radionuclide Monitoring Plan. EPA Region VII agreed that the proposed monitoring plan would meet the requirements of 40 CFR 61, and the regional EPA staff will brief EPA Headquarters. Region VII will then convey Headquarters' comments to the WSSRAP during 1990. If the Radionuclide Monitoring Plan is acceptable, the PMC will issue the proposed monitoring plan in writing for EPA approval. This written plan will be completed and reviewed by the WSSRAP DOE in 1990.

2 ENVIRONMENTAL MONITORING RESULTS

Environmental monitoring is the first line of defense in protecting the public and environmental health and safety. Additionally, environmental monitoring is done to ensure that any potential public exposure is documented and quantified, and to demonstrate compliance with applicable legal and regulatory requirements; to confirm adherence to the U.S. Department of Energy (DOE) environmental protection policies; and to support environmental management decisions.

This portion of the report presents monitoring results and includes discussions about the environmental conditions at the Weldon Spring Site (WSS). The Weldon Spring Remedial Action Project (WSSRAP) is moving toward compliance with DOE Order 5900.2 by presenting parenthetically the standard international (SI) units following the more commonly used unit for these measurements. The WSSRAP is phasing into full compliance by the year 1992 as DOE Order 5900.2 requires.

2.1 Groundwater Monitoirng

All Weldon Spring Chemical Plant/Raffinate Pits/Vicinity Properties (WSCP/WSRP/WSVP) and Weldon Spring Quarry (WSQ) monitoring wells were sampled at least annually during 1989. Wells installed during 1988 or wells of particular importance or interest were sampled quarterly. Through routine monitoring and investigations at the site, an understanding of groundwater quality and hydrogeology has been established over the past several years. Therefore the groundwater monitoring program has been changed since earlier years and made more efficient by avoiding unnecessary or redundant sampling and analysis. Through

these modifications, a high quality program which effectively assesses the groundwater quality has been maintained.

The WSSRAP continues to monitor for uranium, inorganic anions (nitrate, sulfate, chloride, fluoride), and nitroaromatic compounds in the groundwater. Six nitroaromatic compounds have been associated with the WSOW; 1,3,5-trinitrobenzene, 1,3-dinitrobenzene, nitrobenzene, 2,4,6-trinitrotoluene, 2,4-dinitrotoluene and 2,6-dinitrotoluene.

Data tables of all laboratory analytical results presented in this section contain annual concentrations calculated from data generated during 1989 where more than one analysis was conducted. These values are usually compared to background concentrations and/or to U.S. Environmental Protection Agency (EPA) or DOE guidelines. The guidelines are for discussion purposes and may not be strictly applicable. The annual concentration is stated in each column with a fraction in parentheses adjacent to that value. The numerator is the number of samples used to calculate the annual concentration. If only one sample was collected, it was reported as the annual concentration. The denominator is the number of times that particular well was sampled during 1989. An "ND" indicates "Not Detected" and appears only if a particular parameter was not detected above the detection limit in any analyses done on samples obtained from that well during 1989. 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. Individual quarterly results are presented in data tables in Appendix A.

Groundwater quality trend analyses are presented in this report. Chemical and radiological concentrations for each monitoring well included in the monitoring program in 1987, 1988,

and 1989 are presented graphically. Uranium, nitroaromatic compounds, nitrate, and sulfate data were analyzed for trends at both the WSCP/WSRP/WSVP and the WSQ areas, and are presented in this section.

Groundwater monitoring wells are grouped in the trend analyses by location on the horizontal axis of the graph while parameter concentrations are listed on the vertical axis. Symbols representing the annual concentrations for 1987, 1988, and 1989 are plotted for each well. For each well sampled, a symbol appears on the graph at a point intersecting the vertical location line and the horizontal concentration line for that year. The graphic analysis enables the reader at a glance to see consistencies or fluctuations over time.

2.1.1 Groundwater Monitoring at the Weldon Spring Chemical Plant/Raffinate Pits

Groundwater at the WSCP/WSRP became contaminated as a result of the Weldon Spring Ordnance Works (WSOW) operations during World War II and operations at the Uranium Feed Materials Plant during the 1950s and 1960s. The Phase I Water Quality Assessment Report (MKF and JEG, 1987) reported that: "groundwater near the raffinate pits contains elevated amounts of uranium; 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, 1989a), an expanded, comprehensive evaluation of groundwater quality at the WSCP/WSRP/WSVP 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 consists of 59 wells, 28 at the WSCP, eight at the WSRP, and 23 at the WSVP. Figure 2-1 shows the locations of individual wells in the WSCP/WSRP/WSVP monitoring well network. All of these wells are screened in the uppermost unconfined aquifer. The wells are completed in a range of depths in order that the entire uppermost aquifer is monitored. Detailed well construction information for individual wells is available in the 1990 Environmental Monitoring Plan (MKF and JEG, 1990a).

2.1.1.1 Radiological Results

The upper bound for natural uranium background concentrations in groundwater at the WSCP/WSRP/WSVP was determined to be 3.4 pCi/l (0.125 Bq/l) (MKF and JEG, 1989a). EPA has not yet established drinking water standards for uranium; however studies leading to proposed rulemaking are using uranium in the 10 to 40 pCi/l (0.37 to 1.48 Bq/l) range (MKF and JEG, 1989a). The DOE has a derived concentration guideline (DCG) of 550 pCi/l (20.35 2Bq/l).

Each groundwater monitoring well was sampled and analyzed for total natural uranium during 1989. Table 2-1 provides the annual concentrations.

Forty-five of the groundwater monitoring wells have total uranium concentrations below the upper bound for natural background. Eight monitoring wells--MW-2003, MW-2020, MW-2028,

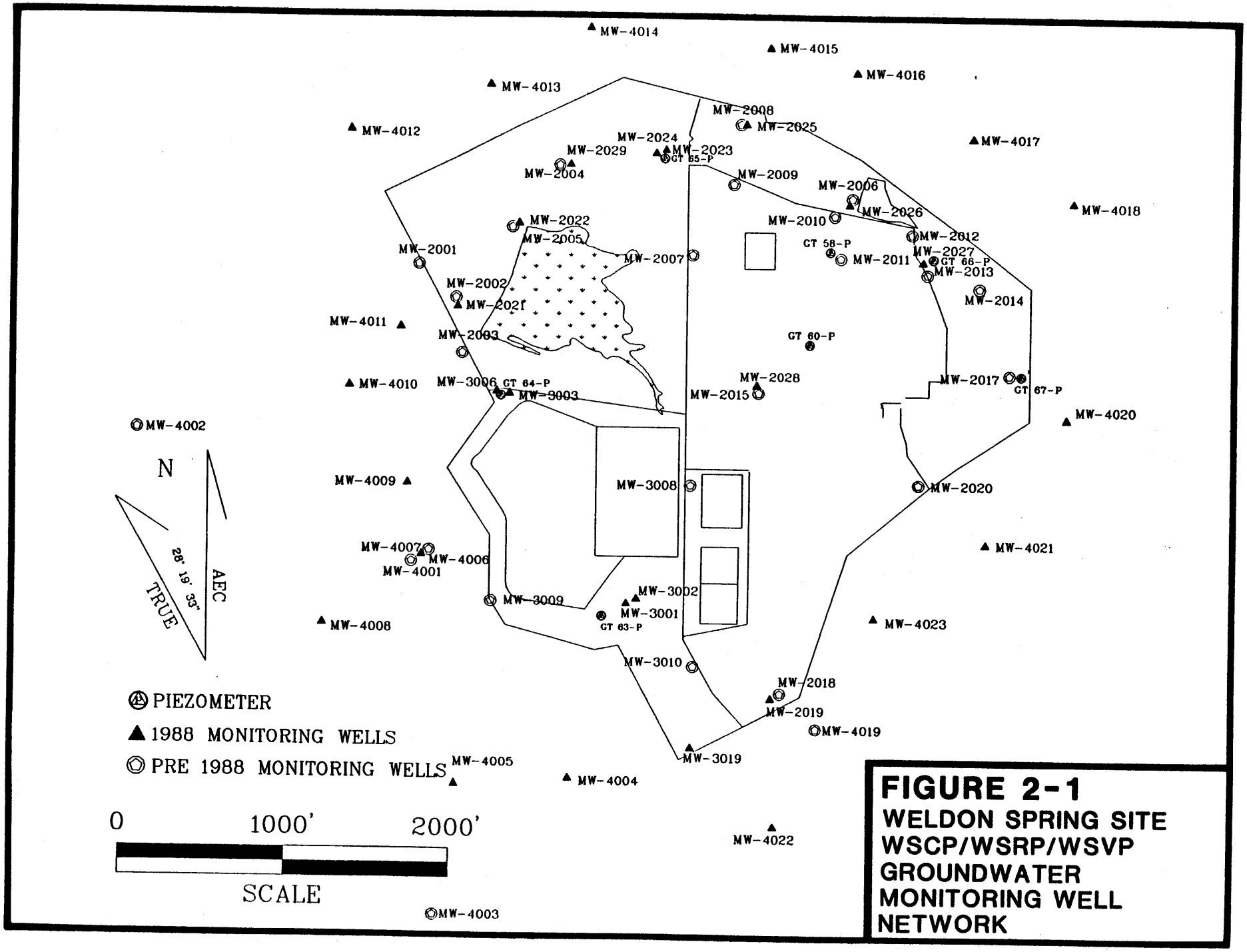


FIGURE 2-1
WELDON SPRING SITE WSCP/WSRP/WSVP GROUNDWATER MONITORING WELL NETWORK

TABLE 2-1 Summary of 1989 Data for Inorganic Anions and Uranium, Weldon Spring Chemical Plant/Raffinate Pits

	Chloride mg/l (0.25)*		Fluoride mg/l (0.25)*		Nitrate mg/l (0.1)*		Sulfate mg/l (1.0)*		Total Uranium pCi/l (1.0)*	
GW-2001	5.80	(1/1) @	ND	(1/1)	50.20	(1/1)	5.80	(1/1)	1.80	(1/1)
GW-2002	7.10	(1/1)	ND	(1/1)	1010.0	(1/1)	95.0	(1/1)	ND	(1/1)
GW-2003	17.20	(1/1)	ND	(1/1)	3330.00	(1/1)	288.00	(1/1)	3.60	(1/1)
GW-2004	1.30	(1/1)	ND	(1/1)	3.80	(1/1)	1.90	(1/1)	1.90	(1/1)
GW-2005	1.60	(1/1)	ND	(1/1)	117.00	(1/1)	3.40	(1/1)	2.40	(1/1)
GW-2006	278.00	(1/1)	ND	(1/1)	29.05	(2/2)	32.40	(1/1)	ND	(1/1)
GW-2007	0.80	(1/1)	ND	(1/1)	ND	(1/1)	14.10	(1/1)	2.40	(1/1)
GW-2008	108.00	(1/1)	ND	(1/1)	16.00	(1/1)	39.50	(1/1)	ND	(1/1)
GW-2009	17.60	(1/1)	ND	(1/1)	6.30	(1/1)	99.20	(1/1)	2.90	(1/1)
GW-2010	82.60	(1/1)	ND	(1/1)	4.30	(1/1)	42.80	(1/1)	1.10	(1/1)
GW-2011	7.70	(1/1)	ND	(1/1)	0.80	(1/1)	37.30	(1/1)	ND	(1/1)
GW-2012	37.20	(1/1)	ND	(1/1)	4.00	(1/1)	415.00	(1/1)	1.00	(1/1)
GW-2013	4.60	(1/1)	ND	(1/1)	3.20	(1/1)	11.90	(1/1)	1.00	(1/1)
GW-2014	22.80	(1/1)	ND	(1/1)	9.00	(1/1)	34.80	(1/1)	1.00	(1/1)
GW-2015	1.40	(1/1)	ND	(1/1)	1.80	(1/1)	96.40	(1/1)	2.60	(1/1)
GW-2017	13.10	(1/1)	ND	(1/1)	1.50	(1/1)	1830.00	(1/1)	15.00	(1/1)
GW-2018	10.60	(1/1)	ND	(1/1)	2.30	(1/1)	9.50	(1/1)	3.10	(1/1)
GW-2019	1.95	(4/4)	0.26	(1/4)	ND	(4/4)	20.12	(4/4)	2.15	(4/4)
GW-2020	15.00	(1/1)	ND	(1/1)	3.70	(1/1)	144.00	(1/1)	9.00	(1/1)
GW-2021	1.15	(4/4)	0.14	(1/4)	ND	(4/4)	12.93	(4/4)	2.67	(3/4)
GW-2022	1.16	(4/4)	0.14	(1/4)	ND	(4/4)	13.98	(4/4)	1.83	(2/4)
GW-2023	1.25	(4/4)	0.25	(1/4)	0.27	(3/4)	32.15	(4/4)	2.77	(4/4)
GW-2024	1.83	(4/4)	0.29	(1/4)	ND	(4/4)	31.58	(4/4)	1.36	(1/4)
GW-2025	1.43	(4/4)	0.25	(1/4)	ND	(4/4)	16.90	(4/4)	1.64	(4/4)
GW-2026	1.38	(4/4)	0.16	(1/4)	0.50	(1/4)	13.05	(4/4)	2.58	(4/4)
GW-2027	1.18	(4/4)	0.17	(1/4)	0.31	(4/4)	12.6	(3/3)	1.73	(3/4)
GW-2028	2.28	(4/4)	0.24	(2/4)	ND	(4/4)	107.18	(4/4)	5.48	(4/4)
GW-2029	2.28	(3/3)	0.19	(1/3)	0.11	(1/4)	23.20	(4/4)	1.79	(4/4)
GW-3001	7.70	(4/4)	0.20	(1/4)	793.50	(4/4)	23.05	(4/4)	3.00	(2/4)
GW-3002	8.15	(4/4)	0.25	(1/4)	0.19	(2/4)	19.30	(4/4)	3.98	(4/4)
GW-3003	10.10	(4/4)	0.22	(1/4)	2036.00	(3/4)	176.75	(4/4)	13.33	(4/4)
GW-3006	5.78	(4/4)	0.28	(2/4)	64.43	(3/4)	59.93	(4/4)	2.07	(3/4)
GW-3008	8.80	(1/1)	ND	(1/1)	4010.00	(1/1)	43.60	(1/1)	5.90	(1/1)
GW-3009	2.60	(1/1)	ND	(1/1)	294.00	(1/1)	58.00	(1/1)	48.00	(1/1)
GW-3010	1.60	(1/1)	ND	(1/1)	5.50	(1/1)	7.60	(1/1)	2.10	(1/1)
GW-3019	1.07	(3/3)	0.25	(1/3)	0.40	(2/3)	7.37	(3/3)	7.61	(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.

* Detection Limit

@ Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1989. For example, 2.00 (2/4) indicates that 4 samples were taken in 1989, 2 of which average 2.00 and the other 2 samples were ND.

TABLE 2-1 Summary of 1989 Data for Inorganic Anions and Uranium, Weldon Spring Chemical Plant/Raffinate Pits (Continued)

	Chloride mg/l (0.25)*		Fluoride mg/l (0.25)*		Nitrate mg/l (0.1)*		Sulfate mg/l (1.0)*		Total Uranium pCi/l (1.0)*	
GW-4001	3.00	(1/1) @	ND	(1/1)	149.00	(1/1)	64.10	(1/1)	1.20	(1/1)
GW-4002	2.50	(1/1)	ND	(1/1)	9.00	(1/1)	25.20	(1/1)	ND	(1/1)
GW-4003	6.28	(4/4)	0.21	(1/4)	3.2	(3/4)	29.50	(4/4)	1.70	(1/4)
GW-4004	3.75	(4/4)	0.34	(4/4)	1.60	(4/4)	30.68	(4/4)	2.73	(4/4)
GW-4005	7.73	(4/4)	0.32	(2/4)	5.12	(4/4)	19.03	(4/4)	1.71	(4/4)
GW-4006	1.60	(1/1)	ND	(1/1)	21.90	(1/1)	32.90	(1/1)	ND	(1/1)
GW-4007	1.08	(4/4)	0.25	(1/4)	ND	(4/4)	12.90	(4/4)	1.70	(4/4)
GW-4008	1.25	(4/4)	0.36	(1/4)	ND	(4/4)	14.60	(4/4)	2.93	(3/4)
GW-4009	1.93	(3/3)	0.30	(2/3)	13.33	(3/3)	28.23	(3/3)	2.20	(3/3)
GW-4010	2.20	(4/4)	0.23	(1/4)	0.42	(4/4)	29.70	(4/4)	4.22	(3/4)
GW-4011	6.00	(4/4)	0.81	(2/4)	87.53	(4/4)	49.83	(4/4)	3.27	(3/4)
GW-4012	4.13	(4/4)	0.30	(1/4)	0.44	(2/4)	46.08	(4/4)	2.41	(4/4)
GW-4013	8.43	(4/4)	0.07	(1/4)	499.00	(4/4)	52.60	(4/4)	1.60	(2/4)
GW-4014	3.78	(4/4)	0.21	(1/4)	39.35	(4/4)	25.45	(4/4)	ND	(4/4)
GW-4015	2.63	(4/4)	0.12	(1/4)	8.78	(4/4)	7.43	(3/4)	1.35	(3/4)
GW-4016	4.43	(4/4)	0.19	(1/4)	ND	(4/4)	21.25	(4/4)	5.09	(4/4)
GW-4017	1.93	(4/4)	0.16	(1/4)	1.84	(4/4)	7.55	(4/4)	2.85	(4/4)
GW-4018	11.10	(4/4)	0.15	(1/4)	6.85	(4/4)	11.35	(4/4)	1.68	(3/4)
GW-4019	1.10	(1/1)	ND	(1/1)	0.84	(1/1)	8.90	(1/1)	1.50	(1/1)
GW-4020	8.58	(4/4)	0.22	(1/4)	2.84	(2/4)	133.00	(4/4)	23.33	(4/4)
GW-4021	1.55	(4/4)	0.15	(1/4)	ND	(4/4)	312.00	(4/4)	12.06	(4/4)
GW-4022	11.63	(4/4)	0.28	(1/4)	1.72	(4/4)	56.38	(4/4)	3.73	(3/4)
GW-4023	15.85	(4/4)	0.18	(1/4)	22.03	(4/4)	137.60	(4/4)	2.50	(3/4)

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

* Detection Limit

@ Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1989. For example, 2.00 (2/4) indicates that 4 samples were taken in 1989, 2 of which average 2.00 and the other 2 samples were ND.

MW-3002, MW-3008, MW-3019, MW-4010 and MW-4016--show annual concentrations above background but below 10 pCi/l. Four wells, MW-2017, MW-3003, MW-4020 and MW-4021 have annual concentrations of uranium in the 10 to 40 pCi/l range. Monitoring wells MW-3009 and MW-4004 have the highest annual concentrations, 50 and 70.50 pCi/l (1.85 and 2.59 Bq/l), 9% and 12% of the DCG respectively. Figure 2-2 highlights those wells with above background (3.4 pCi/l) annual natural uranium concentration. These results are generally consistent with 1988 monitoring and characterization results.

WSCP/WSRP/WSVP URANIUM TREND ANALYSIS

The annual average uranium concentrations reported in previous monitoring reports and this report are displayed for comparison in Figure 2-3. Since 1987, groundwater uranium concentrations generally has not varied dramatically. The exceptions to this are MW-2020 and MW-3009 each of which has both decreased and increased concentrations of uranium with time. The source of uranium contamination in these wells has not yet been removed; therefore it might be expected that concentrations of uranium in groundwater will continue to fluctuate until remedial action removes the source. Monitoring Well 2017 is the only well that continually increased from 1987 to 1989. The cause of this increase is not known. All monitoring wells, with the exception of MW-3009, which is adjacent to the raffinate pits, had annual concentrations of uranium below 40 pCi/l during this three-year period. Overall, increases of uranium concentrations have not been observed.

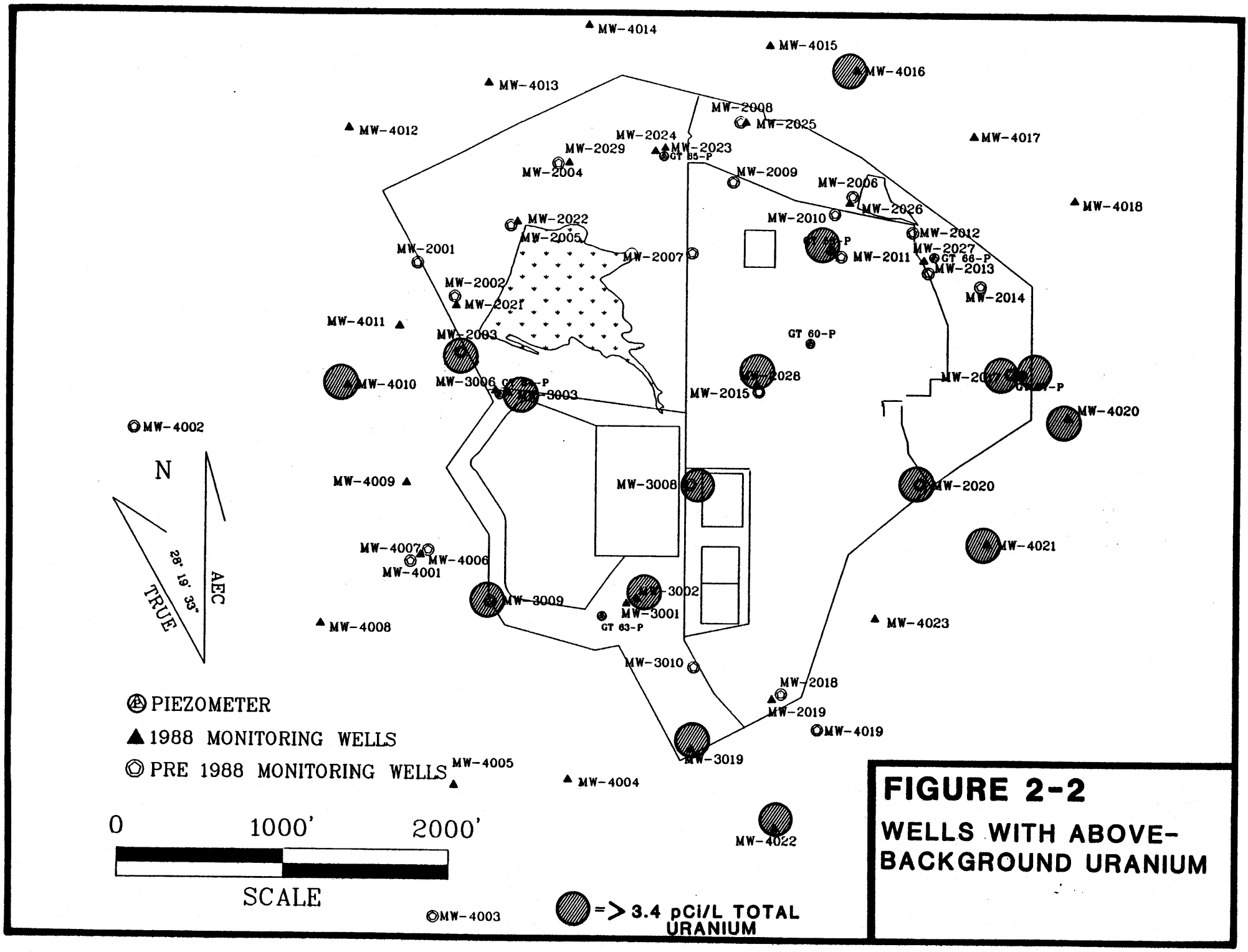


FIGURE 2-2

WELLS WITH ABOVE-BACKGROUND URANIUM

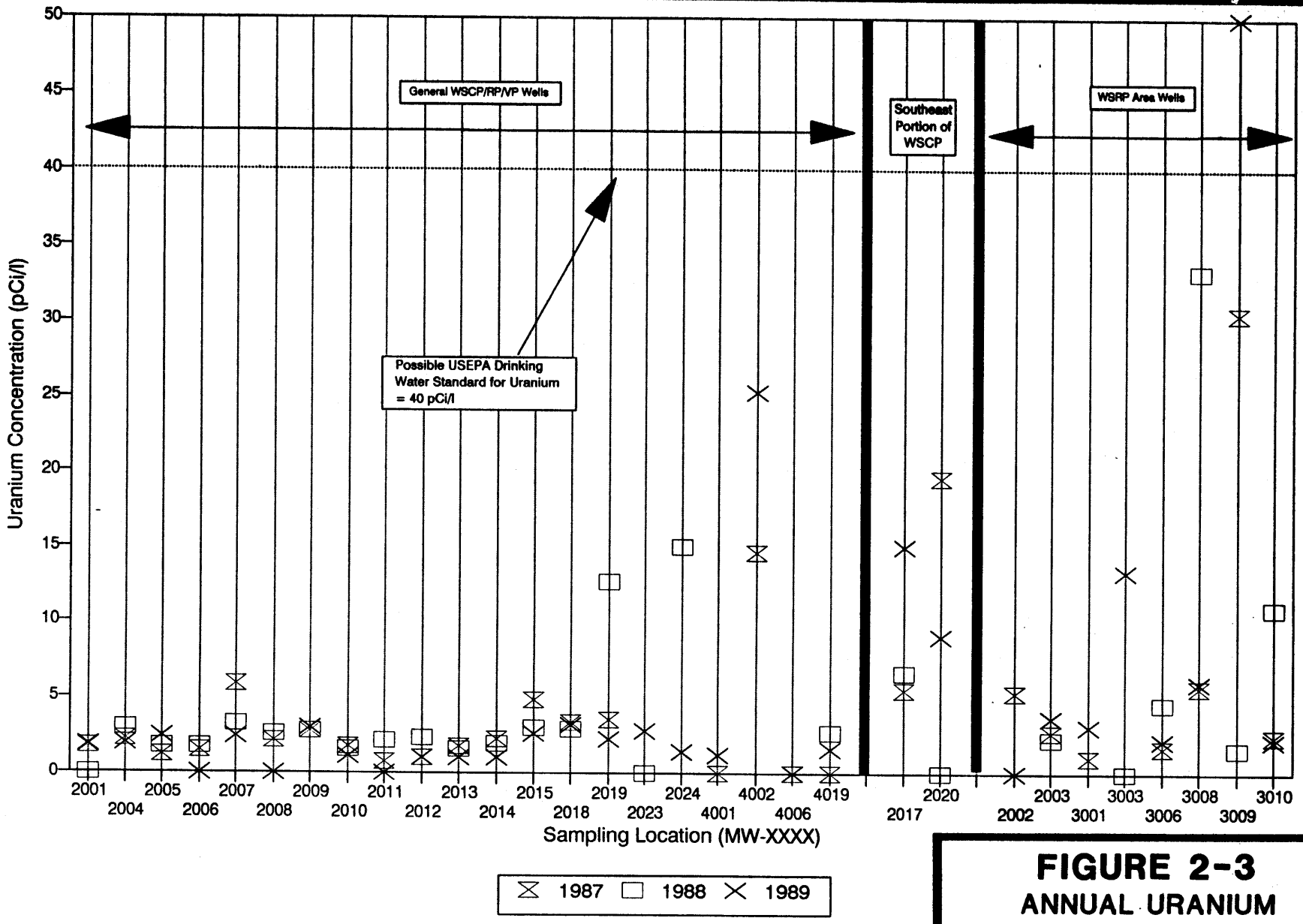


FIGURE 2-3
ANNUAL URANIUM CONCENTRATIONS WSCP/RP/VP GROUNDWATER 1987-1989

2.1.1.2 Analytical Results for Nitroaromatic Compounds

No primary or secondary drinking water standards have been promulgated for any of the six nitroaromatic compounds previously listed. 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 1989. Table 2-2 provides a summary of the results. Nitroaromatic compounds were not detected in 28 monitoring wells. Twenty-four monitoring wells exhibited a cumulative annual nitroaromatic compounds concentration above ND, but below 10 µg/l. Six wells exhibited annual concentrations greater than 10 µg/l. They are MW-2006, MW-2013, MW-4001, MW-4006, MW-4009, and MW-4013. Figure 2-4 shows the locations of these wells and their respective annual concentrations.

Six groundwater monitoring wells--MW-2003, MW-2008, MW-2013, MW-3001, MW-4001 and MW-4006--exhibited annual concentrations of 2,4-DNT above the ambient water quality criteria (0.11 µg/l). Figure 2-5 highlights the locations of wells exhibiting annual concentrations of 2,4-DNT above these criteria. No monitoring wells contained annual concentrations of nitrobenzene exceeding 30 µg/l. Overall the nitroaromatic results are consistent with past environmental monitoring and characterization studies.

TABLE 2-2 Summary of 1989 Data for Nitroaromatic Compounds, Weldon Spring Chemical Plant/Raffinate Pits

	1,3,5-TNB ug/l (0.01)*		1,3-DNB ug/l (0.13)*		2,4,6-TNT ug/l (0.17)*		2,4-DNT ug/l (0.05)*		2,6-DNT ug/l (0.17)*		Nitrobenzene ug/l (0.2)*		Total Nitroaromatics ug/l
GW-2001	ND	(1/1)@	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2002	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.16	(1/1)	ND	(1/1)	0.46
GW-2003	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.55	(1/1)	0.75	(1/1)	ND	(1/1)	1.3
GW-2004	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2005	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.08	(1/1)	ND	(1/1)	ND	(1/1)	0.08
GW-2006	9.62	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	1.60	(1/1)	ND	(1/1)	11.22
GW-2007	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2008	ND	(1/1)	0.58	(1/1)	ND	(1/1)	0.13	(1/1)	ND	(1/1)	ND	(1/1)	0.71
GW-2009	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.19	(1/1)	ND	(1/1)	0.19
GW-2010	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.92	(1/1)	ND	(1/1)	0.92
GW-2011	0.55	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	1.91	(1/1)	ND	(1/1)	2.46
GW-2012	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2013	5.48	(1/1)	ND	(1/1)	2.29	(1/1)	2.47	(1/1)	7.83	(1/1)	ND	(1/1)	18.07
GW-2014	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2015	0.21	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.63	(1/1)	ND	(1/1)	0.84
GW-2017	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2018	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2019	0.07	(2/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.07
GW-2020	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-2021	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND
GW-2022	0.03	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	6.00	(1/4)	6.03
GW-2023	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-2024	0.05	(2/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.05
GW-2025	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-2026	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-2027	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(3/3)	ND	(4/4)	ND
GW-2028	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(3/3)	1.22	(1/4)	ND
GW-2029	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND
GW-3001	0.10	(4/4)	ND	(4/4)	ND	(4/4)	0.39	(2/4)	ND	(4/4)	ND	(4/4)	0.49
GW-3002	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(2/4)	ND	(4/4)	ND	(4/4)	ND
GW-3003	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(2/4)	ND	(4/4)	ND	(4/4)	ND
GW-3006	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(2/4)	ND	(4/4)	ND	(4/4)	ND
GW-3008	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.06	(1/1)	ND	(1/1)	ND	(1/1)	0.06
GW-3009	0.06	(1/1)	ND	(1/1)	ND	(1/1)	0.07	(1/1)	ND	(1/1)	ND	(1/1)	0.13
GW-3010	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-3019	0.04	(1/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	0.04

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

* Detection Limit

@ Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1989. For example, 2.00 (2/4) indicates that 4 samples were taken in 1989, 2 of which were ND and the other 2 samples average 2.00.

TABLE 2-2 Summary of 1989 Data for Nitroaromatic Compounds, Weldon Spring Vicinity Properties (Continued)

	1,3,5-TNB ug/l (0.01)*		1,3-DNB ug/l (0.13)*		2,4,6-TNT ug/l (0.17)*		2,4-DNT ug/l (0.05)*		2,6-DNT ug/l (0.17)*		Nitrobenzene ug/l (0.2)*		Total Nitroaromatics ug/l
GW-4001	47.06	(1/1)	2.31	(1/1)	1.75	(1/1)	0.85	(1/1)	2.68	(1/1)	6.08	(1/1)	60.73
GW-4002	0.02	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.02
GW-4003	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4004	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4005	0.10	(2/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.1
GW-4006	1.93	(1/1)	1.93	(1/1)	ND	(1/1)	0.39	(1/1)	3.50	(1/1)	3.34	(1/1)	11.09
GW-4007	0.02	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.02
GW-4008	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4009	16.52	(1/3)	ND	(3/3)	7.78	(1/3)	ND	(3/3)	1.70	(1/3)	ND	(3/3)	26.00
GW-4010	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4011	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4012	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4013	55.54	(3/4)	0.80	(1/4)	ND	(4/4)	ND	(4/4)	0.95	(2/4)	ND	(4/4)	57.29
GW-4014	0.34	(2/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.34
GW-4015	0.12	(3/4)	0.25	(1/4)	ND	(4/4)	ND	(4/4)	1.36	(4/4)	0.42	(1/4)	2.15
GW-4016	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND	(3/3)	ND
GW-4017	0.05	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.05
GW-4018	0.13	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	013
GW-4019	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-4020	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4021	0.02	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.02
GW-4022	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND
GW-4023	0.30	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	0.30

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

* Detection Limit

@ Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1989. For example, 2.00 (2/4) indicates that 4 samples were taken in 1989, 2 of which were ND and the other 2 samples average 2.00.

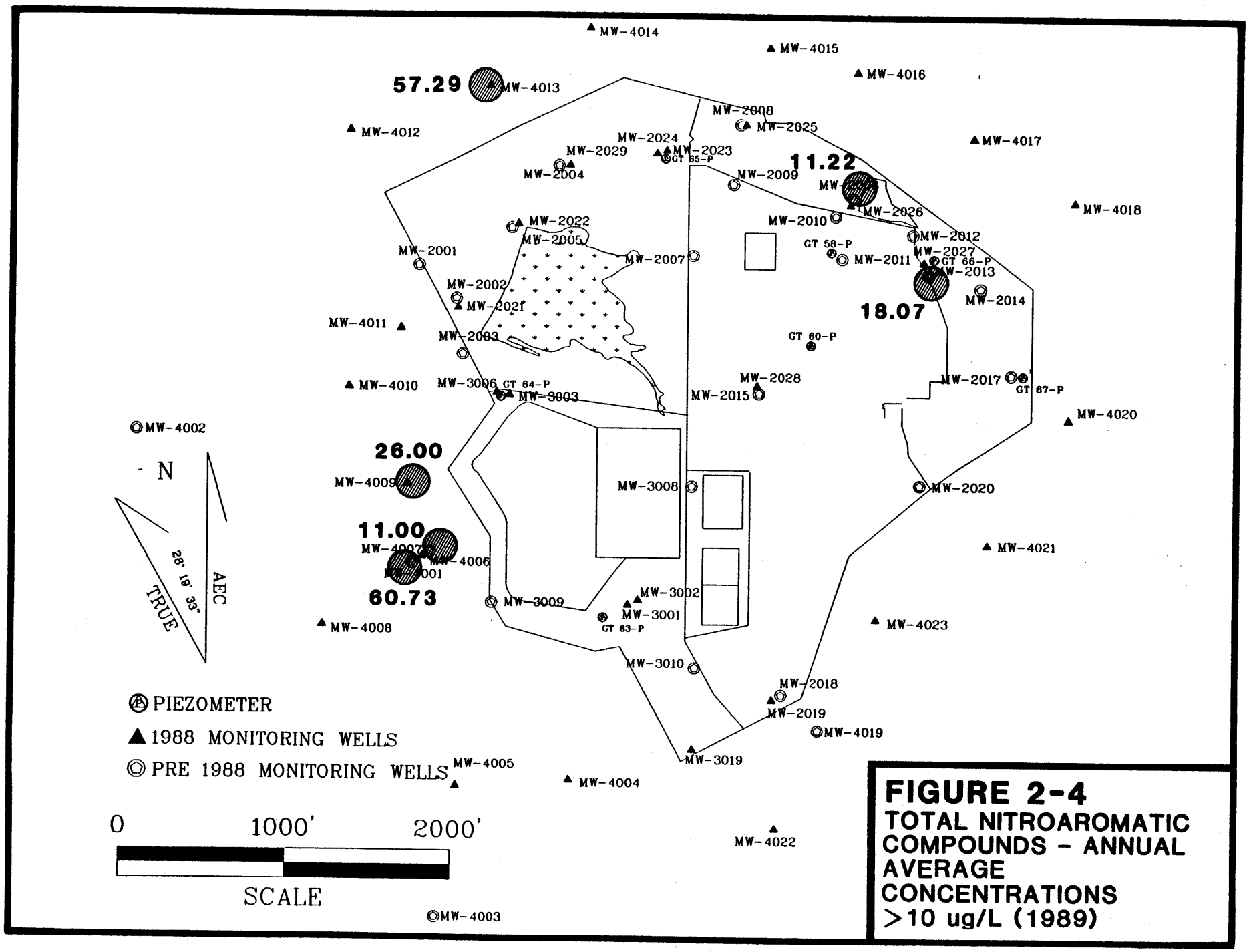


FIGURE 2-4
TOTAL NITROAROMATIC COMPOUNDS - ANNUAL AVERAGE CONCENTRATIONS >10 ug/L (1989)

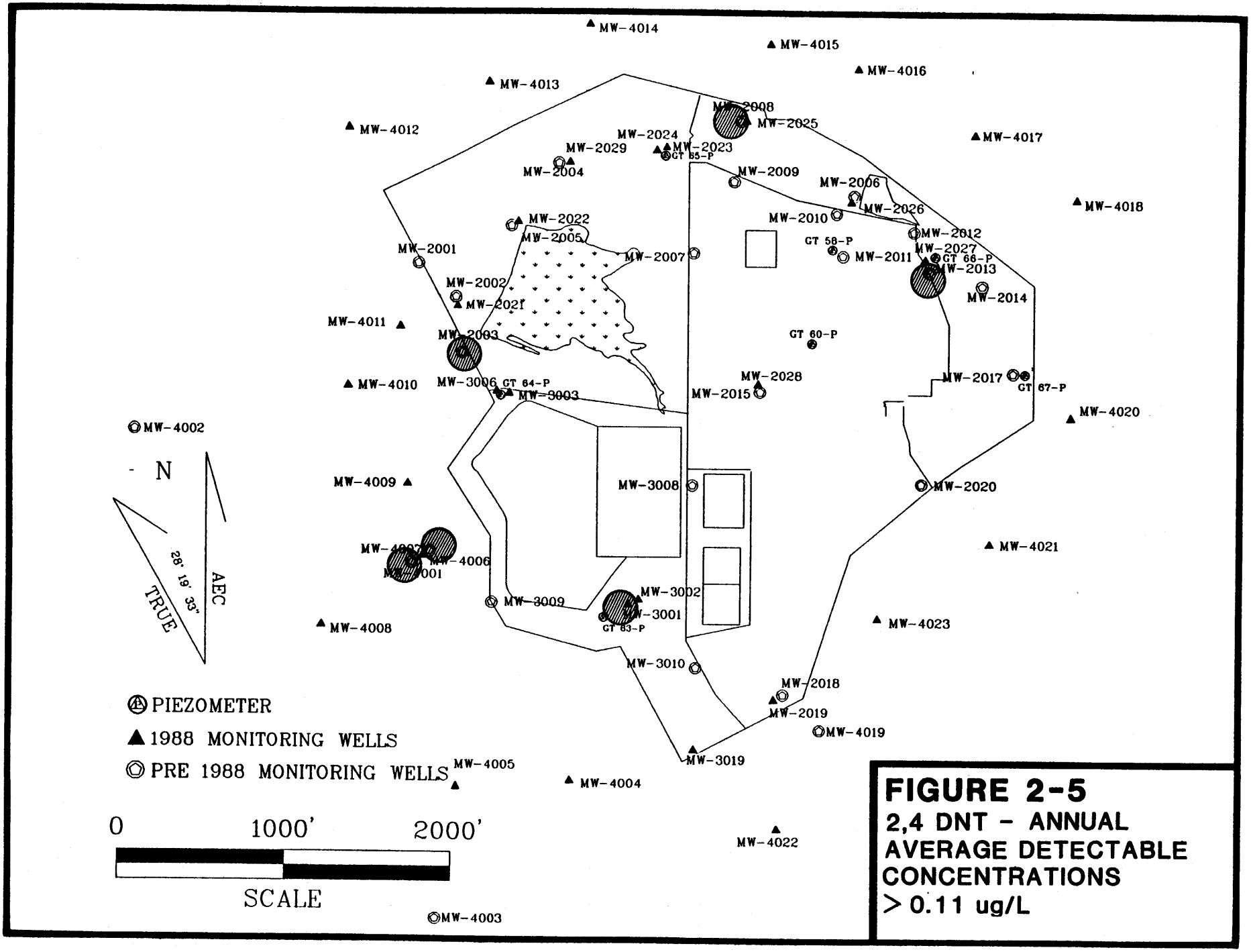


FIGURE 2-5
2,4 DNT - ANNUAL AVERAGE DETECTABLE CONCENTRATIONS > 0.11 ug/L

WSCP/WSRP/WSVP TOTAL NITROAROMATIC COMPOUNDS TREND ANALYSIS

The annual concentrations of total nitroaromatic compounds reported in previous monitoring reports and this report are displayed for comparison in Figure 2-6.

Monitoring wells within the section of the graph labeled "General WSCP/WSRP/WSVP Wells" show a very uniform, relatively low total nitroaromatic compound concentration history. Wells located within the northeast portion of the WSCP historically have had the highest concentrations of total and individual nitroaromatic compounds. Total nitroaromatic compounds concentration in all of these "northeast portion" wells, with the exception of MW-2012, have continually decreased in the period since 1987. MW-2012 had higher concentrations in 1988 than 1987. The cause of this general decrease is not known but may be due to drilling activities in 1988 and 1989.

Groundwater monitoring wells located on the Weldon Spring Training Area (WSTA) generally have displayed consistent levels of nitroaromatic compounds. MW-4001 remained the well with the highest total nitroaromatic compound concentration on the WSTA in 1989.

2.1.1.3 Inorganic Anions Results

As previously discussed, nitrate, sulfate, chloride and fluoride are included in the WSSRAP environmental monitoring program. Table 2-1 displays the annual concentrations of inorganic anions for 1989 at the WSCP/WSRP/WSVP area.

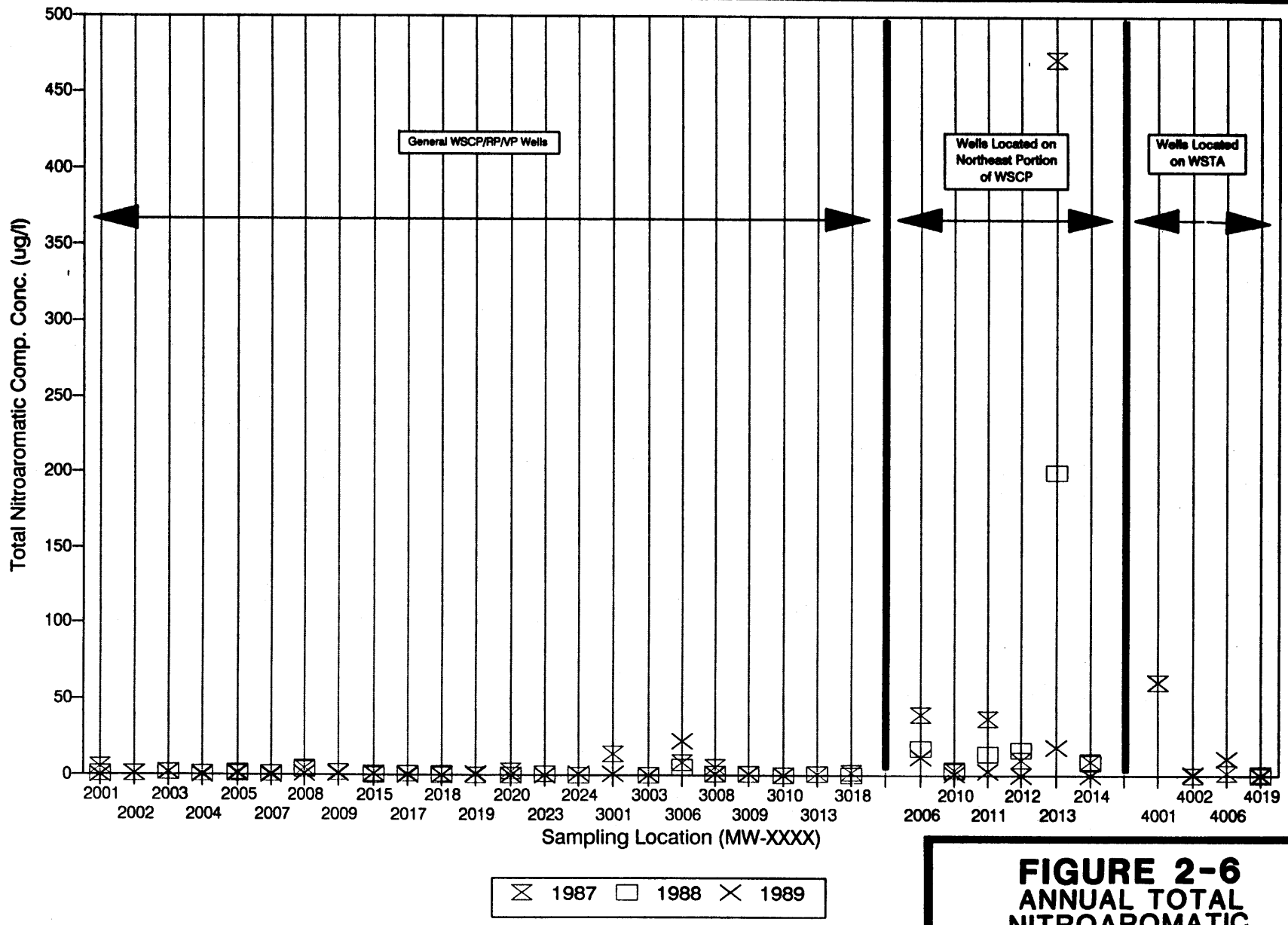


FIGURE 2-6
ANNUAL TOTAL NITROAROMATIC COMPOUND CONCENTRATIONS WSCP/RP/VP GROUNDWATER 1987-1989

NITRATE

The standard issued in the Safe Drinking Water Act for nitrate as nitrogen is 10 mg/l. Converted, this standard is 45 of nitrate. Background nitrate concentrations are below 14.43 mg/l (MKF and JEG, 1989a). During 1989, concentrations exceeding the standard occurred in 12 groundwater monitoring wells. The range of values for these wells is 50.20 mg/l in MW-2001 to 3330.00 mg/l in MW-2003. Figure 2-7 shows the locations of these wells at the WSCP/WSRP/WSVP area.

WSCP/WSRP/WSVP NITRATE TREND ANALYSIS

The nitrate concentrations reported in the previous monitoring reports and this report are displayed for comparison in Figure 2-8. Groundwater monitoring wells in the general WSCP/WSRP/WSVP area have consistently had nitrate concentrations below the drinking water standard of 45 mg/l from 1987 through 1989.

Monitoring wells shown on Figure 2-8 under "Wells at or near WSRP" are located adjacent to or closer to the raffinate pits than the general WSCP/WSRP/WSVP wells discussed above. Generally, they display a trend of increasing nitrate concentration with time. Because the raffinate pits provide hydraulic head to the groundwater system, and because they are a source of nitrate, this increasing concentration of nitrate in groundwater may be expected to continue with time, until the source is eliminated. The size of the nitrate plume does not appear to be changing, indicating that the groundwater velocity is slow.

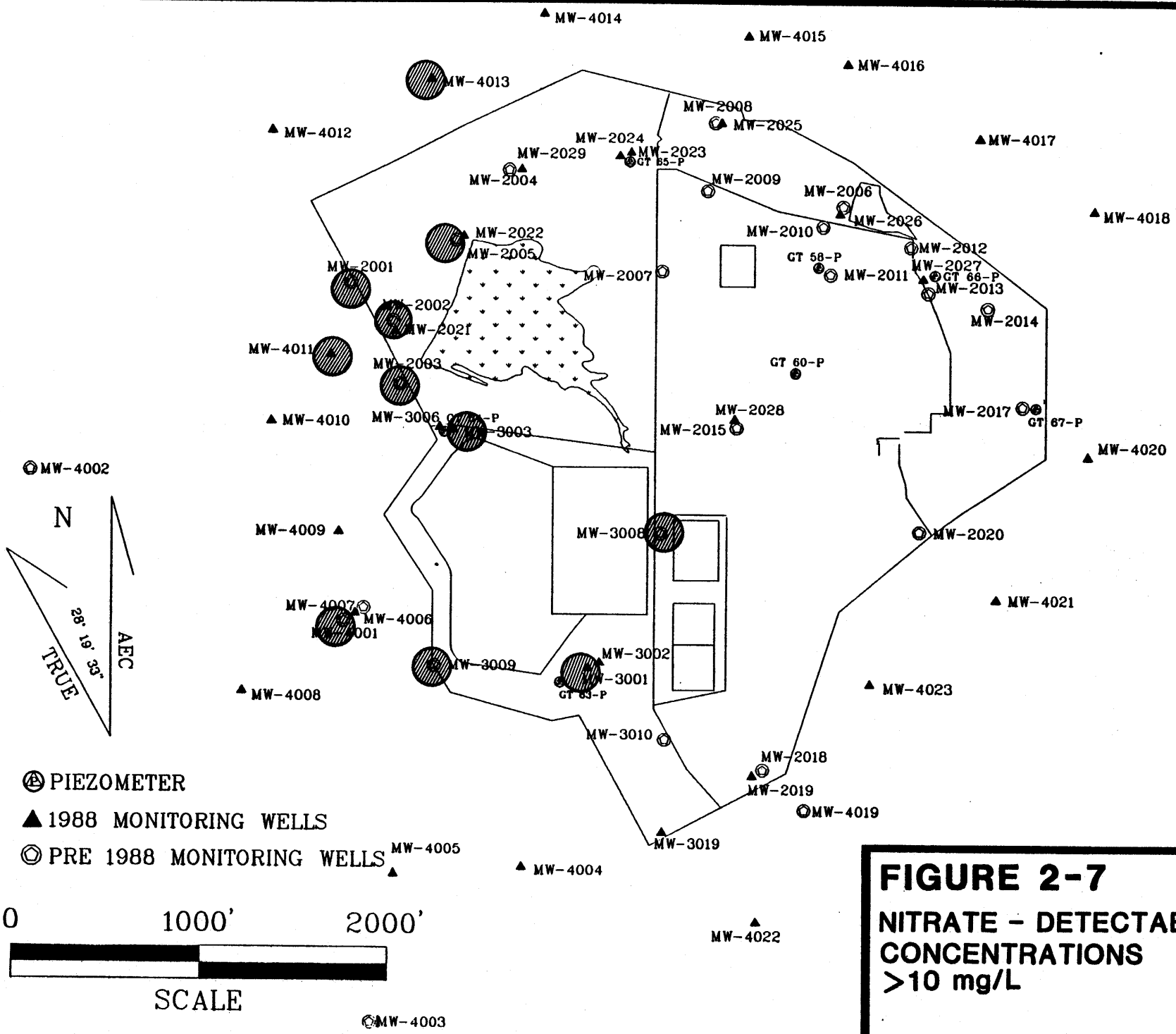


FIGURE 2-7

NITRATE - DETECTABLE CONCENTRATIONS >10 mg/L

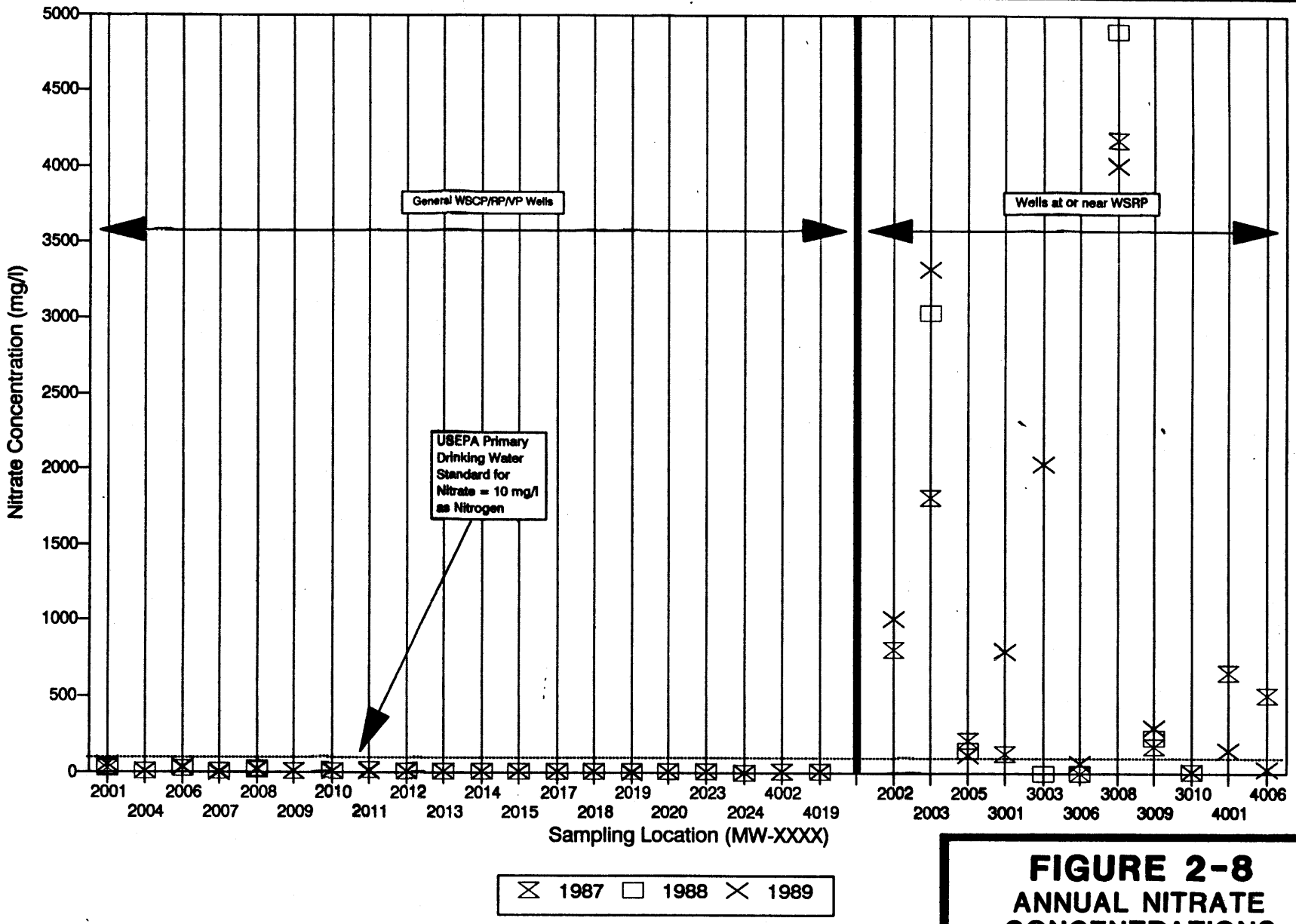


FIGURE 2-8
ANNUAL NITRATE CONCENTRATIONS WSCP/RP/VP GROUNDWATER 1987-1989

SULFATE

The upper bound of natural background sulfate concentrations in the aquifer at the WSCP/WSRP/WSVP was determined to be 50 mg/l (MKF and JEG, 1989a). The EPA secondary drinking water standard for sulfate is 250 mg/l. Twelve wells--MW-2009, MW-2015, MW-2020, MW-2028, MW-3003, MW-3006, MW-3009, MW-4001, MW-4013, MW-4020, MW-4022, and MW-4023--have annual sulfate concentrations between the upper bound of background and the EPA secondary drinking water standard. Four groundwater monitoring wells--MW-2003, MW-2012, MW-2017, and MW-4021--have an annual sulfate concentration higher than the EPA secondary drinking water standard. Figure 2-9 shows locations of wells with annual concentrations either above background and/or above the EPA secondary drinking water standard. The Phase II Groundwater Quality Assessment established that former WSOW processes were the primary source of these areas of sulfate contamination.

WSCP/WSRP/WSVP SULFATE TREND ANALYSIS

The annual concentrations of sulfate reported in previous monitoring reports and this report are displayed for comparison in Figure 2-10. The majority of groundwater monitoring wells on the "General WSCP/WSRP/WSVP Wells" portion of the graph have consistently yielded concentrations of sulfate below the EPA secondary drinking water standard of 250 mg/l during the years 1987 through 1989. The single exception to this is MW-2012, which was sampled during the second quarter of 1989 and contained 415 mg/l sulfate. This may be related to the increase in nitroaromatic concentrations in this well. One well, MW-2017, located in the southern portion of the WSCP, has exhibited

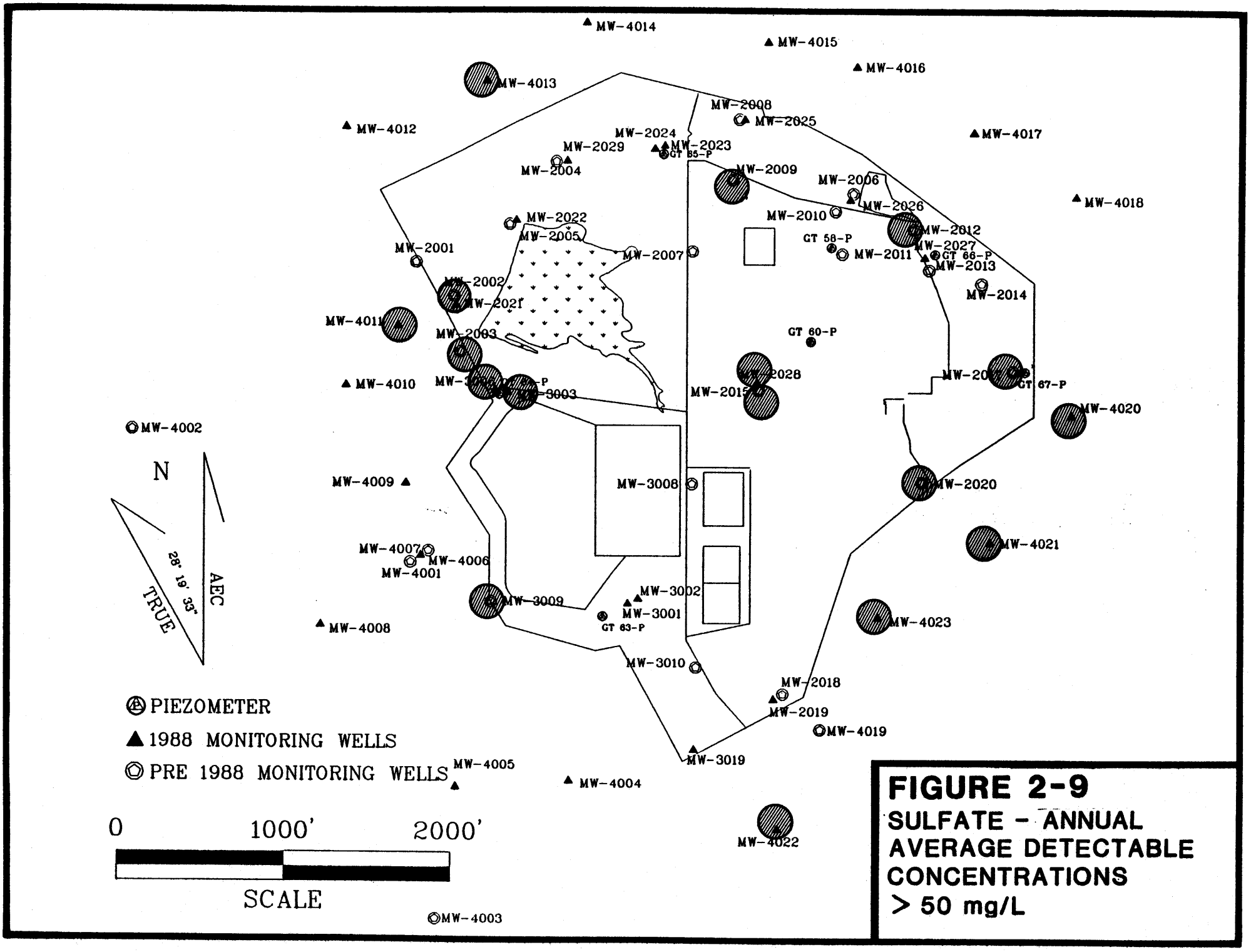


FIGURE 2-9
SULFATE - ANNUAL AVERAGE DETECTABLE CONCENTRATIONS > 50 mg/L

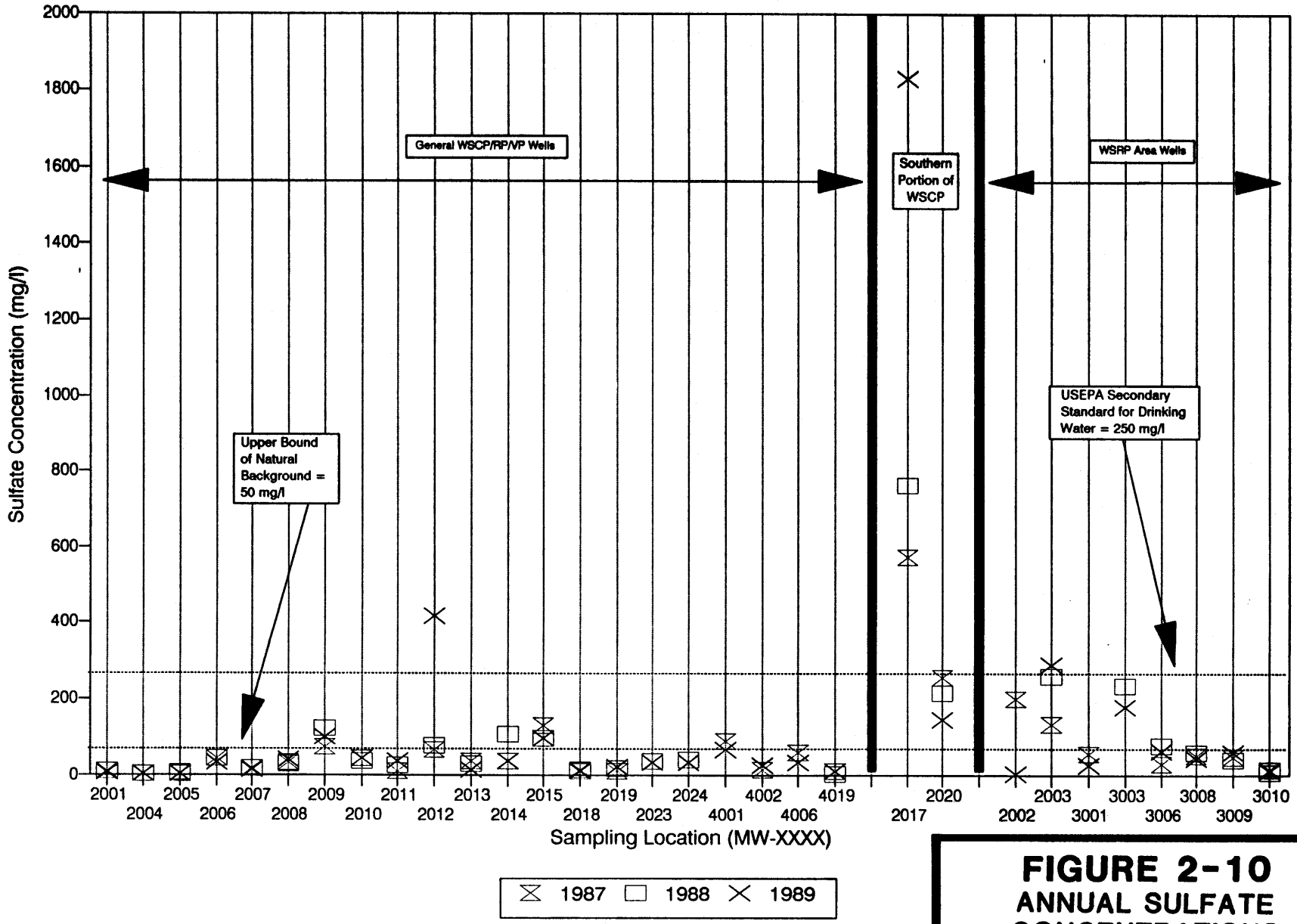


FIGURE 2-10
ANNUAL SULFATE CONCENTRATIONS WSCP/RP/VP GROUNDWATER 1987-1989

increased sulfate concentrations since 1987. Further complicating the picture, a nearby well (MW-2020) considered to be positioned in the same sulfate plume as MW-2017 (MKF and JEG, 1989a), has decreased in sulfate concentration since 1987. The cause of these fluctuations is not known. Another noticeable trend is the increase in nitrate and sulfate concentrations at well MW-2003 and the decreasing concentrations in MW-2002. The cause of these fluctuations is not known but they demonstrate consistency.

CHLORIDE

The upper limit of background concentration of chloride in groundwater at the WSCP/WSRP/WSVP area is 22 mg/l (MKF and JEG, 1989a). The EPA secondary standard for chloride in drinking water is 250 mg/l. Four wells-- MW-2008, MW-2010, MW-2012, and MW-2014-- exhibited annual detectable concentrations of chloride above natural background. Groundwater taken from one well only, MW-2006, exceeded the EPA standard with an annual average detectable concentration of 278.00 mg/l. All five of these wells are located adjacent to a surface 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.

FLUORIDE

Background fluoride concentrations are below 1 mg/l. The maximum contaminant level (MCL) for fluoride is 4.0 mg/l. A secondary MCL is 2.0 mg/l. No samples exceeded background concentrations. This is consistent with previous monitoring.

2.1.2 Groundwater Monitoring at the WSQ

Groundwater near the WSQ has become contaminated as a result of contact with or migration from the radioactive and hazardous substances present in the WSQ. Twenty-six DOE groundwater monitoring wells located at or near the Weldon Spring Quarry were sampled and analyzed during 1989 to monitor for the presence of WSQ related contaminants. Figures 2-11A and 2-11B show the locations of the groundwater monitoring wells. Groundwater samples were analyzed for natural uranium, nitroaromatic compounds, and inorganic anions. 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 screened in the Missouri River alluvium and owned by St. Charles County were also analyzed during 1989. During 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 well field. These samples were analyzed for a suite of parameters including total uranium, metals and inorganic anions. Four separate uranium analyses were run on samples from this background well and the results ranged from 4.8 pCi/l to 9.0 pCi/l with an average value of 6.8 pCi/l. Although not a comprehensive background study, it appears that values in the range of 5 pCi/l or slightly above can constitute background concentrations in the Missouri River alluvium.

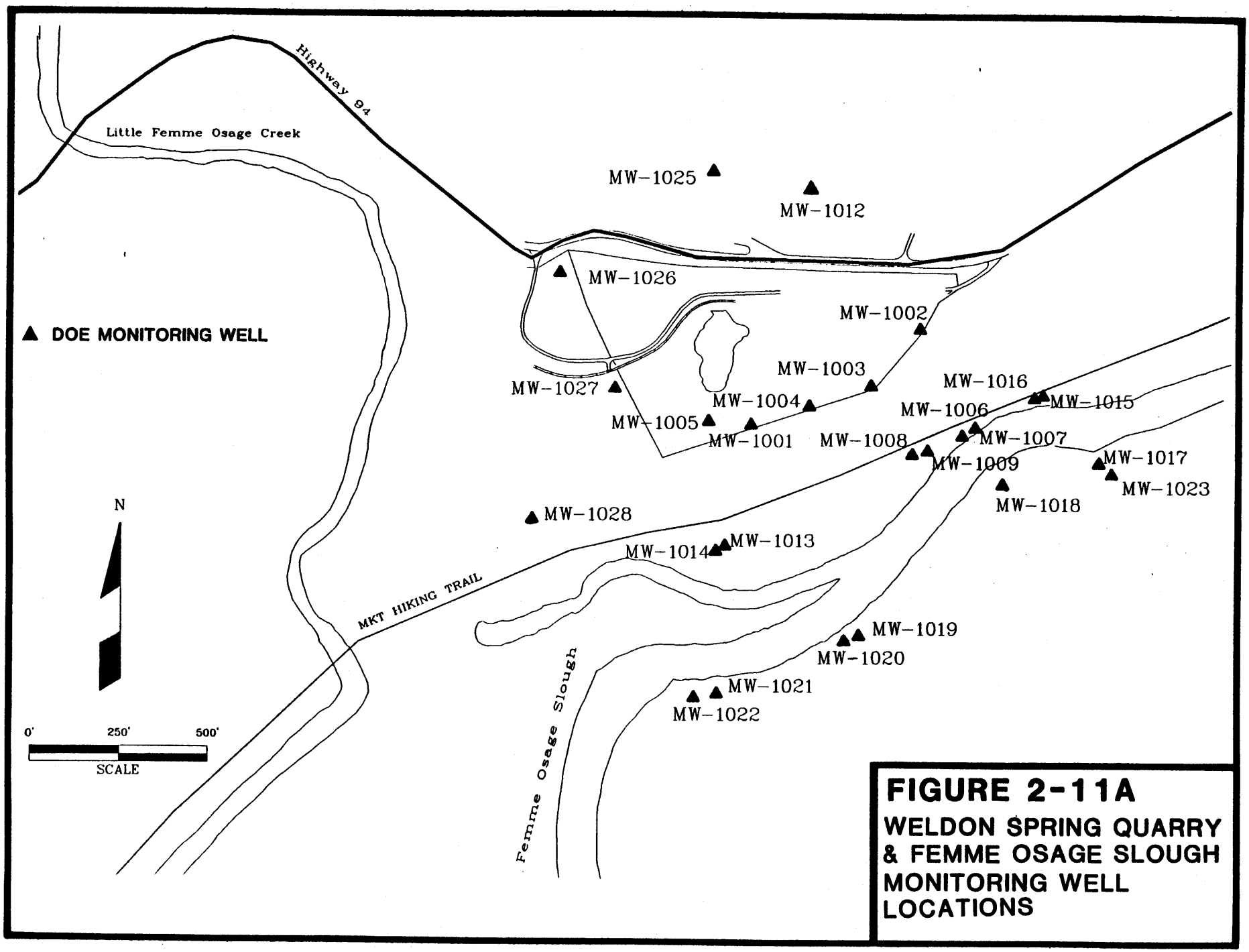


FIGURE 2-11A
WELDON SPRING QUARRY & FEMME OSAGE SLOUGH MONITORING WELL LOCATIONS

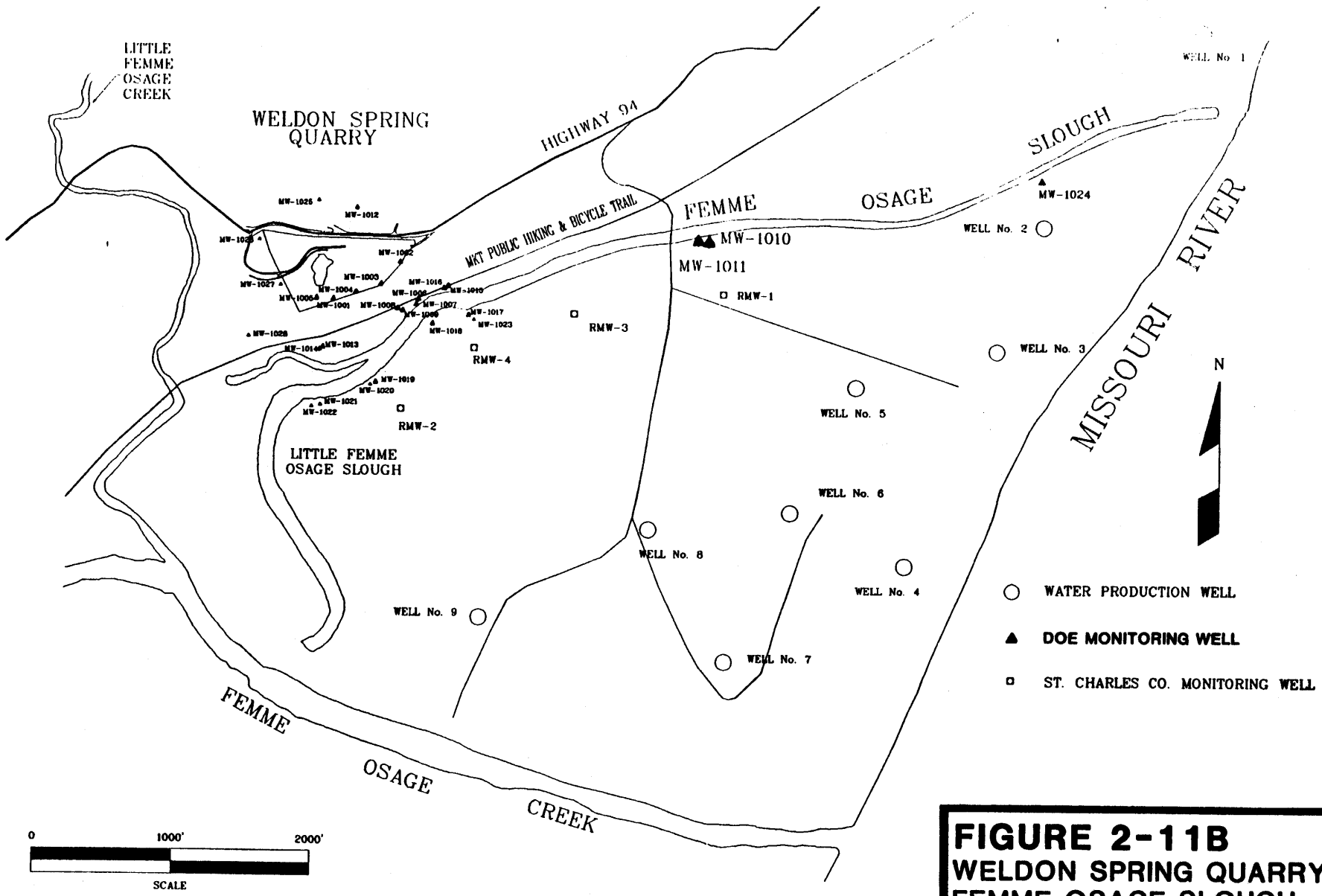


FIGURE 2-11B
WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, & ST. CHARLES CO. WELL FIELD MONITORING WELL LOCATIONS

2.1.2.1 Radiological Results

Groundwater samples from 26 DOE monitoring wells and the four St. Charles County monitoring wells were analyzed for total uranium during 1989. Table 2-3 presents the results of these analyses. The results of the 1989 monitoring near the WSQ indicate that, although uranium concentrations have changed in individual wells, elevated uranium levels remain isolated to the bedrock adjacent to the quarry and the alluvium on the north side of the Femme Osage Slough. Samples from monitoring wells south of the slough exhibited average concentrations below 5 pCi/l. Elevated uranium levels north of the slough ranged from 260 pCi/l at MW-1016 to 4400 pCi/l in MW-1004, immediately adjacent to the quarry waste. Figure 2-12 highlights the wells with above-background uranium concentrations.

Groundwater samples from five wells--MW-1012 and the four St. Charles County groundwater monitoring wells--were analyzed for radium-226, thorium-230 and thorium-232. All analyses for these radionuclides indicated that the levels were below the minimum detection limit with the exception of MW-1012 (with a history of measurable thorium-230) which averaged 1.2 pCi/l thorium-230.

WSQ URANIUM TREND ANALYSIS

The concentrations of uranium at the WSQ reported in previous monitoring reports and this report are displayed for comparison in Figure 2-13. This figure illustrates that uranium is not and has not been present in elevated levels in DOE groundwater monitoring wells located south of the Femme Osage

TABLE 2-3 Summary of 1989 Data for Inorganic Anions and Radionuclides--Weldon Spring Quarry

	Chloride mg/l (0.25)*	Fluoride mg/l (0.25)*	Nitrate mg/l (0.1)*	Sulfate mg/l (1.0)*	Total Uranium pCi/ml (1.0)*	Radium 226 pCi/l (0.2)*	Thorium 230 pCi/l (1.0)*	Thorium 232 pCi/l (1.0)*
GW-1002	16.60 (1/1) @	ND (1/1)	16.30 (1/1)	79.30 (1/1)	3.00 (1/1)			
GW-1004	14.50 (1/1)	0.60 (1/1)	1.90 (1/1)	1000.00 (1/1)	4350.00 (1/1)			
GW-1005	19.90 (1/1)	0.50 (1/1)	ND (1/1)	598.00 (1/1)	1750.00 (1/1)			
GW-1006	31.60 (1/1)	ND (1/1)	9.30 (1/1)	441.00 (1/1)	2400.00 (1/1)			
GW-1007	61.10 (1/1)	ND (1/1)	0.20 (1/1)	184.00 (1/1)	438.00 (1/1)			
GW-1008	14.40 (1/1)	ND (1/1)	2.40 (1/1)	292.00 (1/1)	1380.00 (1/1)			
GW-1009	24.80 (1/1)	ND (1/1)	ND (1/1)	240.00 (1/1)	7.40 (1/1)			
GW-1010	9.80 (1/1)	ND (1/1)	ND (1/1)	ND (1/1)	ND (1/1)			
GW-1011	NOT SAMPLED -- DRY DURING SCHEDULED SAMPLING PERIOD (Q289)							
GW-1012	9.70 (1/1)	ND (1/1)	8.10 (1/1)	81.20 (1/1)	6.0 (3/3)	ND (2/2)	1.20 (1/2)	ND (2/2)
GW-1013	23.40 (4/4)	0.42 (2/4)	ND (4/4)	125.50 (4/4)	802.00 (4/4)			
GW-1014	20.20 (4/4)	0.46 (1/4)	1.30 (1/4)	125.60 (4/4)	874.00 (4/4)			
GW-1015	14.00 (1/1)	ND (1/1)	9.80 (1/1)	219.00 (1/1)	382.00 (4/4)			
GW-1016	10.50 (1/1)	ND (1/1)	2.40 (1/1)	160.00 (1/1)	260.00 (4/4)			
GW-1017	19.30 (1/1)	ND (1/1)	0.40 (1/1)	ND (1/1)	ND (4/4)			
GW-1018	28.80 (1/1)	ND (1/1)	ND (1/1)	49.40 (1/1)	ND (4/4)			
GW-1019	7.70 (1/1)	ND (1/1)	2.40 (1/1)	ND (1/1)	ND (4/4)			
GW-1020	13.90 (1/1)	ND (1/1)	ND (1/1)	ND (1/1)	0.68 (1/4)			
GW-1021	8.60 (1/1)	ND (1/1)	ND (1/1)	ND (1/1)	ND (4/4)			
GW-1022	14.00 (1/1)	ND (1/1)	ND (1/1)	ND (1/1)	ND (4/4)			
GW-1023	5.30 (1/1)	ND (1/1)	ND (1/1)	6.80 (1/1)	1.36 (1/4)			
GW-1024	14.00 (1/1)	0.28 (1/3)	0.20 (1/1)	4.2 (2/3)	1.36 (1/4)			
GW-1025	9.10 (1/1)	ND (1/1)	0.50 (1/1)	131.90 (1/1)	4.08 (4/4)			
GW-1026	2.00 (1/1)	ND (1/1)	ND (1/1)	ND (1/1)	ND (1/1)			
GW-1027	11.80 (1/1)	ND (1/1)	1.00 (1/1)	82.80 (1/1)	649.5 (4/4)			
GW-1028	8.10 (1/1)	ND (1/1)	ND (1/1)	63.80 (1/1)	1.64 (4/4)			
GW-RMW1	9.45 (3/3)	ND (1/1)	ND (1/1)	28.05 (2/3)	1.00 (1/4)	ND (1/1)	ND (1/1)	ND (1/1)
GW-RMW2	2.7 (3/3)	ND (1/1)	ND (1/1)	36.85 (2/2)	4.47 (9/9)	ND (1/1)	ND (1/1)	ND (1/1)
GW-RMW3	13.20 (3/3)	ND (1/1)	ND (1/1)	83.97 (3/3)	1.36 (1/5)	ND (1/1)	ND (1/1)	ND (1/1)
GW-RMW4	6.33 (3/3)	ND (1/1)	1.65 (3/3)	15.23 (3/3)	1.62 (4/5)	ND (1/1)	ND (1/1)	ND (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.

* Detection Limits

@ Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1989. For example, 2.00 (2/4) indicates that 4 samples were taken in 1989, 2 of which average 2.00 and the other 2 samples were ND.

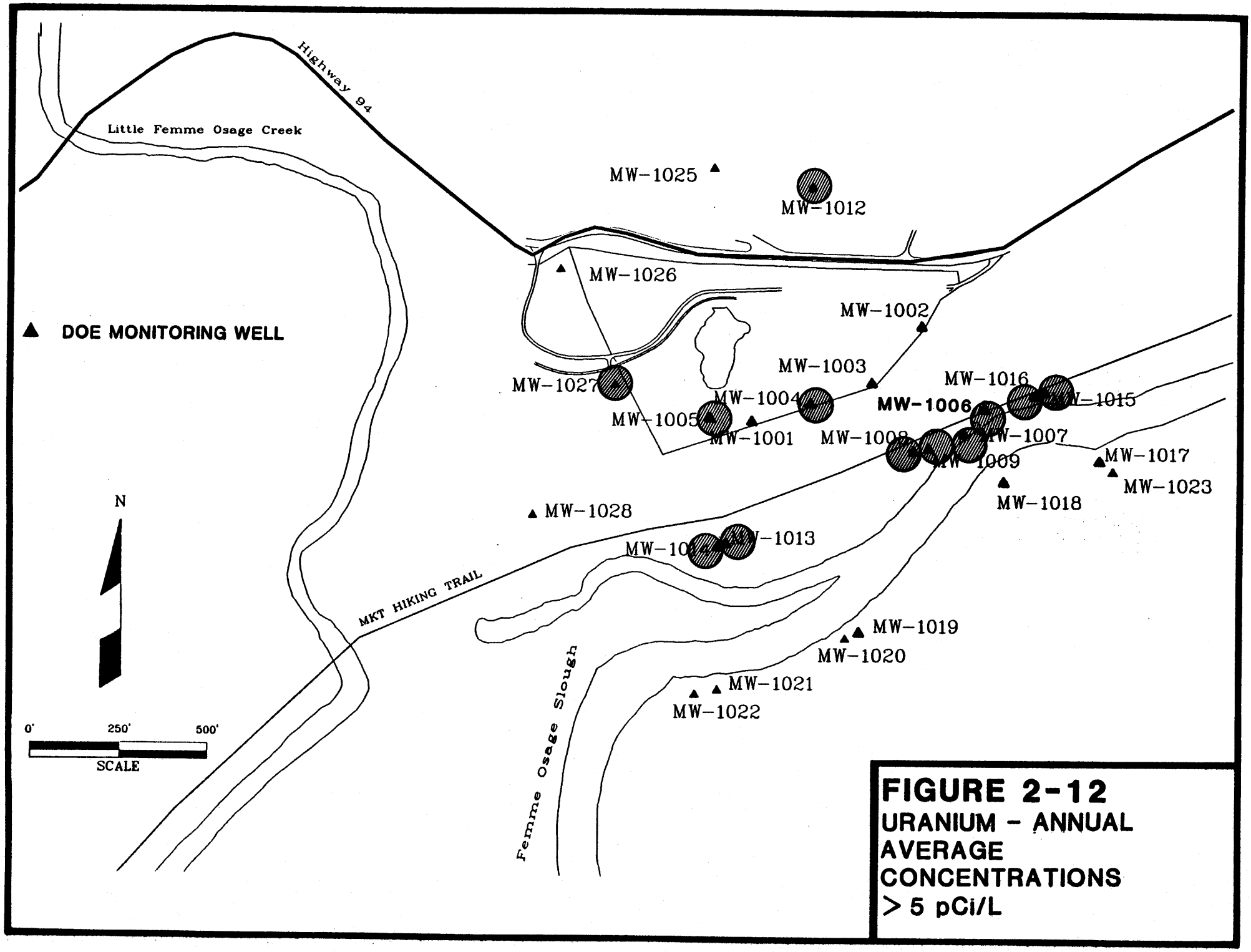


FIGURE 2-12
URANIUM - ANNUAL AVERAGE CONCENTRATIONS > 5 pCi/L

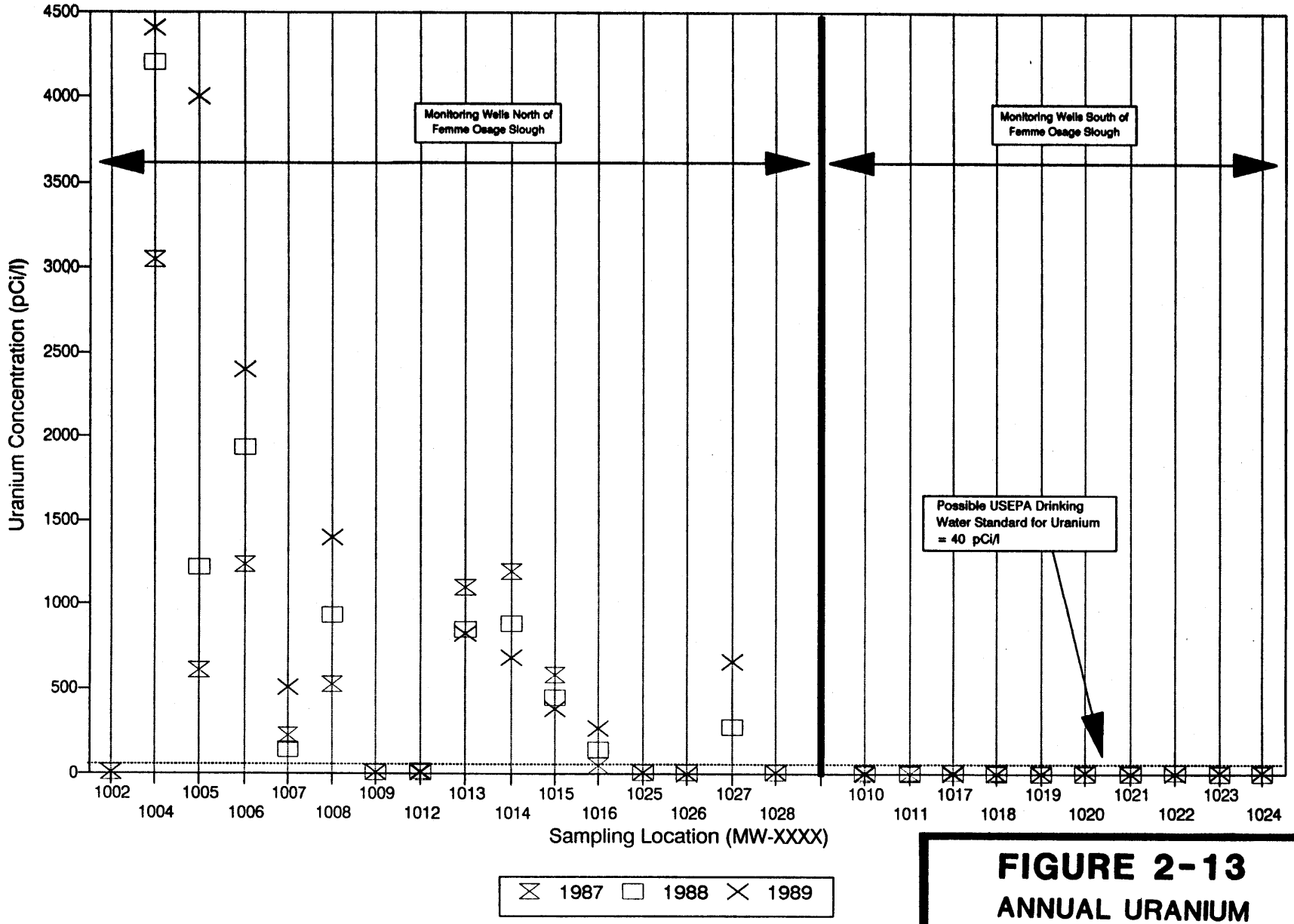


FIGURE 2-13

ANNUAL URANIUM CONCENTRATIONS WSQ GROUNDWATER 1987-1989

Slough. These wells south of the slough each have shown concentrations of uranium within the range of background since 1987.

Wells to the north of the slough and those adjacent to the WSQ display varying degrees and directions of change from 1987 to 1989. The most notable changes and trends have occurred as increases of uranium concentrations in the groundwater monitored by wells MW-1004 and MW-1005 along the WSQ rim and MW-1006 and MW-1008 in the Missouri River alluvium. Other small to moderate concentration variations occurred, both increases and decreases, in the wells in the WSQ area as presented in Figure 2-13. Although the increasing trends in uranium concentrations at select wells call for heightened awareness and review of the groundwater situation, the data continues to indicate no cause for immediate concern for the integrity of the St. Charles County well field and water supply.

2.1.2.2 Analytical Results for Nitroaromatic Compounds

During 1989, samples from the WSQ wells were analyzed for nitroaromatic compounds. Eleven monitoring wells yielded no detectable concentrations of any of the six nitroaromatic compounds during 1989. Analytical results are presented in Table 2-4. Figures 2-14A and 2-14B are maps of the WSQ area annotated with the annual average concentrations of total nitroaromatic compounds.

The 1,3,5-TNB concentrations in monitoring wells MW-1017 through MW-1023 are the result of laboratory contamination based on contamination of the blank sample. No monitoring wells south of the slough showed detectable concentrations of nitroaromatic compounds during 1989.

TABLE 2-4 Summary of 1989 Data for Nitroaromatic Compounds, Weldon Spring Quarry

	1,3,5-TNB ug/l (0.01)*		1,3-DNB ug/l (0.13)*		2,4,6-TNT ug/l (0.17)*		2,4-DNT ug/l (0.05)*		2,6-DNT ug/l (0.17)*		Nitrobenzene ug/l (0.2)*		Total Nitroaromatics ug/l
GW-1002	ND	(1/1)@	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1004	0.86	(1/1)	ND	(1/1)	5.56	(1/1)	0.56	(1/1)	2.42	(1/1)	ND	(1/1)	9.4
GW-1005	0.04	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.04
GW-1006	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	3.24	(1/1)	0.71	(1/1)	3.95
GW-1007	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1008	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1009	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1010	0.02	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.02
GW-1011	NOT SAMPLED -- DRY DURING SCHEDULED SAMPLING PERIOD (Q289)												
GW-1012	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.06	(1/1)	ND	(1/1)	ND	(1/1)	0.06
GW-1013	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.15	(1/1)	ND	(1/1)	ND	(1/1)	0.15
GW-1014	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1015	41.03	(3/4)	ND	(4/4)	5.92	(3/4)	ND	(4/4)	ND	(4/4)	ND	(1/1)	46.95
GW-1016	2.82	(2/4)	0.24	(1/3)	0.79	(1/4)	ND	(4/4)	ND	(4/4)	ND	(4/4)	3.85
GW-1017	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1018	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1019	0.06	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.06
GW-1020	0.52	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.52
GW-1021	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1022	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1023	**	(0/0)	**	(0/0)	**	(0/0)	**	(0/0)	**	(0/0)	**	(0/0)	**
GW-1024	0.06	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.06
GW-1025	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-1026	0.04	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	0.04
GW-1027	0.17	(1/1)	ND	(1/1)	6.23	(1/1)	1.14	(1/1)	1.40	(1/1)	ND	(1/1)	8.94
GW-1028	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-RMW1	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-RMW2	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-RMW3	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND
GW-RMW4	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	ND	(1/1)	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.

* Detection Limits

@ Numerator is number of samples the concentration is based on and denominator is the number of times the location was sampled during 1989. For example, 2.00 (2/4) indicates that 4 samples were taken in 1089, 2 of which were ND and the other 2 samples average 2.00.

** No analysis was performed for this parameter at this location during 1989.

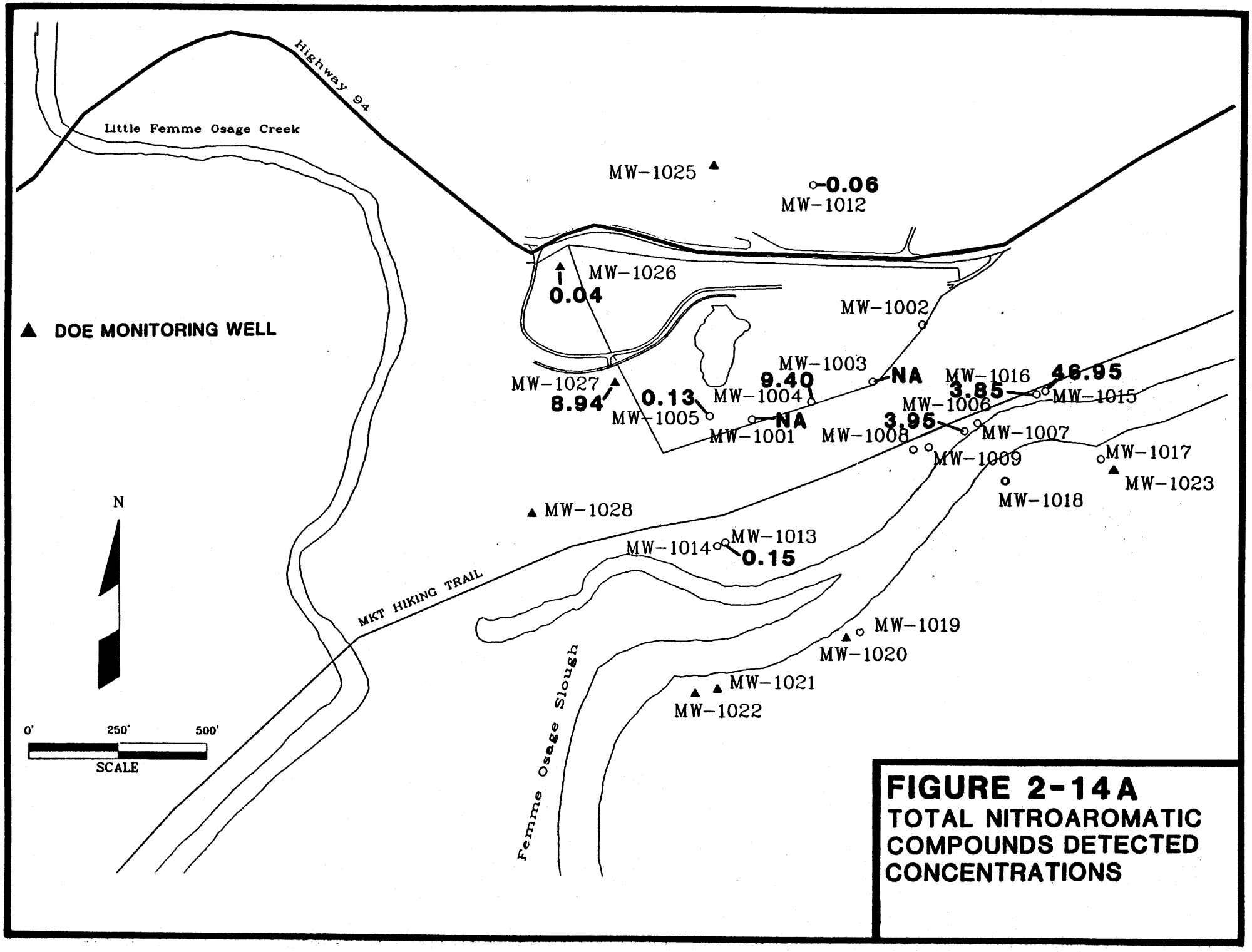


FIGURE 2-14A
TOTAL NITROAROMATIC COMPOUNDS DETECTED CONCENTRATIONS

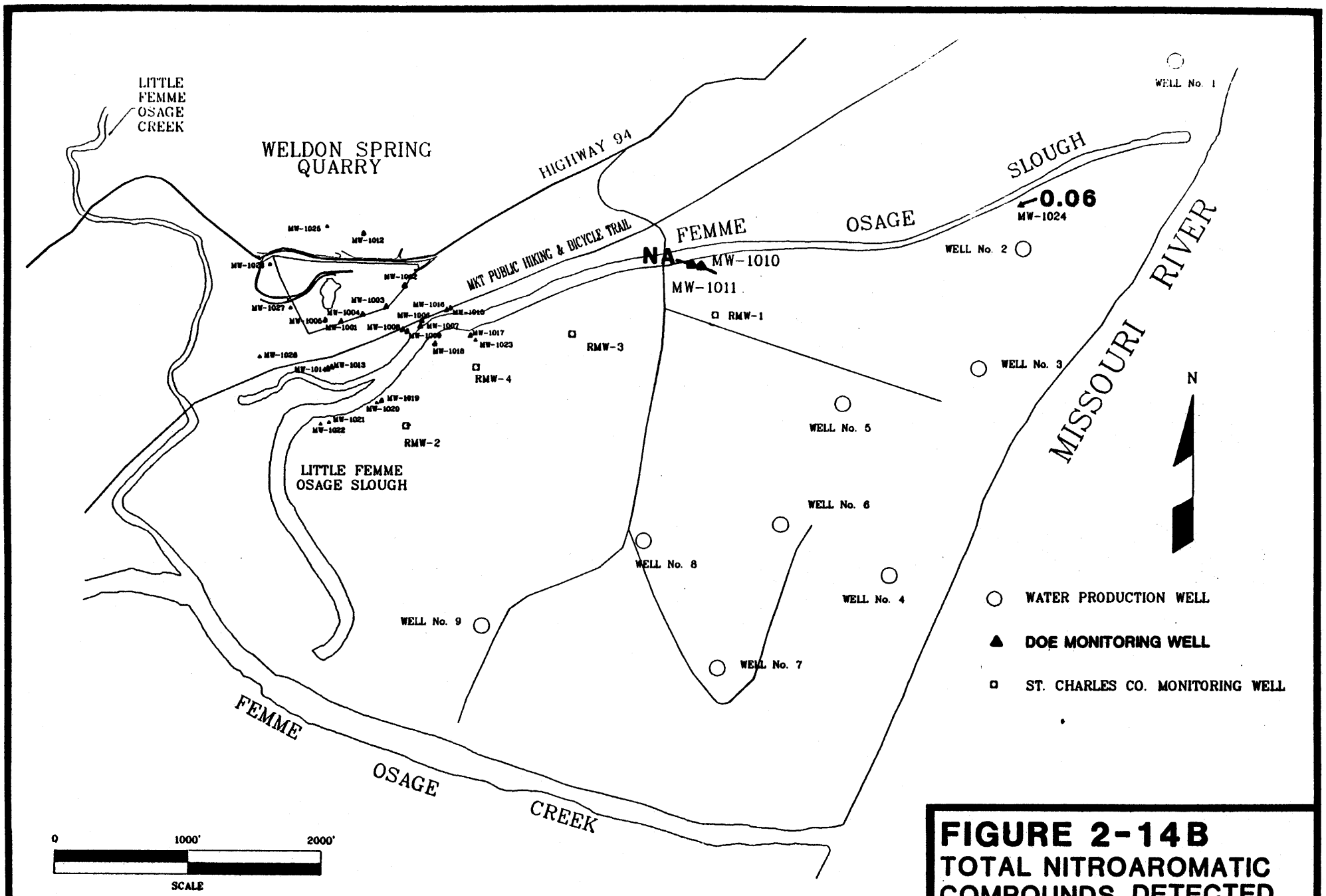


FIGURE 2-14B
TOTAL NITROAROMATIC COMPOUNDS DETECTED CONCENTRATIONS

CONCENTRATIONS OF TOTAL NITROAROMATIC COMPOUNDS IN GROUNDWATER - TREND AT THE WSQ

A comparison of data for years 1989, 1988, and 1987 suggest that concentrations of nitroaromatic compounds in groundwater are generally constant over the three years.

Figure 2-15 plots the historical averages of total nitroaromatic compounds in the WSQ groundwater. No particularly noteworthy trends in contaminant distribution or concentration were detected.

2.1.2.3 Inorganic Anions Results

Monitoring wells were sampled once in 1989 for inorganic anions. Previous WSS annual environmental monitoring reports and characterization sampling events have detected elevated inorganic anion levels in the groundwater in the vicinity of the WSQ. Four inorganic anions--nitrate, sulfate, chloride and fluoride--were targeted for study. Table 2-3 displays the 1989 annual concentrations of inorganic anions for the WSQ area. Inorganic anion results from 1989 are consistent with data reported in both the 1988 and the 1987 environmental monitoring reports. In 1988 and 1989, groundwater samples collected from the upgradient background well referenced in Section 2.1.2.1 provided some limited data on inorganic anions showing background nitrate and sulfate in the alluvial groundwater of <0.1 mg/l and 95 mg/l, respectively.

NITRATE

Table 2-3 presents the measured nitrate levels in the groundwater near the WSQ. The groundwater samples continue to

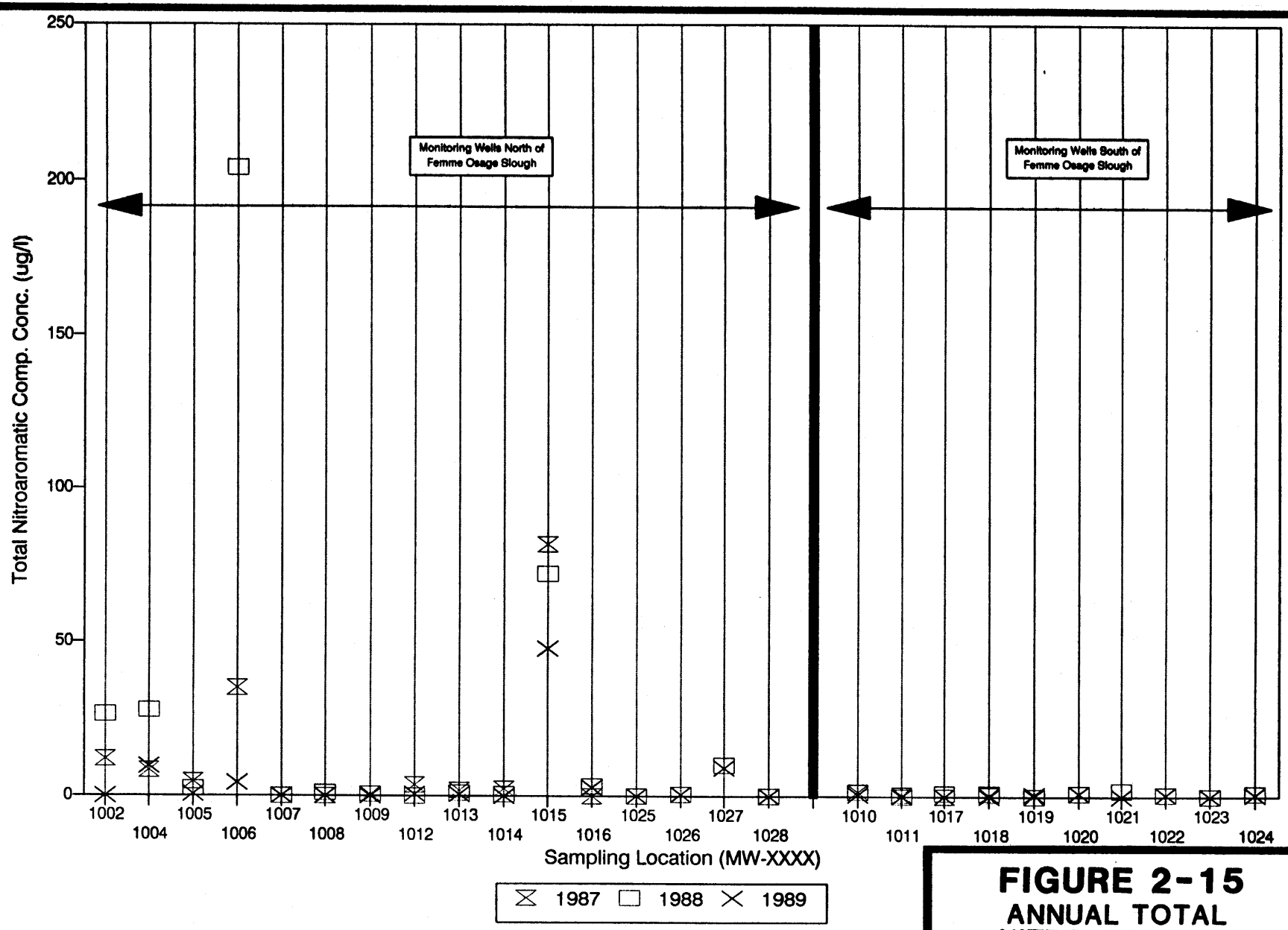


FIGURE 2-15
ANNUAL TOTAL NITROAROMATIC COMPOUND CONCENTRATIONS WSQ GROUNDWATER 1987-1989

indicate no notable groundwater contamination by nitrate, with the highest measured level observed at MW-1002 adjacent to the WSQ. This value is not attributed to contaminant migration from the WSQ, however, since the levels of nitrate in the quarry pond indicate little impact by nitrate from the quarry wastes. Further, the uranium levels in the water of MW-1002 show little impact from quarry migration. Nitrate does not constitute a particular threat to the groundwater system near the WSQ.

WSQ NITRATE TREND ANALYSIS

The annual concentrations of nitrate in groundwater near the WSQ reported in previous monitoring reports and this report are displayed for comparison in Figure 2-16. Overall, nitrate concentrations in individual wells from 1987 to 1989 remained nearly constant.

SULFATE

As will be discussed further in Section 2.2 of this report, 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 WSQ and in the alluvium north of the Femme Osage Slough appear to be elevated as a result of migration from the quarry. The highest 1989 sulfate value of 1,000 mg/l was measured at MW-1004. Wells to the south of the slough remain at background concentration levels.

WSQ SULFATE TREND ANALYSIS

The concentrations of sulfate at the WSQ reported in previous monitoring reports and this report are displayed for

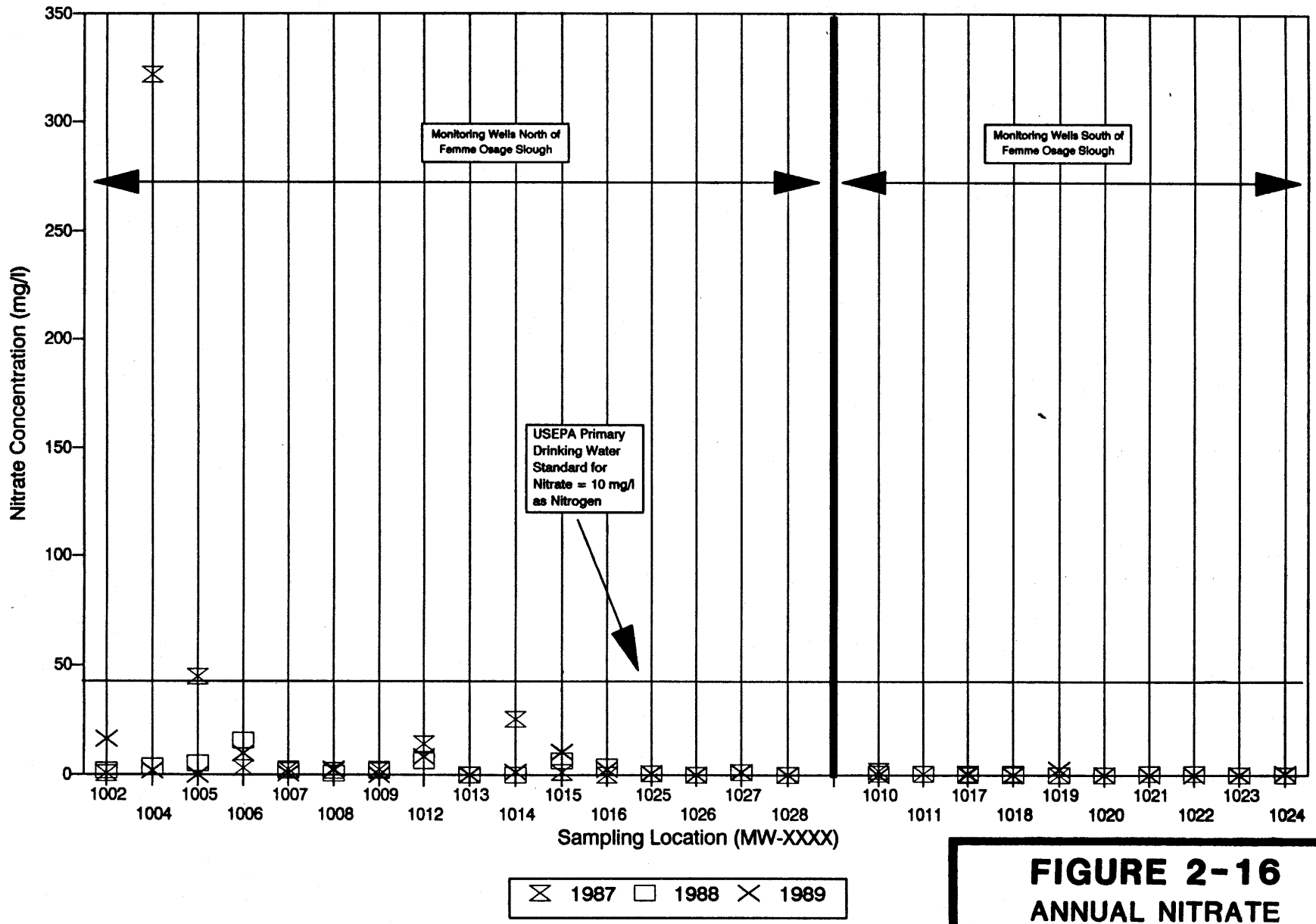


FIGURE 2-16

ANNUAL NITRATE CONCENTRATIONS WSQ GROUNDWATER 1987-1989

comparison in Figure 2-17. Evaluation of the historical sulfate data from samples from near the WSQ indicate a slight but consistent upward trend in concentration. The groundwater between the WSQ and the slough appears to have increased slightly in sulfate content from 1987 to 1989. This trend is consistent with the trend for uranium activity in the groundwater in that same area.

CHLORIDE

Chloride levels were measured once in 1989 from the WSQ monitoring wells. Those data are also presented in Table 2-3. The upper limit for background chloride levels in the bedrock aquifer near the WSCP/WSRP was established in the WSSRAP's 1988 Environmental Monitoring Report at 22 mg/l and it appears from the data from Missouri River alluvial water samples that the background for the alluvium is similar. Based upon comparison with background, chloride levels in the groundwater near the WSQ are slightly elevated in some alluvial wells north of the Femme Osage Slough. The elevated chloride levels remain well below the EPA secondary drinking water standard of 250 mg/l for chloride. Further, the measured chloride levels in groundwater south of the slough remain at background and show no evidence of contaminant migration beyond the slough.

FLUORIDE

Fluoride levels ranged from 0.1 mg/l to 0.6 mg/l in the groundwater near the WSQ. No noteworthy fluoride concentrations were detected, as compared to the EPA's maximum contaminant level of 4.0 mg/l.

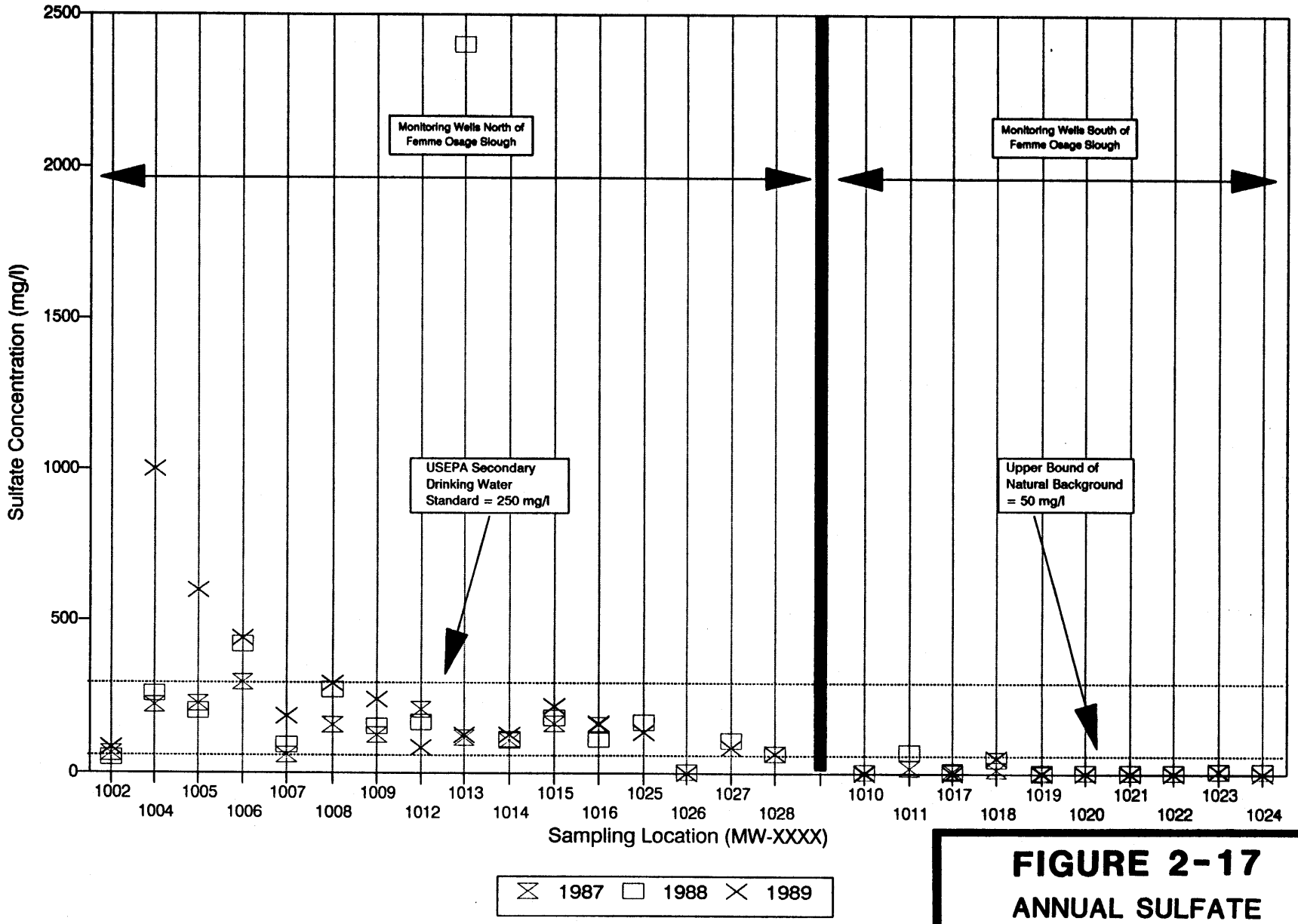


FIGURE 2-17

ANNUAL SULFATE CONCENTRATIONS WSQ GROUNDWATER 1987-1989

CONCLUSIONS OF WSQ GROUNDWATER MONITORING

Groundwater in the vicinity of the WSQ was sampled and analyzed for uranium (and other radiological species at certain wells), nitroaromatics and inorganic anions. The results indicate a slight but consistent increase in the concentrations of the contaminants in the groundwater between the WSQ bulk waste and the Femme Osage Slough. The results further indicate that the integrity of the alluvial groundwater south of the slough remains intact. Overall, the current data indicate that the groundwater contamination present near the WSQ does not pose an imminent threat to the St. Charles County water supply source.

2.2 Surface Water Monitoirng

Surface water samples were collected during 1989 under two distinct programs at the WSS. In one program, samples were collected at the WSCP boundary to monitor the off-site discharge of contaminants via surface water runoff. These samples were collected in compliance with the WSS's National Pollutant Discharge Elimination System (NPDES) permit, issued in November 1988, for storm water runoff and wastewater discharges. The permit requirements and 1989 analytical results are discussed in Section 2.2.1.

In the second program, routine samples were collected quarterly from both on-site and off-site locations where measurable impacts might be detected as part of the WSS Environmental Monitoring Program. This program was designed to fulfill the environmental surveillance requirements of DOE Order 5400.1. Environmental monitoring quantifies and documents any potential public exposure via the surface water pathway and ensures, through detection and implementation of response

measures, the protection of the public's health and safety. All surface water samples collected are analyzed without filtering unless a specific comparison of dissolved versus total contaminant concentrations is desired.

2.2.1 Effluent Monitoring Results

The Weldon Spring Site (WSS) NPDES Permit No. MO-0107701 requires monitoring of five stormwater discharge locations (NP-0001 to NP-0005) and one sanitary wastewater treatment plant discharge (NP-0006). These locations are illustrated in Figure 2-18. A summary of the permit requirements including monitoring parameters and frequencies is presented in Table 2-5. Currently, only discharges from outfall NP-0006, the administration building sanitary wastewater treatment plant, have limitations placed on them. The other five outfalls have monitoring requirements only.

Annual averages of analytical results for the stormwater locations are presented in Table 2-6. This table presents an annual summary of the individual sampling events. Tables presenting analytical results for the individual NPDES sampling events for each outfall may be found in Appendix A.

2.2.1.1 Radiological Analysis

Annual average uranium levels ranged from 6.5 pCi/l (0.241 Bq/l), about 1% of the DCG at the minimum concentration discharge point (NP-0004) to 368 pCi/l (13.62 Bq/l), about 61% of the DCG at the maximum concentration discharge point (NP-0001). 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

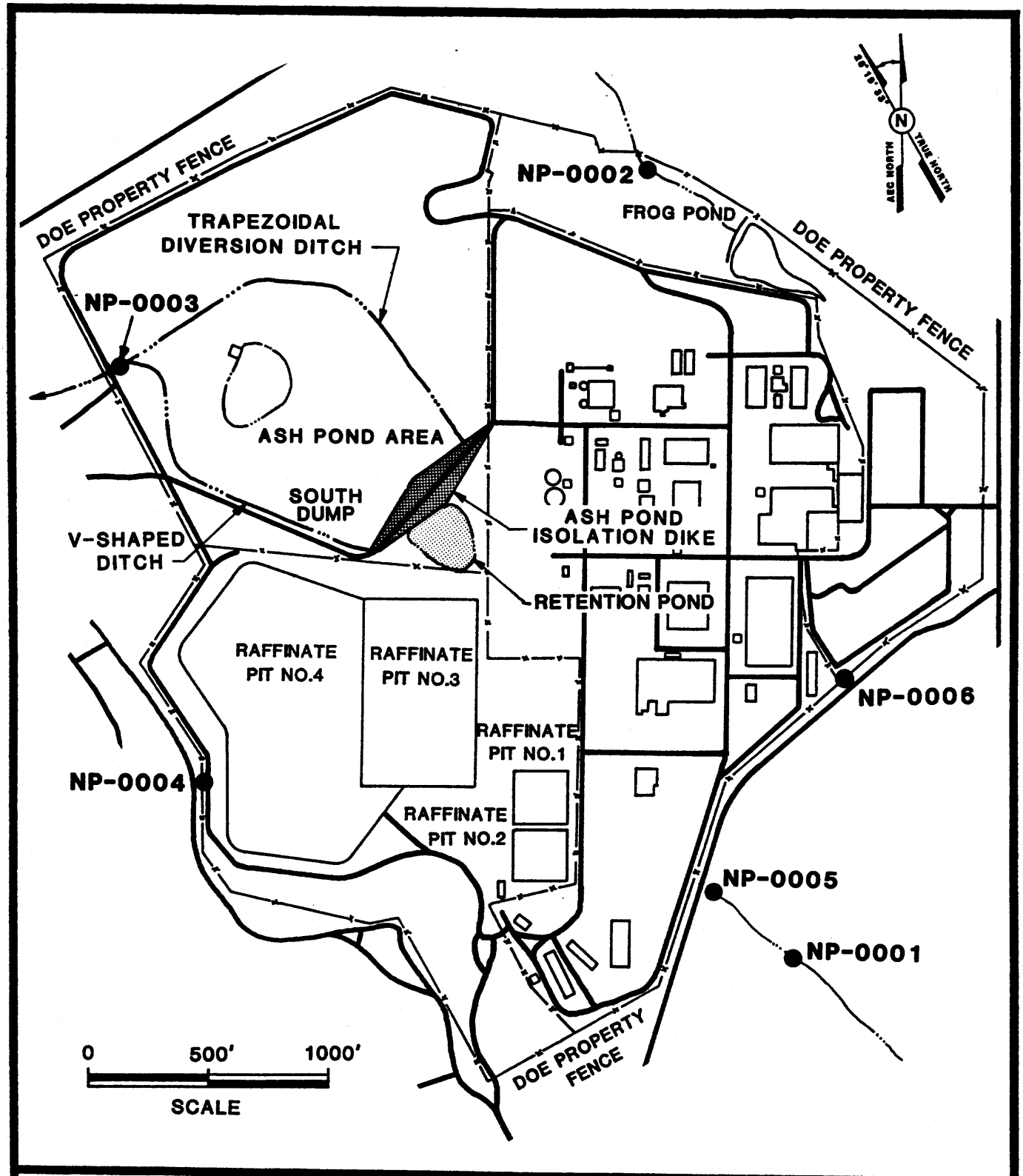


FIGURE 2-18

NPDES MONITORING LOCATIONS

TABLE 2-5 National Pollutant Discharge Elimination System Permit Monitoring Requirements

PARAMETERS	OUTFALL NUMBER **					
	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

** - See Figure 2-18 for locations

F - Limits set for Outfall NP-0006

Q - Quarterly sampling

M - Monthly sampling

TABLE 2-6 1989 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	SETTL. SOLIDS ml/l	SUSP. SOLIDS mg/l	FLOW GPD
NP-0001	4	7.20	368	258	3.95	ND	<0.1	24	47333
NP-0002	11	6.80	145	79	1.87	ND	<0.1	58	214063
NP-0003	14	6.94	280	192	16.45	0.061*	8.0*	574	125870
NP-0004	3	6.90	6.5	3.9	2.47	ND	<0.1	9	1133
NP-0005	11	6.98	347	247	32.23	ND	<0.1	19	57776

* These values were present in a single sample obtained in January. All other values at NP-0003 for lithium and settleable solids were ND and <0.1, respectively.

ranged from 120 to 590 pCi/l (4.44 to 21.83 Bq/l) during 1989. Flows from the process and sanitary sewer outfall (NP-0001) combine with surface runoff from the southeast portion of the WSCP (NP-0005) and discharge into the southeast drainage easement. Uranium concentrations measured at NP-0005 exhibited similar levels with an annual average of 347 pCi/l, 58% of the DCG, and a range of 95 to 570 pCi/l (3.52 to 21.09 Bq/l).

Frog Pond's off-site discharge (NP-0002) exhibited an annual average uranium concentration of 145 pCi/l (5.36 Bq/l), 26% of the DCG. Individual monthly measurements ranged from 25 to 400 pCi/l (0.93 to 14.8 Bq/l). Off-site runoff from the area of Raffinate Pit 4 (NP-0004) exhibited an annual average uranium concentration of 6.5 pCi/l (.24 Bq/l) 1% of the DCG with a range of individual measurements from 3 to 9.7 pCi/l (0.11 to 0.36 Bq/l).

Results for the four NPDES outfalls discussed above are consistent with previous years' monitoring results. In contrast, uranium concentrations measured at Outfall NP-0003, the off-site discharge of the Ash Pond drainage, exhibited a marked decrease compared to previous years' data. The 1988 annual average uranium concentration for this outfall was 1,178 pCi/l (43.59 Bq/l), 214% of the DCG. The 1989 annual average is 280 pCi/l (10.36 Bq/l), 51% of the DCG with an individual sample range from 16 to 1,000 pCi/l (0.59 to 37.0 Bq/l). This marked decrease can be attributed to the completion of the Ash Pond Isolation Project in April 1989 (MKF and JEG, 1990b). This Interim Response Action (IRA) was designed and constructed to divert surface runoff around contaminated areas (South Dump and Ash Pond) thereby decreasing the off-site discharge of uranium at Outfall NP-0003. This IRA is discussed in more detail in Section 3.2.4.

Annual average gross alpha levels generally followed the same pattern as the natural uranium results. The generally good correlation between the average uranium and gross alpha values indicates that virtually all of the offsite radionuclide release is in the form of soluble uranium. However, gross alpha measurements are biased low, probably due to measurement interference from dissolved solids.

If it is assumed that the entire annual precipitation runoff is discharged from these points and that the discharge from each point is proportional to the portion of the site that each point drains, an upper bound estimate of the total uranium released off-site during 1989 can be calculated. The results of these calculations are presented in Table 2-7.

2.2.1.2 Chemical Analysis

The annual average total settleable solids (ml/l) and total suspended solids (mg/l) were highest at the off-site discharge of the Ash Pond drainage (NP-0003). These elevated average values were primarily caused by high values from a sample taken in January. Total settleable solids and suspended solids for that month were measured at 8.0 ml/l and 7,018 mg/l, respectively. Lithium was also detected at 0.061 µg/l, slightly above the detection limit. During that time, the Ash Pond Isolation Project was underway in the Ash Pond drainage causing increased erosion during storm events. Additional erosion control measures were implemented in response to these high values.

The other NPDES locations also exhibited the highest suspended solids concentrations during January. Surface water runoff and resulting flows off-site were highest in January when the site received over four inches of rainfall. Settleable

TABLE 2-7 1989 Estimated Annual Release of Natural Uranium from NPDES Outfalls

OUTFALL LOCATION *	DRAINAGE AREA (acres)	PERCENT OF PRECIPITATION AS RUNOFF**	AVERAGE CONC. (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%	358	12.8	0.017	25.6
NP-0002	39.1	65%	145	26.9	0.015	21.7
NP-0003	60.1	20%	280	12.7	0.014	19.8
NP-0004	5.6	50%	6.5	3.0	0.00007	0.107

* = SEE FIGURE 2-18
** = ESTIMATED

solids measurements were less than 0.1 ml/l at all other storm water monitoring locations. Lithium was not detected at any of the other outfalls during 1989.

Annual average nitrate values ranged from a low of 1.87 mg/l at Outfall NP-0002 to a high of 32.23 mg/l at Outfall NP-0005. These values are generally consistent with the analytical results from 1988.

Outfall NP-0006 is the discharge for the site administration building wastewater treatment facility. The NPDES permit has placed limits on discharges from this outfall for biochemical oxygen demand (BOD) and total suspended solids of 15 and 10 mg/l, respectively. Samples were analyzed quarterly for these parameters by the subcontractor operating this facility. NPDES Permit limitations for the outfall were not exceeded at any time during 1989. Results are presented in a table in Appendix A.

2.2.2 Quarterly Surface Water Monitoring at the WSCP/WSRP Area

Surface water samples were collected quarterly from the eleven locations shown on Figure 2-19 in an effort to maintain a current understanding of site-related contaminant concentrations in potentially affected off-site surface water features. Five of those locations are within or upstream of lakes on the August A. Busch Memorial Wildlife Area. Many of these locations have been sampled by the WSSRAP for three 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. The samples were analyzed for radiological species at all locations and for nitroaromatic compounds and inorganic anions at select locations.

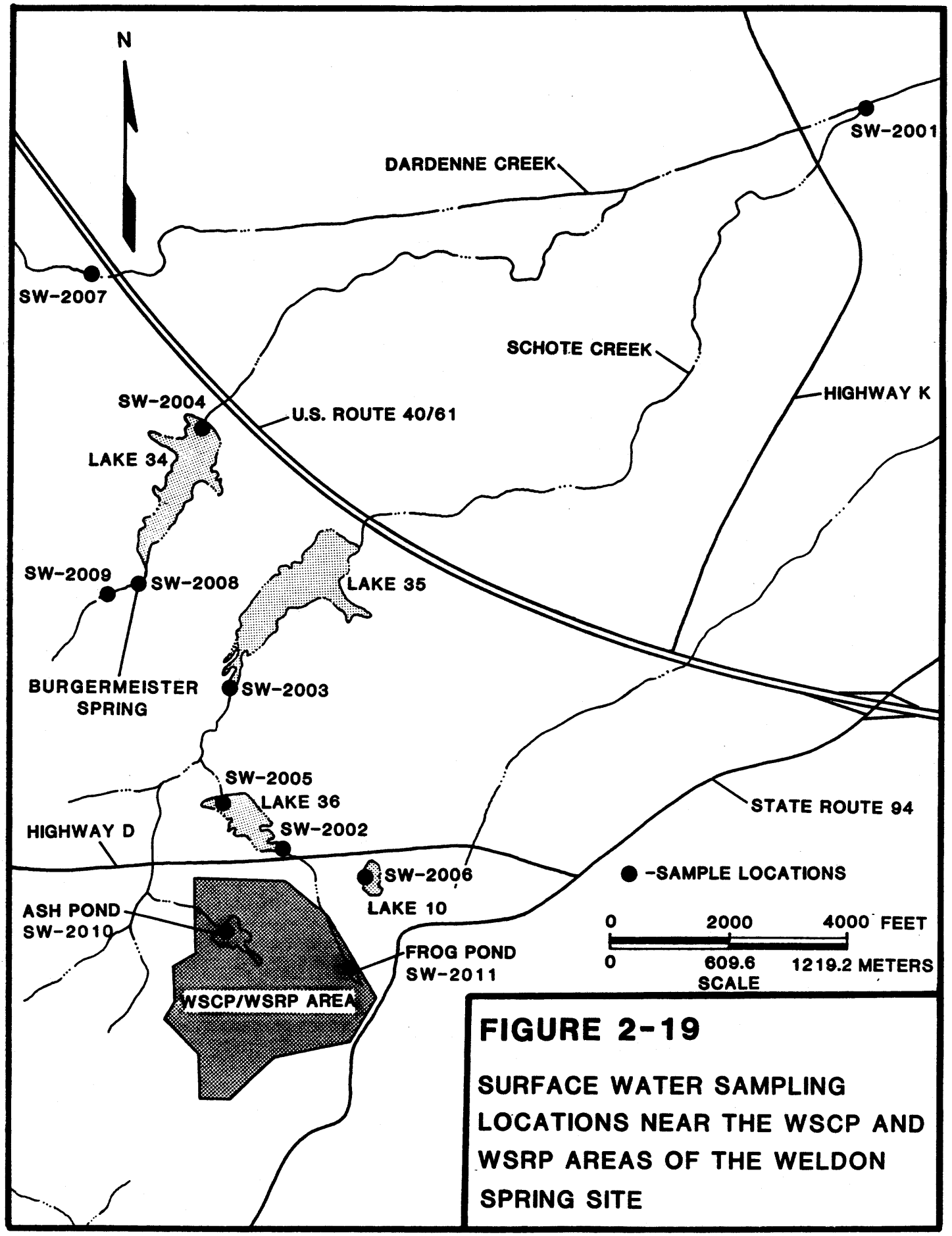


FIGURE 2-19

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

2.2.2.1 Radiological Results

URANIUM MONITORING

The total uranium activities at off-site locations ranged from below the detection limit of 1 pCi/l (0.037 Bq/l) up to 240 pCi/l (8.88 Bq/l) at Burgermeister Spring. The on-site surface water impoundments, two of which were added as sampling locations to the routine monitoring program in 1989, measured levels up to 3,200 pCi/l (118.4 Bq/l).

No significant changes were observed between the average measured values of 1988 and 1989 at any of the quarterly locations. At the furthest downstream location SW-2001 (the confluence of Schote and Dardenne creeks) the average of the quarterly measurements remained unchanged from 1988 while the maximum value declined only slightly. All of the quarterly measured values for that furthest location were within the range of background. No notable pattern in the values was observed relative to time of year.

The quarterly sampling results indicate that uranium continues to migrate from the site at relatively low levels in surface water along known discharge pathways. The concentration (activity) of the dissolved 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 measurement location SW-2001.

A substantial reduction in the concentration of uranium leaving the NP-0003 outfall was achieved with the completion of the diversion structure. Refer to Section 3.2.4 for a full

description of the diversion structure and its environmental protection benefits.

The on-site surface water bodies that were monitored quarterly include the four raffinate pits, the Ash Pond and Frog Pond. The radiological results from those locations are presented in Table 2-8. The highest measured uranium value in the 1989 surface water monitoring program came from Ash Pond at 3,200 pCi/l (118.4 Bq/l). It is important to note that after April 1989 the only on-site surface water body that released directly to off-site surface water pathways was Frog Pond.

THORIUM, RADIUM ISOTOPE MONITORING

Other radiological species (radium and thorium) were monitored in 1989 at the raffinate pits only. Historically, no other monitoring locations have detected elevated levels of those species. The raffinate pits were sampled once in 1989 to maintain a baseline on the radioisotope levels.

According to the 1989 measurements, the quarry pond water contains no radium-226 or thorium-232 above 1 pCi/l (0.037 Bq/l), and thorium-230 activities were measurable at the detection limit of 1 pCi/l (0.037 Bq/l) during two quarters.

2.2.2.2 Chemical Results

The environmental monitoring program for chemical constituents in surface water was slightly expanded from 1988 in the number of monitored locations, but was reduced in the frequency of analyses for selected parameter categories. These changes were made based upon the detailed information available from findings of past investigations at the site. During the

TABLE 2-8 Summary of Analytical Results for 1989 Surface Water Monitoring Locations Near the WSCP/WSRP Area (mg/l)

Location Number	Chloride (0.25)*	Fluoride (0.25)*	Nitrate (0.1)*	Sulfate (1.0)*	Uranium (1 pCi/l)
Chemical Plant					
SW-2001	2	ND	7	9	2
SW-2002	78	ND	ND	51	61
SW-2003	14	ND	1	16	14
SW-2004	13	ND	4	20	25
SW-2005	73	ND	2	24	15
SW-2006	13	ND	ND	10	3
SW-2007	14	ND	3	29	ND
SW-2010	102	0.4	4	40	1356
SW-2011	244	ND	ND	53	209
Raffinate Pits					
SW-3001	14	2	1450	339	307
SW-3002	7	3	ND	623	1161
SW-3003	7	5	925	195	755
SW-3004	8	19	9	370	1666

* Detection Limits (in mg/l)

1989 program, inorganic anions were measured at all locations annually. Nitroaromatic compounds were monitored once at locations that have historically indicated the presence of those compounds.

INORGANIC ANION ANALYSES

The inorganic anions of interest at the Weldon Spring Chemical Plant include chloride, fluoride, nitrate and sulfate. The following sections detail the results and implications of the anion analyses. Annual average results of these analyses are presented in Table 2-8.

CHLORIDE

The chloride levels measured in the eight off-site surface water locations ranged from a low of 1.9 mg/l at SW-2001 (Schote and Dardenne creeks) to 77 mg/l at SW-2002 (the head of Lake 36). SW-2002 and SW-2005 are directly downstream of the Missouri Department of Transportation's maintenance facility, adjacent to the site where road de-icing salt is stockpiled. The SW-2011 sampling location (Frog Pond) also receives direct discharge from the salt storage areas and shows the highest concentration of chloride of all the monitored locations (368 mg/l). Location SW-2011 yielded the only concentration level that exceeded the EPA's secondary drinking water standard of 250 mg/l for chloride.

These results indicate that the chloride levels off-site do not pose a threat to health or safety. No standards exist for protection of aquatic life or biota.

FLUORIDE

The measured fluoride concentrations at all off-site sampling locations remained below the detection limit of 0.25 mg/l. The concentration measured highest in Ash Pond at 0.5 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.

NITRATE

Nitrate concentrations ranged from below the detection limit of 1.0 mg/l to a quarterly high at Burgermeister Spring of 124 mg/l. Two distinct categories of nitrate concentrations are apparent in the measurements from 1989. At locations SW-2001 through SW-2007, and SW-2010 and SW-2011 the nitrate levels ranged from below the detection limit up to 4.2 mg/l. The Burgermeister Spring concentrations consistently are measured at approximately ten times that level. These findings are consistent with the 1988 Environmental Monitoring Report (EMR) and reinforce the conclusion drawn in the 1988 WSS EMR that contaminated groundwater is apparently contributing to the elevated nitrate levels in the Burgermeister Spring. At most locations, the levels of nitrate that are present in the surface water are below drinking water standards and therefore constitute no particular threat to human health or the environment, but they do provide valuable information on the mechanics of contaminant migration from the WSS. Further discussion regarding Burgermeister Spring contamination is presented in Section 2.2.2.3 of this report.

SULFATE

The sulfate measurements made under the surface water monitoring program yielded levels ranging between 9 mg/l at SW-2001 and 56 mg/l at SW-2011.

The pattern of high sulfate values is similar to that of the chlorides migrating from the Highway Department Facility with relative highs at Frog Pond and Lake 36. In addition, however, relatively elevated sulfate levels were detected at Ash Pond and Burgermeister Spring during 1989. These results suggest the presence of an on-site surface source for sulfates within the Ash Pond drainage. Also the sulfate value of 45 mg/l at Burgermeister Spring might suggest a component of sulfate-contaminated groundwater discharging at that point. The measured levels are well below the EPA's secondary drinking water standard of 250 mg/l for sulfate.

The WSSRAP measurements of inorganic anions in the surface water medium around the WSS indicated consistently elevated nitrate, sulfate and chloride levels. The nitrates and sulfates can in most instances be attributed to an on-site source on the WSS; the source for chlorides is located on the adjacent state highway department property. None of the measured anion levels exceeded existing water quality criteria and inorganic anions around the WSS pose no particular environmental or health and safety threat.

NITROAROMATICS MONITORING

The monitoring program for nitroaromatics in 1989 involved annual sampling at each of the off-site locations SW-2001 through SW-2008 (SW-2009 was dry) and quarterly monitoring of the on-site

locations at Ash Pond (SW-2010) and Frog Pond (SW-2011). No monitoring for nitroaromatic compounds was performed during 1989 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. Nitroaromatics were detected at levels above the detection limits only at Burgermeister Spring. A possible positive result was indicated at Lake 34 downstream of Burgermeister Spring; however, a duplicate analysis of the sample did not confirm that result.

The analyzed sample from Lake 10 on the Busch Wildlife Area did indicate a low-level positive result for two nitroaromatic compounds during the second quarter. However, no confidence is placed in those positives since there have been no previous detections in Lake 10, there are no known source areas upstream of that lake, the lake is isolated from subsurface conduit flow influences, blank samples were also contaminated, and at these low quantifiable limits the analyses have proven to be susceptible to false positive results. The positive results in Lake 10 are therefore dismissed as false and Lake 10 is not considered to be contaminated with nitroaromatics. The 1990 sampling and analytical program will include Lake 10 for nitroaromatics to verify the presence or absence of those compounds.

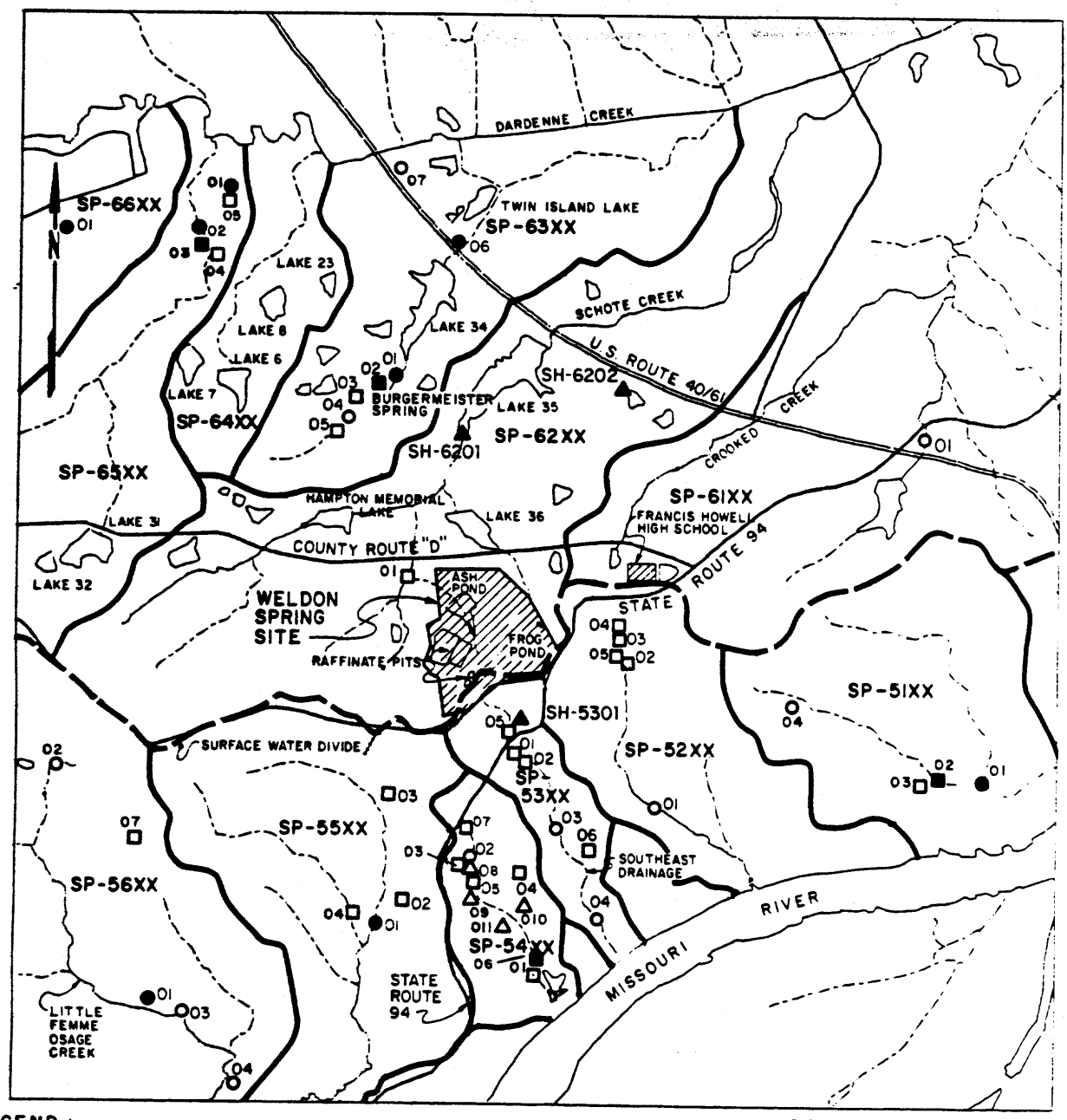
Mixed results were obtained from Frog Pond and again the positive detection of nitroaromatic compounds is questionable. At the Frog Pond, two samples collected during 1989 indicated no nitroaromatic compounds above the detection limit; however during second quarter, relatively high positive levels were detected for three of the six compounds monitored. The pattern of results suggests that again the second quarter positive results probably

constitute laboratory contamination or false positive interpretation. This is substantiated by the contamination of blank samples. Analyses for nitroaromatic compounds will continue at Frog Pond to verify the absence or presence of these contaminants.

2.2.2.3 Spring Monitoring

Other surface water features monitored under the environmental monitoring program are various springs near the WSCP/WSRP area. Some of the springs that are routinely monitored are known to issue contaminated water while others are located geographically so that contamination could reach the spring. Monitoring provides a baseline for establishing that connection. Figure 2-19A displays the spring sampling locations in the WSS area.

The results of the 1989 monitoring of springs in the WSS area are presented in Table 2-9 and indicate no change in the distribution or levels of contaminants at the springs of concern. The highest levels of uranium issue from SP-5301 through SP-5304 in the southeast drainage easement at annual averages ranging from 377 pCi/l (13.95 Bq/l) to 135 pCi/l (4.99 Bq/l). Burgermeister Spring and the estavelle spring (SP-6301 and SP-6302) remain within their historical range at an annual average of 98 pCi/l (3.63 Bq/l) and 90 pCi/l (3.33 Bq/l) respectively. (Note: Location SP-6301 and location SW-2008 are both Burgermeister Spring as they were sampled under two separate programs. That location will be assigned SP-6301 designation exclusively in 1990.)



LEGEND:

SOURCE: MDNR, 1989

- SURFACE WATER DIVIDE BETWEEN MISSISSIPPI RIVER AND MISSOURI RIVER
- DRAINAGE BOUNDARY
- CREEK OR SURFACE DRAINAGE
- POND OR LAKE
- ● PERENNIAL SPRING WITH LARGE MAXIMUM FLOW
- ○ PERENNIAL SPRING WITH SMALL MAXIMUM FLOW
- ■ WET WEATHER SPRING WITH LARGE MAXIMUM FLOW
- □ WET WEATHER SPRING WITH SMALL MAXIMUM FLOW
- ▲ SHALLOW HOLE (SH)
- △ SEEP
- SP-63XX — SPRING OR SEEP IN DESIGNATED DRAINAGE AREA NUMBER 63. XX REPRESENTS THE DESIGNATED SPRING NUMBER IN DRAINAGE 63.

0 3200 6400
SCALE FEET

FIGURE 2-19A

SPRINGS AND SEEPS IN THE VICINITY OF THE WSS

TABLE 2-9 Summary of Annual Averages for Inorganic Anions and Uranium at Springs Near the WSS (mg/l)

Location Number	Chloride (0.25)*	Fluoride (0.25)*	Nitrate (0.1)*	Sulfate (1.0)*	Uranium (1.0 pCi/l)*
SP-5201	17	ND	0.15	70	ND
SP-5203	68	0.3	27	59	2
SP-5301	14	0.4	13	61	324
SP-5302	15	0.4	17	137	362
SP-5303	12	0.3	10	60	231
SP-5304	8.1	ND	6	45	135
SP-5503	10	ND	2.3	55	ND
SP-6301	21	0.2	65	48	98
SP-6302	--	--	--	--	90
SP-6303	14	ND	35	54	3
SP-6306	13	0.3	0.8	8	3

-- No data available for that location.

* Detection Limit

An inconsistently high quarterly sulfate measurement at SP-5302 drove the 1989 annual average for sulfate up to a level unusual for local springs. The source for this unusually high quarterly measurement is uncertain; however laboratory error is suspected. None of the other springs connected to that same flow system, either upstream or downstream, indicated similarly high levels. All of the measured levels remain below the EPA's secondary drinking water standard of 250 mg/l.

At 68 mg/l, the chloride levels at SP-5203 remain elevated, as was documented in the Phase I Spring and Seep Study (MKF and JEG, 1988b). The source for these elevated chloride levels is hypothesized to be the stockpiles of sodium chloride (de-icing salt) at the highway department maintenance facility adjacent to the WSS. No other chloride levels in springs were noteworthy.

The fluoride measurements lay well within the range established as background for fluoride during the Phase I study. No quarterly values were noteworthy.

Nitrate levels above the maximum calculated background level of 14.5 mg/l were detected at three springs--SP-5203, SP-6301 and SP-6303. The highest quarterly nitrate level was detected at Burgermeister Spring (SP-6301) at 124 mg/l with an annual average of 59 mg/l. The annual average for nitrate at Burgermeister Spring is slightly above the EPA's primary drinking water standard equivalent for nitrate of 45 mg/l. It is important to note that Burgermeister Spring does not serve as a regular drinking water/tap water source to which primary drinking water standards apply; however the standard serves as an effective health-based numerical comparison for the purposes of this document. These elevated values indicate contaminant influences to the groundwater system feeding those springs. It is currently

not known whether the sources for the nitrates issuing from these springs is similar or disparate. Spring SP-6301 water contains low-level nitroaromatics, uranium and nitrates; SP-6303 contains higher nitroaromatics, no uranium, and elevated nitrates, and SP-5203 contains high anions and no nitroaromatics or uranium.

In summary, the conditions influencing the resurging water at local springs appear to be remaining constant with no notable variations in contaminant levels or distribution.

2.2.3 Quarterly Surface Water Sampling at the WSQ Area

The nine surface water locations in Figures 2-20 and 2-21 were sampled quarterly and analyzed for uranium, with select locations analyzed additionally for radium-226, thorium-230, thorium-232, nitrate, sulfate, chloride, and fluoride. These locations were chosen for routine monitoring to investigate and document the possibility that surface waters near the 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. Five sampling locations--SW-1003 through SW-1005, SW-1009 and SW-1010--are distributed along the Femme Osage Slough west of, adjacent to, and east of the WSQ. 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 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 Missouri River location furthest upstream above any potential influences

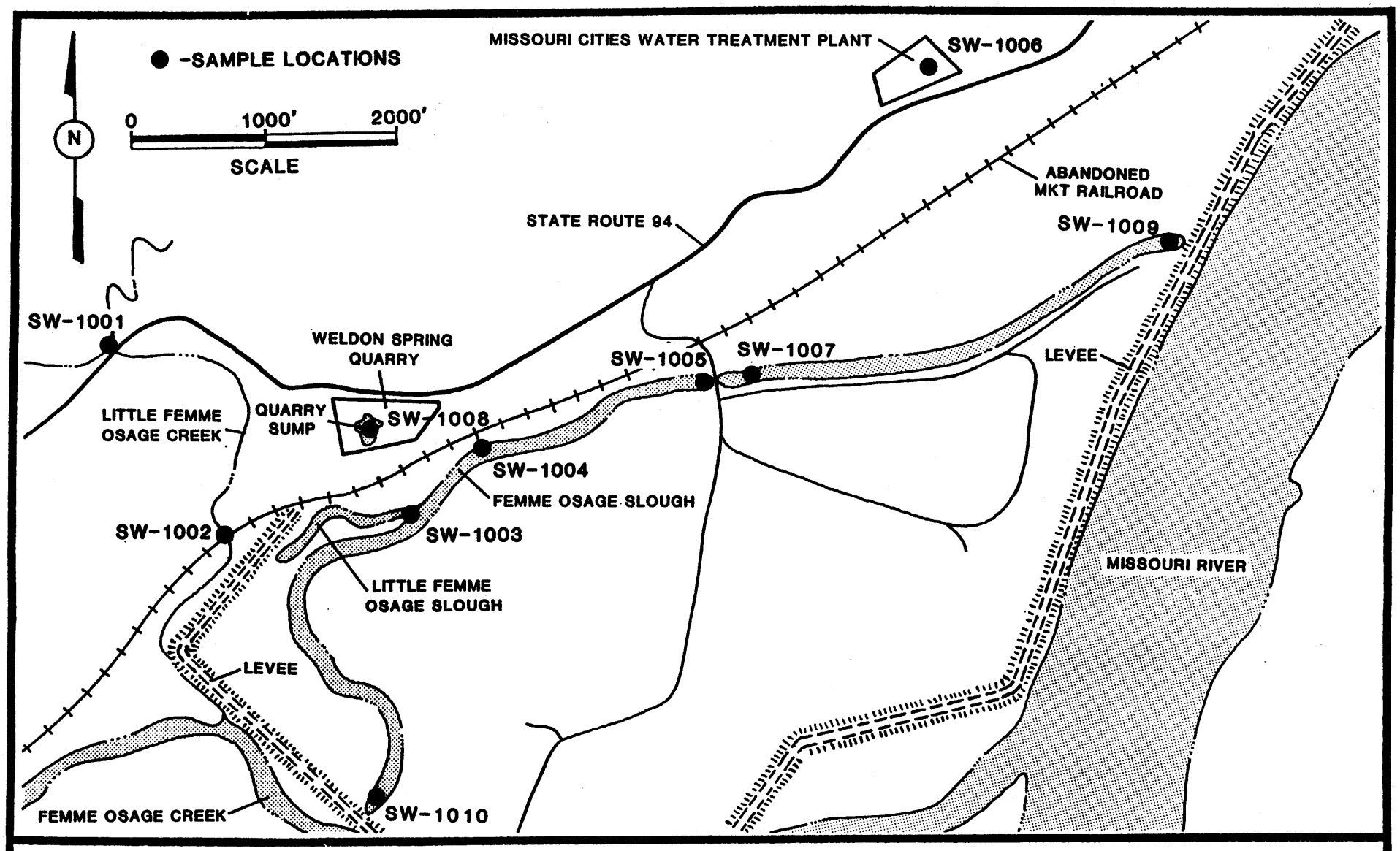


FIGURE 2-20

SURFACE WATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

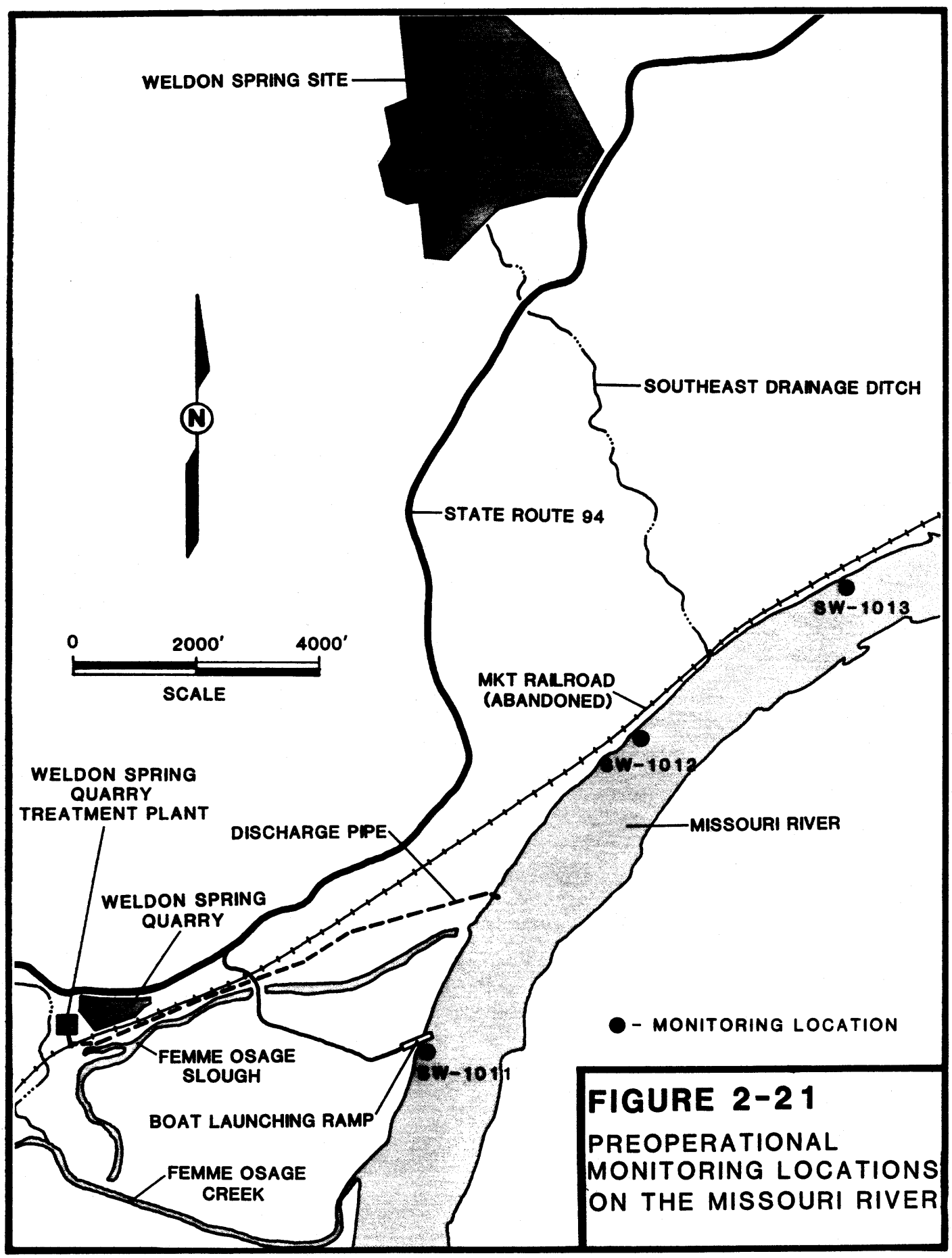


FIGURE 2-21

PREOPERATIONAL MONITORING LOCATIONS ON THE MISSOURI RIVER

from WSS contamination, while SW-1013 is furthest downstream below the outfall point of the southeast drainage easement.

2.2.3.1 Radiological Results

URANIUM

All surface water monitoring locations were sampled quarterly for uranium. Select locations including SW-1008, SW-1011, SW-1012, and SW-1013 were also analyzed for radium-226 and two thorium isotopes once during the monitoring year.

The primary radionuclide of concern at the WSQ and surrounding area is uranium, which was detected at levels ranging from below the detection limit of 1 pCi/l (0.037 Bq/l) to a high of 2,400 pCi/l (88.8 Bq/l) in the quarry pond water within the access-controlled area.

As has been determined in previous monitoring years, no elevated uranium activities were detected in the waters of the Little Femme Osage Creek either up or downstream of the quarry.

The Femme Osage Slough, which is the former channel of the Femme Osage Creek prior to rerouting that stream course, is a nearly unmoving water body. The slough has been known for several years to be receiving uranium contamination from the contaminated groundwater in the bedrock and alluvium to the north. In 1989, the average uranium activities ranged from 18 pCi/l (0.67 Bq/l), 3% of the DCG at SW-1009 to 161 pCi/l (1.68 Bq/l), 29% of the DCG at SW-1004. The annual average results for SW-1003 and SW-1004 were influenced by apparently elevated uranium levels in these portions of the slough. The levels returned to the usual range for those locations by third

quarter. This departure is atrributed to uranium contaminated groundwater discharging to the slough from the north side. The interception of this contaminated groundwater by the slough with evidence of no continued migration south of the slough is consistent with the DOE's data that show the slough has been acting as a barrier to contamination. With uranium activity measured at SW-1010 it is believed that the west end of the slough receives contaminants as water flows westward up the slough during periods of high river stage. The 1990 monitoring program will concentrate on this situation to attempt to characterize the mechanism and define the potential impacts.

Locations SW-1011 to SW-1013 are spaced 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. The results of the measurements yielded average uranium activities which ranged from 2.9 pCi/l (0.107 Bq/l) at SW-1013 (downstream) to 4.4 pCi/l (0.16 Bq/l), less than 1% of the DCG, at SW-1011 (upstream). The values are virtually the same when considering the average counting error at plus or minus 1.0 pCi/l (0.037 Bq/l). The highest measured uranium activity in the Missouri River was detected during the first quarter of 1989 at 6.3 pCi/l (0.23 Bq/l).

Finally, the quarry pond water (SW-1008) was monitored quarterly during 1989 for uranium. The average measured uranium activity was 1,830 pCi/l (67.71 Bq/l), 332% of the DCG, which is similar to the levels measured in 1988 at an average of 1,300 pCi/l (48.1 Bq/l), or 236% of the DCG. The quarry pond remains within the access-controlled area of the quarry and poses little direct threat to the public health.

2.2.3.2 Chemical Results

INORGANIC ANION RESULTS

Inorganic anions were analyzed on an annual basis in samples from locations SW-1001 through SW-1010 (except SW-1006) and more frequently on samples from the quarry pond and on Missouri River water samples (SW-1011 to SW-1013). The inorganic anions category includes chlorides, fluorides, nitrates and sulfates. The results of the analyses are presented below. Table 2-10 presents the annual averages for each parameter measured.

CHLORIDE

The highest measured chloride values were detected in the three Missouri River water samples at annual averages ranging from 23 mg/l at SW-1013 to 29 µg/l at SW-1012. All other measured levels remained well below the Missouri River background concentrations.

The levels measured in 1989 at SW-1001 to SW-1009 have decreased or remained very nearly the same. The relatively slight variations were of a magnitude that can be accounted for by natural dilutional effects.

FLUORIDE

Fluoride levels remained below the detectable limit of 0.25 mg/l at eight of the 12 monitored locations. At the quarry pond, the annual average was 0.57 mg/l while the Missouri River ranged from 0.49 mg/l at SW-1011 to 0.55 mg/l at SW-1013 during the fourth quarter of 1989.

TABLE 2-10 Summary of Analytical Results for 1989 Surface Water Monitoring Locations Near the Weldon Spring Quarry (mg/l)

Location **	Chloride (0.25)*	Fluoride (0.25)*	Nitrate (0.1)*	Sulfate (1.0)*	Uranium + (1.0 pCi/l)*
SW-1001	14	ND	4	ND	2
SW-1002	6	ND	1	38	2
SW-1003	10	ND	ND	125	86
SW-1004	12	ND	ND	141	161
SW-1005	12	ND	ND	91	44
SW-1007	7	ND	ND	90	19
SW-1008	14	0.7	0.4	141	1827
SW-1009	7	ND	ND	96	18
SW-1010	4	ND	ND	101	44
SW-1011	23	ND	3.2	130	4
SW-1012	29	ND	2.3	170	4
SW-1013	23	0.3	2.5	111	3

+ Units for uranium are in pCi/l.
* Detection Limit
** SW-1006 was removed from the surface water sampling program.

NITRATE

The nitrate levels measurable above the detection limit of 0.1 mg/l ranged to as high as 4.2 mg/l at SW-1011 in the Missouri River. All of the levels were insignificantly low as compared to the EPA's primary drinking water standard of 45 mg/l.

SULFATE

The sulfate measurements ranged from below the detection limit of 40 mg/l to as high as 171 mg/l at all locations in the Missouri River during the third quarter of 1989. No unusual patterns are visible in the data other than the relatively high sulfate as background in the Missouri River. The average sulfate level for all quarters from all three locations along the Missouri River was 149 mg/l. All measured levels remained well below the EPA's secondary drinking water standard for sulfate of 250 mg/l.

NITROAROMATICS

Samples were collected at three locations along the slough once annually (SW-1003 to SW-1005) to assess whether detectable levels of nitroaromatics were present in slough water. No levels above the detection limits were discovered.

The quarry pond was sampled quarterly for nitroaromatic compounds. The total quantified concentrations of all six compounds ranged from 2.4 µg/l in the first quarter to 68 µg/l in the fourth quarter. 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.

2.3 Radon Gas Monitoring

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

Radon exposure is a potential environmental impact from the WSS. Therefore, radon has been monitored since 1981. This section discusses the monitoring program and presents a summary of the monitoring results.

2.3.1 Radon Gas Monitoring Program

The radon gas monitoring program uses one pair of radon detectors at 22 permanent locations that are exchanged quarterly. These detectors are deployed at six locations at the Weldon Spring Chemical Plant, six locations at the Weldon Spring Quarry, four locations at the Weldon Spring Raffinate Pits, and six off-site locations. Radon monitoring locations are shown in Figures 2-22, 2-23 and 2-24. On-site detectors were 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 levels near the WSS.

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

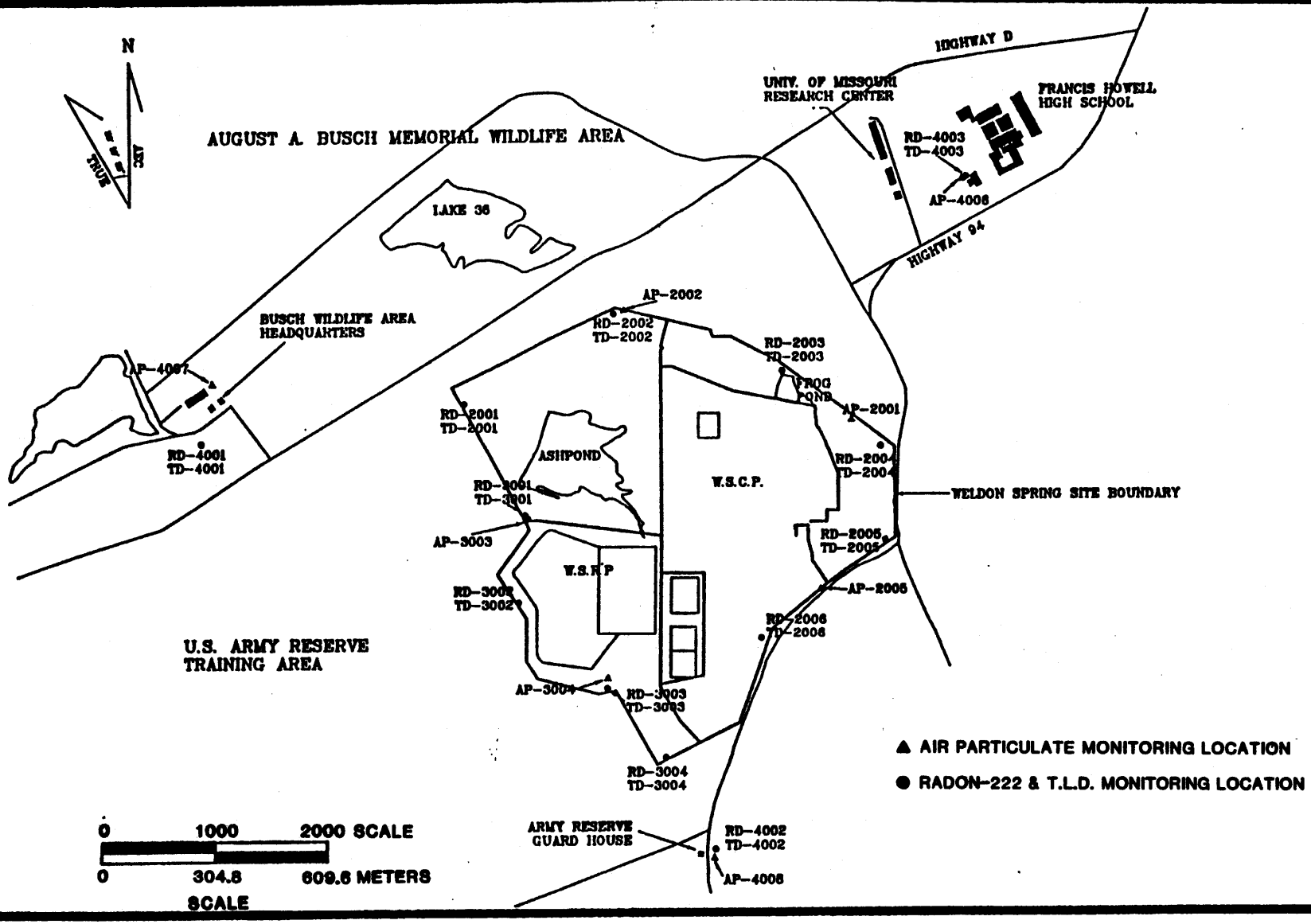


FIGURE 2-22

RADON-222, TLD, AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSCP/WSRP AREA

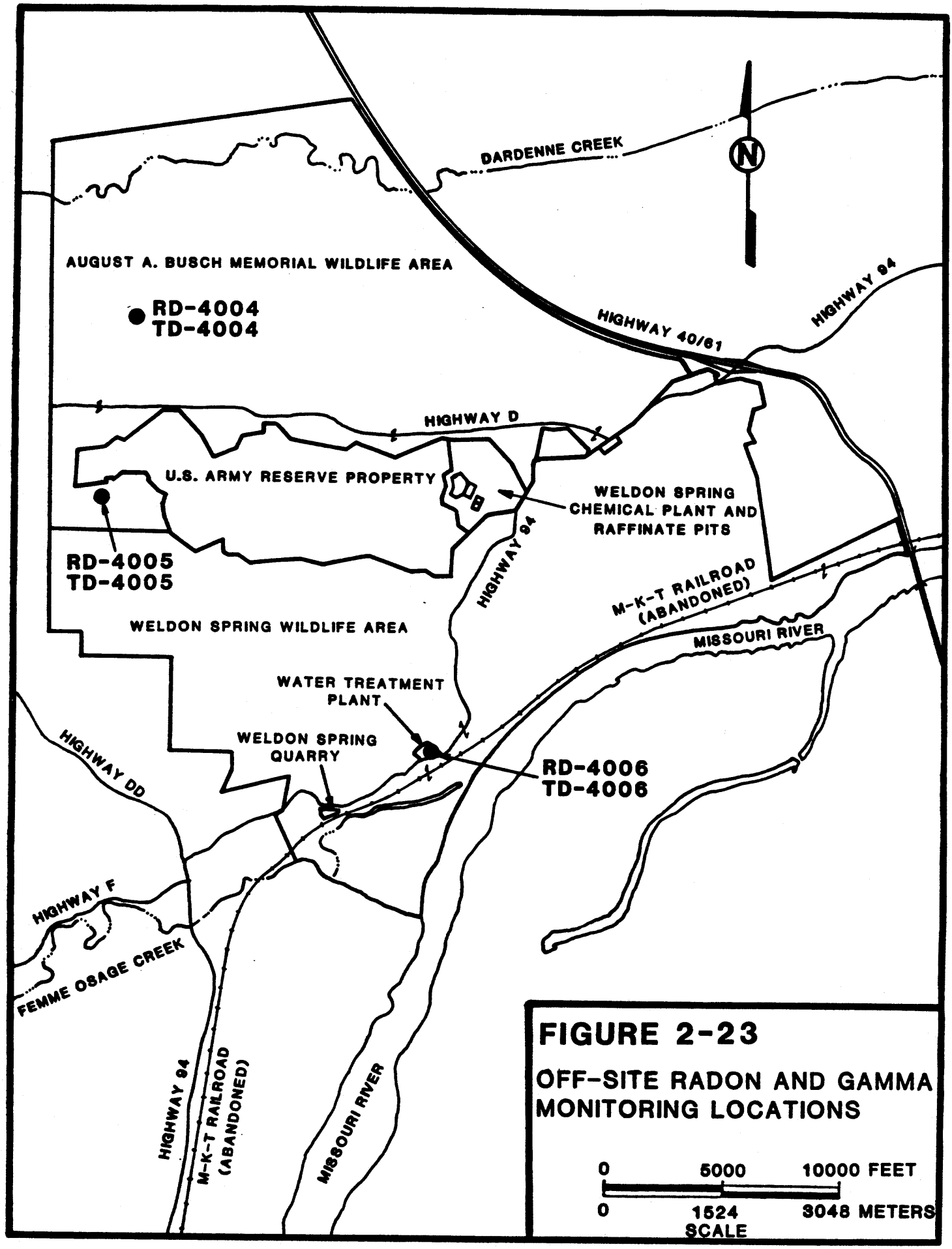


FIGURE 2-23

OFF-SITE RADON AND GAMMA MONITORING LOCATIONS

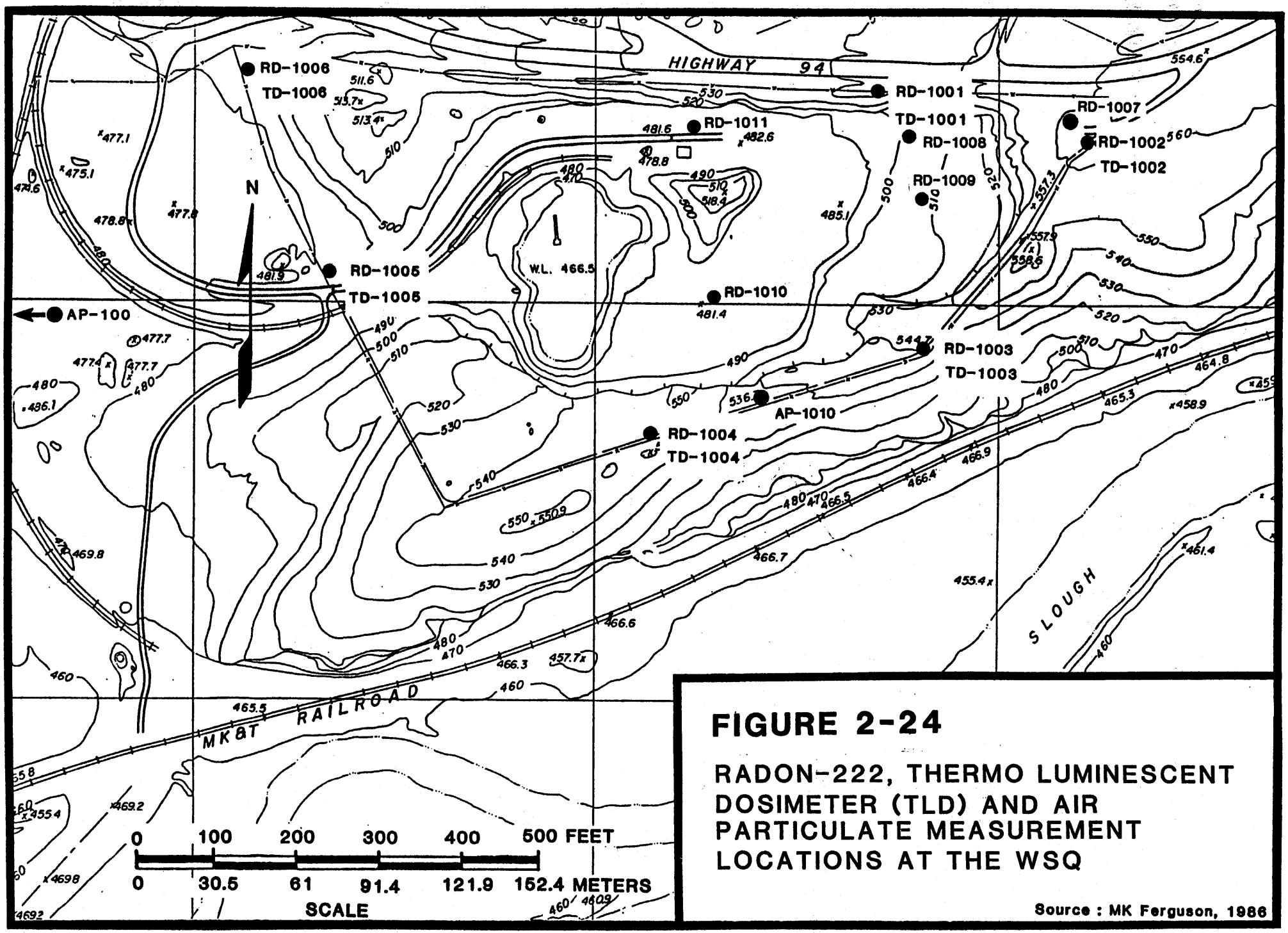


FIGURE 2-24

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

Source : MK Ferguson, 1986

In addition to the Type F detectors, Terradex Track Etch Type M detectors were placed at the permanent quarry monitoring stations in the second quarter of 1989. Type M detectors have a barrier which effectively screens out Rn-220 while allowing Rn-222 to pass through. These detectors were deployed in pairs, adjacent to the Type F detectors. These measurements were taken in order to determine the percentage of Rn-220 which is contributing to the total radon concentration at the quarry perimeter.

2.3.2 Radon Gas Monitoring Results

Table 2-11 summarizes the quarterly and annual average concentration of radon detected at all WSS perimeter and off-site monitoring locations. Also contained in Table 2-11 is a comparison of the measured annual average concentration to the federally permitted concentration for unrestricted areas of 3 pCi/l (110 Bq/^{3}) as authorized by DOE Order 5400.5.

For each monitoring station, annual averages in Table 2-11 were calculated by finding the arithmetic average of the four quarterly replicate values. The standard deviation was calculated by computing the square root of the sum of the squared errors divided by four for each quarterly replicate data point. Due to vandalism, monitoring stations RD-1001 and RD-4005 were missing one of the replicate detectors in the first and third quarter, respectively. In these cases the values of the single remaining detector were reported.

Ambient background concentrations were determined by calculating the arithmetic average of concentrations for the four background locations. These four locations are: RD-4001, RD-4004, RD-4005, and RD-4006. These data yielded an annual

TABLE 2-11 1989 Track Etch Radon Results(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 GUIDELINE(c)
WSQ							
RD-1001	1.0	1.5	2.0	1.5	1.5	0.2	32
RD-1002	1.8	1.3	1.3	2.1	1.6	0.2	35
RD-1003	4.7	0.8	1.3	1.6	2.1	0.4	52
RD-1004	1.1	0.5	0.7	1.2	0.8	0.1	8
RD-1005	1.8	0.7	0.8	1.3	1.1	0.2	18
RD-1006	0.4	0.4	0.7	1.1	0.6	0.1	-
WSCP							
RD-2001	0.7	0.4	0.4	0.7	0.5	0.1	-
RD-2002	0.5	0.4	0.6	0.6	0.5	0.1	-
RD-2003	0.6	0.4	1.1	0.6	0.6	0.1	-
RD-2004	0.3	0.4	0.8	0.6	0.5	0.1	-
RD-2005	0.3	0.3	0.5	0.5	0.4	0.1	-
RD-2006	0.4	0.5	0.7	0.7	0.6	0.1	-
WSRP							
RD-3001	0.6	0.3	0.5	0.6	0.5	0.1	-
RD-3002	0.3	0.3	0.5	0.6	0.4	0.1	-
RD-3003	0.3	0.4	0.7	0.6	0.5	0.1	-
RD-3004	0.3	0.4	0.7	0.4	0.4	0.1	-
OFF SITE							
RD-4001*	0.3	0.4	1.2	0.5	0.6	0.1	-
RD-4002	0.3	0.3	0.4	0.3	0.3	0.1	-
RD-4003	0.3	0.3	0.8	0.3	0.4	0.1	-
RD-4004*	0.4	0.3	0.4	0.6	0.4	0.1	-
RD-4005*	0.6	0.4	0.6	0.4	0.5	0.1	-
RD-4006*	1.3	0.4	0.8	0.5	0.7	0.2	-

(a) RESULTS INCLUDE NATURAL BACKGROUND
(b) DUE TO ROUNDING THE AVERAGED QUARTERLY DATA MAY NOT EQUAL THE ANNUAL AVERAGE
(c) THE DOE CONCENTRATION GUIDELINE FOR Rn-222 IS 3pCi/l (110 Bq/m^3)(ANNUAL AVERAGE ABOVE BACKGROUND) FOR UNCONTROLLED AREAS.
* DENOTES BACKGROUND STATION

background value for radon (Rn-222 plus Rn-220) in 1989 of 0.6 pCi/l (20.5 Bq/m^3).

The quarterly radon concentrations at each monitoring location were compared statistically, at the 95 percent confidence level, to the quarterly concentrations of the four background locations. Only those monitoring locations that were statistically different from background were compared to the DOE guideline.

Radon concentrations at the WSS perimeter and at off-site locations were lower in 1989 than in 1988. Abnormally high values were recorded in 1988 because of the regional drought. The 1988 drought reduced the moisture content of soils; radium-containing wastes thus allowed a greater fraction of radon in the soil and waste voids to diffuse into the atmosphere. The lower radon concentrations measured in 1989 are comparable to concentrations reported in past annual environmental monitoring reports (prior to 1988) and are typical of values expected during years of normal precipitation levels.

Radon concentrations found in the quarry are higher than concentrations measured at other WSS properties because the radium concentrations in quarry wastes are typically higher than other areas and because the quarry is a large depression in the terrain with side walls ranging from 3 to 15 meters high (10 to 50 feet). In conjunction with stable meteorological conditions, this tends to trap emanating radon within the quarry and raises the concentrations along the quarry perimeter.

Radon concentrations measured at the quarry perimeter with Type M detectors, which effectively screen out Rn-220 (thoron), are listed in Table 2-12. Table 2-12 lists the average

TABLE 2-12 Type M Detectors at WSQ in 2nd Quarter of 1989

Location I.D.	No. of Samples[a]	Radon Concentrations pCi/l Type F Detector	STD Dev.	Type M Detector	STD Dev.	Difference	Percentage of Thoron
RD-1001	2	1.45	0.18	1.85	0.28	-0.40	0
RD-1002	2	1.25	0.17	0.75	0.14	0.50	40
RD-1003	2	0.75	0.13	1.05	0.21	-0.30	0
RD-1004	2	0.45	0.10	0.55	0.15	-0.10	0
RD-1005	2	0.70	0.13	1.00	0.21	-0.30	0
RD-1006	2	0.40	0.10	0.45	0.13	-0.05	0

(a) Two samples for each Type F and Type M

concentration of the Type F and Type M detectors at the WSQ monitoring station for the second quarter of 1989. Also contained in the table is the percentage of thoron contribution to the total concentration of radon (Rn-222 plus Rn-220) recorded by the Type F detector at each station.

The concentration at each location was determined by taking the arithmetic average of the replicate values. The estimate of error was calculated by finding the square root of the sum of the squared errors divided by the number of data points.

In Table 2-12 the results of the Type M detectors were subtracted from the results of the Type F detectors to show if Rn-220 (thoron) was contributing to the total radon concentration. Only one location (RD-1002) showed a positive difference between the Type F and Type M detectors. The remaining comparisons of results were equal or showed a negative difference. Because the Type F detectors measure both Rn-222 and Rn-220, a negative difference between the Type F detection result and Type M detector results should not occur. The overall differences are attributable to the uncertainty in the measurement methods. The one positive result, which was measured in the second quarter, is not sufficient evidence to conclude that thoron is contributing to the radon concentration at that location or at the WSQ perimeter. The WSSRAP will evaluate this further by taking measurements during 1990 using continuous monitors.

2.4 Gamma Radiation Exposure Rate Monitoring

Gamma rays are electromagnetic radiation that are emitted from the nucleus of atoms following alpha or beta emissions. The environment naturally contains radioactive substances which emit

gamma radiation. Terrestrial radiation sources are natural radioactive elements in the environment (soil, water). Cosmic radiation is high-energy radiation that originates in outer space and filters through the atmosphere reaching the earth 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 of the U-238 and Th-232 decay series. These radionuclides are found in above-background concentrations on the WSS properties. Therefore, gamma radiation is monitored at the WSS. This section discusses the monitoring program and presents the summary of the results.

2.4.1 Gamma Radiation Exposure Rate Monitoring Program

To monitor exposure from gamma radiation at the WSS, 22 monitoring stations using spherical environmental thermoluminescent dosimeters (TLDs) were deployed. 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 2-22), six monitoring stations are located along the WSQ perimeter fence (Figure 2-24) and six monitoring stations are located off-site (Figures 2-22 and 2-23). 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 which is designed with internal filters to measure penetrating radiation. The TLDs are

exchanged quarterly and returned to TMA/Eberline Laboratory for processing.

In addition to monitoring gamma radiation with TLDs, natural background gamma radiation exposure rates were measured one meter from the ground surface with a pressurized ionization chamber (PIC) from October through December 1988. Total gamma exposure was integrated with the PIC over time intervals ranging from one to three hours at each measurement location.

Five measurements were made in each of three distinct geographical regions in the vicinity of the WSS. These regions have differing soil characteristics and potentially have differing terrestrial gamma exposure rates. The three distinct regions are the dissected glacial till deposits, the alluvial deposition of the Missouri River Valley, and the Salem Plateau.

The WSCP/WSRP is located in a transitional region between the glacial till deposits and the Salem Plateau. The WSQ is located on the Salem Plateau just north of the alluvial deposition region of the Missouri River Valley.

2.4.2 Gamma Radiation Exposure Rate Monitoring Results

Natural background exposure rates measured with the PIC averaged 8.3 ± 1.8 microroentgen (μR)/hr, 9.3 ± 1.1 μR/hr, and 9.1 ± 1.7 μR/hr at two standard deviations for the dissected glacial till, Salem Plateau, and the alluvial deposition of the Missouri River, respectively. At the 95 percent confidence level there is no reason to suspect a difference in gamma exposure rates for the three geological regions. Averaging the results among the regions yields an estimate of the natural background surrounding the WSS of 8.9 ± 0.9 μR/hr at two standard

deviations. This translates to a yearly average gamma exposure of 78 ± 7.9 mR at two standard deviations (8.9 μR/hr times 8,760 hours per year).

To determine background levels of gamma radiation as measured with the TLDs, the gamma exposure at the four background monitoring stations were averaged. This yielded 68 ± 8.0 mR/year at two standard deviations.

The average exposure as measured by the TLDs is significantly lower than the average exposure as measured by the PIC at the 95 percent confidence level. This is probably due to the fact that the PIC measurements were short-term measurements (i.e., hourly) while the TLDs integrate gamma exposure for 13 weeks. Thus the TLD results provide a better estimate of natural background exposure.

Yearly background gamma exposures have been measured previously by the PMC and other contractors for the DOE around the WSS. Results have ranged from 60 to 104 mR/year (BNI, 1985a; BNI, 1985b; BNI, 1984; and MKF and JEG, 1989a). There continues to be agreement between previous monitoring results and current results. This is expected because nothing has significantly changed the configuration or location of the wastes at the WSS.

Table 2-13 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, and at the four background monitoring stations. The results reported in the table include two standard deviations.

TABLE 2-13 Gamma Radiation Exposure Rate Monitoring Results(a) (mR/year)

LOCATION I.D.	FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER	ANNUAL TOTAL(b)	2 ST DEV
QUARRY						
TD-1001	27	TE	21	25	98	7
TD-1002	27	TE	16	18	80	6
TD-1003	23	TE	17	22	82	8
TD-1004	22	TE	16	18	75	15
TD-1005	23	TE	17	21	80	16
TD-1006	20	TE	15	19	71	11
CHEMICAL PLANT						
TD-2001	18	TE	13	22	71	7
TD-2002	20	TE	15	17	68	8
TD-2003	26	TE	13	20	79	20
TD-2004	20	TE	14	18	69	11
TD-2005	18	TE	13	16	62	4
TD-2006	18	TE	15	20	70	11
RAFFINATE PITS						
TD-3001	20	TE	15	20	73	12
TD-3002	16	TE	11	15	56	7
TD-3003	18	TE	14	18	67	6
TD-3004	18	TE	15	15	65	10
OFF SITE						
TD-4001*	21	TE	15	21	75	12
TD-4002	15	TE	11	13	52	7
TD-4003	18	TE	12	14	59	10
TD-4004*	-	TE	-	17	70	3
TD-4005*	17	TE	-	16	66	7
TD-4006*	17	TE	14	16	62	6

(a) RESULTS INCLUDE NATURAL BACKGROUND
(b) DUE TO ROUNDING THE SUMMED QUARTERLY DATA MAY NOT EQUAL THE ANNUAL TOTAL.
* DENOTES BACKGROUND STATION
TE TRANSPORTATION EXPOSURE - NOT REPORTED

A control TLD accompanies each quarterly shipment of TLDs to assess exposure during mailing. All second quarter TLDs (including the control and the background TLDs) had results four times higher than typical quarterly results. This may have been caused by the shipment being x-rayed during transit. For this reason the results for the second quarter were disregarded and the average of the remaining quarterly data was used for the missing second quarter data in order to calculate the annual total.

The first quarter TLD was missing for monitoring station TD-4004 and the third quarter TLD was missing for monitoring station TD-4004 and TD-4005. In order to calculate an annual total gamma exposure rate the missing data was replaced with the average of the remaining quarterly TLD results for those monitoring stations.

At the WSCP/WSRP site perimeters the annual exposures ranged from 56 to 79 mR. At the WSQ site perimeter, the annual exposures ranged from 72 to 98 mR. Annual exposure at the Francis Howell High School was 59 mR. At the Weldon Spring Army Reserve Training Area the annual exposure was 52 mR.

Except for monitoring stations TD-1001, TD-1002, TD-1003, and TD-1005, all of which are located at the WSQ perimeter, there was no reason to suspect at the 95 percent confidence level that gamma exposures exceeded natural background. This conclusion was based on a comparison of the gamma exposure measured at each station to the gamma exposure measured at the four background TLD monitoring stations. Thus at the WSCP/WSRP perimeter, Francis Howell High School, and the Army Reserve Training Area there were no external gamma exposures above natural background levels.

At four of the six quarry monitoring stations gamma exposures exceeded natural background by amounts ranging from 12 to 30 mR/year. Although gamma exposures exceeded background at four quarry stations, the DOE standard authorized in DOE Order 5400.5 of 100 mR/yr above background in unrestricted areas was not exceeded. This information is summarized in Table 2-14. In Table 2-14 the percent of DOE standard was calculated by subtracting the annual average (68 mR/year) from the annual exposure at each station and then dividing by the 100 mR/year DOE standard.

2.5 Radioactive Air Particulate Monitoring

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, naturally occurring radon-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 concentrations and possible emission from the WSS could result from work activities such as movement of equipment or vehicles in contaminated areas or from wind erosion. This section discusses the air particulate monitoring program and presents a summary of the results.

TABLE 2-14 Summary of TLD Monitoring Results of Stations That Exceeded Natural Background*

Station Number	Location	Annual Exposure (mR/year)	Percent of DOE Standard
TD-1001	WSQ North Perimeter	98	30
TD-1002	WSQ East Perimeter	80	12
TD-1003	WSQ SE Perimeter	82	14
TD-1005	WSQ West Perimeter	80	12

* 95 Percent Confidence Level

2.5.1 Radioactive Air Particulate Monitoring Program

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 2-22. Two monitoring stations (AP-4006 and AP-4008) are located off-site at sensitive receptor locations, which are Francis Howell High School and the Army Reserve property. The monitoring station at the August A. Busch Wildlife Area (AP-4007) is used to monitor background levels in the vicinity of the WSCP. The off-site monitoring stations are also shown on Figure 2-22.

In the second quarter of 1989, monitoring of the WSQ was initiated. Two monitors (AP-1009 and AP-1010) were installed at the quarry and one (AP-4011) placed off-site to monitor background levels in the vicinity of the quarry. The quarry monitoring stations are shown on Figures 2-25 and 2-26.

Due to the different geological conditions at the quarry and the WSCP, two background stations are utilized. The quarry background monitoring station is located approximately 0.8 km (0.5 mi) to the west of the quarry. This station is suitable because at that location the predominant wind direction is toward the quarry, and the station is not influenced by radioactive air particulate releases from the quarry, yet it is close enough to the quarry to have the same regional environmental and meteorological characteristics.

The sampling station near the August A. Busch Wildlife Area (ABWA) headquarters is used as a WSCP/WSRP background air monitoring station. This station is approximately 0.8 km (0.5 mile) from the WSCP perimeter in a northwestern direction. The terrain between the WSCP and this sampling station is hilly and

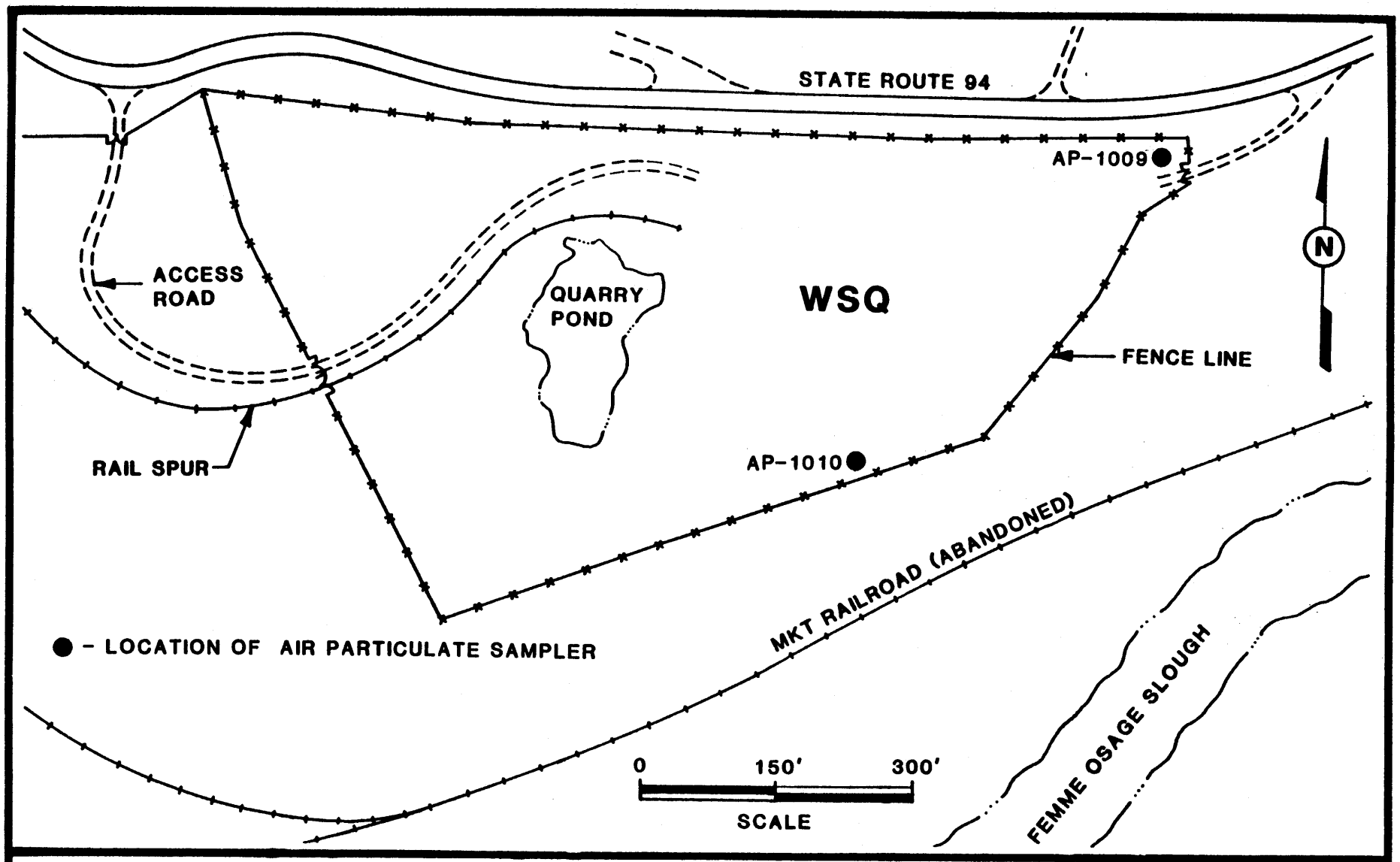


FIGURE 2-25

AIR SAMPLER LOCATIONS AT THE WSQ PERIMETER

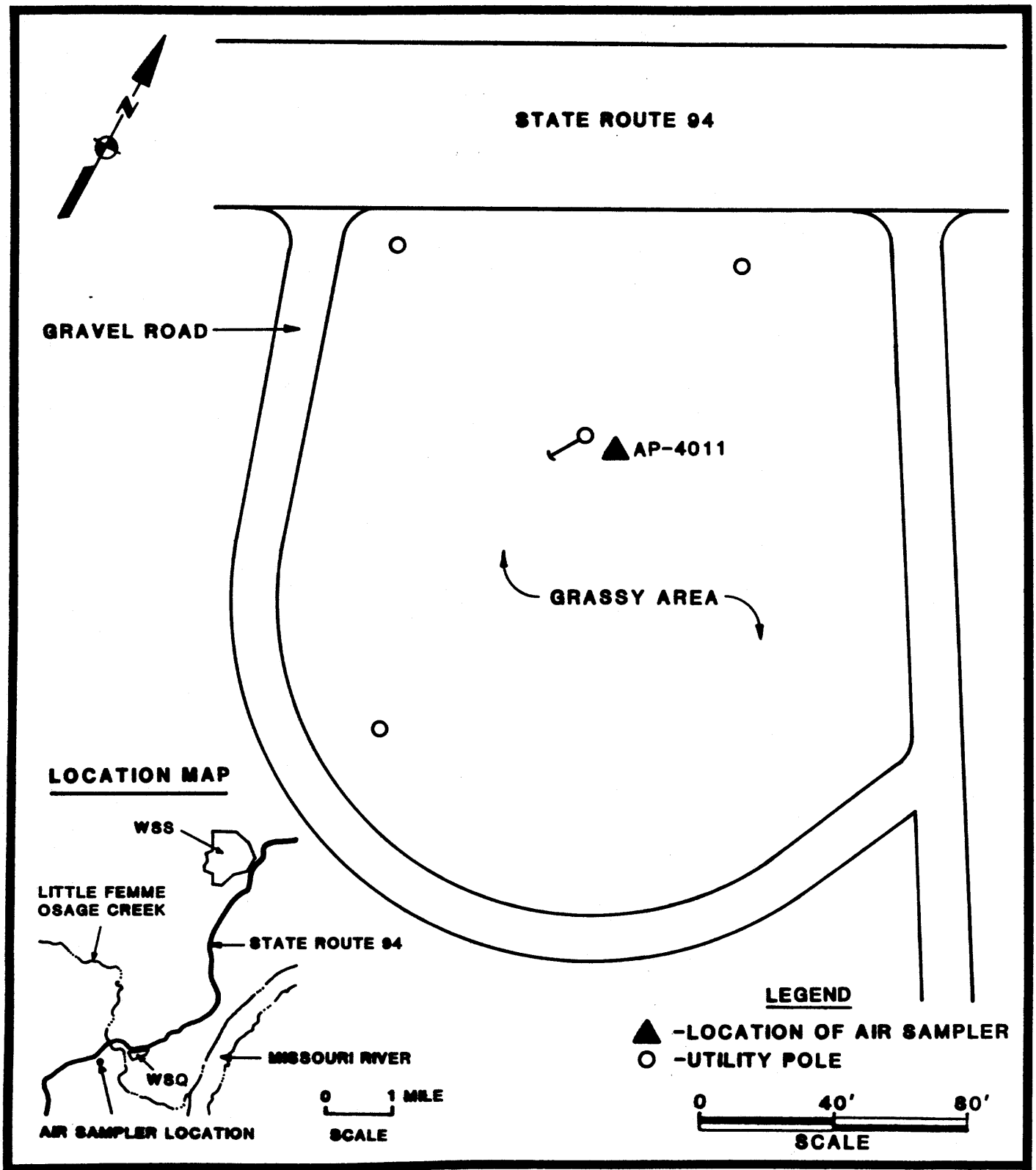


FIGURE 2-26

QUARRY BACKGROUND AIR SAMPLER LOCATION

forested, providing a significant physical barrier to airborne particulates originating from the WSCP/WSRP. In addition, winds from the southeast are relatively rare at the WSCP.

The five air particulate samplers used at the WSCP, the two nearby off-site locations, and the background station at ABWA headquarters were continuous flow dichotomous virtual impactor units operating at a constant total flow of one cubic meter per hour (35 ft^3/hour). These samplers divide suspended particles into two sizes: 2.5 to 10 micrometers in diameter (coarse respirable particles) and less than 2.5 micrometers in diameter (fine respirable particles). Particles larger than 10 micrometers (non-respirable) were not collected because they do not pose a significant risk to human health through inhalation.

Samples were collected on 37-millimeter diameter membrane filters with an effective pore size of 0.8 micrometers. All filters were collected once per week.

The three air particulate samplers used in the quarry monitoring program are constant flow dual diaphragm units operating at a continuous total flow of 2.4 cubic meters per hour (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. Therefore subsequent analysis is conservative when determining radioactivity concentrations of air because some of the collected particles would pose no human health impact. Samples, consisting of 47-millimeter diameter membrane filters with an effective pore size of 0.45 micrometers, were 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.

2.5.2 Radioactive Air Particulate Monitoring Results7

The gross alpha measurements were made with a standard zinc-sulfide 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).

Table 2-15 summarizes the annual average concentration and the standard deviations for the 11 air monitoring locations. The annual average 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 weekly sample concentrations less than the LLD. The < sign in Table 2-15 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. If only one or less weekly

TABLE 2-15 Radiological Air Particulate Results 1989

MONITOR IDENTIFICATION NUMBER	AIR PARTICULATE TYPE	ANNUAL AVG. CONCENTRATION (1E-15 uCi/ml)	STANDARD DEVIATION	NUMBER OF VALUES ABOVE LLD
AP-2001	COARSE	<1.60	--	1
	FINE	<2.67 2	1.30	36
AP-2002	COARSE	<1.60	--	0
	FINE	<2.88	1.63	41
AP-3003	COARSE	<1.52	--	1
	FINE	<3.28	1.72	40
AP-3004	COARSE	<1.59	0.60	3
	FINE	<3.60	5.24	38
AP-2005	COARSE	<1.60	--	1
	FINE	<3.14	1.53	40
AP-4006	COARSE	<1.62	0.97	8
	FINE	<3.37	1.64	41
AP-4007*	COARSE	<1.62	0.35	5
	FINE	<2.87	1.11	34
AP-4008	COARSE	<1.60	0.94	4
	FINE	<3.27	1.48	43
AP-1009	ALL	<4.27	1.81	30
AP-1010	ALL	<4.36	1.75	30
AP-4011*	ALL	<3.83	1.58	30

* INDICATES BACKGROUND MONITOR STATION
TO CONVERT uCi/ml TO Bq/M^3 MULTIPLY BY 3.7E10

result was greater than the LLD, no standard deviation was calculated. This is indicated by NA in the table.

The typical LLD for the dichotomous virtual impactor units used at the WSCP/WSRP was approximately 1.6 x 10^{-15} µCi/ml (.06 mBq/m^3). The dual diaphragm units at the WSQ typically achieved an LLD of approximately 6.4 x 10^{-16} µCi/ml (.02 mBq/m^3). These LLDs are low enough for the detection of Th-232, the radionuclide with the lowest derived concentration guideline (DCG) found at the WSS. The DCG for Th-232 is 7 x 10^{-15} µCi/ml (.26 mBq/m^3). The DOE provides DCGs for airborne contaminants which, inhaled by a member of the public continuously for one year, would result in a committed effective dose equivalent of 100 mrem (1 mSv).

The annual average net alpha activity for each monitoring station was not statistically different at the 95% confidence level from the corresponding background station activity. This is significant because it indicates that there is no release of radioactivity from the site that can be distinguished from background levels.

2.6 Unrestricted-Area Radiological Contamination Monitoirng

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 potentially have surficial contamination. The majority of the processing involved refining uranium and thus it 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.

2.6.1 Unrestricted-Area Radiological Monitoring Program

This program includes radiological surveys of the WSSRAP Administration Building, laboratory, access control point for the site controlled area, WSSRAP trailers and subcontractor trailers, vehicles, site roadways and a portion of the Katy Trail. Radiological surveys are performed at least quarterly and usually monthly. The surveys consist of 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/cm^2). These measurements determine the total radioactivity, fixed plus removable.

Measurements of removable surficial radiation 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. Swipes are analyzed for one minute on a standard alpha scintillation detector. The count rate results are corrected for detector efficiency to yield measurement results in dpm/cm^2.

2.6.2 Unrestricted-Area Radiological Monitoring Results

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 by 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 2-27 shows the monitoring locations for the roadways outside the controlled area. Table 2-16 lists the annual average beta-gamma and alpha monitoring results at each location. Also included in the table are the associated errors of the beta-gamma and alpha results. The reported errors of the beta-gamma results are given as a percentage of the average result.

The results of the monitoring show that only fixed contamination is present at a few locations, but at levels well below the DOE uranium surface contamination guidelines for unrestricted use of 5,000 dpm/100 cm^2. The probable cause of the contamination is deposition of atmospheric releases of uranium dust during the operational period of the Weldon Spring Uranium Feed Materials Plant (WSUFMP). Since monitoring began, no increase in levels has been shown on the uncontrolled area of the roadways at the WSS. Also no removable activity has been found during the monitoring of the roadways.

The Katy Trail is shown on Figure 2-28. An approximate 1,130-m (3,700-ft) 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 a section of the trail that are positioned so as to appropriately represent the entire length of the section monitored.

Table 2-17 lists the average beta-gamma monitoring results for each location. The majority of the monthly survey measurements at each location are below the lower limit of

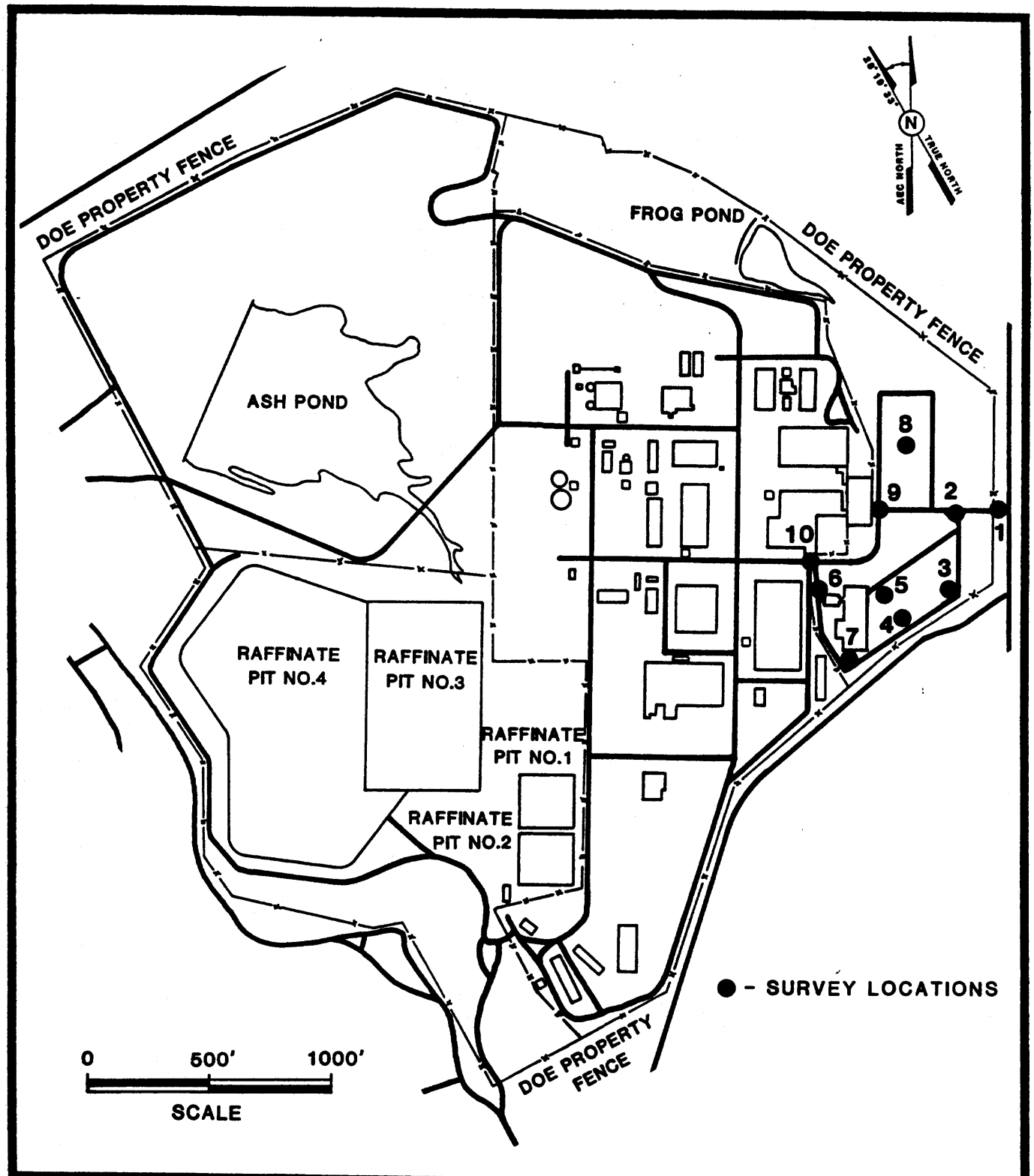


FIGURE 2-27

ROAD SURVEY LOCATIONS

TABLE 2-16 1989 Unrestricted Roadway Monitoring Results(a)

	BETA-GAMMA RESULTS		ALPHA RESULTS	
LOCATION I.D.	ANNUAL AVERAGE	PERCENT DEVIATION	ANNUAL AVERAGE	2 STD. DEV.
1	<672	57	2	3
2	<665	48	2	4
3	<645	37	2	4
4	<1084	43	2	3
5	<1004	55	1	2
6	<816	66	0	2
7	2610	38	1	4
8	1615	23	1	2
9	<1333	35	1	2
10	<914	33	0	0

(a) RESULTS GIVEN IN DISINTEGRATIONS PER MINUTE PER 100 SQUARE CENTIMETERS AREA (DPM/cm^2).

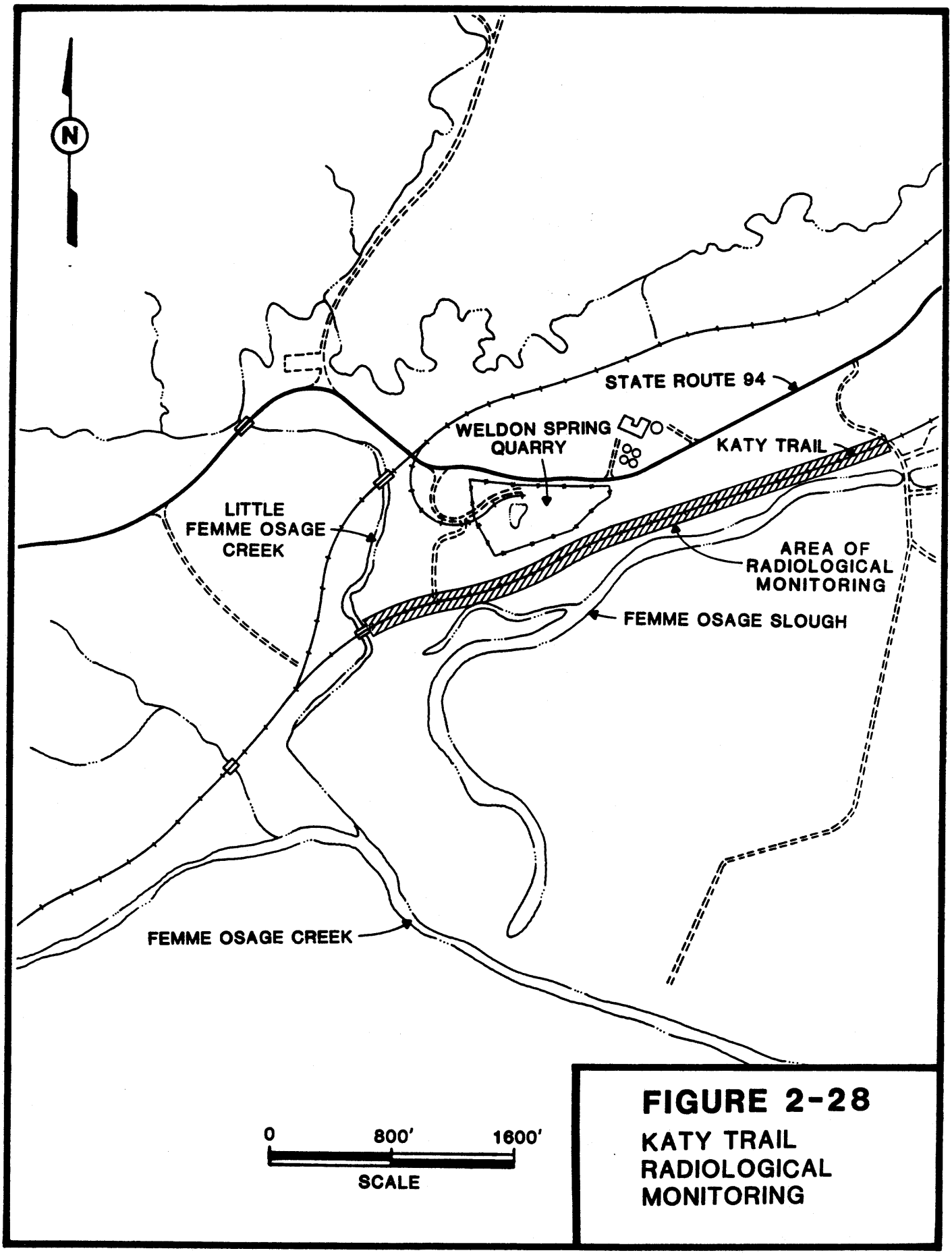


FIGURE 2-28

KATY TRAIL RADIOLOGICAL MONITORING

TABLE 2-17 1989 Katy Trail Monitoring Results

LOCATION NUMBER	AVERAGE* BETA-GAMMA MONITORING RESULTS (DPM/100 cm^2)
1	<727
2	<709
3	<709
4	<709
5	<709
6	<709
7	<709
8	<709
9	<709
10	<709

* Lower limit of detection is 709 dpm/100 cm^2.

detection (LLD) and therefore no standard deviations are reported.

The results of all monitoring locations show that the average beta-gamma results are below the LLD. However, a small isolated area represented by location number one consistently shows higher beta-gamma activity than the other monitoring locations and during one of the surveys had detectable beta-gamma radioactivity. This area is located in the far eastern section of the monitoring area. A soil sample was collected at location number one and analyzed for uranium-238, radium-226, radium-228, thorium-230 and potassium-40. The analysis did not indicate any radionuclide concentrations above background levels. This area will be investigated further to determine the reason for elevated beta-gamma radioactivity. There is no evidence of radioactive material migrating from the WSQ or Femme Osage Slough area onto the Katy Trail and thus there is no identifiable risk from radiological contamination to users of the Katy Trail.

2.6.3 Asbestos Monitoring

Environmental monitoring for asbestos was performed at five site perimeter monitoring locations and at the Francis Howell High School (FHHS) monitoring location. At these locations, worker exposure monitoring and work area sampling were conducted during asbestos abatement operations and at other times when asbestos-containing materials were being handled on the site.

During 1989, three interim response actions were completed which involved asbestos abatement activities, i.e., Administration Building (Building 409) Demolition, Steam Plant (Building 401) Demolition, and Overhead Piping and Support Removal. The asbestos abatement operations associated with these

projects were initiated in November 1988 and were completed in September 1989.

During the period from January through September 1989, site perimeter samples were collected on a weekly basis. Two concurrent samples were collected each week. Sample locations at the site perimeter were selected on the basis of the observed wind direction at the beginning of the sampling period; one sample was designated as an upwind sample and the other sample was designated as a downwind sample.

Also during this period, daily samples were collected at AP-4006, the Francis Howell High School monitoring station. Following completion of asbestos abatement activities, sampling at FHHS station was reduced to a frequency of one sample per week.

Samplers were generally operated for 7-8 hours per day, corresponding to the period during which operations were being conducted at the site.

Two different methods of sample analysis were utilized in the asbestos air monitoring program. All samples were analyzed by Phase Contrast Microscopy (PCM). This method provides a total airborne fiber concentration for fibers having a size and shape which are characteristic of asbestos fibers. This method does not distinguish between asbestos fibers and other airborne fibers having similar characteristics. The results of the PCM samples are reported in fibers per cubic centimeter of air (f/cc). Selected samples were also analyzed using Transmission Electron Microscopy (TEM). This method is capable of positively identifying asbestos fibers, whereas the PCM method is not. The

results of the TEM samples are reported in structures per cubic centimeter of air (s/cc).

The results of the environmental samples collected at the FHHS and site perimeter monitoring stations are provided in Tables 2-18 and 2-19, respectively. The results of the PCM and TEM analyses are reported separately therein.

The average fiber concentration (as determined by PCM analysis) at the upwind monitoring stations (0.001 f/cc), the downwind monitoring stations (0.001 f/cc) and the FHHS monitoring station (0.001 f/cc) are all considered to be within the range of normal background fiber concentrations, indicating that asbestos fibers were effectively contained during the asbestos abatement operations.

This conclusion is also supported by the results of the on-site asbestos monitoring activities. The results of personnel exposure monitoring conducted by site personnel indicate an average worker exposure concentration of 0.065 f/cc. Further, all major asbestos operations which involved stripping of friable asbestos-containing materials from the piping and other building components were performed within specially constructed enclosures having high efficiency particulate air (HEPA) ventilation systems. The purpose of the enclosure is to contain any airborne fibers within the work area and to filter the air as it is discharged to the atmosphere. Asbestos monitoring was performed at each HEPA filter outlet on a daily basis. A total of 174 such samples were collected, with a range from <0.001 f/cc to 0.027 f/cc and an average concentration of 0.006 f/cc.

Thirteen samples collected at the FHHS and site perimeter monitoring stations were analyzed using TEM. (See Tables 2-18

TABLE 2-18 Summary of Asbestos Air Monitoring Results at Francis Howell High School

PCM ANALYSIS

MO/YR	NO. OF SAMPLES COLLECTED	FIBER CONCENTRATION (f/cc) RANGE	AVERAGE(1)
01/89	18	<0.0005--<0.002	0.001
02/89	18	<0.0005--<0.001	0.001
03/89	21	<0.0005-- 0.0007	0.001
04/89	20	<0.0005-- 0.001	0.001
05/89	21	<0.0005-- 0.004	0.001
06/89	16	<0.001 -- 0.017	0.001
07/89	12	0.0006--<0.001	0.001
08/89	21	<0.0005-- 0.003	0.001
09/89	18	<0.001 -- 0.004	0.001
10/89	4	<0.001 -- 0.003	0.002
11/89	4	<0.001 -- 0.001	0.002
12/89	13	<0.001 --<0.001	0.001
		ANNUAL AVE:	0.001

TEM ANALYSIS

MO/YR	NO. OF SAMPLES COLLECTED	FIBER CONCENTRATION (s/cc) RANGE	AVERAGE(1)
03/89	1	<0.002	0.001
05/89	1	<0.001	0.002
06/89	2	<0.001--<0.001	0.001
07/89	2	<0.001-- 0.060	0.031
08/89	1	<0.002	0.002
09/89	1	<0.001	0.001
10/89	1	<0.001	0.001
11/89	1	0.004	0.004
12/89	1	<0.001	0.001
		ANNUAL AVE:	0.001

(1) For purposes of averaging,the detection limits were treated as actual fiber concentrations for those samples reported as below detectable quantities.

TABLE 2-19 Summary of Asbestos Air Monitoring Results for Upwind and Downwind Samples from the Weldon Spring Site Perimeter

PCM ANALYSIS

MO/YR	UPWIND NO. OF SAMPLES COLLECTED	UPWIND FIBER CONCENTRATION (f/cc) RANGE	UPWIND FIBER CONCENTRATION (f/cc) AVERAGE(1)	DOWNWIND NO. OF SAMPLES COLLECTED	DOWNWIND FIBER CONCENTRATION (f/cc) RANGE	DOWNWIND FIBER CONCENTRATION (f/cc) AVERAGE(1)
01/89	5	<0.001 --<0.001	0.001	8	<0.0005--<0.001	0.001
02/89	4	<0.0005--<0.001	0.001	3	<0.001 --<0.001	0.001
03/89	4	<0.0005--<0.0005	0.001	4	<0.0005-- 0.002	0.001
04/89	4	<0.0005--<0.001	0.001	4	<0.0005--<0.001	0.001
05/89	5	<0.001 --<0.002	0.001	5	<0.0005--<0.001	0.001
06/89	4	<0.001 --<0.001	0.001	4	<0.001 -- 0.001	0.001
07/89	4	<0.001 --<0.001	0.001	4	0.0006--<0.001	0.001
08/89	2	<0.001 --<0.001	0.001	2	<0.001 -- 0.001	0.001
09/89	5	0.001 --<0.002	0.002	6	<0.001 --<0.002	0.002
10/89	4	<0.001 -- 0.007	0.003	5	<0.001 -- 0.007	0.004
11/89	5	<0.001 -- 0.001	0.001	6	<0.001 -- 0.001	0.001
12/89	3	<0.001 --<0.001	0.001	3	<0.001 -- 0.001	0.001
		ANNUAL AVE:	0.001		ANNUAL AVE:	0.001

TEM ANALYSIS

MO/YR	UPWIND NO. OF SAMPLES COLLECTED	UPWIND FIBER CONCENTRATION (s/cc) RANGE	UPWIND FIBER CONCENTRATION (s/cc) AVERAGE(1)	DOWNWIND NO. OF SAMPLES COLLECTED	DOWNWIND FIBER CONCENTRATION (s/cc) RANGE	DOWNWIND FIBER CONCENTRATION (s/cc) AVERAGE(1)
07/89	1	<0.001	0.001	1	<0.001	0.001

(1) For purposes of averaging,the detection limits were treated as actual fiber concentrations for those samples reported as below detectable quantities.

and 2-19.) These samples ranged from <0.001 s/cc to 0.060 s/cc. One of the TEM samples collected at the FHHS monitoring station xhibited a relatively high concentration of asbestos, i.e., 0.060 s/cc for the sample collected on July 7, 1989. This sample could not be analyzed by PCM because of the amount of dust loading on the filter. The sample was subsequently analyzed by TEM; however the sample had to be ashed and resuspended prior to TEM analysis. The laboratory indicated that the sample pretreatment procedure could have biased the subsequent analysis on the high side by a factor of up to 10 times the actual concentration, due to the fact that the pretreatment procedure has been shown to fracture the fibers and thereby result in a higher fiber count.

Although the specific cause of the elevated asbestos concentration is not known, an evaluation of the prevailing wind conditions and the TEM results from the site perimeter samples during the same time period suggests that the apparently anomalous asbestos result was unrelated to WSSRAP activities. Another positive asbestos measurement of 0.004 s/cc was obtained at the FHHS monitoring station sample collected on November 1, 1989. This result can be explained on the basis of normal background variability.

As a quality assurance measure, blank samples are periodically submitted to the laboratory for analysis. These samples are subjected to the same analysis as the regular air samples. During calendar year 1989 a total of 61 blank samples were submitted for analysis. Fiber loadings on all of the blank filters were less than 7 fibers per 100 fields which conforms to the requirements of the analytical method.

3 RELATED ACTIVITIES AND SPECIAL STUDIES

Numerous activities were conducted during 1989 to further characterize and improve the environmental conditions at the Weldon Spring Site (WSS). These activities were performed to provide better detail on contaminant distribution and migration mechanisms from the site and enable the U.S. Department of Energy (DOE) to more precisely and completely conduct its remedial actions. Also, several interim response actions were conducted during this monitoring year to reduce or eliminate immediately hazardous conditions at the site. Each of those activities is described below. Table 3-1 presents a list of the related and special study activities accomplished during this monitoring year.

3.1 Characterization Studies

During 1989 four characterization studies were performed to support the Remedial Investigation/Feasibility Study (RI/FS). These characterization studies included the radiological characterization of the Weldon Spring Chemical Plant (WSCP) buildings, the characterization of minor storm water discharge points, studies of the results from the new groundwater monitoring wells, and additional radon monitoring. Principal points of each characterization study are discussed in subsections 3.1.1 through 3.1.5.

3.1.1 Radiological Characterization of WSCP Buildings

To supplement radiological characterization data previously obtained in WSCP buildings, radiation measurements were collected from October 1988 through April 1989 in 25 non-process buildings. No measurements were required in buildings which processed

TABLE 3-1 Characterization Studies and Interim Response Actions Performed in 1989 at the Weldon Spring Site

Activity Name	Area Investigated	Status
Characterization Studies		
Radiological Characterization of the WSCP Buildings	WSCP	Complete
Characterization of Minor Storm Water Discharge Points	WSCP/RP	Complete
Shallow Groundwater Monitoring Wells Results	WSCP/RP	Complete
Radon Decay Product Monitoring	WSQ	Complete
Radon Gas Monitoring Above Quarry Wastes	WSQ	Complete
Interim Response Actions		
Overhead Piping Removal	WSCP	Complete
Building 409 Demolition	WSCP	Complete
Building 401 Demolition	WSCP	Complete
Ash Pond Diversion Project	WSCP/RP	Complete
Containerized Chemical Consolidation	WSCP	Ongoing

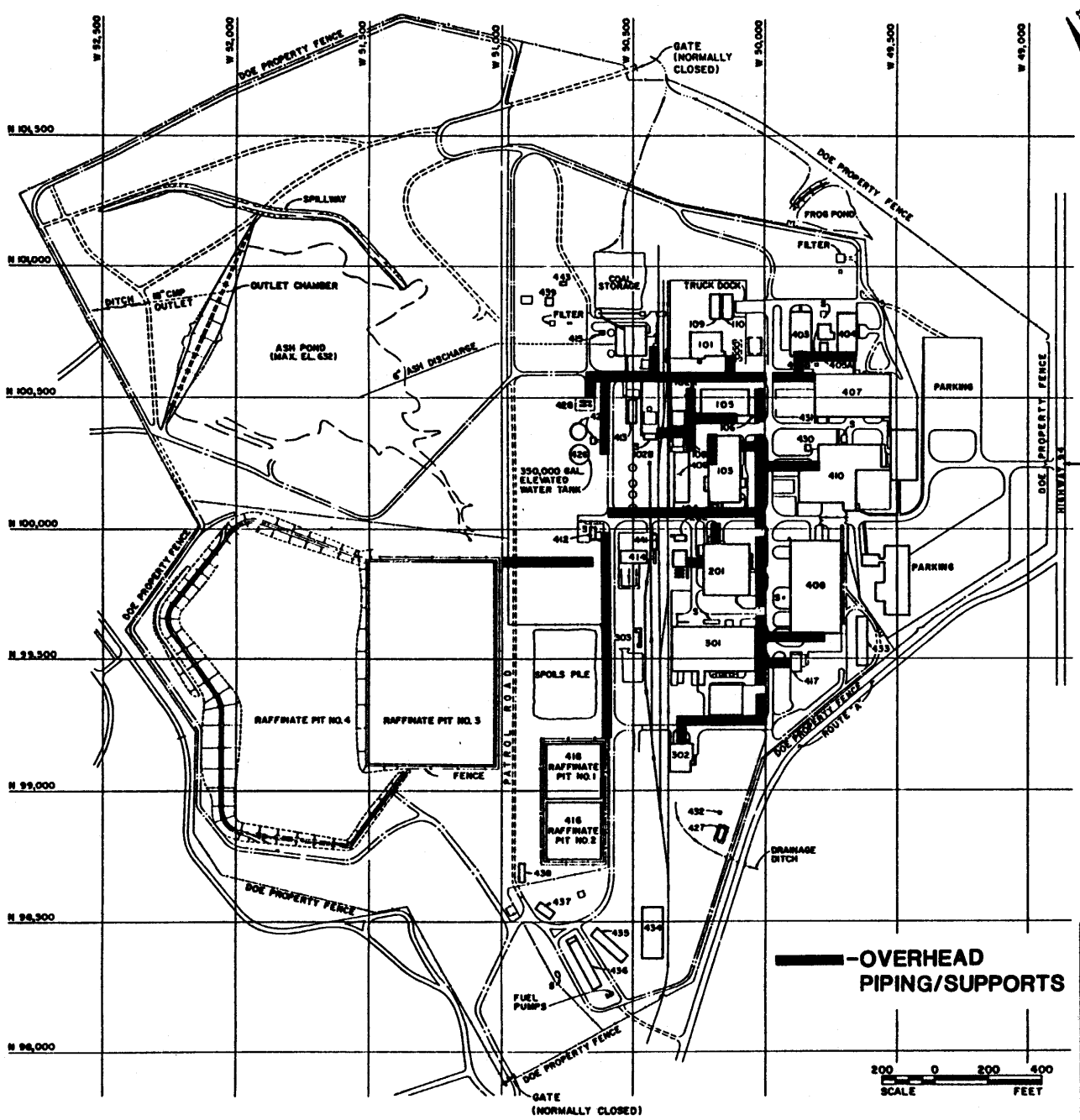
WSCP/RP - Weldon Spring Chemical Plant/Raffinate Pits
WSQ - Weldon Spring Quarry

uranium and thorium because sufficient information had been collected by other investigations. The characterization efforts allowed estimation of which building structural components and equipment were radiologically contaminated and an assessment of the radiation hazards within each building.

Six types of samples or measurements were collected. These were: (1) total beta-gamma radioactivity, (2) removable alpha radioactivity, (3) core samples, (4) bulk samples, (5) 100% scans, and (6) air monitoring.

Results of this characterization effort were combined with previous survey results to provide a comprehensive radiological assessment of all WSCP buildings. This information is detailed in the "Weldon Spring Chemical Plant Buildings Radiological Characterization Report" (MKF and JEG, 1989d).

These surveys have revealed that all structural components and equipment within process buildings (Buildings 101, 103, 105, 108, 201, 301, 403, and 404, see Figure 3-1) are contaminated and cannot be released from the site without decontamination. The contamination level varies in the non-process buildings. Much of the equipment stored in the non-process buildings is contaminated. Some structural components of non-process buildings are not contaminated. In general, horizontal surfaces in non-process buildings have a higher probability of being contaminated than do vertical surfaces. No structural component or equipment in non-process buildings can be released from the site until further radiation measurements are performed on areas which were inaccessible to characterization measurements and to verification of the results of characterization measurements.



BUILDING OR AREA	DESIGNATION
101	FEED PREPARATION AND SAMPLING PLANT
102A	REFINERY TANK FARM
102B	REFINERY TANK FARM
103	DIGESTION AND DENITRATION
104	LIME STORAGE
105	TBP AND ETHER EXTRACTION
106	PROOF SAMPLER
108	NITRIC ACID RECOVERY
109	DRUM STORAGE
110	DRUM STORAGE
201	GREEN SALT PLANT
202	GREEN SALT TANK FARM
301	METALS PLANT
302	MAGNESIUM STORAGE BUILDING
303	CHIP STORAGE
403	CHEMICAL PILOT PLANT
404	METALLURGICAL PILOT PLANT
405A	PILOT PLANTS AUXILIARY
405B	PILOT PLANT AUXILIARY
406	WAREHOUSE
407	LABORATORY
408	MAINTENANCE AND STORES
410	SERVICES
412	ELECTRICAL SUBSTATION
413	COOLING TOWER AND PUMP HOUSE
414	SCRAP CLASSIFICATION AND EQUIPMENT STORAGE
415	CLAY BRICK INCINERATOR
416	RAFFINATE PITS 1 & 2
417	PAINT SHOP
426	ELEVATED WATER TANK
427	PRIMARY SEWAGE TREATMENT PLANT
428	PROPANE AND BUTANE GAS PLANT
429	RESERVE WATER FACILITIES
430	AMBULANCE GARAGE
431	PROOF SAMPLER
432	PROOF SAMPLER
433	STORAGE
434	STORAGE
435	STORAGE
436	STORAGE
437	STORAGE
438	STORAGE
439	FIRE TRAINING
441	CYLINDER STORAGE
443	FIRE TRAINING STORAGE

FIGURE 3-1

WELDON SPRING CHEMICAL PLANT-MAJOR BUILDINGS, FEATURES AND LOCATION OF OVERHEAD PIPING/SUPPORTS

3.1.2 Characterization of Minor Storm Water Discharge Points

Surface water discharge from the site has been routinely monitored at five major discharge points in the past and analyzed for a broad range of contaminants including metals, inorganic anions, nitroaromatics and radiochemical species. Surface water from the areas of known contamination leaves the site at these major discharge points. However, little data existed regarding the character of the runoff crossing the site boundary at the smaller discharge points.

As a result of land surface contours and the configuration of the storm sewer system across the site, approximately 210 acres of land surface drain their surface runoff across the site boundary, either onto or off of the site property. Roughly 30% of that flux is not routinely monitored for contaminants. Where surface water enters the site, it is ultimately discharged via one of the three routinely monitored discharge routes. However it was unknown whether the run-on was contaminated before entering the site.

Sampling was initiated in 1989 to assess the unmonitored surface water exiting the site via minor drainageways.

Measurement data are presented on Figure 3-2. The data indicate that small quantities of surface water contaminated with low levels of uranium are leaving the site at various locations. The results also indicate that at three drainage crossings on the eastern boundary, surface water with slightly elevated uranium levels is flowing onto the site. These results are possibly due to atmospheric deposition off-site during Weldon Spring Uranium Feed Materials Plant (WSUFMP) operations since no other known sources exist within these off-site drainages. Since the levels

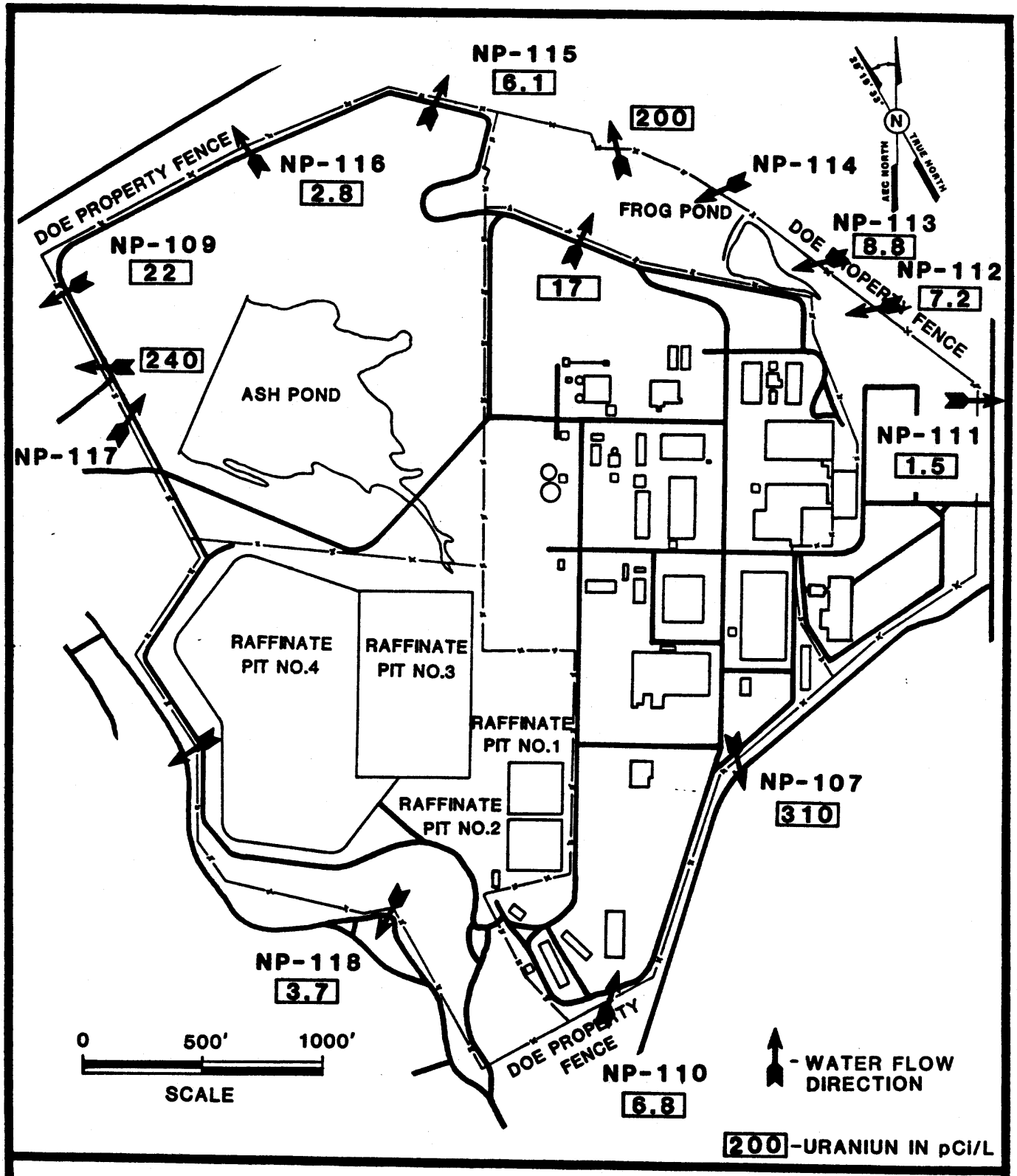


FIGURE 3-2

URANIUM LEVELS MEASURED AT MINOR DISCHARGE POINTS AROUND WSS

are very near to background concentrations and no duplicate data are available to verify or refute the preliminary results, further sampling is needed to determine the source of the uranium.

The highest release from a non-routinely monitored drainage was found to be along a small tributary to the Ash Pond drainage which drains part of the North Dump Area. At a concentration of 22 pCi/l (0.81 Bq/l) in the discharged water, the quantity of uranium contributed to the environment at this release point is relatively insignificant compared with the three major discharge points.

Based on the average annual precipitation rate of 85 cm (Section 1.3), and 65% surface runoff of that precipitation, an average of 22 pCi/l (0.81 Bq/l) would result in 0.66 kg (1.5 lb) of uranium released annually through that discharge point. This represents less than 1% of the total uranium released from the site through the major discharge routes.

3.1.3 Shallow Groundwater Monitoring Well Results

Seven additional groundwater monitoring wells were installed at the WSCP/WSRP area during the summer of 1989 as part of a geotechnical drilling program in support of the WSS RI/FS process being conducted under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The wells were designed and installed to monitor the uppermost saturated zone of the water table aquifer in order to gain additional information regarding the vertical distribution of contaminants present in groundwater. The monitoring wells are identified as GT-58P, GT-60P, GT-63P, GT-64P, GT-65P, GT-66P, and GT-67P. They are

represented by the symbol designated for piezometers in Figure 2-1.

Complete results of the 1989 fourth quarter sampling of the GT-series monitoring wells will be reported in detail in the Groundwater Quality and Hydrogeologic Assessment of the GT-series Monitoring Wells (MKF and JEG, in preparation).

In general, analyses of groundwater samples from these wells did not significantly change the present understanding of groundwater contamination beneath the site. Nitroaromatic compounds were detected in four wells up to a level of 52 µg/l (2,6-dinitrotoluene) in GT-58P. Concentrations up to 8.5 µg/l of other semi-volatile or volatile compounds were detected in six wells. Nitrate was the inorganic ion detected in highest concentration (1,132 mg/l in GT-64P). Analyses for total metals in unfiltered samples revealed concentrations of chromium, copper, cobalt, nickel, and lead in the suspended solids. Metals analysis of filtered samples detected sodium in concentrations above the upper bound of background (MKF and JEG, 1989a).

3.1.4 Radon Decay Product Monitoring

Radon (Rn-222) and thoron (Rn-220) decay products were monitored in the quarry during the first half of 1989. Because elevated radon levels were observed in the WSQ (Section 2.3), monitoring was performed in areas not accessible to the public to evaluate the level of hazard to which workers in the quarry may be exposed. Thus results should be compared to the Derived Air Concentrations (DAC) guidelines for occupational workers. The DAC is used primarily for radiation protection planning purposes. The DAC for Rn-222 decay products is 0.33 Working Level (WL)

(7 micro Joules/cubic meter) ($\mu J/m^3$). The DAC for Rn-220 decay products is 1.0 WL (21 $\mu J/m^3$).

The radon decay product monitoring program involved collecting grab (5-minute) samples with a low-volume air sampler. Samples were collected on the upper gate plateau on the east end of the WSQ and near the quarry sump at RD-1010 and RD-1007 respectively, as shown on Figure 3-3. At each location samples were collected at heights of 15 cm (6 in.) and 1 m (39 in.). Sampling at the two heights was intended to identify possible radon and/or thoron daughter concentration gradients in the atmosphere directly above the waste.

A decay product (daughter) is the resulting element formed by the decay of a radionuclide. As the Rn-222 and Rn-220 decay chain progresses, radon decay products are produced. All the decay products of both Rn-222 and Rn-220 are particles and both decay chains terminate with stable isotopes of lead (Pb).

Concentrations of radon decay products are dependent on the amount of radon gas entering the atmosphere and the state of equilibrium between the activity of the radon and its daughters. The concentration of radon gas changes depending on many variables, as discussed in Section 2.3. Therefore, the daughter concentrations will fluctuate.

At 100-percent equilibrium, the activity of the radon decay products and the parent would be equal. As radon decays, the particles formed attach to airborne particles (dust). Some of these radioactive particles settle out on surfaces, reducing the activity of the airborne daughters. Also, radon disperses before the daughters can grow into equilibrium, so the equilibrium of environmental air is usually less than 50 percent.

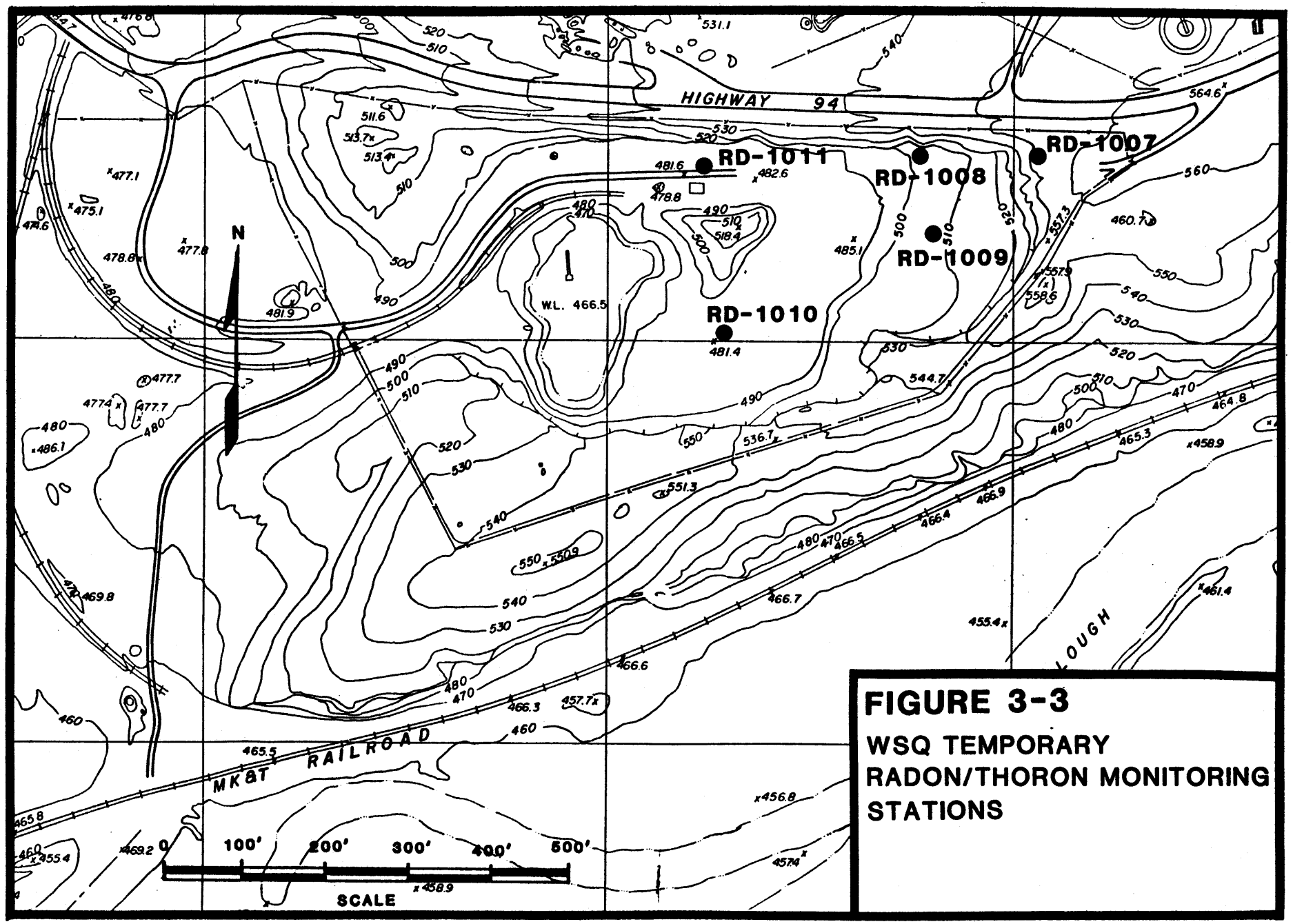


FIGURE 3-3

WSQ TEMPORARY RADON/THORON MONITORING STATIONS

Table 3-2 lists the results of the radon daughter concentration (RDC) and thoron daughter concentration (TDC) measurements at each location and the average concentration is given for the 15 cm and 1 m samples at each location. Results ranged from below the minimum detectable activity (MDA) of 0.0001 WL (0.002 $\mu J/m^3$) to 0.009 WL (0.19 $\mu J/m^3$) for Rn-222 daughters and ranged from less than the MDA of 0.001 WL (0.002 $\mu J/m^3$) to 0.003 WL (0.27 $\mu J/m^3$) for Rn-220 daughters. These concentrations are well below the DAC guidelines. In fact they are below the 0.02 WL (0.4 $\mu J/m^3$) concentration which EPA recommends as a level at which steps should be considered to reduce levels in homes.

Overall data regarding the possible existence of a concentration gradient is inconclusive. No significant concentration gradient was observed, although a few of the measurements at Location No. 2 showed a possible thoron concentration gradient between the two heights.

3.1.5 Radon Gas Monitoring Above Quarry Waste

In March 1989 the WSSRAP installed Type F and Type M track etch detectors within the quarry in order to monitor Rn-222 and Rn-220 concentrations directly above the quarry waste. Type M detectors have a membrane which screens out most Rn-220 (thoron) but allows Rn-222 to pass through, while the Type F allows both gases to pass through. Thus results of Type F monitors would be expected to be greater than or equal to results of Type M monitors. Section 2.3 provides a more detailed description of these detectors.

Ten Type F and ten Type M detectors were placed in duplicate at five temporary monitoring stations within the quarry at a height

TABLE 3-2 Radon Decay Product Monitoring

	LOCATION #1 UPPER RIDGE				LOCATION #2 QUARRY SUMP			
	RADON WL x 10^{-3}		THORON WL x 10^{-3}		RADON WL x 10^{-3}		THORON WL x 10^{-3}	
	GROUND	ONE METER	GROUND	ONE METER	GROUND	ONE METER	GROUND	ONE METER
	1.20		2.60		0.41		0.06	
	3.00		5.00		0.80		1.00	
	1.70	6.50	3.00	0.10	2.60		1.00	
	7.00	6.00	2.00	2.00	1.00	2.00	13.00	4.00
	2.60	6.00	6.30	1.00	1.70	2.00	0.00	2.00
	9.00	3.70	0.10	0.10	4.60	2.70	2.00	0.10
	6.20	4.10	2.20	3.10	3.50	2.90	0.62	2.40
	1.30	0.00	1.00	4.60	1.10	1.00	2.80	2.80
	1.40	1.00	0.00	1.50	2.30	1.90	0.60	0.60
	7.50	5.70	4.40	1.60	5.40	3.60	4.40	2.60
	9.00	5.70	2.00	2.00	5.00	4.90	3.00	3.00
	7.60	5.70	2.50	4.40	5.00	4.20	5.20	2.50
	0.11	0.10	1.30	1.20	0.30	1.50	11.00	1.30
	3.10	1.40	1.00	3.90	1.70	1.60	1.50	1.50
AVE.	4.34	3.83	2.39	2.13	2.53	2.57	3.30	2.07

TO CONVERT TO uJ/m^3 MULTIPLY BY .021

of one meter. In addition, duplicate Type F and Type M detectors were placed at two of the stations (RD-1007 and RD-1008) at a height of 5 cm (2 in.) above the ground to determine if a Rn-222 or Rn-220 gradient exists in the atmosphere directly above the bulk waste. The locations of these temporary monitoring stations are shown on Figure 3-3.

The detectors were deployed for two different intervals: the last month of the first calendar quarter and the entire second calendar quarter of 1989. Table 3-3 contains the results of the monitoring for each period of exposure. The reported concentrations are averages of the two duplicate detectors. Also, two standard deviations of the average reported results are given to define the 95% confidence level (the average plus or minus two standard deviations). The second exposure period was for the entire second quarter of 1989 and is a better representation of long-term concentrations than the first exposure period which was only one month.

The overall results indicate an elevated concentration of radon within the quarry walls compared to the perimeter fence monitors. This is due to the location of the temporary monitors directly above the quarry waste materials. The increase in radon concentrations with respect to the location of the waste is seen through comparison of temporary monitoring station RD-1007 to the perimeter station RD-1002 (see Figure 2-24). These monitoring stations are approximately 15 m (50 ft) apart and at nearly the same elevation. However, station RD-1007, located directly above the waste, has a radon concentration two to three times higher than station RD-1002. The fact that radon concentrations are strongly influenced by proximity to quarry waste materials is further demonstrated by comparison of measurements taken at 5 cm

TABLE 3-3 Radon Monitoring Results Above Quarry Waste~

MONITORING STATION I.D.	HEIGHT FROM GROUND (m)	1st PERIOD TYPE F pCi/l	1st PERIOD TYPE F TWO STD. DEV.	1st PERIOD TYPE M pCi/l	1st PERIOD TYPE M TWO STD. DEV.	2nd PERIOD TYPE F pCi/l	2nd PERIOD TYPE F TWO STD. DEV.	2nd PERIOD TYPE M pCi/l	2nd PERIOD TYPE M TWO STD. DEV.
RD-1007	1	4.7	0.4	1.4	0.3	3.4	0.2	14.5	0.7
	0.05	1410.2	63.0	2062.5	97.7	125.2	6.3	82.5	4.8
RD-1008	1	10.4	0.6	6.0	0.6	29.1	2.4	48.7	2.4
	0.05	23.1	1.1	14.9	1.0	199.9	11.9	152.1	6.0
RD-1009	1	4.6	0.4	3.7	0.5	6.9	0.4	12.9	0.7
RD-1010	1	2.1	0.3	2.3	0.4	8.1	0.4	3.8	0.3
RD-1011	1	3.0	0.4	3.9	0.5	4.2	0.2	4.1	0.3

~ INCLUDES NATURAL BACKGROUND
TO CONVERT TO Bq/m^3, MULTIPLY BY 37

(2 in.) versus measurements taken at 1 m (39 in.) above the waste.

The detectors located 5 cm (2 in.) above the quarry waste at station RD-1007 and RD-1008 both show that Rn-220 (thoron) is contributing to the total radon concentration. The data from the one-meter detectors at all the locations are inconclusive overall to determine the amount of thoron present. In fact, at locations RD-1007 and RD-1009, the Type M detector results are significantly higher than Type F detector results. The inconsistencies are probably due to the different calibration factors employed for the two detector types. The WSSRAP will investigate these apparent inconsistencies further by taking radon decay product measurements during 1990 using continuous monitors.

3.2 Interim Response Actions (IRAs) Performed at the WSS During 1989

During 1989 three Interim Response Actions (IRAs) were conducted that involved release of building structural materials and equipment from the site for unrestricted use or disposal. These IRAs were: (1) dismantling of a network of overhead piping and structural steel supports; (2) dismantling of Building 409, the administration building; and (3) dismantling of Building 401, the steam plant. Salient points of each IRA are discussed in Sections 3.2.1, 3.2.2 and 3.2.3.

Another IRA performed in 1989 was the Ash Pond Isolation project. This project was performed in order to reduce uranium releases from the Ash Pond Outfall. The construction of a diversion dike and channel system around Ash Pond has limited flow of surface water over adjacent contaminated areas, thus

reducing releases of uranium off site. This IRA is discussed in Section 3.2.4.

The containerized chemical consolidation IRA involved consolidation and recontainerization of chemicals remaining from WSUFMP operations. Disposal has been delayed. This IRA is discussed in Section 3.2.5.

IRAs are designed to ensure the health and safety of on-site personnel and to minimize or preclude off-site releases of contamination. They are limited to work that can be performed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and also remain within the constraints of the Council on Environmental Quality Regulations for the National Environmental Policy Act (i.e., they are limited to those actions that do not have an adverse environmental impact and do not limit the choice of remedial alternatives for the site as a whole).

All items that potentially came in contact with radioactive materials were surveyed according to radiological survey and release plans reviewed and approved by the DOE, EPA, and Missouri Department of Health. Structural materials and equipment were not released from the site unless they satisfied the criteria contained in the survey and release plans. These criteria were applied only to rigid surfaces. Liquids, soils, sediments, asbestos or other porous materials that could have been volumetrically (as opposed to surficially) contaminated were not released from the site if they contained any detectable radioactivity in excess of natural background levels.

To provide assurance that results of radiation surveys were accurate an independent verification contractor, Oak Ridge Associated Universities (ORAU), performed spot checks on

materials previously surveyed by the Project Management Contractor (PMC). ORAU personnel found no discrepancies with PMC survey results.

3.2.1 Overhead Piping Removal

During the operation of the chemical plant, overhead piping was used to transfer process chemicals, steam, air, brine, fuel gas, and process waste (raffinates). The pipe network was supported by steel-pipe poles, structural steel, and pipe bents, along with several structural-steel bridges. The piping structures were supported by reinforced concrete foundations. The overhead pipe network lay among several of the chemical plant buildings depicted in Figure 3-1. The overhead pipe distribution system consisted of 15,482 m (50,794 ft) of carbon and stainless steel pipe, 330 bents and 20 bridges. Approximately 33% of the piping was sheathed in asbestos- containing pipe insulation, much of which was in a deteriorated condition. The degradation of the pipe insulation caused sections of the insulation to separate from the pipe. Since the insulation contained asbestos, it posed a potential occupational hazard and as such was designated as an IRA. Dismantlement of the overhead piping and support structures started in January 1989.

Between January 20, 1989 and June 9, 1989, 23 loads of pipe, structural supports, and wire were released for unrestricted use. The released materials weighed approximately 300 metric tons (330 tons).

All pipes that transferred source or by-product (radioactive) materials were assumed to be contaminated and not released from the site. Approximately 200 metric tons (220 tons) of pipe and structural material were not released and are

currently stockpiled adjacent to Building 109. All asbestos-containing insulation was retained on site in Building 434. A detailed discussion of the processes by which the overhead piping was characterized and dismantled is presented in the Radiological and Chemical Completion Report for Overhead Piping Removal, (MKF and JEG, 1990c).

3.2.2 Building 409 Demolition

Building 409, the former Administration Building for the Weldon Spring Chemical Plant (WSCP), was a two-story rectangular structure located in the eastern portion of the WSCP approximately 180 m (600 ft) east of the process building as shown on Figure 3-1. The deteriorating condition of the building (e.g., loose floor tiles, weakened roof, and friable asbestos insulation) posed an occupational hazard to workers. Therefore, the dismantling of the building was proposed as an IRA. Dismantling of the building began in November 1988 and was completed in April 1989.

On the basis of radiation measurements taken by the PMC, it was determined that the majority of the building structure and equipment could be released from the site. This was as expected since the building housed administrative workers and no radioactive materials were processed or stored in the building.

Radiologically contaminated materials retained on the site included tar and gravel roofing, some interior furnishings, and air-handling equipment such as exhaust vents, furnace blowers, and cooling units. Air-handling equipment, especially filters, tended to concentrate any airborne uranium dust during the WSUFMP operations. It is speculated that any interior furnishings found

to be contaminated were moved from other process buildings into Building 409.

The radiologically contaminated roofing material and air handling equipment was placed on pad 303 (see Figure 3-1). The friable roofing material was covered with a protective tarp to prevent spread of contamination by wind or runoff. A detailed discussion of the processes by which Building 409 was characterized and dismantled is presented in the Building 409 Completion Report (MKF and JEG, 1990d).

3.2.3 Building 401 Demolition

Building 401, which was the steam plant for the WSUFMP was a multi-story rectangular structure located in the northwestern section of the WSCP as shown on Figure 3-1.

The deteriorating condition of the building (e.g., weakened roof and friable asbestos insulation) posed a hazard to workers and potential trespassers on the property. Therefore, it was determined that dismantling the building as an IRA would be beneficial to the project. Dismantling of the building began in December 1988 and was completed in December 1989.

Based on the results of radiation measurements performed on Building 401 the following materials were released from the WSSRAP: 459 m^3 (600 yd^3) of rubble, 620 metric tons (683 tons) of scrap metal; 61 m^3 (80 yd^3) of asbestos, and 1.5 m^3 (2 yd^3) of wood.

Radiologically contaminated materials associated with the dismantlement of Building 401 that were retained on the site included 336 m^3 (440 yd^3) of rubble and scrap metal, and 63

metric tons (70 tons) of equipment. The majority of those materials are stored on site in Buildings 109 and 110. The tar and gravel roofing material was drummed and stored on site in Building 434. In addition to the radiologically contaminated materials stored on the site, the asbestos and PCB light ballasts were retained and await radiological assessment. A detailed discussion of the processes by which Building 401 was characterized and dismantled is presented in the Building 401 Completion Report to be issued by the WSSRAP in 1990.

3.2.4 Ash Pond Diversion Project

The surface-water impoundment referred to as Ash Pond was designed and built as a fly ash sedimentation pond for the coal-fired steam plant at the WSUFMP. The main source of radioactive contamination in the Ash Pond area is the South Dump (Figure 3-4). Contaminated materials were burned and disposed of in this area during the operation and decontamination efforts at the WSUFMP. As a result of these activities, contaminants (mainly uranium) in the form of loose sediments and dissolved or suspended materials were freely transported by runoff and associated sediments, thereby contaminating the ash in Ash Pond.

Runoff flowing through the 25 ha (65-acre) Ash Pond watershed intermittently accumulated in Ash Pond and discharged off site when the pond was sufficiently full. This discharge flowed to an unnamed tributary of Schote Creek and eventually affected Lakes 34 and 35 in the August A. Busch Memorial Wildlife Area. Therefore it was determined that performing an Interim Response Action (IRA) by constructing a diversion dike that would redirect the surface water runoff around Ash Pond and the South Dump would be beneficial. This would eliminate leaching and

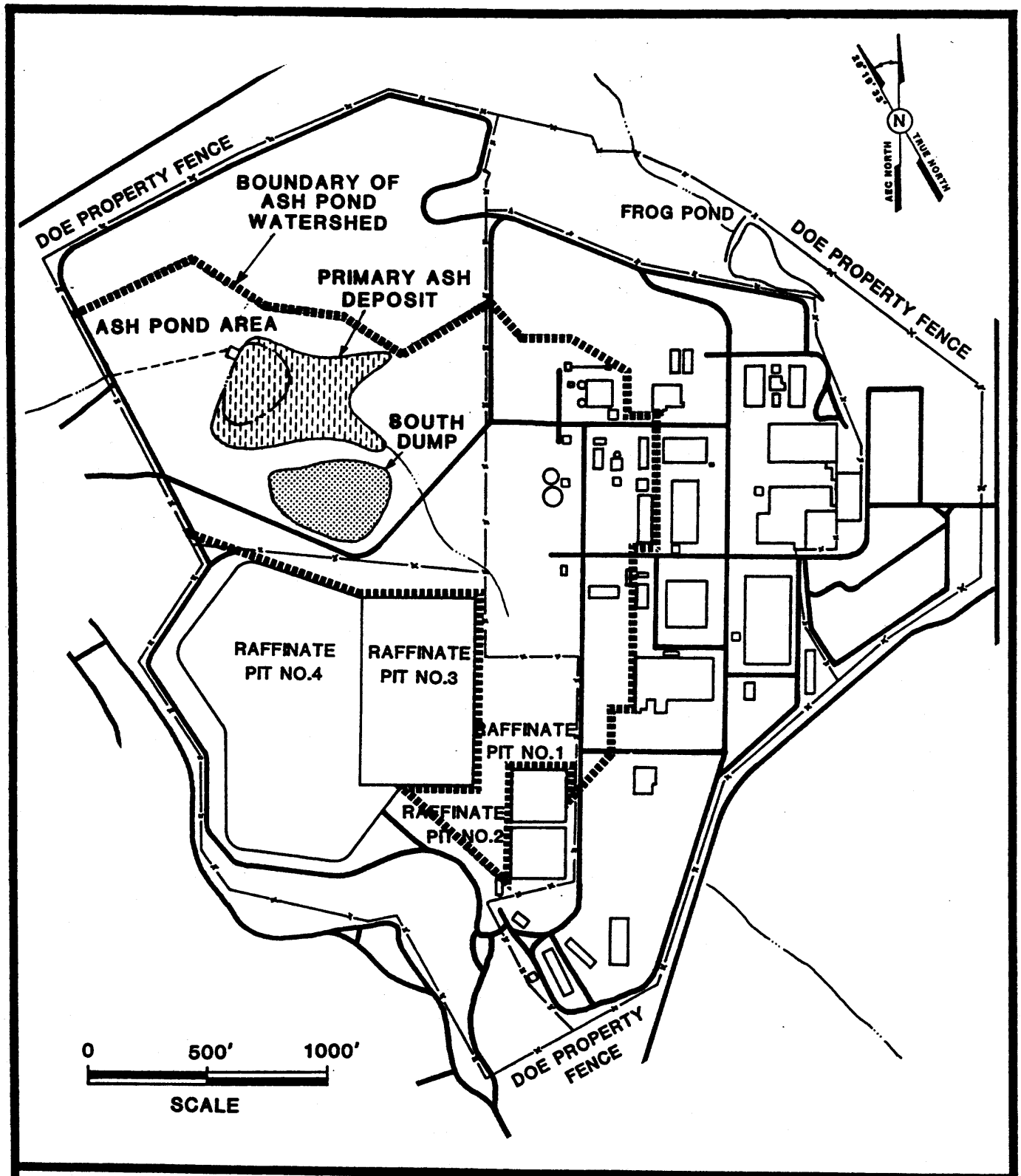


FIGURE 3-4

ASH POND AREA BEFORE CONSTRUCTION OF THE DIVERSION SYSTEM

transport of contaminated materials in these areas, thereby reducing off-site releases of uranium from the Ash Pond discharge.

Construction was initiated in November 1988 and was completed in April 1989. Figure 2-18 shows the final configuration of the Ash Pond diversion dike and how the diversion dike diverts flow through the ditches around the South Dump and Ash Pond areas.

Water samples were collected monthly from the Ash Pond outfall which discharges at the site perimeter as required in the WSCP National Pollutant Discharge Elimination System (NPDES) Permit (see Section 2.2). These samples were collected following a rainfall that produced surface runoff. Prior to the completion of the Ash Pond Diversion Project the uranium concentrations for these samples averaged 1,498 pCi/l (55 Bq/l). Since completion of the project the average uranium concentration in samples collected from May through October 1989 is 145 pCi/l (5.37 Bq/l). The data indicate a tenfold reduction in uranium released at this outfall. Discharges of uranium are now below the DOE DCG level of 550 pCi/l (20.4 Bq/l). A complete description of the isolation project is presented in the WSSRAP document entitled Assessment of Ash Pond Isolation Project Effectiveness issued in February 1990 (MKF and JEG, 1990b).

3.2.5 Containerized Chemical Consolidation

In the fall of 1988, a program was initiated to handle various chemical wastes left behind following closure of the WSCP. The WSSRAP identified, characterized, consolidated, repackaged, and temporarily stored chemical wastes throughout the chemical plant. Due to the complexity of this undertaking, and

in the absence of viable alternatives for the treatment or disposal of radioactive chemical wastes, the chemical-consolidation project has been expanded in scope. What began as a short-term Interim Response Action evolved into an ongoing program.

Work completed to date has addressed radiochemical characterization and repackaging of small containers of chemicals throughout the WSCP. Certain areas of the plant, such as the Building 407 Laboratory, were either omitted or excluded from the initial phase of this project, but are currently being addressed. To date, over 450 drums and storage bags containing various materials have been placed in a secure storage facility.

The original goal to dispose of the containerized chemicals at off-site facilities was not attained in 1989. Disposal methods were not available for chemical wastes mixed with low levels of radioactivity. Continued on-site storage is necessary until appropriate technologies become available. A state-of-the-art storage facility was created on-site during 1989 to ensure that strict administrative control of the waste inventory is maintained. This facility was designed to comply with all applicable statutes, regulations, DOE orders, and best-management practices pertaining to the storage of hazardous waste.

Current activities include handling of containerized chemicals that have not yet been consolidated as well as consolidation of residual chemical substances remaining in tanks, sumps, and process vessels. In-depth chemical and radiological characterization of the hazardous wastes will be performed during 1990.

4 RADIOLOGICAL EXPOSURE

In assessing the health effects of the radioactive materials stored at the chemical plant/raffinate pits, (WSCP/WSRP), quarry (WSQ), and vicinity properties (WSVP) as required by U.S. Department of Energy (DOE) Order 5484.1, radiological exposure was evaluated of persons at Francis Howell High School, the Busch Wildlife Area lakes and the Femme Osage Slough; of the general population within 50 miles of the Weldon Spring Site (WSS); and of a maximally exposed individual.

Individuals could be exposed to radioactivity from the WSS via five principal pathways: (1) direct external gamma radiation, (2) inhalation of radon and radon daughters, (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 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. 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 risk are based on statistical data on large groups of people exposed to radiation under various circumstances. Statistical models are not applicable to single individuals. Therefore, dose equivalents to single individuals 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. Exposures of people in neighboring facilities and populations within 80 km (50 mi) of the WSS are expressed in terms of collective effective dose equivalents or person-rems (person-sievert). All calculations were performed using the methodology described in International Commission on Radiation Protection (ICRP) reports 26 and 30 for a 50-year committed effective dose equivalent (ICRP, 1977, and ICRP 1979).

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

This section identifies 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 direct gamma exposure, airborne dust particle inhalation exposure, and radon daughter inhalation exposure assume a realistic, less than 100% residence time. The amount of fish obtained and ingested from lakes receiving effluents from the WSCP/WSRP site assumes the average consumption rate per year according to U.S. Environmental Protection Agency statistics (EPA, 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.

Gamma exposure rates were determined by means of thermoluminescent detector (TLD) monitoring stations at the Weldon Spring Training Area, the Missouri State Highway Department facility, and the Busch Wildlife Area. Airborne radiological particulates were sampled using continuous air samplers, and radon exposures were measured with track-etch radon monitoring stations at the above three locations. As shown in Section 2 there is no reason to suspect, with 95 percent confidence, that gamma exposure rates, airborne particle 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 1988 a bio-uptake study (MKF and JEG, 1989d) was performed to investigate the possible exposure of humans to chemical and radiological contamination from ingestion of fish and game affected by previous operations at the WSS. This study included fish samples from the three Busch lakes. No measurable radionuclide concentrations above the detection limits were detected.

If it is assumed that the uranium concentration in the fish is equal to the detection limits of the analyses performed on the fish tissue, the concentration in fish from the three lakes would be 0.01, 0.02, and 0.01 pCi/g (0.37, 0.74, and 0.37 mBq/g), respectively. Radium and thorium concentrations in lake sediments and water were not above normal background levels and thus were not considered as a source of possible exposure. Using an average consumption rate of 6.5 grams/day for fresh-water fish

(EPA, 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 the lakes are presently used for drinking or irrigation, but ingestion of lake water by an individual could possibly occur during recreational activities. In this scenario it is assumed that an individual could ingest lake water while swimming. Swimming can result in the ingestion of 0.05 liters per hour on average (EPA, 1988). Assuming that the individual swims in Lake 34, which has the highest average surface water concentration (25 pCi/l, or 925 Bq/m^3) for 12 hours per year, 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. The hypothetical individual is assumed to spend an average of approximately two days per year at the lakes consuming 200 mg per 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), the calculated dose would be below 1 mrem (0.01 mSv).

A maximally exposed individual would receive a total dose 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.

4.2 Radiation Dose From the WSQ to a Maximally Exposed Individual

This section discusses the committed estimated effective dose equivalent to a hypothetical individual assumed to frequent the perimeter of the WSQ and receive a radiation dose by three of

the five pathways identified above. No private residences are adjacent to the WSQ site; therefore, all calculations of direct gamma exposure, airborne particle 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.

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 days per year. Average residence time per day is estimated to be 12 minutes (ANL, 1989). An actual exposure would occur of an individual who drives by the site twice per day, but it would be so insignificant relative to the walking scenario that it was not used in the calculation.

Data from three environmental TLD monitoring stations were used to evaluate the dose by direct gamma exposure to the hypothetical individual. The dose from external gamma radiation was calculated by multiplying the length of time the individual is exposed by the radiation field strength. Using these conservative assumptions and the highest measured gamma exposure rate (30 μR/hr at TD-1001), the calculated dose equivalent would be 1.5 mrem (0.015 mSv).

Airborne particulate monitoring at the WSQ was initiated in May and resulted in an average alpha concentration of 4.3×10^{-15} μCi/ml (.16 mBq/m^3). At the 95% confidence level there is no reason to suspect that airborne particle concentrations measured from May to December exceeded natural background. Thus it is assumed that no measurable exposure from this pathway occurred.

The risk associated with radon-222 is due primarily to inhalation of its short-lived decay products. Data from the three 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 1.0 pCi/l (37 Bq/m^3) above normal background. Assuming 50% equilibrium between radon gas and its daughters and 1.7 rem/ working level month (WLM) (17 mSv/WLM) (NCRP, 1985; ICRP, 1977), the annual calculated effective dose equivalent from inhalation of radon daughters is 2 mrem (.02 mSv).

The dose to the maximally exposed individual from the three pathways discussed above consists of a total of 3.5 mrem (0.055 mSv) from direct gamma exposure, inhalation of radon daughters and inhalation of radioactive air particulates.

4.3 Radiation Dose From WSVPs to a Maximally Exposed Individual

This section discusses the estimated effective dose equivalent to a hypothetical individual assumed to frequent the largest vicinity property (VP), 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 radioactive airborne particle 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 per 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 particles and radon daughter concentrations were not measured.

Gamma exposure 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 four hours per week, 50 weeks per year. The measurements were taken with a pressurized ion chamber (PIC) on the bank of the slough in an area of known radiological soil contamination. Using the measured gamma exposure rate of 10.3 μR/hr, which is 2.5 μR/hr in excess of natural background, the calculated dose equivalent would be 2 mrem (.02 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 (0.37 mBq/g). Using the average annual consumption rate of 6.5 grams/year (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 (.055 mSv) from direct gamma exposure and consumption of fish tissue.

4.4 Population Doses

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.

This section summarizes the radiation exposure potential for populations surrounding the WSS. The exposures are shown to be indistinguishable from natural background. Therefore, no risks are projected.

4.4.1 Dose to Francis Howell High School Population

To determine dose equivalents accurately, the radiation exposure should be measured at the point where the collective dose equivalent is to be estimated. Collective dose equivalent is determined by multiplying calculated doses by the number of persons exposed. The Francis Howell High School (FHHS) is located 0.8 kilometers (0.5 miles) northeast of the WSCP.

Samples of radioactive airborne particles were collected weekly at the FHHS station, and radon concentrations and external gamma exposure rates were monitored quarterly. Water supplied to the school from the St. Charles County well field was also sampled and analyzed quarterly.

No radiation level or radionuclide concentration in air or water has ever exceeded natural or normal background radioactivity at the 95 percent confidence level at the FHHS station. This being the case, no risk is determined and no measurable adverse health effects are predicted to occur.

4.4.2 Population Doses Within 80 Kilometers (50 Miles)

The collective effective dose equivalent to the general public within an 80-km (50-mi) radius of the WSS must be calculated or estimated, since it is unreasonable to attempt pathway-specific measurements relative to every individual. The exposure pathways considered were: external exposure to gamma radiation, inhalation of radon and radon daughters, inhalation of radioactive airborne particles, and ingestion of water, fish, or game containing radioactivity.

At the three off-site gamma radiation monitoring stations, all measurements were at normal background levels (see Section 2.4). Likewise, measurements at the four off-site radon monitoring stations and air particulate monitoring stations were indistinguishable from background levels (see Sections 2.3 and 2.5, respectively). Therefore, the WSS does not contribute any measurable radiation dose to the general public via these three pathways.

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 fraction of persons living within 80 km (50 mi) of the site consumes fish or game affected by the WSS; hence this is not a significant exposure pathway (see Section 4.3). Therefore, cumulative radiation dose to the population within an 80-km (50-mi) radius resulting from radioactive materials present at the WSS is indistinguishable from the dose that the same population receives from naturally occurring radiation sources.

4.5 Radiation Dose To Individuals From Contaminated Lakes

This section calculates the realistic effective dose equivalent of an individual who uses Lakes 34, 35, 36, and the Femme Osage Slough solely for recreational purposes. The lakes are located in the Busch Wildlife Area and the Femme Osage Slough in the Weldon Spring Wildlife Area. They are used for recreational activities such as fishing and boating. None of the water bodies are presently used for drinking water or irrigation. In contrast to the previous sections, the analyses presented here attempt to realistically estimate the dosage to an individual in very plausible settings.

The potential radiation dose to individuals resulting from recreational activities at these lakes was estimated for the following potential pathways:

External: Swimming, boating, and direct exposure from the water body; and

Internal: Accidental ingestion of contaminated water.

The assumed individual spent 12 hours per year swimming and boating at the location of the contaminated water bodies. Also, this individual was assumed to ingest one liter of water from a canteen filled from one of the water bodies.

For purposes of calculation, thorium-234, protactinium-234, and uranium-234 were assumed to be in a state of secular equilibrium. In this analysis, the dose represents the 50-year effective committed dose equivalent expressed in millisievert per year (mSv/yr) and millirem per year (mrem/yr).

The total dose commitments estimated for a hypothetical individual from these exposure assumptions is much less than 1 mrem (0.01 mSv). These radiation pathways contribute an insignificant health risk to individuals or the general population.

5 FUTURE ENVIRONMENTAL MONITORING AT THE WELDON SPRING SITE

The environmental monitoring approach employed at the Weldon Spring Site (WSS) in 1990 has been modified from previous programs by several factors including issuance of DOE Order 5400.1 and the completion of numerous characterization activities. The effects of these factors are detailed in the Environmental Monitoring Plan (MKF and JEG, 1990a) for the WSS.

The groundwater monitoring program for 1990 will generally consist of semi-annual sampling of all Weldon Spring Chemical Plant/Weldon Spring Raffinate Pits (WSCP/WSRP) wells and all Weldon Spring Quarry (WSQ) wells north of the Femme Osage Slough. These samples will be analyzed for nitroaromatic compounds, inorganic anions and natural uranium. This program is designed to detect changes in contaminant concentrations and distribution. Quarterly monitoring is performed on monitoring and production wells south of the Femme Osage Slough. This portion of the groundwater monitoring program has been developed with the Missouri Department of Natural Resources and St. Charles County and is designed to document the safety of the well field, as well as detect contamination south of the slough. Analytical parameters include an annual scan for compounds known or suspected to be present in the WSQ and quarterly analyses for uranium, inorganic anions and nitroaromatic compounds.

The surface water monitoring program remains essentially unchanged from 1989. Surface water samples will generally be analyzed for uranium, with select locations analyzed for inorganic anions and/or nitroaromatic compounds. Preoperational monitoring (as required by DOE Order 5400.1) will continue in 1990. Effluent monitoring will continue as detailed in the National Pollutant Discharge Elimination System (NPDES) Permit.

Radon, gamma exposure and air particulate monitoring will be performed at the same locations and frequencies as in 1989.

Meteorological monitoring will be expanded during 1990 to include on-site measurements of hourly windspeed, wind direction, air temperature and precipitation.

The entire scope of routine effluent monitoring and environmental surveillance is detailed in the 1990 Environmental Monitoring Plan (EMP) for the WSS. The EMP discusses rationale, monitoring locations, and analytical methods to be used.

6 REFERENCES

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APPENDIX A
Quarterly Monitoring Data

TABLE A-1 Quarterly Results -- Total Uranium-Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		3.0		
GW-1004		4350		
GW-1005		1750		
GW-1006		2400		
GW-1007		438		
GW-1008		1380		
GW-1009		7.4		
GW-1010		ND		
GW-1012	5.6	4.9	6.0	ND
GW-1013	865	752	776	816.00
GW-1014		907	764	952.00
GW-1015	207	487	154	680
GW-1016	106	98	672	163
GW-1017	ND	ND	ND	ND
GW-1018	ND	ND	ND	
GW-1019	ND	ND	ND	ND
GW-1020	ND	ND	ND	.680
GW-1021	ND	ND	ND	ND
GW-1022	ND	ND	ND	ND
GW-1023	ND	ND	ND	1.36
GW-1024	ND	ND	ND	1.36
GW-1025	2.5	3.8	3.8	4.08
GW-1026	ND	ND		ND
GW-1027	447	823	913	415.0
GW-1028	1.6	1.4	1.5	2.04
GW-2001		1.8		
GW-2002		ND		
GW-2003		3.6		
GW-2004		1.90		
GW-2005		2.4		
GW-2006		ND		
GW-2007		2.4		
GW-2008		ND		
GW-2009		2.9		
GW-2010		1.1		
GW-2011		ND		
GW-2012		1.0		
GW-2013		1.0		
GW-2014		1.0		
GW-2015		2.6		
GW-2017		15		

TABLE A-1 Quarterly Results -- Total Uranium-Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2018		3.1		
GW-2019	2.7	2.6	2.6	0.68
GW-2020		9.0		
GW-2021	2.8	3.0	2.2	ND
GW-2022	2.3	ND	ND	1.36
GW-2023	2.0	2.0	3.0	4.08
GW-2024	ND	2.8	ND	1.36
GW-2025	1.9	1.6	1.7	1.36
GW-2026	1.6	1.6	4.4	2.72
GW-2027	2.6	ND	1.9	0.680
GW-2028	1.5	2.6	11	6.80
GW-2029	1.3	2.8	1.0	2.04
GW-3001	2.6	ND	3.4	ND
GW-3002	2.6	7.8	2.8	2.72
GW-3003	9.8	17	17	9.52
GW-3006	1.2	ND	2.3	2.72
GW-3008		5.9		
GW-3009		48		
GW-3010		2.1		
GW-3019		7.8	5.5	9.52
GW-4001		1.2		
GW-4002		ND		
GW-4003	ND	1.7	ND	ND
GW-4004	4.3	2.0	1.9	272
GW-4005	2.1	1.7	1.0	2.04
GW-4006		ND		
GW-4007	1.4	3.4	1.3	.680
GW-4008	2.8	1.9	ND	4.08
GW-4009	1.4	1.8		3.40
GW-4010		5.4	2.5	4.76
GW-4011	2.5	4.4	2.9	ND
GW-4012	1.3	3.5	2.8	2.04
GW-4013	ND	1.8	1.4	ND
GW-4014	ND	ND	ND	ND
GW-4015	ND	1.6	1.1	1.36
GW-4016	5.1	4.6	5.2	5.44
GW-4017	3.2	2.1	2.7	3.40
GW-4018	ND	1.7	1.3	2.04
GW-4019		1.5		
GW-4020	26	25	28	14.3

TABLE A-1 Quarterly Results -- Total Uranium-Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-4021	11	18	9.7	9.52
GW-4022	2.1	4.2	4.9	ND
GW-4023	2.3	3.2	2.0	ND

TABLE A-2 Quarterly Results -- 2,4-Dinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		ND		
GW-1004		0.56		
GW-1005		ND		
GW-1006		ND		
GW-1007		ND		
GW-1008		ND		
GW-1009		ND		
GW-1010		ND		
GW-1012		0.06		
GW-1013		0.15		
GW-1014		ND		
GW-1015	ND	ND	ND	ND
GW-1016	ND	ND	ND	ND
GW-1017		ND		
GW-1018		ND		
GW-1019		ND		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND		
GW-1024			ND	ND
GW-1025		ND		
GW-1026		ND		
GW-1027		1.14		
GW-1028		ND		
GW-2001		ND		
GW-2002		ND		
GW-2003		0.55		
GW-2004		ND		
GW-2005		0.08		
GW-2006		ND		
GW-2007		ND		
GW-2008		0.13		
GW-2009		ND		
GW-2010		ND		
GW-2011		ND		
GW-2012		ND		
GW-2013		2.47		
GW-2014		ND		
GW-2015		ND		
GW-2017		ND		

TABLE A-2 Quarterly Results -- 2,4-Dinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2018		ND		
GW-2019	ND	ND	ND	
GW-2020		ND		
GW-2021		ND	ND	ND
GW-2022	ND	ND	ND	ND
GW-2023	ND	ND	ND	ND
GW-2024	ND	ND	ND	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND
GW-2027	ND	ND	ND	ND
GW-2028	ND	ND	ND	ND
GW-2029	ND		ND	ND
GW-3001	0.42	0.35	ND	ND
GW-3002	ND	ND	ND	ND
GW-3003	ND	ND	ND	ND
GW-3006	ND	ND	ND	ND
GW-3008		0.06		
GW-3009		0.07		
GW-3010		ND		
GW-3019		ND	ND	ND
GW-4001		0.85		
GW-4002		ND		
GW-4003	ND	ND	ND	ND
GW-4004	ND	ND	ND	ND
GW-4005	ND	ND	ND	ND
GW-4006		0.39		
GW-4007	ND	ND	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	ND	ND		ND
GW-4010	ND	ND	ND	ND
GW-4011	ND	ND	ND	ND
GW-4012	ND	ND	ND	ND
GW-4013	ND	ND	ND	ND
GW-4014	ND	ND	ND	ND
GW-4015	ND	ND	ND	ND
GW-4016		ND	ND	ND
GW-4017	ND	ND	ND	ND
GW-4018	ND	ND	ND	ND
GW-4019		ND		

TABLE A-2 Quarterly Results -- 2,4-Dinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-4020	ND	ND	ND	ND
GW-4021	ND	ND	ND	ND
GW-4022	ND	ND	ND	ND
GW-4023	ND	ND	ND	ND

TABLE A-3 Quarterly Results -- 2,6-Dinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		ND		
GW-1004		2.42		
GW-1005		ND		
GW-1006		3.24		
GW-1007		ND		
GW-1008		ND		
GW-1009		ND		
GW-1010		ND		
GW-1012		ND		
GW-1013		ND		
GW-1014		ND		
GW-1015	ND	ND	ND	ND
GW-1016	ND	ND	ND	ND
GW-1017		ND		
GW-1018		ND		
GW-1019		ND		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND		
GW-1024			ND	ND
GW-1025		ND		
GW-1026		ND		
GW-1027		1.40		
GW-1028		ND		
GW-2001		ND		
GW-2002		0.47		
GW-2003		0.75		
GW-2004		ND		
GW-2005		ND		
GW-2006		1.60		
GW-2007		ND		
GW-2008		ND		
GW-2009		0.19		
GW-2010		0.92		
GW-2011		1.91		
GW-2012		ND		
GW-2013		7.83		
GW-2014		ND		
GW-2015		0.63		
GW-2017		ND		
GW-2018		ND		

TABLE A-3 Quarterly Results -- 2,6-Dinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2019	ND	ND	ND	ND
GW-2020		ND		
GW-2021		ND	ND	ND
GW-2022	ND	ND	ND	ND
GW-2023	ND	ND	ND	ND
GW-2024	ND	ND	ND	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND
GW-2027	ND	ND	ND	
GW-2028	ND	ND	ND	ND
GW-2029	ND		ND	ND
GW-3001	ND	ND	ND	ND
GW-3002	ND	ND	ND	ND
GW-3003	ND	ND	ND	ND
GW-3006	ND	ND	ND	ND
GW-3008		ND		
GW-3009		ND		
GW-3010		ND		
GW-3019		ND	ND	ND
GW-4001		2.68		
GW-4002		ND		
GW-4003	ND	ND	ND	ND
GW-4004	ND	ND	ND	ND
GW-4005	ND	ND	ND	ND
GW-4006		3.50		
GW-4007	ND	ND	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	ND	1.70		ND
GW-4010	ND	ND	ND	ND
GW-4011	ND	ND	ND	ND
GW-4012	ND	ND	ND	ND
GW-4013	ND	1.21	0.68	ND
GW-4014	ND	ND	ND	ND
GW-4015	1.21	2.04	0.83	ND
GW-4016		ND	ND	ND
GW-4017	ND	ND	ND	ND
GW-4018	ND	ND	ND	ND
GW-4019		ND		
GW-4020	ND	ND	ND	ND
GW-4021	ND	ND	ND	ND

TABLE A-3 Quarterly Results -- 2,6-Dinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-4022	ND	ND	ND	ND
GW-4023	ND	ND	ND	ND

TABLE A-4 Quarterly Results -- 2,4,6-Trinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		ND		
GW-1004		5.56		
GW-1005		ND		
GW-1006		ND		
GW-1007		ND		
GW-1008		ND		
GW-1009		ND		
GW-1010		ND		
GW-1012		ND		
GW-1013		ND		
GW-1014		ND		
GW-1015	2.45	4.81	10.50	ND
GW-1016	ND	ND	0.79	ND
GW-1017		ND		
GW-1018		ND		
GW-1019		ND		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND	ND	ND
GW-1025		ND		
GW-1026		ND		
GW-1027		6.23		
GW-1028		ND		
GW-2001		ND		
GW-2002		ND		
GW-2003		ND		
GW-2004		ND		
GW-2005		ND		
GW-2006		ND		
GW-2007		ND		
GW-2008		ND		
GW-2009		ND		
GW-2010		ND		
GW-2011		ND		
GW-2012		ND		
GW-2013		2.29		
GW-2014		ND		
GW-2015		ND		
GW-2017		ND		
GW-2018		ND		
GW-2019	ND	ND	ND	ND

TABLE A-4 Quarterly Results -- 2,4,6-Trinitrotoluene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2020		ND		
GW-2021		ND	ND	ND
GW-2022	ND	ND	ND	ND
GW-2023	ND	ND	ND	ND
GW-2024	ND	ND	ND	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND
GW-2027	ND	ND	ND	ND
GW-2028	ND	ND	ND	ND
GW-2029	ND		ND	ND
GW-3001	ND	ND	ND	ND
GW-3002	ND	ND	ND	ND
GW-3003	ND	ND	ND	ND
GW-3006	ND	ND	ND	ND
GW-3008		ND		
GW-3009		ND		
GW-3010		ND		
GW-3019		ND	ND	ND
GW-4001		1.75		
GW-4002		ND		
GW-4003	ND	ND	ND	ND
GW-4004	ND	ND	ND	ND
GW-4005	ND	ND	ND	ND
GW-4006		ND		
GW-4007	ND	ND	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	ND	7.78		ND
GW-4010	ND	ND	ND	ND
GW-4011	ND	ND	ND	ND
GW-4012	ND	ND	ND	ND
GW-4013	ND	ND	ND	ND
GW-4014	ND	ND	ND	ND
GW-4015	ND	ND	ND	ND
GW-4016		ND	ND	ND
GW-4017	ND	ND	ND	ND
GW-4018	ND	ND	ND	ND
GW-4019		ND		
GW-4020	ND	ND	ND	ND
GW-4021	ND	ND	ND	ND
GW-4022	ND	ND	ND	ND
GW-4023	ND	ND	ND	ND

TABLE A-5 Quarterly Results -- Nitrobenzene Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		ND		
GW-1004		ND		
GW-1005		ND		
GW-1006		0.71		
GW-1007		ND		
GW-1008		ND		
GW-1009		ND		
GW-1010		ND		
GW-1012		ND		
GW-1013		ND		
GW-1014		ND		
GW-1015	ND	ND	ND	ND
GW-1016	ND	ND	ND	ND
GW-1017		ND		
GW-1018		ND		
GW-1019		ND		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND	ND	ND
GW-1025		ND		
GW-1026		ND		
GW-1027		ND		
GW-1028		ND		
GW-2001		ND		
GW-2002		ND		
GW-2003		ND		
GW-2004		ND		
GW-2005		ND		
GW-2006		ND		
GW-2007		ND		
GW-2008		ND		
GW-2009		ND		
GW-2010		ND		
GW-2011		ND		
GW-2012		ND		
GW-2013		ND		
GW-2014		ND		
GW-2015		ND		
GW-2017		ND		
GW-2018		ND		
GW-2019	ND	ND	ND	ND
GW-2020		ND		

TABLE A-5 Quarterly Results -- Nitrobenzene Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2021		ND	ND	ND
GW-2022	6.00	ND	ND	ND
GW-2023	ND	ND	ND	ND
GW-2024	ND	ND	ND	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND
GW-2027	ND	ND	ND	ND
GW-2028	1.22	ND	ND	ND
GW-2029	ND		ND	ND
GW-3001	ND	ND	ND	ND
GW-3002	ND	ND	ND	ND
GW-3003	ND	ND	ND	ND
GW-3006	ND	ND	ND	ND
GW-3008		ND		
GW-3009		ND		
GW-3010		ND		
GW-3019		ND	ND	ND
GW-4001		6.08		
GW-4002		ND		
GW-4003	ND	ND	ND	ND
GW-4004	ND	ND	ND	ND
GW-4005	ND	ND	ND	ND
GW-4006		3.34		
GW-4007	ND	ND	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	ND	ND		ND
GW-4010	ND	ND	ND	ND
GW-4011	ND	ND	ND	ND
GW-4012	ND	ND	ND	ND
GW-4013	ND	ND	ND	ND
GW-4014	ND	ND	ND	ND
GW-4015	ND	0.42	ND	ND
GW-4016		ND	ND	ND
GW-4017	ND	ND	ND	ND
GW-4018	ND	ND	ND	ND
GW-4019		ND		
GW-4020	ND	ND	ND	ND
GW-4021	ND	ND	ND	ND
GW-4022	ND	ND	ND	ND
GW-4023	ND	ND	ND	ND

TABLE A-6 Quarterly Results -- 1,3-Dinitrobenzene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		ND		
GW-1004		ND		
GW-1005		ND		
GW-1006		ND		
GW-1007		ND		
GW-1008		ND		
GW-1009		ND		
GW-1010		ND		
GW-1012		ND		
GW-1013		ND		
GW-1014		ND		
GW-1015	ND	ND	ND	ND
GW-1016	ND	0.24	ND	
GW-1017		ND		
GW-1018		ND		
GW-1019		ND		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND	ND	ND
GW-1025		ND		
GW-1026		ND		
GW-1027		ND		
GW-1028		ND		
GW-2001		ND		
GW-2002		ND		
GW-2003		ND		
GW-2004		ND		
GW-2005		ND		
GW-2006		ND		
GW-2007		ND		
GW-2008		0.58		
GW-2009		ND		
GW-2010		ND		
GW-2011		ND		
GW-2012		ND		
GW-2013		ND		
GW-2014		ND		
GW-2015		ND		
GW-2017		ND		
GW-2018		ND		
GW-2019	ND	ND	ND	ND

TABLE A-6 Quarterly Results -- 1,3-Dinitrobenzene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2020		ND		
GW-2021		ND	ND	ND
GW-2022	ND	ND	ND	ND
GW-2023	ND	ND	ND	ND
GW-2024	ND	ND	ND	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND
GW-2027	ND	ND	ND	ND
GW-2028	ND	ND	ND	ND
GW-2029	ND		ND	ND
GW-3001	ND	ND	ND	ND
GW-3002	ND	ND	ND	ND
GW-3003	ND	ND	ND	ND
GW-3006	ND	ND	ND	ND
GW-3008		ND		
GW-3009		ND		
GW-3010		ND		
GW-3019		ND	ND	ND
GW-4001		2.31		
GW-4002		ND		
GW-4003	ND	ND	ND	ND
GW-4004	ND	ND	ND	ND
GW-4005	ND	ND	ND	ND
GW-4006		1.93		
GW-4007	ND	ND	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	ND	ND		ND
GW-4010	ND	ND	ND	ND
GW-4011	ND	ND	ND	ND
GW-4012	ND	ND	ND	ND
GW-4013	ND	0.80	ND	ND
GW-4014	ND	ND	ND	ND
GW-4015	ND	ND	ND	ND
GW-4016		ND	ND	ND
GW-4017	ND	ND	ND	ND
GW-4018	ND	ND	ND	ND
GW-4019		ND		
GW-4020	ND	ND	ND	ND
GW-4021	ND	ND	ND	ND
GW-4022	ND	ND	ND	ND
GW-4023	ND	ND	ND	ND

TABLE A-7 Quarterly Results -- 1,3,5-Trinitrobenzene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		ND		
GW-1004		0.86		
GW-1005		0.04		
GW-1006		ND		
GW-1007		ND		
GW-1008		ND		
GW-1009		ND		
GW-1010		0.02		
GW-1012		ND		
GW-1013		ND		
GW-1014		ND		
GW-1015	11.82	38.42	72.94	ND
GW-1016	0.18	ND	5.46	ND
GW-1017		ND		
GW-1018		ND		
GW-1019		0.06		
GW-1020		0.52		
GW-1021		ND		
GW-1022		ND	ND	ND
GW-1025		ND		
GW-1026		0.04		
GW-1027		0.17		
GW-1028		ND		
GW-2001		ND		
GW-2002		0.03		
GW-2003		ND		
GW-2004		ND		
GW-2005		ND		
GW-2006		9.62		
GW-2007		ND		
GW-2008		ND		
GW-2009		ND		
GW-2010		ND		
GW-2011		0.55		
GW-2012		ND		
GW-2013		5.48		
GW-2014		ND		
GW-2015		0.21		
GW-2017		ND		
GW-2018		ND		
GW-2019	ND	0.06	0.07	ND

TABLE A-7 Quarterly Results -- 1,3,5-Trinitrobenzene
Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2020		ND		
GW-2021		ND	ND	ND
GW-2022	ND	0.03	ND	ND
GW-2023	ND	ND	ND	ND
GW-2024	ND	0.03	0.07	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND
GW-2027	ND	ND	ND	ND
GW-2028	ND	ND	ND	ND
GW-2029	ND		ND	ND
GW-3001	0.17	0.04	0.09	ND
GW-3002	ND	ND	ND	ND
GW-3003	ND	ND	ND	ND
GW-3006	ND	ND	ND	ND
GW-3008		ND		
GW-3009		0.06		
GW-3010		ND		
GW-3019		0.04	ND	ND
GW-4001		47.06		
GW-4002		0.02		
GW-4003	ND	ND	ND	ND
GW-4004	ND	ND	ND	ND
GW-4005	ND	0.02	0.18	ND
GW-4006		17.33		
GW-4007	ND	0.02	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	ND	16.52		ND
GW-4010	ND	ND	ND	ND
GW-4011	ND	ND	ND	ND
GW-4012	ND	ND	ND	ND
GW-4013	ND	44.80	32.81	89.0
GW-4014	ND	0.27	0.41	ND
GW-4015	0.10	0.12	0.13	ND
GW-4016		ND	ND	ND
GW-4017	ND	0.05	ND	ND
GW-4018	ND	ND	0.13	ND
GW-4019		ND		
GW-4020	ND	ND	ND	ND
GW-4021	ND	0.015	ND	ND
GW-4022	ND	ND	ND	ND
GW-4023	ND	ND	0.30	ND

TABLE A-8 Quarterly Results -- Nitrate Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		16.30		
GW-1004		1.90		
GW-1005		ND		
GW-1006		9.30		
GW-1007		0.20		
GW-1008		2.40		
GW-1009		ND		
GW-1010		ND		
GW-1012		8.10		
GW-1013	ND	ND	ND	ND
GW-1014	ND	1.30	ND	ND
GW-1015		9.80		
GW-1016		2.40		
GW-1017		0.40		
GW-1018		ND		
GW-1019		2.40		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND		
GW-1023		ND	ND	ND
GW-1025		0.50		
GW-1026		ND		
GW-1027		1.00		
GW-1028		ND		
GW-2001		50.20		
GW-2002		1010.00		
GW-2003		3330.00		
GW-2004		3.80		
GW-2005		117.00		
GW-2006	29.4	28.70		
GW-2007		ND		
GW-2008		16.00		
GW-2009		6.30		
GW-2010		4.30		
GW-2011		0.80		
GW-2012		4.00		
GW-2013		3.20		
GW-2014		9.00		
GW-2015		1.80		
GW-2017		1.50		
GW-2018		2.30		
GW-2019	ND	ND	ND	ND

TABLE A-8 Quarterly Results -- Nitrate Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-2020		3.70		
GW-2021	ND	ND	ND	ND
GW-2022	ND	ND	ND	ND
GW-2023	0.20	0.20	0.40	ND
GW-2024	ND	ND	ND	ND
GW-2025	ND	ND	ND	ND
GW-2026	ND	ND	ND	0.5
GW-2027	0.20	0.53	0.20	ND
GW-2028	ND	ND	ND	ND
GW-2029	ND	0.11	ND	ND
GW-3001	1050.00	935.00	893	296.0*
GW-3002	0.20	ND	0.18	ND
GW-3003	2050.00	2175.00	1885	312,000.0a
GW-3006	ND	1.30	4.00	188.0
GW-3008		4010.00		
GW-3009		294.00		
GW-3010		5.50		
GW-3019		0.59	0.20	ND
GW-4001		149.00		
GW-4002		9.00		
GW-4003	3.30	3.20	3.10	2100.0**
GW-4004	1.70	1.90	2.30	.50
GW-4005	6.30	6.50	6.20	1.47*
GW-4006		21.90		
GW-4007	ND	ND	ND	ND
GW-4008	ND	ND	ND	ND
GW-4009	0.60	0.40		39*
GW-4010	0.30	1.00	0.29	0.09
GW-4011	95.10	101.00	133.00	21.0*
GW-4012	ND	0.33	0.55	ND
GW-4013	657.00	522.00	456	361.0
GW-4014	9.40	7.90	13.10	127.0
GW-4015	5.40	22.40	6.00	1.3
GW-4016	ND	ND	ND	ND
GW-4017	2.30	2.00	2.60	0.47*
GW-4018	8.20	8.20	9.70	1.3
GW-4019		0.84		

TABLE A-8 Quarterly Results -- Nitrate Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-4020	5.50	0.18	ND	ND
GW-4021	ND	ND	ND	ND
GW-4022	3.00	2.00	1.80	0.09*
GW-4023	25.70	23.30	28.90	10.2*

* Value is suspect since analytical holding time was exceeded.

a Documented laboratory error responsible for erroneously high result. Not entered into Annual Average.

** Value inconsitent with all previous historical data; holding time exceeded. Laboratory error suspected. Value not entered into annual average.

TABLE A-9 Quarterly Results -- Sulfate Weldon Spring Site

	Q189	Q289	Q389	Q489
GW-1002		79.30		
GW-1004		1000.00		
GW-1005		598.00		
GW-1006		441.00		
GW-1007		184.00		
GW-1008		292.00		
GW-1009		240.00		
GW-1010		ND		
GW-1012		81.20		
GW-1013	136.00	130	124.00	112
GW-1014	131.50	126.00	125.00	120
GW-1015		219.00		
GW-1016		160.00		
GW-1017		ND		
GW-1018		49.40		
GW-1019		ND		
GW-1020		ND		
GW-1021		ND		
GW-1022		ND		
GW-1023		6.80	3.2	5.2
GW-1025		131.90		
GW-1026		ND		
GW-1027		82.80		
GW-1028		63.80		
GW-2001		5.80		
GW-2002		95.00		
GW-2003		288.00		
GW-2004		1.90		
GW-2005		3.40		
GW-2006		32.40		
GW-2007		14.10		
GW-2008		39.50		
GW-2009		99.20		
GW-2010		42.80		
GW-2011		37.30		
GW-2012		415.00		
GW-2013		11.90		
GW-2014		34.80		
GW-2015		96.40		
GW-2017		1830.00		
GW-2018		9.50		
GW-2019	18.70	21.30	17.9	22.6

TABLE A-9 -- Quarterly Results -- Sulfate Weldon Spring Site (Continued)

	Q189	Q289	Q389	Q489
GW-2020		144.00		
GW-2021	13.50	13.40	12.80	12.0
GW-2022	16.20	13.40	12.50	13.8
GW-2023	55.40	25.90	25.20	22.1
GW-2024	35.80	34.80	32.50	23.2
GW-2025	18.70	16.70	16.10	16.1
GW-2026	13.60	13.70	13.00	11.9
GW-2027	12.40	14.90	10.50	
GW-2028	112.00	95.70	108	113.0
GW-2029	27.10		16.60	26.2
GW-3001	23.30	28.0	20.50	20.4
GW-3002	19.50	19.4	19.0	19.3
GW-3003	190.00	191.00	153.00	173.0
GW-3006	45.00	80.40	71.10	43.2
GW-3008		43.60		
GW-3009		58.00		
GW-3010		7.60		
GW-3019		10.30	6.60	5.2
GW-4001		64.10		
GW-4002		25.20		
GW-4003	29.90	28.50	32.00	27.6
GW-4004	35.20	28.10	30.40	29
GW-4005	18.80	16.10	19.20	22
GW-4006		32.90		
GW-4007	14.80	13.90	13.00	9.9
GW-4008	14.30	16.90	15.00	12.2
GW-4009	29.60	16.10		39
GW-4010	24.10	42.70	25.80	26.2
GW-4011	51.40	49.70	52.40	45.8
GW-4012	50.70	47.90	45.80	39.9
GW-4013	61.30	54.90	51.00	43.2
GW-4014	24.90	29.00	26.40	21.5
GW-4015	4.80	11.50	6.00	ND
GW-4016	19.70	32.90	20.80	11.6
GW-4017	7.70	10.20	5.10	7.2
GW-4018	11.60	13.70	8.20	11.9
GW-4019		8.90		
GW-4020	127.50	136.00	148.00	121.0
GW-4021	282.00	308.00	315.00	343.0
GW-4022	67.90	70.90	43.20	43.5
GW-4023	82.40	285.00	94.50	88.5

TABLE A-10 1989 Quarterly NPDES Results for Outfall NP-0001

DATE	pH	TOTAL URANIUM pCi/l	GROSS ALPHA pCi/l	NITRATE mg/l	LITHIUM mg/l	SETTL. SOLIDS ml/l	SUSP. SOLIDS mg/l	FLOW GPD
JAN. 5	6.77	120 +/- 10	80 +/- 9	2.20	ND	<0.1	84	70000
APR. 4	7.18	500 +/- 50	290 +/- 30	4.10	ND	<0.1	7	14400
JUL. 21	7.60	590 +/- 60	470 +/- 50	5.90	ND	<0.1	4	28800
OCT. 6	7.25	260 +/- 30	190 +/- 20	3.60	ND	<0.1	2	57600
MINIMUM	6.77	120	80	2.20	ND	<0.1	2	14400
MAXIMUM	7.60	590	470	5.90	ND	<0.1	84	70000
AVERAGE	7.20	368	258	3.95	ND	<0.1	24	42700

TABLE A-11 1989 MONTHLY NPDES RESULTS FOR OUTFALL NP-0002

DATE	pH	TOTAL URANIUM pCi/l	GROSS ALPHA pCi/l	NITRATE mg/l	LITHIUM mg/l	SETTL. SOLIDS ml/l	SUSP. SOLIDS mg/l	FLOW GPD
JAN. 5	6.51	26 +/- 2	16 +/- 5	3.80	ND	<0.1	320	720000
FEB. 3	6.45	220 +/- 30	140 +/- 21	1.40	ND	<0.1	55	50093
MAR. 9	6.13	400 +/- 40	95 +/- 10	2.30	ND	<0.1	35	61920
APR. 4	7.13	97 +/- 10	57 +/- 8	3.20	ND	<0.1	54	626832
MAY 9	7.23	110 +/- 20	54 +/- 6	1.80	ND	<0.1	6	123840
JUN. 19	7.19	86 +/- 9	49 +/- 8	0.82	ND	<0.1	25	52704
JUL. 20	6.85	200 +/- 20	150 +/- 20	2.20	ND	<0.1	12	131789
AUG. 22	6.90	150 +/- 20	86 +/- 13	ND	ND	<0.1	34	35107
AUG. 24	6.26	91 +/- 10	66 +/- 11	1.40	ND	<0.1	53	385444
SEP. 1	6.93	110 +/- 20	87 +/- 13	0.53	ND	<0.1	46	161665
OCT. 6	7.17	100 +/- 10	65 +/- 9	1.20	ND	<0.1	3	5299
NOV. (NO FLOW)								0
DEC. (NO SAMPLE)								
MINIMUM	6.13	26	16	ND	ND	<0.1	3	5299
MAXIMUM	7.23	400	150	3.80	ND	<0.1	320	720000
AVERAGE	6.80	145	79	1.87*	ND	<0.1	58	214063

TABLE A-12 1989 Monthly NPDES Results for Outfall NP-0003

MONTH	pH	TOTAL URANIUM pCi/l	GROSS ALPHA pCi/l	NITRATE mg/l	LITHIUM mg/l	SETTL. SOLIDS ml/l	SUSP. SOLIDS mg/l	FLOW GPD
JAN. 5	6.80	200 +/- 20	280 +/- 55	4.90	0.061	8.0	7018	927360
FEB. 3	6.24	1000 +/- 100	620 +/- 60	75.60	ND	<0.1	66	30617
MAR. 9	6.21	370 +/- 40	240 +/- 30	98.80	ND	<0.1	20	50256
APR. 4	6.99	750 +/- 80	460 +/- 50	12.80	ND	<0.1	6	246384
MAY 9	7.44	140 +/- 20	67 +/- 8	0.85	ND	<0.1	13	19728
JUN. 19	7.25	250 +/- 30	71 +/- 9	0.20	ND	<0.1	12	6062
(Dup.)	7.25	200 +/- 20	89 +/- 10	0.21	ND	<0.1	16	
JUL. 21	6.86	240 +/- 30	230 +/- 30	1.40	ND	<0.1	6	82901
AUG. 24	6.94	16 +/- 2	9 +/- 5	0.43	ND	<0.1	178	94882
SEP. 1	7.04	86 +/- 9	85 +/- 12	0.82	ND	<0.1	46	22094
(Dup.)	7.04	87 +/- 9	75 +/- 12	0.83	ND	<0.1	63	
OCT. 6	7.09	150 +/- 20	74 +/- 13	0.50	ND	<0.1	11	14530
NOV. 15	7.06	326 ‡	270 +/- 50	ND	ND	<0.1	ND	5443
DEC. 29	6.92	109 ‡	120 +/- 10	ND	ND	<0.1	4	10181
MINIMUM	6.21	16	9	ND	ND	<0.1	4	5443
MAXIMUM	7.44	1000	620	19.80	0.061	8.0	7018	927360
AVERAGE	6.94	280	192	16.45*	ND**	<0.1**	574*	125870

TABLE A-13 1989 Quarterly NPDES Results for Outfall NP-0004

DATE	pH	TOTAL URANIUM pCi/l	GROSS ALPHA pCi/l	NITRATE mg/l	LITHIUM mg/l	SETTL. SOLIDS ml/l	SUSP. SOLIDS mg/l	FLOW GPD
JAN. 11	6.82	6.8 +/- 1.7	ND	5.00	ND	<0.1	2	1000
APR. 13	6.78	9.7 +/- 1.6	3.9 +/- 2.7	2.40	ND	<0.1	4	1400
AUG. 22	7.09	3.0 +/- 0.9	ND	ND	ND	<0.1	21	1000
4th QTR. (NO FLOW)								0
MINIMUM	6.78	3.0	3.9	ND	ND	<0.1	2	0
MAXIMUM	7.09	9.7	3.9	5.00	ND	<0.1	21	1400
AVERAGE	6.90	6.5	3.9	3.70*	ND	<0.1	9	850

* = Averages do not include ND (not detected) values.

TABLE A-14 1989 Monthly NPDES Results for Outfall NP-0005

DATE	pH	TOTAL URANIUM pCi/l	GROSS ALPHA pCi/l	NITRATE mg/l	LITHIUM mg/l	SETTL. SOLIDS ml/l	SUSP. SOLIDS mg/l	FLOW GPD
JAN. 5	6.99	95 +/- 10	70 +/- 8	17.80	ND	<0.1	51	400320
FEB. 3	6.37	540 +/- 50	420 +/- 40	48.00	ND	<0.1	25	5229
MAR. 9	6.37	400 +/- 40	240 +/- 30	117.00	ND	<0.1	8	22020
APR. 4	7.23	440 +/- 50	310 +/- 40	30.70	ND	<0.1	56	47376
MAY 9	7.31	490 +/- 50	240 +/- 30	61.00	ND	<0.1	9	14688
(Dup.)	7.31	380 +/- 40	240 +/- 30	61.4	ND	<0.1	12	
JUN. 19	7.33	470 +/- 50	210 +/- 30	13.80	ND	<0.1	18	7200
JUL. 21	7.11	570 +/- 60	580 +/- 60	1.40	ND	<0.1	6	15379
AUG. 24	6.46	150 +/- 20	140 +/- 20	1.00	ND	<0.1	23	32602
SEP. 1	7.08	180 +/- 20	200 +/- 20	1.20	ND	<0.1	ND	27643
OCT. 6	7.17	100 +/- 10	65 +/- 9	1.20	ND	<0.1	3	5299
NOV. (NO FLOW)								0
DEC. (NO SAMPLE)								
MINIMUM	6.37	95	65	1.00	ND	<0.1	ND	0
MAXIMUM	7.33	570	580	117.00	ND	<0.1	56	400320
AVERAGE	6.98	347	247	32.23	ND	<0.1	21*	52523

TABLE A-15 1989 Quarterly NPDES Results for Outfall NP-0006

DATE	pH	SUSP. SOLIDS mg/l	FECAL COLIFORMS #/100ml	BOD mg/l	FLOW GPD
MAR. 1	7.80	2	<1	<6.0	2800
JUN. 14	7.20	5	<1	<6.0	6912
AUG. 1	7.20	5	<2	<3.0	2045
MINIMUM	7.20	2			2045
MAXIMUM	7.80	5			6912
AVERAGE	7.40	4			3919

TABLE A-16 Quarterly Uranium Activities for Surface Water at the Weldon Spring Quarry (pCi/L)

Location Number	Q1	Q2	Q3	Q4
SW-1001	ND	--	ND	2.0
SW-1002	ND	ND	ND	2.0
SW-1003	26	252	24	42
SW-1004	40	557	38	40
SW-1005	49	90	21	21
SW-1006	ND			ND
SW-1007	21	16	--	--
SW-1008	1600	2400	1200	2108
SW-1009	15	28	12	17
SW-1010	31	39	59	45
SW-1011	6.3	4.5	3.5	2.0
SW-1012	2.4	--	4.0	2.7
SW-1013	2.0	2.8	4.1	4.1

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (e.g. dry).

TABLE A-17 Quarterly Sulfate Concentrations for Surface Water at the Weldon Spring Quarry (mg/L)

Location Number	Q1	Q2	Q3	Q4
SW-1001		--		
SW-1002		37.9		
SW-1003		125.7		
SW-1004		141.3		
SW-1005		91.3		
SW-1006				
SW-1007		89.7		
SW-1008	132	142	121	167
SW-1009		95.5		
SW-1010		101.2		
SW-1011		88.8	171	147
SW-1012		--	170	151
SW-1013	126	37.2	171	124

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (e.g. dry).

TABLE A-18 Quarterly Nitrate Concentrations for Surface Water at the Weldon Spring Quarry (mg/L)

Location Number	Q1	Q2	Q3	Q4
SW-1001		--		
SW-1002		0.8		
SW-1003		ND		
SW-1004		ND		
SW-1005		ND		
SW-1006				
SW-1007		ND		
SW-1008	0.2	ND	0.37	0.64
SW-1009		ND		
SW-1010		ND		
SW-1011		4.2	2.2	1.0
SW-1012		--	2.3	0.72
SW-1013	0.43	0.8	2.3	0.69

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (e.g. dry).

TABLE A-19 Quarterly Chloride Concentrations for Surface Water at the Weldon Spring Quarry (mg/L)

Location Number	Q1	Q2	Q3	Q4
SW-1001		--		
SW-1002		5.7		
SW-1003		9.8		
SW-1004		11.5		
SW-1005		12.2		
SW-1006				
SW-1007		7.3		
SW-1008	12.1	13.2	11.6	17.6
SW-1009		7.3		
SW-1010		4.4		
SW-1011		14	20.9	35.0
SW-1012		--	20.7	37.5
SW-1013	24.5	8.8	20.7	37.5

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (e.g. dry).

TABLE A-20 Quarterly Fluoride Concentrations for Surface Water at the Weldon Spring Quarry (mg/L)

Location Number	Q1	Q2	Q3	Q4
SW-1001		--		
SW-1002		ND		
SW-1003		ND		
SW-1004		ND		
SW-1005		ND		
SW-1006				
SW-1007		ND		
SW-1008	0.6	0.54	0.61	0.99
SW-1009		ND		
SW-1010		ND		
SW-1011		ND	ND	0.49
SW-1012		--	ND	0.53
SW-1013	0.3	ND	ND	0.55

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (e.g. dry).

TABLE A-21 Quarterly Uranium Activities for Surface Water at the Weldon Spring CP/RP Area (pCi/L)

Location Number	Q1	Q2	Q3	Q4
SW-2001	160	3.2	2.0	1.4
SW-2002	110	65	6.4	--
SW-2003	20	10	12	--
SW-2004	39	22	15	23
SW-2005	24	20	5.4	8.8
SW-2006	4.4	ND	ND	1.4
SW-2007	ND	ND	ND	ND
SW-2008		90	100	82
SW-2009	--	--	--	--
SW-2010	3200	719	--	--
SW-2011	280	320	150	28

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (dry).

TABLE A-22 Quarterly Sulfate Concentrations for Surface Water at the Weldon Spring CP/RP Area (mg/l)

Location Number	Q1	Q2	Q3	Q4
SW-2001		8.5		
SW-2002		50.6		
SW-2003		15.6		
SW-2004		19.6		
SW-2005		23.6		
SW-2006		9.7		
SW-2007		28.6		
SW-2008		36.4		
SW-2009	--	--	--	--
SW-2010	52	23.1	--	--
SW-2011	50.4	55.2	44.9	52.5

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (dry).

TABLE A-23 Quarterly Nitrate Concentrations for Surface Water at the Weldon Spring CP/RP Area (mg/l)

Location Number	Q1	Q2	Q3	Q4
SW-2001		6.9		
SW-2002		nd		
SW-2003		0.8		
SW-2004		4.2		
SW-2005		1.5		
SW-2006		ND		
SW-2007		2.9		
SW-2008		42.2		
SW-2009	--	--	--	--
SW-2010	3.8	ND	--	--
SW-2011	ND	ND	ND	0.6

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (dry).

TABLE A-24 Quarterly Chloride Concentrations for Surface Water at the Weldon Spring CP/RP Area (mg/l)

Location Number	Q1	Q2	Q3	Q4
SW-2001		1.9		
SW-2002		77.5		
SW-2003		13.9		
SW-2004		13.3		
SW-2005		72.5		
SW-2006		13.1		
SW-2007		14		
SW-2008		11.9		
SW-2009	--	--	--	--
SW-2010	7.6	2.6	--	--
SW-2011	122	368	297	165

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (dry).

TABLE A-25 Quarterly Fluoride Concentrations for Surface Water at the Weldon Spring CP/RP Area (mg/l)

Location Number	Q1	Q2	Q3	Q4
SW-2001		ND		
SW-2002		ND		
SW-2003		ND		
SW-2004		ND		
SW-2005		ND		
SW-2006		ND		
SW-2007		ND		
SW-2008		ND		
SW-2009	--	--	--	--
SW-2010	0.5	0.3	--	--
SW-2011	ND	ND	ND	ND

Blank space implies no sample collected according to plan.
-- Implies sampling location unable to be sampled (dry).

APPENDIX B
Glossary of Technical Terms

APPENDIX B

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 approximately 2.5 acres. It is 10,000 square meters.

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.

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 then 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 C
Acronyms and Abbreviations

APPENDIX C

ACRONYMS AND ABBREVIATIONS

AABMWA	August A. Busch Memorial Wildlife Area
ACM	Asbestos Containing Material
AEC	Atomic Energy Commission
ANL	Argonne National Laboratory
BNI	Bechtel National Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
DA	Department of the Army
DCG	Derived Concentration Guides
DI	Deionized Water
DNT	Dinitrotoluene
DOC	Department of Conservation
DOE	U.S. Department of Energy
EMPP	Environmental Monitoring Program Plan
EMR	Environmental Monitoring Report
EPA	Environmental Protection Agency
FCCA	Federal Facilities Compliance Agreement
FIDLER	Field Instrument for the Detection of Low Energy Radiation
HSL	Hazardous Substance List
ICRP	International Commission on Radiation Protection
LCS	Laboratory Control Samples
MDNR	Missouri Department of Natural Resources
MSHD	Missouri State Highway Department
NCRP	National Council on Radiation Protection
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIOSH	National Institute for Occupational Safety & Health
NLO	National Lead of Ohio
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NVLAP	National Voluntary Laboratory Accreditation Program
ORNL	Oak Ridge National Laboratory
ORAU	Oak Ridge Associated Universities
OSHA	Occupational Safety & Health Administration
PCB	Polychlorinated Biphenyl
PCM	Phase Contrast Microscopy
PE	Performance Evaluation
PIC	Pressurized Ionization Chamber
PMC	Project Management Contractor
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act

ACRONYMS AND ABBREVIATIONS (Continued)

RPD	Relative Percent Difference
SARA	Superfund Amendments and Reauthorization Act
SFMP	Surplus Facilities Management Program
SWMU	Solids Waste Management Unit
TBP	Tributyl Phosphate
TEM	Transmission Electron Microscopy
TLD	Thermoluminescent Dosimeter
TNT	Trinitrotoluene
TSCA	Toxic Substance Control Act
TSD	Treatment Storage or Disposal Facility
TWA	Time-Weighted Average
UNC	United Nuclear Corporation
USDA	United States Department of Agriculture
WSCP	Weldon Spring Chemical Plant
WSOW	Weldon Spring Ordnance Works
WSQ	Weldon Spring Quarry
WSRP	Weldon Spring Raffinate Pits
WSS	Weldon Spring Site
WSSRAP	Weldon Spring Site Remedial Action ProjectWSTA Weldon Spring Training Area
WSUFMP	Weldon Spring Uranium Feed Materials Plant
WSVP	Weldon Spring Vicinity Property

APPENDIX D
Quality Assurance

APPENDIX D
QUALITY ASSURANCE

The quality assurance (QA) program implemented in 1989 was greatly expanded from the previous year's program. In addition to increasing the number of field quality control blanks and duplicates collected, a data verification program was initiated to ensure that samples were preserved, shipped, maintained and analyzed in accordance with established procedures. The scope of this QA program includes all routine environmental and radiological characterization activities. The QA program is composed of two components: field and analytical QA evaluations.

The QA program for field activities included the following:

- Preparation of site-specific sampling plans and sampling procedures for collection of all environmental samples.

- Proper documentation of sample collection including sample collection forms, field logbooks, chain-of-custody records and quarterly summary sheets.

- Review of all sample tracking documentation and analytical results in accordance with the Environmental Monitoring Data Verification SOP 4.9.1.

- Collection of quality control (QC) blanks, trip blanks, and equipment blanks for characterization sampling.

- Annual audit of all field procedures with follow-up corrective programs, if required.

The analytical QA program for laboratory analyses used a number of different types of quality control samples to document the validity of the data generated. These samples included:

- Method Blanks (one per batch, each batch not to exceed 20 samples). Method blanks contain all the reagents used in the preparation and analysis of samples to assess contamination arising from reagents, glassware and other materials used in the analysis.

- Laboratory Control Samples/Spiked Blanks (LCS - one per batch, each batch not to exceed 20 samples). These samples were prepared by adding known quantities of compounds of interest to deionized water. They were used to establish that instruments and procedures were in control.

- Calibration Check Samples (as needed, or per method). Calibration standards were periodically used to verify that the original calibrations were still valid.

- Duplicate and Spiked Samples (5% duplicate; 5% spike). Duplicate samples were analyzed to enable an estimate of the precision of the analytical procedures. Spiked samples were measured to determine the accuracy of the analytical procedure and assess matrix effects. For analyses conducted according to the Contract Laboratory Program (CLP) methodology, these controls are termed matrix spike and matrix spike duplicate samples.

- Blind QC Samples (one per 20 samples). Blind QC samples were inserted into the sample load in a fashion unrecognizable to the laboratory. These samples were

used in addition to the standard duplicate sample analysis discussed above, to assess analytical precision.

- Interlaboratory Evaluation (annually). In order to assess comparability of data, sample splits were shipped to different laboratories to provide a measure of analytical or method bias.

The laboratories performing analyses maintained internal quality assurance programs that involved routine calibration of counting instruments, source and background counts, routine yield determinations for radiochemical procedures, and replicate analyses to check precision.

The specific monitoring activities included in the environmental monitoring program were measurements of radon concentration, air particulate analysis for radioactivity, and surface water and groundwater analyses for various organic, inorganic, and radioactive species. The quality assurance results for each monitoring activity, except radon, are discussed in the following text. Due to its unique measurement method, the radon quality assurance results are already included in Section 2.3 of this report.

Groundwater Quality Assurance

Field Evaluation

Field audits of all procedures associated with the collection of environmental samples were conducted during 1989. These audits were conducted by individuals from the Quality Assurance staff, who function independently from the field sampling team. All field personnel are trained and knowledgeable of the procedures used for sample collection. Standard Operating Procedures associated with the collection of environmental samples included:

- Groundwater sampling
- pH measurement in water
- Specific conductance measurement in water
- Water sample filtering
- Sampling equipment decontamination
- Sampling packaging for shipment
- Chain-of-custody

QA/QC audit reports of field procedures cited no findings of nonconformance, and no corrective action resulted.

Quality Assurance Field Blanks

Evaluation of equipment and water blanks were audited quarterly to assess field performance. Table D-1 shows the results from all equipment and water blanks taken during 1989. The equipment blanks were taken at locations which do not have dedicated well samplers in order to ensure that equipment decontamination procedures are effective in preventing contaminant carryover. The equipment blanks were designated as

TABLE D-1 QA Blank Analytical Results

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
QUARTER 2 SAMPLING RESULTS:											
GW-2022	ND	ND	ND	ND	0.03*	ND	ND	0.93	ND	13.40	ND
GW-2022-PB	ND	ND	ND	ND	0.06*	ND	ND	ND	ND	ND	ND
GW-2026	ND	ND	ND	ND	ND	ND	ND	1.40	ND	13.70	1.6(0.6)
GW-2026-FB	ND	ND	ND	ND	0.13*	0.14	ND	ND	ND	ND	ND
GW-3008	ND	0.06	ND	ND	ND	ND	ND	8.80	4010	43.60	5.9(1.4)
GW-3008-FB	ND	ND	ND	ND	0.31*	ND	ND	ND	ND	ND	ND
GW-3008-WB	ND	ND	ND	ND	0.06*	ND	ND	ND	ND	ND	ND
GW-4003	ND	ND	ND	ND	ND	ND	ND	6.40	3.20	28.50	1.7(0.7)
GW-4003-BB	ND	ND	ND	ND	0.43*	ND	ND	ND	ND	ND	ND
GW-4013	ND	ND	1.21	ND	44.80	0.80	ND	8.50	522.00	54.90	1.8(0.8)
GW-4113-WB	ND	ND	ND	ND	0.24*	ND	ND	ND	ND	ND	ND
GW-4017	ND	ND	ND	ND	0.05	ND	ND	1.90	2.00	10.20	2.1(0.9)
GW-4017-PB	ND	0.09	ND	ND	ND	ND	ND	ND	ND	ND	ND
QUARTER 3 SAMPLING RESULTS:											
GW-1013	-	-	-	-	-	-	ND	18.90	ND	124.00	890
GW-1013-WB	-	-	-	-	-	-	ND	ND	ND	ND	ND
GW-1027	-	-	-	-	-	-	-	-	-	-	910(100)
GW-1027-PB	-	-	-	-	-	-	-	-	-	-	ND
GW-4020	ND	ND	ND	ND	ND	ND	ND	9.70	ND	148.00	28(3)
GW-4020-PB	ND	ND	ND	ND	0.28*	ND	ND	ND	ND	ND	ND
GW-0000-WB	ND	ND	ND	0.29	ND	ND	ND	ND	ND	ND	ND

TABLE D-1 QA Blank Analytical Results (Continued)

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
QUARTER 4 SAMPLING RESULTS:											
GW-0000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.04
GW-1026	-	-	-	-	-	-	-	-	-	-	<0.68
GW-1026-PB	-	-	-	-	-	-	-	-	-	-	<0.68
GW-1026-PB	-	-	-	-	-	-	-	-	-	-	<0.68
GW-2019	ND	ND	ND	ND	ND	ND	0.260	2.2	ND	22.6	-
GW-2019-FB	ND	ND	ND	ND	ND	ND	ND	2.2	ND	ND	-
GW-4013	ND	ND	ND	ND	89	ND	0.070	8.5	361.0	43.2	<2.04
GW-4013-PB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16.32
GW-4021	-	-	-	-	-	-	-	-	-	-	9.52
GW-4021-PB	-	-	-	-	-	-	-	-	-	-	<0.68

FB-Distilled water blank taken in the field.
BB-Bailer blank.
PB-Pump blank.
WB-Distilled water blank taken from onsite lab.
*-Suspect due to method blank contamination.

either pump or bailer blanks based upon the method of sample collection utilized at that particular well. The equipment blanks were prepared by adding deionized water into the sampling pump and bailer after normal field decontamination. The deionized water was then transferred into the sample containers and analyzed. Since 1,3,5-trinitrobenzene (TNB) was present in method blanks as well as equipment and water blanks, it was dismissed as a laboratory contamination problem. The results from the pump blank taken at GW-4017 indicate possible carryover of low levels of 2,4-dinitrotoluene (DNT); however since the sample taken at GW-4017 does not contain 2,4-DNT this result is questionable. None of the equipment blanks indicated inorganic anion contamination. The equipment blanks in general indicate that decontamination methods are every effective in preventing contaminant carryover.

Water blanks and field blanks were the two types of deionized water blanks taken in 1989. The samples designated as water blanks were deionized water taken from the on-site laboratory supply. The water blanks were generally clean for all parameters except 1,3,5-TNB which, as previously explained, was also in the method blank. One water blank taken in the third quarter contained trace levels of nitrobenzene; however since the result is lower than the USATHAMA detection limit it is suspect. Field blanks were deionized water blanks taken while out in the field to evaluate the possible introduction of contaminants during field activities. One field blank contained 1,3-dinitrobenzene (DNB), once again at levels lower than the USATHAMA detection limit making this result questionable. All other field blanks were generally clean. A total of 17 equipment and water blanks were analyzed during 1989 and contamination as a result of field activities was not indicated.

Analytical Quality Assurance

Expanded data verification and validation programs were initiated in 1989 to ensure that all analytical results were precise, accurate, representative, complete, and comparable to the historical database. Data verification is a preliminary review of sampling documentation and analytical results performed on 100% of the samples in accordance with Environmental Monitoring Data Verification SOP 4.9.1. Data validation is a much more comprehensive review and analysis of laboratory results and documentation.

The number of duplicate samples taken in 1989 was double that taken from the previous year. The results of duplicate analyses are presented in Table D-2. Generally good agreement exists between duplicate samples. Relative percent difference (RPD) between duplicates was calculated and appeared to be within acceptable analytical intervals for precision. As expected, variance between laboratories was observed for 1,3,5-TNB due to laboratory contamination of the primary lab. There are also slight variances in nitrate values between labs. These variances appear to be related to differing methodologies employed for nitrate analysis.

Radiological Air Particulate Quality Assurance

After an initial gross alpha analysis was performed on the samples (filters), quality control (QC) measurements were obtained through subsequent gross alpha analysis without changing any of the analytical parameters. There were 51 QC measurements obtained; approximately 6% of the total samples were analyzed twice. The precision of the gross alpha measurements were determined by comparing the original gross alpha analysis to the

TABLE D-2 QC Blind Duplicate Analytical Results

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
Average relative percent difference:							12%	27%	56%	19%	
QUARTER 1 SAMPLING RESULTS:											
GW-RMW1	-	-	-	-	-	-	-	-	-	-	ND
GW-RMW1-DU1	-	-	-	-	-	-	-	-	-	-	ND
GW-RMW1-DU2	-	-	-	-	-	-	-	-	-	-	0.68
GW-1015	2.45	ND	ND	ND	11.82	ND	-	-	-	-	210(20)
GW-1015-DU	2.40	0.40	ND	ND	10.25	ND	-	-	-	-	160(20)
GW-1023	-	-	-	-	-	-	-	-	-	-	ND
GW-1023-DU1	-	-	-	-	-	-	-	-	-	-	ND
GW-1023-DU2	-	-	-	-	-	-	-	-	-	-	0.68
GW-2019	ND	ND	ND	ND	ND	ND	ND	1.6	ND	18.7	2.7(1.1)
GW-2019-DU1	ND	ND	ND	ND	ND	ND	ND	1.4	ND	17.9	4.9(1.4)
GW-2021	-	-	-	-	-	-	ND	1.20	ND	13.50	2.8(0.8)
GW-2021-DU1	-	-	-	-	-	-	0.140	ND	ND	12	-
GW-2021-DU2	-	-	-	-	-	-	-	-	-	-	4.08
GW-2026	ND	ND	ND	ND	ND	ND	-	-	-	-	1.6(0.5)
GW-2026-DU	ND	ND	ND	ND	ND	ND	-	-	-	-	-
GW-2029	-	-	-	-	-	-	-	-	-	-	1.3(0.8)
GW-2029-DU	-	-	-	-	-	-	-	-	-	-	<0.68
GW-3001	ND	0.42	ND	ND	0.17	ND	ND	8.40	10.50	23.30	2.6(0.7)
GW-3001-DU1	ND	0.53	ND	ND	0.07	ND	ND	8.10	9.70	23.70	3.1(0.8)
GW-3001-DU2	-	-	-	-	-	-	-	-	-	-	3.4
GW-3001-DU3	ND	ND	ND	ND	ND	ND	-	-	-	-	-
GW-4003	ND	ND	ND	ND	ND	ND	ND	6.50	3.30	29.90	ND
GW-4003-DU	ND	ND	ND	ND	ND	ND	ND	6.50	3.30	29.90	ND
GW-4008	-	-	-	-	-	-	-	-	-	-	2.8(0.7)
GW-4008-DU	-	-	-	-	-	-	-	-	-	-	5.44

TABLE D-2 QC Blind Duplicate Analytical Results (Continued)

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
Average relative percent difference:							12%	27%	56%	19%	
QUARTER 1 SAMPLING RESULTS: (Continued)											
GW-4016	-	-	-	-	-	-	ND	4.20	ND	19.70	-
GW-4016-DU	ND	ND	ND	ND	ND	ND	0.240	ND	ND	8	-
GW-4022	ND	ND	ND	ND	ND	ND	ND	16.2	3.00	67.90	2.1(0.7)
GW-4022-DU	ND	ND	ND	ND	ND	ND	ND	16.5	2.60	64.80	2.8(1.0)
QUARTER 2 SAMPLING RESULTS:											
GW-1006	ND	ND	3.24	0.71	ND	ND	ND	31.60	9.30	441.00	2400(300)
GW-1006-DU1	25.20	0.19	2.36	ND	105.74	ND	ND	33.00	9.30	447.00	3500(400)
GW-1006-DU3	ND	ND	ND	ND	18	ND	0.200	41	1.77	495	-
GW-1006-DU2	-	-	-	-	-	-	-	-	-	-	2992
GW-1007	-	-	-	-	-	-	-	-	-	-	510(60)
GW-1007-DU	-	-	-	-	-	-	-	-	-	-	38.08
GW-1015	4.81	ND	ND	ND	38.42	ND	ND	14.0	9.8	219	490(50)
GW-1015-DU1	ND	ND	ND	ND	ND	ND	0.300	18	2.01	168	-
GW-1015-DU2	-	-	-	-	-	-	-	-	-	-	360.4
GW-1017	ND	ND	ND	ND	ND	ND	ND	19.30	0.40	ND	ND
GW-1017-DU	ND	ND	ND	ND	0.37	ND	ND	13.90	ND	ND	ND
GW-2002	ND	ND	0.47	ND	0.03	ND	ND	7.10	1010	95	ND
GW-2002-DU	ND	ND	ND	ND	ND	ND	ND	9	182	80	-
GW-2006	ND	ND	1.60	ND	9.62	ND	ND	278	28.70	32.40	ND
GW-2006-DU1	ND	ND	1.66	ND	9.75	ND	ND	277	27.90	31.90	1.3(0.6)
GW-2006-DU2	ND	ND	ND	ND	ND	ND	ND	256	6.2	30	-
GW-2006-DU3	-	-	-	-	-	-	-	-	-	-	<0.68
GW-2013	2.29	2.47	7.83	ND	5.48	ND	ND	4.60	3.20	11.90	1.0(0.5)
GW-2013-DU	0.60	1.03	2.88	ND	0.43	ND	ND	4.50	3.20	11.80	2.9(0.9)

TABLE D-2 QC Blind Duplicate Analytical Results (Continued)

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
Average relative percent difference:							12%	27%	56%	19%	
QUARTER 2 SAMPLING RESULTS: (Continued)											
GW-2021	-	-	-	-	-	-	-	-	-	-	3.0(0.8)
GW-2021-DU	-	-	-	-	-	-	-	-	-	-	4.08
GW-3001	-	-	-	-	-	-	-	-	-	-	ND
GW-3001-DU	-	-	-	-	-	-	-	-	-	-	3.4
GW-3002	-	-	-	-	-	-	-	-	-	-	7.8(1.3)
GW-3002-DU	-	-	-	-	-	-	-	-	-	-	2.04
GW-3009	-	-	-	-	-	-	-	-	-	-	50(5)
GW-3009-DU	-	-	-	-	-	-	-	-	-	-	58.48
GW-4008	-	-	-	-	-	-	-	-	-	-	1.9(0.7)
GW-4008-DU	-	-	-	-	-	-	-	-	-	-	5.44
GW-4010	ND	ND	ND	ND	ND	ND	ND	3.7	1.00	42.70	5.4(1.3)
GW-4010-DU1	ND	ND	ND	ND	ND	ND	ND	4.0	1.00	43.30	4.1(1.2)
GW-4010-DU2	ND	ND	ND	ND	ND	ND	0.220	4	0.1	37	-
GW-4013	ND	ND	1.21	ND	44.80	0.80	ND	8.5	522.00	ND	1.8(0.8)
GW-4013-DU	ND	ND	ND	ND	0.24	ND	ND	ND	ND	ND	ND
GW-4015	ND	ND	2.04	0.42	0.12	ND	ND	5.70	22.40	11.50	1.6(0.8)
GW-4015-DU	ND	ND	ND	ND	ND	ND	0.130	ND	1.64	7	-
GW-4022	ND	ND	ND	ND	ND	ND	ND	13.0	2.00	70.90	4.2(1.1)
GW-4022-DU1	ND	ND	ND	ND	ND	ND	ND	12.9	2.00	70.90	3.9(1.0)
GW-4022-DU2	ND	ND	ND	ND	ND	ND	0.290	15	0.3	63	-
GW-4022-DU3	-	-	-	-	-	-	-	-	-	-	<0.68
QUARTER 3 SAMPLING RESULTS:											
GW-RMW4	ND	ND	ND	ND	ND	ND	ND	11.50	0.65	11.50	1.6(0.9)
GW-RMW4-DU	ND	ND	ND	ND	ND	ND	ND	11.40	0.19	11.60	1.6(0.8)

TABLE D-2 QC Blind Duplicate Analytical Results (Continued)

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
Average relative percent difference:							12%	27%	56%	19%	
QUARTER 3 SAMPLING RESULTS: (Continued)											
GW-1014	-	-	-	-	-	-	ND	19.20	ND	125.00	880(90)
GW-1014-DU1	-	-	-	-	-	-	ND	19.10	ND	125.00	1000(100)
GW-1014-DU2	-	-	-	-	-	-	0.351	21.5	ND	129	-
GW-1017	-	-	-	-	-	-	-	-	-	-	ND
GW-1017-DU	-	-	-	-	-	-	-	-	-	-	<0.68
GW-2019	ND	ND	ND	ND	0.07	ND	ND	1.50	ND	17.9	2.6(0.8)
GW-2019-DU	ND	ND	ND	ND	ND	ND	0.202	1.50	ND	85	-
GW-2023	ND	ND	ND	ND	ND	ND	ND	1.20	0.40	25.20	3.0(0.8)
GW-2023-DU	ND	ND	ND	ND	ND	ND	ND	1.20	0.40	25.20	1.7(0.7)
GW-2028	ND	ND	ND	ND	ND	ND	ND	1.80	ND	108	-
GW-2028-DU	ND	ND	ND	ND	ND	ND	0.194	1.8	ND	114	-
GW-3003	ND	ND	ND	ND	ND	ND	ND	8.70	1885	153.00	-
GW-3003-DU	ND	ND	ND	ND	ND	ND	0.194	16.3	436	144	-
GW-4003	ND	ND	ND	ND	ND	ND	ND	6.00	3.10	32.00	-
GW-4003-DU	ND	ND	ND	ND	ND	ND	0.228	6.8	0.65	33	-
GW-4011	ND	ND	ND	ND	ND	ND	ND	5.90	133	52.4	2.9(1.4)
GW-4011-DU	ND	ND	ND	ND	ND	ND	ND	5.70	133	51.7	5.9(1.8)
GW-4013	ND	ND	0.68	ND	32.81	ND	ND	7.20	456	51.00	-
GW-4013-DU	ND	ND	ND	ND	76	ND	0.089	6.8	63.2	40	-
GW-4014	-	-	-	-	-	-	-	-	-	-	ND
GW-4014-DU	-	-	-	-	-	-	-	-	-	-	0.68
GW-4018	ND	ND	ND	ND	0.13	ND	ND	9.60	9.70	8.20	1.3(0.6)
GW-4018-DU	ND	ND	ND	ND	ND	ND	ND	9.60	9.80	8.00	1.0(0.6)

TABLE D-2 QC Blind Duplicate Analytical Results (Continued)

SAMPLE ID	2,4,6-TNT (ug/l)	2,4-DNT (ug/l)	2,6-DNT (ug/l)	Nitro-benzene (ug/l)	1,3,5-Trinitro-benzene (ug/l)	1,3-Dinitro-benzene (ug/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Nat. Uranium Total (pCi/L)
Detection Limits:	0.50	0.20	0.60	0.60	0.03	0.40	0.25	0.25	0.10	1.00	-
Average relative percent difference:							12%	27%	56%	19%	
QUARTER 4 SAMPLING RESULTS:											
GW-RMW2	-	-	-	-	-	-	-	-	-	-	3.4
GW-RMWX-DU	-	-	-	-	-	-	-	-	-	-	4.76
GW-1013	-	-	-	-	-	-	ND	18.90	ND	124.00	-
GW-1013-DU	-	-	-	-	-	-	0.439	20.7	0.05	120	-
GW-1016	-	-	-	-	-	-	-	-	-	-	163.2
GW-1016-DU	-	-	-	-	-	-	-	-	-	-	190.0
GW-1026	-	-	-	-	-	-	-	-	-	-	<0.68
GW-1026-DU	-	-	-	-	-	-	-	-	-	-	<0.68
GW-2025	ND	ND	ND	ND	ND	ND	0.250	1.2	ND	16.1	1.36
GW-2025-DU	ND	ND	ND	ND	ND	ND	0.202	1.2	ND	15.4	<0.68
GW-2027	ND	ND	ND	ND	ND	ND	0.167	1.3	ND	10.5	0.68
GW-2027-DU	ND	ND	ND	ND	ND	ND	0.174	1.2	ND	14.1	0.68
GW-3003	ND	ND	ND	ND	ND	ND	0.219	14.0	312,000	173.0	9.52
GW-3003-DU	ND	ND	ND	ND	ND	ND	0.219	16.8	112,000	157.0	10.2
GW-3006	ND	ND	ND	ND	ND	ND	0.258	3.4	188.0	43.2	2.72
GW-3006-DU	ND	ND	ND	ND	ND	ND	0.210	3.8	0.2	35.1	<0.68
GW-4009	-	-	-	-	-	-	-	-	-	-	3.4
GW-4009-DU	-	-	-	-	-	-	-	-	-	-	2.04
GW-4012	ND	ND	ND	ND	ND	ND	0.304	3.4	ND	39.9	2.04
GW-4012-DU	ND	ND	ND	ND	ND	ND	0.304	3.4	ND	33.0	5.44
GW-4016	ND	ND	ND	ND	ND	ND	0.190	3.8	ND	11.6	5.44
GW-4016-DU	ND	ND	ND	ND	ND	ND	0.210	3.7	ND	10.8	4.76
GW-4020	ND	ND	ND	ND	ND	ND	0.219	6.2	ND	121.0	14.28
GW-4020-DU	ND	ND	ND	ND	ND	ND	0.219	5.9	ND	121.0	14.96

QC analysis. The standard deviation of the initial results and the QC result was calculated and then divided by the average of the two measurements to obtain the precision of each measurement. The average precision of this sample group was calculated to be 16.6% ± 2.5% at a 90% confidence level.

External Gamma Monitoring Quality Assurance

During each calendar quarter the radiation levels at two gamma monitoring stations were measured with duplicate thermoluminescent dosimeters, allowing an assessment of the precision of the external gamma measurements.

The field duplicate results for 1989 are summarized per station and per quarter in Table D-3. All second quarter measurement results, including the control and background TLDs, had results four times higher than typical quarterly results. This was probably caused by the shipment being x-rayed during transit. For this reason the second quarter results were disregarded. Overall, the duplicate dosimeters are consistent with the primary detectors, indicating good precision.

TABLE D-3 External Gamma Monitoring Quality Assurance - Duplicate and Control Results

Location Number	Results mrem/Quarter
1ST QUARTER	
Control	12.22
TD-1005	22.62
TD-1005 - Duplicate	19.89
2ND QUARTER	
Control *	77.61
3RD QUARTER	
Control	6.89
TD-1004	14.95
TD-1004 - Duplicate	15.60
4TH QUARTER	
Control	10.01
TD-1005	20.67
TD-1005 - Duplicate	20.15
TD-3001	20.02
TD-3001 - Duplicate	17.81

* All 2nd Quarter badges exposed during transportation

APPENDIX E
Standards for Protection of the Public in the Vicinity of DOE Facilities

APPENDIX E

STANDARDS FOR PROTECTION OF THE PUBLIC IN THE VICINITY OF DOE FACILITIES

RADIATION STANDARDS

A. DOSE LIMITS

1. All Pathways

The effective dose equivalent for any member of the public from all routine DOE operations[1] (natural 2background and medical exposures excluded) shall not exceed the values given below:

	Effective dose equivalents[2] mrem/year	(mSv/year)
Occasional annual exposures	500	(5)
Prolonged period of exposures[3]	100	(1)

No individual organ shall receive an annual dose equivalent in excess of 5 rem/year (50 mSv/year).

2. Air Pathway Only (Limits of 40 CFR 61, Subpart H)

	Dose Equivalent mrem/year	(mSv/year)
Whole body dose	25	(.25)
Any organ	75	(.75)

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.

3. For the purposes of these standards, a prolonged exposure will be one that lasts, or is predicted to last, longer than 5 years.

B. DERIVED CONCENTRATION GUIDES (DCG)

The following table contains a listing of the DCG values for the ingestion of drinking water and inhalation of air for members of the public. The values are based on an annual dose equivalent rate of 100 mrem/yr. Five columns of information are shown in the table: 1) radionuclide; 2) drinking water ingestion DCG in units of µCi/ml; 3) drinking water DCG in units of Bq/ml; 4) inhalation DCG in units of µCi/ml; 5) inhalation DCG in units of Bq/mL.

Only a single mode of exposure was considered--either ingestion or inhalation.

The DCG values are given for individual radionuclides. For known mixtures of radionuclides, the sum of the ratio of the observed concentration of a particular radionuclide and its corresponding DCG for all radionuclides in the mixture must not exceed 1.0.

It should be noted that the values given in the table only account for drinking water and inhaling air, and do not include other potentially significant environmental pathways. A more complete pathway analysis is required for calculating public radiation dose equivalent resulting from the operation of DOE facilities when more complex environmental pathways are involved.

	Drinking Water		Inhaled Air	
Radionuclide	µCi/mL	Bq/mL	µCi/mL	Bq/mL
Uranium-238	6.0E-07	2.2E-02	1.0E-13	3.07-09
Uranium-235	6.0E-07	2.2E-02	1.0E-13	3.7E-09
Uranium-234	5.0E-07	1.9E-02	9.0E-14	3.3E-09
Thorium-232	5.0E-08	1.9E-03	7.0E-15	2.6E-10
Thorium-230	3.0E-07	1.1E-02	4.0E-14	1.5E-09
Radium-228	1.0E-07	3.7E-03	3.0E-12	1.1E-07
Radium-226	1.0E-07	3.7E-03	1.0E-12	3.7E-08

C. RADON

Above-background radon-222 concentrations in the atmosphere at or above any location outside the facility site shall not exceed an annual average concentration of 3 pCi/L (DOE Order 5480.1A, Attachment XI-1).

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	Lithium	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

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

APPENDIX F
Conversion Factors

CONVERSION FACTORS

1 millisievert (mSv)	=	100 mrem
1 milliroentgen (mR)	=	1 mrem (for gamma radiation)
1 Curie (Ci)	=	3.7×10^{10}dps (disintegration/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 cy
1 mm	=	.039 inches
1 ha	=	2.47 acres

APPENDIX G
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