DOE/OR/20722-262

Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-81OR20722

ST. LOUIS AIRPORT SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1989

St. Louis, Missouri

May 1990

Bechtel National, Inc.

DOE/OR/20722--262

DE91 002529

ST. LOUIS AIRPORT SITE
ENVIRONMENTAL REPORT FOR
CALENDAR YEAR 1989

MAY 1990

Prepared for

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

Under Contract No. DE-AC05-81OR20722

By

Bechtel National, Inc.

P.O. Box 350

Oak Ridge, Tennessee

Bechtel Job No. 14501

SUMMARY ASSESSMENT
ENVIRONMENTAL COMPLIANCE ACTIVITY
U.S. DEPARTMENT OF ENERGY
FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM
ST. LOUIS AIRPORT SITE

BACKGROUND AND OVERVIEW

To evaluate the environmental compliance record of the St. Louis Airport Site (SLAPS), managed as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), it is necessary to describe the history of the site.

In 1946, the Manhattan Engineer District (MED), a predecessor of the Atomic Energy Commission (AEC) and Department of Energy (DOE), acquired the 8.78-ha (21.7-acre) tract now known as SLAPS to store residues resulting from the processing of uranium ores at a facility in St. Louis. Uranium processing at this facility was conducted under a contract with MED/AEC until 1957. Processing residues sent to SLAPS included pitchblende raffinate residues, radium-bearing residues, barium sulfate cake, Colorado raffinate residues, and contaminated scrap. Most of the residues were stored in bulk on open ground. Some contaminated materials and scrap were buried at the western end and in other parts of the site. The site was fenced to prevent casual entry and limit direct radiation exposure to the public.

In 1966 and 1967, most of the stored residues were sold and moved approximately 0.8 km (0.5 mi) north to a site on Latty Avenue in Hazelwood. On-site structures were razed, buried, and covered with 0.3 to 1 m (1 to 3 ft) of clean fill. Although these activities reduced surface dose rates to acceptable levels, buried deposits of residues containing uranium-238, radium-226, and thorium-230 remained on the site.

In 1973, the tract was transferred by quitclaim deed from AEC to the City of St. Louis, at the City's request. The 1985 Energy

and Water Appropriations Act (Public Law 98-360) authorized DOE to take the necessary steps to consolidate and dispose of waste materials from the Latty Avenue properties located in Hazelwood and nearby St. Louis Airport vicinity properties locally by reacquiring, stabilizing, and using SLAPS in a manner acceptable to the City of St. Louis. In September 1989, SLAPS was one of many FUSRAP properties in the St. Louis area added to the Environmental Protection Agency's (EPA) National Priorities List (NPL). Placement of the site on the NPL mandates a review of multiple options for remediation of SLAPS. This will be conducted as part of the remedial investigation/feasibility study (RI/FS) process to be conducted for SLAPS.

During its history, SLAPS has been subject to evolving federal and state environmental regulations. The following summary describes compliance requirements as they currently exist.

Clean Air Act (CAA) and National Emission Standards for Hazardous Air Pollutants (NESHAPs)

As stated in CERCLA 121, Superfund remedial actions must comply with substantive requirements of the CAA and other environmental laws when they are applicable or relevant and appropriate. Because SLAPS is not a DOE-owned or -leased facility, demonstration of compliance with NESHAPs by DOE is not required.

DOE Orders for Radionuclide Releases

Site releases must comply with specific DOE orders that place quantitative limits, called derived concentration guides (DCGs), and dose limits for radiological releases from DOE facilities. Results of environmental monitoring conducted in 1989 show that SLAPS is in compliance with DOE orders.

Clean Water Act (CWA)

SLAPS does not have any state or federal water permits. An environmental compliance assessment conducted by Oak Ridge National Laboratory (ORNL) in October 1989 did not find any deficiencies under the CWA.

Resource Conservation and Recovery Act (RCRA)

As stated in CERCLA 121, Superfund remedial actions must comply with substantive requirements of RCRA and other environmental laws when they are applicable or relevant and appropriate. RCRA permits are not required for on-site actions. No known RCRA-regulated waste is present at SLAPS. Additionally, an environmental compliance assessment conducted by ORNL in October 1989 did not find any deficiencies under RCRA.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

SLAPS is on the NPL, and a Federal Facilities Agreement (FFA) for site remedial action has been developed and is awaiting signature.

Toxic Substances Control Act (TSCA)

As stated in CERCLA 121, Superfund remedial actions must comply with substantive requirements of TSCA and other environmental laws when they are applicable or relevant and appropriate. TSCA-regulated waste is not present at SLAPS. The environmental compliance assessment of the site by ORNL in 1989 did not find any deficiencies under TSCA.

National Environmental Policy Act (NEPA)

Although a formal NEPA determination has not been made for final cleanup of the site, completion of an environmental impact study (EIS) is expected to be required as part of the overall effort for St. Louis FUSRAP sites on the NPL. Compliance with NEPA for site remedial actions will be accomplished by incorporating those elements required by an EIS into the format of the CERCLA remedial investigation/feasibility study.

ABSTRACT

The environmental monitoring program, which began in 1984, continued during 1989 at the St. Louis Airport Site (SLAPS) in St. Louis County, Missouri. SLAPS and its vicinity properties, including ditches north and south of the site, were designated for cleanup as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a United States Department of Energy (DOE) program to identify and decontaminate or otherwise control sites where residual radioactive material remains from the early years of the nation's atomic energy program. The site is currently owned by the City of St. Louis and controlled by the St. Louis Airport Authority. At present, no environmental permits are issued for SLAPS. The DOE environmental monitoring program at SLAPS is conducted by Bechtel National, Inc., project management contractor for FUSRAP.

The monitoring program at SLAPS measures radon concentrations in air; external gamma dose rates; and uranium, thorium, and radium concentrations in surface water, groundwater, and sediment. Additionally, several nonradiological parameters are measured in groundwater.

To assess the potential effect of SLAPS on public health, the potential radiation dose was estimated for a hypothetical maximally exposed individual. Based on the scenario described in this report, this hypothetical individual would receive an external exposure approximately equivalent to 6 percent of the DOE radiation protection standard of 100 mrem/yr. This exposure is less than a person receives during two round-trip flights from New York to Los Angeles (because of greater amounts of cosmic radiation at higher altitudes).

The cumulative dose to the population within an 80-km (50-mi) radius of SLAPS that results from radioactive materials present at the site is indistinguishable from the dose the same population receives from naturally occurring radioactive sources.

Results of 1989 monitoring show that SLAPS is in compliance with the DOE radiation protection standard.

CONTENTS

CONTENTS

(continued)

FIGURES

TABLES

TABLES

(continued)

1.0 INTRODUCTION

This report presents the findings of the environmental monitoring program conducted at the St. Louis Airport Site (SLAPS) during calendar year 1989. SLAPS and its vicinity properties were designated for remedial action under the Department of Energy (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP is a program to identify and decontaminate or otherwise control sites where residual radioactive material remains from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has authorized DOE to remedy. Routine radiological monitoring of the site has been authorized by DOE to be conducted by Bechtel National, Inc. (BNI), project management contractor for FUSRAP. As part of this monitoring, BNI began sampling Coldwater Creek in March 1984. The on-site groundwater monitoring program, which BNI began performing in October 1983, is a continuation of the program formerly conducted by Oak Ridge National Laboratory (ORNL). In October 1984 BNI began measuring radon and external gamma radiation levels.

1.1 LOCATION AND DESCRIPTION

SLAPS is an 8.8-ha (21.7-acre) site located in the Cities of Hazelwood and Berkeley, Missouri, approximately 24 km (15 mi) from downtown St. Louis. SLAPS lies immediately north of the Lambert-St. Louis International Airport and is bounded by the Norfolk and Western Railroad and Banshee Road on the south, Coldwater Creek on the west, and McDonnell Boulevard on the north and east. It is 0.8 km (0.5 mi) south of the Hazelwood Interim Storage Site (HISS), a DOE facility located in the City of Hazelwood, Missouri. Figure 1-1 shows the location of SLAPS, and Figure 1-2 is an aerial photograph of the site.

SLAPS is located in the upper half of the Coldwater Creek watershed. Coldwater Creek originates about 5.8 km (3.6 mi) south of SLAPS at a small, spring-fed lake in Overland, Missouri; flows

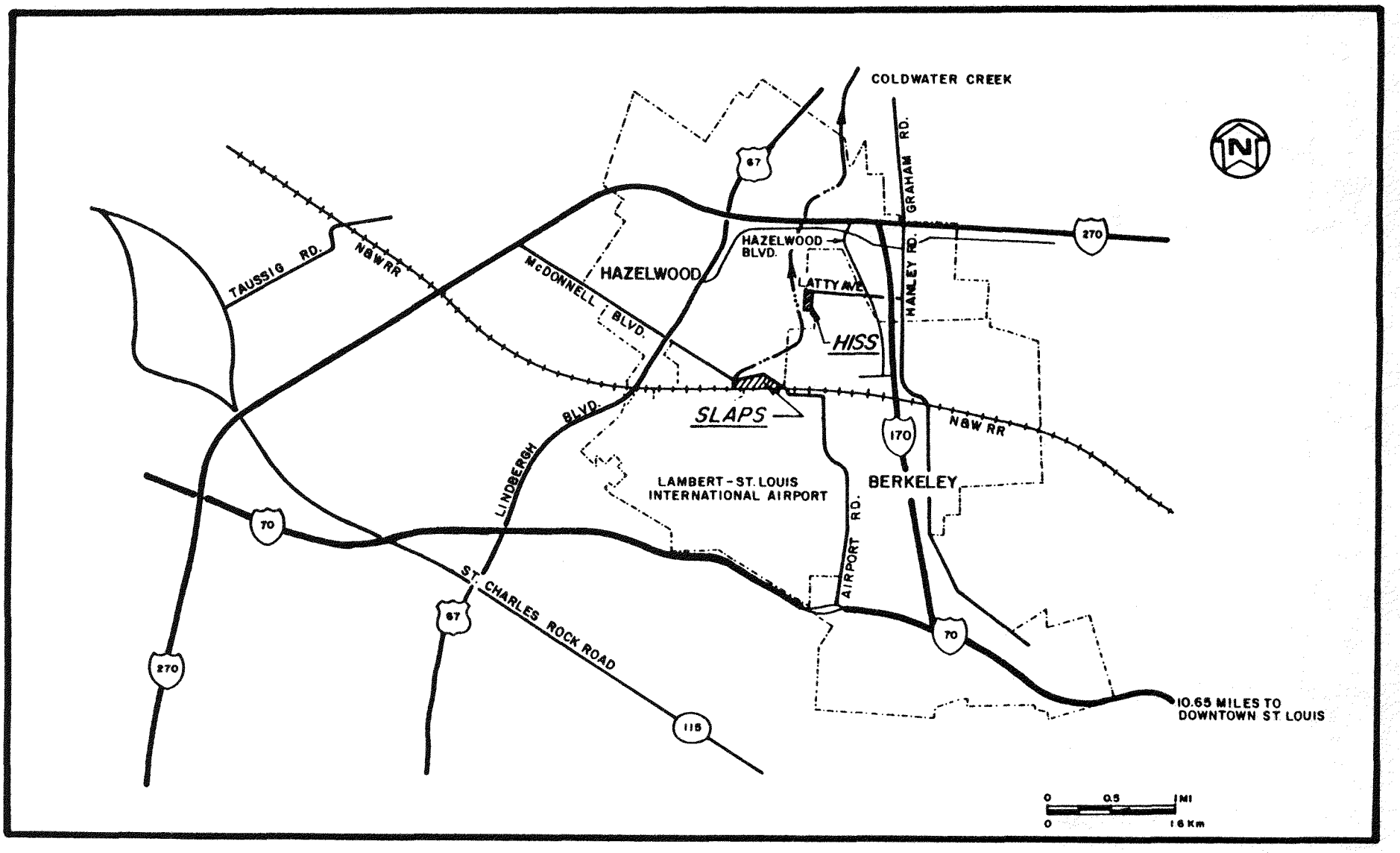


FIGURE 1-1 LOCATION OF SLAPS

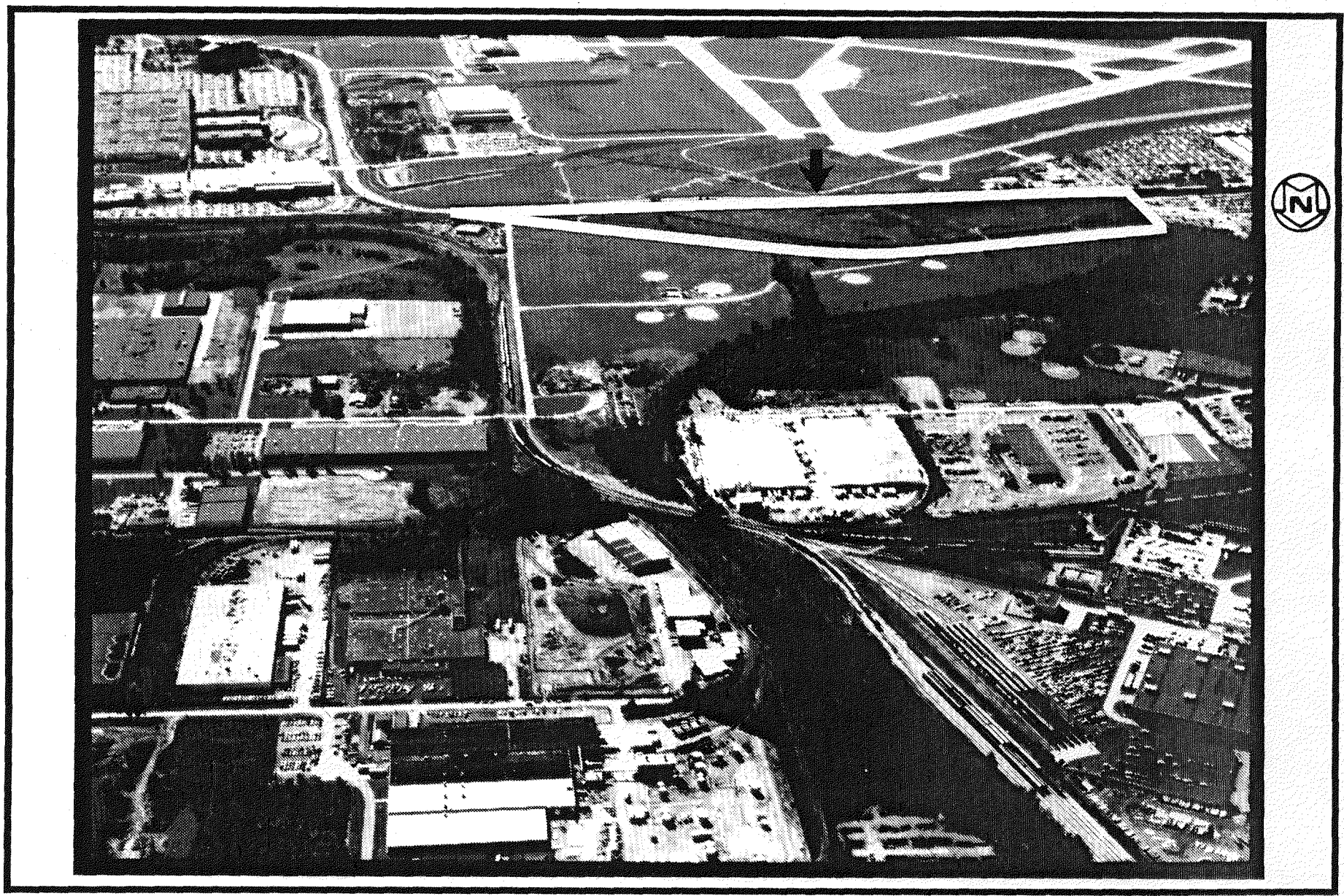


FIGURE 1-2 AERIAL VIEW OF SLAPS AND VICINITY

along the western end of the site; and discharges to the Missouri River approximately 6 km (4 mi) upstream of its confluence with the Mississippi River. Passing through culverts under the Lambert-St. Louis International Airport, flow in Coldwater Creek is influenced by stormwater runoff from the upstream areas of residential, commercial, industrial, and airport land (Ref. 1).

Rainwater from SLAPS leaves the site by evaporation, seepage into groundwater, or surface drainage to Coldwater Creek. Surface drainage from the site is intercepted by drainage channels along the northern and southern boundaries of the site that direct flow into Coldwater Creek. To halt erosion of the western end of SLAPS, a gabion wall consisting of rock-filled wire baskets was constructed in 1985 along the section of Coldwater Creek bordering the site.

There are no facilities on Coldwater Creek that withdraw water for human consumption. Approximately 22 km (14 mi) away from SLAPS, Coldwater Creek empties into the Missouri River, which in turn empties into the Mississippi River. The closest surface water treatment facility is on the Mississippi River, approximately 13 km (8 mi) downstream of the confluence of the Mississippi and the Missouri (Ref. 2).

Groundwater monitored at SLAPS occurs in two groundwater systems. The "upper" unconfined system occurs in a zone of unconsolidated glacial sediments that extends from about 3.4 to 11 m (11 to 35 ft) below the ground surface. The "lower" system occurs in lacustrine sediments below a clayey aquitard and above bedrock, in a zone about 11 to 27 m (36 to 87 ft) below the ground surface. Groundwater is also known to occur in Paleozoic bedrock several hundred feet below the surface of the site. There are no plans at present to install monitoring wells in the bedrock aquifer.

Groundwater is not used for any purpose in the SLAPS area. The nearest well (an industrial well) is about 4 km (2.5 mi) northwest of the site. The water needs for the area are met with treated water from the Mississippi River.

The climate at SLAPS is classified as modified continental. The average annual daily temperature ranges from 7.4 to 18.6°C (45.4 to 65.5°F). The highest average monthly temperature is 31.6°C (89°F) (July) and the lowest is -6.7°C (19.9°F) (January). Normal annual precipitation is slightly over 89 cm (35 in.). The average annual snowfall is about 66 cm (26 in.). Prevailing winds tend to be from the south, the northwest, and west-northwest. Average wind speeds range from 12.2 to 19.0 km/h (7.6 to 11.8 mph). Figure 1-3 shows the distribution of wind direction and speed for the SLAPS vicinity (Ref. 3).

The nearest residential population center comprises 75 to 100 people and is located about 0.8 km (0.5 mi) west of the site in an industrially zoned area of Hazelwood. The next nearest (about 1,500 people) is about 1.6 km (1 mi) northwest of the site along Chapel Ridge Drive. Most of Hazelwood's population is north of Interstate 270, more than 2.4 km (1.5 mi) north of the site (Ref. 2). Land use immediately adjacent to the site is varied (Figure 1-4, Ref. 2). More than two-thirds of the land within 0.8 km (0.5 mi) of the site is used for transportation-related purposes, primarily Lambert-St. Louis International Airport. Land immediately adjacent to the site is also used for commercial and recreational purposes.

1.2 SITE HISTORY

In 1946, the Manhattan Engineer District (MED), a predecessor of the Atomic Energy Commission (AEC) and DOE, acquired the 8.8-ha (21.7-acre) tract now known as SLAPS to store residues resulting from the processing of uranium ores at a facility in St. Louis.

Uranium processing at this facility was conducted under a contract with MED/AEC until 1957. Processing residues sent to the tract now known as SLAPS included pitchblende raffinate residues, radium-bearing residues, barium sulfate cake, Colorado raffinate residues, and contaminated scrap. Most of the residues were stored

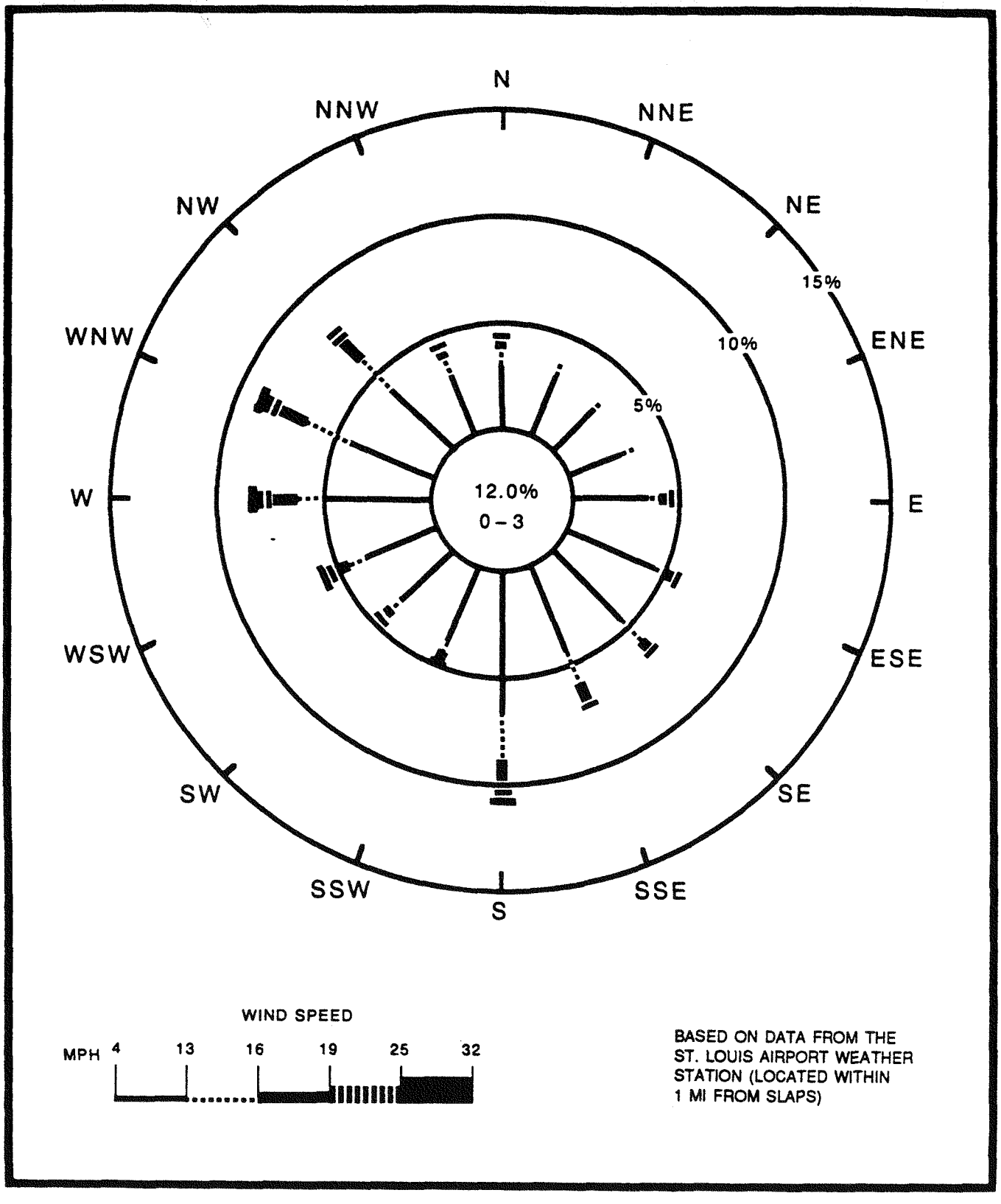
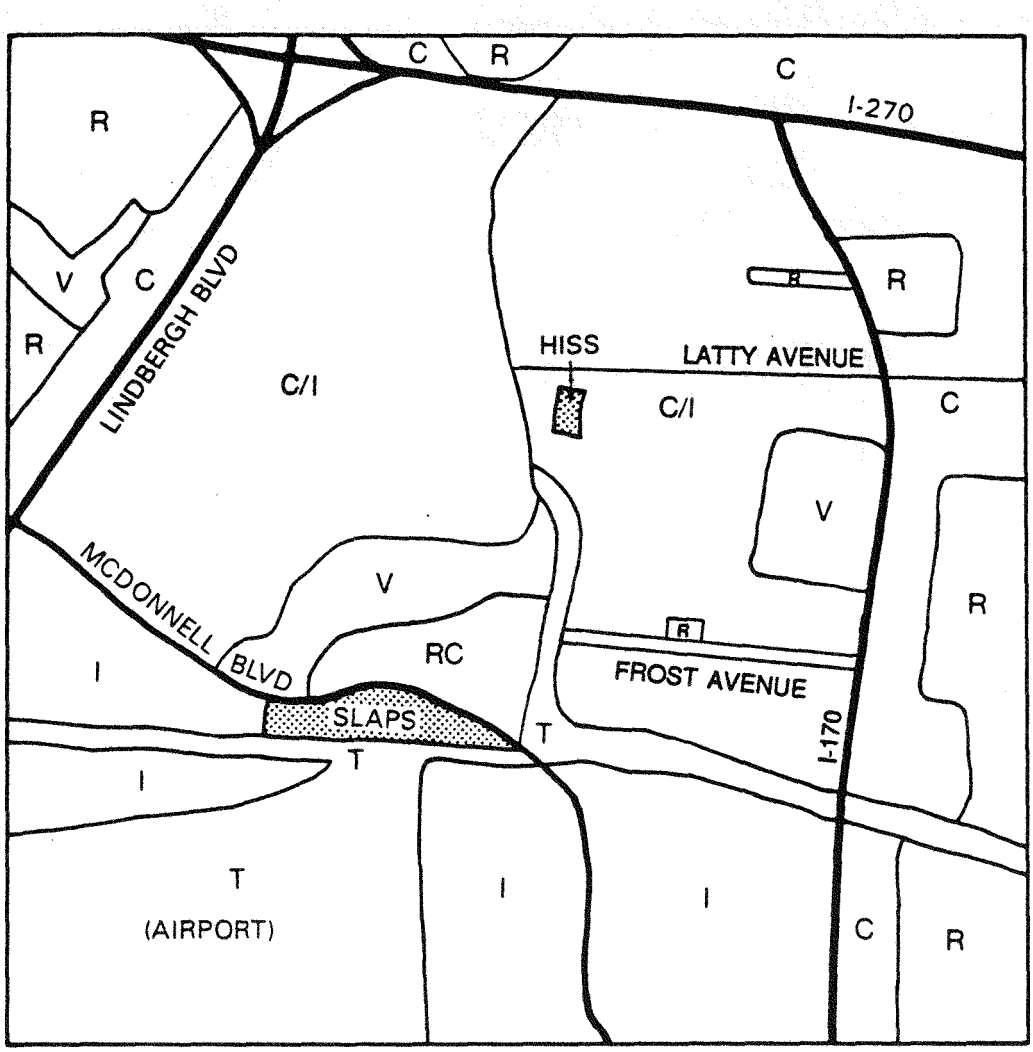


FIGURE 1-3 ANNUAL WIND ROSE FOR SLAPS



BASED ON AERIAL PHOTOGRAPHS, SITE VISITS AND USGS TOPOGRAPHIC MAP 1:24000 SCALE, FLORISSANT, MO (PHOTO REVISED 1982)

R RESIDENTIAL	C/I MIXED COMMERCIAL AND INDUSTRIAL
C COMMERCIAL	V VACANT
T TRANSPORTATION	RC RECREATIONAL
I INDUSTRIAL	

0 0.5 MI
0 0.8 KM

N

FIGURE 1-4 GENERALIZED LAND USE IN THE VICINITY OF SLAPS

in bulk on open ground. Some contaminated materials and scrap were buried at the western end and in other parts of the site. To limit direct radiation exposure to the public, the site was fenced to prevent casual entry.

In 1966 and 1967, most of the stored residues were sold and moved approximately 0.8 km (0.5 mi) north to a site on Latty Avenue. On-site structures were razed, buried on the site, and covered with 0.3 to 1 m (1 to 3 ft) of clean fill. Although these activities reduced the surface dose rates to acceptable levels, buried deposits of residue containing uranium-238, radium-226, and thorium-230 remained on the site (Ref. 4).

In 1973, the tract was transferred by quitclaim deed from AEC to the City of St. Louis, at the City's request. The 1985 Energy and Water Appropriations Act (Public Law 98-360) authorized DOE to take the necessary steps to consolidate and dispose of waste materials from the Latty Avenue site and the nearby St. Louis Airport vicinity properties locally by reacquiring, stabilizing, and using the old 8.8-ha (21.7-acre) AEC airport site in a manner acceptable to the City of St. Louis.

From 1976 through 1978, ORNL conducted a radiological investigation of SLAPS (Ref. 5). This survey indicated the presence of elevated concentrations of uranium-238 and radium-226 in drainage ditches north and south of McDonnell Boulevard. In 1981, the drainage ditches were designated for remedial action under FUSRAP.

In 1982, BNI performed radiological characterizations of the ditches on either side of McDonnell Boulevard and portions of Coldwater Creek (Ref. 6). Neither of these surveys included measuring thorium-230 in soil. During 1986, however, archived soil samples from the ditches were reanalyzed to determine thorium-230 content, and new samples from the ditches and Coldwater Creek were radiologically and chemically analyzed. Concentrations of thorium-230 ranged from 0.6 to 2,608 pCi/g in the samples analyzed.

Additional radiological characterization and limited geological and chemical characterization of SLAPS were undertaken

during 1986 and included installation of 10 groundwater monitoring wells at the site (Ref. 7). Radiological characterization was also performed on three properties immediately adjacent to SLAPS: the ball field property north of the site, the railroad bordering the site on the south, and a triangular-shaped area between the SLAPS fence line and McDonnell Boulevard at the eastern end of the site.

In October 1989, SLAPS was added to the Environmental Protection Agency's (EPA) National Priorities List. A remedial investigation and feasibility study will be completed to define the nature and extent of contamination and evaluate alternatives for cleanup operations.

1.3 HYDROGEOLOGICAL CHARACTERISTICS OF THE SITE

The hydrogeological characteristics of SLAPS remain unchanged from those reported previously. The upper groundwater system is represented by an unconfined water table flowing generally from east to northwest and west. The lower groundwater system is a semiconfined system flowing generally the same as the upper system. The interpretations presented here are based on groundwater levels measured in calendar year 1989.

A set of monitoring wells was installed at the site by Roy F. Weston, Inc., in 1981 before the environmental monitoring program began (Ref. 8). As a cost conservation measure., these wells are not used for groundwater level measurements but are used to obtain samples for environmental monitoring. Wells installed at SLAPS by BNI in mid-1986 and at the adjacent ball field in 1988 supplied the hydrogeological data used in this report (see Figure 1-5). A summary of well construction information is given in Table 1-1. An example of well construction details is included as Appendix E.

In previous reports the two groundwater systems at SLAPS have been referred to as "shallow" and "deep" (Refs. 9 and 10). In this report the nomenclature has been changed to "upper" and "lower" groundwater systems to be consistent with data being reported for the ball field area (Ref. 11). Well numbers ending in "S" monitor

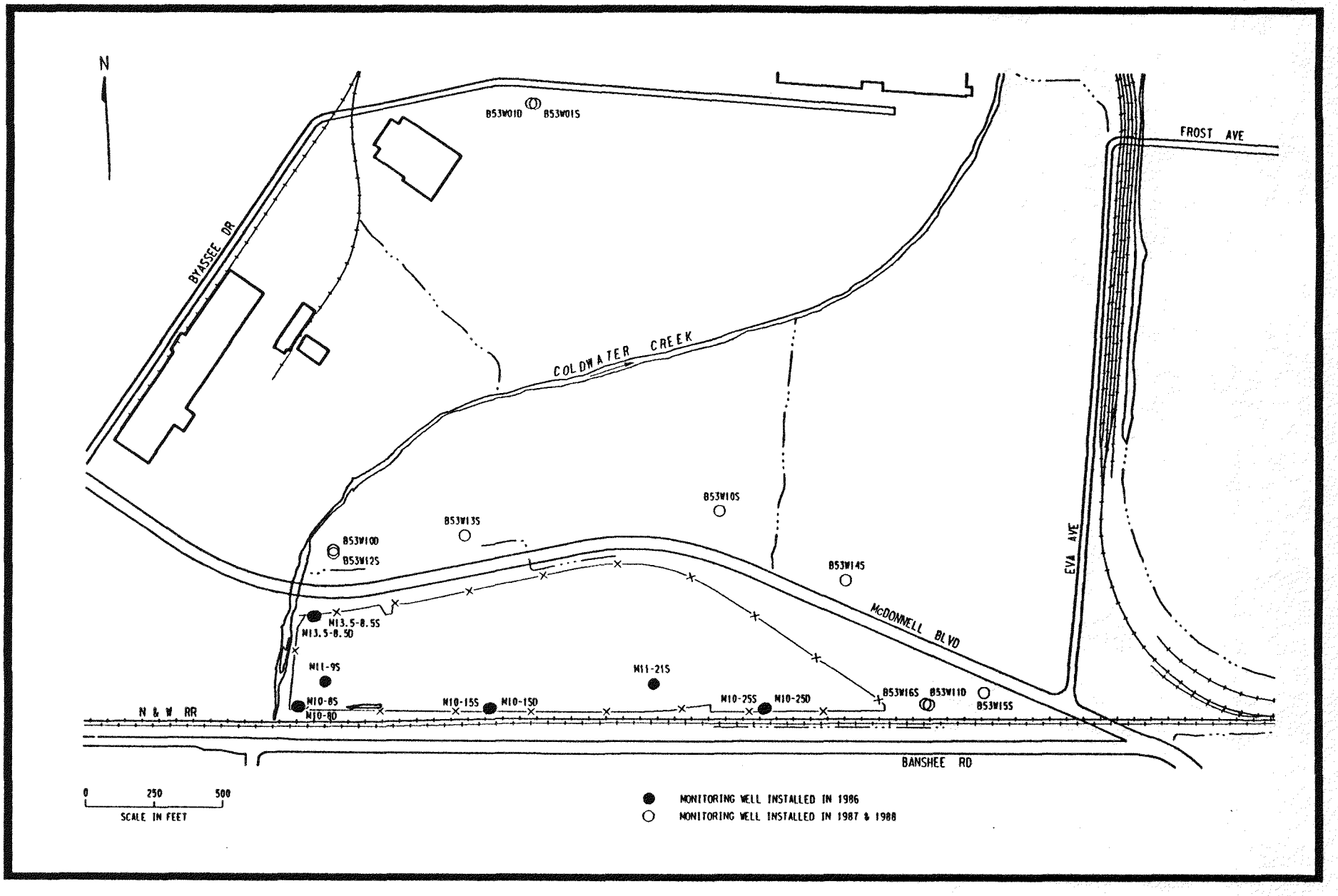


FIGURE 1-5 MONITORING WELL LOCATIONS FOR SLAPS AREA WATER LEVEL MEASUREMENTS

134F133.DGN

TABLE 1-1

SLAPS MONITORING WELL CONSTRUCTION SUMMARY

Well Number[a]	Completion Date	Total Depth [m (ft)]	Screened Interval Below Ground [m-m (ft-ft)]	Construction Material
A[b]	1979	9.0 (29.5)	No Documentation	PVC[c]
B[b]	1979	8.8 (29.0)	No Documentation	PVC
C[b]	1979	6.7 (22.0)	No Documentation	PVC
D[b]	1979	6.7 (22.0)	No Documentation	PVC
E[b]	1979	6.1 (20.0)	No Documentation	PVC
F[b]	1979	6.7 (22.0)	No Documentation	PVC
B53W10S	Jan. 1988	14.9 (49.0)	12.5-14.0 (40.9-45.9)	Stainless Steel
B53W12S	Jan. 1988	10.7 (35.0)	8.7-10.2 (28.5-33.5)	Stainless Steel
B53W13S	Feb. 1988	9.0 (29.5)	6.3-7.9 (20.8-25.8)	Stainless Steel
B53W14S	Feb. 1988	10.4 (34.0)	6.9-8.4 (22.7-27.7)	Stainless Steel
B53W15S	Jan. 1988	6.6 (21.5)	4.6-6.2 (15.2-20.2)	Stainless Steel
B53W16S	Feb. 1988	7.3 (24.0)	4.8-6.3 (15.8-20.8)	Stainless Steel
M10-15S	July 1986	8.8 (29.0)	4.3-7.4 (14.2-24.2)	Stainless Steel
M10-25S	July 1986	8.2 (27.0)	4.3-7.3 (14.0-24.0)	Stainless Steel
M10-8S	July 1986	8.8 (29.0)	5.8-7.3 (18.9-24.0)	Stainless Steel
M11-21[d]	July 1986	7.0 (23.0)	4.2-5.7 (13.8-18.8)	Stainless Steel
M11-9[d]	July 1986	10.1 (33.0)	5.9-8.9 (19.3-29.3)	Stainless Steel
M13.5-8.5S	July 1986	9.8 (32.0)	5.9-8.9 (19.3-29.3)	Stainless Steel
B53W01S[e]	Nov. 1987	8.4 (27.7)	6.1-7.7 (20.0-25.1)	Stainless Steel
B53W10D	Jan. 1988	25.1 (82.3)	21.7-24.7 (71.1-81.1)	Stainless Steel
B53W11D	Jan. 1988	24.3 (79.8)	20.9-23.9 (68.5-78.5)	Stainless Steel
B53W01D[e]	Nov. 1987	28.5 (93.5)	25.2-28.2 (82.5-92.5)	Stainless Steel

TABLE 1-1

(continued)

Well Number[a]	Completion Date	Total Depth [m (ft)]	Screened Interval Below Ground [m-m (ft-ft)]	Construction Material
M10-15D	July 1986	26.6 (87.1)	24.4-25.9 (80.0-85.0)	Stainless Steel
M10-25D	July 1986	15.9 (52.0)	12.0-13.5 (39.3-44.3)	Stainless Steel
M10-8D	July 1986	22.4 (73.5)	19.6-21.1 (64.4-69.3)	Stainless Steel
M13.5-8.5D	July 1986	22.6 (74.0)	19.6-21.2 (64.4-69.4)	Stainless Steel

[a]Wells designated with an "S" are installed in the upper groundwater system (also see footnote d); wells designated with a "D" are in the lower groundwater system.

[b]Wells installed by Roy F. Weston, Inc. Limited information is available; being investigated. Locations are shown in Figure 3-1.

[c]PVC - polyvinyl chloride.

[d]Well installed in upper groundwater system.

[e]Well used to represent background conditions.

the upper groundwater system and numbers ending in "D" monitor the lower groundwater system. Background information on site geology, hydrogeology, and well installation methods can be found in Refs. 8 through 10.

Groundwater levels at SLAPS in 1989 were measured weekly with an electric downhole probe water level indicator.

1.3.1 Upper Groundwater System

The unconfined upper groundwater system occurs in a zone beginning approximately 3.4 to 10.7 m (11 to 35 ft) below the ground surface (Ref. 8). Wells in this zone are screened in unconsolidated glacial materials at depths from 4.2 to 14.0 m (13.8 to 45.9 ft) above a clayey aquitard (Ref. 9). Groundwater levels measured in 1989 for each well are shown as hydrographs (Figures 1-6 and 1-7). Precipitation records for the St. Louis area are presented beneath the hydrographs.

The hydrographs for the upper groundwater system show apparent seasonal fluctuations in groundwater levels. The water levels are highest during the spring, then slowly fall 0.6 to 2.4 m (2 to 8 ft) until the lowest water levels are reached in the fall and winter. The water level changes for each well correlate reasonably well both with each other and with the major precipitation events. As reported in Ref. 11, the upper system water levels decrease in winter and the lower system wells remain stable. This behavior may be associated with discharge of shallow groundwater into Coldwater Creek.

The slope and flow direction of the upper groundwater system were determined from potentiometric surface maps. A potentiometric surface is defined as the level to which water will rise in tightly cased wells. Delineation of the potentiometric surface of an aquifer indicates groundwater slope and flow direction. The dates for the information shown on the two potentiometric surface maps (Figures 1-8 and 1-9) were chosen because they represent seasonal high and low water level periods. The groundwater flow direction is generally toward the northwest. The contours suggest a smooth

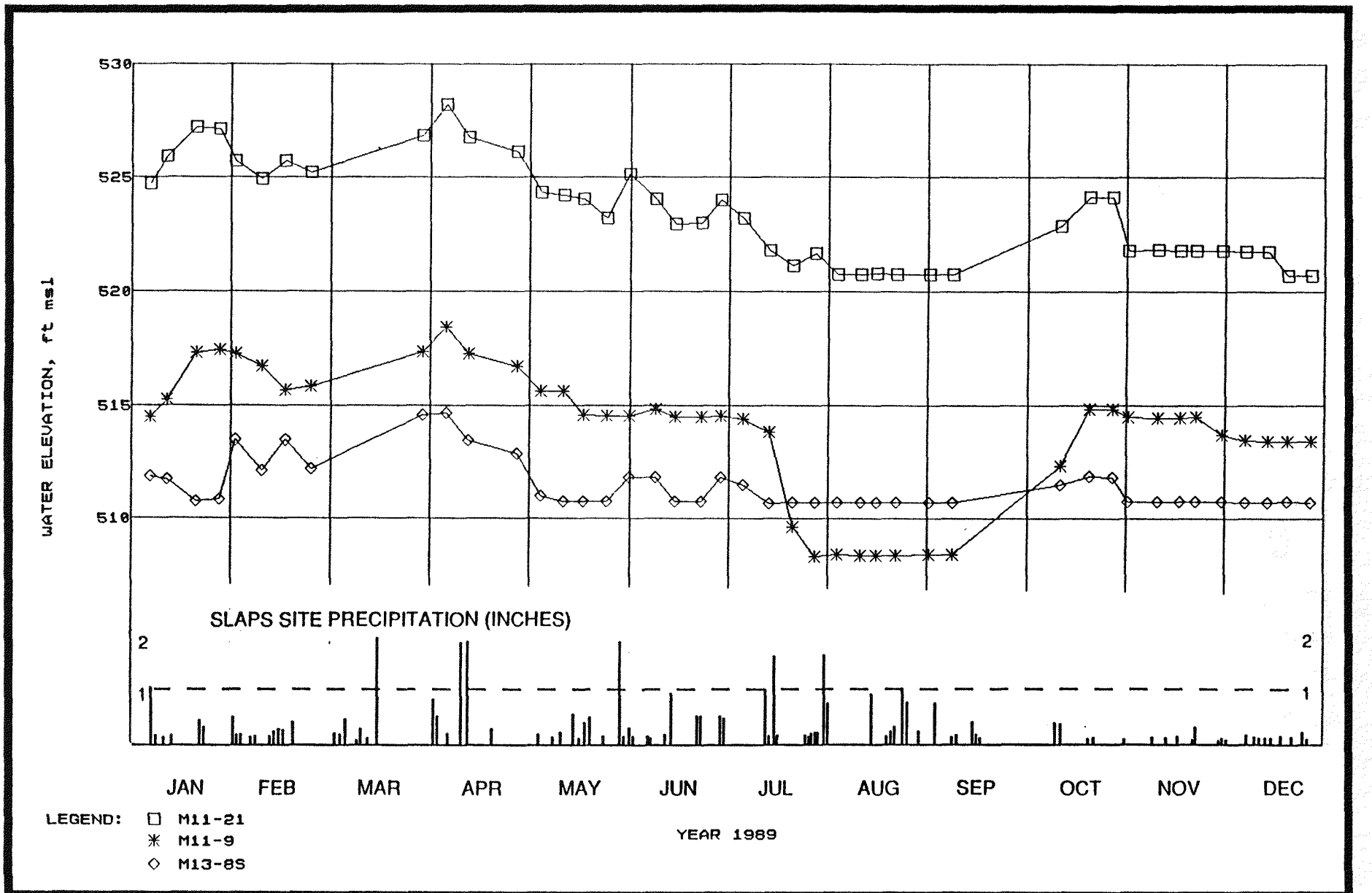


FIGURE 1-6 HYDROGRAPHS OF UPPER GROUNDWATER SYSTEM WELLS M11-21, M11-9, AND M13.5-8.5S

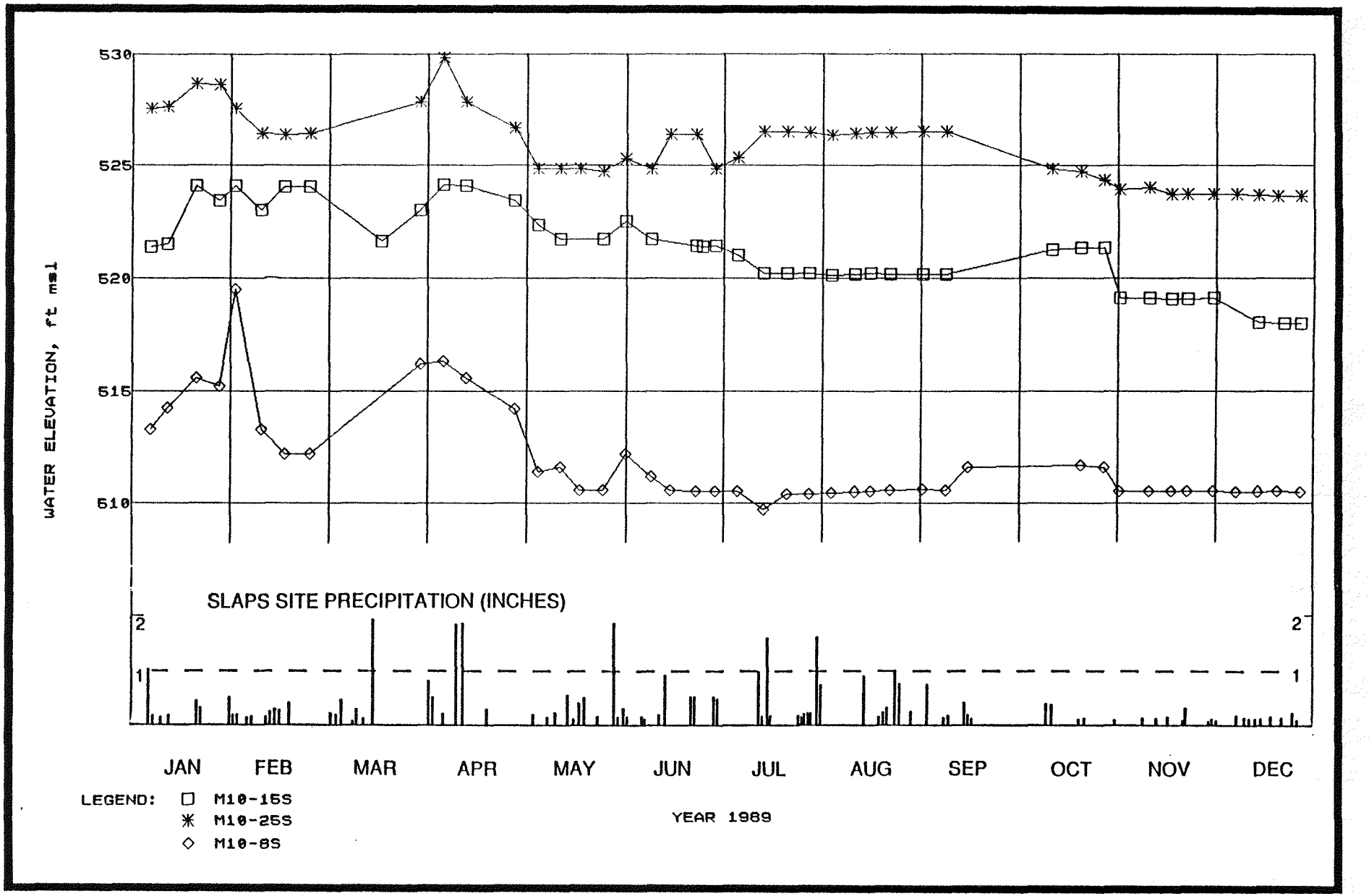


FIGURE 1-7 HYDROGRAPHS OF UPPER GROUNDWATER SYSTEM WELLS M10-15S, M10-25S, AND M10-8S

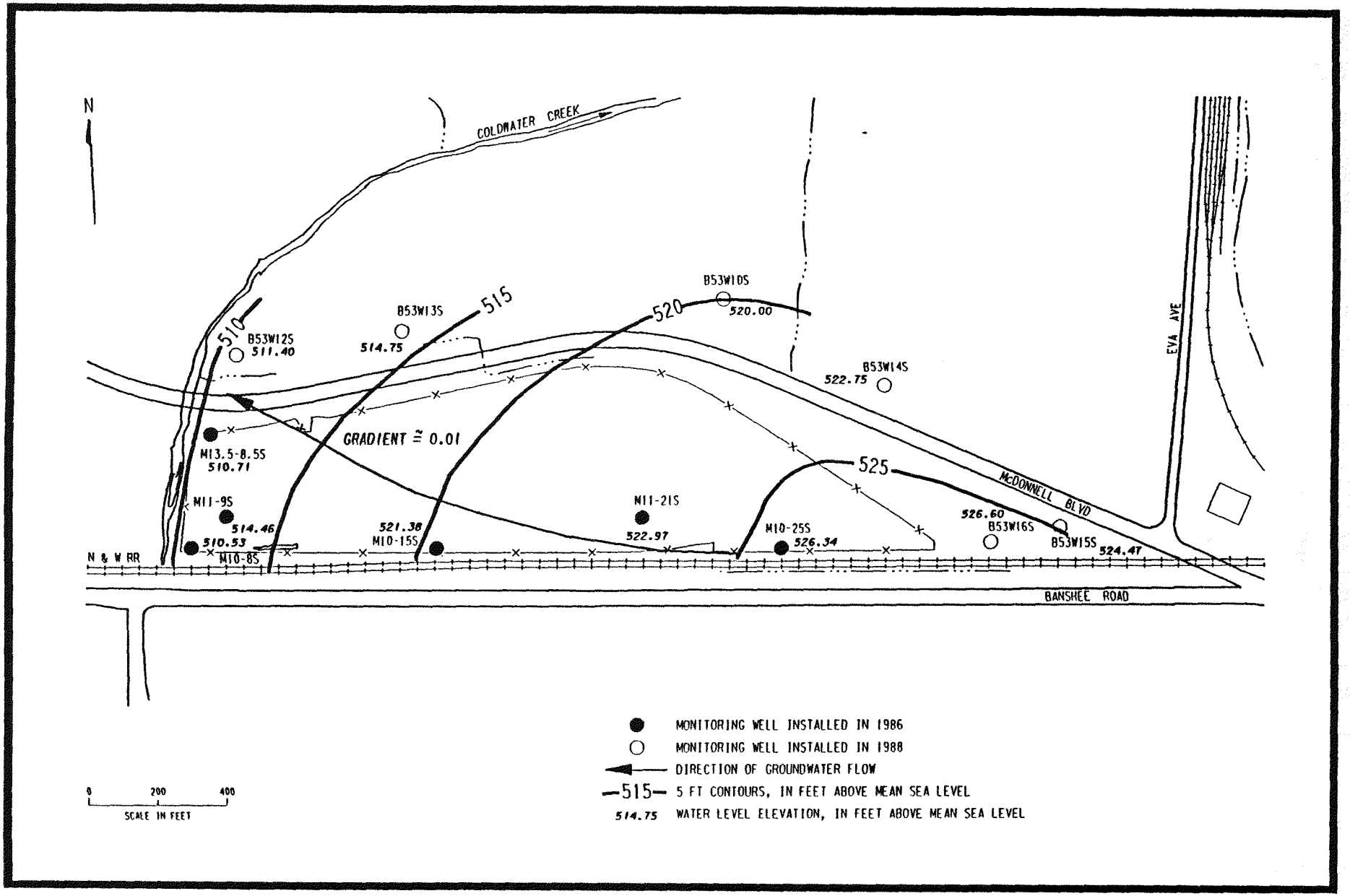


FIGURE 1-8 SLAPS UPPER GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE (6/23/89)

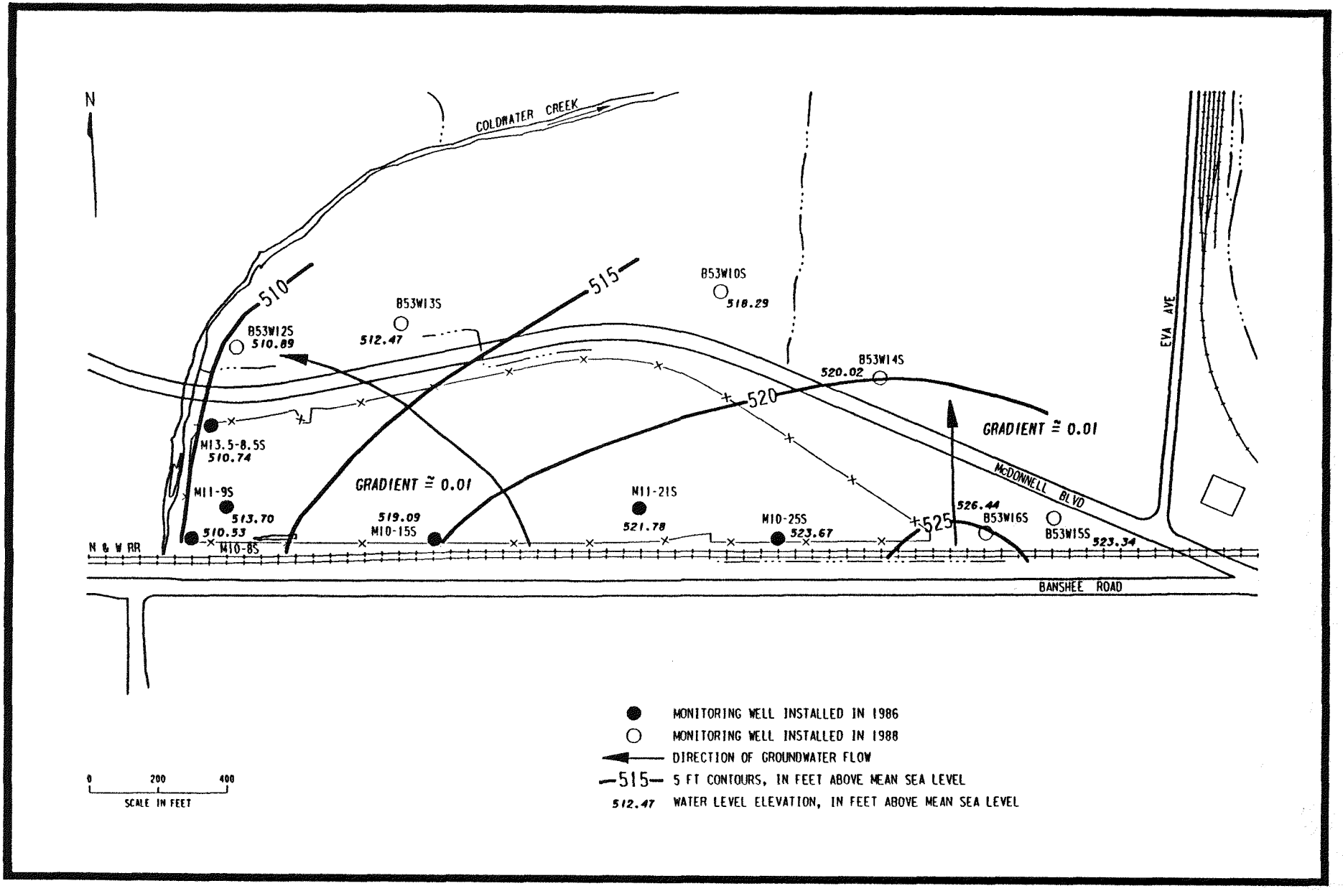


FIGURE 1-9 SLAPS UPPER GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE (11/30/89)

gradient slope, approximately parallel to the slope of site topography, and the groundwater flows into Coldwater Creek (Ref. 8). The slope for both dates is on the order of 0.009.

1.3.2 Lower Groundwater System

The lower groundwater system is located in glacial sediments below the clayey aquitard and above bedrock (Ref. 10). The lower groundwater system starts at approximately 11 m (35 ft) below ground and bottoms out at 27 m (87 ft) below ground surface. The lower system wells are screened at depths ranging from 12.0 m (39.3 ft) (top) to 28.2 m (92.5 ft) (bottom). Hydrographs of wells monitoring the lower groundwater system are shown in Figure 1-10. Precipitation records for the St. Louis area (collected at the St. Louis Airport) are also shown on the hydrographs.

The hydrographs for the lower system (Figure 1-10) show little seasonal variation of water levels, unlike those for the upper system. The inconsistent behavior of the lower system wells seen in 1988 (Ref. 11) is not repeated. The water levels for all lower system wells show moderately good correlation with each other. Correlation of water levels with precipitation data is inconsistent, which indicates a minimal influence of recharge at the site.

Slope and flow direction for the lower groundwater system were determined using two potentiometric surface maps (Figures 1-11 and 1-12), for the same dates as those for Figures 1-8 and 1-9. The potentiometric surface maps show a consistent gradient direction from east to west, with a slope ranging from 0.0052 to 0.0066.

1.3.3 Conclusions

Both the lower and upper groundwater systems flow generally toward the west or northwest. The upper system has a slope of approximately 0.009, and the lower system has a slope of approximately 0.006. No significant changes in hydrogeologic characteristics were observed between 1988 and 1989.

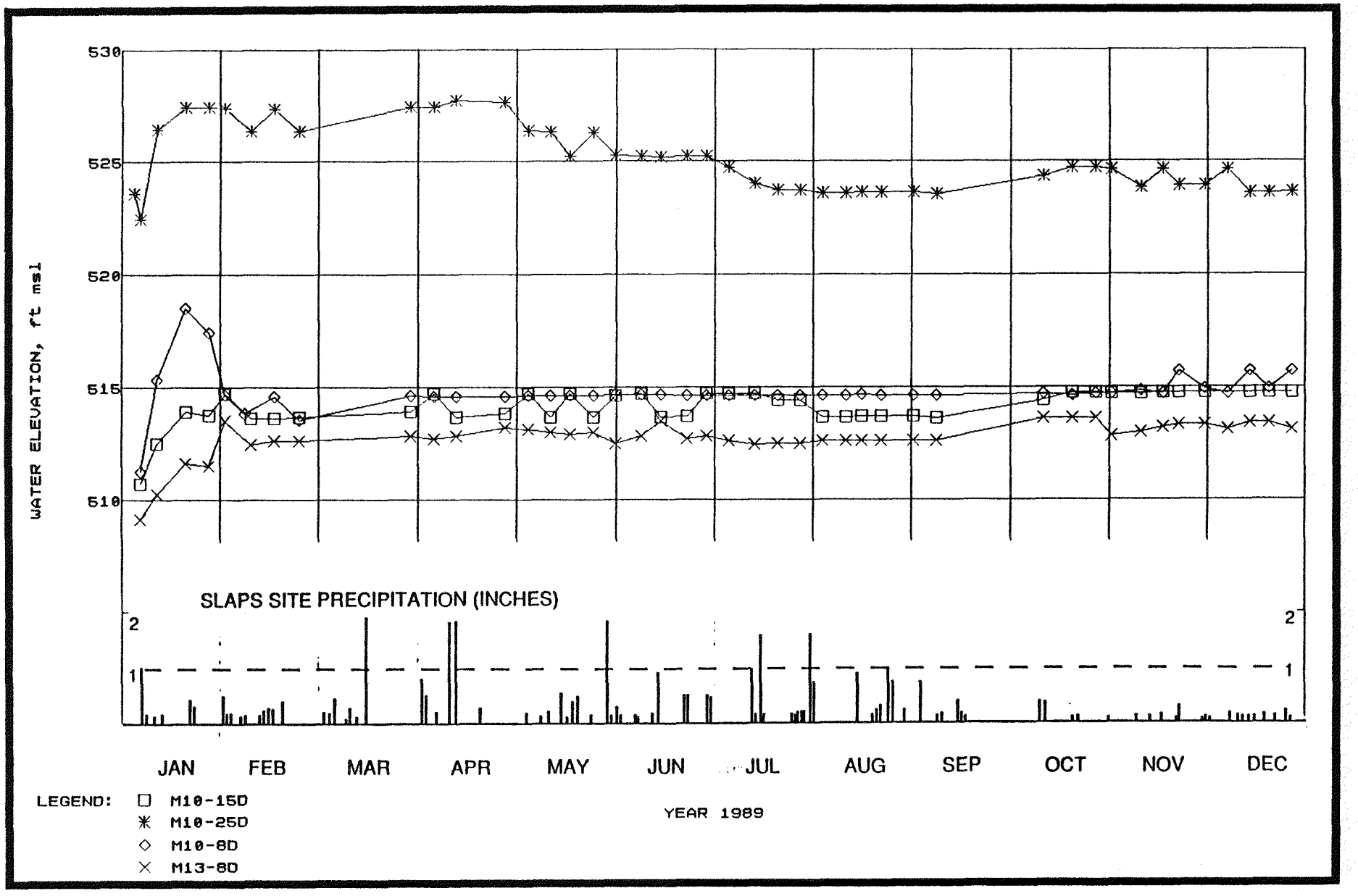


FIGURE 1-10 HYDROGRAPHS OF LOWER GROUNDWATER SYSTEM WELLS M10-15D, M10-25D, M10-8D, AND M13.5-8.5D

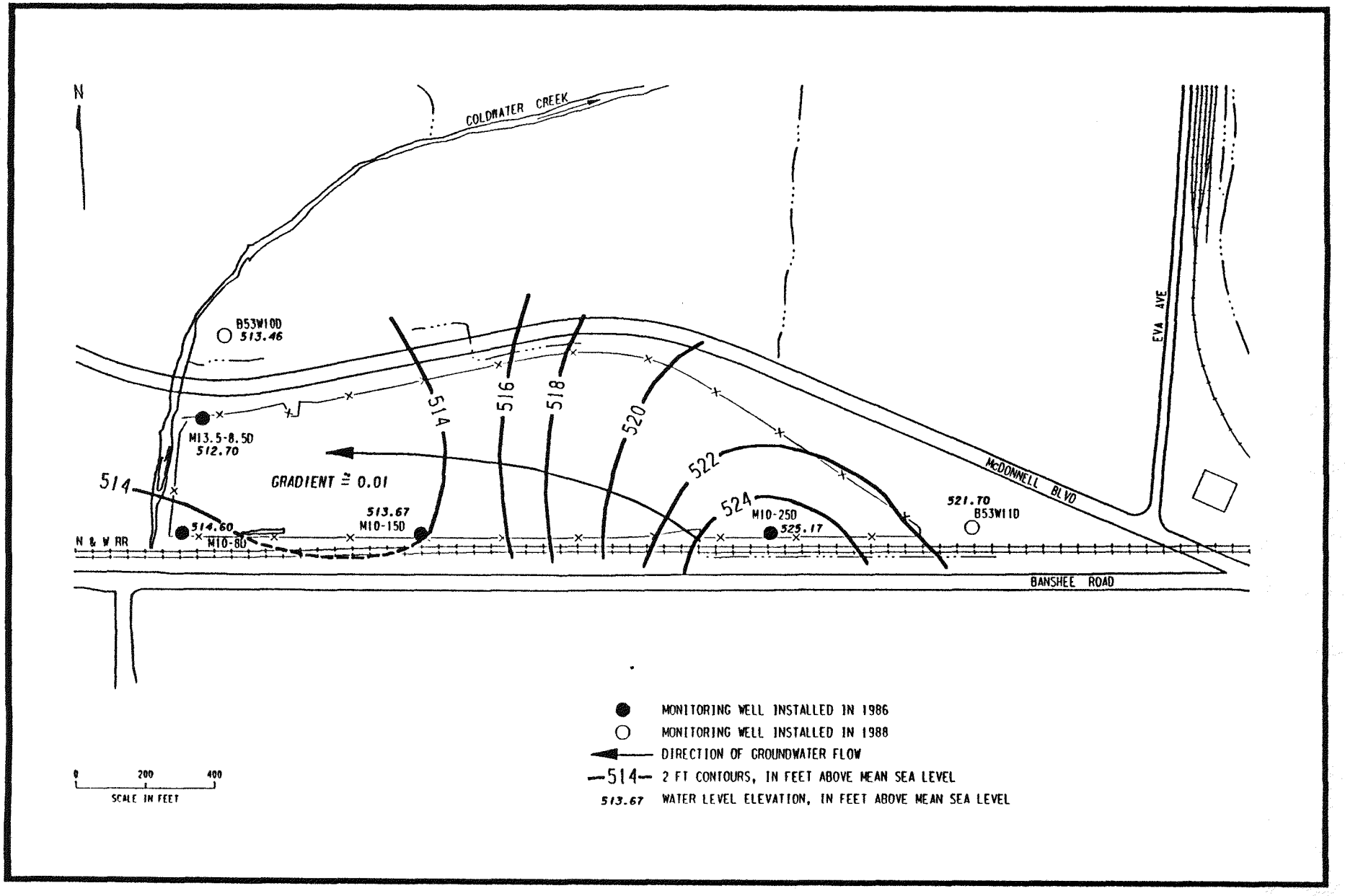


FIGURE 1-11 SLAPS LOWER GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE (6/23/89)

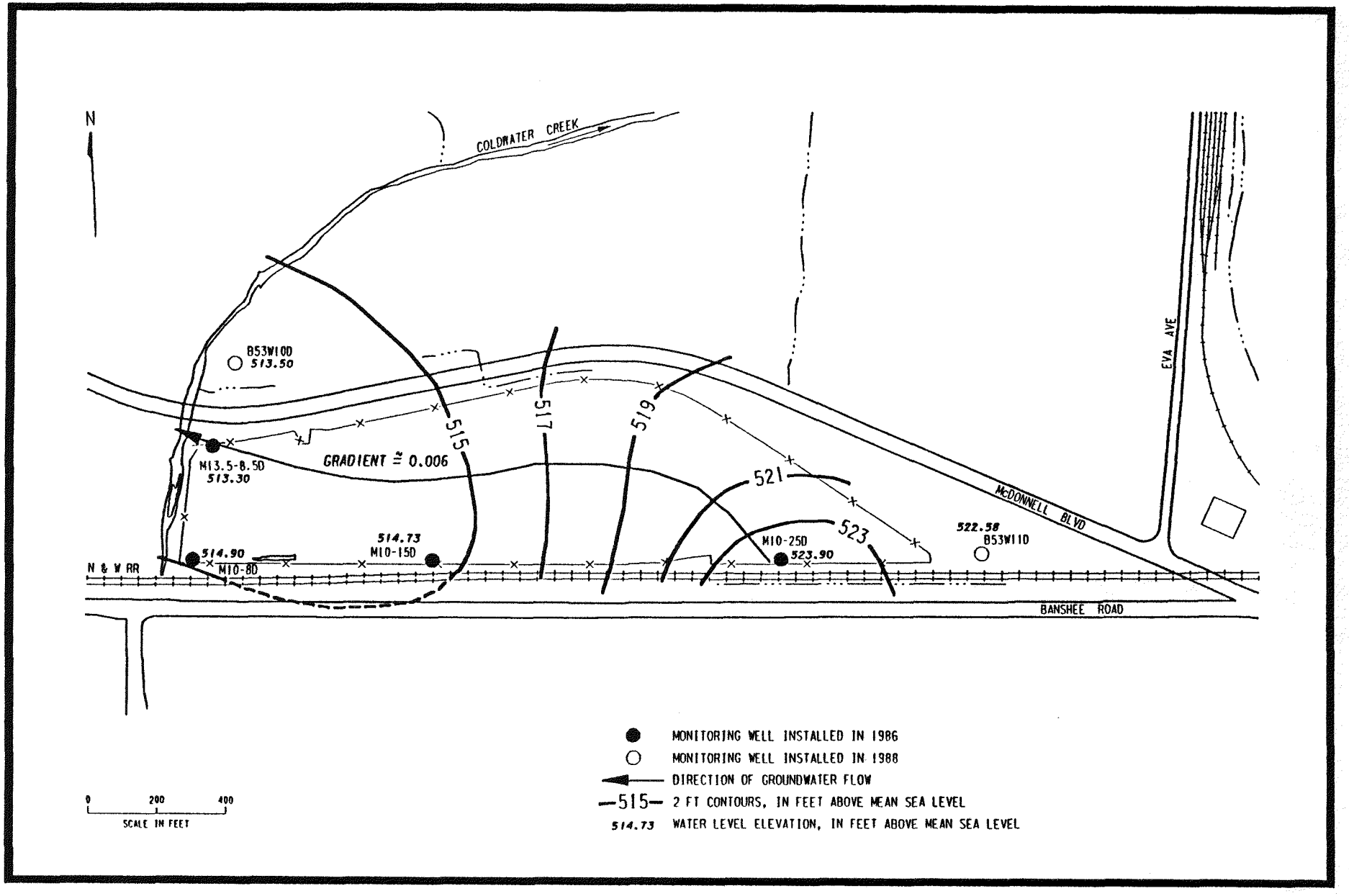


FIGURE 1-12 SLAPS LOWER GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE (11/30/89)

2.0 SUMMARY OF MONITORING RESULTS

The environmental monitoring program at SLAPS, which began in 1984, continued in 1989; water and sediments were sampled, and radon and external gamma radiation levels were measured to verify compliance with the DOE radiation protection standard of 100 mrem/yr (Ref. 12). The potential radiation dose that might be received by a hypothetical maximally exposed individual was calculated to evaluate the site's compliance with the current DOE radiation protection standard.

Annual average radon concentrations (including background) in 1989 ranged from 5×10^{-10} to 2.0×10^{-9} μCi/ml (0.5 to 2.0 pCi/L) (see Subsection 3.1). The average background level in 1989 ranged from 5 to 6×10^{-10} μCi/ml (0.5 to 0.6 pCi/L).

Average external gamma radiation levels measured at the SLAPS boundary ranged from 29 to 1,938 mrem/yr above background, which averaged 56 mrem/yr in 1989. The highest value was measured in an area of known contamination (see Subsection 3.2).

In surface waters, the highest average concentrations of total uranium, radium-226, and thorium-230 were 4×10^{-9}, 4×10^{-10}, and 3×10^{-10} μCi/ml (4, 0.4, and 0.3 pCi/L), respectively (see Subsection 3.3). These values are approximately the same as the background concentrations measured upstream of SLAPS. Measured concentrations of the radionuclides in surface water at SLAPS have remained relatively constant since 1985 (see Subsection 3.7.3) (Refs. 11, 14-16). Monitoring results from 1984 can be found in Ref. 13.

The highest annual average uranium concentration in groundwater was 5.28×10^{-6} μCi/ml (5,280 pCi/L). The highest average radium-226 concentration was 9×10^{-10} μCi/ml (0.9 pCi/L), and the highest average thorium-230 concentration was 1.1×10^{-8} μCi/ml (11 pCi/L) (see Subsection 3.4.1). These radium-226 and thorium-230 concentrations approximate levels measured in background wells and are within DOE derived concentration guidelines. Elevated uranium values occurred in five on-site wells that are in areas of known contamination.

Because SLAPS is fenced, the public does not have access to these wells. Furthermore, there is no known consumption of groundwater in the vicinity of the site. Groundwater that might discharge to Coldwater Creek is monitored as part of the surface water monitoring program. Current indications are that this transport pathway has not resulted in degradation of surface water quality.

Chemical analyses of well water detected 5 organic pollutants and 14 metals (Subsection 3.4.2). Analytical results for samples from background wells reflect the overall poor quality of groundwater in the vicinity.

In sediments collected immediately downstream of the site, the highest annual average concentration was 2.5 pCi/g for total uranium, 1.2 pCi/g for radium-226, and 2.9 pCi/g for thorium-230 (see Subsection 3.5). These concentrations are approximately equal to or lower than background concentrations measured upstream of the site. As a point of reference, the observed concentrations may be compared with the levels of radioactivity in phosphate fertilizers listed in Appendix D.

The potential radiological dose that could be received by a hypothetical maximally exposed individual was calculated. This hypothetical individual is one who is assumed to have been adjacent to the site and who walked the northern fence line of the site twice a day, five days a week. The maximum exposure for this individual would be 6 mrem/yr above background. This exposure is approximately equivalent to 6 percent of the DOE radiation protection standard of 100 mrem/yr.

The cumulative dose to the population within an 80-km (50-mi) radius of SLAPS that would result from radioactive materials present at the site is indistinguishable from the dose the same population receives from naturally occurring radioactive sources. Results of 1989 monitoring show that SLAPS is in compliance with the DOE radiation protection standard.

3.0 DATA COLLECTION, ANALYSIS, AND EVALUATION

This section provides the results of 1989 environmental monitoring at SLAPS. It also describes the sampling, monitoring, and analytical procedures used. Calculations were made to determine the estimated maximum possible radiation dose based on environmental conditions, measurements recorded, and evaluation of potential exposure pathways.

Data are presented in summary tables that include number of data points collected, and minimum, maximum, and average values. Individual sources of error (e.g., analytical error or sampling error) were not estimated. The "less than" notation (<) is used to denote specific sample analysis results that are below the limit of sensitivity of the analytical method, based on a statistical analysis of parameters. When computing annual averages, values reported as less than a given limit of sensitivity (detection limit) are considered equal to that limit of sensitivity. In previous environmental monitoring reports, when two or more such values were involved in calculating an annual average, the reported value carried the "less than" notation. This year, because limits of sensitivity varied from quarter to quarter, an increasing number of results are at or below the limit of sensitivity, and because data error terms are not reported, a more conservative method of computing annual averages is being employed. Annual averages carry the "less than" notation only if all of the quarterly values involved in the calculation were less than the limit of sensitivity.

During 1989, the monitoring program for SLAPS measured radon concentrations in air; external gamma dose rates; and uranium, thorium, and radium concentrations in surface water, groundwater, and sediment. In addition, several nonradiological parameters were measured in groundwater.

Trend tables are provided for radon and external gamma radiation levels and for radionuclides measured in surface water and groundwater (see Subsection 3.7). These tables list annual

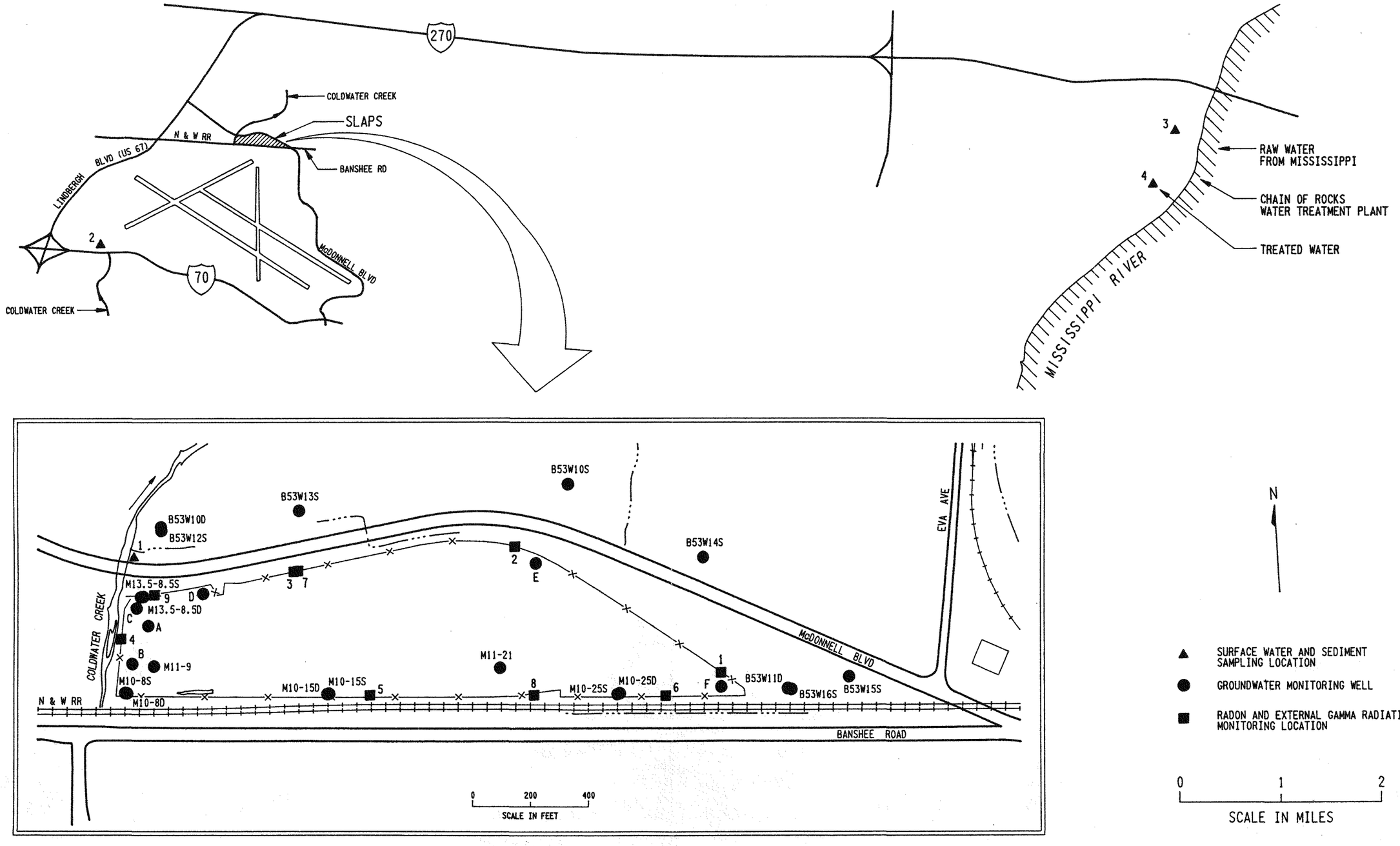
averages for each monitoring location for 1985 through 1989 to allow for comparisons of data and identification of trends in monitoring results.

3.1 RADON SAMPLING

Nine radon detectors are maintained along the site boundary, spaced so as to ensure adequate detection capability under most atmospheric conditions. The locations of the radon monitors are shown in Figure 3-1. Three background detectors are maintained off site.

Radon concentrations are determined using monitors purchased from the Terradex Corporation. These devices (Terradex Type F Track-Etch) consist of an alpha-sensitive film contained in a small plastic cup covered by a membrane through which radon can diffuse. Radon will diffuse through the membrane (in or out of the cup) when a concentration gradient exists; therefore, it will equilibrate with radon in the outside air. Alpha particles from the radioactive decay of radon and its daughters in the cup create tiny tracks when they collide with the film. When returned to Terradex for processing, the films are placed in a caustic etching solution to enlarge the tracks. Under strong magnification, the tracks can be counted. The number of tracks per unit area (i.e., tracks/mm^2) is related through calibration to the concentration of radon in air. Fresh Track-Etch monitors are obtained from Terradex each quarter. Site personnel place these units in each sampling station and return the exposed monitors to Terradex for analysis.

Table 3-1 reports the radon concentrations measured at the 11 monitoring stations. The annual average concentrations ranged from 5×10^{-10} to 2×10^{-9} μCi/ml (0.5 to 2 pCi/L). Background concentrations ranged from 5 to 6×10^{-10} μCi/ml (0.5 to 0.6 pCi/L) and have not been subtracted. Based on measured radon concentrations at SLAPS, the on-site radon source has a minimal effect on radon concentrations in the area. All measurements were less than the DOE guideline of 3.0 pCi/L.



134F132.DGN GIGO

FIGURE 3-1 SLAPS ENVIRONMENTAL MONITORING LOCATIONS

TABLE 3-1

CONCENTRATIONS OF RADON-222 AT SLAPS, 1989

Sampling Station[a]	Number of Samples	Concentration (10^{-9} µCi/ml)[b,c] Minimum	Maximum	Average
1	4	<0.1	0.9	0.5
2	4	0.7	2.4	2.0
3	4	0.5	1.0	0.8
4	4	0.4	1.1	0.7
5	4	0.7	1.7	1.0
6	4	0.3	1.0	0.6
7[d]	4	0.6	1.3	0.9
8	4	0.9	2.9	1.8
9	4	<0.3	1.0	0.6
Background				
16[e]	4	<0.3	0.8	0.5
17[f]	4	<0.3	0.9	0.5
18[g]	4	0.4	0.8	0.6

[a]Locations of sampling stations are shown in Figure 3-1 (also see footnotes e, f, g).

[b]Background has not been subtracted. Note that some stations have radon concentrations below background values.

[c]1 x 10^{-9} µCi/ml is equivalent to 1 pCi/L.

[d]Station 7 is a quality control for station 3.

[e]Located in Florissant, Missouri, 24 km (15 mi) northeast of SLAPS.

[f]Located at McDonnell Blvd., 0.8 km (0.5 mi) east of SLAPS. Established in April 1988.

[g]Located in St. Charles County, Missouri, approximately 32 km (20 mi) southwest of SLAPS. Established in April 1988.

For comparisons of radon concentrations measured from 1985 through 1989, see Subsection 3.7.1.

3.2 EXTERNAL GAMMA RADIATION

External gamma radiation levels were measured at the nine on-site monitoring stations that correspond to the radon (Terradex) detector stations shown in Figure 3-1.

External gamma radiation levels are measured using lithium fluoride thermoluminescent dosimeters (TLDs). Beginning in 1988, the system of measurement utilizes tissue-equivalent dosimeters to provide values that are more realistic in terms of radiation dose to the tissues of the body at a depth of 1 cm (0.4 in.). Each monitoring station contains a minimum of four dosimeters, which are exchanged after approximately one year of accumulated exposure. For example, a dosimeter placed in the station in October 1988 would be removed in October 1989 and replaced with a new dosimeter. Each dosimeter contains five individual lithium fluoride chips (each group of five chips preselected on the basis of having a reproducibility of ±3 percent across a series of laboratory exposures), the responses of which are averaged. Analysis is performed by Thermo Analytical/Eberline (TMA/E). The average value is then corrected for the shielding effect of the shelter housing (approximately 8 percent). The corrected value is then converted to millirem per year by dividing by the number of days of exposure and subsequently multiplying by 365 days.

Because the current measurement system allows for dosimeter detection intervals of approximately a year versus the 3-month interval previously used, the current system is more sensitive to low radiation levels than the system used previously. Although the tissue-equivalent TLDs used are "state-of-the-art," one should keep in mind when examining the external gamma radiation results that the dosimeter accuracy is approximately ±10 percent at levels of 100 mrem/yr to 1 rem/yr and ±25 percent at radiation levels of approximately 70 mrem/yr.

The results of the measurements for external gamma radiation are presented in Table 3-2. For each quarter, an average of the background levels measured was subtracted from measurements taken at the site boundary to provide an estimate of radiation levels resulting from residual materials at the site. Annual radiation levels ranged from 29 to 1,938 mrem/yr above average background at the monitoring locations. The highest radiation level occurred at station 2, which is in an area known to be contaminated. The elevated level is due to this station's proximity to a ditch located between the site fence and McDonnell Boulevard (Ref. 7). The radioactive contamination in the ditches will be cleaned up as part of the remedial action to be conducted at the site, and these areas will be monitored along with the site itself until remedial action is complete.

The next highest annual average gamma radiation level measured at SLAPS in 1989 was 132 mrem/yr above background. The annual average background radiation level was 56 mrem/yr. For comparisons of external radiation levels measured from 1985 through 1989, see Subsection 3.7.2.

The background external gamma radiation value for a given location is not constant. Because the background radiation value is a combination of both natural terrestrial sources and cosmic radiation sources, factors such as the location of the detector in relation to surface rock outcrops, stone or concrete structures, or highly mineralized soil can affect the value measured. Independent of the placement of the detector at the site are the factors of site altitude, annual barometric pressure cycles, and the occurrence and frequency of solar flare activity (Ref. 17). Because of these factors, it is not abnormal for some stations at the boundary of a site to have external gamma radiation values less than the background level measured some distance from the site.

In April 1988, additional background monitoring stations were established at the Federal Aviation Administration Building,

TABLE 3-2

EXTERNAL GAMMA RADIATION LEVELS AT SLAPS, 1989

Sampling Station[a]	Number of Measurements	Radiation Level (mrem/yr)[b] Minimum	Maximum	Average
1	4	32	48	41
2	4	1584	2326	1938
3[c]	4	61	105	86
4	4	26	132	57
5	4	20	34	29
6	4	18	41	32
7[c]	4	82	100	89
8[d]	4	25	38	34
9	4	112	147	132
Background				
16[e]	4	52	71	61
17[f]	3	55	67	62
18[g]	3	40	48	45

[a]Locations of sampling stations are shown in Figure 3-1 (also see footnotes e, f, g).

[b]Measured background has been subtracted from the readings taken at the nine sampling locations shown in Figure 3-1.

[c]Stations 3 and 7 are quality control stations.

[d]Station 8 was moved in April 1987.

[e]Located in Florissant, Missouri, 24 km (15 mi) northeast of SLAPS.

[f]Located at McDonnell Blvd., 0.8 km (0.5 mi) east of SLAPS. Station established in April 1988. Because the sampling regime dictates that TLDs be exposed for one full year before reading, no data are available for the first quarter of 1989.

[g]Located at St. Charles County Airport, approximately 32 km (20 mi) southwest of SLAPS. Location established in April 1988. Because the sampling regime dictates that TLDs be exposed for one full year before readings are taken, no data are available for the first quarter of 1989.

located 0.8 km (0.5 mi) east of SLAPS at McDonnell Blvd., and at St. Charles County Airport, located approximately 32 km (20 mi) southwest of SLAPS in St. Charles County.

3.3 SURFACE WATER SAMPLING

During 1989, sampling was performed to determine the concentrations of uranium, radium, and thorium in surface water and groundwater at both off-site and on-site locations (Figure 3-1).

Surface water samples were collected quarterly from four off-site locations. Water samples were taken from Coldwater Creek approximately 15 m (50 ft) downstream of the ditch that runs along McDonnell Boulevard (location 1) and at the intersection of the creek and Interstate 70 (location 2). Location 2 is upstream of SLAPS and provides an indication of background concentrations. Locations 3 and 4 are at the Chain of Rocks Water Treatment Plant downstream of the point at which Coldwater Creek discharges into the Missouri River, which then discharges into the Mississippi River.

Samples were collected using nominal 1-L (0.26-gal) grab samples to fill a 3.8-L (1.0-gal) container and were analyzed by TMA/E. Total uranium was determined by a fluorometric method. Radium-226 concentrations in water were determined by radon emanation. (This method consists of precipitating radium as sulfate and transferring the treated sulfate to a radon bubbler, where radon-222 is allowed to come to equilibrium with its radium-226 parent. The radon-222 is then withdrawn into a scintillation cell and counted by the gross alpha technique. The quantity of radon-222 detected in this manner is directly proportional to the quantity of radium-226 originally present in the sample.) Thorium-230 was eluted in solution, electrodeposited on stainless steel discs, and counted by alpha spectrometry.

The results of analyses for uranium, radium-226, and thorium-230 at all sampling locations are presented in Table 3-3.

TABLE 3-3

CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN SURFACE WATER IN THE VICINITY OF SLAPS, 1989

Sampling Location[a]	Number of Samples	Concentration (10^{-9} µCi/ml)[b] Minimum	Maximum	Average
Total Uranium				
1[c]	4	<3	6	4
2	4[d]	<3	<3	<3
3	3	<3	6	4
4	4	<3	5	4
Radium-226				
1[c]	4	0.1	0.5	0.3
2	4[d]	0.1	0.4	0.3
3	3	0.4	0.4	0.4
4	4	0.1	0.5	0.3
Thorium-230				
1[c]	4	<0.1	<0.6	0.3
2	4[d]	<0.1	0.2	0.1
3	3	<0.1	<0.1	0.1
4	4	<0.1	0.5	0.2

[a] Sampling locations are shown in Figure 3-1.

[b] 1×10^{-9} µCi/ml is equivalent to 1 pCi/L.

[c] Location is upstream of the site and represents background. Background values have not been subtracted.

[d] Sample lost in transit to the laboratory in the fourth quarter.

The average concentrations of each of these radionuclides at the three sampling locations downstream of SLAPS (including the Chain of Rocks Water Treatment Plant) were nearly equal to the background concentrations measured upstream of the site. These values may be compared with the levels of radioactivity in the commonly consumed liquids listed in Appendix D of this report.

For comparisons of radionuclide concentrations measured in surface water from 1985 through 1989, see Subsection 3.7.3.

3.4 GROUNDWATER SAMPLING

During 1989, groundwater samples were collected quarterly from 16 on-site wells. After the wells had been bailed dry or three casing volumes had been removed, the wells were allowed to recharge before nominal 1-L (0.26-gal) grab samples were collected to fill a 3.8-L (1.0-gal) container. Samples were analyzed by TMA/E for total uranium, radium-226, and thorium-230 using the methods applied to surface water analyses (see Subsection 3.3). Analyses for chemical indicator parameters, metals, organic compounds, pesticides, and polychlorinated biphenyls (PCBs) were performed by Weston Analytical Laboratory.

3.4.1 Radiological

Results of analyses for concentrations of total uranium, radium, and thorium in groundwater are presented in Table 3-4. Quarterly averages for radium-226 ranged from 4 to 9 x 10^{-10} μCi/ml (0.4 to 0.9 pCi/L). For thorium-230, averages ranged from 1 x 10^{-10} to 1.1 x 10^{-8} μCi/ml (0.1 to 11 pCi/L). Averages for total uranium in groundwater ranged from <3 x 10^{-9} to 5.28 x 10^{-6} μCi/ml (<3 to 5,281 pCi/L). Radium-226 and thorium-230 concentrations approximate levels measured in background wells and are within DOE derived concentration guidelines.

Concentrations of total uranium in several of the shallow wells at SLAPS are high because the wells are located in areas of known subsurface contamination. However, because SLAPS is fenced,

TABLE 3-4

CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN GROUNDWATER AT SLAPS, 1989

Sampling Location[a]	Number of Samples	Concentration (10^{-9} µCi/ml)[b] Minimum	Maximum	Average
Total Uranium				
Well A	4	1828	2302	2065
Well B	4	4739	6161	5281
Well C	4	11	35	20
Well D	4	521	948	773
Well E	4	122	264	205
Well F[c]	4	217	305	266
Well M10-25S	4	24	51	33
Well M10-25D	4	<3	4	3
Well M11-21	4	95	101	96
Well M10-15S	4	5	17	11
Well M10-15D	4	<3	<3	<3
Well M10-8S	4	<3	60	21
Well M10-8D	4	<3	9	5
Well M11-9	4	4333	5281	4807
Well M13.5-8.5S	4	<3	4	3
Well M13.5-8.5D	4	<3	<3	<3
Background				
Well B53W01S[d]	2	<3	<3	<3
Well B53W01D[d]	2	<3	<3	<3
Radium-226				
Well A	4	0.3	0.5	0.4
Well B	4	0.5	0.8	0.6
Well C	4	0.4	0.6	0.5
Well D	4	0.3	1.0	0.5
Well E	4	0.4	0.7	0.6
Well F[c]	4	0.2	1.0	0.4
Well M10-25S	4	0.4	0.6	0.5
Well M10-25D	4	0.4	1.5	0.7
Well M11-21	4	0.5	0.9	0.7
Well M10-15S	4	0.3	0.6	0.4
Well M10-15D	4	0.6	1.5	0.9
Well M10-8S	4	0.3	0.5	0.4
Well M10-8D	4	0.4	0.8	0.6
Well M11-9	4	0.3	0.9	0.5
Well M13.5-8.5S	4	0.3	0.7	0.5
Well M13.5-8.5D	4	0.4	0.8	0.6

TABLE 3-4

(continued)

Sampling Location[a]	Number of Samples	Concentration (10^{-9} µCi/ml)[b] Minimum	Maximum	Average
Radium-226 (continued)				
Background				
Well B53W01S[d]	4	0.2	1.9	0.7
Well B53W01D[d]	4	0.9	1.1	1.0
Thorium-230				
Well A	4	1.1	5.2	2.9
Well B	4	0.5	1.7	1.1
Well C	4	<0.1	0.3	0.1
Well D	4	0.5	2.7	1.4
Well E	4	1.3	2.3	1.7
Well F[c]	4	0.4	1.2	0.8
Well M10-25S	4	0.1	0.2	0.1
Well M10-25D	4	0.1	2.2	0.8
Well M11-21	4	6.2	15.0	11.0
Well M10-15S	4	0.4	2.9	1.3
Well M10-15D	4	0.1	3.3	1.0
Well M10-8S	4	0.1	0.5	0.3
Well M10-8D	4	<0.1	0.6	0.3
Well M11-9	4	<0.2	1.5	0.8
Well M13.5-8.5S	4	0.1	0.4	0.2
Well M13.5-8.5D	4	0.2	1.1	0.6
Background				
Well B53W01S[d]	4	<0.1	0.8	0.3
Well B53W01D[d]	4	0.3	0.6	0.4

[a]Sampling locations are shown in Figure 3-1. Background locations B53W01D and B53W01S are shown in Figure 1-5.

[b]1×10^{-9} µCi/ml is equivalent to 1 pCi/L.

[c]Upgradient well.

[d]New well; first sampled in July 1988. Located at Byassee Drive, approximately 0.8 km (0.5 mi) northwest of SLAPS.

the public does not have access to these wells; furthermore, there is no known consumption of groundwater in the vicinity of the site. Groundwater that might discharge to Coldwater Creek is monitored as part of the surface water monitoring program. Current indications are that this potential transport pathway has not resulted in degradation of surface water quality. As a result, there is no evidence that anyone is being exposed to levels of radiation that approach the DOE radiation pretection standard of 100 mrem/yr.

For a discussion of the comparisons of radionuclide concentrations in groundwater measured from 1985 through 1989, see Subsection 3.7.4.

3.4.2 Chemical

In April 1987, monitoring of the groundwater for chemical indicator parameters began at SLAPS. These parameters include pH, specific conductance, total organic carbon (TOC), and total organic halides (TOX). These parameters are indicators of changes in the inorganic and organic composition of the groundwater.

Specific conductance and pH measure changes in the inorganic composition of the groundwater. Acidity and basicity are measured by pH. A change in pH affects the solubility and mobility of chemical contaminants in groundwater. Specific conductance measures the capacity of water to conduct an electrical current. Conductivity generally increases with elevated concentrations of dissolved solids. Waters with high salinities or high total dissolved solids exhibit high conductivities.

Groundwater is analyzed for TOC and TOX to determine the organic content of the water. TOC measures the total organic carbon content of water but is not specific to a given contaminant. TOX measures organic compounds containing halogens, which are organic compounds containing fluorine, chlorine, bromine, and iodine.

Table 3-5 lists the ranges of measured concentrations of the four indicator parameters. Most of the pH and TOC levels are within the range of levels in the background wells (B53W01S and

B53W01D). Elevated TOX values occurred in wells B, M11-21, and M11-9. Specific conductance levels indicate that many of the wells show levels several times greater than background of total dissolved solids. Analytical results for chemical indicators show that the groundwater is of low quality. Wells with historically high levels of uranium (A, B, D, E, M11-9, and M11-21) exhibit elevated specific conductance values.

In January 1989, analyses were performed for priority pollutant organics, including 36 volatile organic compounds (VOCs); 65 base/neutral and acid extractable compounds (BNAEs); and 27 pesticides and polychlorinated biphenyls (PCBs). The samples were also filtered and analyzed for the following metals: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc. Some of these metals (e.g., molybdenum and selenium) were chosen because they are typically found associated with the processing of uranium ores.

Concentrations of many of the analytes were below the limit of detection for the respective analytical method. Table 3-6 lists the parameters for which analyses were conducted, but for which analytes were not detected.

Five organic compounds were detected at low concentrations: the pesticide Endosulfan I, 1,2-dichloroethene, trichloroethene, toluene, and bis(2-ethylhexyl)phthalate. The 1,2-dichloroethene and trichloroethene can be related to the elevated TOX values measured in groundwater samples. This would also explain the high TOX values in wells B and M11-9. These compounds are typically associated with solvents, and their presence is likely tied to industrial activity in the area. Several samples and their associated blanks contained methylene chloride and acetone at similar levels. For this reason, these compounds are deemed laboratory artifacts and are not reported. Several other blanks showed the presence of trichloroethene and bis(2-ethylhexyl) phthalate at very low levels. These low levels did not affect the

TABLE 3-5

CONCENTRATIONS OF INDICATOR PARAMETERS IN GROUNDWATER AT SLAPS, 1989

Sampling Location (Well No.)[a]	Parameter			
	pH (Standard Units)[b]	Total Organic Carbon (mg/L)	Total Organic Halides (µg/L)[c]	Specific Conductance (µmhos/cm)
A	6.7 - 6.8	6.0 - 18.6	ND - 48	1590 - 1770
B	6.6	7.6 - 24.5	31 - 240	6970 - 8070
C	6.9	6.8 - 7.8	ND - 83	1580 - 1800
D	6.9	6.3 - 11.8	ND - 89	1970 - 2580
E	6.8 - 7.0	2.8 - 5.0	ND - 23	4880 - 6000
F[d]	7.2 - 7.4	3.9 - 4.9	ND - 67	699 - 823
M10-8S	6.9 - 7.0	5.8 - 21.1	ND - 20	1360 - 2070
M10-8D	7.3 - 7.4	5.6 - 12.0	ND - 27	850 - 987
M10-15S	7.0 - 7.1	1.4 - 6.7	ND - 40	1750 - 3130
M10-15D	7.2 - 7.3	5.1 - 14.1	ND - 30	960 - 9690
M10-25S	7.2 - 7.4	6.7 - 22.9	ND - 63	811 - 923
M10-25D	7.0 - 7.1	2.6 - 9.7	ND - 56	1150 - 1400
M11-9	6.5 - 6.6	8.7 - 17.0	73 - 320	7780 - 8920
M11-21	7.0	4.5 - 17.7	ND - 149	22 - 2500
M13.5-8.5S	6.9 - 7.0	8.2 - 15.9	ND - 45	1620 - 1770
M13.5-8.5D	7.4 - 7.6	7.1 - 9.9	ND - 69	670 - 970
Background				
B53W01S	6.9 - 7.1	2.8 - 44.8	ND - 23	909 - 958
B53W01D	7.1 - 7.3	5.5 - 23.3	ND - 45	1040 - 1100

[a]Sampling locations are shown in Figure 3-1; background locations are shown in Figure 1-5.

[b]Data available for three quarters.

[c]ND - no detectable concentration.

[d]Upgradient well.

TABLE 3-6

METALS, PESTICIDES, PCBs, VOLATILE ORGANICS, AND BNAE COMPOUNDS NOT DETECTED IN GROUNDWATER AT SLAPS, 1989

BNAEs[a]

Phenol
bis(2-chloroethyl)ether
2-chlorophenol
1,3-dichlorobenzene
1,4-dichlorobenzene
Benzyl alcohol
1,2-dichlorobenzene
2-methylphenol
bis(2-chloroisopropyl)ether
4-methylphenol
N-nitroso-di-n-propylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-nitrophenol
2,4-dimethylphenol
Benzoic acid
bis(2-chloroethoxy)methane
2,4-dichlorophenol
1,2,4-trichlorobenzene
Naphthalene
4-chloroaniline
Hexachlorobutadiene
4-chloro-3-methylphenol
2-methylnaphthalene
Hexachlorocyclopentadiene
2,4,6-trichlorophenol
2,4,5-trichlorophenol
2-chloronaphthalene
2-nitroaniline
Dimethylphthalate
Acenaphthylene
2,6-dinitrotoluene
3-nitroaniline
Acenaphthene
2,4-dinitrophenol
4-nitrophenol
Dibenzofuran
2,4-dinitrotoluene
Diethylphthalate
4-chlorophenyl-phenylether
Fluorene
4-nitroaniline
4,6-dinitro-2-methylphenol
N-nitrosodiphenylamine
4-bromophenyl-phenylether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Di-n-butylphthalate
Fluoranthene
Pyrene
Butylbenzylphthalate
3,3'-dichlorobenzidine
Benzo(a)anthracene
Chrysene
Di-n-octyl phthalate
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenzo(a,h)anthracene
Benzo(g,h,i)perylene

Volatile Organics

Chloromethane
Bromomethane
Vinyl chloride
Chloroethane
Methylene chloride
Acetone
Carbon disulfide
1,1-dichloroethene
1,1-dichloroethane
Chloroform
1,2-dichloroethane
2-butanone
1,1,1-trichloroethane
Carbon tetrachloride
Vinyl acetate
Bromodichloromethane
1,2-dichloropropane
Cis-1,3-dichloropropene
Dibromochloromethane
1,1,2-trichloroethane
Benzene
Trans-1,3-dichloropropene
Bromoform
4-methyl-2-pentanone
2-hexanone
Tetrachloroethene
1,1,2,2-tetrachloroethane
Chlorobenzene
Ethylbenzene
Styrene
Xylene (total)
Acrolein
Acrylonitrile

PCBs[b]

Aroclor-1016
Aroclor-1221
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260

Pesticides

Alpha-BHC
Beta-BHC
Delta-BHC
Gamma-BHC (Lindane)
Heptachlor
Aldrin
Heptachlor epoxide
Diedrin
4,4'-DDE
Endrin
Endosulfan II
4,4'-DDD
Endosulfan sulfate
4,4'-DDT
Methoxychlor
Endrin ketone
Alpha-chlordane
Gamma-chlordane
Toxaphene

Metals

Antimony
Arsenic
Beryllium
Cadmium
Cobalt
Lead
Molybdenum
Silver
Thallium
Vanadium

[a] Base/neutral and acid extractable compounds.
[b] Polychlorinated biphenyls.

sample, and the data have been reported. Phthalate is a plasticizer that is typically found in groundwater from commercial/industrial areas. Analytical results for organic chemical constituents present in detectable quantities are listed in Table 3-7.

Metal ions are normal constituents of groundwater resulting from the soil through which the groundwater flows. Metal ions can also be introduced as a result of previous waste management activities. Concentrations of metals that were detected in groundwater are given in Table 3-8. Barium, calcium, iron, magnesium, manganese, sodium, and zinc were found in site monitoring wells and background wells. In general, elevated levels of calcium and magnesium, which are common in the area (as evidenced by their concentration in background wells), reduce the acceptability of groundwater for industrial or residential use. Metals that were not found at background well locations but were found in groundwater from the site included aluminum, boron, chromium, and selenium. These metals are typically present in trace (<100μg/L) levels in groundwater (Ref. 18). However, given their somewhat elevated concentrations, it is possible that these metals are present as a result of the waste at the site. Additional groundwater data for the site will be reported and evaluated as part of the remedial investigation report that is being prepared for the St. Louis FUSRAP sites.

3.5 SEDIMENT SAMPLING

During 1989, samples consisting of approximately 500 g of sediment (1.1 lb) were collected off site at surface water sampling locations 1 and 2 (Figure 3-1). TMA/E analyzed the samples for total uranium, radium-226, and thorium-230. Concentrations of isotopic uranium and thorium-230 were determined by alpha spectrometry, whereby the uranium and thorium-230 are leached, extracted, and electroplated on metal substrates. Total uranium

TABLE 3-7

ANALYTICAL RESULTS FOR ORGANIC CHEMICALS

DETECTED IN GROUNDWATER AT SLAPS, 1989

Sampling Location (Well Number)[a]	Concentration (µg/L)[b]				
	Endosulfan I	1,2-dichloro-ethene (total)	Trichloro-ethene	Toluene	Bis(2-ethylhexyl) phthalate
A	ND	ND	ND	11	22
B	ND	77	110	ND	ND
C	ND	ND	ND	ND	ND
D	ND	ND	ND	ND	ND
E	ND	ND	ND	ND	ND
F	ND	ND	ND	ND	ND
M11-21	ND	ND	ND	ND	ND
M10-25S	0.060	ND	ND	ND	36
M10-25D	ND	ND	ND	ND	430
M10-8S	0.090	ND	ND	ND	ND
M10-8D	0.060	ND	ND	61	170
M13.5-8.5S	ND	ND	ND	ND	140
M13.5-8.5D	ND	ND	ND	ND	200
M11-9	ND	95	130	170	170
M10-15D	ND	ND	ND	ND	15
M10-15S	ND	ND	ND	ND	100
Background					
B53W01D	ND	ND	ND	ND	2200
B53W01S	ND	ND	ND	ND	ND

[a]Sampling locations are shown in Figure 3-1.

[b]ND--below limit of detection.

TABLE 3-8

ANALYTICAL RESULTS FOR METALS DETECTED IN GROUNDWATER AT SLAPS, JANUARY 1989

Sampling Location (Well Number)[a]	Concentration (µg/L)[b]													
	Al	Ba	B	Ca	Cr	Cu	Fe	Mg	Mn	Ni	K	Se	Na	Zn
A	300	ND	503	181,000	20.1	ND	155	60,100	320	ND	ND	333	49,400	37.2
B	643	255	268	923,000	ND	47.3	150	302,000	1,370	ND	ND	178	158,000	35.2
C	217	273	200	193,000	21.3	ND	ND	82,200	511	ND	ND	ND	39,400	ND
D	245	ND	201	277,000	ND	ND	130	92,500	5,800	ND	ND	ND	76,000	21.9
E	266	ND	204	555,000	ND	ND	160	60,500	ND	ND	ND	5,560	109,000	ND
F	ND	ND	ND	73,700	ND	ND	ND	39,300	ND	ND	ND	105	24,000	ND
M11-21	203	ND	258	309,000	ND	ND	101	70,000	59	ND	ND	859	84,400	ND
M10-25S	ND	233	ND	250,000	ND	ND	2,420	64,800	6,850	ND	ND	ND	57,000	34.1
M10-25D	ND	699	106	69,700	ND	ND	1,920	34,200	3,230	ND	5,930	ND	55,700	ND
M10-8S	ND	ND	238	82,900	ND	322	ND	30,100	1,050	ND	ND	ND	23,400	ND
M10-8D	ND	358	ND	128,000	ND	ND	105	38,700	2,730	ND	ND	ND	53,100	26.2
M13.5-8.5S	ND	286	ND	236,000	ND	ND	897	68,400	3,710	ND	ND	ND	55,200	43.6
M13.5-8.5D	ND	ND	451	83,600	ND	ND	315	34,000	1,100	58.5	ND	ND	54,800	333
M11-9	669	272	142	998,000	ND	50.3	254	334,000	4,170	ND	ND	ND	180,000	47.4
M10-15D	ND	434	192	98,500	ND	ND	2,780	38,800	3,930	ND	8,490	ND	44,200	23.7
M10-15S	ND	ND	308	261,000	ND	ND	112	127,000	94.6	ND	ND	315	80,100	ND
Background														
B53W01D	ND	540	ND	112,000	ND	ND	ND	42,000	2,100	ND	ND	ND	48,000	13.8
B53W01S	ND	311	ND	112,000	ND	ND	141	47,400	1,150	ND	ND	ND	21,500	31.3

[a]Sampling locations are shown in Figure 3-1.

concentrations were obtained by summing the results from isotopic uranium analyses. Radium-226 concentrations were determined by radon emanation (described in Subsection 3.3).

Analytical results for uranium, radium-226, and thorium-230 (based on dry weight) are presented in Table 3-9. The annual average concentrations of total uranium, radium-226, and thorium-230 at the downstream sampling location were 2.5, 1.2, and 2.9 pCi/g, respectively. The concentration of radium-226 is the same as the background concentration measured at upstream location 2. Total uranium concentration at location 2 is slightly lower than at downstream location 1. The average thorium-230 concentration at location 1 is higher than that at location 2. All of the measured radionuclide concentrations are within the DOE guidelines for soils. (Currently DOE does not have guidelines for radioactivity levels in sediments.)

3.6 RADIATION DOSE

To assess the environmental significance of possible release of radioactivity from materials stored at SLAPS, radiological exposure pathways were evaluated to calculate the potential dose to a hypothetical maximally exposed individual. This individual is one who is assumed to be adjacent to the site and who, when all potential routes of exposure are considered, receives the greatest dose. An appraisal of potential pathways (exposure to external radiation, ingestion of water, and inhalation of radon) suggested that external gamma radiation was the only plausibly significant exposure mode.

The dose from ingesting groundwater or surface water runoff from SLAPS was not calculated because it was considered unrealistic that ingestion of this water could occur. SLAPS is fenced and locked, and a member of the public could only gain access to the water by trespassing on the property. To consume groundwater from a well at SLAPS, the trespasser would have to be equipped with a means of removing the well cap (which is locked) and of extracting the groundwater, such as a bailer or pump.

TABLE 3-9

CONCENTRATIONS OF RADIUM-226, THORIUM-230, AND TOTAL URANIUM IN SEDIMENT IN THE VICINITY OF SLAPS, 1989

Sampling Location[a]	Number of Samples	Concentration [pCi/g (dry)] Minimum	Maximum	Average
Radium-226				
1	4	1.0	1.4	1.2
2	4	0.8	1.8	1.2
Thorium-230				
1	4	0.9	6.0	2.9
2	4	0.5	0.9	0.8
Total Uranium				
1	4	1.6	4.2	2.5
2	4	0.8	2.8	1.9

[a]Sampling locations are shown in Figure 3-1. Location 1 is downstream of the site and location 2 is upstream.

Radon concentrations measured at all boundary sampling locations except two were within the normal levels and variations associated with background measurements. Given the amount of time that the maximally exposed individual would spend near these locations, the dose from radon inhalation would be indistinguishable from the dose received from background concentrations. Consequently, this pathway would not contribute additional dose to the maximally exposed individual and was not considered in dose calculations presented in Subsection 3.6.1. Measured radon concentrations are discussed in Subsection 3.1.

3.6.1 Dose to the Maximally Exposed Individual

To identify the individual in the vicinity of SLAPS who would receive the highest dose from on-site radioactive materials, the dose from exposure to external gamma radiation was calculated at various monitoring locations that could be accessible to the public. From these calculations, it was determined that the highest overall dose would be received by an individual who walked daily along the northern site boundary. Because the area adjacent to SLAPS is normally unoccupied, exposure was calculated assuming that the maximally exposed individual walked next to the fence line twice a day, 5 days per week. It was also assumed that the individual walked at a rate of 4.8 km/h (3 mph) next to the 0.8-km (0.5-mi) northern site boundary and during this period was exposed to an average of the annual exposure rates observed at locations 1, 2, and 3.

The external exposure to this individual would be 6 mrem/yr above background. This exposure is approximately equivalent to 6 percent of the DOE radiation protection standard of 100 mrem/yr and is approximately equal to the exposure a person would receive during two round-trip flights from Los Angeles to New York as a result of the greater amounts of cosmic radiation at higher altitudes (see Appendix D). This scenario is highly conservative in that it is unlikely that any individual would spend so much time at this location.

3.6.2 Dose to the Population in the Vicinity of SLAPS

The dose to the 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 SLAPS, these pathways are direct exposure to gamma radiation, inhalation of radon, and ingestion of water containing radioactive constituents.

The contribution to the population dose made by gamma radiation from on-site radioactive materials is too small to be measured because gamma radiation levels decrease rapidly as distance from a small-area source of radiation increases. For example, if the gamma exposure rate at a distance of 0.9 m (3 ft) from a small-area radioactive source were 100 mrem/yr, the exposure rate at a distance of 6.4 m (21 ft) would be indistinguishable from naturally occurring background radiation. Similarly, radon is known to dissipate rapidly as distance from the radon source increases (Ref. 19). Therefore, radon exposure does not contribute measurably to population dose.

On the basis of radionuclide concentrations measured in water leaving the site, it also appears that there is no plausible pathway by which ingestion of water could result in a significant dose to the population. As water migrates farther from the source, radionuclide concentrations are further reduced, lowering potential doses to even less harmful levels.

Because the contributions to population dose via all 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 of SLAPS that results from radioactive materials present at the site is indistinguishable from the dose the same population receives from naturally occurring radioactive sources.

3.7 TRENDS

The environmental monitoring program at SLAPS was established to allow an annual assessment of the environmental conditions at the site, to provide a historical record for year-to-year comparisons, and to permit detection of trends. In the following subsections, 1989 annual averages for each monitoring location for radon, external gamma radiation, surface water, and groundwater are compared with results for 1985 through 1988 (Refs. 11, 14-16). As the environmental monitoring program at SLAPS continues and more data are collected, comparisons and analyses of trends will become more meaningful.

3.7.1 Radon

As shown in Table 3-10, overall radon levels remained relatively constant as compared with previous levels. Radon concentrations along the northern boundary of the site are heavily influenced by soil moisture and the presence or absence of standing water in the ditch that abuts the fence line.

3.7.2 External Gamma Radiation

As shown in Table 3-11, external gamma radiation levels at the site boundary have not changed discernibly since monitoring began in 1984. Overall, the 1989 external gamma radiation levels remained stable as compared with the 1988 values.

3.7.3 Surface Water

Measured concentrations of radionuclides in surface water at SLAPS have remained relatively stable since 1985 and remain about equal to the upstream values. Surface water data for the period 1985-1989 are given in Table 3-12.

TABLE 3-10

ANNUAL AVERAGE CONCENTRATIONS OF RADON-222 AT SLAPS, 1985-1989[a]

Sampling Station[b]	Concentration (10^{-9} µCi/ml)[c,d]				
	1985	1986	1987	1988	1989
1	0.5	0.4	1.6	1.1	0.5
2	1.2	3.5	3.6	1.2	2.0
3	0.8	0.8	0.7	1.0	0.8
4	0.4	0.9	0.8	1.0	0.7
5	0.8	0.6	2.1	2.1	1.0
6	0.5	0.6	0.5	0.8	0.6
7	0.5	0.7	0.8	0.7	0.9
8	1.0	0.7	1.3	1.8	1.8
9[e]	--	--	3.1	1.0	0.6
Background					
16[f]	0.5	0.3	0.4	0.4	0.5
17[g]	--	--	--	0.4	0.5
18[h]	--	--	--	0.5	0.6

[a]Data sources for 1985-1988 are the annual site environmental reports for those years (Refs. 11, 14-16).

[b]Locations of sampling stations are shown in Figure 3-1 (also see footnotes f, g, h).

[c]Background has not been subtracted.

[d]1 x 10^{-9} µCi/ml is equivalent to 1 pCi/L.

[e]Detector installed in April 1987.

[f]Background detector installed in 1985 in Florissant, Missouri, approximately 24 km (15 mi) northeast of SLAPS.

[g]Background detector installed in April 1988 at McDonnell Blvd., approximately 0.8 km (0.5 mi) east of SLAPS.

[h]Background detector installed in April 1988 in St. Charles County, approximately 32 km (20 mi) southwest of SLAPS.

TABLE 3-11

ANNUAL AVERAGE EXTERNAL GAMMA RADIATION LEVELS AT SLAPS, 1985-1989[a]

Sampling Station[b]	Radiation Level (mrem/yr)[c] 1985	1986	1987	1988	1989
1	46	14	34	47	41
2	2087	1363	1557	2128	1938
3	116	67	87	101	86
4	57	21	38	38	57
5	3	81	67	45	29
6	41	10	35	43	32
7[d]	93	43	58	129	89
8	12	17	25	38	34
9[e]	--	--	110	129	132
Background					
16[f]	99	97	77	73	61
17[g]	--	--	--	--	62[i]
18[h]	--	--	--	--	45[i]

[a]Data sources for prior years are the annual site environmental reports for those years (Refs. 11, 14-16).

[b]Locations of sampling stations are shown in Figure 3-1 (also see footnotes f, g, h).

[c]Measured background has been subtracted from the readings taken at the nine sampling locations shown in Figure 3-1.

[d]Station 7 is a quality control for station 3.

[e]Station 9 was established in April 1987.

[f]Located in Florissant, Missouri, 24 km (15 mi) northeast of SLAPS.

[g]Located at McDonnell Blvd., 0.8 km (0.5 mi) east of SLAPS; installed in April 1988.

[h]Located at St. Charles County Airport, approximately 32 km (20 mi) southwest of SLAPS; installed in April 1988.

[i]Because of the measurement system operating parameters, data from these new sites were used for measurements in the last three quarters only.

TABLE 3-12

ANNUAL AVERAGE CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN SURFACE WATER IN THE VICINITY OF SLAPS, 1985-1989[a]

Sampling Location[b]	Concentration (10^{-9} µCi/ml)[c]				
	1985	1986	1987	1988	1989
Total Uranium					
1[d]	3.4	4.3	4.2	4.0	4.6
2	<3.0	<3.0	<3.0	4.0	<3.4
3	<3.0	<3.0	<4.0	4.0	4.3
4	<3.0	3.5	<4.0	3.0	4.1
Radium-226					
1[d]	0.2	0.2	0.4	0.3	0.3
2	0.1	0.3	0.3	0.5	0.3
3	0.2	0.2	0.3	0.3	0.4
4	0.1	0.2	0.3	0.2	0.3
Thorium-230					
1[d]	0.4	<0.2	0.4	0.3	0.3
2	<0.4	<0.2	0.2	0.1	0.1
3	<0.5	0.3	0.3	0.3	<0.1
4	<0.4	<0.2	<0.2	<0.1	0.2

[a]Data sources for 1985-1988 are the annual site environmental reports for those years (Refs. 11, 14-16).

[b]Sampling locations are shown in Figure 3-1.

[c]1×10^{-9} µCi/ml is equivalent to 1 pCi/L.

[d]Location is upstream of the site and serves as background. Background values have not been subtracted.

3.7.4 Groundwater

Ten new wells installed in 1986 were added to the groundwater monitoring program in April 1987. Uranium, radium-226, and thorium-230 values for 1987 through 1989 in these new wells are presented in Table 3-13. Concentrations of total uranium in groundwater have remained consistently high in wells A, B, D, E, and M11-9. These wells are located in or adjacent to buried radioactive materials. Levels of radium-226 and thorium-230 have been generally stable at low levels.

Uranium concentrations in groundwater are influenced by the rate at which groundwater moves through the site. For years in which there is a deficit in rainfall and thus a reduced recharge of the groundwater, uranium levels can be expected to rise. Uranium concentrations have not changed substantively from well to well.

Because SLAPS is fenced, the public does not have access to these wells and there is no known consumption of groundwater in the vicinity of the site. Based on analytical results for surface water and hydrogeological studies concerning discharge of groundwater into Coldwater Creek, there is no evidence that surface water downstream of the site has been degraded. Therefore, there is no reason to suspect that any member of the public receives an internal dose of radiation that would approach the DOE radiation protection standard of 100 mrem/yr.

TABLE 3-13

ANNUAL AVERAGE CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN GROUNDWATER AT SLAPS, 1985-1989[a]

Sampling Location[b,c]	Concentration (10^{-9} µCi/ml)[d]				
	1985	1986	1987	1988	1989
Total Uranium					
Well A	2375	1184	1139	1700	2065
Well B	4735	6570	5829	5590	5281
Well C	36	16	13	18	20
Well D	474	802	637	475	773
Well E[e]	114	540	576	197	819
Well F[e]	177	146	106	265	266
Well M10-25S	--	--	25	39	33
Well M10-25D	--	--	4	4	3
Well M11-21	--	--	45	73	96
Well M10-15S	--	--	11	9	11
Well M10-15D	--	--	9	5	<3
Well M10-8S	--	--	32	19	21
Well M10-8D	--	--	5	4	5
Well M11-9	--	--	4578	4620	4807
Well M13.5-8.5S	--	--	4	4	3
Well M13.5-8.5D	--	--	<3	<3	<3
Background[f]					
Well B53W01S	--	--	--	3	<3
Well B53W01D	--	--	--	4	<3
Radium-226					
Well A	0.2	0.3	0.3	0.4	0.4
Well B	0.2	0.3	0.3	0.6	0.6
Well C	0.2	0.3	0.4	0.5	0.5
Well D	0.1	0.3	0.1	0.3	0.5
Well E[e]	0.2	0.5	0.3	0.6	0.6
Well F[e]	0.1	0.2	0.3	0.6	0.4
Well M10-25S	--	--	0.2	0.6	0.5
Well M10-25D	--	--	0.2	0.4	0.7
Well M11-21	--	--	0.5	0.7	0.7
Well M10-15S	--	--	0.3	0.8	0.4
Well M10-15D	--	--	0.4	0.9	0.9
Well M10-8S	--	--	0.4	0.5	0.4
Well M10-8D	--	--	0.3	0.6	0.6
Well M11-9	--	--	0.5	0.8	0.5
Well M13.5-8.5S	--	--	0.5	0.8	0.5
Well M13.5-8.5D	--	--	0.5	0.6	0.6

TABLE 3-13

(continued)

Sampling Location[b,c]	Concentration (10^{-9} µCi/ml)[d]				
	1985	1986	1987	1988	1989
Radium-226 (continued)					
Background[f]					
Well B53W01S	--	--	--	0.6	0.7
Well B53W01D	--	--	--	1.1	1.0
Thorium-230					
Well A	2.3	<0.4	0.8	2.8	2.9
Well B	0.3	1.2	1.4	2.0	1.1
Well C	0.2	0.2	0.9	0.3	0.1
Well D	1.3	0.3	0.9	0.9	1.4
Well E[e]	1.0	0.4	0.9	4.8	1.7
Well F[e]	1.1	0.2	1.7	2.0	0.8
Well M10-25	--	--	0.2	0.4	0.1
Well M10-25D	--	--	<0.8	0.5	0.8
Well M11-21	--	--	15.2	52.0	11.0
Well M10-15S	--	--	1.8	5.3	1.3
Well M10-15D	--	--	0.4	1.3	1.1
Well M10-8S	--	--	0.2	0.5	0.3
Well M10-8D	--	--	<0.1	0.3	0.3
Well M11-9	--	--	0.3	1.0	0.8
Well M13.5-8.5S	--	--	0.4	0.7	0.2
Well M13.5-8.5D	--	--	<0.1	0.7	0.6
Background[f]					
Well B53W01S	--	--	--	0.2	0.3
Well B53W01D	--	--	--	0.2	0.4

[a]Data sources for 1985-1988 are the annual site environmental reports for those years (Refs. 11, 14-16).

[b]Sampling locations are shown in Figure 3-1, and background locations are shown in Figure 1-5.

[c]The "M" wells were added to the environmental monitoring program in April 1987.

[d]1×10^{-9} µCi/ml is equivalent to 1 pCi/L.

[e]Upgradient well.

[f]Wells established for background in July 1988.

4.0 RELATED ACTIVITIES AND SPECIAL STUDIES

4.1 RELATED ACTIVITIES

Site maintenance, security, and monitoring continued.

4.2 SPECIAL STUDIES

No special studies were carried out in 1989.

REFERENCES

1. Roy F. Weston, Inc. Evaluation of Environmental Impact Associated with the Former Airport Storage Site of the Atomic Energy Commission, St. Louis County, Missouri, March 1980.

2. Roy F. Weston, Inc. Environmental Impact Assessment of the Former Airport Storage Site of the Atomic Energy Commission, St. Louis County, Missouri, July 1979.

3. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Wind - Ceiling - Visibility Data at Selected Airports, Interagency Agreement DOT-FA79WAI-057, National Climatic Data Center, Asheville, N.C., January 1981.

4. U.S. Department of Energy. Remedial Action Work Plan for the St. Louis Airport Disposal Site, DOE/OR-868, Rev. 1, Oak Ridge, Tenn., December 1986.

5. Oak Ridge National Laboratory. Formerly Utilized MED/AEC Sites Remedial Action Program Radiological Survey of the St. Louis Airport Storage Site, DOE/E8-0005/16, Oak Ridge, Tenn., September 1979.

6. Bechtel National, Inc. Radiological Survey of the Ditches at the St. Louis Airport Storage Site (SLAPSS), Oak Ridge, Tenn., August 1983.

7. Bechtel National, Inc. Radiological and Limited Chemical Characterization Report for the St. Louis Airport Site, DOE/OR/20722-163, Oak Ridge, Tenn., August 1987.

8. Roy F. Weston, Inc. Formerly Utilized Sites Remedial Action Program, St. Louis Airport Storage Site, Technical Series, Volume 1: Site Characterization, Number 1: Site History,

Topographical and Radiological Data Analysis, Geological and Hydrological Data, DOE/OR/20722-1, West Chester, Pa., January 1982.

9. Bechtel National, Inc. St. Louis Airport Site 1986 Field Drilling Activities, Geotechnical Discussion, Letter Report from G.P. Crotwell (BNI) to S.W. Ahrends (DOE/TSD), January 21, 1987.

10. Bechtel National, Inc. Preliminary Geological, Hydrogeological, and Chemical Characterization Report for the Ball Field Area - Hazelwood and Berkeley, Missouri, DOE/OR20722-211, Oak Ridge, Tenn., February 1989.

11. Bechtel National, Inc. St. Louis Airport Site Annual Site Environmental Report - Calendar Year 1988, DOE/OR/20722-220, Oak Ridge, Tenn., April 1989.

12. U.S. Department of Energy. Order 5400.5, Radiation Protection of the Public and the Environment, February 8, 1990.

13. Bechtel National, Inc. St. Louis Airport Storage Site (SLAPSS) Environmental Monitoring Summary - Calendar Year 1984, DOE/OR/20722-59, Oak Ridge, Tenn., July 1985.

14. Bechtel National, Inc. St. Louis Airport Site Annual Site Environmental Report - Calendar Year 1985, DOE/OR/20722-100, Oak Ridge, Tenn., April 1986, revised September 1986.

15. Bechtel National, Inc. St. Louis Airport Site Annual Site Environmental Report - Calendar Year 1986, DOE/OR/20722-145, Oak Ridge, Tenn., May 1987.

16. Bechtel National, Inc. St. Louis Airport Site Annual Site Environmental Report - Calendar Year 1987, DOE/OR/20722-199, Oak Ridge, Tenn., April 1988.

17. Eisenbud, M. Environmental Radioactivity. New York: Viking Press, 1987.

18. U.S. Geological Survey. Study and Interpretation of the Chemical Characteristics of Natural Water, Water-Supply Paper 1473, Washington, D.C., 1970.

19. Bechtel National, Inc. Niagara Falls Storage Site Environmental Monitoring Report - Calendar Year 1984, DOE/OR/20722-55, Oak Ridge, Tenn., July 1985.

APPENDIX A
QUALITY ASSURANCE

QUALITY ASSURANCE

A comprehensive quality assurance (QA) program involving sampling, data management, and analysis was maintained to ensure that the data reported were representative of actual concentrations in the environment. The QA program meets the requirements of DOE Order 5700.6B and ANSI/ASME NQA-1.

QA sampling requirements were ensured through the following:

- Samples at all locations collected using established procedures
- Sampling program design provided for spikes, trip blanks, field blanks, and quality control (QC) duplicate sampling
- Chain-of-custody procedures implemented to maintain traceability of samples and corresponding analytical results

Data management QA was achieved through:

- Completion and recording of parameter-specific data review checklists for each analysis report
- Use of calculation sheets for constructing data tables and documenting computations
- Double-checking of and concurrence on calculations
  - By the originator
  - By an independent, equally qualified second party

System QA audits are conducted by BNI FUSRAP project QA personnel to verify adherence with laboratory procedures and to evaluate the appropriateness and effectiveness of the procedures. Audit team leaders and auditors are trained and certified in accordance with project procedures. Technical specialists participate as auditors under the direction of the audit team leader when warranted by the nature of the activities being audited. Audit reports are prepared for each audit conducted.

Audit findings that require corrective action and followup are documented, tracked, and resolved, as verified by the project QA supervisor.

Routine radioanalyses for the FUSRAP Environmental Monitoring Program were performed under subcontract by TMA/E, Albuquerque, New Mexico. This laboratory maintained an internal quality assurance program that involved routine calibration of counting instruments, source and background counts, routine yield determinations of radiochemical procedures, and replicate analyses to check precision. The accuracy of radionuclide determination was determined through the use of standards traceable to the National Institute of Standards and Technology (NIST), when available. When NIST standards were not available, standards from the New Brunswick Laboratory were used. The laboratory 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. Table A-1 summarizes results of the EPA comparison studies for water samples. TMA/E has applied and been accepted for readmission into the DOE Laboratory Quality Assessment Program for Radioactive Materials, coordinated by the DOE Environmental Laboratory, New York, New York.

Interlaboratory comparison of the tissue-equivalent TLD results was provided by participation in the International Environmental Dosimeter Project sponsored jointly by DOE, NRC, and EPA.

Chemical analyses were performed under subcontract by Weston Analytical Laboratory, Lionsville, Pennsylvania. Weston's standard practices manual was reviewed and accepted by BNI. The laboratory maintains an internal QA program that involves the following.

TABLE A-1

SUMMARY COMPARISON OF WATER SAMPLE RESULTS

(EPA and TMA/E)

Analysis and Sample Date	Value (pCi/L) EPA	Value (pCi/L) TMA/E	Ratio (TMA/E:EPA)[a]
Alpha			
1/89	41.0 ± 10.0	49.0 ± 1.0	1.20
4/89	8.0 ± 5.0	13.0 ± 1.0	1.63
6/89	30.0 ± 8.0	33.0 ± 2.7	1.10
7/89	29.0 ± 7.0	30.3 ± 2.1	1.04
11/89	4.0 ± 5.0	4.3 ± 0.6	1.08
Beta			
1/89	54.0 ± 5.0	53.0 ± 1.7	0.98
4/89	4.0 ± 5.0	5.3 ± 0.6	1.33
6/89	50.0 ± 5.0	58.3 ± 1.5	1.17
7/89	57.0 ± 5.0	51.0 ± 3.0	0.89
11/89	6.0 ± 5.0	6.7 ± 0.6	1.12
Ra-226			
1/89	5.0 ± 0.8	5.5 ± 0.3	1.10
3/89	3.50 ± 0.50	3.67 ± 0.06	1.05
5/89	4.90 ± 0.7	4.03 ± 0.25	0.82
7/89	3.50 ± 0.50	3.87 ± 0.15	1.11
10/89	17.7 ± 2.7	17.2 ± 0.5	0.97
Ra-228			
1/89	5.2 ± 0.8	6.1 ± 0.2	1.17
3/89	10.3 ± 1.5	11.3 ± 0.7	1.10
5/89	1.70 ± 0.30	1.77 ± 0.30	1.04
7/89	3.60 ± 0.50	5.20 ± 1.04	1.44
10/89	18.3 ± 2.7	24.8 ± 0.3	1.36
U (Natural)			
1/89	5.0 ± 6.0	5.3 ± 0.6	1.06
5/89	5.0 ± 6.0	5.0 ± 0.0	1.00
7/89	3.00 ± 6.00	3.00 ± 0.00	1.00
9/89	41.0 ± 6.0	39.7 ± 1.2	0.97

[a]This ratio can be used to determine the accuracy of TMA/E's analytical procedures.

For inorganic analyses, the program includes:

- Initial calibration and calibration verification
- Continuing calibration verification
- Reagent blank analyses
- Matrix spike analyses
- Duplicate sample analyses
- Laboratory control sample analyses
- Interlaboratory QA/QC

For organic analyses, the program includes:

- Gas chromatography/mass spectrometry instrumentation for both volatile and semivolatile compound analysis
- Initial multilevel calibration for each Hazardous Substances List (HSL) compound
- Matrix spike analyses
- Reagent blank analyses
- Interlaboratory QA/QC
- Continuing calibration for each HSL compound
- Addition of surrogate compounds to each sample and blanks for determining percent recovery information

Weston is currently an EPA-designated Contract Laboratory Program (CLP) laboratory for both organic and inorganic analyses. This requires passing EPA's blind performance evaluation testing each quarter. The technical specifications in BNI's subcontract with Weston specify QA/QC at, and in some cases beyond, the CLP level.

Currently, Weston participates in drinking water, wastewater, and/or hazardous waste certification programs. They are certified (or pending) in 35 such state programs. Continued certification hinges upon Weston's ability to pass regular performance evaluation testing.

Weston's QA program also includes an independent overview by their project QA coordinator and a corporate vice president who audits their program activities quarterly.

APPENDIX B
ENVIRONMENTAL STANDARDS AND CONVERSION FACTORS

ENVIRONMENTAL STANDARDS

The DOE radiation protection standard of 100 mrem/yr above background level includes exposure from all pathways except medical treatments (Ref. 12). Evaluation of exposure pathways and resulting dose calculations are based on assumptions such as occupancy factors in determining the dose from external gamma radiation; subtraction of background concentrations of radionuclides in air, water, and soil before calculating dose; closer review of water use, using the data that most closely represent actual exposure conditions rather than maximum values as applicable; and using average consumption rates of food and water per individual rather than maximums. Use of such assumptions will result in calculated doses that more accurately reflect the exposure potential from site activities.

TABLE B-1

CONVERSION FACTORS

1 gal	=	3.785 L
1 yd^3	=	0.765 m^3
1 ft	=	0.3048 m
1 yr	=	8,760 h
1 L	=	1,000 ml
1 μCi	=	1,000,000 pCi
1 pCi	=	0.000001 μCi
1 pCi/L	=	10^{-9} μCi/ml
1 pCi/L	=	0.000000001 μCi/mL
1 μCi/ml	=	1,000,000,000 pCi/L
10^{-6}	=	0.000001
10^{-7}	=	0.0000001
10^{-8}	=	0.00000001
10^{-9}	=	0.000000001
10^{-10}	=	0.0000000001
7×10^{-10}	=	0.0000000007

APPENDIX C
ABBREVIATIONS AND ACRONYMS

ABBREVIATIONS

Al	aluminum
Ba	barium
B	boron
Ca	calcium
cm	centimeter
cm/s	centimeters per second
Cr	chromium
Cu	copper
Fe	iron
ft	foot
ft msl	feet above mean sea level
g	gram
gal	gallon
h	hour
ha	hectare
in.	inch
K	potassium
km	kilometer
km/h	kilometers per hour
L	liter
lb	pound
m	meter
m^3	cubic meter
Mg	magnesium
mg	milligram
mg/L	milligrams per liter
mi	mile
ml	milliliter
Mn	manganese
mph	miles per hour
mrem	millirem
mrem/yr	millirem per year

ABBREVIATIONS
(continued)

μCi/ml	microcuries per milliliter
μg/L	micrograms per liter
μR/h	microroentgens per hour
Na	sodium
Ni	nickel
pCi	picocurie
pCi/g	picocuries per gram
pCi/L	picocuries per liter
Se	selenium
yd^3	cubic yard
yr	year
Zn	zinc

ACRONYMS

AEC	Atomic Energy Commission
BNAE	base/neutral and acid extractable
BNI	Bechtel National, Inc.
CLP	Contract Laboratory Program
DOE	Department of Energy
EPA	Environmental Protection Agency
FUSRAP	Formerly Utilized Sites Remedial Action Program
HISS	Hazelwood Interim Storage Site
HSL	Hazardous Substances List
ICPAES	inductively coupled plasma atomic emission spectrometry
MED	Manhattan Engineer District
ORNL	Oak Ridge National Laboratory
NIST	National Institute of Standards and Technology
PCB	polychlorinated biphenyl
QA	quality assurance
QC	quality control
SLAPS	St. Louis Airport Site
TLD	thermoluminesent dosimeter
TMA/E	Thermo Analytical/Eberline
TOC	total organic carbon
TOX	total organic halides
VOC	volatile organic compound

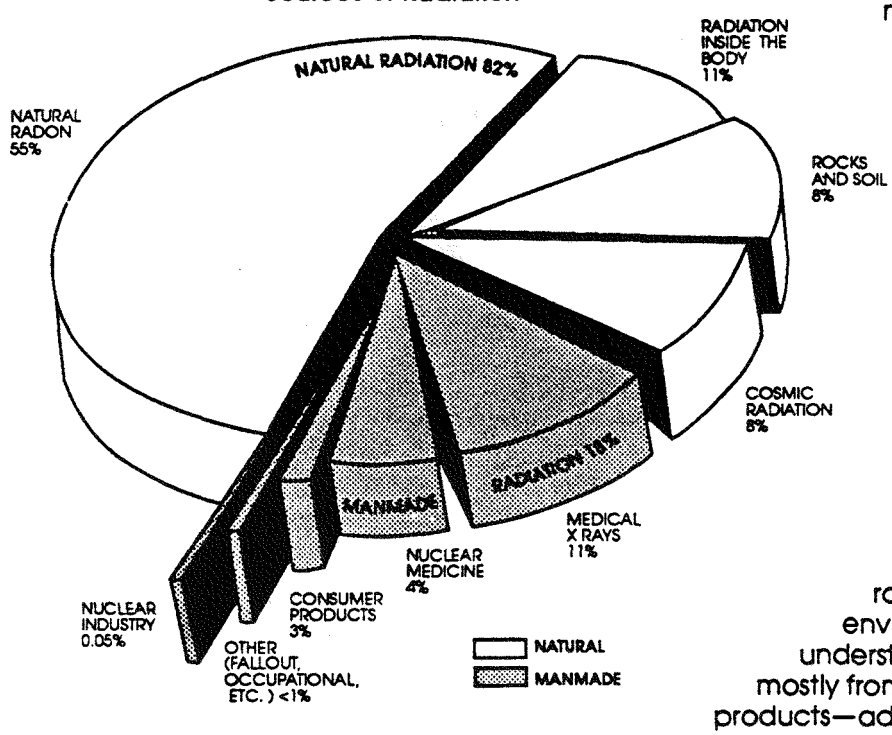
APPENDIX D
RADIATION IN THE ENVIRONMENT

Radiation in the Environment

Radiation is a natural part of our environment. When our planet was formed, radiation was present—and radiation surrounds it still. Natural radiation showers down from the distant reaches of the cosmos and continuously radiates from the rocks, soil, and water on the Earth itself.

During the last century, mankind has discovered radiation, how to use it, and how to control it. As a result, some manmade radiation has been added to the natural amounts present in our environment.

Sources of Radiation



Many materials—both natural and manmade—that we come into contact with in our everyday lives are radioactive. These materials are composed of atoms that release energetic particles or waves as they change into more stable forms. These particles and waves are referred to as *radiation*, and their emission as *radioactivity*.

As the chart on the left shows, most environmental radiation (82%) is from natural sources. By far the largest source is radon, an odorless, colorless gas given off by natural radium in the Earth's crust. While radon has always been present in the environment, its significance is better understood today. Manmade radiation—mostly from medical uses and consumer products—adds about eighteen percent to our total exposure.

TYPES OF IONIZING RADIATION

Radiation that has enough energy to disturb the electrical balance in the atoms of substances it passes through is called *ionizing radiation*. There are three basic forms of ionizing radiation.

Alpha

Alpha particles are the largest and slowest moving type of radiation. They are easily stopped by a sheet of paper or the skin. Alpha particles can move through the air only a few inches before being stopped by air molecules. However, alpha radiation is dangerous to sensitive tissue inside the body.

Beta

Beta particles are much smaller and faster moving than alpha particles. Beta particles pass through paper and can travel in the air for about 10 feet. However, they can be stopped by thin shielding such as a sheet of aluminum foil.

Gamma

Gamma radiation is a type of electromagnetic wave that travels at the speed of light. It takes a thick shield of steel, lead, or concrete to stop gamma rays. X rays and cosmic rays are similar to gamma radiation. X rays are produced by manmade devices; cosmic rays reach Earth from outer space.

Units of Measure

Radiation can be measured in a variety of ways. Typically, units of measure show either 1) the total amount of radioactivity present in a substance, or 2) the level of radiation being given off.

The radioactivity of a substance is measured in terms of the number of transformations (changes into more stable forms) per unit of time. The *curie* is the standard unit for this measurement and is based on the amount of radioactivity contained in 1 gram of radium. Numerically, 1 curie is equal to 37 billion transformations per second. The amounts of radioactivity that people normally work with are in the millicurie (one-thousandth of a curie) or microcurie (one-millionth of a curie) range. Levels of radioactivity in the environment are in the picocurie, or pCi (one-trillionth of a curie) range.

Levels of radiation are measured in various units. The level of gamma radiation in the air is measured by the *roentgen*. This is a relatively large unit, so measurements are often calculated in milliroentgens. Radiation absorbed by humans is measured in either *rad* or *rem*. The rem is the most descriptive because it measures the ability of the specific type of radiation to do damage to biological tissue. Again, typical measurements will often be in the millirem (mrem), or one-thousandth of a rem, range. In the international scientific community, absorbed dose and biological exposure are expressed in *grays* and *seiverts*. 1 gray (Gy) equals 100 rad. 1 seivert (Sv) equals 100 rem. On the average, Americans receive about 360 mrem of radiation a year. Most of this (97%) is from natural radiation and medical exposure. Specific examples of common sources of radiation are shown in the chart below.

Cosmic Radiation

Cosmic radiation is high-energy gamma radiation that originates in outer space and filters through our atmosphere.

Sea Level ..... 26 mrem/year
(increases about 1/2 mrem for each additional 100 feet in elevation)
Atlanta, Georgia (1,050 feet)
..... 31 mrem/year
Denver, Colorado (5,300 feet)
..... 50 mrem/year
Minneapolis, Minnesota (815 feet)
..... 30 mrem/year
Salt Lake City, Utah (4,400 feet)
..... 46 mrem/year

Terrestrial Radiation

Terrestrial sources are naturally radioactive elements in the soil and water such as uranium, radium, and thorium. Average levels of these elements are 1 pCi/gram of soil.

United States (average) ..... 26 mrem/year
Denver, Colorado ..... 63 mrem/year
Nile Delta, Egypt ..... 350 mrem/year
Paris, France ..... 350 mrem/year
Coast of Kerala, India ..... 400 mrem/year
Mcaipe, Brazil ..... 2,558 mrem/year
Pocos De Caldas, Brazil ..... 7,000 mrem/year

Buildings

Many building materials, especially granite, contain naturally radioactive elements.

U.S. Capitol Building ..... 85 mrem/year
Base of Statue of Liberty ..... 325 mrem/year
Grand Central Station ..... 525 mrem/year
The Vatican ..... 800 mrem/year

Radon

Radon levels in buildings vary, depending on geographic location, from 0.1 to 200 pCi/liter.
Average Indoor Radon Level ..... 1.5 pCi/liter
Occupational Working Limit ..... 100.0 pCi/liter

RADIATION IN THE ENVIRONMENT

Because the radioactivity of individual samples varies, the numbers given here are approximate or represent an average. They are shown to provide a perspective for concentrations and levels of radioactivity rather than dose.

mrem = millirem
pCi = picocurie

Food

Food contributes an average of 20 mrem/year, mostly from potassium-40, carbon-14, hydrogen-3, radium-226, and thorium-232.

Beer ..... 390 pCi/liter
Tap Water ..... 20 pCi/liter
Milk ..... 1,400 pCi/liter
Salad Oil ..... 4,900 pCi/liter
Whiskey ..... 1,200 pCi/liter
Brazil Nuts ..... 14 pCi/g
Bananas ..... 3 pCi/g
Flour ..... 0.14 pCi/g
Peanuts & Peanut Butter ..0.12 pCi/g
Tea ..... 0.40 pCi/g

Medical Treatment

The exposures from medical diagnosis vary widely according to the required procedure, the equipment and film used for x rays, and the skill of the operator.

Chest X Ray ..... 10 mrem
Dental X Ray,Each ..... 100 mrem

Consumer Goods

Cigarettes–two packs/day
(polonium-210) ..... 8,000 mrem/year
Color Television ..... <1 mrem/year
Gas Lantern Mantle
(thorium-232) ..... 2 mrem/year
Highway Construction ..... 4 mrem/year
Airplane Travel at 39,000 feet
(cosmic) ..... 0.5 mrem/hour
Natural Gas Heating and Cooking
(radon-222) ..... 2 mrem/year
Phosphate Fertilizers ..... 4 mrem/year

Natural Radioactivity in Florida Phosphate Fertilizers (in pCi/gram)

	Normal Superphosphate	Concentrated Superphosphate	Gypsum
Ra-226	21.3	21.0	33.0
U-238	20.1	58.0	6.0
Th-230	18.9	48.0	13.0
Th-232	0.6	1.3	0.3

Porcelain Dentures
(uranium) ..... 1,500 mrem/year
Radioluminescent Clock
(promethium-147) ..... <1 mrem/year
Smoke Detector
(americium-241) ..... 0.01 mrem/year

International Nuclear Weapons Test Fallout from pre–1980 atmospheric tests
(average for a U.S. citizen) ..... 1 mrem/year

References

ect of Ionizing Radiation on Human Health, The. Arthur C. Upton. New York University Medical Center. Atomic Industrial Forum. 1984.
ects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980. Committee on the Biological Effects of Ionizing Radiation. National Academy Press, 1984.
izing Radiation Exposure of the Population of the United States: Report Number 93. National Council on Radiation Protection and Measurements, 1987.
diation Exposure of the U.S. Population from Consumer Products and Miscellaneous Sources: Report Number 95. National Council on Radiaton Protection and Measurments , 1987.
diation in Medicine and Industry. A.P. Jacobson and G.P. Sakolosky, 1980.
dioactivity in Consumer Products. U.S. Nuclear Regulatory Commission, 1978.

PERSPECTIVE: How Big is a Picocurie?

The *curie* is a standard measure for the intensity of radioactivity contained in a sample of radioactive material. It was named after French scientists Marie and Pierre Curie for their landmark research into the nature of radioactivity.

The basis for the curie is the radioactivity of one gram of radium. Radium decays at a rate of about 2.2 trillion disintegrations ($2.2X10^{12}$) per minute. A *picocurie* is one trillionth of a curie. Thus, a picocurie represents 2.2 disintegrations per minute.

To put the relative size of one *trillionth* into perspective, consider that if the Earth were reduced to one trillionth of its diameter, the "pico earth" would be smaller in diameter than a speck of dust. In fact, it would be six times smaller than the thickness of a human hair.

The difference between the curie and the picocurie is so vast that other metric units are used between them. These are as follows:

Millicurie = $\frac{1}{1,000}$ **(one thousandth) of a curie**

Microcurie = $\frac{1}{1,000,000}$ **(one millionth) of a curie**

Nanocurie = $\frac{1}{1,000,000,000}$ **(one billionth) of a curie**

Picocurie = $\frac{1}{1,000,000,000,000}$ **(one trillionth) of a curie**

The following chart shows the relative differences between the units and gives analogies in dollars. It also gives examples of where these various amounts of radioactivity could typically be found. The number of disintegrations per minute has been rounded off for the chart.

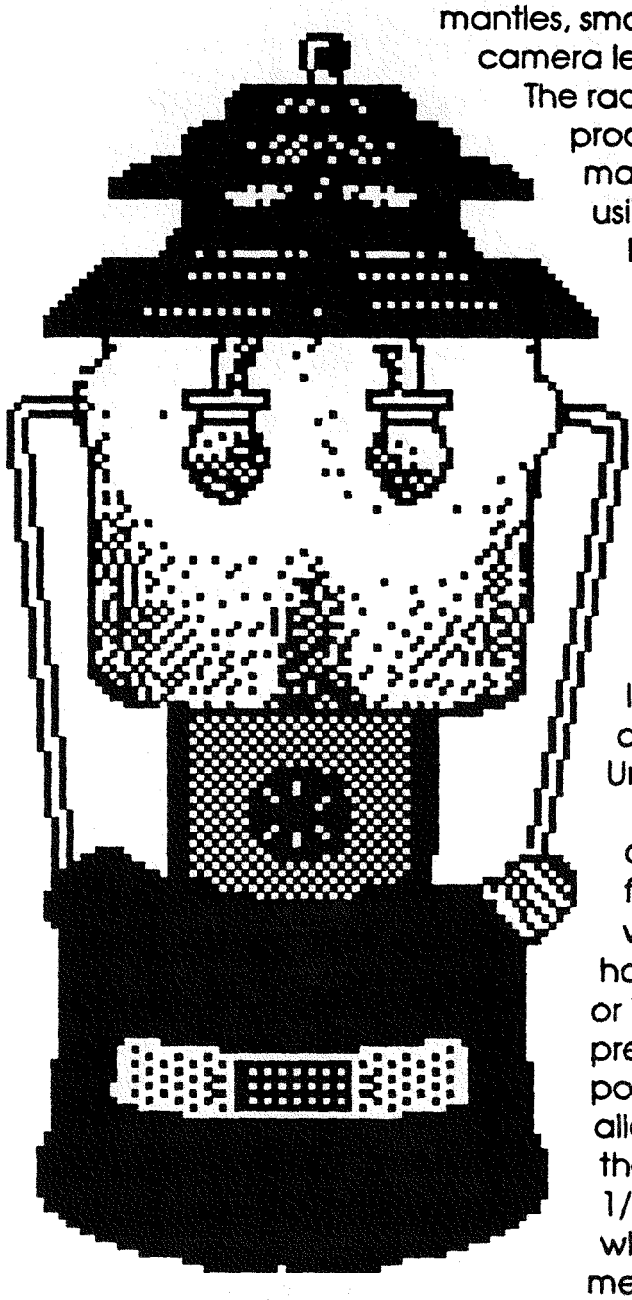
UNIT OF RADIOACTIVITY	SYMBOL	DISINTEGRATIONS PER MINUTE	DOLLAR ANALOGY	EXAMPLES OF RADIOACTIVE MATERIALS
1 Curie	Ci	$2x10^{12}$ or 2 Trillion	2 Times the Annual Federal Budget	Nuclear Medicine Generator
1 Millicurie	mCi	$2x10^{9}$ or 2 Billion	Cost of a New Interstate Highway from Atlanta to San Francisco	Amount Used for a Brain or Liver Scan
1 Microcurie	µCi	$2x10^{6}$ or 2 Million	All-Star Baseball Player's Salary	Amount Used in Thyroid Tests
1 Nanocurie	nCi	$2x10^{3}$ or 2 Thousand	Annual Home Energy Costs	Consumer Products
1 Picocurie	pCi	2	Cost of a Hamburger and Coke	Background Environmental Levels

Chart provided by W.L. Beck, Bechtel National, Inc

PERSPECTIVE: Radioactivity in Gas Lantern Mantles

Around the House

Many household products contain a small amount of radioactivity. Examples include gas lantern mantles, smoke detectors, dentures, camera lenses, and anti-static brushes. The radioactivity is added to the products either specifically to make them work, or as a result of using compounds of elements like thorium and uranium in producing them. The amount of radiation the products gives off is not considered significant. But with today's sensitive equipment, it can be detected.



Lanterns: In a New Light

About 20 million gas lantern mantles are used by campers each year in the United States.

Under today's standards, the amount of natural radioactivity found in a lantern mantle would require precautions in handling it at many Government or industry sites. The radioactivity present would contaminate 15 pounds of dirt to above allowable levels. This is because the average mantle contains 1/3 of a gram of thorium oxide, which has a specific activity (a measure of radioactivity) of approximately 100,000 picocuries per gram. The approximately 35,000 picocuries of radioactivity in the mantle would, if thrown onto the ground, be considered low-level radioactive contamination.

From information provided by W.I. Beck, Bechtel National, Inc.

APPENDIX E
SAMPLE WELL CONSTRUCTION DETAILS

ONITORING WELL	PROJECT	WELL NO.
	ST LOUIS AIRPORT SITE	B53W12S

O.	SITE	COORDINATES
1	Ballfield Area	N 1566 E 927

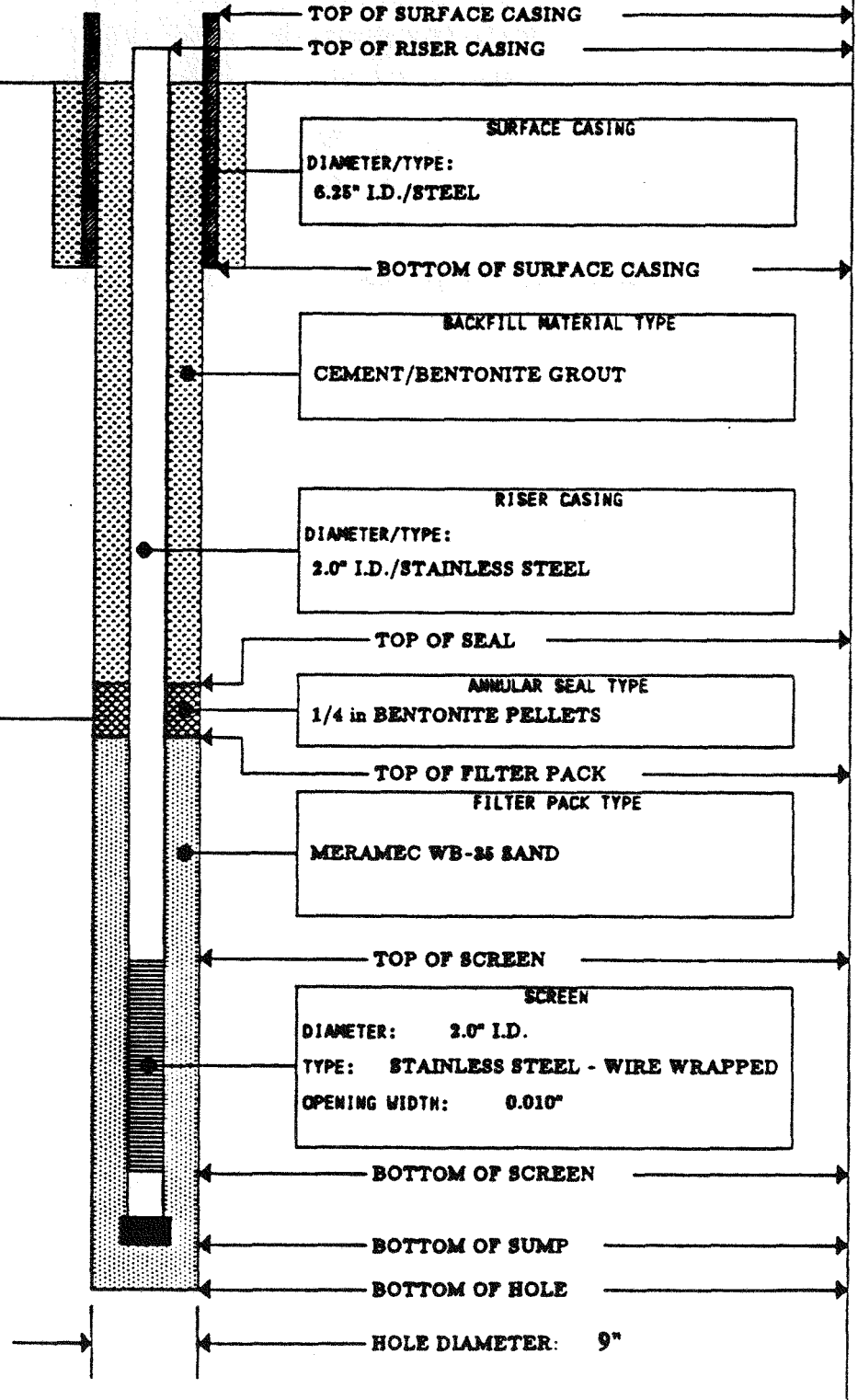
	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
88	1-19-88	G. CHERRY	TOP OF 2' RISER PIPE.

LIZED GEOLOGIC LOG

.5

9.5
'EY SILT

5.0
' CLAY



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	2.0	527.4
TOP OF RISER CASING	1.5	526.9
	0.0	525.4
BOTTOM OF SURFACE CASING	3.2	522.2
TOP OF SEAL	21.9	503.5
TOP OF FILTER PACK	24.1	501.3
TOP OF SCREEN	28.5	496.9
BOTTOM OF SCREEN	33.5	491.9
BOTTOM OF SUMP	34.5	490.9
BOTTOM OF HOLE	35.0	490.4

APPENDIX F

DISTRIBUTION LIST FOR ST. LOUIS AIRPORT SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1989

DISTRIBUTION LIST FOR ST. LOUIS AIRPORT SITE
ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1989

Media:

Editor, North County Publications
9320 Lewis and Clark Boulevard
St. Louis, Missouri 63136

Environmental Editor
St. LOUIS POST-DISPATCH
1710 North Tucker Boulevard
St. Louis, Missouri 63101

News Editor
Suburban St. Louis Newspaper Group
7020 Chippewa Street
St. Louis, Missouri 63119

News Director
KDNL-TV
1215 Cole Street
St. Louis, Missouri 63106

News Director
KETC-TV
6996 Milbrook Boulevard
St. Louis, Missouri 63130

News Director
KMOX-TV
One Memorial Drive
St. Louis, Missouri 63102

News Director
KPLR-TV
4935 Lindell
St. Louis, Missouri 63108

News Director
KSDK-TV
1111 Olive Street
St. Louis, Missouri 63105

News Director
KTVI-TV
5915 Berthold Avenue
St. Louis, Missouri 63110

News Director
Radio Station KMOX
One Memorial Drive
St. Louis, Missouri 63102

Federal:

Mr. Morris Kay, Administrator (5 copies)
U.S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Missouri 66101

Mr. Gene Gunn, Superfund Section
U.S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Missouri 66101

Mr. Robert Morby, Superfund Section
U.S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Mr. Craig Bernstein
Federal Facilities Coordinator
U.S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Missouri 66101

Mr. William Gunter, Director (2 copies)
Criteria and Standards Division
Office of Radiation Programs
U.S. Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460

Mr. Gary Kepko
U.S. Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460

Mr. George DeBuchannanne, Chief
Office of Radiohydrology
U.S. Department of Interior
Geological Survey, MS 140
Reston, Virginia 22000

Mr. Leland Rouse
Fuel Cycle Safety Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Mr. James Zerega
U.S. Army Corps of Engineers
210 Tucker Boulevard, North
St. Louis, Missouri 63101-1986

State:

Mr. Tracy Mehan, Director
State of Missouri
Department of Natural Resources
P.O. Box 176
Jefferson City, Missouri 65102

Mr. Ron Kucera
State of Missouri
Department of Natural Resources
P.O. Box 176
Jefferson City, Missouri 65102

Dr. David Bedan (5 copies)
State of Missouri
Department of Natural Resources
P.O. Box 176
Jefferson City, Missouri 65102

Mr. John R. Crellin, Director
Bureau of Environmental Epidemiology
Division of Health
State of Missouri
Department of Social Services
P.O. Box 570
Jefferson City, Missouri 65102

Local:

Honorable Glennon Robinson
Mayor, City of Hazelwood
415 Elm Grove
Hazelwood, Missouri 63042

Ms. Natalie Rullkoetter
Executive Director
St. Louis County Municipal League
7900 Forsyth Boulevard, Suite A-8
St. Louis, Missouri 63105

Mr. Ed Carlstom
City Manager
City of Hazelwood
415 Elm Grove
Hazelwood, Missouri 63042

Mr. John W. Spell
Administrative Chief
Industrial Hygiene Section
Department of Community Health and Medical Care
801 S. Brentwood Boulevard
Clayton, Missouri 63105

Mr. Jose Hernandez
Division of Public Works
City of Hazelwood
415 Elm Grove
Hazelwood, Missouri 63042

Honorable William Miller
Mayor, City of Berkeley
6140 North Hanley Road
Berkeley, Missouri 63134

Mr. William Powers
Acting Interim City Manager
City of Berkeley
6140 North Hanley Road
Berkeley, Missouri 63134

Mr. Emmanuel Malang
Superintendent of Public Works
City of Berkeley
6140 North Hanley Road
Berkeley, Missouri 63134

Honorable Vincent C. Schoemehl, Jr.
Mayor, City of St. Louis
Tucker and Market Streets
St. Louis, Missouri 63103

Mr. Thomas A. Villa, President
St. Louis Board of Aldermen
Tucker and Market Streets
St. Louis, Missouri 63103

Mr. Robert H. Dierker, Jr.
Assistant City Counselor
City of St. Louis
314 City Hall
St. Louis, Missouri 63103

Ms. Dian Sharma
Health Commissioner
City of St. Louis
Department of Health and Hospitals
Division of Health
P.O. Box 14702
St. Louis, Missouri 63178-4702

General Donald Bennett
Director of Airports
Lambert-St. Louis International Airport
P.O. Box 10036
St. Louis, Missouri 63145

Mr. H. C. Milford
County Executive
County Government Center
Clayton, Missouri 63105

Ms. Dee A. Joyner
Executive Assistant
41 Central
Clayton, Missouri 63105

Honorable Conrad W. Bowers
Mayor, City of Bridgeton
11955 Natural Bridge Road
Bridgeton, Missouri 63044

Mr. David A. Visintainer
City of St. Louis
Department of Public Utilities
Water Division
Supply and Purifying Section
Chain of Rocks Water Treatment Plant
10450 Riverview Boulevard
St. Louis, Missouri 63137

Mr. Kenneth Baldwin, Director
St. Louis County Department of
Community Health and Medical Care
111 S. Meramec Avenue
Clayton, Missouri 63105

Mr. Christopher E. Byrn
St. Louis County Department of
Community Health and Medical Care
111 S. Meramec Avenue
Clayton, Missouri 63105

Congressional:

Honorable Christopher S. Bond
U.S. Senate
321 Hart Senate Office Building
Washington, D.C. 20510

Honorable John Danforth
U.S. Senate
460 Russell Senate Office Building
Washington, D.C. 20510

Ms. Clair Elsberry
Senator Danforth's Office
1223 Jefferson Street
Jefferson City, Missouri 65101

Ms. Joann Digman
Senator Bond's Office
815 Olive Street, Room 220
St. Louis, Missouri 63101

Honorable Jack Buechner
U.S. House of Representatives
502 Cannon House Office Building
Washington, D.C. 20515

Ms. Frances Herrity
Congressman Buechner's Office
13545 Barrett Parkway
Suite 150
Bellwin, Missouri 63021

Honorable William L. Clay
U.S. House of Representatives
2470 Rayburn House Office Building
Washington, D.C. 20515

Mr. Frederick Searcy
Congressman Clay's Office
6197 Delmar
St. Louis, Missouri 63112

Honorable Richard Gephardt
U.S. House of Representatives
1421 Longworth House Office Building
Washington, D.C. 20515

Honorable Harold L. Volkmer
U.S. House of Representatives
2411 Rayburn House Office Building
Washington, D.C. 20515

Miscellaneous:

Mr. Park Owen (2 copies)
Remedial Action Program Information Center
Oak Ridge National Laboratory
Martin Marietta Energy Systems, Inc.
P.O. Box 2008
Oak Ridge, Tennessee 37831-6255

Distribution (27 copies)
Office of Scientific and Technical Information
U.S. Department of Energy
P.O. Box 62
Oak Ridge, Tennessee 37831

Dr. Henry D. Royal
Associate Professor of Radiology
Mallinckrodt Institute of Radiology
510 S. Kingshighway Blvd.
St. Louis, Missouri 63110

Mr. Arbie Hollenberg
256 Alma Drive
Hazelwood, Missouri 63042

Ms. Jean Ruggeri
547 Greenway
Florissant, Missouri 63031

Mr. Wallace Randall
B&R Truss Co.
6490 McDonnell Blvd.
Berkeley, Missouri 63134

Mr. Jim C. Hugh
1170 Weihapt
Florissant, Missouri 73031

Mr. Nick Beskid (3 copies)
Energy and Environmental Systems Division
Argonne National Laboratory
9700 South Cass Avenue, Building 362
Argonne, Illinois 60439

Ms. Meredith Bollmeier
258 Cedar Groves
St. Charles, Missouri 63303

Mr. Joseph Copeland, Director
Health, Safety, and Environmental Affairs
McDonnell Douglas Corporation
P.O. Box 516
St. Louis, Missouri 63166

Mrs. William Bousquette
53 Trent Drive
St. Louis, Missouri 63124

Mrs. Kay Drey
515 West Point Avenue
University City, Missouri 63130

Mr. Harold Heitmann
Executive Director, National
Environmental Trust
146 Clarkson Executive Park
St. Louis, Missouri 63011

Mr. Roger Keller, Attorney
Mallinckrodt, Inc.
675 McDonnell Boulevard
P.O. Box 5840
St. Louis, Missouri 63134

Ms. Pat Hicks
Public Relations Director
Mallinckrodt, Inc.
P.O. Box 5840
St. Louis, Missouri 63134

Mr. Dean Jarboe
Futura Coatings
9200 Latty Avenue
Hazelwood, Missouri 63042

Ms. Betty Wilson
St. Louis County League of Women Voters
6655 Delmar, Room 304
St. Louis, Missouri 63130

Ms. Sandy Delcoure
3029 Willow Creek
Florissant, Missouri 63031

Mr. George Rifakes
Cotter Corporation
P.O. Box 767
Chicago, Illinois 60690

Mr. J. L. Tuepker
Vice President for Production
St. Louis County Water Company
535 N. New Ballas Road
St. Louis, Missouri 63141

Mr. Samuel R. Price
245 Palm Drive
Hazelwood, Missouri 63042

Mr. J. D. Berger
Oak Ridge Associated Universities
P.O. Box 117
Oak Ridge, Tennessee 37831-0117

Mr. Roger Pryor
Missouri Coalition for the
Environment
6267 Delmar Road
St. Louis, Missouri 63130

Ms. Mary Halliday
St. Charles Countians Against
Hazardous Waste
3655 Highway D
Defiance, Missouri 63341

Ms. A. Gale Jordan
Norfolk and Western Railroad
3 Commercial Place
Norfolk, Virginia 23510-2191

DOE-Headquarters:

Ms. M. J. Jameson, Press Secretary
Office of Press Secretary
PA-1, Room 7B-192, HQ, FORSTL

Mr. Edward R. Williams, Director
Office of Environmental Analysis
PE-50, Room 4G-036, HQ, FORSTL

Mr. John C. Tseng, Director (5 copies)
Office of Environmental Guidance and Compliance
EH-23, Room 7A-075, HQ, FORSTL

Mr. Randal S. Scott, Director (2 copies)
Office of Environmental Audit
EH-24, Room 3E-094, HQ, FORSTL

Ms. Carol M. Borgstrom, Director (2 copies)
Office of NEPA Project Assistance
EH-25, Room 3E-080, HQ, FORSTL

Acting Director
Division of Eastern Area Programs
Office of Environmental Restoration
EM-42, Room D-430, HQ, GTN

Off-site Remediation Branch
Division of Eastern Area Programs
Office of Environmental Restoration
EM-421, Room D-428, HQ, GTN

DOE-ORO:

J. T. Alexander, M-4 (3 copies)
L. K. Price, EW-93
J. G. Hart, Jr., EW-93
D. G. Adler, EW-93
S. K. Oldham, EW-93
Peter. J. Gross, SE-31 (3 copies)