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SUPERCEDED

ANNUAL ENVIRONMENTAL MONITORING REPORT WELDON SPRING, MISSOURI

Calendar Year 1986

Weldon Spring Site Remedial Action Project

WSSRAP

WELDON SPRING SITE

ANNUAL ENVIRONMENTAL MONITORING REPORT

CALENDAR YEAR 1986

Prepared for:

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WELDON SPRING SITE ANNUAL ENVIRONMENTAL MONITORING REPORT

WELDON SPRING, MISSOURI

CALENDAR YEAR 1987

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ABSTRACT

This report represents a summary of the environmental monitoring activities conducted during 1986 in and around the Weldon Spring Site (WSS), a U.S. Department of Energy (DOE) surplus facility located in St. Charles County, Missouri. The WSS is part of the Surplus Facilities Management Program, a DOE program to plan and manage the final disposition of retired DOE-owned facilities. The WSS comprises two (2) physically separate areas: the 89.5-hectare (221-acre) Weldon Spring Chemical Plant (WSCP) and Weldon Spring Raffinate Pits (WSRP) area, and the 3.6-hectare (9-acre) Weldon Spring Quarry (WSQ) area.

The WSRP and WSQ areas are presently used for the interim storage of radioactively contaminated waste materials. The WSCP was transferred to the DOE from the Department of the Army (DA) on October 1, 1985. Records of routine environmental monitoring by the DA during previous years are unavailable. During 1986, additional groundwater monitoring wells were installed and surface water sampling locations added on and around the WSCP. Routine sampling of these wells did not begin until the first quarter of 1987.

The WSS was formerly used for the processing of radioactive materials. Radioactivity, above current applicable limits for areas of unrestricted use, exists at the site, and elevated levels of radiation will be present until remedial action is completed. Detailed explanations regarding radiation levels measured in 1986 can be found in the summary in Section 2.0 and the related activities and special studies described in Section 3.0.

The monitoring program at the WSS during 1986 measured uranium, radium-226, and thorium-230 concentrations in surface water, groundwater, and sediment; radon gas concentrations in air; and external gamma radiation exposure rates. Potential radiation

doses to the public were also calculated, based on assumed exposure periods and the above measurements. Radon concentrations, external gamma exposure rates, and radionuclide concentrations in groundwater and surface water at the site were generally equivalent to previous years' levels. Other than radon gas monitoring, no airborne radioactivity measurements were made.

The maximum calculated annual radiation dose to a hypothetically exposed individual at the WSRP and WSCP area was 3 mrem, or 3 percent of the DOE radiation protection standard. The calculated annual maximum radiation dose to a hypothetically exposed individual at the WSQ was 0.5 mrem, or less than 1 percent of the DOE radiation protection standard of 100 mrem. Therefore, based on the data and dose calculations, the site currently complies with DOE Offsite Dose Standards.

1.0 INTRODUCTION

This report presents the findings of the environmental monitoring conducted at the Weldon Spring Site (WSS) during calendar year 1986. Annual environmental monitoring reports have been prepared for this site since 1981. The WSS is part of the Department of Energy (DOE) Surplus Facilities Management Program (SFMP), one of two remedial action programs under the direction of the DOE Division of Facility and Site Decommissioning Projects. The WSS comprises the Weldon Spring Raffinate Pits (WSRP), the Weldon Spring Chemical Plant (WSCP), and the Weldon Spring Quarry (WSQ). These areas encompass 21.1, 68.4, and 3.6 hectare (ha) (52, 169, and 9 acres) respectively. The WSRP and WSCP areas are contiguous. The WSQ is approximately 6.4 km (4 miles) to the south-southwest.

When custody for 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 - 5/14/85). 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 to the extent possible.

During the years 1981 to 1985, the WSRP and WSQ were under caretaker status by the DOE. The WSCP was controlled by the DA. The environmental monitoring programs during those years were performed to determine changes (if any) in the radiological levels in and around the WSRP and WSQ. Quarterly environmental monitoring data was not collected by DA in and around the WSCP. With the transfer of the WSCP 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 and WSRP as well as the WSQ. Six monitoring wells were installed in the WSQ area. In and around the WSCP, 19 new wells were sited and installed where no previous monitoring wells existed. These well installations were completed in late 1986. In addition, fugitive dust samplers around the WSS perimeter and at nearby locations were installed in late 1986. A more complete description of the much expanded WSS Environmental Monitoring Program for 1987 is provided in Section 5.0 of this report.

This 1986 Environmental Monitoring Report presents the results from essentially the same groundwater monitoring locations as in previous years. However, some expanded surface water monitoring data is available (Section 2.2). In addition, a number of related activities and special studies were conducted at the WSS during 1986 which are directly applicable to environmental monitoring. The results of these activities are discussed in Section 3.0.

In 1984, a radiological characterization of the WSQ was completed. Along with the radiological data, selected samples were analyzed for a variety of chemical species as well. These data became available in late 1985 and early 1986. The results led to a much more comprehensive second characterization of the material in the WSQ. This second characterization effort emphasized chemical determinations. The results of the second study became available in March, 1987. Sections 3.1 and 3.2 discuss these chemical characterization efforts at the WSQ.

Also performed in 1986 was a sampling effort to chemically characterize the sludge material in the raffinate pits at the WSRP area. These results are discussed in Section 3.3.

Several agencies outside the DOE were also involved in sampling at the WSS during 1986. The U.S. Geological Survey (USGS) performed limited sampling around the WSRP and the WSQ areas. The Missouri Department of Natural Resources (MODNR) collected samples from both the WSQ and WSRP. The results of these studies are discussed in Section 3.4.

Based on the sampling results from 1986, Section 4.0 of this report presents calculations of the maximum radiation dose to hypothetically exposed individuals at the WSCP/WSRP and WSQ areas. The occupancy factors and exposure assumptions between the two physical locations results in different calculated doses. In addition, the doses to the population at large in the vicinity of the WSS are also calculated.

The sections which follow provide background on the history of the site, its environmental setting and the results from previous years' monitoring. Appendix A presents a discussion of the Environmental Guidelines to which results in this report are compared. For a definition of most of the technical terms used in this report, the lay reader is urged to consult Appendix B. Appendix C contains a description of some of the quality assurance methods applied to sampling and analysis performed for this monitoring effort.

1.1 LOCATION AND DESCRIPTION

The WSS is located in St. Charles County, Missouri, about 48 km (30 miles) west of St. Louis. The WSRP and WSCP areas are accessed from Missouri State Route 94, approximately 3.2 km (2 miles) southwest of the junction of Route 94 and U.S. Route 40/61. The WSQ is accessed from Route 94, approximately 6.4 km (4 miles) south-southwest of the WSRP and WSCP areas. The Missouri River is located approximately 2.4 km (1.5 miles) southeast of the WSRP and WSCP areas and 1.6 km (1 mile) east of the WSQ. The Mississippi River lies approximately 22.4 km (14 miles) northeast of the WSRP and WSCP areas and roughly 28.8 km (18 miles) northeast of the WSQ. The general location of these properties is illustrated in Figure 1-1.

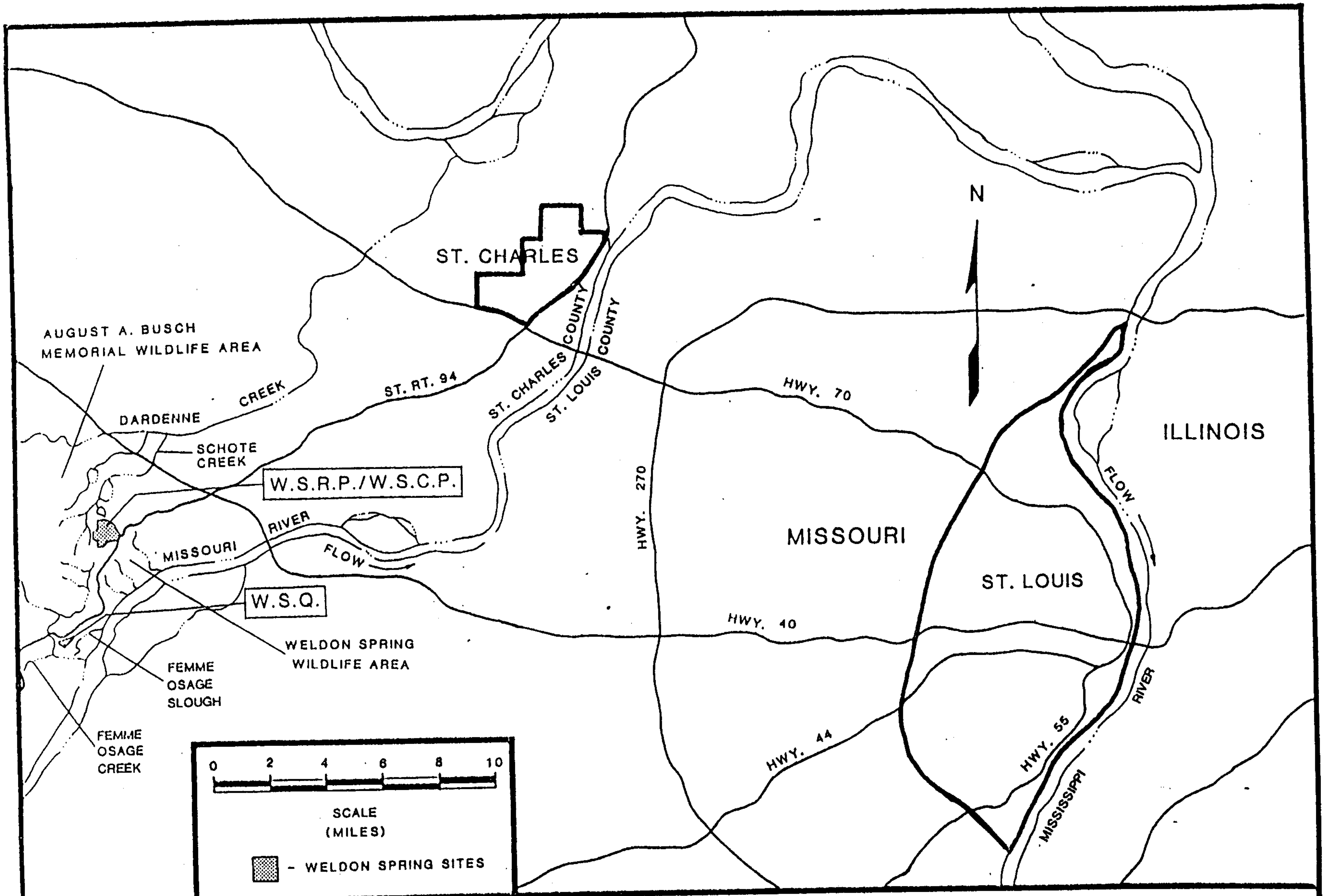

FIGURE 1-1

MAP OF THE W.S.S. AREA.

The WSS is used for the storage of uranium and thorium residues, waste materials, and contaminated rubble. In addition to environmental monitoring, engineering activities are being conducted to minimize the migration of contaminants from these facilities into surface water and groundwater.

Characterization activities have been conducted at the WSRP and WSQ, and are in progress at the WSCP, to provide information on the types and magnitude of contamination present. This information will be used in evaluating the course of remedial actions to be conducted at the site. Brief descriptions of each of the areas 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 foreground. The 21.1-ha (52-acre) WSRP area includes four pits that cover approximately 10.5-ha (26-acres) (see Figure 1-3). These pits contain radioactive residues (called raffinates) from uranium and thorium processing operations at the former Weldon Spring Feed Materials Plant (now the WSCP). The surface area, volume, and preliminary estimates of the contents of the pits are summarized in Table 1-1. Section 3.2 discusses the pit contents based on 1986 sampling in greater detail.

Access to the area is controlled by a 2.1-m (7-ft.) high fence that encloses the DOE property. Each pit is enclosed by a fence at least 4 feet in height. The pit drains and all transfer lines from the pits to the WSCP storm sewer have been sealed (NLO, 1981). Water covers the residues in the pits. In past summers, however, the water in Pits 1 and 2 has evaporated, leaving the exposed residue surface dry and cracked. The water levels in Pits 3 and 4 fluctuate, but surface water is always present.

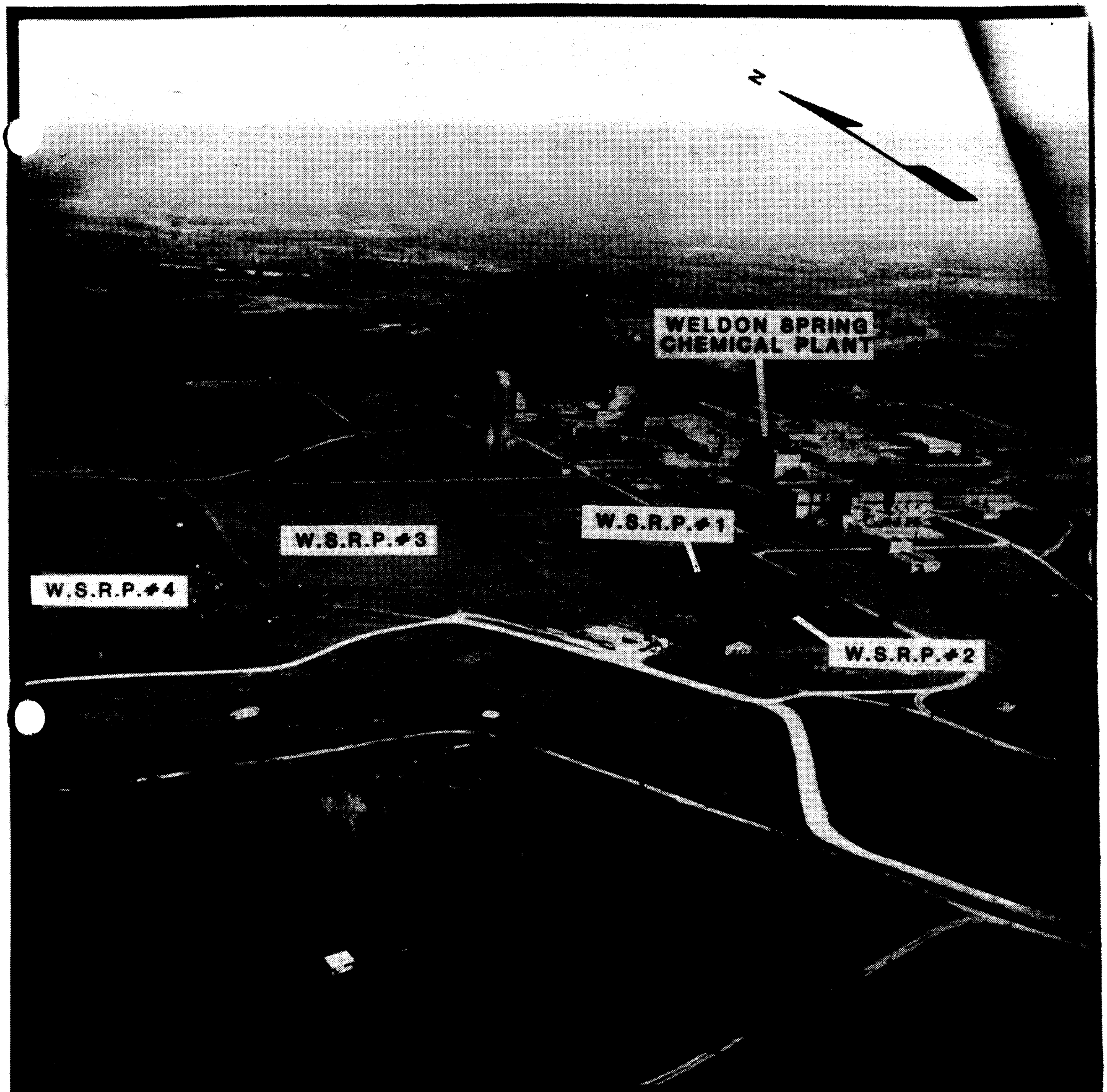

FIGURE 1-2

AERIAL VIEW OF THE W.S.R.P. AND W.S.C.P..

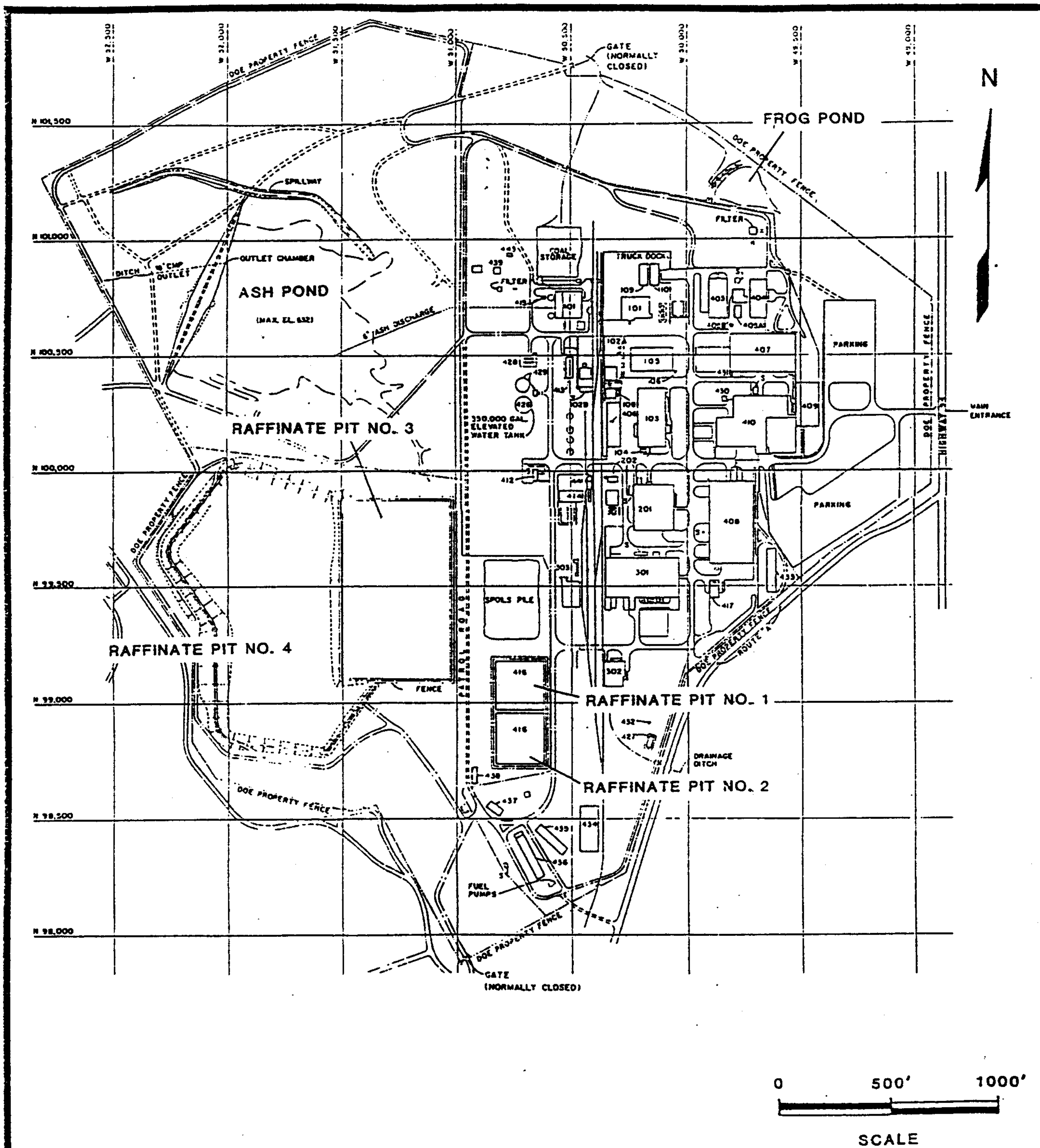

FIGURE 1-3

MAP OF THE W.S.R.P./W.S.C.P..

TABLE 1-1

CHARACTERISTICS OF THE FOUR RAFFINATE PITS AND

ACTIVITY LEVELS OF MAJOR RADIONUCLIDES

IN THE CURRENTLY STORED MATERIALS

Characteristic	Pit 1	Pit 2	Pit 3	Pit 4
Year Constructed	1958	1958	1959	1964
Surface Area, ha (acres)	0.5 (1.2)	0.5 (1.2)	3.4 (8.4)	6.1 (15.0)
Pit Volume, m^3 cubic yards	14,060 (18,500)	14,060 (18,500)	126,692 (166,700)	337,744 (444,400)
Waste Volume, m^3 cubic yards	13,224 (17,400)	13,224 (17,400)	98,496 (129,600)	42,256 (55,600)
Radionuclide	**Activity (pCi/g)**			
Uranium-238	710	470	520	620
Uranium-234	810	560	570	610
Thorium-232	100	120	120	120
Thorium-230	24,000	24,000	14,000	1,600
Radium-228	850	200	100	60
Radium-226	430	440	460	11

Source: M-K Ferguson Conceptual Design Report, 1987.

Weldon Spring Chemical Plant

The 68.4-ha (169-acre) WSCP is located immediately east of the WSRP area (Figure 1-3). The WSCP, which operated as the Weldon Spring Feed Materials Plant until 1966, comprises 13 major buildings and approximately 30 smaller buildings. Of the former, five were used as process buildings, and eight were major support buildings. The entire site is fenced. Access is controlled at a manned gate-house and site security is presently maintained by 24-hour guards routinely patrolling the site.

Weldon Spring Quarry

The WSQ, an abandoned, 3.6-ha (9-acre) limestone quarry, is located approximately 6.4 km (4 miles) 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. A gravel road enters the site from Route 94 at the quarry floor, and a short dirt road provides access to the security gate at the upper level. An unused railroad spur enters the site at the lower level and extends approximately one-third the length of the WSQ. The WSQ is essentially a closed basin; surface water within the rim flows to the quarry floor and into a sump pond, which covers approximately 0.2-ha (0.5 acre). The pond contains approximately 12 million liters (3 million gallons) of water and is up to 6.1 m (20 feet) deep. The amount of water in the pond varies according to seasonal variations in precipitation and temperature.

The only structures on the site are a small storage shed and a sampling platform in the sump area. Access to the site is restricted by a locked, 2.1-m (7-ft) high chain-link fence topped by three strands of barbed wire; the fence completely surrounds the DOE property. The amounts and types of known wastes in the WSQ are summarized in Table 1-2.

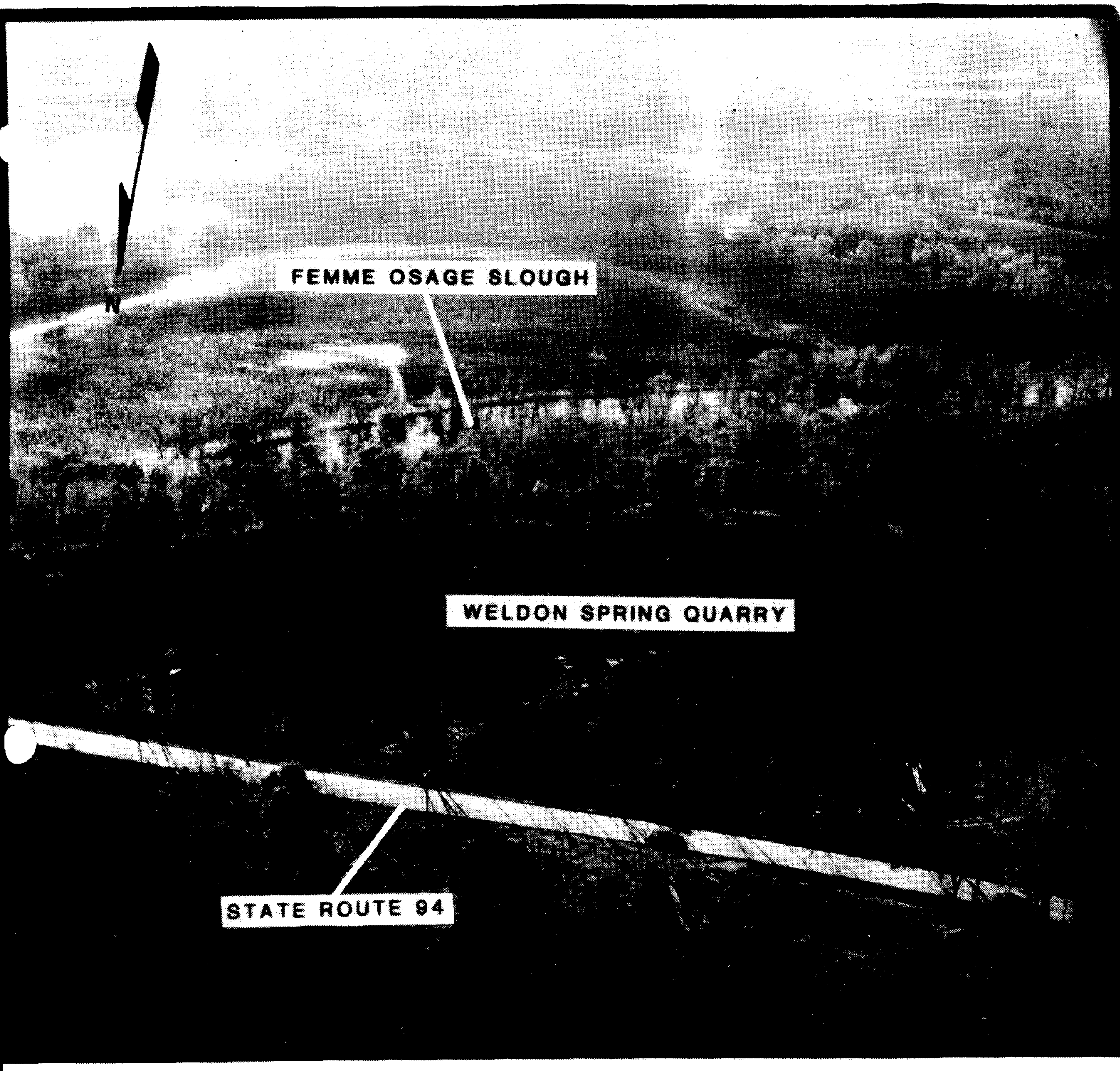

FIGURE 1-4

AERIAL VIEW OF THE W.S.Q..

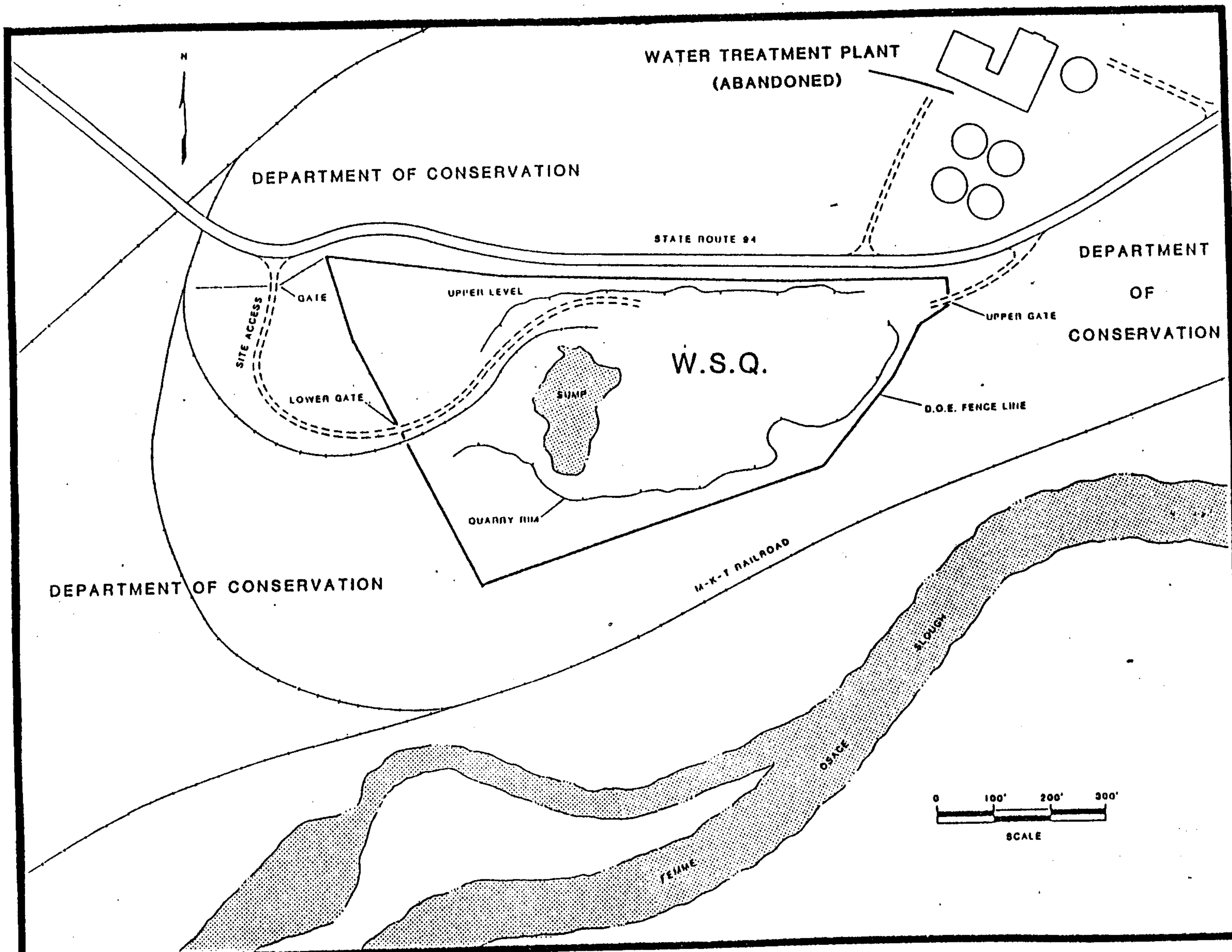

FIGURE 1-5

MAP OF THE W.S.Q..

TABLE 1-2

ESTIMATED VOLUMES OF RADIOACTIVE WASTES STORED IN THE WSQ

Type of Waste	Date Deposited	Volume cubic meters (cubic yards)	Comments
3.8 Percent Thorium Residues	1959	140.1 (185)	Drummed residues; volume estimated; most of the residues under water; principal source of radioactivity is Thorium-232 decay series.
Destrehan St. Plant Demolition Rubble	1963-1964	38,000 (50,000)	Contaminated equipment, building rubble; estimate of uranium & thorium content not available; principal source of radioactivity is Uranium-238 decay series.
3 Percent Thorium Residues	1966	422 (555)	Drummed residues; volume estimated; stored above water level; principal source of radioactivity is Thorium-232 decay series.
Weldon Spring Feed Materials Plant Rubble	1968-1969	4,222 (5,555)	Contaminated equipment, building rubble; uranium and thorium content and radioactivity not available; principal sources of radioactivity are Uranium-238 & Thorium-232 decay series.
	TOTALS	42,784 (56,295)	

Source: (NLO, 1981).

1.2 SITE HISTORY

In 1956, the Atomic Energy Commission (AEC) acquired approximately 89.1 ha (220 acres) of the original Weldon Spring Ordnance Works from the DA for use as a uranium feed material plant. The plant was operated as an integrated facility for the conversion of uranium ore concentrates to pure uranium trioxide, intermediate compounds, and uranium metal. A relatively small amount of thorium was also processed. Wastes generated during these operations were stored in the four raffinate pits in the WSRP area. The feed materials plant ceased operations in 1966.

In 1958, the AEC acquired title to the WSQ from the DA. The WSQ had been used earlier by the DA for disposal of trinitrotoluene (TNT) contaminated rubble during the operation of the Weldon Spring Ordnance Works. 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 1963 and 1964, approximately 38,000 cubic meters (50,000 cubic yards) of contaminated materials from the St. Louis facility were deposited in the WSQ (See Table 1-1) (NLO, 1977).

Following the shutdown of the feed materials plant in 1966, the AEC returned the facility to the DA in 1967 for planned use as a defoliant production plant (to be known as the Weldon Spring Chemical Plant). The Army started removing equipment and decontaminating the buildings in 1968. Approximately 4,220 cubic meters (5,555 cubic yards) of contaminated material were hauled to the WSQ. In addition, an undetermined amount of contaminated piping, ducting, drums, and other scrap were dumped into Pit 4 at the WSRP.

The defoliant project was cancelled in 1969 before any process equipment was installed for herbicide production. The DA retained the responsibility for the land and the facilities at the WSCP, but the 21.1-ha (52-acre) tract encompassing the raffinate pits was transferred back to the AEC. The 3.6-ha (9-acre) WSQ also remained under the control of the AEC. The AEC contracted with National Lead Company of Ohio (NLO) to periodically visit the WSRP and WSQ sites to perform environmental monitoring, maintain the pit embankments, and perform maintenance and surveillance tasks as necessary. In October 1981, Bechtel National Incorporated,(BNI) under contract to DOE (successor to AEC), assumed management responsibility for the WSRP and WSQ from NLO. BNI managed these facilities in caretaker status until 1986.

In November 1984, DOE was directed by the Office of Management and Budget to assume custody and accountability for the WSCP from the DA. This transfer occurred on October 1, 1985.

In February 1985, 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 this Weldon Spring Site Remedial Action Project was selected in February 1986. In July, 1986, a DOE Project office was established on site. The PMC, M-K Ferguson Company, assumed control of the WSS on October 1, 1986.

1.3 ENVIRONMENTAL SETTING

The WSRP and WSCP areas are located on the Missouri-Mississippi River surface drainage divide. The topography is gently undulating and generally slopes northward to the Mississippi River. To the southeast are bluffs that overlook the floodplain of the Missouri River. Though the bedrock under the site is fractured, it is overlain by a deposit of impermeable clay approximately 7.6 to 9.1-m (25 to 30-feet) thick. Streams do not cross the properties, but incipient drainageways convey surface water runoff to off-site streams.

Most surface drainage from the WSRP area discharges either via an intermittent stream in the Army Reserve Training Area to the west or into Ash Pond on the WSCP property. Discharges from the intermittent stream and Ash Pond combine near County Road D and flow northward into Schote Creek, and from there enter Dardenne Creek, which discharges into the Mississippi River. An additional surface drainage system reaching the Mississippi River exits at the WSCP area from Frog Pond. Frog Pond drains storm water events from most of the plant area (concrete surfaces draining into the storm water sewer). Surface water flow from the northeastern edge of the WSCP also drains to Frog Pond.

Drainage from the southern portion of the WSCP property flows southeast to the Missouri River. This drainage originates from two sources. The first is from the sanitary sewer system for the WSCP. This sanitary sewer system was taken out of service in 1986. It does, however, receive some flow as leakage from the storm water runoff system into the sanitary sewer system. This drain pipe merges with the process sewer (which is also unused). The second portion of the flow down the southeast drainage is due to overland flow from the southern portion of the site during precipitation events.

With the exception of the Missouri River floodplain to the south, the topography of the WSQ area is rugged. Drainage in the area flows to the Missouri River, 1.6 km (1 mile) to the east, through the Femme Osage Creek and Little Femme Osage Creek (Figure 1-6).

Approximately 213.4 m (700 feet) to the south of the WSQ, toward the Missouri River, lies a 2.4 km (1.5 mile) 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. The average level of water in the slough is approximately 137.2 m (450 feet) above mean sea level; its level is affected, however, by the levels of the Missouri River and groundwater (NLO, 1975).

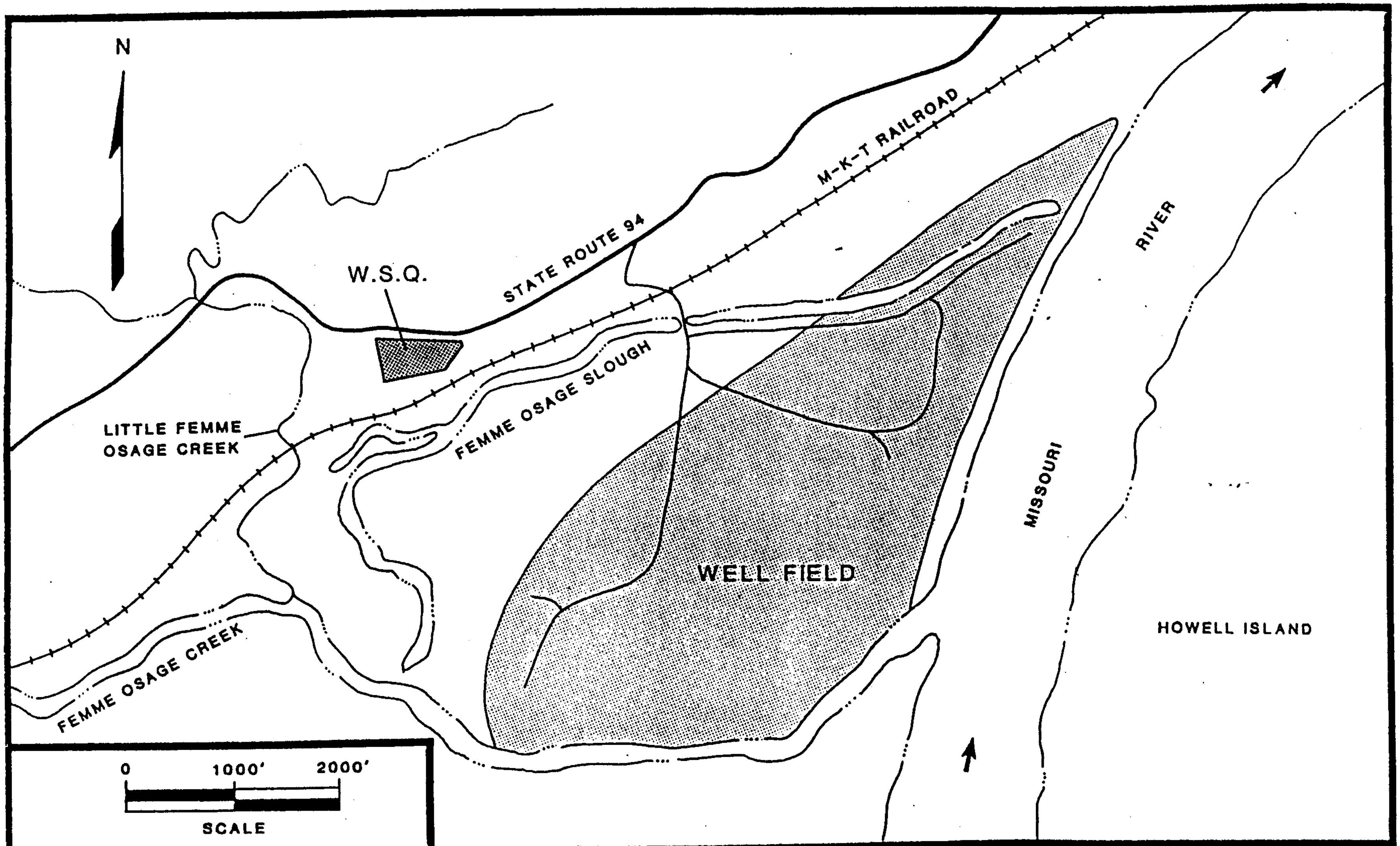

FIGURE 1-6

ST. CHARLES COUNTY WELL FIELD.

Groundwater in the vicinity of the WSRP and WSCP areas may occur in two separate zones: perched lenses and the underlying bedrock. Perched groundwater may be present in small, isolated deposits of coarse-grained glacial drift. The raffinate pits are separated from the underlying groundwater by clays of low permeability (BNI, 1984).

Groundwater in the vicinity of the WSQ occurs both in bedrock and alluvium. The limestone bedrock contains solution channels and fractures that exhibit highly complex flow paths. These flow paths are capable of transmitting groundwater to the surrounding creeks and alluvium (BNI, 1985). The primary water supply for St. Charles County is obtained from a well field that draws water from the Missouri River valley alluvium approximately 0.8 km (0.5 mile) southeast of the WSQ (Figure 1-6).

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 cm (39 inches), with the heaviest rainfall occurring in spring and early summer. The monthly average temperature is 13 degrees C (56 degrees F), with the average daily minimum being 7 degrees C (45 degrees F) and the average daily maximum being 19 degrees C (66 degrees F). Wind speeds and directions recorded at the WSS during 1985 are given in Figure 1-7. 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) (Gale Research, 1985).

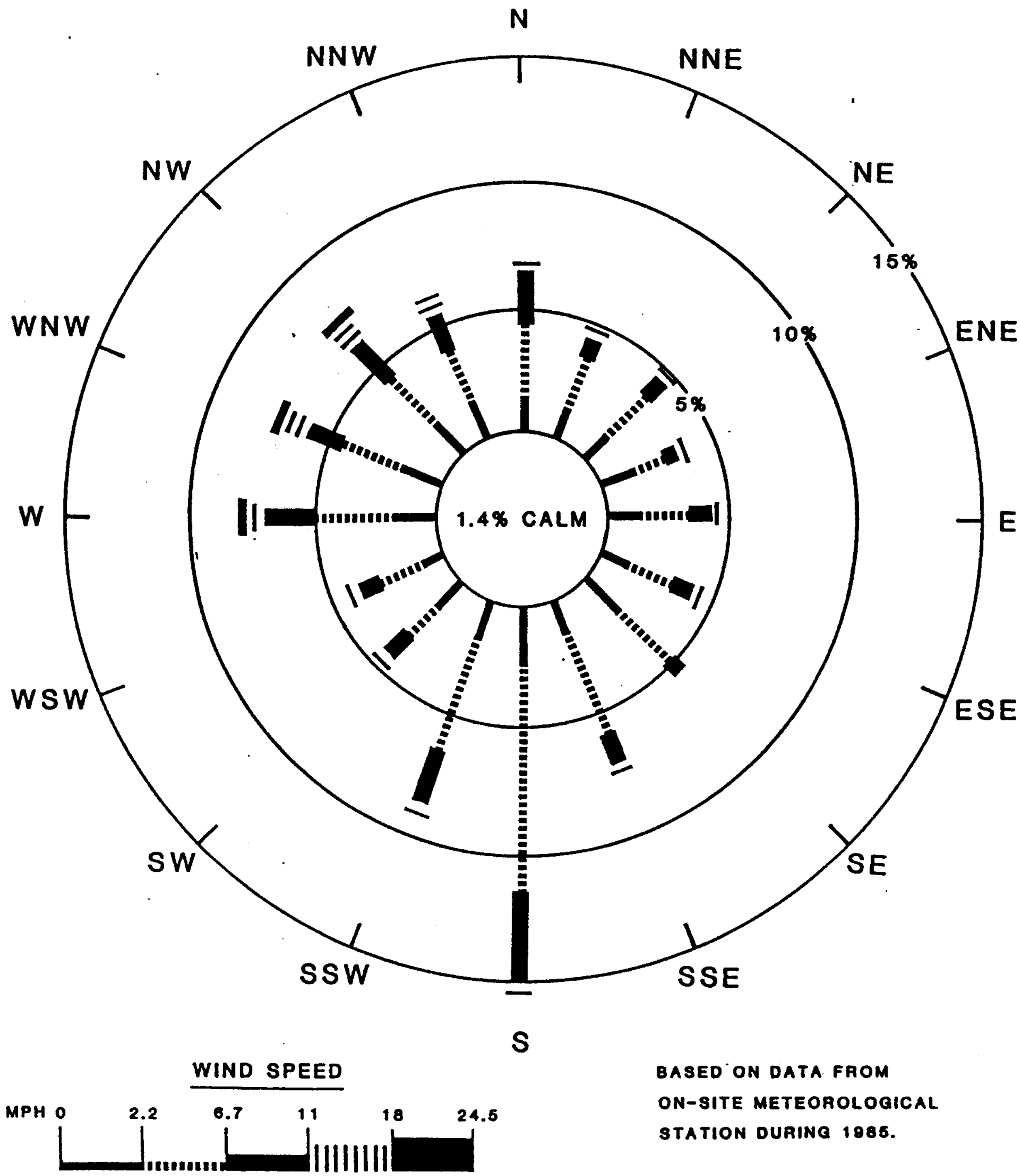

FIGURE 1-7

ANNUAL WIND ROSE FOR THE W.S.S., 1985.

Population of the WSS Area

The nearest communities, Weldon Spring and Weldon Spring Heights, are located approximately 3.2 km (2 miles) east of the WSRP and WSCP areas. While the population of each of these communities is small (70 and 144, respectively), the population of St. Charles County is more than 140,000 (U.S. Department of Commerce, 1980).

Land Use in the Vicinity of the WSS

Figure 1-8 is a generalized land use map for the WSS area. The land to the west of the WSRP area is used as an Army Reserve and National Guard training area. A Missouri State Highway Department Maintenance facility is located immediately east of the WSCP, and the Francis Howell High School is located within 1.6 km (1 mile) to the east. The rest of the land around the WSRP/WSCP area is used for wildlife management. The August A. Busch Memorial Wildlife Area lies to the north, and the Weldon Spring Wildlife Area to the east and south. The latter also surrounds the WSQ.

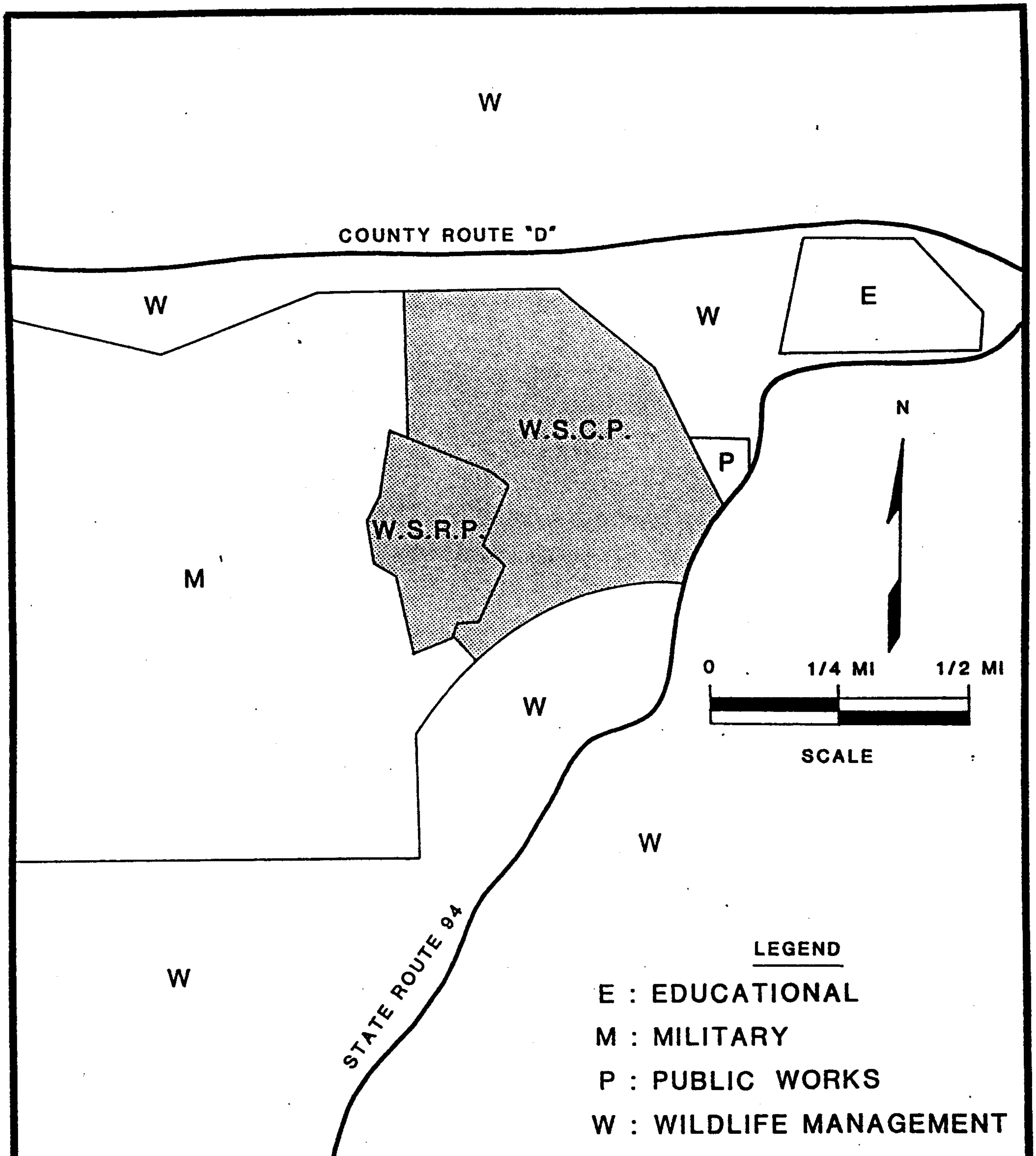

FIGURE 1-8

GENERALIZED LAND USES IN THE VICINITY OF THE W.S.R.P. AND W.S.C.P..

2.0 ENVIRONMENTAL MONITORING RESULTS

The 1986 environmental program monitored potential release or exposure pathways. Samples were collected from each of the following potential release pathways: groundwater, surface water, and air. Specific concentrations of radon-222 gas and exposure levels from external gamma radiation were also monitored. Characterization efforts will be conducted during 1987 to evaluate potential sources of soil contamination at the WSCP.

This section provides the results of the 1986 environmental monitoring program. Each subsection contains a description of the sampling, monitoring and analytical procedures followed as well as a comparison of results with applicable DOE guidelines.

During each quarter of 1986, groundwater samples were collected from a total of 26 monitoring wells. Six (6) wells surrounding the raffinate pits, 5 wells surrounding the quarry, and 15 wells in the Femme Osage Slough area were sampled.

Surface water samples were collected from 26 locations in and around the WSS each quarter. In addition, 3 sediment samples were collected from the outfall of Frog Pond.

Radon-222 gas and gamma radiation were monitored at 6 locations at the WSRP area, 15 locations at the WSCP area, 6 locations at the WSQ and 4 offsite locations.

Data from these measurements are presented in summary tables by sample matrix category. Summaries of data include sampling location, quarterly data recorded, average value, and percent of the Derived Concentration Guides (DCG). Each average value listed is the arithmetic average of the sum of individual results for the respective radionuclide and sampling location. Individual sources of error (e.g., analytical error or sampling error) were not estimated.

The "less than" notation (<) is used to denote analytical results that are below the limit of sensitivity of the analytical method based on a statistical analysis of parameters. In computing the averages, values less than the limit of sensitivity of the analytical method are considered to be equal to the limit of sensitivity. Annual averages, made up of multiple quarterly values reported as less than the lower limit of detection, were computed by calculating (and reporting) the value that the average was less than.

2.1 GROUNDWATER

During 1986, groundwater samples were collected quarterly from twenty-six (26) locations at the WSS as a part of the environmental monitoring program. Monitoring wells were selected for sampling based on past analytical and well construction data. Six monitoring wells were sampled in the WSRP area. The locations of these wells are shown in Figure 2-1. Groundwater samples were collected from the 20 locations in and near the WSQ shown in Figures 2-2 and 2-3. All groundwater samples were analyzed for dissolved uranium, radium-226, and thorium-230.

Monitoring wells in the WSRP area are completed in the clay till overlying the bedrock of Burlington-Keokuk Formation (a cherty limestone). These wells were dry each quarter in 1986, as they have been since installation, with the exception of well number W-2. These dry wells indicate unsaturated conditions in the clay till on the perimeter of Raffinate Pits 3 and 4. These wells are designed to detect lateral migration of water from the raffinate pits into the groundwater system. Analysis of the single groundwater sample collected from the WSRP in 1986 indicated uranium, radium-226, and thorium-230 activities less than 1 pCi/L, or less than 1 percent of their DCGs.

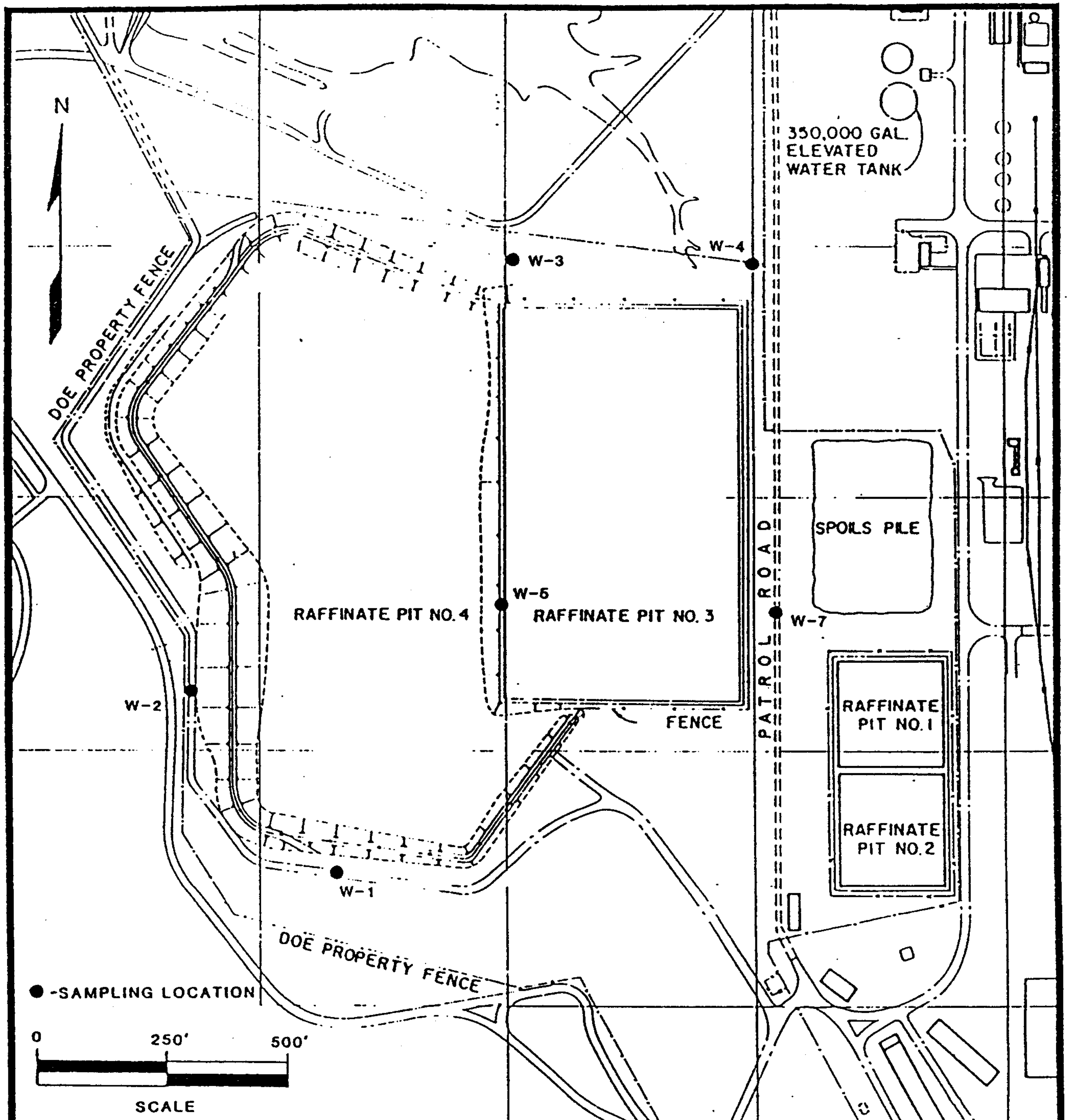

FIGURE 2-1

GROUNDWATER MONITORING LOCATIONS AT THE W.S.R.P. FOR THE 1986 ENVIRONMENTAL MONITORING PROGRAM.

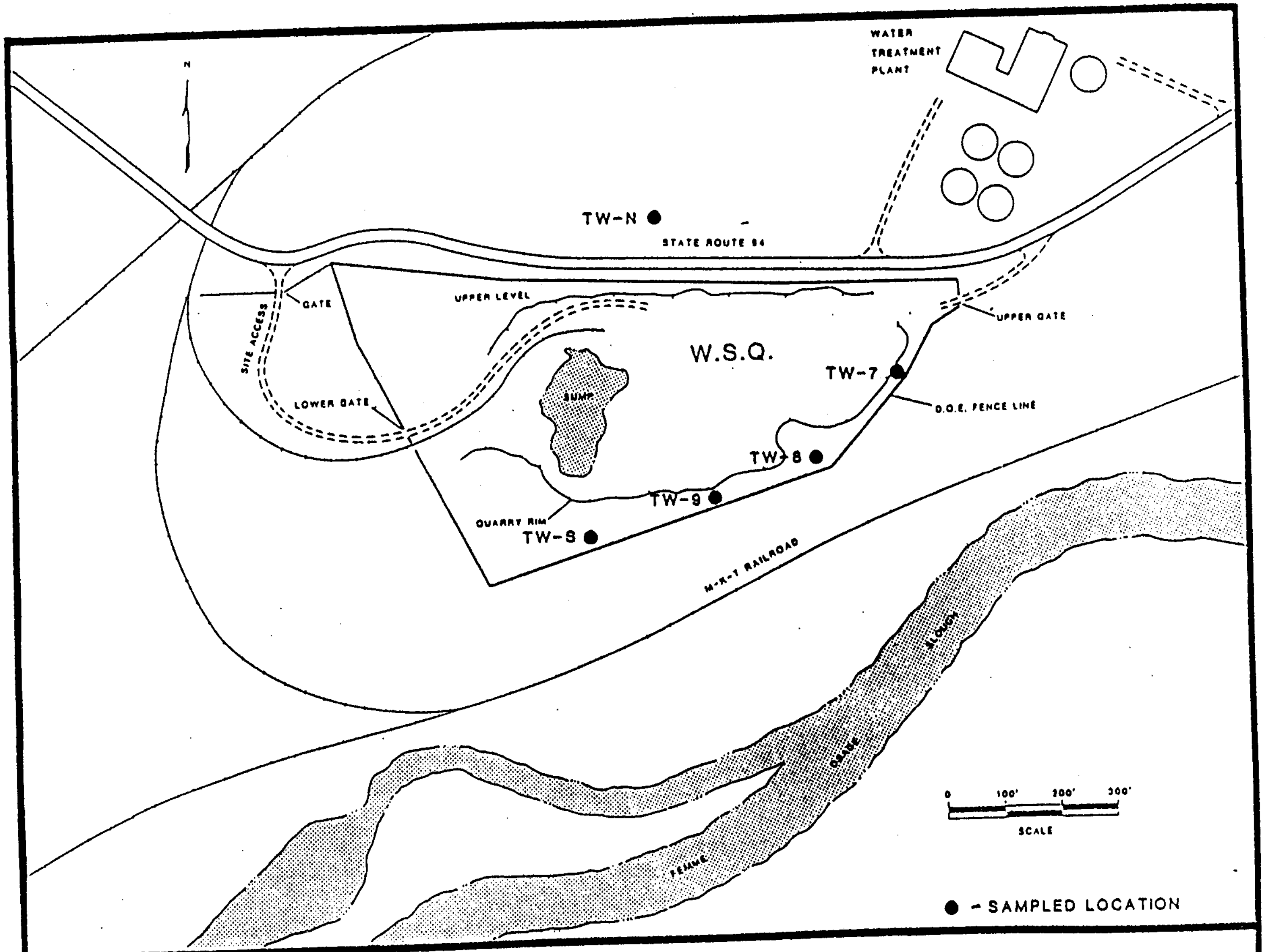

FIGURE 2-2

GROUNDWATER MONITORING LOCATIONS AT THE W.S.Q..

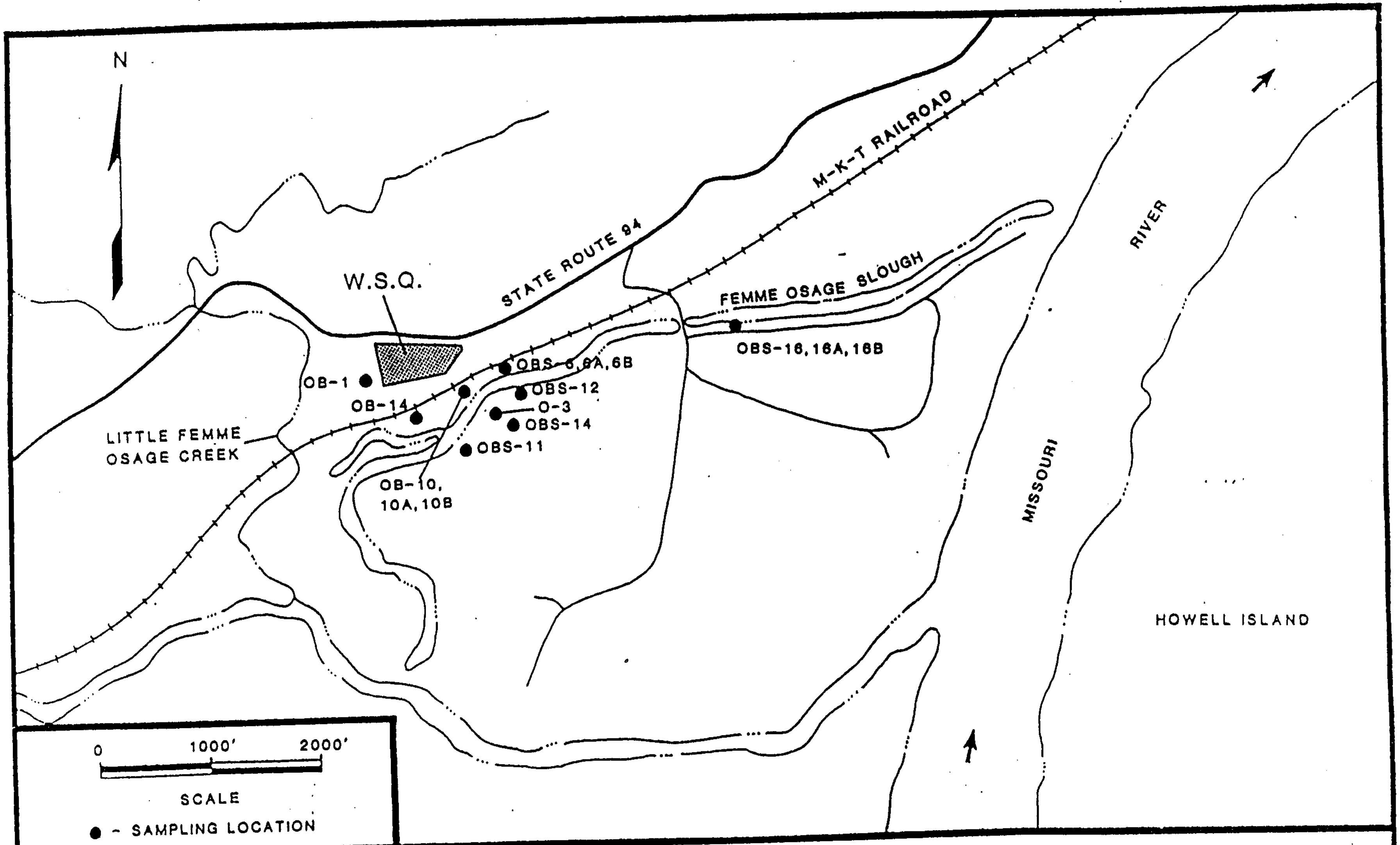

FIGURE 2-3

GROUNDWATER MONITORING LOCATIONS IN THE VICINITY OF THE W.S.Q..

Groundwater samples were collected from 4 locations inside the WSQ and 1 location (TW-N) north of the WSQ. These samples had average uranium concentrations ranging from less than 3.0 pCi/L to 8,160 pCi/L. These values range from less than 1 percent of the DCG to more than 1360 percent of the DCG. Average radium-226 values range from less than 1.0 pCi/L, less than 1 percent of the DCG, to 1.2 pCi/L, 1.2 percent of the DCG. Thorium-230 values average from less than 1.0 pCi/L to 15 pCi/L, a maximum of 5 percent of the DCG. Individual values are shown in Tables 2-1, 2-2, and 2-3. The maximum thorium-230 value was detected in TW-N during the third quarter. Slightly elevated uranium values were also detected in the third quarter. These elevated levels are suspected to be due to analytical error, sampling error, or labeling error. This groundwater monitoring well will be sampled as a part of the 1987 Environmental Monitoring Program. The results will then be evaluated to determine the reason for the elevated levels.

The 4 existing monitoring wells included in the Environmental Monitoring Program inside the WSQ were replaced during the second quarter of 1986. Monitoring well TW-N (outside the WSQ) was replaced during the fourth quarter of 1986. The old wells were installed in 1960 and 1978 and were open to bedrock over a long depth interval. These old wells did not meet current EPA guidelines for the construction of monitoring wells. In an attempt to improve the quality of monitoring at the WSQ, these old wells were replaced with wells meeting current EPA guidelines. The old wells were permanently sealed with a cement-bentonite grout.

Two monitoring locations may have been adversely affected by this grouting program. At monitoring wells TW-7 and TW-8, the new wells may have been installed too close to the old sealed well. The grout from these old wells could have sealed a significant portion of the solution-enlarged fractures in the Kimmswick Limestone. This grouting program appears to have isolated these two new wells from the contaminated groundwater. This isolation

TABLE 2-1

ACTIVITY LEVELS OF DISSOLVED NATURAL URANIUM IN GROUNDWATER

AT THE WSS, 1986

Page 1 of 2

LOCATION	ACTIVITY (pCi/L) (a)(b) 1ST QTR	2ND QTR	3RD QTR	4TH QTR	AVERAGE	% of DCG
WSQ						
TW-7	267	WS	---	---	267	49
TW-7(NEW)	---	---	4	<2	<3	<1
TW-8	8160	WS	---	---	8160	1483
TW-8(NEW)	---	---	NSD	<2	<2	<1
TW-9	3060	WS	---	---	3060	556
TW-9(NEW)	---	---	1564	2500	2032	369
TW-S	5	WS	---	---	5	<1
TW-S(NEW)	---	---	NSD	11	11	2
TW-N	<3	WS	19	---	11	2
TW-N(NEW)	---	---	---	<2	<2	<1

TW -7,8,9,S-- Replaced July 86
TW-N-- Replaced Nov 86
WS: Well Sealed and Redrilled
NS: Not Sampled
NSD: Not Sampled Dry
NSF: Not Sampled Flooded
NSDM: Not Sampled Damaged
(a) DOE Guideline for Natural Uranium in Water is 550 pCi/L, Based on DOE Standard of 100 mrem/year
(b) 1.0 pCi/L = 37 Bq/m^3

TABLE 2-1

ACTIVITY LEVELS OF DISSOLVED NATURAL URANIUM IN GROUNDWATER

AT THE WSS, 1986

LOCATION	ACTIVITY (pCi/L) (a)(b) 1ST QTR	2ND QTR	3RD QTR	4TH QTR	AVERAGE	% of DCG
WSQ-AREA						
OB-1	10	NSD	NSD	8	9	<2
O-3	<3	<3	NS	<2	<3	<1
OB-6	317	102	143	NSDM	187	34
OB-6A	88	NS	367	630	362	66
OB-6B	3264	NS	197	<2	1154	210
OB-10	4692	NSD	2584	NSDM	3638	661
OB-10A	496	NSD	NSD	470	483	88
OB-10B	75	NSD	31	<2	36	<7
OBS-11	NS	NS	<3	NS	<3	<1
OBS-12	<3	<3	<3	<2	<3	<1
OB-14	1700	218	1564	1489	1243	226
OBS-14	NS	NS	<3	NS	<3	<1
OBS-16	<3	<3	NSF	NS	<3	<1
OBS-16A	<3	4	NSF	NS	<4	<1
OBS-16B	<3	<3	NSF	NS	<3	<1

WS: Well Sealed and Redrilled
NS: Not Sampled
NSD: Not Sampled Dry
NSF: Not Sampled Flooded
NSDM: Not Sampled Damaged
(a) DOE Guideline for Natural Uranium in Water is 550 pCi/L, Based on DOE Standard of 100 mRem/Year
(b) 1.0 pCi/L = 37 Bq/m^3

TABLE 2-2

ACTIVITY LEVELS OF DISSOLVED RADIUM-226 IN GROUNDWATER

AT THE WSS, 1986

LOCATION	ACTIVITY (pCi/L) (a)(b) 1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	AVERAGE	% of DCG
WSQ						
TW-7	1.2	WS	---	---	1.20	1.20
TW-7(NEW)	---	---	0.7	0.0	0.35	0.35
TW-8	0.2	WS	---	---	0.20	0.20
TW-8(NEW)	---	---	NSD	0.2	0.20	0.20
TW-9	0.3	WS	---	---	0.30	0.30
TW-9(NEW)	---	---	1.5	0.1	0.80	0.80
TW-S	0.6	WS	---	---	0.60	0.60
TW-S(NEW)	---	---	NSD	0.0	0.00	0.00
TW-N	0.4	WS	NSLL	---	0.40	0.40
TW-N(NEW)	---	---	---	0.3	0.30	0.30

TW- 7,8,9,S--Replaced July 86
TW-N--Replaced Nov 86
WS: Well Sealed and Redrilled
NSD: Not Sampled Dry
NSLL: No Sample Lost By Lab
(a) DOE Guideline for Radium-226 in Water is 100 pCi/L, Based on DOE Standard of 100 mRem/Year
(b) 1.0 pCi/L =37 Bq/m^3

TABLE 2-2

ACTIVITY LEVELS OF DISSOLVED RADIUM-226 IN GROUNDWATER

AT THE WSS, 1986

LOCATION	ACTIVITY (pCi/L)(a)(b) 1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	AVERAGE	% of DCG
WSQ-AREA						
OB-1	0.2	NSD	NSD	0.2	0.20	0.20
O-3	0.5	0.4	NS	0.2	0.37	0.37
OB-6	0.5	0.4	0.3	NSDM	0.40	0.40
OB-6A	0.4	NS	0.5	0.0	0.30	0.30
OB-6B	0.2	NS	0.9	0.2	0.43	0.43
OB-10	0.1	NSD	0.2	NSDM	0.15	0.15
OB-10A	0.3	NSD	NSD	0.1	0.20	0.20
OB-10B	0.5	NSD	1.1	0.0	0.53	0.53
OBS-11	NS	NS	0.4	NS	0.40	0.40
OBS-12	0.1	0.4	1.3	0.5	0.58	0.58
OB-14	0.4	0.4	0.5	0.7	0.50	0.50
OBS-14	NS	NS	1.4	NS	1.40	1.40
OBS-16	0.1	1.4	NSF	NS	0.75	0.75
OBS-16A	0.2	0.3	NSF	NS	0.25	0.25
OBS-16B	0.1	0.5	NSF	NS	0.30	0.30

NS: Not Sampled
NSD: Not Sampled Dry
NSF: Not Sampled Flooded
NSDM: Not Sampled Damaged
(a) DOE Guideline for Radium-226 in Water is 100 pCi/L, Based on DOE Standard of 100 mRem/Year
(b) 1.0 pCi/L =37 Bq/m^3

TABLE 2-3

ACTIVITY LEVELS OF DISSOLVED THORIUM-230 IN GROUNDWATER

AT THE WSS, 1986

Page 1 of 2

LOCATION	ACTIVITY (pCi/L) (a)(b) 1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	AVERAGE	% of DCG
WSQ						
TW-7	<0.1	WS	---	---	<0.10	<0.04
TW-7(NEW)	---	---	<0.5	0.0	<0.25	<0.08
TW-8	<0.1	WS	---	---	<0.10	<0.04
TW-8(NEW)	---	---	NSD	0.0	0.00	0.00
TW-9	0.5	WS	---	---	0.50	0.16
TW-9(NEW)	---	---	6.0	0.0	3.00	1.00
TW-S	<0.1	WS	---	---	<0.10	<0.04
TW-S(NEW)	---	---	NSD	0.0	0.00	0.00
TW-N	0.5	WS	15.0	---	7.50	2.50
TW-N(NEW)	---	---	---	0.0	0.00	0.00

TW- 7,8,9,S--Replaced July 86
TW-N--Replaced Nov 86
WS: Well Sealed and Redrilled
NSD: Not Sampled Dry
(a) DOE Standard for Thorium-230 in Water is 300 pCi/L
(b) 1.0 pCi/L = 37 Bq/m^3

TABLE 2-3

ACTIVITY LEVELS OF DISSOLVED THORIUM-230 IN GROUNDWATER

AT THE WSS, 1986

LOCATION	ACTIVITY (pCi/L) (a)(b) 1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	AVERAGE	% of DCG
WSQ-AREA						
OB-1	<0.1	NSD	NSD	0.3	<0.20	0.06
O-3	<0.2	<0.2	NS	0.0	0.13	0.04
OB-6	<0.1	<0.2	5.0	NSDM	1.77	0.58
OB-6A	<0.5	NS	3.0	0.0	1.17	0.40
OB-6B	0.9	NS	6.0	0.0	2.30	0.76
OB-10	0.2	NSD	<0.5	NSDM	0.35	0.12
OB-10A	<0.1	NSD	NSD	0.0	<0.05	<0.02
OB-10B	<0.2	NSD	<0.5	0.0	<0.23	<0.08
OBS-11	NS	NS	2.0	NS	2.00	0.66
OBS-12	<0.1	<0.3	<0.2	0.2	<0.20	0.06
OB-14	<0.1	<0.2	7.0	0.0	1.83	0.62
OBS-14	NS	NS	4.0	NS	4.00	1.34
OBS-16	<0.3	<0.3	NSF	NS	<0.30	<0.10
OBS-16A	<0.1	<0.3	NSF	NS	<0.20	<0.06
OBS-16B	<0.1	<0.6	NSF	NS	<0.35	<0.12

NS: Not Sampled
NSD: Not Sampled Dry
NSF: Not Sampled Flooded
NSDM: Not Sampled Damaged
(a) DOE Standard for Thorium-230 in Water is 300 pCi/L
(b) 1.0 pCi/L = 37 Bq/m^3

is apparent in TW-8 where the uranium activity levels changed from 8,160 pCi/L in the first quarter of 1986 to less than 2.0 pCi/L in the fourth quarter. Monitoring well TW-7 exhibits a similar isolation, with uranium activity levels dropping from 26.7 pCi/L to less than 3.0 pCi/L from the first to the fourth quarter.

Monitoring of these two wells will continue in 1987 and locations for replacement wells will be investigated. If suitable locations are found, replacement wells may be installed. These new wells will be constructed in such a manner to prevent a similar occurrence.

Fifteen wells were also sampled between the WSQ and the St. Charles County Well Field. These wells had uranium activity levels ranging from less than 2.0 pCi/L, less than 1 percent of the DCG, to 3,638 pCi/L, 606 percent of the DCG, in Well OB-10. Radium-226 concentrations were less than 1.0 pCi/L, less than 1 percent of the DCG, in all wells except OBS-14, where the value was 1.4 pCi/L (1.4 percent of the radium DCG). Thorium-230 values ranged from less than 1.0 pCi/L to 7.0 pCi/L. This latter value is 2.3 percent of the thorium DCG.

Several locations were not sampled during the third quarter due to flooding by the Missouri River. Three of the fifteen wells yielded groundwater with average uranium activity levels exceeding the DCG. These wells are located between the now-abandoned MKT railroad tracks and the north bank of the Femme Osage Slough. All monitoring wells to the south of the slough exhibited activity levels less than 1 percent of the DCG for all parameters. It appears that contaminated groundwater migration is retarded by the fine-grained sediment underlying the Femme Osage Slough.

Several of the wells are damaged and were not sampled because the extent of damage compromised the integrity of the well. Previous results from these wells will be evaluated and the need for replacement wells will be determined. Samples were split with the MODNR at two wells (OBS-11 and OBS-14) during the third quarter of 1986. The results of this sampling are discussed in Section 3.4.

2.2 SURFACE WATER AND SEDIMENT RESULTS

During 1986, surface water samples were collected quarterly from 26 locations in and around the WSS. The locations are shown on Figures 2-4, 2-5, 2-6, and 2-7. These samples were collected as grab samples and were analyzed for total natural uranium, radium-226, and thorium-230. Sediment samples were collected from two locations (29 and 30) during the second quarter and one sample was collected from location 30 in the first quarter.

Surface water samples were analyzed from 6 locations at the WSCP (Figure 2-6). Average uranium activity levels ranged from 29 pCi/L, five percent of the DCG, to 2,700 pCi/L, 450 percent of the DCG. The highest activity was present in the Ash Pond outfall, which was sampled only once as it was dry during sampling efforts in the first three quarters. All other outfalls sampled had substantially lower uranium levels. Radium-226 and thorium-230 activity levels were less than 1.0 pCi/L for all six surface water locations. These levels are less than one percent of the respective DCGs. The analytical results are presented in Table 2-4, 2-5, and 2-6.

Fifteen offsite locations were sampled to monitor offsite migration via surface water during 1986. Two locations (3 and 4) near the WSRP were dry during all quarters and are not listed in the tables. Ten of these locations had average uranium concentrations less than 3.0 pCi/L for all quarters of 1986. Radium-226 and thorium-230 activities were less than 1.0 pCi/L, also less than 1 percent of the respective DCGs. The remaining three locations 35, 36, 37 (Busch Area Lakes 34, 35 and 36) had

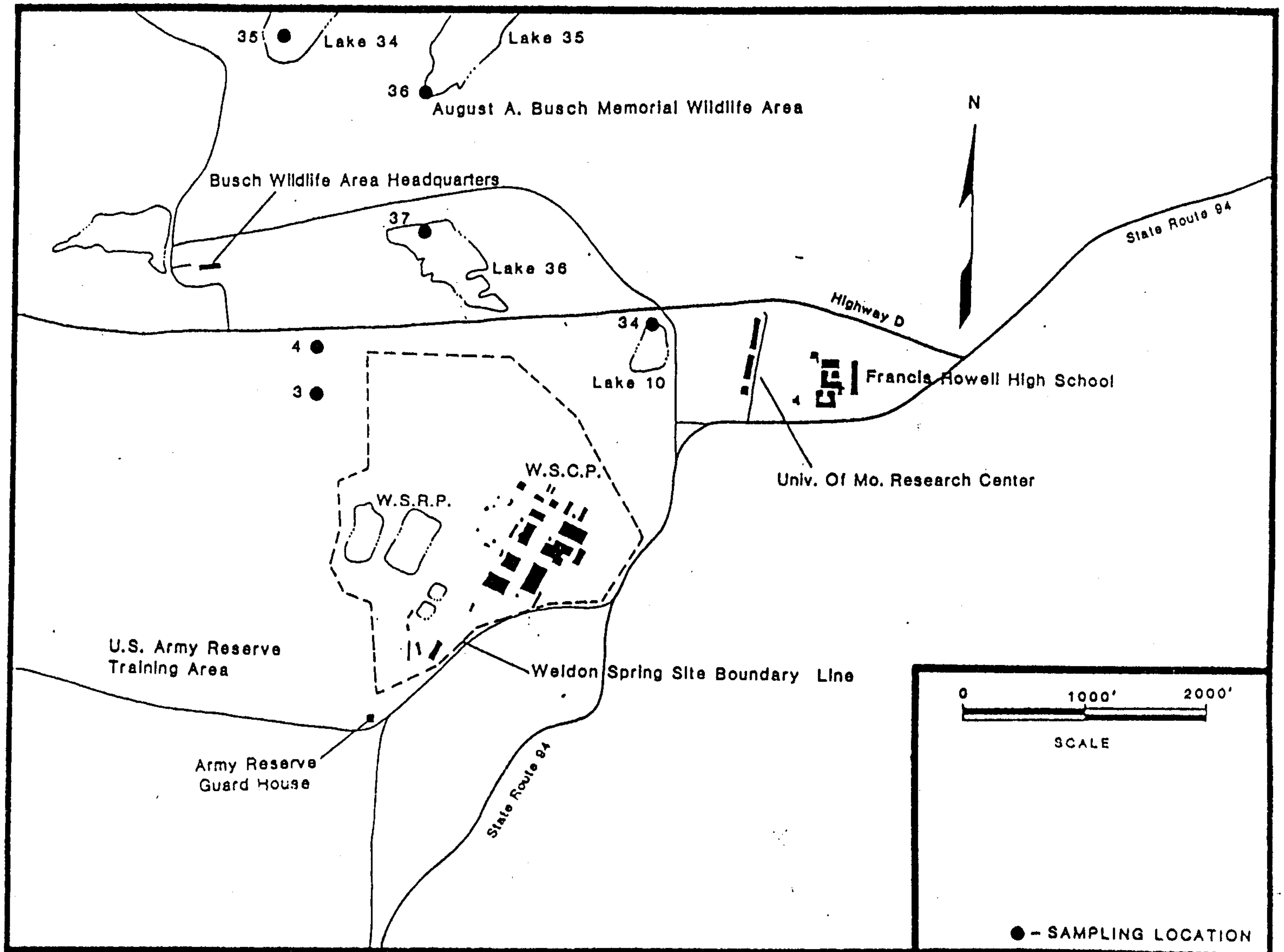

FIGURE 2-4

SURFACE WATER SAMPLING LOCATIONS NEAR THE W.S.R.P. AND W.S.C.P..

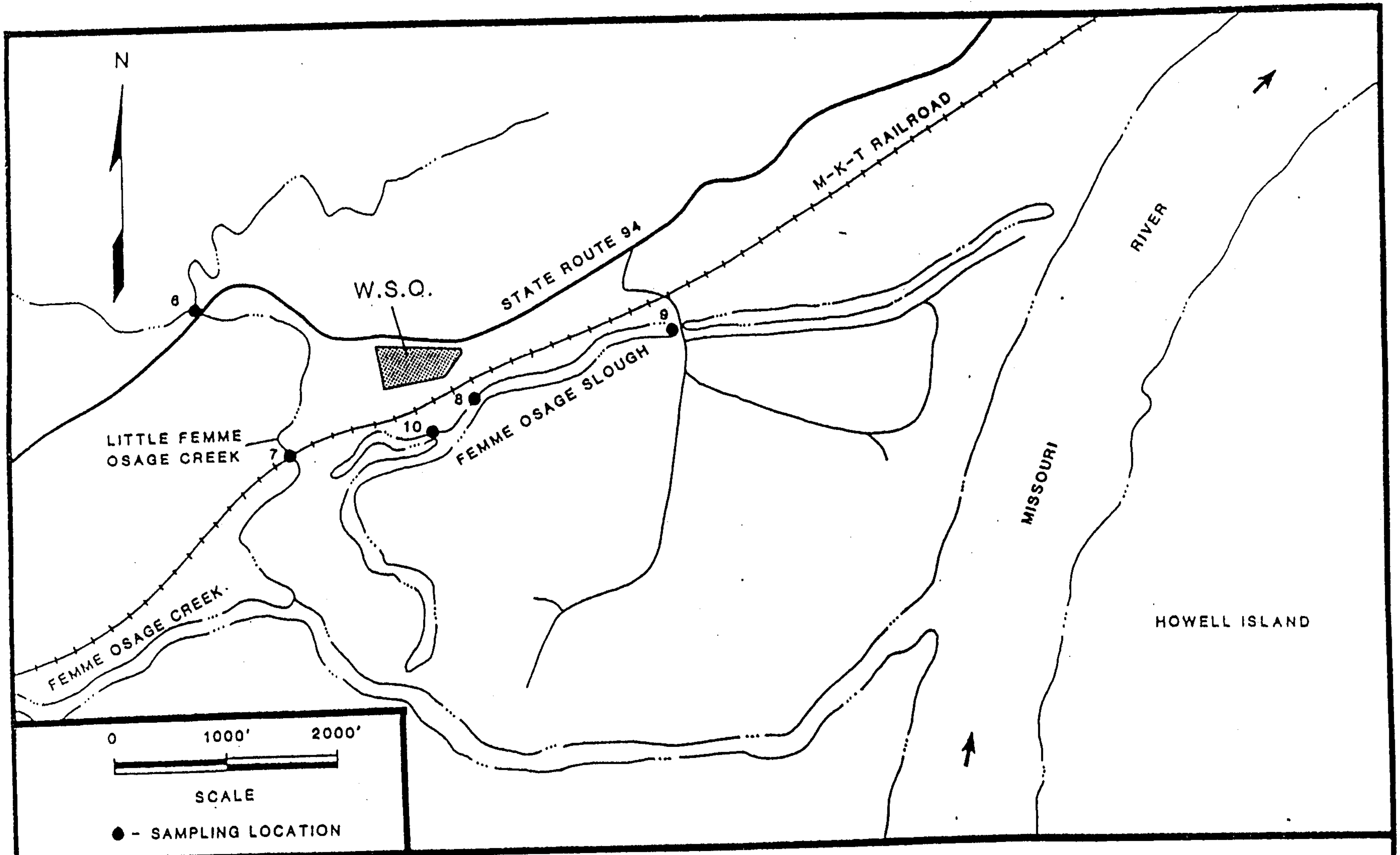

FIGURE 2-5

SURFACE WATER SAMPLING LOCATIONS NEAR THE W.S.Q..

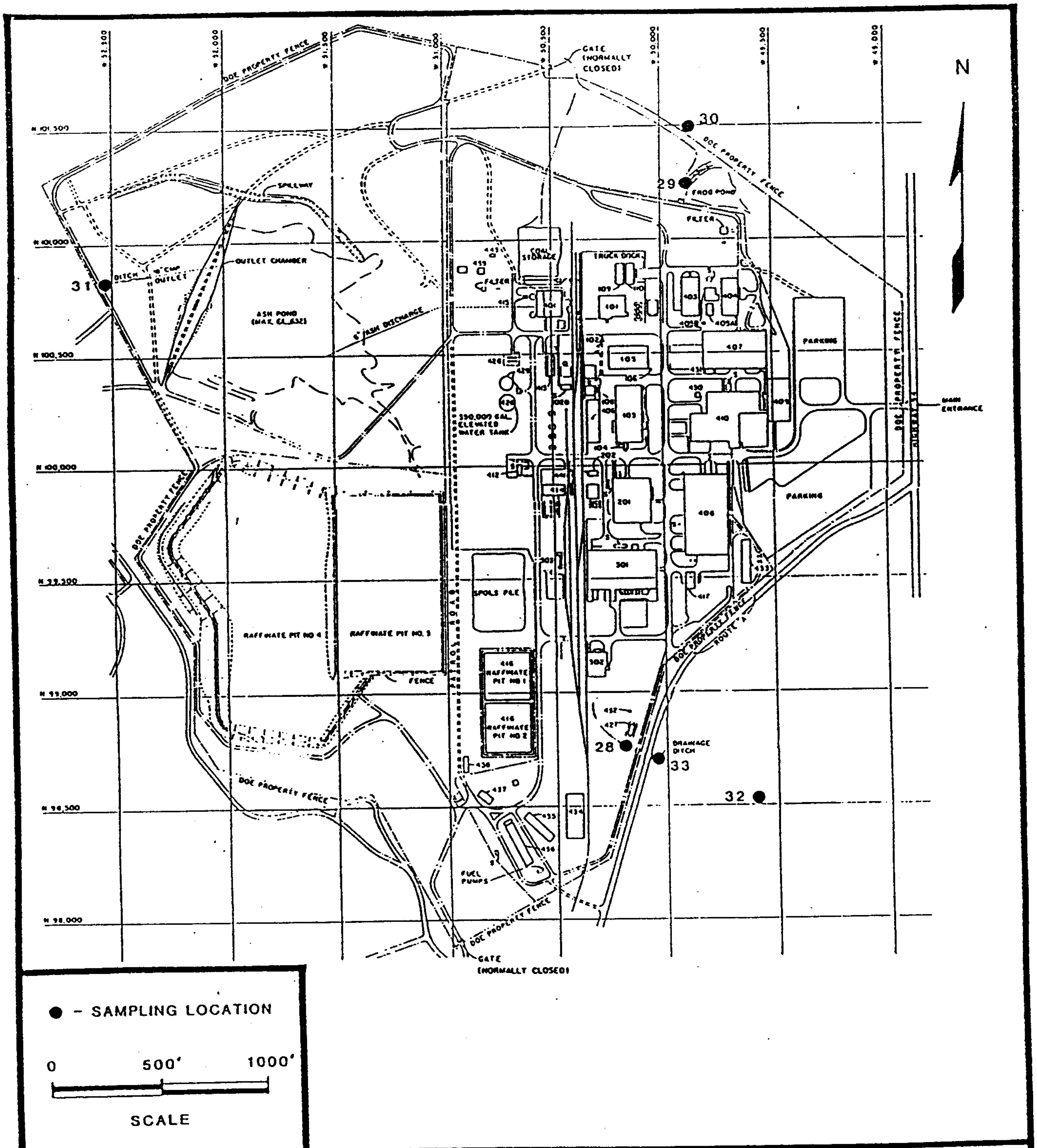

FIGURE 2-6

SURFACE WATER SAMPLING LOCATIONS AT THE W.S.C.P..

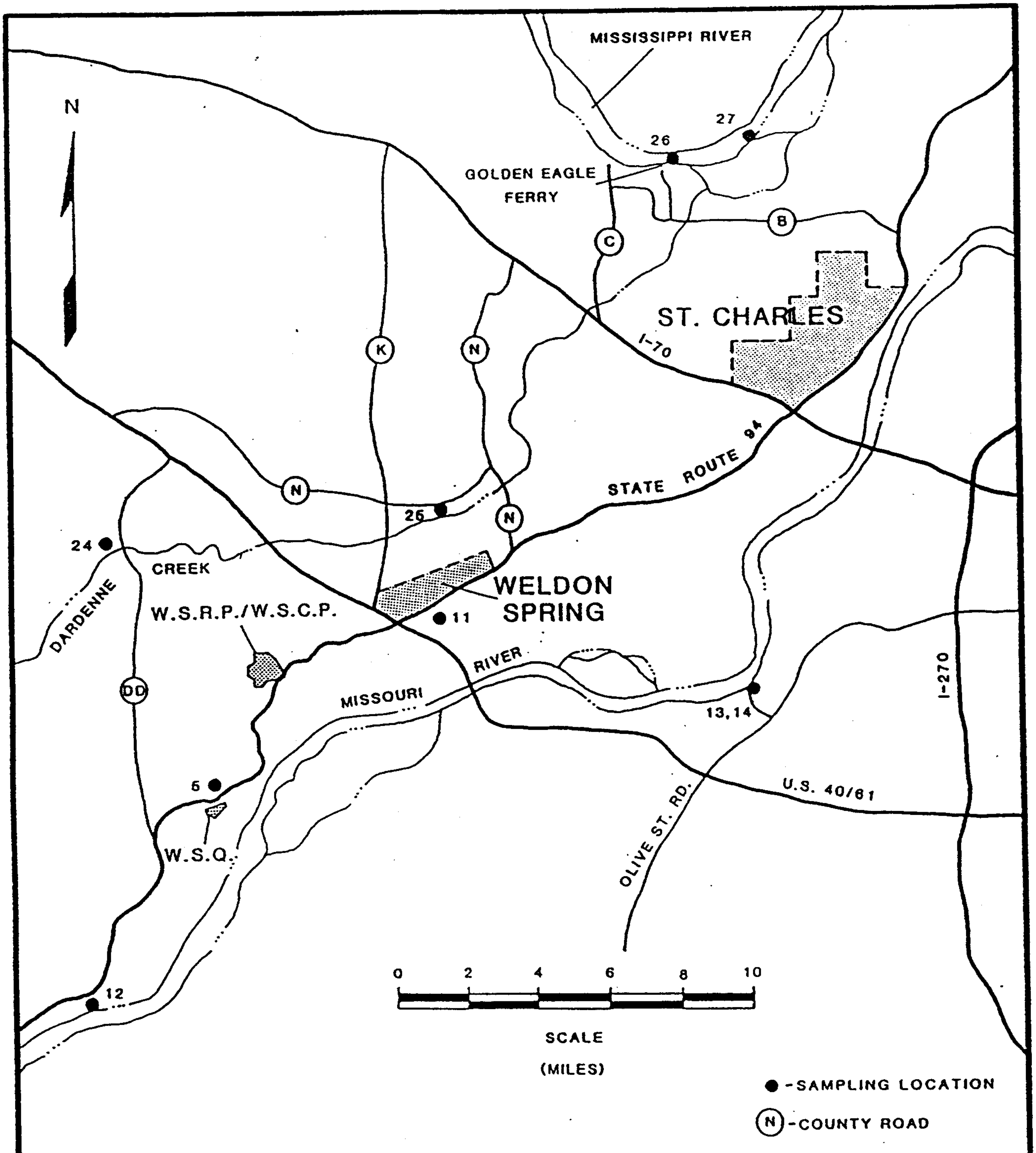

FIGURE 2-7

OFF-SITE SURFACE WATER SAMPLING LOCATIONS FOR THE W.S.S..

TABLE 2-4

ACTIVITY LEVELS OF DISSOLVED NATURAL URANIUM IN SURFACE WATER

AT THE WSS, 1986

Page 1 of 2

	ACTIVITY (pCi/L)(a)(b)					
LOCATION	1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	AVERAGE	% of DCG
WSQ						
6	<3	NSD	NSD	<2	<3	<1
7	<3	NSD	NSD	<2	<3	<1
8	82	NSD	63	13	53	10
9	82	NSD	54	10	49	9
10	116	NSD	58	8	61	11
OFFSITE						
5	<3	<3	3	<2	<3	<1
11	<3	<3	<3	<2	<3	<1
12	<3	<3	3	<2	<3	<1
13	<3	<3	<3	9	<4	<1
14	<3	<3	3	<2	<3	<1
24	<3	<3	<3	<2	<3	<1
25	<3	<3	<3	<2	<3	<1
26	<3	<3	<3	NSAD	<3	<1
27	<3	<3	<3	<2	<3	<1

NSD: Not sampled Dry
NSLT: No Sample Lost in Transit
NSAD: Not Sampled Access Denied
(a) DOE Guideline for Natural Uranium in Water is 550 pCi/L, Based on DOE Standard of 100 mRem/Year
(b) 1.0 pCi/L = 37 Bq/m^3

TABLE 2-4

ACTIVITY LEVELS OF DISSOLVED NATURAL URANIUM IN SURFACE WATER

AT THE WSS, 1986

LOCATION	ACTIVITY (pCi/L) (a)(b) 1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	AVERAGE	% of DCG
WSCP						
28	75	NSLT	88	8	57	10
29	23	NSLT	66	<2	30	5
30	24	NSLT	63	<2	29	5
31	NSD	NSD	NSD	2700	2700	491
32	197	NSLT	136	4	112	20
33	177	NSD	136	150	154	28
34	<3	<3	<3	<2	<3	<1
35	7	18	17	25	17	3
36	<3	10	14	17	11	2
37	25	39	40	41	36	7

NSD: Not sampled Dry
NSLT: No Sample Lost in Transit
(a) DOE Guideline for Natural Uranium in Water is 550 pCi/L, Based on DOE Standard of 100 mRem/Year
(b) 1.0 pCi/L = 37 Bq/m^3

TABLE 2-5

ACTIVITY LEVELS OF DISSOLVED RADIUM-226 IN SURFACE WATER

AT THE WSS, 1986

LOCATION	ACTIVITY (pCi/L) [a][b] 1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	AVERAGE	% of DCG
WSQ						
6	0.4	NSD	NSD	0.0	0.20	0.20
7	0.4	NSD	NSD	0.0	0.20	0.20
8	0.3	NSD	0.2	0.1	0.20	0.20
9	0.2	NSD	0.6	0.0	0.27	0.27
10	0.4	NSD	0.5	0.5	0.47	0.47
OFFSITE						
5	0.4	0.7	0.7	0.6	0.60	0.60
11	<0.1	0.2	<0.1	0.0	<0.10	<0.10
12	0.1	0.4	2.0	0.0	0.63	0.63
13	0.2	0.4	0.1	0.0	0.18	0.18
14	<0.1	0.5	0.4	0.1	0.28	0.28
24	0.2	0.3	0.4	0.0	0.23	0.23
25	0.2	0.3	0.2	0.2	0.23	0.23
26	0.1	0.4	0.4	NSAD	0.30	0.30
27	0.2	0.3	0.1	0.1	0.18	0.18

NSD: Not Sampled Dry
NSAD: Not Sampled Access Denied
(a) DOE Guideline for Radium-226 in Water is 100 pCi/L, Based on DOE Standard of 100 mRem/Year
(b) 1.0 pCi/L =37 Bq/m^3

TABLE 2-5

ACTIVITY LEVELS OF DISSOLVED RADIUM-226 IN SURFACE WATER

AT THE WSS, 1986

LOCATION	ACTIVITY (pCi/L) [a][b] 1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	AVERAGE	% of DCG
WSCP						
28	<0.1	NSLT	0.4	0.0	0.17	0.17
29	<0.1	NSLT	0.9	0.0	0.33	0.33
30	0.3	NSLT	0.3	0.0	0.20	0.20
31	NSD	NSD	NSD	0.1	0.10	0.10
32	0.3	NSLT	0.7	0.2	0.40	0.40
33	0.2	NSD	0.4	0.0	0.20	0.20
34	0.2	0.6	0.3	0.0	0.28	0.28
35	0.3	0.5	0.3	0.0	0.28	0.28
36	0.2	0.3	0.2	0.0	0.18	0.18
37	0.1	0.3	0.1	0.0	0.13	0.13

NSD: Not Sampled Dry
NSLT: No Sample Lost in Transit
(a) DOE Guideline for Radium-226 in Water is 100 pCi/L, Based on DOE Standard of 100 mRem/Year
(b) 1.0 pCi/L =37 Bq/m^3

TABLE 2-6

ACTIVITY LEVELS OF DISSOLVED THORIUM-230 IN SURFACE WATER

AT THE WSS, 1986

LOCATION	ACTIVITY (pCi/L) (a) (b) 1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	AVERAGE	% of DCG
WSQ						
6	<0.1	NSD	NSD	0.0	<0.05	<0.02
7	<0.1	NSD	NSD	0.0	<0.05	<0.02
8	0.6	NSD	<0.4	0.0	0.33	0.12
9	0.2	NSD	0.6	0.3	0.37	0.12
10	<0.1	NSD	<0.3	0.0	<0.13	<0.04
OFFSITE						
5	<0.1	<0.3	<0.3	0.0	<0.18	<0.06
11	<0.1	<0.1	<0.2	0.2	<0.15	<0.04
12	0.1	<0.2	1.3	0.0	0.40	0.14
13	<0.1	<0.2	<0.3	0.0	<0.15	<0.04
14	<0.1	<0.1	<0.5	0.0	<0.18	<0.06
24	<0.1	<0.2	<0.2	0.0	<0.13	<0.04
25	<0.1	<0.1	<0.6	0.0	<0.20	<0.06
26	0.1	<0.1	<0.4	NSAD	<0.20	<0.06
27	<0.2	<0.2	<0.2	0.1	<0.18	<0.06

NSD: Not Sampled Dry
NSAD: Not Sampled Access Denied
(a) DOE Standard for Thorium-230 in Water is 300 pCi/L
(b) 1.0 pCi/L = 37 Bq/m^3

TABLE 2-6

ACTIVITY LEVELS OF DISSOLVED THORIUM-230 IN SURFACE WATER

AT THE WSS, 1986

LOCATION	ACTIVITY (pCi/L) (a) (b) 1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	AVERAGE	% of DCG
WSCP						
28	<0.7	NSLT	<1.0	0.0	<0.57	<0.18
29	<0.1	NSLT	<4.0	0.0	<1.37	<0.46
30	<0.1	NSLT	<4.0	0.0	<1.37	<0.46
31	NSD	NSD	NSD	0.0	0.00	0.00
32	0.3	NSLT	<0.6	0.0	0.30	1.00
33	<0.4	NSD	<0.7	0.0	<0.37	<0.12
34	<0.2	<0.2	<0.3	0.0	<0.18	<0.06
35	<0.2	<0.2	<0.4	0.0	<0.20	<0.06
36	<0.1	<0.4	<0.3	0.2	<0.25	<0.08
37	<0.1	<0.2	<0.4	0.0	<0.18	<0.06

NSD: Not Sampled Dry
NSLT: No Sample Lost in Transit
(a) DOE Standard for Thorium-230 in Water is 300 pCi/L
(b) 1.0 pCi/L = 37 Bq/m^3

average uranium concentrations ranging from 11 pCi/L, 2 percent of the DCG, to 36 pCi/L, 6 percent of the DCG. Radium-226 and thorium-230 concentrations averaged less than 1.0 pCi/L, less than 1 percent of the DCG. Elevated uranium levels at locations 35, 36 and 37 (Lakes 34, 35, and 36 respectively) are attributed to direct surface runoff from the WSS, or in the case of Lake 34, runoff from a contaminated spring.

Five surface water locations were sampled quarterly near the WSQ in 1986. Two of these locations, 6 and 7 (Little Femme Osage Creek, upstream and downstream), had uranium activity levels less than 3.0 pCi/L, which is less than 1 percent of the DCG. Radium-226 and thorium-230 activity levels averaged less than 1.0 pCi/L, also less than 1 percent of the respective DCGs. The remaining three locations 8, 9 and 10, all in the Femme Osage Slough, had uranium concentrations averaging from 49 pCi/L to 61 pCi/L, 8 to 10 percent of the DCG. This uranium contamination may be attributed to a combination of potential sources including: recharge to the slough from contaminated groundwater, contamination from the vicinity property located just north of the north bank of the Femme Osage Slough, or contamination from water pumped from the WSQ sump during the 1960's. Radium-226 and thorium-230 activities were less than 1.0 pCi/L, less than 1 percent of their DCGs.

The three sediment samples obtained during 1986 were collected in the drainage way from Frog Pond. Two samples were collected during the second quarter and one sample from the first quarter. These samples were analyzed for uranium, radium-226, and thorium-230. Uranium activity levels ranged from 31 pCi/g to 51 pCi/g, less than the remedial action guidelines of 60 pCi/g per 100 square meters. Radium-226 activity levels from 1 pCi/g to 1.7 pCi/g were present in the sediments, below the remedial action guidelines of 5 pCi/g per 100 square meters for the top six inches of soil. Thorium-230 activity levels were also below the excavation criteria. The radionuclide sediment data is shown in Table 2-7.

TABLE 2-7

RADIONUCLIDE ACTIVITIES IN SEDIMENT

RADIONUCLIDE	LOCATION NUMBER	QUARTERLY ACTIVITY (pCi/g, dry) 1ST	2ND	3RD	4TH	MEAN
Total Uranium						
	29	NS	51	NS	NS	51
	30	38	31	NS	NS	34
Radium-226						
	29	NS	1.0	NS	NS	1.0
	30	1.4	1.7	NS	NS	1.5
Thorium-230						
	29	NS	1.5	NS	NS	1.5
	30	0.9	1.1	NS	NS	1.0

NS: Not Sampled
SOURCE: WSSRAP, 1987.

2.3 RADON

The radon monitoring program continued in 1986 using Terradex Track Etch Cups at 31 locations. Fifteen detectors were placed at the WSCP, 6 at the WSRP, 6 at the WSQ, and 4 at offsite locations including a detector at the Busch Wildlife Area to establish background radon gas activity levels. (See Figures 2-8, 2-9 and 2-10).

At all of the properties, detectors were spaced along the site boundaries or near areas of contamination to ensure adequate detection capability under various atmospheric conditions. A total of 9 detectors were placed for quality control, two detectors each at the WSRP, the WSQ, offsite; and 3 were placed at the WSCP. (See Figures 2-8, 2-9 and 2-10.)

Table 2-8 summarizes the average annual activity levels of radon gas in air at the WSS, and shows them to be essentially at or near background levels. The background sample location (R15) at the Busch Wildlife area had an annual average of 0.47 pCi/L. The annual average activity levels at the WSCP ranged from 0.18 pCi/L to 0.49 pCi/L. The highest annual average above background was equal to 14 percent of the DOE Guideline of 3 pCi/L (annual average above background). At the WSRP the annual average activity levels ranged from 0.31 pCi/L to 0.64 pCi/L, with the highest activity levels above background equal to 18 percent of DOE Guideline. The WSQ annual average activity levels ranged from 0.24 pCi/L to 1.86 pCi/L, with the highest activity level above background equal to 53 percent of DOE Guideline. At offsite locations, the measured annual average activity level ranged from 0.22 pCi/L to 0.36 pCi/L, with the highest activity level equal to 10 percent of DOE guideline.

2.4 EXTERNAL GAMMA DOSE RATES

The external gamma exposure rates were measured using lithium

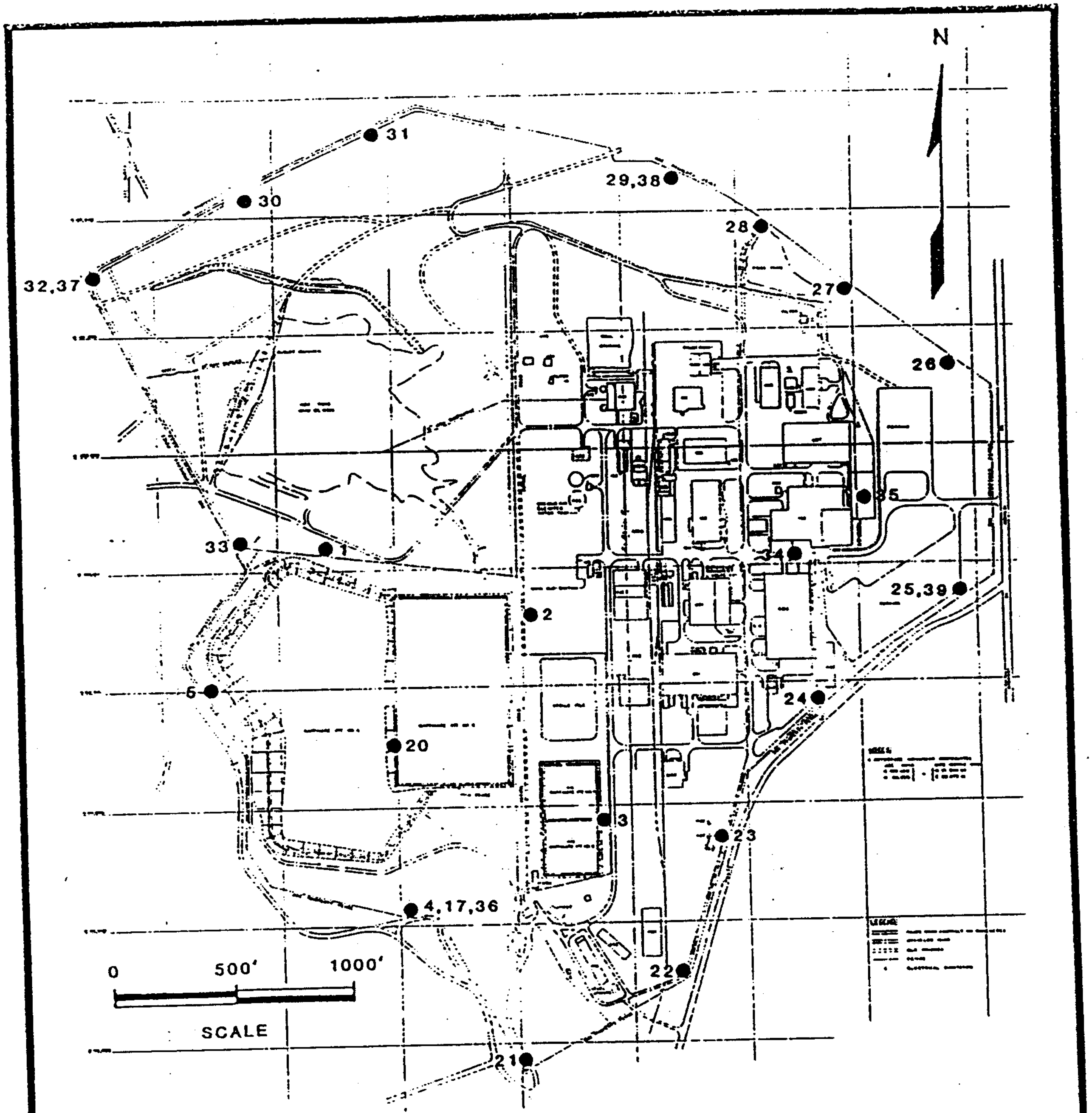

FIGURE 2-8

Radon And External Gamma Monitoring Locations
At The W.S.R.P. And W.S.C.P..

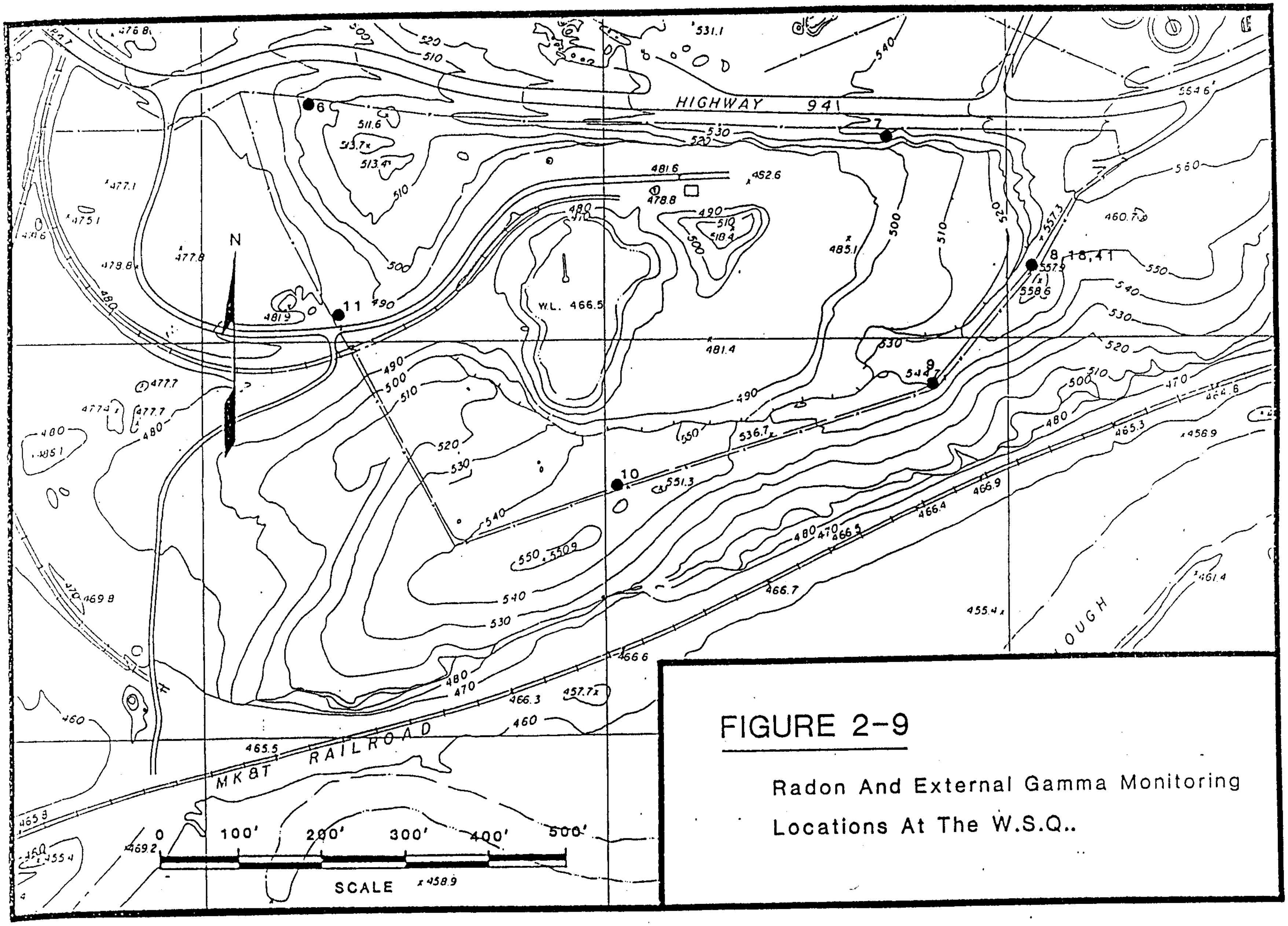

FIGURE 2-9

Radon And External Gamma Monitoring Locations At The W.S.Q..

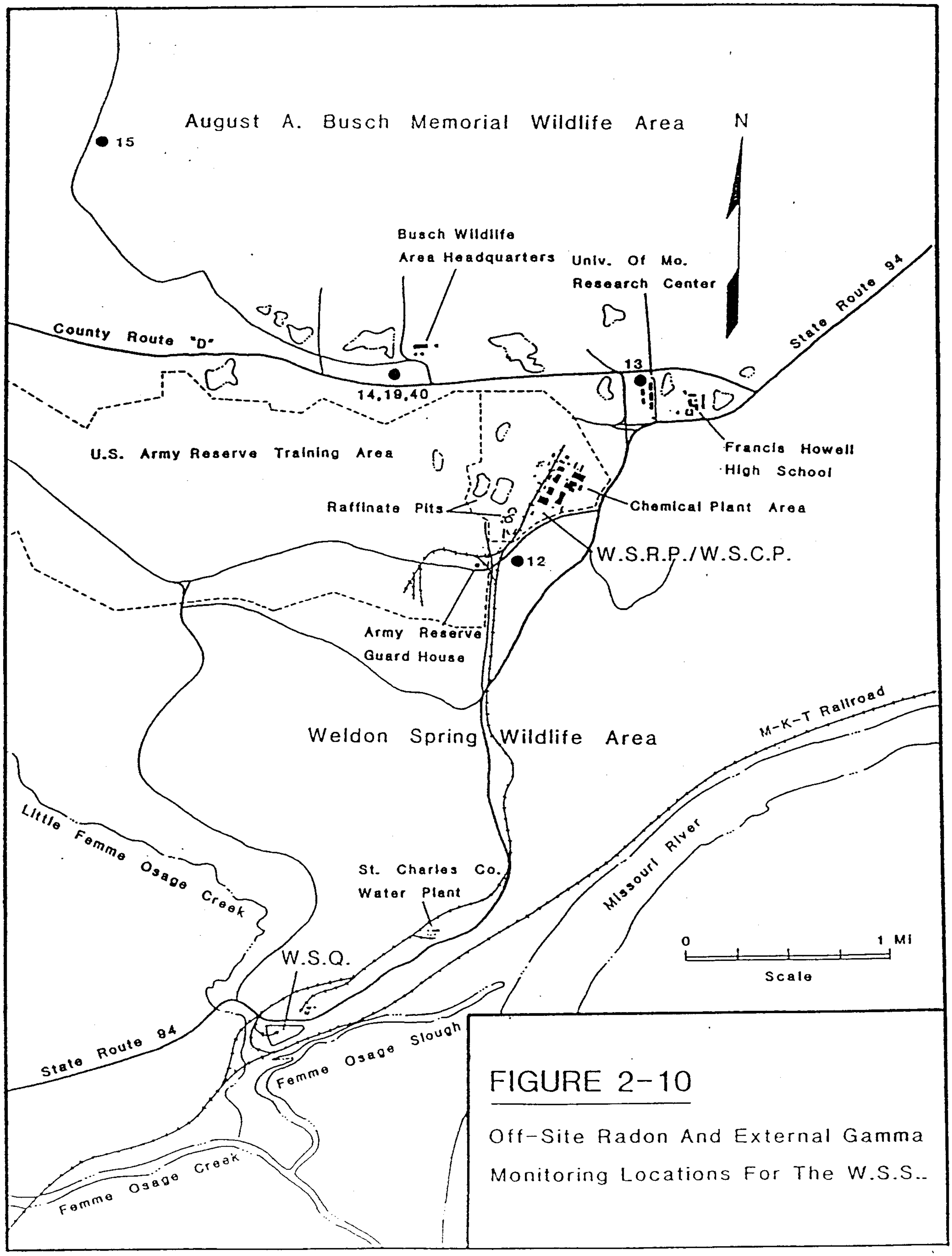

FIGURE 2-10

Off-Site Radon And External Gamma Monitoring Locations For The W.S.S..

TABLE 2-8

Radon-222 Gas Activity

At The WSS, 1986 *

Sample Location	(pCi/Liter) /Quarter 1	2	3	4	Annual Average	(j) Percentage of Guideline
WSCP						
R21	0.10	0.97	0.6	0.1	0.44	12.75
R22	0.53	0.23	0.4	0.0	0.29	8.36
R23	0.31	1.04	0.4	0.2	0.49	14.05
R24	0.12	0.30	0.6	0.0	0.26	7.35
R25	0.16	0.66	0.1	0.0	0.23	6.63
R26	0.14	0.37	0.4	0.1	0.25	7.28
R27	0.13	0.40	0.6	0.1	0.31	8.86
R28	0.19	0.35	0.3	0.4	0.31	8.93
R29	0.27	(i)	0.6	0.2	0.36	10.28
R30	0.19	0.63	0.7	0.1	0.40	11.67
R31	0.35	0.56	0.4	0.1	0.35	10.16
R32	0.19	0.44	0.2	0.1	0.23	6.70
R33	0.30	0.37	0.5	0.0	0.29	8.43
R34	0.09	0.30	0.5	0.3	0.30	8.57
R35	0.27	0.58	0.2	0.2	0.31	9.01
R37(d)	0.04	0.33	0.4	0.1	0.22	6.27
R38(e)	0.27	1.01	0.4	0.2	0.47	13.54
R39(f)	0.14	0.28	0.3	0.0	0.18	5.19
Background						
R15(g)	0.38	0.52	0.5	(i)	0.47	13.45

* All Samples include Background
(d) R37 is QC for R32
(e) R38 is QC for R29
(f) R39 is QC for R25
(g) R15 is Located at Busch Wildlife Area
(h) Not Sampled
(i) Detector Damaged
(j) DOE Concentration Guideline for Radon-222 is 3 pCi/L (annual ave. above background) for uncontrolled areas and 100 pCi/L (annual ave. above background) for controlled areas

TABLE 2-8

Radon-222 Gas Activity

At The WSS, 1986 *

Sample Location	(pCi/Liter) /Quarter 1	2	3	4	Annual Average	(j) Percentage of Guideline
WSRP						
R1	0.23	0.33	0.9	1.1	0.64	18.44
R2	0.31	0.79	0.9	0.2	0.55	15.85
R3	0.29	0.37	0.6	0.2	0.37	10.52
R4	0.50	0.46	0.7	0.2	0.47	13.40
R5	0.23	0.30	0.6	0.1	0.31	8.86
R17(a)	0.21	0.59	0.4	0.2	0.35	10.09
R36(a)	0.21	1.54	0.3	0.1	0.54	15.49
R20	0.31	0.85	0.5	0.2	0.47	13.40
WSQ						
R6	0.19	0.26	0.3	0.2	0.24	6.84
R7	0.65	1.13	1.0	0.6	0.85	24.35
R8	1.02	2.08	1.4	0.7	1:30	37.46
R9	1.00	0.59	0.3	0.5	0.60	17.22
R10	0.36	0.28	1.0	0.2	0.46	13.26
R11	0.36	0.66	0.3	0.4	0.43	12.39
R18(b)	1.66	2.56	2.4	0.8	1.86	53.46
R41(b)	1.22	1.42	1.3	1.0	1.24	35.59
Offsite						
R12	0.14	0.75	0.2	0.0	0.27	7.85
R13	0.14	0.35	0.5	0.1	0.27	7.85
R14	0.19	0.33	0.7	0.2	0.36	10.23
R19(c)	0.21	0.47	0.6	0.1	0.35	9.94
R40(c)	0.19	0.30	0.3	0.1	0.22	6.41

* All Sample results include background
(a) R17 and R36 are QC for R4
(b) R18 and R41 are QC for R8
(c) R19 and R40 are QC for R14
(i) Detector Damaged
(j) DOE Concentration Guideline for Radon-222 is 3 pCi/L (annual ave. above background) for uncontrolled areas and 100 pCi/L (annual ave. above background) for controlled areas

fluoride thermoluminescent dosimeter (TLDs). The TLDs were exchanged quarterly. The sampling locations for external gamma dose rate measurements are the same as for radon (see Figures 2-8, 2-9, 2-10). The detectors were placed in such a manner as to ensure adequate measurement of potential exposure of members of the public.

The results of external gamma dose rate measurements are presented in Table 2-9. At the WSRP area perimeter, the highest gamma exposure rate above background was 11.47 mR/yr.

If a full time occupancy is assumed for that area, the subsequent dose rate would be about 11 percent of the DOE radiation protection standard of 100 mrem/yr (1 mSv/yr) (Appendix A). At the WSQ, the highest exposure rate above background was 31.46 mR/yr. If a full time occupancy is assumed for that area, the subsequent dose rate would be about 32 percent of the DOE radiation protection standard of 100 mrem/yr (1 mSv/yr). At the offsite locations, the highest gamma exposure rate above background was, 12.86 mR/yr. At the WSCP site boundary, the highest gamma exposure rate above background was 10.25 mR/yr.

TABLE 2-9

TLD External Radiation Measurement At WSS, 1986

Sample Location	mR / Exposure Interval 1	2	3	4	Average	Calculated mR / Week 1	2	3	4	Average	uR/h	Total mR/Yr	Total-Background mR/Yr	% Above Background
WSRP														
T1	(h)	35.3	25.2	44.4	35.0	(h)	1.70	1.42	2.85	1.99	11.85	103.76	29.72	40.14
T2	(h)	35.4	29.4	40.2	35.0	(h)	1.71	1.66	2.58	1.98	11.81	103.42	29.37	39.67
T3	---	35.2	(i)	38.8	37.0	---	1.70	(i)	2.49	2.10	12.47	109.24	35.20	47.54
T4	(h)	31.0	22.0	34.0	29.0	(h)	1.50	1.24	2.18	1.64	9.76	85.51	11.47	15.49
T5	(h)	24.6	23.0	31.0	36.7	(h)	1.19	1.30	1.99	1.49	8.89	77.87	3.82	5.16
T17(a)	(h)	28.0	22.4	29.8	26.7	(h)	1.35	1.26	1.91	1.51	8.97	78.56	4.52	6.10
T36(a)	(h)	29.6	23.8	31.8	28.4	(h)	1.43	1.34	2.04	1.60	9.54	83.60	9.56	12.91
T20	(h)	33.2	31.0	(i)	32.1	(h)	1.60	1.75	(i)	1.68	9.97	87.34	13.30	17.96
WSQ														
T6	(i)	30.0	---	33.0	31.5	(i)	1.45	---	2.12	1.79	10.63	93.08	19.03	25.70
T7	(h)	37.8	31.4	38.4	35.9	(h)	1.83	1.77	2.47	2.02	12.04	105.50	31.46	42.49
T8	(h)	37.2	29.6	37.6	34.8	(h)	1.80	1.67	2.41	1.96	11.67	102.20	28.16	38.03
T9	(i)	35.4	25.2	38.6	33.1	(i)	1.71	1.42	2.48	1.87	11.13	97.51	23.46	31.69
T10	(h)	31.2	27.0	37.4	31.9	(h)	1.51	1.52	2.40	1.81	10.77	94.38	20.34	27.46
T11	(h)	28.6	23.4	30.8	27.6	(h)	1.38	1.32	1.98	1.56	9.29	81.34	7.30	9.86
T18(b)	(h)	32.8	31.6	39.8	34.7	(h)	1.58	1.78	2.56	1.97	11.75	102.90	28.85	38.97
T41(b)	(i)	36.2	26.4	40.0	34.2	(i)	1.75	1.49	2.57	1.94	11.53	100.98	26.94	36.38
OFFSITE														
T12	(h)	(i)	20.2	29.6	24.9	(h)	(i)	1.14	1.90	1.52	9.05	79.26	5.21	7.04
T13	(h)	27.6	21.6	31.6	26.9	(h)	1.33	1.22	2.03	1.53	9.09	79.60	5.56	7.51
T14	(h)	29.2	26.6	32.6	29.5	(h)	1.41	1.50	2.09	1.67	9.92	86.90	12.86	17.37
T19(c)	(h)	28.2	22.8	32.2	27.7	(h)	1.36	1.29	2.07	1.57	9.37	82.04	8.00	10.80
T40(c)	(h)	28.4	24.4	31.6	28.1	(h)	1.37	1.38	2.03	1.59	9.48	83.08	9.04	12.21
EXPOSURE INTERVAL (DAYS)	(119)	(145)	(124)	(109)	(124)									

(a) T17 and T36 are QC for T4
(b) T18 and T41 are QC for T8
(c) T19 and T40 are QC for T14
(h) Data invalidated due to transit exposure
(i) TLD missing

TABLE 2

TLD External Radiation Measurement At HSS, 1986

Sample Location	mR / Exposure Interval 1	2	3	4	Average	Calculated mR / Week 1	2	3	4	Average	uR/h	Total mR/Yr	Total-Background mR/Yr	% Above Background
HSCP														
T21	(h)	21.0	24.2	29.6	24.9	(h)	1.01	1.37	1.90	1.43	8.49	74.39	0.35	0.47
T22	(h)	24.6	20.2	26.2	23.7	(h)	1.19	1.14	1.68	1.34	7.96	69.70	0.00	0.00
T23	(h)	23.8	22.9	31.8	26.1	(h)	1.15	1.29	2.04	1.49	8.89	77.87	3.82	5.16
T24	(h)	31.0	28.0	33.0	30.7	(h)	1.15	1.58	2.12	1.62	9.62	84.30	10.25	13.85
T25	(h)	30.8	21.4	33.4	28.5	(h)	1.49	1.21	2.15	1.62	9.62	84.30	10.25	13.85
T26	(h)	24.0	21.0	33.0	26.0	(h)	1.16	1.12	2.12	1.47	8.73	76.46	2.42	3.26
T27	(h)	27.5	23.2	30.5	27.1	(h)	1.33	1.31	1.96	1.53	9.13	79.95	5.91	7.98
T28	(h)	26.8	22.2	29.8	26.3	(h)	1.29	1.25	1.91	1.48	8.83	77.35	3.30	4.46
T29	(h)	(i)	20.6	28.2	24.4	(h)	(i)	1.16	1.81	1.49	8.84	77.43	3.39	4.58
T30	(h)	29.6	24.8	28.2	27.5	(h)	1.43	1.40	1.81	1.55	9.21	80.65	6.60	8.92
T31	(h)	30.0	24.0	31.2	28.4	(h)	1.45	1.36	2.00	1.60	9.54	83.60	9.56	12.91
T32	(h)	23.8	20.2	29.2	24.4	(h)	1.15	1.14	1.88	1.39	8.27	72.48	0.00	0.00
T33	(h)	26.6	24.4	30.2	27.1	(h)	1.28	1.38	1.94	1.53	9.13	79.95	5.91	7.98
T34	(h)	33.8	24.6	39.0	32.5	(h)	1.63	1.39	2.50	1.84	10.95	95.94	21.90	29.58
T35	(h)	23.8	21.2	28.5	24.5	(h)	1.15	1.20	1.83	1.39	8.29	72.65	0.00	0.00
T37(d)	(h)	23.8	19.0	29.8	24.2	(h)	1.15	1.07	1.91	1.38	8.19	71.78	0.00	0.00
T38(e)	(h)	(i)	20.2	30.4	25.3	(h)	(i)	1.14	1.95	1.55	9.20	80.56	6.52	8.80
T39(f)	(h)	24.0	18.8	28.8	23.9	(h)	1.16	1.06	1.85	1.36	8.08	70.74	0.00	0.00
Background														
T15(g)	(h)	30.4	24.2	(i)	27.3	(h)	1.47	1.37	(i)	1.42	8.45	74.04	0.00	0.00
EXPOSURE INTERVAL (DAYS)	(119)	(145)	(124)	(109)	(124)									

(d) T37 is QC for T32
(e) T38 is QC for T29
(f) T39 is QC for T25
(g) T15 is Located at Busch Wildlife Area
(h) Data invalidated due to transit exposure
(i) TLD missing

3.0 RELATED ACTIVITIES AND SPECIAL STUDIES

In addition to the routine monitoring activities conducted during 1986, several activities in support of the Environmental Impact Statement (EIS) were initiated. These activities were designed to collect further data in order to more definitively characterize waste materials from the two interim storage areas; the WSQ and the WSRP. Two additional programs were initiated by the USGS and the MODNR to assess groundwater quality.

What follows is an overview and rationale of the special programs conducted in 1986; the number and types of samples collected; the chemical and radiological analytical results; and the conclusions, determinations, and limitations of the information collected.

3.1 CHEMICAL CHARACTERIZATION OF THE WSQ

Investigation performed by Lawrence Berkeley prior to September 1984 provided preliminary information on the waste inventory in the WSQ. A more intensive characterization of the WSQ waste materials was conducted by Bechtel National and Eberline Analytical Corporation during the periods of October to December 1984, and April to May 1985. (BNI, September 1985). During this survey, measurements of surface beta-gamma radiation levels, near surface gamma radiation levels, and gamma radiation measured 3 feet above ground surface throughout the quarry area were made. Radon gas emanation rate from radiologic waste sources was also measured. Boreholes were drilled and logged for gamma activity. Soil, water, and sediment samples were collected and analyzed for predominantly radiological parameters. A limited number of samples were analyzed for chemical parameters.

Results from this effort indicated concentrations of uranium in soils from WSQ boreholes in excess of the DCG's. Analysis of water and sediments from the quarry sump showed elevated concentrations of uranium-234 and 235. Priority pollutant organics, pesticides, and PCB's were not detected. Chromium and mercury were detected, but at concentrations less than drinking water standards.

Soil samples were analyzed to test whether soils exhibited the characteristics of EP Toxicity (metals leachability). Several metals (barium, cadmium, chromium, lead, and selenium) exhibited leachable species, although no leachable metals in excess of EP Toxicity standards were detected.

While this effort was able to characterize the waste in the quarry radiologically, the number of samples analyzed for chemical parameters was not sufficient to allow for statistical confidence to characterize the heterogenous waste in the WSQ. A confirmatory sampling effort was conducted by BNI and TMA/Eberline from October to December 1986. This investigation focused on the level of organic compounds that might be present in the soils, debris, and waters of the quarry. Sixteen boreholes were drilled, with composites samples prepared over three feet intervals. Composite samples were analyzed for priority pollutant organics, PCB's and nitroaromatic species.

The results and interpretations from this investigation were not available at the time of this report. A report summarizing the data from this effort will be available during the second quarter of 1987.

3.2 WATER QUALITY AT THE WSQ AND SURROUNDING AREAS

In September 1986, twelve samples were collected from waters influenced by the waste material present in the quarry. The purpose of this survey was to assess the migration of nonradiological compounds into the alluvial aquifer and surface waters of the well field. This sampling effort was conducted immediately prior to the confirmatory chemical characterization of the quarry waste materials. The analytical data from this program was incorporated into the Draft Environmental Impact Statement (DEIS).

Of the twelve samples collected for analysis, eight samples were collected from groundwater monitoring wells (TW-N, TW-S, TW-7, TW-9, O-3, OB-6A, OB-14, and OBS-12), two from the Quarry Sump waters, and two samples from the Femme Osage Slough.

Water samples were analyzed for priority pollutants, nitrate and nitroaromatics. Priority pollutant analysis included: volatile organics, semi-volatile organics, pesticides, metals, and PCB's.

Results from this sampling indicated that volatile organics were not present in any of the samples with the exception of the Quarry Sump and TW-7 which showed levels of toluene at 5 parts per billion (ppb) and 12 ppb respectively.

Semi-volatile organics, PCB's, and pesticides associated with environmental contamination were not detected in any samples. Benzene hexachloride (BHC), formerly used as an agricultural pesticide was detected (0.28 ppb) in the samples from the Femme Osage Slough. BHC is most likely related to past agricultural applications nearby since BHC was not detected in any quarry samples.

Metals analysis indicated a variety of metals present in all water tested. Concentrations of several metals (arsenic, lead, and manganese) exceeded drinking water standards at two wells (O-3, and TW-7) Figures 2-2 and 2-3. Additional samples will be collected during 1987 from alluvial wells to better evaluate the level of metals in this aquifer. This will enable a better comparison between background and contaminant metal concentrations. Nitroaromatics (TNT and decomposition residues) were detected in several samples. TNT was detected in the Quarry

Sump at a concentration of 4.6 ppb. TNT was not detected at any other location. Several of the decomposition products (2,4-dinitrotoluene, 4-amino-2,6-dinitrotoluene) were detected at wells OB-14 and TW-7. However, the laboratory analytical recovery data (quality control) for these decomposition products was poor, therefore confidence in the chemical data associated with the presence of these compounds is poor. Additional samples will be collected and analyzed for nitroaromatics in 1987 as part of Phase I Assessment Program. This data will be used to confirm or deny the presence of decomposition products in wells surrounding the WSQ.

3.3 CHEMICAL CHARACTERIZATION OF THE WSRP

In December 1985, sediment samples were collected from the raffinate pits for chemical analysis to determine whether the sediment exhibited characteristics of RCRA wastes. These tests included tests for ignitability, corrosivity, reactivity, and EP Toxicity. Samples were also analyzed for PCB's, isotopic uranium, isotopic thorium, isotopic radium, lead-210, and polonium-210. Radiological and PCB analyses were performed in support of, and have been incorporated into the DEIS. PCB compounds were not detected in any pit sediment.

A total of eighteen sediment samples were analyzed for hazardous waste characteristics. Testing indicated no leachable metals in excess of EP toxicity values. EP Toxicity herbicides and PCB compounds were not detected in any of the raffinate pit sediment samples. Samples did not exhibit the characteristics of ignitability, corrosivity, or reactivity.

3.4 USGS AND MODNR SAMPLING

During 1986, both the U.S. Geological Survey (USGS) and the Missouri Department of Natural Resources (MODNR) performed sampling on and near the WSS. The USGS published two reports during 1986 entitled "Compilation and Preliminary Interpretation of Hydrological Data for the Weldon Spring Radioactive Waste-Disposal Sites, St. Charles County, Missouri -- A Progress Report" (Water-Resources Investigation Report, 85-4272) and "Hydrological Data for the Weldon Spring Radioactive Waste-Disposal Sites, St. Charles County, Missouri - 1984-1986" (Open-File Report 86-488). The first report presented background data and sample results from existing wells. The USGS installed 10 monitoring wells on the Busch Wildlife Area in early 1986. The open file report presents water quality data from numerous wells and surface water bodies on and around the WSS. This document reported nitrate and uranium contamination of 5 wells near the WSRP. Also noted in this report is the uranium contamination of 13 wells north of the Femme Osage Slough near the WSQ.

The elevated nitrate levels reported by the USGS range from 53 mg/L to 990 mg/L, 5 to 99 times the Missouri State drinking water standard of 10 mg/L. Confirmatory sampling conducted by DOE in 1986 supported these values. At the present time, numerous potential sources are being investigated. These include: the Weldon Spring Ordnance Works processes, the Nitric Acid Tank Farm, the Raffinate Pits and past spills of nitric acid at the WSCP.

The USGS considered uranium values to be above background if the concentration exceeded 5 parts per billion (ppb) (greater than 3.5 pCi/L). Two of the wells near the WSRP were less than 2 ppb above background, approaching the error limit of the analysis. The remaining 3 wells near the WSRP, had uranium concentrations ranging from 50 ppb to 86 ppb (35 pCi/L to 56 pCi/L). Analysis of water from these wells performed by DOE did not completely confirm eariler USGS results. Additional sampling and analysis will be performed to better evaluate the uranium concentration at these locations.

In addition to the wells near the WSRP, the USGS also sampled 13 monitoring wells in the WSQ area. Data from this sampling effort corresponds with radiologic data collected by DOE during characterization activities.

The MODNR sampled 13 wells in September of 1986. Five of the wells are located in the WSRP portion of the WSS. Eight of the wells are located near the WSQ. The samples were analyzed for lithium, total dissolved solids, sulfate, nitrate, gross alpha activity, and gross beta activity. Levels above background were not detected in any of the wells. At two of these wells (OBS-11 and OBS-14) samples were split with nearly identical background results obtained. The wells near the WSQ are located on the south side of the Femme Osage Slough.

4.0 RADIOLOGICAL EXPOSURE

To assess the health effects of the radioactive materials stored at the Weldon Spring Sites, the maximum radiological exposure of a hypothetical individual was evaluated for the area surrounding the WSQ and the WSRP/WSCP areas. This individual is one who is assumed, when all potential routes of exposure are considered, to receive the largest credible dose. An appraisal of potential pathways suggest that external gamma irradiation and ingestion of tissue from fish containing natural uranium, radium-226, and thorium-230 are the principal exposure modes. These pathways will be addressed to determine all potential sources of exposure.

For each of the pathways considered at a given site, almost all organs in the body receive some radiological exposure. However, depending on the route of internal deposition and the chemical characteristics of the radionuclide(s) involved, certain organs or tissues may receive a higher exposure than others. These are referred to as "organs at risk" because the effect of the exposure is greater or maximized in them.

Radium, thorium, and uranium entering the body via ingestion have a greater tendency to migrate and incorporate into the bone, kidney, intestines and gonads. These are the main or most at risk organs for the ingestion pathway. Establishing an internal dose to these tissues by converting measured concentrations in water and fish required several assumptions. An intake rate was postulated for the consumption of fish. The International Commission on Radiological Protection (ICRP 23) estimated that a normal dietary intake would be 22 grams of fish per day. An official from the Missouri Department of conservation stated that it was possible for an individual to fish from the lakes on the Wildlife Area and consume this amount over a period of one (1) year.

Radionuclide intakes were converted to internal doses to these tissues most at risk using the methodology described in ICRP 26 and 30 and the Committed Dose Equivalent Tables for U.S. DOE Population Dose Calculations. All internal doses represent the intake of radionuclides over a one year time interval with a calculated 50 year dose commitment. The 50 year dose commitment concept provides for the fact that an intake of a radionuclide with a long half-life (such as radium, thorium, and uranium) may result in an internal exposure for many years.

Gamma radiation from external sources is assumed to irradiate the body uniformly. The total or whole body is therefore the principal organ at risk for external gamma radiation exposure. All internal organs are assumed to be exposed to the same level as the entire body. The exposure to an organ resulting from both internal and external sources is additive.

Inhalation of radon and its subsequent radioactive daughters is also a pathway; however, an accurate, quantitative determination of dose is not possible because of uncertainties concerning the distribution of exposure. Measured radon concentrations have been compared to applicable DOE guidelines. The highest annual average for uncontrolled areas at the WSQ and WSRP/WSCP are equal to approximately 42 and 14 percent of the DOE Guidelines, respectively.

To identify the individual in the vicinity of the WSRP/WSCP and the WSQ who would receive the highest dose from radioactive materials present on-site, the combined dose from the ingestion of tissue from fish and exposure to external gamma radiation were calculated with results from various monitoring locations that could be accessible to the public.

4.1 MAXIMUM DOSE AT WSRP/WSCP TO A HYPOTHETICALLY EXPOSED INDIVIDUAL

At the WSRP/WSCP, the highest average gamma exposure rate in an unrestricted area including normal background (84 mR/yr.) was measured at a vicinity property located 0.5 miles from the site. The highest average gamma exposure rate at the site fenceline including normal background was 83 mR/yr., measured near the Raffinate Pits. Normally, as the distance from a radioactive source increases, the gamma activity will decrease rapidly. Since the vicinity property location has a higher exposure rate, the small difference is probably due to the normal variance for natural deposits of radionuclides in soil. Many soils and fertilizers contain elevated amounts of naturally occurring radionuclides. The calculation for the difference from background activity, which was measured as 74 mR/year, may be biased from any true difference, due to these naturally occurring radionuclides.

Using the highest average gamma exposure rate above background, 10 mR/yr., with a 40 hour per week occupancy factor, the annual dose is 2.4 mrem (2.4E-02 mSv). Therefore, the maximum dose to a hypothetically exposed individual is 2.4 mrem (2.4E-02 mSv).

A realistic pathway analysis for internal deposition shows that the maximum dose to an individual would result from ingestion of tissue from contaminated fish from Lakes 34 and 35. Incidental exposures and the direct exposure from the water are negligible in this calculation. Portions of the surface water exiting the site from Ash Pond outfall flows overland to Lake 35. The remaining surface water from Ash Pond enters subsurface drainage which flows into Burgermeister Spring and ultimately into Lake 34. Because the dilution factors between Ash Pond outfall and the area lakes are not documented, the dose from ingestion of tissue from fish from these lakes are based on a worst case concentration. Using no dilution factors, the surface water measurement at the outfall is used to calculate an equivalent tissue concentration of fish in the lakes. Other studies (Wang, 1986) suggest that the uptake of uranium in fish living in such waters is on the order of 0.3 percent. Until this is verified, all calculations are conservative and use a 1:1 ratio for intake to uptake. The average uranium, radium-226, and thorium-230 activity levels at the outfall are 2,700, 0.1, and 0 pCi/L, respectively. In a one year period, ingestion of tissue from fish living in waters at this activity level would result in an effective dose equivalent. An effective dose equivalent is the product of all tissues and organs at risk and their whole body weighting factors. The effective dose equivalent for fish from these lakes is 0.25 mrem (2.5E-03 mSv).

The 2.37 mrem (2.4E-02 mSv) dose from external gamma radiation and the 0.25 mrem (2.5E-03 mSv) dose from the ingestion of fish tissue are added together to calculate the total dose. The maximally exposed individual at the WSRP/WSCP would receive a total of 2.6 mrem (2.6E-02 mSv).

4.2 MAXIMUM DOSE AT THE WSQ TO A HYPOTHETICALLY EXPOSED INDIVIDUAL

For the properties surrounding the WSQ, there is no routine occupancy. The external gamma radiation dose to a member of the public was calculated assuming an individual walks past the site along Highway 94 twice per day. The highest exposure rate, 31.46 mR/yr above the background measurement, is on the northern perimeter. Using this measurement, the calculated annual dose from this activity is 0.5 mrem (5.2E-03 mSv), assuming a daily exposure of approximately 20 minutes.

A realistic pathway analysis for internal deposition shows the maximum internal dose to an individual would result from ingestion of contaminated fish from the Femme Osage Slough. Using the same conservative assumptions used for the WSCP/WSRP area and the location in the slough with the highest average surface water activity level an equivalent tissue activity level of the fish was determined.

The highest average uranium, radium-226, and thorium-230, activity levels from a sampling location in the Slough are 61, 0.47, and 0.13 pCi/L, respectively. Ingestion of tissue from fish who live in waters at this concentration would result in an annual effective dose equivalent, of 0.01 mrem (1.0E-04 mSv).

The 0.5 mrem/yr (5.2E-03 mSv/yr) dose from external gamma radiation and the 0.01 mrem/yr (1.0E-05 mSv/yr) internal dose from the ingestion of fish tissue are added together to calculate the total affective dose equivalent. The hypothetically exposed individual at the WSQ would receive 0.5 mrem/yr (5.3E-03 mSv/yr).

4.3 DOSE TO THE POPULATION IN THE VICINITY OF THE WSS

The dose to a population represents the conceptual cumulative radiation dose to all residents within an 80-km (50 mi) radius of a given site. This calculated dose includes contributions from all potential pathways. For the WSS these pathways are: direct exposure to gamma radiation, inhalation of radon gas, and ingestion of water, fish or game animals containing radioactivity.

The contribution to the population dose made by gamma radiation from the radioactive materials present on-site is too small to be measured; gamma radiation levels decrease rapidly as distance from the source of contamination increases. For example, if the gamma exposure rate at a distance of 0.9 m (3 ft) from the radioactive source were 1000 mrem/yr, the exposure rate at a distance of 6.4 m (21 ft) from the source would be indistinguishable from naturally occurring background radiation. Similarly, radon gas is known to dissipate rapidly as distance from the radon source increases. Therefore, exposure from the low radon concentrations at the WSS does not contribute significantly to population dose.

On the basis of radionuclide activity levels measured in water leaving the WSS, it also appears that there is no predictable pathway by which ingestion of water, fish or game animals could result in a significant dose to the population. As water migrates farther from the source, radionuclide concentrations are further reduced, thereby lowering potential doses to even less significant levels. Since the contributions to population dose via all three potential exposure pathways are inconsequential, calculation of dose to the population is not warranted. The cumulative dose to the population within an 80 km (50 mi) radius resulting from radioactive materials present at the WSS would be indistinguishable from the dose that the same population would receive from naturally occurring radioactive sources.

5.0 FUTURE ENVIRONMENTAL MONITORING AT THE WSS

In 1987, the Environmental Monitoring Program will be expanded in order to monitor release pathways for both radiological and chemical constituents. The program will be dynamic in nature, changing to meet the monitoring needs of the site, as new physical or analytical data is assimilated, or as release pathways are better understood. These release pathways include: groundwater (via subsurface migration), surface water (via storm water runoff), and air. Previous years' programs have focused attention on potential exposure due to release of radiological constituents only.

In order to evaluate potential releases associated with former solid waste management units (SWMU), past management practices, or accidental spills related to the former ordnance works and the existing uranium processing facility, certain inorganic and organic constituents will be added to the radiological parameters in the Environmental Monitoring Program. Inorganic constituents include species such as nitrate, sulfate, chloride, fluoride, and total organic carbon. Organic constituents include nitroaromatic compounds such as TNT and DNT and their breakdown products.

Requirements for investigation of past and existing SWMU's were incorporated in the Resource Recovery Conservation Act (RCRA) as part of the 1984 Hazardous and Solid Waste Amendments. SWMU's are defined as any discernible waste management unit at a facility from which potentially hazardous constituents might migrate, irrespective of whether the unit was intended for the management of solid and/or hazardous waste. SWMU's include containers, tanks, piping, surface impoundments, waste piles, water treatment units, and areas contaminated by "routine", deliberate, or systematic discharges from process areas.

Some specific SWMU's located at the WSCP include the nitric, sulfuric, and hydrofluoric acid tanks. Additional chemical constituents being added to the Environmental Monitoring Program are intended to monitor potential releases from these inactive SWMU's and areas resulting from past management practices or accidental spills. The primary SWMU's at the WSRP are the Raffinate Pits themselves and possibly the spoils pile.

Table 5-1 summarizes the quarterly environmental activities planned for the 1987 Environmental Monitoring Program. A total of 34 monitoring wells on and around the WSS will be sampled quarterly. This is an increase of an additional 16 monitoring wells over previous programs. The four monitoring wells surrounding the WSRP, screened in the overburden and routinely dry, will no longer be included in the monitoring program. Six additional monitoring wells screened in the limestone bedrock will be sampled as replacements. Lysimeters will be installed at varying depths surrounding the WSRP. These lysimeters will be used to monitor pore water in the unsaturated soils surrounding the pits. Surface water samples will be collected from 20 locations where measurable impacts from drainage originating at the Weldon Spring Site may be detected. A total of 19 locations will be monitored quarterly for radon gas and external gamma exposure. While the number of locations is half the previous years' program, the total number of detectors will remain the same. This will improve the precision and accuracy of the radon and gamma measurements. In addition to the quarterly sampling, storm water runoff from 5 outfalls at the WSCP and the WSRP will be collected monthly, as required by the proposed National Pollutant Discharge Elimination System (NPDES) Permit for the Weldon Spring Site.

Although DOE has not performed fugitive dust sampling for radiological parameters at the site perimeter as part of past years' environmental monitoring programs, it is not expected that measurable levels (significantly above background) do not exist. However, DOE installed eight samplers in late 1986 at five perimeter locations and three nearby sensitive receptor

Table 5-1 Quarterly Monitoring Activities

LOCATION	NUMBER OF SAMPLES/QUARTER					
	GROUND WATER SAMPLES COLLECTED	SURFACE WATER SAMPLES COLLECTED	NPDES* SAMPLES COLLECTED	RADON-222 MONITORING STATIONS	TLD MONITORING STATIONS	AIR PARTICULATES MONITORING STATIONS**
WSCP	13	5	5	5	5	3
WSRP	8			5	5	2
WSQ	12	6		6	6	
OFFSITE	1	9		3	3	3
TOTALS	34	20	5	19	19	8

* PROPOSED IN THE NEW PERMIT; SAMPLES COLLECTED ONCE PER MONTH FOR A TOTAL OF 15 SAMPLES PER QUARTER.

** SAMPLES COLLECTED TWICE PER WEEK FOR A TOTAL OF 208 SAMPLES PER QUARTER.

locations.

Air monitoring will be performed at these locations to establish ambient baseline data and to monitor for potential off-site releases. The program will also assess the effectiveness of engineering controls at the site during remedial action.

Potential emissions from the site (primarily during remedial action construction) include particulate matter, asbestos, radioactive particles, metals and unknown chemicals. A separate program (site characterization study) will determine the presence of these chemicals at the site. If the presence of other chemicals is confirmed, air sampling for additional parameters may be instituted if airborne transport of the chemicals presents a potential hazard.

Carbon monoxide, sulfur dioxide, nitrogen oxides, ozone, and volatile organic compounds are not expected to be emitted from the site in significant quantities since there will be no significant combustion processes used during remedial action. As such, these parameters will not be measured at the site.

Air samples will be collected at the five perimeter stations and at the three nearby sensitive receptor stations.

In March 1987, a Phase I Assessment will be conducted at the WSS. The Phase I Assessment is a one-time program to evaluate the water quality at 19 new monitoring wells (installed in 1986), 30 existing wells, and 17 surface water locations. The purpose of this program is to obtain an complete overview of the quality of the water influenced by the WSS. Analytical parameters to be determined include:

1. RADIOLOGICAL PARAMETERS - Dissolved uranium; radium-226 and 228; thorium-230 and 232; gross alpha and gross beta activity,

2. <u>INORGANIC CONSTITUENTS</u> - EPA Contract Lab Program (CLP) metals, nitrate, sulfate, fluoride, chloride, TOC, and

3. <u>ORGANIC CONSTITUENTS</u> - EPA Hazardous Substance List.

The results from this sampling will be available in mid-1987. The data will be evaluated and a determination made for each sampling location as to whether additional monitoring is appropriate. If required, the Environmental Monitoring Program will be amended to reflect any changes in monitoring requirements based on the Phase I Assessment. These amendments may include the recommendation that additional monitoring wells be installed and that certain existing wells be replaced. In addition, this may allow better monitoring of existing conditions and/or anticipated conditions during future remedial actions. These additional wells, should any be necessary, are not intended to characterize aquifers, but rather are to monitor changes before, during, and after remedial actions. Additional wells may be needed for characterization and/or monitoring at the WSS.

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APPENDICES

APPENDIX A

ENVIRONMENTAL GUIDELINES

The radiation protection standard and associated Derived Concentration Guides (DCG) applicable to Department of Energy installations are listed below.

The radiation protection standard is 100 mrem/yr.

RADIONUCLIDE	TRANSPORT MEDIUM	LIMITING DCG (UNRESTRICTED AREA)
Uranium-Natural	Water	550 pCi/L
Radium-226	Water	100 pCi/L
Radon-222	Air	3 pCi/L
Thorium-230	Water	300 pCi/L

APPENDIX B

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATION

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).

ALARA: An acronym for "As Low as Reasonably Achievable". This refers to the DOE goal of keeping releases of radioactive substances to the environment and exposures of human 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 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.

BETA PARTICLE: Charged particle emitted from the nucleus of an atom, with a mass and charge equal in magnitude to that of the electron.

COMMITTED DOSE EQUIVALENT: The total dose equivalent averaged throughout a tissue in the 50 years after intake of a radionuclide into the body.

CONTAMINATION: The inclusion of foreign substances in or on the surfaces of soils, structures, areas, objects, or personnel.

CURIE: A measure of the rate of radioactive decay. One Curie (Ci) is equal to 37 billion disintegrations per second (3.7×10^{10} dis/s), which is approximately equal to the decay of one gram of Radium-226.

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.

DISCHARGE: In groundwater hydrology, the rate of flow (usually from a well) at a given instant in terms of volume per unit 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: Radiation per unit 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 film badge (TLD).

APPENDIX C

QUALITY ASSURANCE

A comprehensive quality assurance program was maintained to ensure that the data collected were representative of actual concentrations in the environment. First, extensive environmental data were obtained to prevent reliance on only a few results, which might not be representative of the existing range of concentrations. Second, newly collected data were compared with both recent results and historical data for each location and each environmental medium to ensure that deviations from previous conditions were identified and evaluated. Third, samples at all locations were collected using published procedures to ensure consistency in sample collection. Fourth, each analytical laboratory verified the quality of the data by conducting a continuing program of analytical quality control, participating in interlaboratory crosschecks, and performing replicate analyses, and splitting samples with other recognized laboratories. Fifth, chain-of-custody procedures were implemented to maintain traceability of samples and corresponding analytical results. This program ensures that the monitoring data can be used to evaluate accurately the environmental impacts from site operations.

Laboratories performing analyses maintained an internal quality assurance program that involved routine calibration of counting instruments, source and background counts, routine yield determinations for radiochemical procedures, and replicate analyses to check precision. The accuracy of radionuclide determinations was ensured through the use of standards traceable to the National Bureau of Standards, when available. The laboratories also participated in the Environmental Protection Agency's (EPA) Laboratory Intercomparison Studies Program. In this program, samples of different environmental media (water, milk, air filters, soil, foodstuffs, and tissue ash) containing one or more radionuclides in known amounts were prepared and distributed to the participating laboratories. After the samples were analyzed, the results were forwarded to EPA for comparison with known values and with the results from other laboratories. This program enabled the laboratory to regularly evaluate the accuracy of its analyses and take corrective action if needed.

Interlaboratory comparison of the TLD results was provided by participation in the International Environmental Dosimeter Project sponsored jointly by the Department of Energy, the Nuclear Regulatory Commission, and the EPA.

Assurance of the quality of dose calculations was provided in several ways. First, comparisons were made against past calculated doses and significant differences, if any, were verified. Second, all computed doses were double-checked by the originator and by an independent party who also checked all input data and assumptions used in the calculations.

APPENDIX D

CONVERSION FACTORS

1 yr	=	8760 hours
1 liter	=	1000 mL
1 mSv	=	100 mrem
1 mr	=	1 mrem (for gamma radiation)
1 uCi	=	1,000,000 pCi
1 Ci	=	1,000,000 uCi
1 pCi/L	=	10^{-9} uCi/mL
1 uCi/mL	=	1,000,000,000 pCi/L
1 Ci	=	3.7×10^{-10} dps
1 Bq	=	1 disintegration per second
1 M^3	=	1000 liters
10^{-6}	=	1.E-06 (scientific notation)
10^{-6}	=	0.000001
10^{-10}	=	0.0000000001
7×10^{-10}	=	0.0000000007

APPENDIX E

ABBREVIATIONS

AEC	Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
BNI	Bechtel National, Inc.
DA	Department of the Army
DCG	Derived Concentration Guides
DNT	Dinitrotoluene
DOE	U.S. Department of Energy
EPA	Environmental Protection Agency
ICRP	International Commission on Radiological Protection
MODNR	Missouri Department of Natural Resources
MSL	Mean Sea Level
NLO	National Lead of Ohio
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
PCB	Polychlorinated Biphenyl
RCRA	Resource Conservation Recovery Act
SFMP	Surplus Facilities Management Program
TLD	Thermoluminescent Dosimeter
TNT	Trinitrotoluene
USGS	United States Geological Survey
WSCP	Weldon Spring Chemical Plant
WSRP	Weldon Spring Raffinate Pit
WSQ	Weldon Spring Quarry
WSVP	Weldon Spring Vicinity Property

APPENDIX F

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