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Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-91OR21949

ST. LOUIS AIRPORT SITE ANNUAL ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990

St. Louis, Missouri

August 1991

Bechtel National, Inc.

080563

91-572

Department of Energy
Oak Ridge Operations
P.O. Box 2001
Oak Ridge, Tennessee 37831-8723

August 26, 1991

Distribution

ANNUAL SITE ENVIRONMENTAL REPORT - ST. LOUIS AIRPORT SITE

Enclosed for your information is a copy of the 1990 Annual Site Environmental Report for the U.S. Department of Energy's St. Louis Airport Site located in your region. This report is prepared and published annually for distribution to interested local, state, and federal agencies; members of the public; and the press.

If you have any questions on the content of this report or desire additional information, please contact me either directly at (615) 576-9634 or you may call toll-free at (800) 253-9759.

Sincerely,

David G. Adler, Site Manager
Former Sites Restoration Division

Enclosure

DOE/OR/21949-288

ST. LOUIS AIRPORT SITE
ANNUAL ENVIRONMENTAL REPORT
FOR CALENDAR YEAR 1990

ST. LOUIS, MISSOURI

AUGUST 1991

Prepared for

United States Department of Energy
DOE Field Office, Oak Ridge
Under Contract No. DE-AC05-91OR21949

By

Bechtel National, Inc.
Oak Ridge, Tennessee

Bechtel Job No. 14501

EXECUTIVE SUMMARY

Environmental monitoring of the U.S. Department of Energy's (DOE) St. Louis Airport Site (SLAPS) and surrounding area began in 1984. SLAPS is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a DOE program to decontaminate or otherwise control sites where residual radioactive materials remain from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has authorized DOE to remedy.

It is DOE policy to conduct operations in an environmentally responsible manner that provides protection of human health and the environment. To that end, DOE is committed to incorporating national environmental protection and restoration programs, minimizing risks to the public and the environment, and addressing potential environmental hazards before they pose a threat to public welfare or environmental quality.

Environmental monitoring programs are developed and implemented on a site-specific basis to reflect facility characteristics, applicable regulations, hazard potential, quantities and concentrations of materials released, extent and use of affected land and water, and local public interest or concern. The environmental monitoring program at SLAPS includes sampling networks for radon concentrations in air; external gamma radiation exposure; and total uranium, radium-226, and thorium-230 concentrations in surface water, sediment, and groundwater. Additionally, several nonradiological parameters are measured in groundwater. Environmental monitoring programs have been established at DOE-managed sites to confirm adherence to DOE environmental protection policies; to determine the effect of site operations on human health and the environment; and to ensure compliance with legal and regulatory requirements imposed by federal, state, and local agencies.

Monitoring results are compared with applicable Environmental Protection Agency (EPA) standards; federal, state, and local applicable or relevant and appropriate requirements (ARARs); and/or

DOE derived concentration guidelines (DCGs). Environmental standards, ARARs, and DCGs are established to protect public health and the environment. Results from the 1990 environmental monitoring program demonstrated that the concentrations of contaminants of concern were all below applicable standards, ARARs, and guidelines.

During 1990, annual average radon concentrations (including background) for each monitoring station ranged from 0.4 to 0.9 pCi/L (0.02 to 0.03 Bq/L), well below the DOE guideline of 3.0 pCi/L at the boundary. The annual average external gamma radiation exposure level at SLAPS was 295 mR/yr above background at the property line; the high average was due to the high exposure levels at stations 2 and 9 (maximum levels were 2054 and 143 mR/yr above background, respectively). The contaminant levels at locations 2 and 9 exceeded the DCG of 100 mR/yr above background; however, these stations are located in areas of known contamination. Annual average radionuclide concentrations in surface water ranged from 0.2E-9 to 0.5E-9 μCi/ml (7E-3 to 20E-3 Bq/L), 0.1E-9 to 0.3E-9 μCi/ml (4E-3 to 10E-3 Bq/L), and 3E-9 to 6E-9 μCi/ml (0.1 to 0.2 Bq/L) for radium-226, thorium-230, and total uranium, respectively. (Note: 1E-n = 1 x 10^{-n}.) These concentrations are well below the DOE DCGs of 100E-9, 300E-9, and 600E-9 μCi/ml for radium-226, thorium-230, and total uranium, respectively. Annual average concentrations of radium-226, thorium-230, and total uranium in sediment ranged from 0.8 to 2.7 pCi/g (0.02 to 0.1 Bq/g), 0.6 to 2.2 pCi/g (0.02 to 0.08 Bq/g), and 1.2 to 2.1 pCi/g (0.04 to 0.08 Bq/g), respectively. Annual average concentrations in groundwater ranged from 0.2E-9 to 1.5E-9 μCi/ml (7E-3 to 56E-3 Bq/L), 0.2E-9 to 11.9E-9 μCi/ml (7E-3 to 0.44 Bq/L), and <3E-9 to 4553E-9 μCi/ml (0.1 to 169 Bq/L) for radium-226, thorium-230, and total uranium, respectively. The annual average concentrations of uranium in groundwater for wells A, B, D, and M11-9 exceeded the DCG of 600E-9 μCi/ml. These wells are installed either through or adjacent to buried radioactive materials. However, because SLAPS is fenced, the

public does not have access to these capped and locked wells; in addition, there is no known consumption of groundwater in the vicinity of the site.

Groundwater samples were also collected and analyzed for the following indicator parameters: specific conductance, pH, total organic carbon (TOC), and total organic halides (TOX). Annual average specific conductance ranged from 714 to 6865 μmhos/cm, and annual average pH values ranged from 6.6 to 7.5. The results showed TOC annual average concentrations ranging from 3.4 to 22 mg/L and TOX concentrations ranging from 20 to 123 μg/L.

To verify that the site is in compliance with the DOE radiation protection standard and to assess the potential effect of the site on public health, the potential radiation dose was calculated for a hypothetical maximally exposed individual and the population within 80 km (50 mi) of the site. Based on a conservative scenario, this hypothetical individual would receive an annual exposure excluding background of approximately 4.5 mrem/yr (0.045 mSv/yr). The population within an 80-km (50-mi) radius of SLAPS would receive a collective dose of 1.1 person-rem/yr (0.011 person-Sv/yr) from materials present onsite. This collective population dose is extremely small compared with the collective population dose due to natural background gamma radiation of 1.4E+5 person-rem/yr (1.4E+3 person-SV/yr) for the population within 80 km (50 mi) of SLAPS.

Site activities in 1990 were limited to maintenance. SLAPS was in compliance with all applicable regulations during 1990 and has remained in compliance since 1984, when the environmental monitoring program and remedial action began.

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ACRONYMS

AMS	Annotated Missouri Statutes
ARAR	applicable or relevant and appropriate requirement
BNI	Bechtel National, Inc.
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSR	Code of State Regulations
CWA	Clean Water Act
CX	categorical exclusion
DCG	derived concentration guideline
DOE	Department of Energy
EA	environmental assessment
EE/CA	engineering evaluation/cost analysis
EIS	environmental impact statement
EPA	Environmental Protection Agency
FFA	federal facilities agreement
FR	Federal Register
FUSRAP	Formerly Utilized Sites Remedial Action Program
HISS	Hazelwood Interim Storage Site
NCP	National Oil and Hazardous Substances Contingency Plan
NEPA	National Environmental Policy Act
NPL	National Priorities List
PCB	polychlorinated biphenyl
PERALS	photon/electron-rejecting alpha liquid scintillation

ACRONYMS

(continued)

QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation/feasibility study
SLAPS	St. Louis Airport Site
TCL	Target Compound List
TCLP	toxicity characteristic leaching procedure
TETLD	tissue-equivalent thermoluminescent dosimeter
TMA/E	Thermo Analytical/Eberline
TOC	total organic carbon
TOX	total organic halides
TSCA	Toxic Substances Control Act
USC	United States Code

UNITS OF MEASURE

Bq	becquerel
C	Celsius
cm	centimeter
F	Fahrenheit
ft	foot
ft MSL	feet above mean sea level
g	gram
h	hour
ha	hectare
in.	inch
km	kilometer
L	liter
m	meter
μCi	microcurie
mg	milligram
mi	mile
ml	milliliter
mph	miles per hour
mR	milliroentgen
mrem	millirem
mSv	millisievert
pCi	picocurie
Sv	sievert
yd	yard
yr	year

1.0 INTRODUCTION

Environmental monitoring of the U.S. Department of Energy's (DOE) St. Louis Airport Site (SLAPS) and surrounding area began in 1984. This document describes the environmental monitoring program, the program's implementation, and the monitoring results for 1990.

1.1 DOE INVOLVEMENT

SLAPS is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a DOE program to decontaminate or otherwise control sites where residual radioactive materials remain from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has authorized DOE to remedy.

DOE and the Environmental Protection Agency (EPA) Region VII negotiated a federal facilities agreement (FFA) defining the specific responsibilities and interactions of both agencies regarding DOE's remedial action activities at the St. Louis site. The final agreement was signed in June 1990.

In the FFA, it is stated that the intent of the agreement is to:

- Ensure that the environmental impacts associated with past and present activities at all of the St. Louis FUSRAP sites are thoroughly investigated and that appropriate remedial action is taken as necessary to protect public health or welfare and the environment

- Establish a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions at the St. Louis site in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), National Oil and Hazardous Substances Contingency Plan (NCP), and Superfund guidance and policy

- Facilitate cooperation, exchange of information, and participation of the parties in such actions

1.2 SITE HISTORY

The history of SLAPS began in 1946 when the Manhattan Engineer District, predecessor to the Atomic Energy Commission and DOE, acquired the present 8.78-ha (21.7-acre) tract to store residues resulting from uranium ore processing. The stored residues included barium sulfate cake, pitchblende raffinate residues, radium-bearing residues, Colorado raffinate residues, and contaminated scrap. Most were stored in bulk on open ground, although some were buried. During 1966 and 1967, most of the stored residues were sold and removed from the site. Later, DOE began the steps necessary to consolidate and dispose of the remaining waste material under the authority of the 1985 Energy and Water Appropriations Act (Public Law 98-360).

The SLAPS property has been owned by the City of St. Louis since 1973. In September 1989, SLAPS was placed on EPA's National Priorities List (NPL), which mandates a review of remediation options for the site.

1.3 SITE DESCRIPTION

SLAPS is located in eastern Missouri within the cities of Hazelwood and Berkeley (St. Louis County) (Figure 1-1). The SLAPS property includes one office trailer, a small storage pile [770 to 1200 m^3 (1000 to 1500 yd^3)], and approximately 237 drums of waste and drill spoils from radiological characterization activities conducted at SLAPS and vicinity properties. Figure 1-2 is an aerial view of the site, which is currently being used for interim storage of radioactive waste and equipment pending further remediation. No effluents are generated on the property, which is entirely fenced, and public access is restricted.

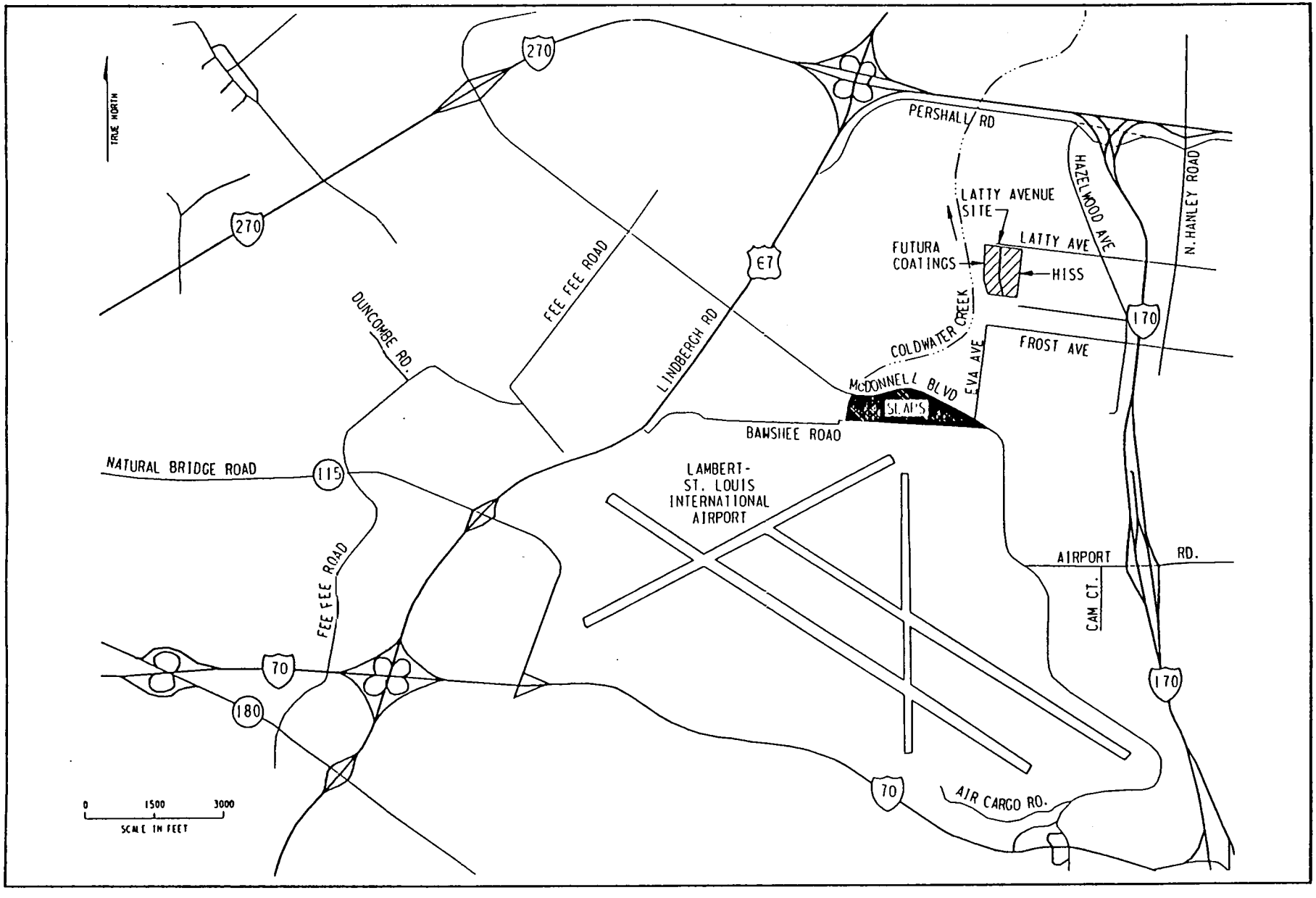

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Figure 1-1
Location of SLAPS

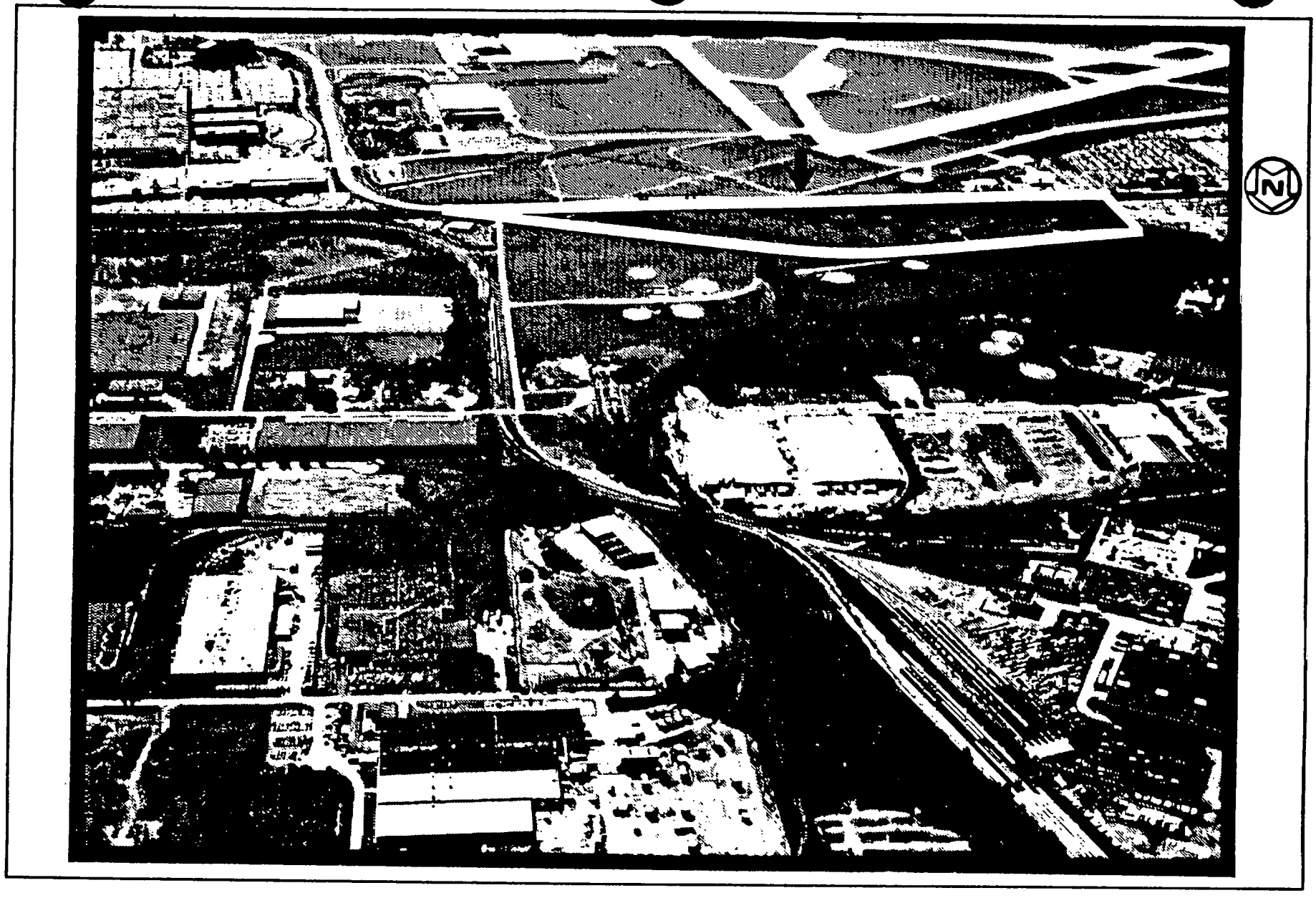

Figure 1-2
Aerial View of SLAPS and Vicinity

1.4 LAND USE

As shown in Figure 1-3, land use in the vicinity of the site is predominantly commercial and industrial. The site is bordered by McDonnell Boulevard and adjacent recreational fields to the north and east; the Norfolk and Western Railroad, Banshee Road, and the Lambert-St. Louis International Airport to the south; and Coldwater Creek to the west (BNI 1990).

The principal source of potable water in the SLAPS area is treated water from the Mississippi River; the treatment facility (Chain of Rocks Water Treatment Facility) is located approximately 14 km (9 mi) from SLAPS. Approximately 100 percent of the water for Hazelwood and Berkeley comes from this source. The nearest surface water body, Coldwater Creek, is not used for drinking water. The creek runs adjacent to the site and empties into the Missouri River, which discharges into the Mississippi River.

The nearest residential areas, primarily mixtures of single- and multiple-family dwellings, are approximately 0.8 km (0.5 mi) west of the site. The total population of the area lying within an 80-km (50-mi) radius of SLAPS is in excess of 2.5 million, based on a population of 2.2 million for St. Louis County.

1.5 CLIMATE

Table 1-1 is a summary of climatological data from the National Oceanic and Atmospheric Administration for the St. Louis vicinity for 1990. Monthly temperature extremes ranged from -18 to 38.9°C (0 to 102°F). Average monthly wind speeds ranged from 5.0 to 19 km/h (3.0 to 11.4 mph), and the predominant wind direction was from the southwest. A climatological factor that could have affected data results was the extremely high precipitation experienced during the second quarter of 1990; monthly rainfall totals in May were over 22.9 cm (9 in.), and 11.9 cm (4.7 in.) of this precipitation fell within one 48-h period.

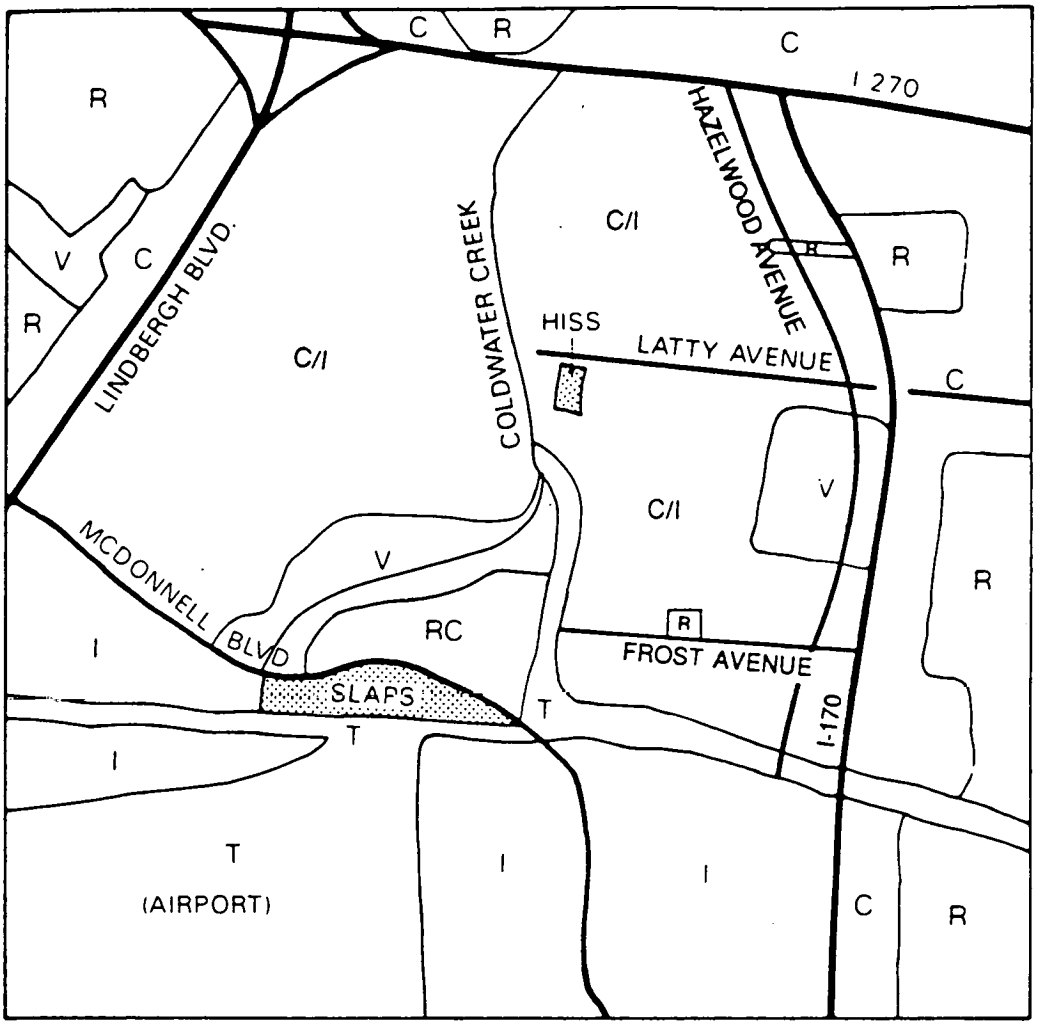

Figure 1-3
Generalized Land Use in the Vicinity of SLAPS

TABLE 1-1

SUMMARY OF CLIMATOLOGICAL DATA FOR

THE ST. LOUIS VICINITY, 1990

Month	Temperature (°F) Min	Max	Avg	Total Precip (in.)	Wind Avg Speed (mph)	Resultant Direction
January	19	71	42.9	1.42	11.4	SW
February	17	71	41.3	3.53	9.7	WSW
March	22	84	49.8	2.66	9.6	SSW
April	29	90	55.7	3.07	10.5	SW
May	46	85	63.6	9.59	10.5	SSW
June	51	96	77.2	3.02	10.3	SSW
July	57	102	80.2	3.34	8.9	SSW
August	57	101	77.9	2.84	7.9	SSE
September	45	101	74.1	0.78	9.2	SSW
October	35	87	58.1	4.96	9.4	SW
November	31	80	52.7	3.36	9.9	SW
December	0	67	34.7	6.52	3.0	WSW

Source: BNI 1991.

2.0 SUMMARY OF ENVIRONMENTAL COMPLIANCE

During its history, SLAPS has been subject to evolving federal and state environmental regulations. The primary regulatory guidelines and limits are given in the DOE orders and authorized by six federal acts [the Clean Air Act (CAA); the Clean Water Act (CWA); the Resource Conservation and Recovery Act (RCRA); the Toxic Substances Control Act (TSCA); CERCLA; and the National Environmental Policy Act (NEPA)]. The following summaries describe compliance requirements as they existed in 1990, as well as anticipated future regulatory requirements that could affect the site.

2.1 PRIMARY REGULATORY GUIDELINES

DOE Orders for Radionuclide Releases

Site releases must comply with specific DOE orders [5400 series and DOE Order 5820.2A, "Radioactive Waste Management" (DOE 1988)] that establish quantitative limits, derived concentration guidelines (DCGs), and dose limits for radiological releases from DOE facilities. The applicable guidelines and dose limits are presented in Appendix C. For EPA permitting purposes, DOE orders are treated as legal requirements, and remedial activities conducted by DOE are considered "federally permitted actions" [54 Federal Register (FR) 22524].

A review of environmental monitoring results for the 1990 shows that SLAPS was in compliance with all applicable radionuclide release standards in DOE orders. Detailed monitoring results for radionuclides are presented in Section 4.0.

Clean Air Act and National Emission Standards for Hazardous Air Pollutants

The primary federal statute governing air emissions is the CAA [42 United States Code (USC) 7401 et seq.], as amended. Federal

regulations governing air emissions are contained in 40 Code of Federal Regulations (CFR) Parts 50 through 87 and 29 CFR Part 1910.

The only potential sources of onsite air emissions at SLAPS are radionuclide emissions from the waste pile and soil. To date, SLAPS does not have or require any state or federal air permits. According to DOE Headquarters interpretation, SLAPS is not subject to the requirements of Subpart Q of the National Emission Standards for Hazardous Air Pollutants because it is not owned or leased by DOE (DOE 1990a). However, this subpart and equivalent state regulations may be considered applicable or relevant and appropriate requirements (ARARs) under CERCLA during remedial action.

Clean Water Act

Waters discharged to navigable waters of the United States are regulated under the federal CWA, as amended (33 USC 1251 et seq.), and its associated EPA regulations (40 CFR Parts 122, 136, 403, and 405 through 471). Missouri has enacted its own Clean Water Law, which is found in Title 12, Annotated Missouri Statutes (AMS), Chapter 204.

Because SLAPS has no point-source discharges (e.g., drainage conduits such as ditches), DOE does not hold any federal or state water permits. Non-point-source discharges of stormwater runoff are the only discharges to surface water. During remedial actions, CWA stormwater discharge requirements may be considered ARARs under CERCLA.

On November 16, 1990, EPA promulgated changes to its stormwater regulation provisions. Although these provisions did not affect reporting obligations for 1990, significant changes in compliance reporting and monitoring are anticipated for 1991. DOE is evaluating whether a stormwater discharge permit will be required for SLAPS. In the interim, a plan is being developed to comply with the regulation by November 18, 1991; the plan will include a data collection methodology that covers all applicable regulatory parameters referenced in the regulation.

Resource Conservation and Recovery Act

RCRA (40 USC 6901 et seq.) is the principal federal statute governing the management of hazardous waste. EPA regulations for implementing RCRA are contained in 40 CFR Parts 260 through 271. Missouri is an authorized state for implementation of the RCRA program; state RCRA requirements can be found in Missouri Hazardous Waste Management Law, AMS, Title 16, Chapter 260. Missouri hazardous waste regulations are contained in 10 Code of State Regulations (CSR), Division 25. These regulations are considered ARARs under CERCLA (see Appendix C).

Results from characterization studies have indicated that neither RCRA-regulated wastes nor radioactive wastes containing RCRA-regulated wastes are present at SLAPS. However, since the last characterization activities were completed, the toxicity characteristic leaching procedure (TCLP) has replaced the extraction procedure for testing for the RCRA characteristic of toxicity. Before excavation of any materials, the TCLP will be performed if knowledge of the waste is insufficient. Absent generation of RCRA-regulated waste in any sampling or remediation process, it is anticipated that state hazardous waste regulations will not be applicable.

Toxic Substances Control Act

The most common toxic substances regulated by TSCA (15 USC 2601 et seq.) include polychlorinated biphenyls (PCBs) and asbestos. Like RCRA requirements, TSCA requirements will have to be met in CERCLA remedial actions where they are applicable or relevant and appropriate. EPA regulations regarding the production, use, storage, handling, and disposal of PCBs are codified in 40 CFR Part 761. Asbestos is regulated under 40 CFR Part 763.

PCB management involves monitoring of in-service equipment, storage and disposal of equipment removed from service, cleanup and management of spill residues, and recordkeeping and reporting. In addition to the EPA regulations, the State of Missouri also has

regulations governing the management of PCB waste that largely incorporate the requirements of 40 CFR Part 761 (EPA TSCA regulations) by reference. These regulations are found in Chapter 13 of the Missouri Hazardous Waste Management Rules (10 CSR, Division 25).

SLAPS contains only residues, contaminated materials, and scrap from uranium processing operations. TSCA-regulated waste or waste regulated by state PCB regulations has not been detected at SLAPS, and the provisions of TSCA are expected to remain inapplicable (DOE 1990b).

Comprehensive Environmental Response, Compensation, and Liability Act

CERCLA (42 USC 9601 et seq.) is the primary source of statutory authority for response actions to be conducted at SLAPS. EPA regulations governing cleanup activities are found in 40 CFR Part 300, which is the NCP. CERCLA Section 121 mandates that CERCLA remedial actions comply with substantive requirements of environmental laws when they are applicable or relevant and appropriate.

Because SLAPS is on the NPL, an FFA is required for site remedial action. EPA and DOE have entered into an FFA (signed on June 26, 1990) that integrates all response actions at SLAPS and at other St. Louis FUSRAP sites, including HISS/Futura and vicinity properties (EPA 1990).

The FFA integrates the provisions of CERCLA with other applicable and relevant laws. Specifically, the parties to the FFA intend that activities covered by the agreement will achieve compliance with CERCLA and will meet or exceed all ARARs. Compliance with CERCLA during remediation of FUSRAP sites such as SLAPS is ensured by extensive interactions with EPA and monitoring of compliance by DOE Headquarters. During 1990 all of the requirements of the FFA were met. The remedial investigation of the site has been completed and the remedial investigation/ feasibility study (RI/FS) is being prepared. This document is scheduled to be completed in 1994.

National Environmental Policy Act

Although a formal NEPA determination has not been made for final cleanup of SLAPS, completion of an environmental impact statement (EIS) is required as part of the overall effort for St. Louis FUSRAP sites on the NPL. Preparation of the EIS will be integrated with the preparation of the RI/FS currently being developed. Compliance with NEPA for site remedial actions will be accomplished by incorporating those elements required by an EIS into the format of the CERCLA RI/FS to produce an RI/FS-EIS for the St. Louis sites. This document is scheduled for completion in fiscal year 1994.

An engineering evaluation/cost analysis (EE/CA) has been conducted to assess removal alternatives on the SLAPS vicinity properties and expansion of the storage capacity and update of existing facilities at Hazelwood Interim Storage Site (HISS). An environmental assessment (EA), for NEPA purposes, will be integrated into the EE/CA to produce an EE/CA-EA addressing a proposed plan to store contaminated soil from SLAPS vicinity properties at HISS.

On November 2, 1990, DOE proposed to amend its NEPA guidelines and codify the results as regulations in 10 CFR Part 1021 (55 FR 46444). Among the proposed revisions is an expansion of the list of categorical exclusions (CXs) available since September 7, 1990. A CX is a class of actions that normally do not require the preparation of either an EIS or an EA. One CX concerns site characterization and environmental monitoring under CERCLA and RCRA. The codification of the amended guidelines would streamline the decision-making process when determining the appropriate NEPA documentation.

Other Major Environmental Statutes and Executive Orders

In addition to the aforementioned DOE orders and statutes, several other major environmental statutes have been reviewed for applicability. For example, the Federal Insecticide, Fungicide, and Rodenticide Act; the Endangered Species Act; the Safe Drinking

Water Act; and the National Historic Preservation Act have all been found to impose no current requirements on SLAPS. In addition, Executive Orders 11988 ("Floodplain Management") and 11990 ("Protection of Wetlands"), and state laws and regulations have been reviewed for applicability and compliance. SLAPS is in compliance with, or not subject to, all applicable environmental statutes, regulations, and executive orders.

2.2 APPLICABLE ENVIRONMENTAL PERMITS

Currently, no permits have been identified as necessary for SLAPS. As regulations change in the future, the need for permits will be reviewed with regard to CERCLA Section 121. Section 121 requires that substantive requirements of applicable regulations be met, but exempts onsite activities at CERCLA sites such as SLAPS from administrative permitting requirements. The NEPA process will be integrated into the EE/CA procedure.

2.3 ENVIRONMENTAL IMPACT STATEMENTS AND ENVIRONMENTAL ASSESSMENTS

Because the work at SLAPS will be conducted under an integrated CERCLA/NEPA process, an RI/FS-EIS will be prepared before any remedial actions are conducted. Some near-term response actions at the vicinity properties near SLAPS are possible; any planned response actions will be evaluated using the EE/CA procedure provided by CERCLA.

2.4 SUMMARY OF COMPLIANCE IN CALENDAR YEAR 1991 (FIRST QUARTER)

During the first quarter of calendar year 1991, there continued to be full regulatory compliance at SLAPS. Environmental monitoring continues, as does review of potentially applicable regulations for their impact on the site.

3.0 ENVIRONMENTAL PROGRAM INFORMATION

Routine monitoring for radiation, radioactive materials, and chemical substances on and off SLAPS is used to document compliance with appropriate standards, provide the public with information, provide a historical record for year-to-year comparisons, and identify environmental impacts. The environmental monitoring program assists in fulfilling the DOE policy of protecting public health and the environment and reducing negative environmental impacts.

The objectives of this report are to:

- Highlight significant programs and efforts
- Describe the environmental monitoring program
- Report 1990 radiological and nonradiological conditions of the site and surrounding areas
- Provide comparison between monitoring results and applicable regulations
- Provide trend analyses, where applicable, to indicate increases or decreases in environmental impact

The primary audience for the environmental monitoring results includes the general public; property owners; community interest groups; technical staffs of federal, state, and local government agencies; and regulatory personnel.

3.1 SUMMARY OF ENVIRONMENTAL MONITORING PROGRAM

3.1.1 Environmental Monitoring Requirements

Environmental monitoring at SLAPS was conducted to meet the requirements for environmental monitoring of radioactive materials found in the DOE orders dealing with radiation protection of the public and the environment. These requirements include the monitoring of radionuclides in groundwater, surface water, and

sediment. Radon monitoring was conducted at the SLAPS boundary to ensure compliance with DOE orders.

Requirements for environmental monitoring of nonradiological parameters are found in DOE Order 5400.1 (DOE 1989). Nonradiological parameters were monitored to obtain baseline information on groundwater quality, not to satisfy any regulatory requirements.

3.1.2 Monitoring Networks

The following common criteria were used in establishing the monitoring networks at SLAPS:

- All radon and direct gamma exposure monitoring stations, except background locations, are onsite and accessible only to employees and authorized visitors.

- Some radon and gamma exposure rate stations are located on or near the property line to allow determination of exposure at the "fenceline" as required by DOE orders.

- All groundwater wells have locking caps to provide security.

- Background stations are located offsite in areas known to be uncontaminated.

The medium-specific networks at SLAPS include:

- Eleven radon monitoring stations (12 detectors) (8 at the property line and 3 offsite)
- Eleven gamma radiation monitoring stations (12 detectors) (8 at the property line and 3 offsite)
- Seven surface water monitoring locations (6 offsite downstream and 1 offsite upstream)
- Five sediment monitoring locations (4 offsite downstream and 1 offsite upstream)

- Twenty-one groundwater monitoring locations (3 offsite upgradient, 16 onsite downgradient, and 2 offsite background wells)

Details on the monitoring networks are provided in Sections 4.0 and 5.0.

3.1.3 Summary of Environmental Monitoring Data

The following subsections summarize environmental monitoring results for SLAPS for calendar year 1990. Detailed discussions of radiological and nonradiological results are provided in Sections 4.0 and Section 5.0.

Radon

Annual average radon concentrations ranged from 0.4 to 0.9 pCi/L (0.02 to 0.03 Bq/L) including an average background level of 0.5 pCi/L (0.02 Bq/L) (Subsection 4.1.1). The radon concentrations at all monitoring locations were below the DOE guideline of 3.0 pCi/L for interim storage sites and remained close to background throughout the year. Thoron monitoring was not conducted at SLAPS because thorium-232, thoron's parent radionuclide, is present only at very low concentrations.

External gamma radiation exposure

The annual average gamma radiation exposure level along the property line was 295 mR/yr. The average includes results from one location that has very high levels (annual average 1970 mR/yr); without this location, the annual average would be 55 mR/yr above background. High, spotty concentrations of radionuclides in the ditches along McDonnell Boulevard are responsible for the high exposure level. Detailed information on gamma exposure monitoring data can be found in Subsection 4.1.2.

Surface water

Surface water sampling was performed quarterly to determine concentrations of total uranium, radium-226, and thorium-230 and to assess any impact of site discharges to Coldwater Creek. Average annual concentrations in surface water ranged from 0.2E-9 to 0.5E-9 μCi/ml (7E-3 to 20E-3 Bq/L), 0.1E-9 to 0.3E-9 μCi/ml (4E-3 to 10E-3 Bq/L), and 3E-9 to 6E-9 μCi/ml (0.11 to 0.22 Bq/L) for radium-226, thorium-230, and total uranium, respectively. Radionuclide concentrations at downstream sampling locations were essentially the same as upstream (background) concentrations, and all contaminant levels were below the DOE DCGs of 100E-9, 300E-9, and 600E-9 μCi/ml for radium-226, thorium-230, and total uranium, respectively. More detailed information can be found in Subsection 4.1.3.

Sediment

Sediment samples were collected in conjunction with surface water samples as a check for deposition of the contaminants of interest (total uranium, radium-226, and thorium-230). Concentrations of the radionuclides in downstream sediment did not differ notably from the concentrations found in upstream or background samples. Average annual radionuclide concentrations in sediment ranged from 0.8 to 2.7 pCi/g (0.02 to 0.1 Bq/g), 0.6 to 2.2 pCi/g (0.02 to 0.08 Bq/g) and 1.2 to 2.1 pCi/g (0.04 to 0.08 Bq/g) for radium-226, thorium-230, and total uranium, respectively. For comparison, these concentrations are much lower than the levels of radioactivity in phosphate fertilizers listed in Appendix F. There are currently no guidelines for radionuclide concentrations in sediment; however, these concentrations are less than the 5 pCi/g soil guideline for the top 15 cm (6 in.) of soil for radium-226 and thorium-230 and the 50 pCi/g guideline for total uranium (Appendix C). Additional details are provided in Subsection 4.1.4.

Groundwater

Radionuclide concentration results for groundwater samples from SLAPS were in general agreement with previous groundwater assessment data. Analytical results show that groundwater quality upgradient (background) of SLAPS is essentially the same as that downgradient. The groundwater quality is poor, but this is typical for an industrialized urban area.

Quarterly groundwater samples were analyzed for total uranium, dissolved radium-226, dissolved thorium-230, and chemical indicator parameters [specific conductance, pH, total organic carbon (TOC), and total organic halides (TOX)].

Radionuclide concentration levels for all samples were below applicable guidelines (Subsection 4.1.5), with the exception of total uranium values. 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, the public does not have access to these wells; furthermore, there is no known consumption of groundwater in the vicinity of the site. Thorium-230 concentrations were only slightly above background levels except for those in well M11-21, which were elevated. Well M11-21 is located in a area of known contamination, which might explain elevated levels of thorium-230. With one exception, annual average background levels for radium-226 were higher than all onsite levels.

3.2 APPLICABLE ENVIRONMENTAL PERMITS

The FFA for the St. Louis FUSRAP sites provides, in conjunction with DOE policy, that all applicable permit conditions will be met even though no permit applications are required; SLAPS does not have any state or federal permits. CERCLA Section 121 provides the statutory authority for an exemption to permitting requirements for onsite CERCLA remedial actions.

3.3 ENVIRONMENTAL IMPACT STATEMENTS AND ENVIRONMENTAL ASSESSMENTS

As stated in Section 2.0, the work at SLAPS will be conducted under an integrated CERCLA/NEPA process, and an RI/FS-EIS will be prepared before any remedial actions are conducted. The RI/FS-EIS is scheduled for completion in 1994. Some near-term response actions at the vicinity properties near SLAPS are possible; any planned response actions will be evaluated using the EE/CA procedure provided by CERCLA.

3.4 SUMMARY OF ENVIRONMENTAL ACTIVITIES

In October, a one-time sampling study was conducted to evaluate the need for expanding the isotopic analyses currently performed. Twenty percent of the surface water, sediment, and groundwater samples taken for routine analyses were also analyzed for gross alpha and gross beta; Table 3-1 summarizes these data. In general, the gross alpha and beta results and the current sampling program results are in agreement. Even though the sum of the results of the primary analyses conducted (total uranium, radium-226, and thorium-230) does not always exactly equal the values of the gross radioanalyses, the data are consistent overall.

Factors contributing to differences between the data are (1) the contribution of alpha-emitting daughters in the decay chain that are not included in the analysis list above, (2) poor counting statistics for gross alpha and beta results when analyzing samples with very low concentrations of radionuclides, and (3) the presence of potassium-40. Potassium-40, a beta emitter, is one of Earth's most abundant naturally occurring radionuclides. Because gross alpha and gross beta values did not vary a large amount (e.g., an order of magnitude), there is no indication of a need to expand the isotopic analyses performed for the current program.

TABLE 3-1

SUMMARY OF GROSS ALPHA AND GROSS BETA

RESULTS FOR SLAPS, 1990

Sampling Location[a]	Gross Alpha	Gross Beta	Sum of Isotopic Analyses
Surface Water[b]			
7	5	11	3.3
Sediment[c]			
1	18	13	3.9
Groundwater[b]			
A	1600	3300	2076
C	34	14	15.8
M13.5-8.5S	6	5	3.3
M13.5-8.5D	5	6	4.0

[a]Sampling locations are shown in Figures 4-3 and 4-4.

[b]Concentrations are given in E-9 μCi/ml.
Note: 1E-9 μCi/ml is equivalent to 0.037 Bq/L.

[c]Concentrations are given in pCi/g. Note: 1 pCi/g is equivalent to 0.037 Bq/g.

3.5 SELF-ASSESSMENTS

During 1990, DOE conducted two major self-assessments of the FUSRAP environmental monitoring program: one in June by the DOE Oak Ridge Operations Environmental Protection Division, the second in November by the DOE Headquarters Office of Environmental Audits. Findings from these two self-assessments focused on monitoring techniques, field documentation of monitoring events, and planning for environmental monitoring locations and events. As a result of the June assessment, corrective actions were developed and implemented prior to the next quarter's environmental monitoring. Actions remaining consist of developing environmental monitoring plans [required by DOE Order 5400.1 (DOE 1989)] to document the logic behind the environmental monitoring networks for FUSRAP sites. Work on these plans is currently under way; they are scheduled to be published by December 1991.

4.0 RADIOLOGICAL ENVIRONMENTAL PROGRAM

SLAPS is not an active site and produces no effluents; therefore, the only possibility for contamination to be released would be through contaminant migration.

Radiological environmental monitoring at SLAPS in 1990 included sampling for:

- radon concentrations in air
- onsite external gamma radiation exposure
- total uranium, radium-226, and thorium-230 concentrations in surface water, sediment, and groundwater

The monitoring systems include onsite, property-line, and offsite stations to provide sufficient information on the site's potential effects on human health and the environment. Radiological parameters were monitored as specified by the DOE orders (5400 series) dealing with radiation protection of the public and the environment.

Some of the quarterly results are reported using a "less than" (<) sign. This 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, quarterly values reported as less than a given limit of sensitivity are considered equal to that limit of sensitivity. Additionally, all quarterly data are reported as received from the laboratory; however, the reported averages, standard deviations, and expected ranges are reported using the smallest number of significant figures from the quarterly data (e.g., 3.2 and 32 both have two significant figures). Some of the data are reported using scientific notation, and the exponent has been identified by E (e.g., 1E-9 = 1×10^{-9}). The methodology for calculating averages and standard deviation is given in Appendix A.

The following subsections discuss the monitoring program and any possible radioactive contaminant migration from the site.

4.1 ENVIRONMENTAL MONITORING FOR RADIOLOGICAL CONTAMINANTS

4.1.1 Radon Monitoring

One major pathway of radiation exposure from the uranium-238 decay series arises from inhalation of the short-lived radon and radon daughter products. Radon is a radioactive (alpha-emitting) gas that is very mobile in air. Radon monitoring was conducted at SLAPS to assess the impacts of the contaminants at the site on radon levels nearby.

Program description

Radon concentrations were obtained quarterly using monitors that contain a piece of alpha-sensitive film enclosed in a small plastic two-piece cup. Radon diffuses through a seam or membrane (depending on the manufacturer of the detector) of the cup until the radon concentrations inside and outside the cup reach equilibrium. Alpha particles from the radioactive decay of radon and its daughters in the cup create tiny tracks when they collide with the film. After they are collected, the films are placed in a caustic etching solution to enlarge the tracks; under strong magnification, the tracks are counted. The number of tracks per unit area (i.e., tracks/mm^2) is related through calibration to the radon concentration in air.

Radon detectors are maintained at eight property-line (Figure 4-1) and at three offsite (background) locations (locations given in Table 4-1). Detectors are spaced along the site boundary to ensure adequate detection capability under most atmospheric conditions.

Data and discussion

The maximum ambient air radon concentration level detected was 1.9 pCi/L (0.07 Bq/L), at location 2. The annual average concentrations ranged from 0.4 to 0.9 pCi/L (0.02 to 0.03 Bq/L)

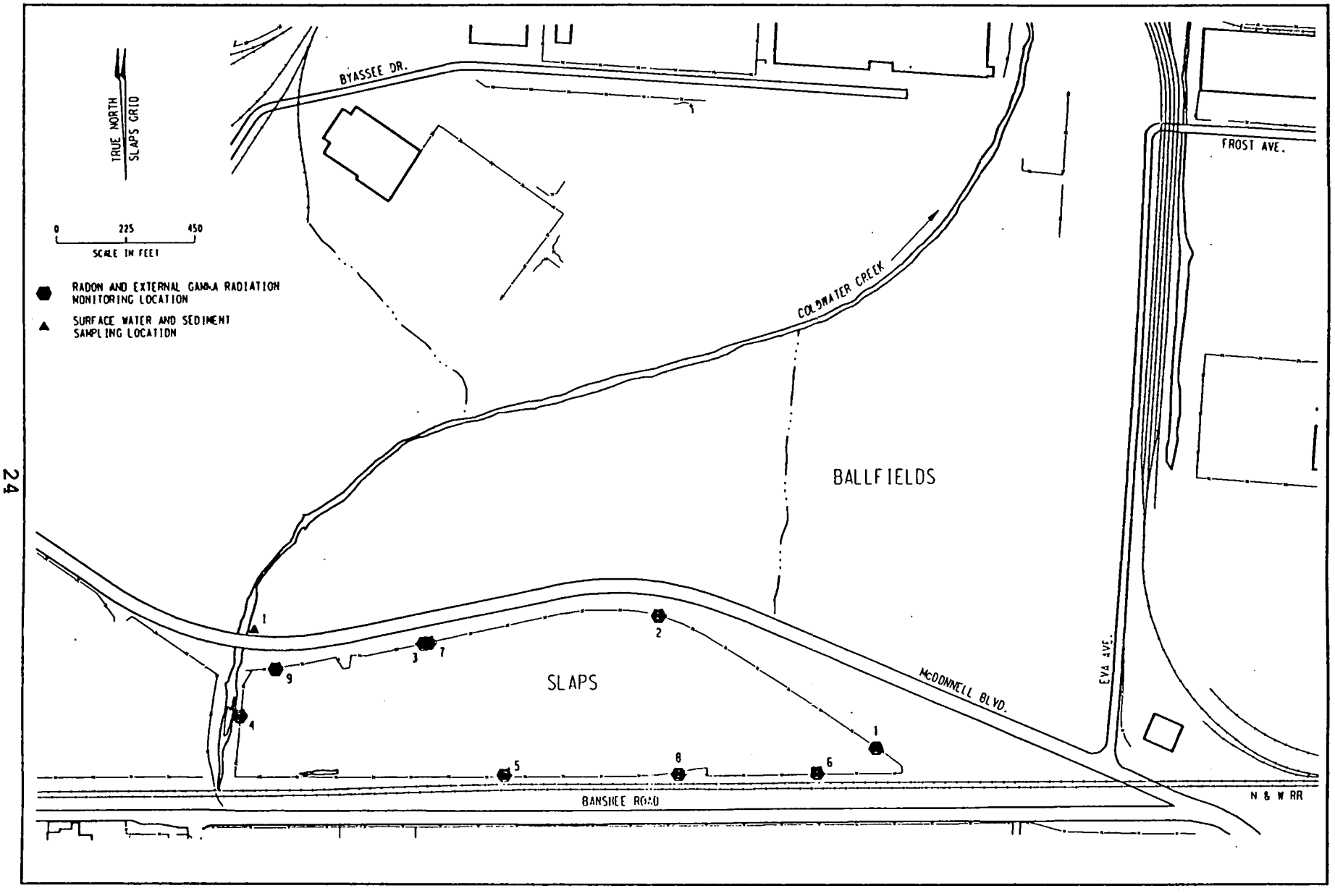

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Figure 4-1
Onsite Radon, External Gamma Radiation, Surface Water,
and Sediment Sampling Locations at SLAPS

TABLE 4-1

CONCENTRATIONS[a,b] OF RADON

AT SLAPS, 1990

Sampling Location[c]	Quarter 1	2	3	4	Min	Max	Avg
Property Line							
1	<0.4	<0.3	<0.4	<0.3	0.3	0.4	0.4
2	0.9	0.2	0.5	1.9	0.2	1.9	0.9
3	0.4	<0.3	<0.4	0.5	0.3	0.5	0.4
4	0.6	<0.3	<0.4	0.6	0.3	0.6	0.5
5	1.2	<0.3	<0.4	1.2	0.3	1.2	0.8
6	0.5	<0.3	<0.4	0.5	0.3	0.5	0.4
8	1.0	<0.3	<0.4	1.8	0.3	1.8	0.9
9	0.7	<0.3	<0.4	0.4	0.3	0.7	0.5
Quality Control							
7[d]	0.6	<0.3	<0.4	0.4	0.3	0.6	0.4
Background							
16[e]	0.5	<0.3	<0.4	1.1	0.3	1.1	0.6
17[f]	<0.4	<0.3	<0.4	<0.3	0.3	0.4	0.4
18[g]	<0.4	<0.3	<0.4	<0.3	0.3	0.4	0.4

[a]Concentrations are given in units of pCi/L (1 pCi/L = 0.037 Bq/L).

[b]Background has not been subtracted from the values reported for property-line stations. Note: Concentrations at some stations were below values at background stations.

[c]Onsite sampling locations are shown in Figure 4-1.

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

[e]Detector moved in October 1990 from 6500 Las Sombrias Lane, Florissant, Missouri, approximately 24 km (15 mi) northeast of SLAPS, to 4517 Oakland Drive, St. Louis, approximately 26 km (16 mi) southeast of SLAPS.

[f]Located at McDonnell Blvd., approximately 0.8 km (0.5 mi) east of SLAPS.

[g]Located at the St. Charles County, Missouri, airport, approximately 32 km (20 mi) northwest of SLAPS.

(see Table 4-1). No annual average was higher than 30 percent of the DOE interim storage site guideline of 3.0 pCi/L at the boundary.

Trends

Table 4-2 presents trends for concentrations of radon in air measured from 1986 through 1990. The expected value ranges shown are based on calculation of the standard deviation of the yearly mean. The expected range provides a rough check on whether there are any apparent trends in the data. If the range varies a great deal from location to location, or if data from any station consistently fall outside the expected range, then a trend could be present. Annual average and individual quarterly radon concentrations for 1990 fell within the expected value range for each monitoring location. This is a good indication that there is no upward trend in radon concentrations at SLAPS, which is to be expected because there have been no recent activities that would disturb the source of the radon. Five of the stations (1, 2, 5, 8, and 9) had large ranges, which indicates large fluctuations in the yearly means for the station. The data indicate that the trends are downward; the high values occurred during extremely dry years when radon concentrations are typically higher.

4.1.2 External Gamma Exposure Monitoring

External gamma radiation levels are measured as part of the routine environmental monitoring program to confirm that direct radiation from SLAPS is not significantly increasing radiation levels above natural background levels and to ensure compliance with environmental regulations.

Program description

Since 1988, the external gamma radiation monitoring system has used tissue-equivalent thermoluminescent dosimeters (TETLDs) to

TABLE 4-2

TREND ANALYSIS FOR CONCENTRATIONS[a,b]

OF RADON AT SLAPS, 1986-1990

Sampling Location[c]	Annual Average Concentration 1986	1987	1988	1989	1990	Average Value	Standard Deviation	Expected Range[d]
Property Line								
1	0.4	1.6	1.1	0.5	0.4	0.8	0.5	0.0 - 1.9
2	3.5	3.6	1.2	2.0	0.9	2.2	1.3	0.0 - 4.8
3	0.8	0.7	1.0	0.8	0.4	0.7	0.2	0.3 - 1.2
4	0.9	0.8	1.0	0.7	0.5	0.8	0.2	0.4 - 1.2
5	0.6	2.1	2.1	1.0	0.8	1.3	0.7	0.0 - 2.8
6	0.6	0.5	0.8	0.6	0.4	0.6	0.1	0.3 - 0.9
8	0.7	1.3	1.8	1.8	0.9	1.3	0.7	0.0 - 2.8
9[f]	--	3.1	1.0	0.6	0.5	1.3	1.2	0.0 - 3.7
Quality Control								
7[e]	0.7	0.8	0.7	0.9	0.4	0.7	0.2	0.3 - 1.1
Background								
16[g]	0.3	0.4	0.4	0.5	0.6	0.4	0.1	0.2 - 0.7
17[h]	--	--	0.4	0.5	0.4	0.4	0.1	0.3 - 0.5
18[i]	--	--	0.5	0.6	0.4	0.5	0.1	0.3 - 0.7

NOTE: Sources for 1986-1989 data are the annual site environmental reports for those years (BNI 1987a, 1988, 1989a, 1990).

[a]Concentrations are given in units of pCi/L (1 pCi/L = 0.037 Bq/L).

[b]Measured background has not been subtracted.

[c]Onsite sampling locations are shown in Figure 4-1.

[d]Average value ±2 standard deviations.

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

[f]Detector installed in April 1987.

[g]Detector moved in October 1990 from 6500 Las Sombrias Lane, Florissant, Missouri, approximately 24 km (15 mi) northeast of SLAPS to 4517 Oakland Drive, St. Louis, approximately 26 km (16 mi) southeast of SLAPS.

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

[i]Located at the St. Charles County, Missouri, airport, approximately 32 km (20 mi) northwest of SLAPS. Detector installed in April 1988.

provide realistic values of radiation exposures to the tissues of the body. When exposed to penetrating radiation (such as gamma or cosmic radiation), thermoluminescent materials absorb and store a portion of the energy. If the material is heated, the stored energy is released as light. The light is measured and used to calculate an equivalent exposure.

Each dosimetry station contains a minimum of four dosimeters. One dosimeter in each station will have been exposed for a full year at the end of each quarter, at which time the fully exposed dosimeter is exchanged with a new dosimeter. Each dosimeter contains five individual lithium fluoride chips that were preselected on the basis of having a reproducibility of ±3 percent across a series of laboratory exposures. The responses are averaged, and the average value is then corrected for the shielding effect of the shelter housing (approximately 8 percent). The corrected value is then converted to milliroentgen per year. (In determining dose, 1 mR/yr is approximately equal to 1 mrem/yr.)

External gamma radiation levels are measured at eight property-line (Figure 4-1) and three offsite locations (locations are given in Table 4-3). Background radiation level detectors are stationed at the same locations as the background radon detectors.

Data and discussion

The results of external gamma radiation monitoring are presented in Table 4-3. Although TETLDs are state of the art, the dosimeter accuracy is approximately ±10 percent at levels between 100 and 1000 mR/yr and ±25 percent at radiation levels in the range of 70 mR/yr.

The annual average gamma radiation exposure level at SLAPS in 1990 was 295 mR/yr at the property line; this high average value is due primarily to results from station 2, which had an annual average level of 1970 mR/yr because of the high levels of contamination in the surrounding ditches. If the values for this station were dropped from the average, the exposure level would be reduced to an annual average rate of 55 mR/yr above background.

TABLE 4-3

AVERAGE EXTERNAL GAMMA RADIATION LEVELS[a,b] AT SLAPS, 1990

Sampling Location[c]	Quarter 1	2	3	4	Average
Property Line					
1	31	40	36	39	37
2	1869	1995	1961	2054	1970
3	83	85	80	--[d]	83
4	30	40	25	--[d]	32
5	31	34	29	34	32
6	31	48	38	24	35
8	36	39	36	38	37
9	125	145	115	143	132
Quality Control					
7[e]	82	96	81	84	86
Background					
16[f]	63	65	55	58	60
17[g]	60	69	58	53	60
18[h]	50	54	50	50	51

[a]Levels are given in units of mR/yr. Dosimeters evaluated each quarter have been in place for 1 year.

[b]Measured background has been subtracted from the readings taken at the property-line stations.

[c]Onsite sampling locations are shown in Figure 4-1.

[d]TETLD missing.

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

[f]Station moved in October 1990 from 6500 Las Sombrias Lane, Florissant, Missouri, approximately 24 km (15 mi) northeast of SLAPS, to 4517 Oakland Drive, St. Louis, approximately 26 km (16 mi) southeast of SLAPS.

[g]Located at McDonnell Blvd., approximately 0.8 km (0.5 mi) east of SLAPS.

[h]Located at the St. Charles County, Missouri, airport, approximately 32 km (20 mi) northwest of SLAPS.

background. The highest annual average external gamma level at the property line was 2054 mR/yr at location 2. All of the levels for locations 2 and 9 were at or above 115 mR/yr; these high levels could present a potential for a hypothetical member of the public standing at either location continuously for the entire year to receive a dose greater than the DOE guideline of 100 mrem/yr above background. This DOE standard includes exposure from all pathways except medical treatments and exposures from radon (DOE 1990b). Information on public exposure can be found in Subsection 4.2.

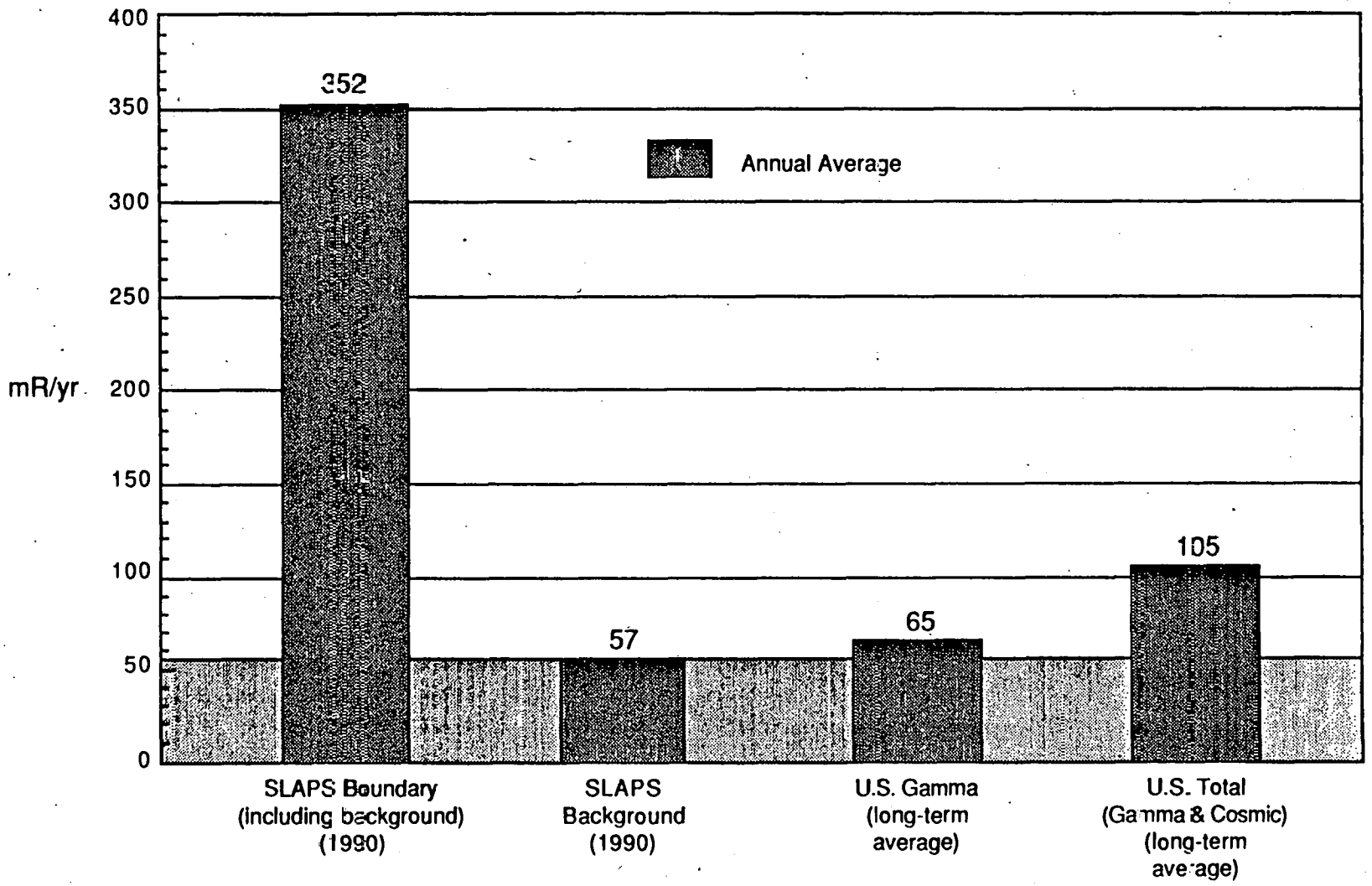
The background external gamma radiation value for a given location is not constant because the value is affected by a combination of both natural terrestrial and cosmic radiation sources and factors such as the location of the detector in relation to surface rock outcrops, stone or concrete structures, or highly mineralized soil. Detectors are also influenced by site altitude, annual barometric pressure cycles, and the occurrence and frequency of solar flare activity (Eisenbud 1987).

Because of these factors, the background radiation level is not constant from one location to another even over a short time. Thus it is not abnormal for some stations at the boundary of a site to have an external gamma radiation value less than the background level measured some distance from the site.

For comparison, Figure 4-2 shows the annual average external gamma radiation levels for the site boundary and background and for the nation. Based on these data, the radioactive material at SLAPS does not present an immediate health threat to the public from external gamma radiation because access to the material by the general public is limited.

Trends

Trends in external gamma exposure levels measured from 1986 through 1990 are presented in Table 4-4. The expected values shown are based on calculation of the standard deviation of the yearly mean. The expected range provides a rough check on whether to see if there are any trends present in the data. If the range varies a



Source: Martin Marietta Energy Systems, Inc., 1989. *Portsmouth Gaseous Diffusion Plant Site Environmental Report for 1988*, ES/ESH-8/V4, Oak Ridge, Tenn.

The DOE guideline for external gamma exposure is 100 mrem/yr above background level (DOE 1990c). Note: 1 mrem is approximately equivalent to 1 mR.

Figure 4-2
External Gamma Radiation Exposure Rates

TABLE 4-4

TREND ANALYSIS FOR EXTERNAL GAMMA RADIATION LEVELS[a,b]

AT SLAPS, 1986-1990

Sampling Location[c]	Annual Average Levels 1986	1987	1988	1989	1990	Average Value	Standard Deviation	Expected Range[d]
Property Line								
1	14	34	47	41	37	34	11	12 - 56
2	1363	1557	2128	1938	1970	1791	284	1220 - 2360
3	67	87	101	86	83	85	11	63 - 110
4	21	38	38	57	32	37	12	13 - 61
5	81	67	45	29	32	51	20	11 - 91
6	10	35	43	32	35	31	11	9 - 53
8	17	25	38	34	37	30	8.0	14 - 46
9[f]	--	110	129	132	132	126	9.2	108 - 144
Quality Control								
7[e]	43	58	129	89	86	81	30	21 - 140
Background								
16[g]	97	77	73	61	60	74	13	48 - 100
17[h]	--	--	--	62	60	61	1.0	59 - 63
18[i]	--	--	--	45	51	48	3.0	42 - 54

NOTE: Sources for 1986-1989 data are the annual site environmental reports for those years (BNI 1987a, 1988, 1989a, 1990).

[a]Levels are given in units of mR/yr.

[b]Measured background has been subtracted from values measured at the onsite locations.

[c]Onsite sampling locations are shown in Figure 4-1.

[d]Average value ±2 standard deviations.

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

[f]Station established in April 1987.

[g]Station moved in October 1990 from 6500 Las Sombrias Ln, Florissant, Missouri, approximately 24 km (15 mi) northeast of SLAPS to 4517 Oakland Drive, St. Louis, Missouri, approximately 26 km (16 mi) southeast of SLAPS.

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

[i]Located at the St.Charles County, Missouri, airport, approximately 32 km (20 mi) northwest of SLAPS. Established in April 1988.

great deal from location to location, or if a station consistently falls outside the expected range, then a trend could be present. Background radiation levels at SLAPS did not change notably between 1986 and 1990. All of the quarterly data fall within the expected range, and the standard deviation of the annual means is also comparable for most of the locations. Although location 2 had measured values well above background levels, there appears to be no general upward trend. This is as anticipated because no work was performed at the site during 1990.

4.1.3 Surface Water Monitoring

Surface water monitoring was conducted to ensure compliance with environmental regulations and to determine whether runoff from SLAPS contributes to surface water contamination in the area.

Program description

Surface water samples were collected quarterly at sampling locations established on the basis of potential contaminant migration and discharge routes from the site. Sampling points were located both upstream [location 2 (Figure 4-3)], to establish background conditions; and downstream [locations 1, 3, and 4 (Figures 4-1 and 4-3)], to determine the effect of runoff from the site on the surface waters in the vicinity. Per request from the State of Missouri, three surface water sampling locations were added to the program during 1990. These locations [5, 6, and 7 (Figure 4-3)], approximately 13-16 km (8-9 mi) northeast of SLAPS, are designed to study the possible effects of the site on the Missouri River.

Surface water samples were analyzed for radium-226, thorium-230, and total uranium. Radium-226 concentrations were determined by radon emanation. This method for detecting radon consists of precipitating radium-226 as sulfate and transferring the treated sulfate to a radon bubbler, where the radon-222 is

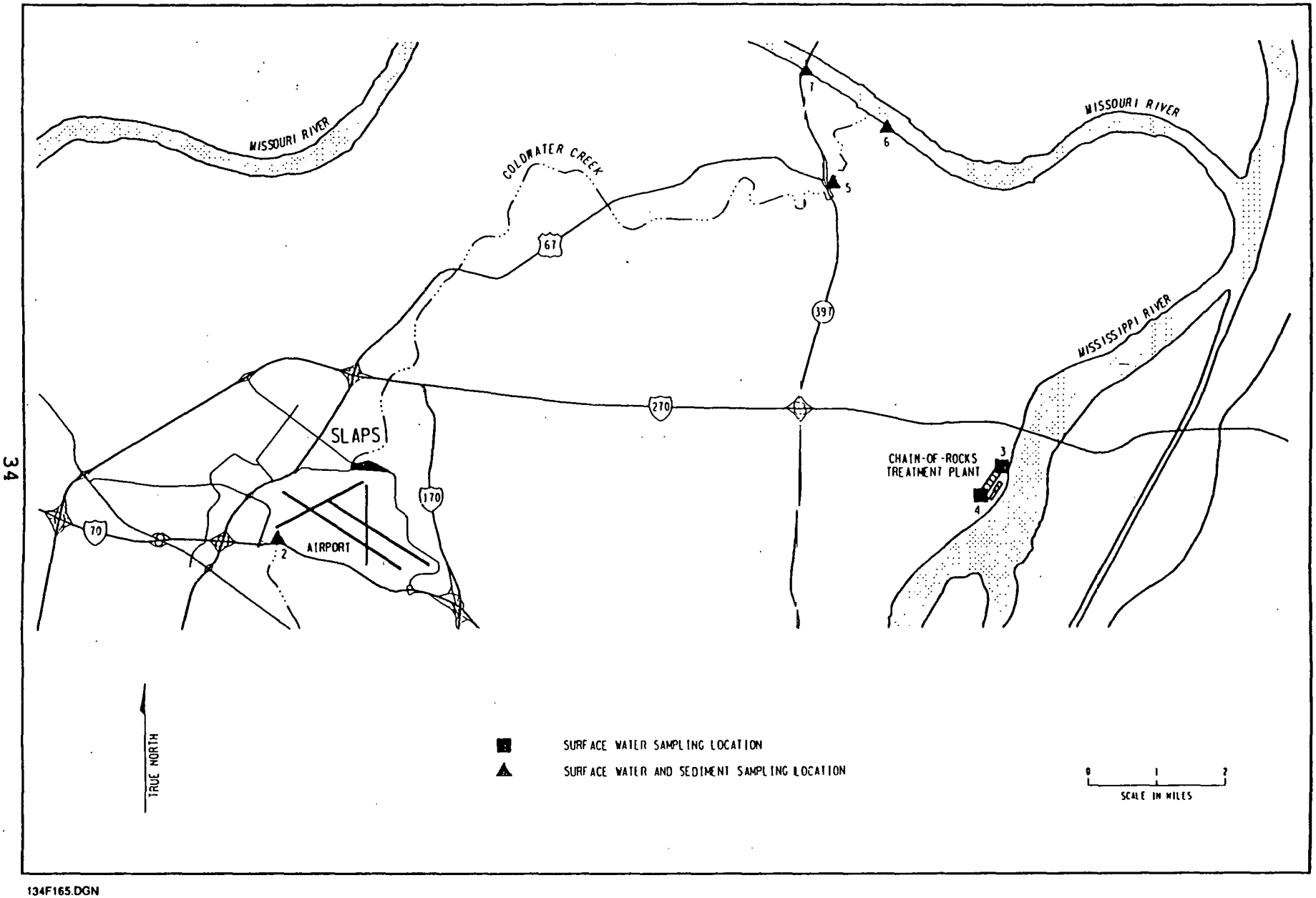


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Figure 4-3
Offsite Surface Water and Sediment Sampling Locations in the SLAPS Area

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 concentrations were determined by the photon/electron-rejecting alpha liquid scintillation (PERALS) method. This method begins with the coprecipitation of radionuclides from a sample by using lead sulfate. Radium is separated onto barium sulfate and precipitated with diethylene-triamine-pentaacetate solution. Thorium is then separated sequentially from barium sulfate supernate by extraction into di(2-ethylhexyl)phosphoric acid. The thorium is then counted on the PERALS instrument. This method has approximately a 95 percent recovery rate for thorium in samples.

Total uranium in surface water is typically measured using the fluorometric method, which is a very sensitive and dependable method for determining trace concentrations of uranium. The first step is to dispense a measured aliquot (typically 0.1 ml) of sample onto a flux pellet made of sodium fluoride (98 percent) and lithium fluoride (2 percent). After the pellet is dried, the uranium is fused to the pellet by a rotary fusion burner. After cooling, the fluorescence of the fused pellet is measured by a fluorometer; the measured fluorescence is directly proportional to the concentration of total uranium in the sample as compared with spikes, standards, and blanks.

Data and discussion

Table 4-5 presents 1990 concentrations of total uranium, radium-226, and thorium-230 in surface water. The annual average concentration of total uranium was below 3E-9 μCi/ml (0.1 Bq/L) at the upstream location (location 2) and ranged from 3E-9 to 6E-9 μCi/ml (0.1 to 0.2 Bq/L) at downstream locations. Downstream surface water locations potentially affected by the site showed no elevated levels. The absence of elevated levels in the

TABLE 4-5

CONCENTRATIONS[a] OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN SURFACE WATER IN THE VICINITY OF SLAPS, 1990

Sampling Location[b]	Quarter 1	2	3	4	Min	Max	Avg
Total Uranium[c]							
1	6	7	5	4	4	7	6
2[d]	4	3	ND[e]	3	3	4	3
3	3	3	3	3	3	3	3
4	4	3	3	3	3	4	3
5	3	3	3	3	3	3	3
6	3	3	3	3	3	3	3
7	3	3	3	3	3	3	3
Radium-226							
1	0.3	0.3	0.6	0.2	0.2	0.6	0.4
2[d]	0.3	0.3	ND[e]	0.4	0.3	0.4	0.3
3	0.2	0.2	0.2	0.3	0.2	0.3	0.2
4	0.3	0.3	0.4	0.6	0.3	0.6	0.4
5	0.3	0.3	0.5	0.1	0.1	0.5	0.3
6	0.2	0.3	0.9	0.4	0.2	0.9	0.5
7	0.2	0.3	0.5	0.2	0.2	0.5	0.3
Thorium-230							
1	<0.1	0.3	<0.2	<0.2	<0.1	0.3	0.2
2[d]	<0.1	0.1	ND[e]	<0.3	<0.1	<0.3	0.2
3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
4	0.1	0.2	<0.1	0.1	<0.1	0.3	0.1
5	0.1	0.1	<0.1	<0.1	<0.1	0.1	0.1
6	0.1	0.3	0.1	0.6	0.1	0.6	0.3
7	0.1	0.3	<0.2	<0.4	0.1	<0.4	0.3

[a]Concentrations are given in units of E-9 μCi/ml. Background values have not been subtracted.
Note: 1E-9 μCi/ml is equivalent to 0.037 Bq/L.

[b]Sampling locations are shown in Figures 4-1 and 4-3.

[c]Total uranium concentrations are determined by using the fluorometric method.

[d]Location 2 serves as an upstream (background) sampling station.

[e]No sample data available.

downstream locations may indicate that uranium is not migrating from the site via surface water. Total uranium concentrations were well below the DOE DCG of 600E-9 μCi/ml (22 Bq/L).

The annual average concentration of radium-226 was 0.3E-9 μCi/ml (0.01 Bq/L) at the upstream (background) location and ranged from 0.2E-9 to 0.5E-9 μCi/ml (7E-3 to 19E-3 Bq/L) at downstream locations. Radium-226 concentrations remained close to background throughout the year and were well below the DOE DCG of 100E-9 μCi/ml (3.7 Bq/L).

The annual average concentration of thorium-230 was 0.2E-9 μCi/ml (7E-3 Bq/L) at the upstream (background) location and ranged from 0.1E-9 to 0.3E-9 μCi/ml (4E-3 to 10E-3 Bq/L) at downstream locations. Thorium-230 concentrations remained close to background throughout the year and were well below the DOE DCG of 300E-9 μCi/ml (11 Bq/L).

Trends

Annual average radionuclide concentrations measured from 1986 through 1990 are presented in Table 4-6. The expected value ranges shown are based on the calculation of standard deviation of the yearly mean. The expected range provides a rough check on whether there are any trends present in the data. If the range varies a great deal from location to location, or if a location consistently falls outside the expected range, then a trend could be present. In general, the ranges were fairly consistent between data sets, and quarterly results for 1990 fell within the expected range of values. No upward trends were identified and there was no observable effect on the Missouri or Mississippi River.

4.1.4 Sediment Monitoring

Sediment monitoring is conducted to determine whether contaminants are collecting in offsite sediment and to ensure compliance with environmental regulations.

TABLE 4-6

TREND ANALYSIS FOR TOTAL URANIUM, RADIUM-226, AND THORIUM-230 CONCENTRATIONS[a] IN SURFACE WATER IN THE VICINITY OF SLAPS, 1986-1990

Sampling Location[b]	Annual Average Concentration 1986	1987	1988	1989	1990	Average Value	Standard Deviation	Expected Range[c]
				Total Uranium[d]				
1	4.3	4.2	4.0	4.6	6.0	4.6	0.72	3.2 - 6.0
2[e]	3.0	3.0	4.0	3.4	3.0	3.3	0.39	2.5 - 4.1
3	3.0	4.0	4.0	4.6	3.0	3.7	0.63	2.4 - 5.0
4	3.5	4.0	3.0	4.1	3.0	3.5	0.47	2.6 - 4.4
5[f]	--	--	--	--	3.0	--	--	--
6[f]	--	--	--	--	3.0	--	--	--
7[f]	--	--	--	--	3.0	--	--	--
				Radium-226				
1	0.2	0.4	0.3	0.3	0.4	0.3	0.07	0.2 - 0.4
2[e]	0.3	0.3	0.5	0.3	0.3	0.3	0.08	0.1 - 0.5
3	0.2	0.3	0.3	0.4	0.2	0.3	0.07	0.2 - 0.4
4	0.2	0.3	0.2	0.3	0.4	0.3	0.07	0.2 - 0.4
5[f]	--	--	--	--	0.3	--	--	--
6[f]	--	--	--	--	0.5	--	--	--
7[f]	--	--	--	--	0.3	--	--	--
				Thorium-230				
1	0.2	0.4	0.3	0.3	0.2	0.3	0.09	0.1 - 0.5
2[e]	0.2	0.2	0.1	0.1	0.2	0.2	0.05	0.1 - 0.3
3	0.3	0.3	0.3	0.1	0.1	0.2	0.1	0.0 - 0.4
4	0.2	0.2	0.1	0.2	0.1	0.2	0.05	0.1 - 0.3
5[f]	--	--	--	--	0.1	--	--	--
6[f]	--	--	--	--	0.3	--	--	--
7[f]	--	--	--	--	0.3	--	--	--

NOTE: Sources for 1986-1989 data are the annual site environmental reports for those years (BNI 1987a, 1988, 1989a, 1990).

TABLE 4-6
(continued)

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[a]Concentrations are given in units of E-9 µCi/ml. Background values have not been subtracted. Note: 1E-9 µCi/ml is equivalent to 0.037 Bq/L.

[b]Sampling locations are shown in Figures 4-1 and 4-3.

[c]Expected range = average value ±2 standard deviations.

[d]Total uranium concentrations were determined by using the fluorometric method.

[e]Location 2 serves as an upstream (background) sampling station.

[f]Location not established until 1990; trend analysis not applicable.

Program description

Sediment samples were collected quarterly at surface water sampling locations where sediment is present. Sampling points were located upstream (location 2), to establish background conditions; and downstream (locations 1, 5, 6, and 7), to determine the effect of the site on sediment in the vicinity of SLAPS and on the Missouri River (Figures 4-1 and 4-3).

Sediment samples were analyzed for total uranium, radium-226, and thorium-230. Isotopic uranium, radium-226, and thorium-230 were eluted in solution, organically extracted, electroplated to a stainless steel disc, and counted by alpha spectrometry. Total uranium concentrations were calculated by summing the results of the isotopic uranium analyses.

Currently, there are no DOE DCGs for radionuclides in sediment; therefore, sediment concentrations have been compared with FUSRAP soil guidelines (Appendix C).

Data and discussion

Table 4-7 presents 1990 concentrations of total uranium, radium-226, and thorium-230 in sediment. The annual average concentration of total uranium was 1.6 pCi/g (0.059 Bq/g) at the upstream (background) location and ranged from 1 to 2.1 pCi/g (0.04 to 0.078 Bq/g) at downstream locations. Total uranium concentrations remained close to background.

The annual average concentration of radium-226 was 2.7 pCi/g (0.10 Bq/g) at the upstream (background) location and ranged from 0.8 to 1 pCi/g (0.03 to 0.04 Bq/g) at downstream locations. Radium-226 levels remained close to background throughout the year and were below the FUSRAP soil guideline of 5 pCi/g in the top 15 cm (6 in.) of soil.

The annual average concentration of thorium-230 was 0.7 pCi/g (0.03 Bq/g) at the upstream (background) location and ranged from 0.6 to 2 pCi/g (0.02 to 0.07 Bq/g) at downstream locations. One slightly elevated level [5.8 pCi/g (0.21 Bq/g)] at location 1 may

TABLE 4-7

CONCENTRATIONS[a] OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN SEDIMENT IN THE VICINITY OF SLAPS, 1990

Sampling Location[b]	Quarter 1	2	3	4	Min	Max	Avg
Total Uranium[c]							
1	1.9	1.8	3.1	1.5	1.5	3.1	2.1
2[d]	1.2	1.6	1.8	1.8	1.2	1.8	1.6
5	1.4	1.2	1.3	0.8	0.8	1.4	1
6	0.9	1.6	1.8	1.3	0.9	1.8	1
7	1.3	1.2	1.4	1.4	1.2	1.4	1.3
Radium-226							
1	0.9	1.2	1.5	1.4	0.9	1.5	1
2[d]	1.0	2.7	2.4	4.7	1.0	4.7	2.7
5	0.6	1.5	0.2	1.0	0.2	1.5	0.8
6	0.6	1.0	1.2	1.0	0.6	1.2	1
7	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Thorium-230							
1	0.8	1.1	5.8	1.0	0.8	5.8	2
2[d]	0.5	0.7	0.9	0.7	0.5	0.9	0.7
5	0.8	3.2	0.5	0.8	0.5	3.2	1
6	0.8	0.6	0.8	0.7	0.6	0.8	0.7
7	0.5	0.4	0.7	0.7	0.4	0.7	0.6

[a]Concentrations are given in units of pCi/g. Note: 1 pCi/g is equivalent to 0.037 Bq/g. Background values have not been subtracted.

[b]Sampling locations are shown in Figures 4-1 and 4-3.

[c]Total uranium concentrations were determined by summing the concentrations of uranium-234, uranium-235, and uranium-238.

[d]Location 2 serves as an upstream (background) sampling station; all other locations are downstream.

be due to the excessive amount of rain before the second-quarter sampling; the spotty contamination along the Coldwater Creek embankments may have migrated downstream during the high-water stages associated with the rain. Thorium-230 concentrations remained below the FUSRAP soil guideline of 5 pCi/g in the top 15 cm (6 in.) of soil. There appears to have been no influence from SLAPS on the Missouri River.

For comparison, these concentrations are much less than the levels of radioactivity in phosphate fertilizers listed in Appendix F.

Trends

Annual average radionuclide concentrations measured from 1986 through 1990 are presented in Table 4-8. The expected values shown are based on calculation of the standard deviation of the yearly mean. The expected range provides a rough check on whether there are any trends present in the data. If the range varies a great deal from location to location, or if a station consistently falls outside the expected range, then a trend could be present. All average annual concentrations for radionuclides in sediment for 1990 fell within the expected ranges. The small standard deviation indicates that radium-226 and total uranium concentrations have remained fairly constant. The thorium-230 at location 1 had a relatively large standard deviation; however, no discernible trend was present. The lack of discernible trends for thorium-230 may result from migration and re-collection of the spotty contamination along Coldwater Creek.

4.1.5 Groundwater Monitoring

Groundwater monitoring is conducted to provide information on potential migration of contaminants through the groundwater system and to ensure compliance with environmental regulations.

TABLE 4-8

TREND ANALYSIS FOR TOTAL URANIUM, RADIUM-226, AND THORIUM-230 CONCENTRATIONS[a] IN SEDIMENT IN THE VICINITY OF SLAPS, 1986-1990

Sampling Location[b]	Annual Average Concentration 1986[c]	1987	1988	1989	1990	Average Value	Standard Deviation	Expected Range[c]
Total Uranium[d]								
1	2.0	1.3	2.6	2.5	2.1	2.1	0.46	1.2 - 3.0
2[e]	2.6	1.6	1.7	1.9	1.6	1.9	0.38	1.1 - 2.7
5[f]	--	--	--	--	1	--	--	--
6[f]	--	--	--	--	1	--	--	--
7[f]	--	--	--	--	1.3	--	--	--
Radium-226								
1	1.2	1.4	1.0	1.2	1	1	0.2	0.6 - 1.4
2[e]	1.1	1.0	1.5	1.2	2.7	1.5	0.62	0.26 - 2.7
5[f]	--	--	--	--	0.8	--	--	--
6[f]	--	--	--	--	1	--	--	--
7[f]	--	--	--	--	0.9	--	--	--
Thorium-230								
1	1.0	1.3	5.4	2.9	2	3	2	0.00 - 7
2[e]	1.2	1.6	1.3	0.8	0.7	1.1	0.33	0.44 - 1.8
5[f]	--	--	--	--	1	--	--	--
6[f]	--	--	--	--	0.7	--	--	--
7[f]	--	--	--	--	0.6	--	--	--

NOTE: Sources of 1986-1989 data are the annual site environmental reports for those years (BNI 1987a, 1988, 1989a, 1990).

[a]Concentrations are given in units of pCi/g. Note: 1 pCi/g is equivalent to 0.037 Bq/g.

[b]Sampling locations are shown in Figures 4-1 and 4-3.

TABLE 4-8

(continued)

[c]Expected range = average value ±2 standard deviations.

[d]Total uranium concentrations were determined by summing the concentrations of uranium-234, uranium-235, and uranium-238.

[e]Location 2 serves as an upstream sampling location; all other locations are downstream.

[f]Sampling locations 5, 6, and 7 were added to the program in 1990; trend analysis is not applicable.

Program description

The monitoring well system is designed to provide sufficient coverage of area groundwater conditions. Sampling points are both upgradient (wells B53W11D, B53W16S, and B53W15S), to establish background conditions; and downgradient (all other wells), to determine the effects of the site on groundwater in the vicinity (Figure 4-4). Background monitoring wells are B53W01S and B53W01D.

Quarterly groundwater samples were analyzed for total uranium, radium-226, and thorium-230 in the same manner as surface water samples.

Sampling results

Table 4-9 presents 1990 concentrations of total uranium, radium-226, and thorium-230 in groundwater. The annual average concentrations of total uranium ranged from 3E-9 to 4E-9 μCi/ml (0.1 to 0.2 Bq/L) at upgradient locations and from 3E-9 to 4553 μCi/ml (0.1 to 168 Bq/L) at downgradient locations. Concentrations of total uranium in several of the shallow wells at SLAPS are high because the wells are in areas of known subsurface contamination. However, because SLAPS is fenced, the public does not have access to these capped and locked wells; furthermore, there is no known consumption of groundwater in the vicinity of the site. Total uranium concentrations were below the DOE DCG of 600E-9 μCi/ml (22 Bq/L) in all wells except A, B, D, and M11-9.

Annual average concentrations of radium-226 ranged from 0.2E-9 to 0.8E-9 μCi/ml (0.007 to 0.03 Bq/L) at the upgradient locations and from 0.4E-9 to 1.5E-9 μCi/ml (0.02 to 0.056 Bq/L) at downgradient locations. Background averages for radium ranged from 0.4E-9 to 1E-9 μCi/ml (0.02 to 0.04 Bq/L). Radium-226 concentrations were comparable to background levels and well below the DOE DCG of 100E-9 μCi/ml (3.7 Bq/L).

Annual average concentrations of thorium-230 ranged from 0.2E-9 to 2E-9 μCi/ml (0.001 to 0.07 Bq/L) at upgradient locations and from 0.2E-9 to 12E-9 μCi/ml (7E-3 to 0.44 Bq/L) at downgradient

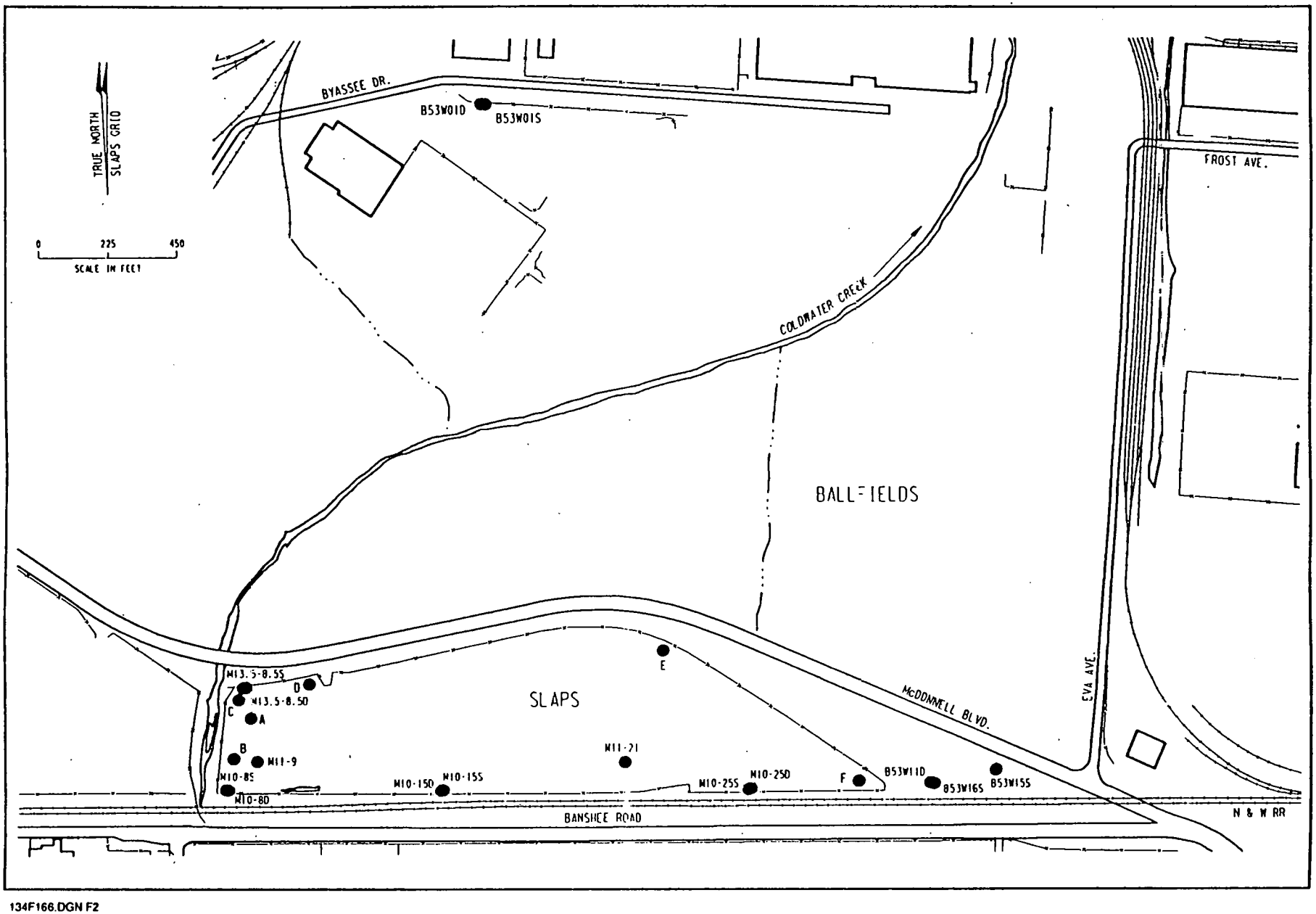

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Figure 4-4
Wells Monitored for Radiological and
Chemical Contamination in the SLAPS Area in 1990

TABLE 4-9

CONCENTRATIONS[a] OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN GROUNDWATER AT SLAPS, 1990

Sampling Location[b]	Quarter 1	2	3	4	Min	Max	Avg
			Total Uranium[c]				
A	2201	1868	3602	2068	1868	3602	2435
B	4869	5203	5870	2268	2268	5870	4553
C	13	26	20	15	13	26	19
D	800	667	800	494	494	800	690
E	127	240	200	187	127	240	189
F	160	253	227	167	160	253	202
M10-8S	6	8	7	4	4	8	6
M10-8D	<3	<3	5	<3	3	5	4
M10-15D	9	<3	9	<3	3	9	6
M10-15S	<3	7	<3	7	3	7	5
M10-25S	45	52	73	61	45	73	58
M10-25D	<3	<3	4	<3	3	4	3
M11-9	5469	<3	<3	2268	3	5469	1936
M11-21	73	93	87	80	73	93	83
M13.5-8.5S	5	<3	<3	<3	3	5	4
M13.5-8.5D	<3	13	<3	<3	3	13	6
B53W11D[d]	<3	<3	<3	5	3	5	4
B53W15S[d]	<3	<3	<3	<3	3	3	3
B53W16S[d]	<3	<3	<3	<3	3	3	3
Background							
B53W01S[e]	<3	<3	<3	<3	3	3	3
B53W01D[e]	<3	--[f]	<3	<3	3	3	3
			Radium-226				
A	0.3	0.2	1.2	0.4	0.2	1.2	0.5
B	0.7	0.5	0.8	0.3	0.3	0.8	0.6
C	0.4	0.4	0.6	0.5	0.4	0.6	0.5
D	0.4	0.2	0.7	0.1	0.1	0.7	0.4
E	0.5	0.3	0.7	0.4	0.3	0.7	0.5
F	0.3	0.4	1.1	0.3	0.3	1.1	0.5
M10-8S	0.5	<0.1	0.7	0.7	0.1	0.7	0.5
M10-8D	0.5	0.8	1.1	0.7	0.5	1.1	0.8
M10-15D	0.3	0.9	0.7	1.6	0.3	1.6	0.9
M10-15S	0.3	0.4	1.1	0.3	0.3	1.1	0.5
M10-25S	0.5	0.4	1.1	0.2	0.2	1.1	0.6
M10-25D	0.6	0.6	0.8	0.7	0.6	0.8	0.7
M11-9	0.4	1.6	0.2	0.3	0.2	1.6	0.6
M11-21	0.3	0.5	0.6	0.7	0.3	0.7	0.5
M13.5-8.5S	0.8	0.7	1.2	0.2	0.2	1.2	0.7
M13.5-8.5D	0.6	0.4	4.0	0.8	0.6	0.8	1.5
B53W11D[d]	0.3	0.3	0.3	2.3	0.3	2.3	0.8
B53W15S[d]	0.2	0.2	0.5	0.4	0.2	0.5	0.3
B53W16S[d]	0.2	0.2	0.2	0.1	0.1	0.2	0.2
Background							
B53W01S[e]	0.2	0.2	0.9	0.2	0.2	0.9	0.4
B53W01D[e]	0.9	0.5	1.1	1.6	0.5	1.6	1.0

TABLE 4-9

(continued)

Sampling Location[b]	Quarter 1	2	3	4	Min	Max	Avg
			Thorium-230				
A	5.7	1.4	1.3	7.9	1.3	7.9	4.1
B	3.9	0.5	0.3	0.1	0.1	3.9	1.2
C	0.1	0.1	0.1	0.3	0.1	0.3	0.2
D	1.7	1.0	0.6	2.3	0.6	2.3	1.4
E	0.6	1.3	0.6	0.3	0.3	1.3	0.6
F	0.2	0.8	0.3	0.4	0.2	0.8	0.4
M10-8S	0.4	<0.2	0.1	0.1	0.1	0.4	0.2
M10-8D	0.7	1.7	0.6	0.4	0.4	1.7	0.9
M10-15D	0.6	0.5	0.2	0.7	0.2	0.7	0.5
M10-15S	0.7	1.7	0.6	0.9	0.6	1.7	1.0
M10-25S	0.4	0.2	0.1	0.3	0.1	0.4	0.3
M10-25D	0.3	0.2	0.1	0.3	0.1	0.3	0.2
M11-9	0.2	<0.2	0.3	<0.1	0.1	0.3	0.2
M11-21	3.4	9.2	5.8	29.0	3.4	29.0	12
M13.5-8.5S	<0.1	0.4	0.5	0.1	0.1	0.5	0.3
M13.5-8.5D	0.5	0.4	1.1	0.2	0.2	1.1	0.6
B53W11D[d]	0.2	0.5	0.3	6.9	0.2	6.9	2.0
B53W15S[d]	0.2	0.6	0.3	1.6	0.2	1.6	0.7
B53W16S[d]	<0.1	0.4	0.1	0.3	0.1	0.4	0.2
Background							
B53W01S[e]	0.2	<0.2	<0.1	0.2	0.1	0.2	0.2
B53W01D[e]	0.8	0.4	0.2	0.3	0.2	0.8	0.4

[a]Concentrations are given in E-9 μCi/ml. Note: 1E-9 μCi/ml is equivalent to 0.037 Bq/L.

[b]Sampling locations are shown in Figure 4-4.

[c]Total uranium concentrations were determined by using the fluorometric method.

[d]Upgradient well.

[e]Well established for background measurements in July 1988.

[f]No verifiable results for total uranium in well B53W01D for second-quarter sampling.

locations. Background averages for thorium ranged from 0.2E-9 to 0.4E-9 μCi/ml (7E-9 to 15E-3 Bq/L). Thorium-230 concentrations were only slightly above background, except for one concentration [29E-9 μCi/ml (1.1 Bq/L)] in M11-21. Thorium-230 concentrations were below the DOE DCG of 300E-9 μCi/ml (11 Bq/L).

Trends

Annual average radionuclide concentrations in groundwater measured from 1986 through 1990 are presented in Table 4-10. The expected values shown are based on calculation of the standard deviations of the yearly mean. The expected range provides a rough check on whether there are any trends present in the data. If the range varies a great deal from location to location, or if a station consistently falls outside the expected range, then a trend could be present. Even though values tended to fall within these ranges, there are three possible trends indicated for total uranium.

Uranium levels are apparently increasing in well A, from 1184E-9 μCi/ml (43.8 Bq/L) in 1986 to 2435E-9 μCi/ml (90.1 Bq/L) in 1990. Wells B and M10-8S show an overall decrease in uranium levels over the past five years; in well B, concentrations have steadily decreased from 6570E-9 μCi/ml (243 Bq/L) in 1986 to 4553E-9 μCi/ml (169 Bq/L) in 1990. The standard deviation for thorium-230 in well M11-21 was large but does not indicate a trend; the large standard deviation is due to high average levels detected in 1988. Apparently these high levels were an anomaly because 1987, 1989, and 1990 average results ranged from 11E-9 to 15.2E-9 μCi/ml (0.41 to 0.56 Bq/L). The well is located in the center of the site and in an area known to be contaminated.

4.2 POTENTIAL DOSE TO THE PUBLIC

This section contains information on exposures to the maximally exposed individual and the general public from the radioactive materials at SLAPS. As expected for a relatively stable site such

TABLE 4-10

TREND ANALYSIS FOR TOTAL URANIUM, RADIUM-226, AND THORIUM-230

CONCENTRATIONS[a] IN GROUNDWATER AT SLAPS, 1986-1990

Sampling Location[b]	Annual Average Concentration 1986	1987	1988	1989	1990	Average Value	Standard Deviation	Expected Range[c]
Total Uranium[d]								
A	1184	1139	1700	2065	2435	1705	500.9	703.2 - 2707
B	6570	5829	5590	5281	4553	5565	661.1	4243 - 6887
C	16	13	18	20	19	17	2.5	12 - 22
D	802	637	475	773	690	675	116.1	443 - 907
E	540	576	197	819	189	464	241.3	0.00 - 946
F	146	106	265	266	202	197	63.7	69.6 - 324
M10-8S[e]	--	32	19	21	6	20	9	2 - 38
M10-8D[e]	--	5	4	5	4	5	0.5	4 - 6
M10-15D[e]	--	9	5	3	6	6	2	2 - 10
M10-15S[e]	--	11	9	11	5	9	3	3 - 15
M10-25S[e]	--	25	39	33	58	39	12	15 - 63
M10-25D[e]	--	4	4	3	3	4	0.5	3 - 5
M11-9[e]	--	4578	4620	4807	1936	3985	1186	1613 - 6357
M11-21[e]	--	45	73	96	83	74	19	36 - 110
M13.5-8.5S[e]	--	4	4	3	4	4	0.4	3 - 5
M13.5-8.5D[e]	--	3	3	3	6	4	1	2 - 6
B53W11D[f,g]	--	--	--	--	4	--	--	--
B53W15S[f,g]	--	--	--	--	3	--	--	--
B53W16S[f,g]	--	--	--	--	3	--	--	--
Background								
B53W01S[h]	--	--	3	3	3	3	0	3
B53W01D[h]	--	--	4	3	3	3	0.5	2 - 4
Radium-226								
A	0.3	0.3	0.4	0.4	0.5	0.4	0.07	0.3 - 0.5
B	0.3	0.3	0.6	0.6	0.6	0.5	0.2	0.1 - 0.9
C	0.3	0.4	0.5	0.5	0.5	0.4	0.08	0.2 - 0.6
D	0.3	0.1	0.3	0.5	0.4	0.3	0.1	0.1 - 0.5
E	0.5	0.3	0.6	0.6	0.5	0.5	0.1	0.3 - 0.7
F	0.2	0.3	0.6	0.4	0.5	0.4	0.1	0.2 - 0.6
M10-8S[e]	--	0.4	0.5	0.4	0.5	0.5	0.05	0.4 - 0.6
M10-8D[e]	--	0.3	0.6	0.6	0.8	0.6	0.2	0.2 - 1
M10-15D[e]	--	0.4	0.9	0.9	0.9	0.8	0.2	0.4 - 1.2

TABLE 4-10

(continued)

Sampling Location[b]	Annual Average Concentration 1986	1987	1988	1989	1990	Average Value	Standard Deviation	Expected Range[c]
Radium-226 (cont'd)								
M10-15S[e]	--	0.3	0.8	0.4	0.5	0.5	0.2	0.1 - 0.9
M10-25S[e]	--	0.2	0.6	0.5	0.6	0.5	0.2	0.1 - 0.9
M10-25D[e]	--	0.2	0.4	0.7	0.7	0.5	0.2	0.1 - 0.9
M11-9[e]	--	0.5	0.8	0.5	0.6	0.6	0.1	0.4 - 0.8
M11-21[e]	--	0.5	0.7	0.7	0.5	0.6	0.1	0.4 - 0.8
M13.5-8.5S[e]	--	0.5	0.8	0.5	0.7	0.6	0.1	0.4 - 0.8
M13.5-8.5D[e]	--	0.5	0.6	0.6	1.5	0.6	0.4	0 - 1
B53W11D[f,g]	--	--	--	--	0.8	--	--	--
B53W15S[f,g]	--	--	--	--	0.3	--	--	--
B53W16S[f,g]	--	--	--	--	0.2	--	--	--
Background								
B53W01S[h]	--	--	0.6	0.7	0.4	0.6	0.1	0.4 - 0.8
B53W01D[h]	--	--	1.1	1.0	1.0	1.0	0.05	0.9 - 1.1
Thorium-230								
A	0.4	0.8	2.8	2.9	4.1	2	1	0 - 4.0
B	1.2	1.4	2.0	1.1	1.2	1.4	0.32	0.76 - 2.0
C	0.2	0.9	0.3	0.1	0.2	0.3	0.3	0 - 0.9
D	0.3	0.9	0.9	1.4	1.4	1	0.4	0.2 - 2
E	0.4	0.9	4.8	1.7	0.6	2	2	0 - 4
F	0.2	1.7	2.0	0.8	0.4	1	0.7	0 - 2
M10-8S[e]	--	0.2	0.5	0.3	0.2	0.3	0.1	0.1 - 0.5
M10-8D[e]	--	0.1	0.3	0.3	0.9	0.4	0.3	0 - 1
M10-15D[e]	--	0.4	1.3	1.1	0.5	0.8	0.4	0 - 1.6
M10-15S[e]	--	1.8	5.3	1.3	1.0	2.4	1.7	0 - 5.8
M10-25S[e]	--	0.2	0.4	0.1	0.3	0.3	0.1	0.1 - 0.5
M10-25D[e]	--	0.8	0.5	0.8	0.2	0.6	0.3	0 - 1
M11-9[e]	--	0.3	1.0	0.8	0.2	0.6	0.3	0 - 1
M11-21[e]	--	15.2	52.0	11.0	11.9	22.5	17.1	0 - 56.7
M13.5-8.5S[e]	--	0.4	0.7	0.2	0.3	0.4	0.2	0.1 - 0.8
M13.5-8.5D[e]	--	0.1	0.7	0.6	0.6	0.5	0.2	0.1 - 0.9
B53W11D[f,g]	--	--	--	--	2.0	--	--	--
B53W15S[f,g]	--	--	--	--	0.7	--	--	--
B53W16S[f,g]	--	--	--	--	0.2	--	--	--

TABLE 4-10
(continued)

			Thorium-230 (cont'd)					
Background								
B53W01S[h]	--	--	0.2	0.3	0.2	0.2	0.05	0.1 - 0.3
B53W01D[h]	--	--	0.2	0.4	0.4	0.3	0.09	0.1 - 0.5

NOTE: Data sources for 1986-89 are the annual site environmental reports for those years (BNI 1987a, 1988, 1989a, 1990)

[a]Concentrations are given in E-9 μCi/ml. Note: 1E-9 μCi/ml is equivalent to 0.037 Bq/L.

[b]Sampling locations are shown in Figure 4-4.

[c]Expected range = average value ±2 standard deviations.

[d]Total uranium concentrations were determined by using the fluorometric method.

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

[f]Upgradient well.

[g]The "B53" wells were added to the environmental monitoring program in January 1990.

[h]Well established for background in July 1988.

as SLAPS, all calculated doses were below the DOE guidelines. Doses to the general public can come from either external or internal exposures. Exposures to radiation from radionuclides outside the body are called external exposures; exposures to radiation from radionuclides deposited inside the body are called internal exposures. This distinction is important because external exposures occur only when a person is near the source of the radionuclides, but internal exposures begin as soon as radionuclides are taken into the body and continue as long as the radionuclides reside in the body.

To assess the potential health effects of the materials stored at SLAPS, radiological exposure pathways were evaluated and radiation doses were calculated for a hypothetical maximally exposed individual and for the population within 80 km (50 mi) of the site. The combined effect from all pathways from all DOE sources can then be compared with DOE guidelines. The pathways considered are surface water, groundwater, air, and direct exposure. Exposures from radon and radon daughters are not considered in these calculations because radon exposure is controlled through compliance with concentration requirements for boundaries (Appendix B). All doses presented in this section are estimated and do not represent actual doses. A summary is provided in Table 4-11.

4.2.1 Maximally Exposed Individual

The hypothetical maximally exposed individual is assumed to live near the site and work at the ball field across the street from the site. Using these assumptions, the following doses have been calculated.

Direct exposure

The yearly dose to a hypothetical person working continuously at the ball field across the street from SLAPS can be calculated by using the equation given in Appendix B for direct exposure. The

TABLE 4-11

SUMMARY OF CALCULATED DOSES[a] AT SLAPS, 1990

Type	Dose to Hypothetical Maximally Exposed Individual (mrem/yr)[b]	Collective Dose for Population Within 80 km of Facility (person-rem/yr)[b]
Direct gamma radiation[c]	4	--[d]
Drinking water	--[d]	--[d]
Ingestion	--[d]	--[d]
Air immersion	--[d]	--[d]
Inhalation[e]	0.47	1.1
Total	4.5	1.1
Background[f]	57	1.4E+10[g]
DOE guideline[h]	100	NA[i]
Percent of guideline (excluding background)	4.5	NA[i]

[a]Does not include radon.

[b]1 mrem/yr = 0.01 mSv/yr; 1 person-rem/yr = 0.01 person-Sv/yr.

[c]Does not include contribution from background.

[d]Negligible contribution.

[e]Calculated using EPA's AIRDOS model (Version 3.0).

[f]Direct gamma exposure only.

[g]Calculated by the following: 57 mrem/yr x (2.5E+6 people).

[h]Source: DOE 1990c.

[i]NA - Not applicable.

calculated dose for this hypothetical maximally exposed individual is 4 mrem/yr (0.04 mSv/yr), well below the DOE guideline of 100 mrem/yr. This is an extremely conservative approach because it is unlikely that an individual would work at one location in the ball field for an entire year.

Drinking water pathway

Only one pathway, either groundwater or surface water, is used to determine the maximally exposed individual's committed dose. The maximally exposed individual would obtain 100 percent of his drinking water from either surface water or groundwater in the vicinity of the site. Concentrations of total uranium, radium-226, and thorium-230 in the vicinity of SLAPS are barely detectable above normal background levels. Because there are no wells within 3.2 km (2 mi) of the site, groundwater is not a credible exposure pathway; therefore the dose contribution of these radionuclides from groundwater to the hypothetical maximally exposed individual was not calculated.

Coldwater Creek, which is downgradient of the site, empties into the Missouri River. The large flow of this river would dilute any detectable radionuclide concentration; therefore, the dose contribution from surface water to a hypothetical maximally exposed individual was not calculated.

Air pathway

To calculate a conservative dose to the hypothetical maximally exposed individual, it was assumed that the individual lived and worked within 300 m (1000 ft) of the site. Air doses determined using EPA's AIRDOS model, version 3.0, were found to be negligible [0.47 mrem/yr (0.0047 mSv/yr)], well below the 10 mrem/yr limit given in 40 CFR Part 61, Subpart H, and the DOE 100 mrem/yr basic dose limit. The 1990 Clean Air Act compliance report is provided in Appendix H.

Total dose

The total dose for the hypothetical maximally exposed individual would be the sum of the doses calculated for each exposure pathway. When these doses are added together, the total dose is 4.5 mrem/yr (0.045 mSv/yr). This dose is comparable to the dose an individual would receive from one flight from New York to Los Angeles (Appendix F).

4.2.2 Population Dose

The collective dose that the general population living within 80 km (50 mi) of the site would receive is calculated as follows.

Direct exposure

Because SLAPS is located in an industrial area, it is remote from the general population. Both distance from the site and intervening structures reduce direct gamma exposure from SLAPS (see Table 4-12). Therefore, it is assumed that there is no detectable exposure to the general public.

Drinking water pathway

There are no wells within 3.2 km (2 mi) downgradient of the site (see Subsection 6.1.2) and there is a significant distance [32 km (20 mi)] to a drinking water intake point on the Mississippi River; therefore, it is reasonable to assume that the general public would not receive a committed dose in drinking water from radionuclides from SLAPS.

Air

The AIRDOS model provides an effective dose equivalent for contaminants transported via the atmospheric pathway at different distances from the site (Table 4-12). Using these effective dose

TABLE 4-12

MAXIMUM EFFECTIVE DOSE TO THE GENERAL PUBLIC FROM SLAPS, 1990

Distance from the Site (m)	Effective Dose Equivalent (mrem/yr)[a,b]	Population Dose (person-rem/yr)[c,d]
0 - 1,000	4.7E-1[e]	0.18
1,000 - 3,000	4.7E-2	0.15
3,000 - 10,000	5.9E-3	0.21
10,000 - 80,000	6.6E-4	0.52
	Total Dose	1.1

[a]To be conservative, the effective dose equivalent used for each range was that for the distance closest to the site. The DOE DCG is 100 mrem/yr above background.

[b]Values were obtained using AIRDOS (Appendix B).

[c]A population density of 1.24E-4 person/m^2 was used in the calculation.

[d]Calculated using:
Population dose = population density x π x [(outer radius)^2 - (inner radius)^2] x effective dose equivalent.

[e]Effective dose equivalent for 500 m.

equivalents and the population density, the collective dose for the general population within 80 km (50 mi) of the site was calculated to be 1.1 person-rem/yr (0.011 person-Sv/yr).

Total population dose

The total population dose is the sum of the doses from all exposure pathways. Because the only pathway with a major contribution to the population dose is the atmospheric pathway, the total population dose is equal to that given for the atmospheric pathway [1.1 person-rem/yr (0.011 person-Sv/yr)]. The collective population dose is extremely small when compared with the collective population dose due to natural background gamma radiation of 1.4E+5 person-rem/yr (1.4E+3 person-Sv/yr) for the same population within 80 km (50 mi) of SLAPS.

5.0 NONRADIOLOGICAL ENVIRONMENTAL PROGRAM

Site characterization has shown that nonradiological contamination of the soil at SLAPS is not substantially different from background levels and does not pose a potential threat to human health or the environment via an airborne pathway (e.g., resuspension of soil) or a surface water pathway (e.g., runoff from site and/or collection in sediments). Nonradiological groundwater monitoring is conducted mainly to obtain a baseline of the groundwater quality in the SLAPS area. SLAPS is not an active site; therefore, the only "effluents" would be contaminant migration.

Program description

Groundwater samples were collected from the same locations as those in the radiological groundwater monitoring system (Figure 4-4). Monitoring points were both upgradient (wells B53W11D, B53W16S, and B53W15S) and downgradient (all other locations), to determine the effect of the site on the groundwater in the vicinity. The background monitoring wells were B53W01S and B53W01D.

Indicator parameters monitored at SLAPS include specific conductance, pH, TOC, and TOX. These parameters indicate changes in the inorganic and organic composition of the groundwater.

Specific conductance and pH readings indicate changes in the inorganic composition of the groundwater. Specific conductance measures the capacity of water to conduct an electrical current. Generally, conductivity increases with an elevated concentration of dissolved solids or salinity. Acidity or alkalinity of the water is expressed as pH. A change in pH affects the solubility and mobility of chemical contaminants in water. TOC and TOX determine organic content: TOC measures the total organic content of the groundwater but is not specific to a given organic contaminant; TOX measures organic compounds containing halogens (e.g., halogenated hydrocarbons).

Data and discussion

Analytical results for indicator parameters show that groundwater at SLAPS is generally of poor quality, which is typical in industrial/urban areas. Annual averages for specific conductance ranged from 714 to 6865 μmhos/cm; this wide range indicates that the amount of dissolved solids in the groundwater is not constant across the site. As shown in Table 5-1, annual average pH values ranged from 6.6 to 7.5. Annual average TOC levels ranged from 3.4 to 22 mg/L, and annual average TOX levels ranged from less than 20 to 123 μg/L. TOC and TOX results are shown in Table 5-2. The elevated TOC level from third-quarter sampling of well M10-15D (62.3 mg/L) and the elevated TOX level from wells B53W16S and M11-21 (140 μg/L) are not considered high for these parameters. Overall, TOC and TOX average results remain relatively stable.

Trends

Indicator analyses such as TOC and TOX are used as gross indicators for the presence of organics. Because these indicator parameters can fluctuate greatly between sampling events, trend analyses are not feasible. Consistently high TOC and/or TOX results would indicate the need for organic screening analyses to identify concentrations of specific organic contaminants. If specific contaminants were consistently detected, trend analyses would be conducted. In cases where broad-screen organic analyses were performed to support a site characterization or remedial investigation, the data would be presented in the annual environmental report, but trend analyses would not be performed.

TABLE 5-1

ANALYTICAL RESULTS FOR INDICATOR PARAMETERS

IN GROUNDWATER AT SLAPS, 1990

Sampling Location[a]	Quarter 1	2	3	4	Min	Max	Avg
			Specific Conductance[b] (μmhos/cm)				
A	1440	1400	1380	1533	1380	1533	1438
B	6900	6930	6610	7020	6610	7020	6865
C	1570	1780	1660	1660	1570	1780	1668
D	2140	2090	2040	1297	1297	2140	1892
E	5720	4380	4810	5400	4380	5720	5078
F	759	680	701	717	680	759	714
M10-8S	1420	1460	1390	1433	1390	1460	1426
M10-8D	843	790	848	8720	790	8720	2800
M10-15S	2620	2630	2560	2770	2560	2770	2645
M10-15D	981	933	919	1030	919	1030	966
M10-25S	797	746	785	793	746	797	780
M10-25D	1170	1160	1380	1214	1160	1380	1231
M11-9	8930	5370	720	7410	720	8930	5608
M11-21	2220	7580	--[c]	1838	1838	7580	3879
M13.5-8.5S	1790	1820	1520	1559	1520	1820	1672
M13.5-8.5D	873	875	900	8880	873	8880	2882
B53W11D[d]	708	738	7440	698	698	7440	2396
B53W15S[d]	810	746	741	793	741	810	773
B53W16S[d]	1200	1220	1190	1130	1130	1220	1185
Background							
B53W01S	860	808	873	800	800	873	835
B53W01D	1050	1020	941	950	941	1050	990
			pH[b] (standard units)				
A	6.9	6.7	6.8	6.3	6.3	6.9	6.7
B	6.6	6.6	6.6	6.5	6.5	6.6	6.6
C	7.0	6.9	6.9	6.4	6.4	7.0	6.8
D	6.9	6.8	6.8	6.9	6.8	6.9	6.9
E	7.4	6.8	6.9	6.5	6.5	7.4	6.9
F	7.3	7.2	7.3	6.1	6.1	7.3	7.0
M10-8S	7.0	6.9	7.0	6.3	6.3	7.0	6.8
M10-8D	7.4	7.3	7.3	6.5	6.5	7.4	7.1
M10-15S	6.8	6.9	7.0	6.5	6.5	7.0	6.8
M10-15D	7.2	7.1	7.3	7.0	7.0	7.3	7.1

TABLE 5-1

(continued)

Sampling Location[a]	Quarter 1	2	3	4	Min	Max	Avg
			pH[b] (standard units) (cont'd)				
M10-25S	7.4	7.1	7.3	6.3	6.3	7.4	7.0
M10-25D	7.0	7.1	7.1	6.1	6.1	7.1	6.8
M11-9	6.5	6.5	7.8	6.5	6.5	7.8	6.8
M11-21	7.2	7.1	--[c]	6.7	6.7	7.2	6.9
M13.5-8.5S	7.0	6.9	6.9	6.4	6.4	7.0	6.8
M13.5-8.5D	7.5	7.3	7.3	7.2	7.2	7.5	7.3
B53W11D[d]	8.8	7.5	6.7	6.9	6.7	8.8	7.5
B53W15S[d]	7.3	7.0	7.2	6.4	6.4	7.3	7.0
B53W16S[d]	7.1	6.9	7.1	6.7	6.7	7.1	7.0
Background							
B53W01S	7.0	7.4	7.0	6.3	6.3	7.4	6.9
B53W01D	6.3	7.2	7.3	7.0	6.3	7.3	7.0

[a]Sampling locations are shown in Figure 4-4.

[b]First three-quarters' results based on laboratory measurement of parameters; fourth-quarter measurements were taken in the field.

[c]No sample data available for third-quarter sampling.

[d]Upgradient well.

TABLE 5-2

CONCENTRATIONS OF TOTAL ORGANIC CARBON AND TOTAL ORGANIC HALIDES IN GROUNDWATER AT SLAPS, 1990

Sampling Location[a]	Quarter 1	2	3	4	Min	Max	Avg
Total Organic Carbon (mg/L)							
A	9.4	15.7	5.8	6.3	5.8	15.7	9.3
B	9.2	9.3	10.8	8.4	8.4	10.8	9.4
C	26.7	36.0	14.5	5.2	5.2	36.0	21
D	12.5	17.0	6.7	7.6	6.7	17.0	11
E	4.0	4.2	3.6	3.2	3.2	4.2	3.8
F	3.4	4.4	3.7	2.2	2.2	4.4	3.4
M10-8S	11.5	6.6	8.9	7.2	6.6	11.5	8.6
M10-8D	7.0	6.9	6.4	10.7	6.4	10.7	7.8
M10-15S	4.6	3.9	3.9	1.9	1.9	4.6	3.6
M10-15D	7.5	9.3	62.3	8.2	7.5	62.3	22
M10-25S	4.3	7.3	3.9	3.2	3.2	7.3	4.7
M10-25D	6.5	7.9	6.3	2.5	2.5	7.9	5.8
M11-9	14.5	9.4	9.1	6.6	6.6	14.5	9.9
M11-21	4.8	3.4	--[b]	6.8	3.4	6.8	5.0
M13.5-8.5S	7.6	12.7	9.7	11.5	7.6	12.7	10
M13.5-8.5D	8.4	17.0	26.2	7.8	7.8	26.2	15
B53W11D[c]	1.1	3.8	6.7	4.9	1.1	6.7	4.1
B53W15S[c]	2.3	1.9	6.3	3.4	1.9	6.3	3.5
B53W16S[c]	5.3	6.3	2.6	1.1	1.1	6.3	3.8
Background							
B53W01S	4.1	3.7	3.7	1.2	1.2	4.1	3.2
B53W01D	7.4	5.4	5.4	6.1	5.4	7.4	6.1
Total Organic Halides (μg/L)							
A	<20[d]	27	31	<20	<20	31	25[e]
B	70	<20	64	76	<20	76	58[e]
C	21	<20	37	96	<20	96	44[e]
D	130	27	71	<20	<20	130	62[e]
E	<20	<20	<20	120	<20	120	45[e]
F	52	39	<20	70	<20	70	45[e]
M10-8S	<20	<20	<20	<20	<20	20	20[e]
M10-8D	34	21	<20	<20	<20	34	24[e]
M10-15S	<20	52	<20	76	<20	76	42[e]
M10-15D	<20	<20	<20	<20	<20	20	20[e]
M10-25S	<20	48	<20	93	<20	93	45[e]
M10-25D	<20	41	47	<20	<20	47	32[e]

TABLE 5-2

(continued)

Sampling Location[a]	Quarter 1	2	3	4	Min	Max	Avg
Total Organic Halides (μg/L) (cont'd)							
M11-9	77	67	48	120	48	120	78[e]
M11-21	140	100	100	110	100	140	113[e]
M13.5-8.5S	33	66	<20	44	<20	66	41[e]
M13.5-8.5D	<20	88	<20	29	<20	88	39[e]
B53W11D[c]	<20	<20	<20	<20	<20	<20	<20
B53W15S[c]	24	47	25	<20	<20	47	29
B53W16S[c]	140	92	140	120	92	140	123
Background							
B53W01S	71	<20	<20	<20	<20	71	33
B53W01D	<20	<20	<20	91	<20	91	38

[a]Sampling locations are shown in Figure 4-4.

[b]No sample data available for third-quarter sampling.

[c]Upgradient well.

[d]<20 - not found above detection limit of 20 μg/L.

[e]Annual averages are conservative, based on assuming a value of 20 μg/L when results were below detection limits.

6.0 GROUNDWATER PROTECTION PROGRAM

6.1 HYDROGEOLOGICAL CHARACTERISTICS

6.1.1 Site Hydrogeology

SLAPS is located within a 38.8-km^2 (15-mi^2) shallow subsurface depression in bedrock known as the Florissant Basin, the site of a glacial lake that was filled with more than 28.8 m (100 ft) of silts, clays, and fine-grained sand. The bedrock underlying these lacustrine deposits at SLAPS is limestone and shales of Pennsylvanian and Mississippian geologic age. Bedrock was only encountered during drilling in some of the deeper wells at SLAPS. Coldwater Creek, which is the main surface water drainage in the basin, borders the west side of SLAPS (BNI 1987a).

Groundwater at the site consists of two systems. The upper groundwater system is represented by an unconfined water table flowing generally from the southeast to the north, northwest, and west. The lower groundwater system is a semiconfined system flowing in the same overall direction as the upper system. The water table in the upper groundwater system occurs in a zone approximately 0.6 to 7.8 m (2 to 25.7 ft) below the ground surface. Wells in this zone are screened in unconsolidated lacustrine materials at depths from 4.2 to 14.6 m (13.8 to 47.8 ft). The potentiometric surface in the lower groundwater system occurs in a zone from 0.4 to 7 m (1.2 to 22.7 ft) below ground surface. Wells in the lower system are screened at depths ranging from 12.0 to 28.2 m (39.3 to 92.5 ft).

6.1.2 Groundwater Quality and Usage

A well canvass of the combined HISS and SLAPS areas conducted in 1987 and 1988 yielded records for eight offsite wells. Four of these wells are or were used to obtain water for irrigation, two were used for domestic purposes, and one is used for industrial

purposes. No information is available on water usage for the last well. There are no known wells that are currently used for drinking water or for public water supply; water needs in the area are usually met by treated Mississippi River water (BNI 1989b).

6.2 GROUNDWATER MONITORING

6.2.1 Methods

The hydrogeological interpretations presented here are based on groundwater levels measured in 37 monitoring wells during 1990 (Figure 6-1). Groundwater levels are measured at weekly intervals using an electric downhole probe water level indicator.

Groundwater monitoring wells were installed at SLAPS in several phases. A set of six monitoring wells was installed at the site by Roy F. Weston, Inc., in 1981 before the environmental monitoring program began (Roy F. Weston, Inc. 1982). Wells installed at SLAPS by Bechtel National, Inc. (BNI) in mid-1986 and at the adjacent ball fields in 1988 supplied the hydrogeological data used in this report. A summary of well construction information for wells monitored in 1990 is given in Table 6-1. An example of well construction details is included in Appendix E. Further background information on site geology, hydrogeology, and well construction can be found in reports by BNI (1987b, 1989b) and Roy F. Weston, Inc. (1982).

Water level measurements from monitoring wells are used to prepare two types of graphic exhibits (hydrographs and potentiometric surface maps) that show hydrogeological conditions at the site. Hydrographs are line graphs that display changes in water levels for each monitoring well throughout the year (Appendix E). The SLAPS hydrographs also include bar graphs of U.S. Weather Service precipitation records for the St. Louis area as an aid in evaluating the influence of precipitation on water level behavior.

The amount of slope (gradient) and flow direction of the SLAPS groundwater systems are determined from potentiometric surface (water level) maps. These maps are prepared by plotting water

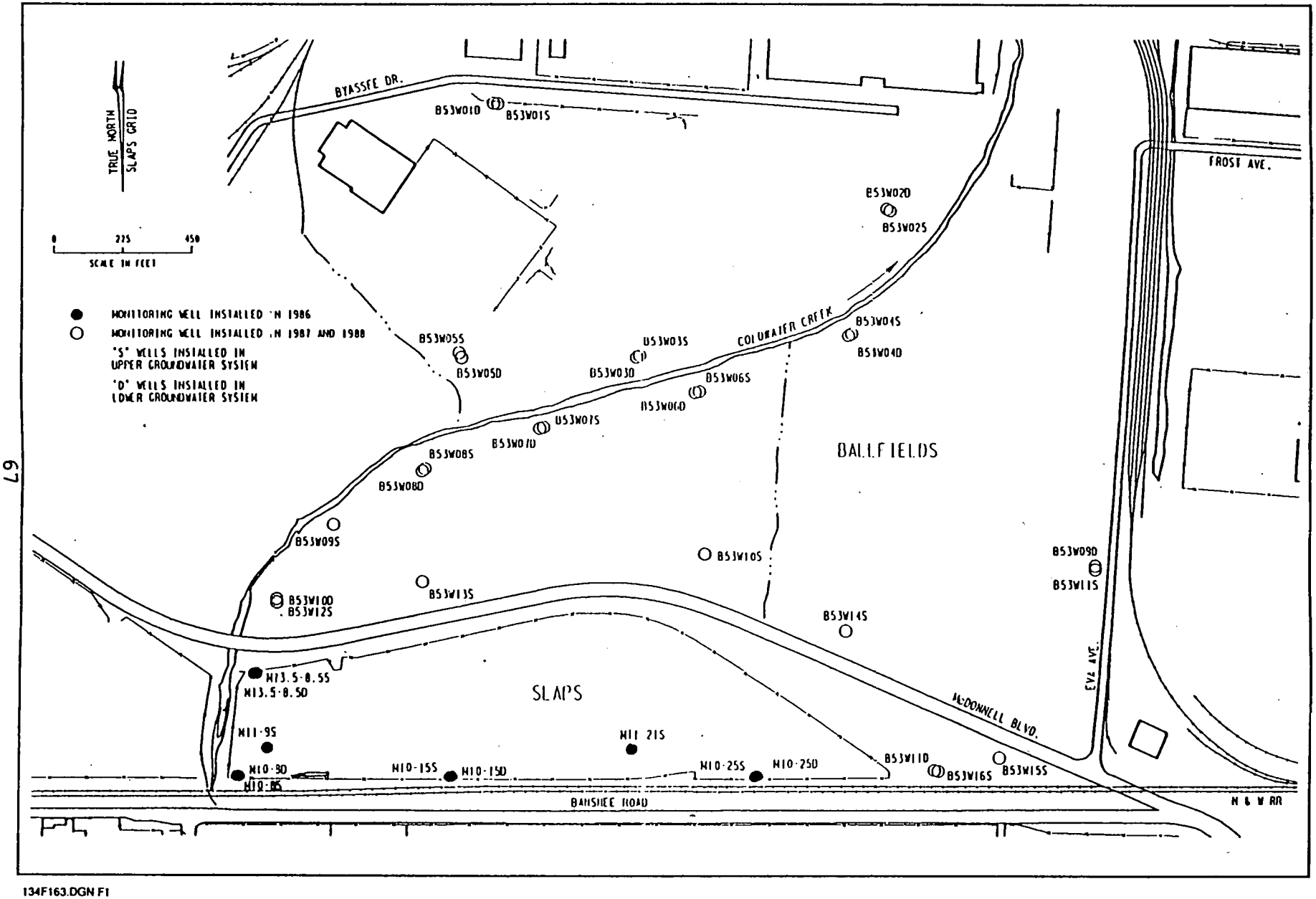

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Figure 6-1
Wells Used for Water Level Measurements in the SLAPS Area in 1990

TABLE 6-1

CONSTRUCTION SUMMARY FOR WELLS MONITORED IN 1990

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
B53W02D	Nov. 1987	25 (81.9)	21.4-24.4 (70.1-80.1)	Stainless Steel
B53W02S	Nov. 1987	6.7 (22.0)	4.6-6.1 (15.1-20.1)	Stainless Steel
B53W03D	Nov. 1987	22.2 (73.0)	18.5-21.5 (60.5-70.5)	Stainless Steel
B53W03S	Nov. 1987	7.2 (23.5)	4.8-6.3 (15.6-20.6)	Stainless Steel
B53W04D	Jan. 1988	24.7 (81.0)	20.7-23.7 (67.8-77.8)	Stainless Steel
B53W04S	Jan. 1988	14.9 (49.0)	13.1-14.6 (42.8-47.8)	Stainless Steel
B53W05D	Nov. 1987	25.5 (83.5)	21.5-24.6 (70.6-80.6)	Stainless Steel
B53W05S	Nov. 1987	8.7 (28.5)	6.9-8.4 (22.5-27.5)	Stainless Steel
B53W06D	Jan. 1988	23.6 (77.4)	18.4-21.4 (60.3-70.3)	Stainless Steel
B53W06S	Jan. 1988	11.3 (37.0)	9.2-10.8 (30.3-35.3)	Stainless Steel
B53W07D	Jan. 1988	27.1 (89.0)	23.2-26.2 (76.0-86.0)	Stainless Steel
B53W07S	Jan. 1988	10.7 (35.0)	8.8-10.3 (28.9-33.9)	Stainless Steel
B53W08D	Jan. 1988	28.0 (91.7)	24.7-27.7 (80.9-90.9)	Stainless Steel
B53W08S	Jan. 1988	11.4 (37.5)	9.5-11.1 (31.3-36.3)	Stainless Steel
B53W09D	Feb. 1988	22.7 (74.5)	18.6-21.7 (61.1-71.1)	Stainless Steel
B53W09S	Jan. 1988	10.7 (35.0)	8.8-10.3 (28.9-33.9)	Stainless Steel
B53W10S	Jan. 1988	14.9 (49.0)	12.5-14.0 (40.9-45.9)	Stainless Steel
B53W11S	March 1988	7.3 (24.0)	4.8-6.4 (15.9-20.9)	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

TABLE 6-1
(continued)

Well Number[a]	Completion Date	Total Depth [m (ft)]	Screened Interval Below Ground [m-m (ft-ft)]	Construction Material
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
B53W01D[e]	Nov. 1987	28.5 (93.5)	25.2-28.2 (82.5-92.5)	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
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. Locations are shown in Figure 4-4.

[c]PVC - polyvinyl chloride.

[d]Well installed in upper groundwater system.

[e]Well used to represent background conditions.

Note: Water level elevations for wells monitored in 1990 are shown as hydrographs in Appendix E.

level measurements for selected dates (representing winter and late summer) on a base map and contouring the values.

6.2.2 Results and Conclusions

All the hydrographs prepared for water levels measured in 1990 are shown in Appendix E. The wells at SLAPS have been placed into two groups to allow separate discussion of the upper and lower groundwater systems.

Upper groundwater system

Hydrographs from the upper groundwater system show slight seasonal fluctuations in groundwater levels. Groundwater levels were highest during the spring, and then slowly fell to their lowest levels in the fall. This repeated the seasonal fluctuations seen in 1988 and 1989 (BNI 1989b, 1990). The water level changes for each well appear to be related to those of other wells and also to precipitation events. This indicates that many of the wells are experiencing rapid recharge from precipitation. As reported for 1988 and 1989 (BNI 1989b, 1990), the upper system water levels decreased in the winter but the lower system wells remained stable.

The slope and flow direction of the upper groundwater system were determined from potentiometric surface maps (Figures 6-2 and 6-3). The dates plotted are representative of winter and late summer. Water levels for B53W04S were not plotted on either map because the data could not be validated. The general flow pattern is toward Coldwater Creek; however, flow into a small tributary to Coldwater Creek in the ball field area is also apparent. Wells B53W16S, B53W15S, and M10-25S generally have the highest water levels (elevation above mean sea level); wells closer to Coldwater Creek have lower water levels. Water levels in wells north of the creek are typically 1.44 to 2.88 m (5 to 10 ft) lower than water levels in wells south of the creek, which reflects the lower land surface elevations on the north side of the stream. The slope for all potentiometric surfaces was calculated using the northwest flow direction.

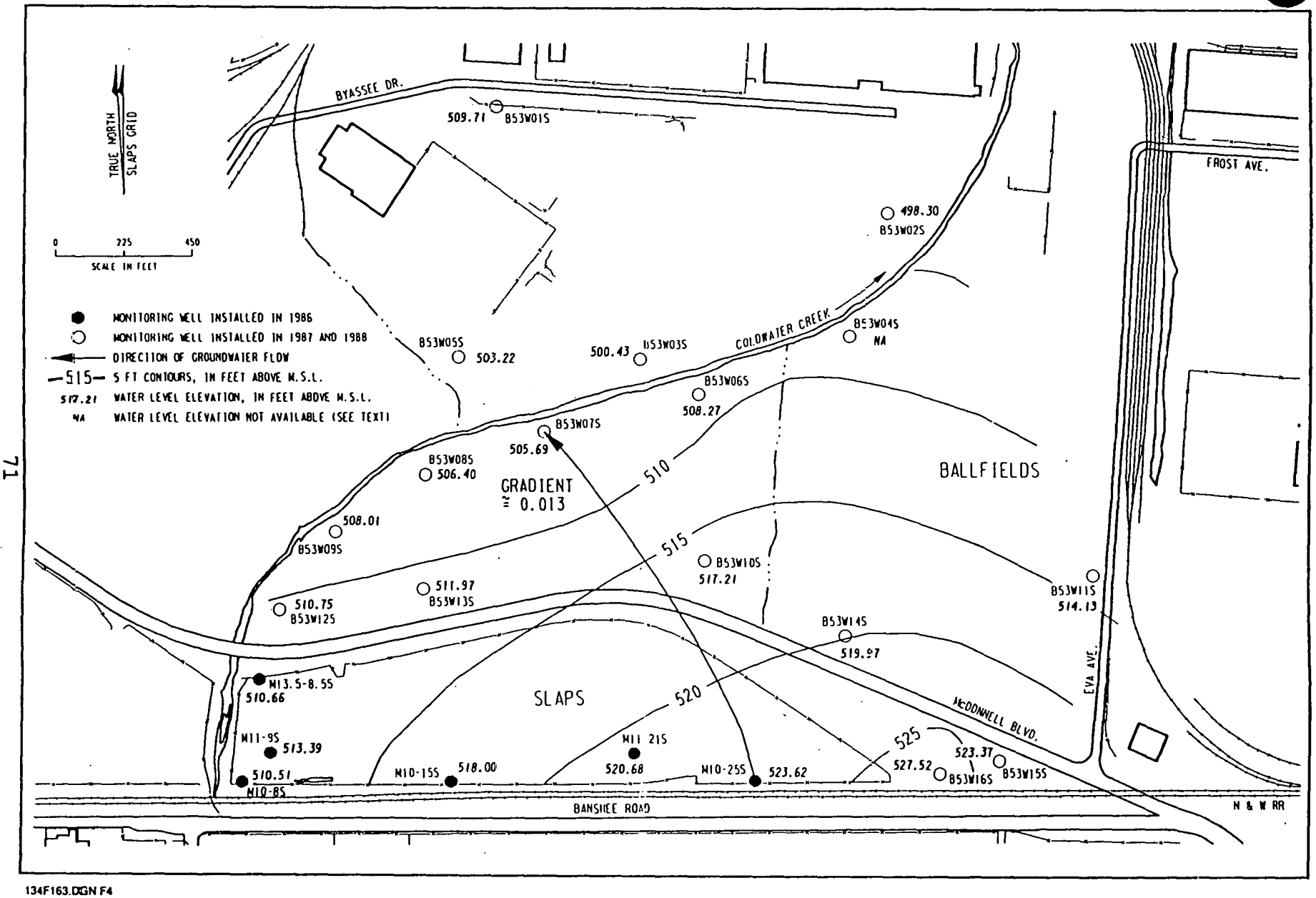

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Figure 6-2
Potentiometric Map of Upper Groundwater System (1/19/90)

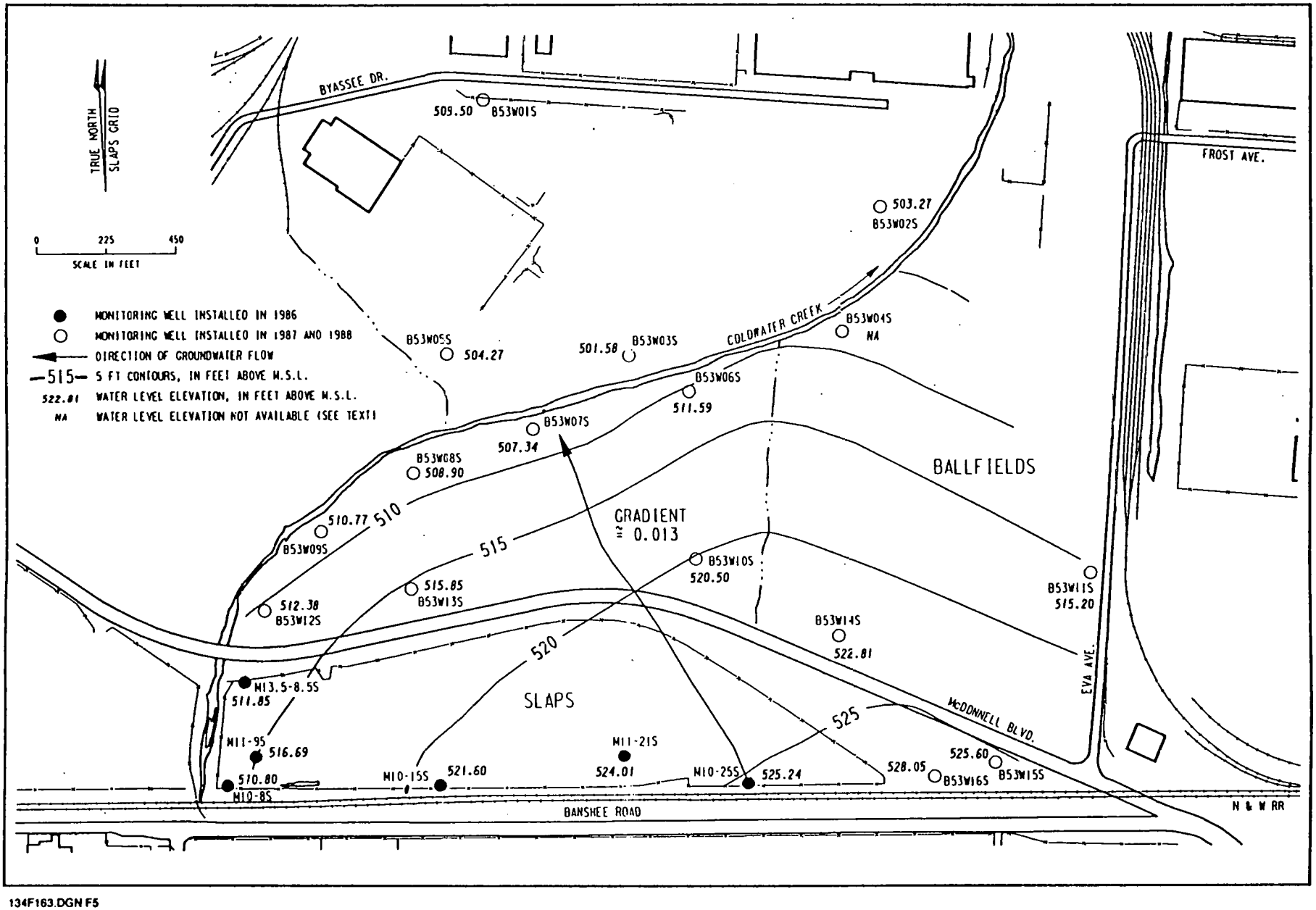

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Figure 6-3
Potentiometric Map of Upper Groundwater System (8/24/90)

The flow direction was to the west and northwest in 1989 (BNI 1990) and to the west in 1988 (BNI 1989b). The 1990 gradients were 0.013 for both winter and late summer. The similar flow direction and gradient for each season reveals that the slight variations from spring to fall shown on the hydrographs do not affect the slope of the potentiometric surface or the direction of groundwater flow (Figures 6-2 and 6-3).

Lower groundwater system

Unlike those for the upper groundwater system, hydrographs for the lower groundwater system show little seasonal variation in groundwater levels. Similar to 1989, water levels in the wells of the lower system were relatively constant (BNI 1990). Comparison of water levels with precipitation events shown on the hydrographs reveals that there is no apparent relationship between the two; however, changes in water levels in each well are consistently similar to changes in the other wells.

The slope and flow direction of the SLAPS lower groundwater system were determined from potentiometric surface maps (Figures 6-4 and 6-5). The dates plotted were representative of winter and late summer. Water levels for B53W04D were not plotted on either map because the data could not be validated. The general flow pattern appears to be unrelated to surface features at the site; however, the apparent high area at the east end of the site may be the result of a discontinuity in the semiconfining layer above the lower groundwater system near well M10-25 (BNI 1989b). This would allow water from the upper groundwater system to drain into the lower groundwater system. Flow gradients for 1990 were calculated using the north and west flow directions. The slope for all potentiometric surfaces was calculated using the westward flow direction in 1988 and 1989 (BNI 1989a, BNI 1990). The 1990 gradients for flow to the west and northwest were 0.005 in the winter and 0.007 in the late summer. The 1990 gradient for flow to the north was 0.009 in winter (Figure 6-4) and 0.011 in late summer (Figure 6-5).

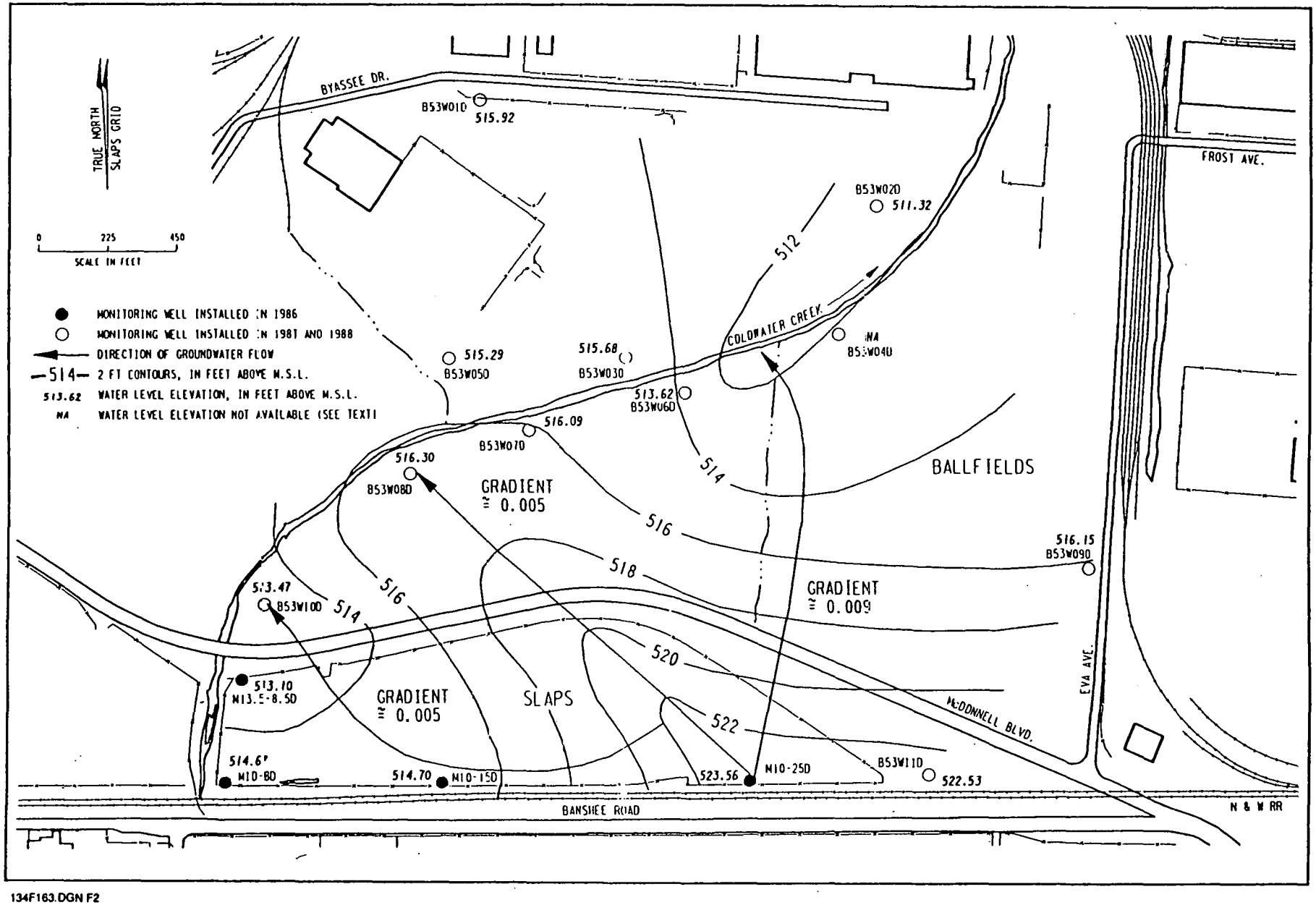

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Figure 6-4
Potentiometric Map of Lower Groundwater System (1/19/90)

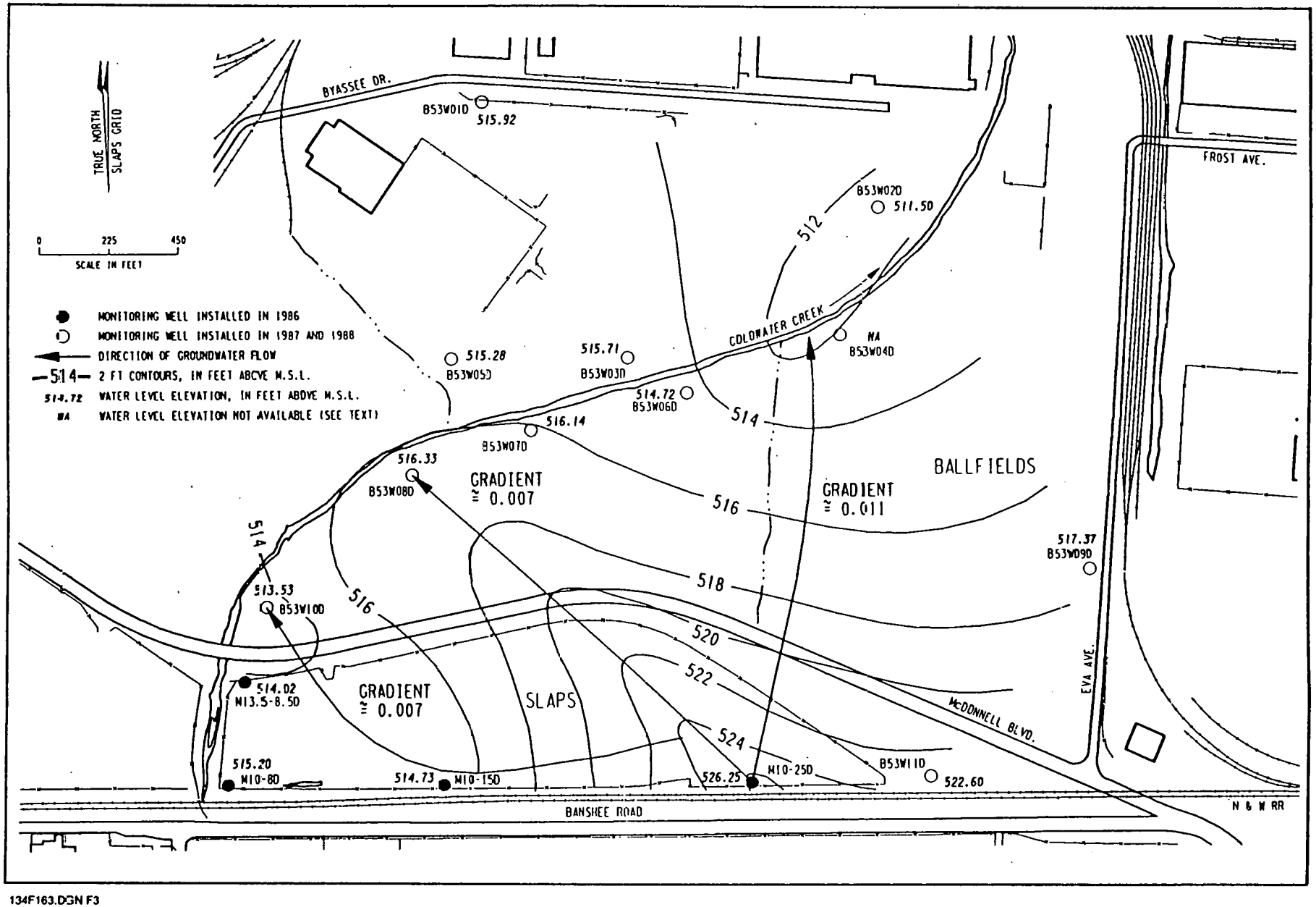

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Figure 6-5
Potentiometric Map of Lower Groundwater System (8/3/90)

7.0 QUALITY ASSURANCE

A comprehensive quality assurance (QA) program involving sampling, data management, and analysis is maintained to ensure that the data reported are 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 are ensured through the following:

- Samples at all locations are collected using established procedures as outlined in the FUSRAP Integrated Environmental Monitoring Instruction Guide, 191-00-IG-003

- The sampling program design provides for trip blanks, matrix spike and spike duplicates, field blanks (daily), and quality control (QC) duplicate sampling (minimum of 1 in 20)

- Chain-of-custody procedures are performed to maintain traceability of samples and corresponding analytical results

Data management QA is 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 and concurrence on calculations
  - By the originator
  - By an independent, equally qualified second party

- Report preparation and presentations

System QA audits are conducted by BNI FUSRAP project QA personnel to verify adherence to 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 are performed under subcontract by Thermo Analytical/Eberline (TMA/E), Albuquerque, New Mexico. This laboratory participates in the collaborative testing and interlaboratory comparison program with EPA at Las Vegas, Nevada. In this program, samples of various environmental media (water, milk, air filters, and soil) containing one or more radionuclides in known amounts are prepared and distributed to participating laboratories. After analysis, results are forwarded to EPA for comparison with known values and with the results from other laboratories. This program enables the laboratory to regularly evaluate the accuracy of its analyses and take corrective action, if needed. Table 7-1 summarizes results of the comparison studies for water samples. TMA/E also participates in the DOE Environmental Measurements Laboratory interlaboratory quality assessment program. This program consists of receiving and analyzing environmental samples (air filters, water, and soil) on a quarterly basis for specific radiochemical analyses (Table 7-2).

Interlaboratory comparison of the TETLD results is provided by participation in the International Environmental Dosimeter Project sponsored jointly by DOE, EPA, and the Nuclear Regulatory Commission.

Chemical analyses are performed under subcontract by Weston Analytical Laboratory, Lionsville, Pennsylvania. Weston's standard

TABLE 7-1

SUMMARY COMPARISON OF WATER SAMPLE RESULTS[a,b]

(EPA and TMA/E)

Analysis and Sample Date	Value (pCi/L)[c] EPA	Value (pCi/L)[c] TMA/E	Ratio (TMA/E:EPA)[d]
Alpha			
1/90	12.0 ± 5.0	9.33 ± 1.5	0.78
4/90	90 ± 12.0	96 ± 12	1.07
5/90	22.0 ± 6.0	26.3 ± 2.3	1.20
9/90	10.0 ± 5.0	11.0 ± 1.0	1.10
Beta			
1/90	12.0 ± 5.0	11.7 ± 2.1	0.98
4/90	52.0 ± 5.0	46.0 ± 6.0	0.88
5/90	15.0 ± 5.0	15.0 ± 1.0	1.0
9/90	10.0 ± 5.0	11.0 ± 1.0	1.10
Ra-226			
3/90	4.9 ± 0.7	6.1 ± 0.4	1.24
4/90	5.0 ± 0.8	2.8 ± 0.1	0.56
7/90	12.1 ± 1.8	10.1 ± 0.1	0.84
9/90	12.1 ± 1.8	10.1 ± 0.1	0.84
U (Natural)			
3/90	4.0 ± 6.0	4.0 ± 0.0	1.0
4/90	20.0 ± 6.0	18.7 ± 1.5	0.94
7/90	20.8 ± 3.0	19.8 ± 1.1	0.95

[a]Results from U.S. EPA Interlaboratory Comparison Program.

[b]Samples were for comparison only and not site-specific.

[c]1 pCi/L is equivalent to 0.037 Bq/L.

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

TABLE 7-2

SUMMARY COMPARISON OF AIR, SOIL, AND WATER SAMPLE RESULTS[a,b]

(EML and TMA/E)

Sample Type	Analysis (09/07/90)	Value		Ratio (TMA/E:EML)[c]
		EML	TMA/E	
Air (Bq/fil)	U-234	0.013	0.022 ± 0.012	1.69
Air (Bq/fil)	U-238	0.013	0.021 ± 0.012	1.62
Soil (Bq/kg)	U-234	28.3	23.9 ± 1.1	0.85
Soil (Bq/kg)	U-238	27.3	23.4 ± 1.0	0.86
Water (Bq/L)	U-234	0.236	0.232 ± 0.019	0.98
Water (Bq/L)	U-238	0.244	0.250 ± 0.041	1.03

[a]Results from Environmental Measurements Laboratory interlaboratory quality assessment program.

[b]Samples were for comparison only and not site-specific.

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

practices manual has been reviewed and accepted by BNI. Weston maintains an internal QA program, and is audited by BNI FUSRAP personnel on a semiannual basis. The internal QA program involves the following for inorganic chemical analyses:

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

For organic chemical analyses the QA program involves:

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

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

Weston's QA program also includes an independent overview by its project QA coordinator.

REFERENCES

Bechtel National, Inc. (BNI), 1987a. St. Louis Airport Site Annual Site Environmental Report - Calendar Year 1986, DOE/OR/20722-145, Oak Ridge, Tenn. (March).

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

BNI, 1988. St. Louis Airport Site Annual Site Environmental Report - Calendar Year 1987, DOE/OR/20722-199, Oak Ridge, Tenn. (April).

BNI, 1989a. St. Louis Airport Site Annual Site Environmental Report - Calendar Year 1988, DOE/OR/20722-220, Oak Ridge, Tenn. (April).

BNI, 1989b. Preliminary Geological, Hydrogeological, and Chemical Characterization Report for the Ball Field Area - Hazelwood and Berkeley, Missouri, DOE/OR/20722-211, Oak Ridge, Tenn. (February).

BNI, 1990. St. Louis Airport Site Environmental Report for Calendar Year 1989, DOE/OR/20722-262, Oak Ridge, Tenn. (May).

BNI, 1991. Memorandum, E. M. McNamee to C. M. Sekula, "Climatological Data for 1990 for the St. Louis Area," BNI CCN 076489 (April 3).

Cember, H., 1983. Introduction to Health Physics. Oxford: Pergamon Press.

Department of Energy (DOE), 1988. Order 5820.2A, "Radioactive Waste Management" (September 26).

DOE, 1989. Order 5400.1, "General Environmental Protection Program" (January 9).

DOE, 1990a. Memorandum, James Wagoner II (Decontamination and Decommissioning Division) to William Seay (Technical Services Division), "Clean Air Act Regulatory Requirements Applicable to FUSRAP," BNI CCN 067256 (March 22).

DOE, 1990b. Formerly Utilized Sites Remedial Action Program Environmental Compliance Assessment for the St. Louis Airport Site, St. Louis, Missouri, Oak Ridge, Tenn. (March 23).

DOE, 1990c. Order 5400.5, "Radiation Protection of the Public and the Environment" (February 5).

Department of Health, Education, and Welfare (HEW), 1970. Radiological Health Handbook, Rockville, Md. (January).

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

Environmental Protection Agency (EPA), Region VII, 1990. "Federal Facility Agreement for DOE St. Louis and Hazelwood Sites, Missouri," Docket No. VII-90-F-0005 (June 26).

Roy F. Weston, Inc., 1982. 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, West Chester, Pa. (January).

APPENDIX A
METHODOLOGY FOR STATISTICAL ANALYSIS OF DATA

METHODOLOGY FOR STATISTICAL ANALYSIS OF DATA

Average annual concentrations are calculated by averaging the results of all four quarters of sampling. When possible, sampling results are compiled in computer spreadsheets and the minimum, maximum, and average values are calculated for all quarters of data.

Minimums and maximums are derived by comparing sampling results and determining the lowest and highest for the year. An example is given below.

Thorium-230 Results (pCi/L)

Sampling Location	Quarter				Minimum Value	Maximum Value
	1	2	3	4		
1	13	7	12	5	5	13

Because 5 pCi/L is less than any other result, it is entered into the minimum value column; 13 pCi/L, the greatest result reported, is entered into the maximum value column.

Average annual concentrations are calculated by adding the results for the year and dividing by the number of quarters for which data have been taken and reported (usually four). An example is given below.

First, results reported for the year are added.

$$13 + 7 + 12 + 5 = 37$$

Next, the sum of all results is divided by the number of quarters for which data were taken and reported. In this example there were data for all four quarters.

$$37 \div 4 = 9.25$$

Because there are two single-digit numbers (5 and 7), the result is rounded to 9 (number of significant figures is 1). This value is entered into the average value column.

Thorium-230 Results (pCi/L)

Sampling Location	Quarter 1	2	3	4	Average Value
1	13	7	12	5	9

Expected concentration ranges are calculated to provide a basis for trend analysis of the data. These expected ranges are calculated by taking the average of the annual average concentrations for the past five years (when possible) and calculating a standard deviation for these data. The lower expected range is calculated by subtracting two standard deviations from the average value, and the upper range is calculated by adding two standard deviations to the average values. An example of these calculations is shown below.

Thorium-230 Results (pCi/L)

Sampling Location	Year 1986	1987	1988	1989	1990	Average Value	Standard Deviation
1	10	5	14	8	5	8	4

The formula for calculation of the standard deviation of a sample xi, ..., xn is:

$$S = \sqrt{S^2} = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n - 1}}$$

Where S = Standard deviation

x_i = Individual values

$\bar{x}$ = Average of values

n = Number of values

n	x_i	$\bar{x}$	$(x_i - \bar{x})$	$(x_i - \bar{x})^2$
1	10	8.4	1.6	2.6
2	5	8.4	-3.4	11.56
3	14	8.4	5.6	31.36
4	8	8.4	-0.4	0.16
5	5	8.4	-3.4	11.56

$$\sum (X_i - \bar{x})^2 = 57.24$$

$$S = \sqrt{\frac{57.24}{5 - 1}} = \sqrt{\frac{57.24}{4}} = \sqrt{14.31} = 3.78,$$

which rounds to 4 because there is only one significant figure.

The calculation for the expected ranges for this example is shown below.

Lower expected range: $8 - 2(4) = 0$
Upper expected range: $8 + 2(4) = 20$ (rounded to one significant figure)

Annual average values for the current year are compared with these ranges to indicate a possible anomaly or trend. If a discernible trend is found from this comparison, the data are presented in the appropriate section of the report.

APPENDIX B

POPULATION EXPOSURE METHODOLOGY

POPULATION EXPOSURE METHODOLOGY

DOSE CALCULATION METHODOLOGY

DOE Order 5400.5 requires that the impacts of the site on both the hypothetical maximally exposed individual and the population within 80 km (50 mi) of the site be evaluated. For radioactive materials, this evaluation is usually conducted by calculating the dose received by a hypothetical maximally exposed individual and the general population and comparing this dose with DOE guidelines. This appendix describes the methodology used to calculate the doses given in Subsection 4.2.

PATHWAYS

The purpose of the dose calculation is to identify the potential routes or pathways that are available to transmit either radioactive material or ionizing radiation to the receptor. In general, the pathways are (1) direct exposure to gamma radiation, (2) atmospheric transport of radioactive material, (3) transport of radioactive material via surface water or groundwater, (4) bioaccumulation of radioactive materials in animals used as a food source, and (5) uptake of radioactive materials into plants used as a food source. For FUSRAP sites, the primary pathways are direct gamma radiation and transport of radioactive materials by the atmosphere, groundwater, and surface water. The others are not considered primary pathways because FUSRAP sites are not located in areas where significant sources of livestock are raised or foodstuffs are grown.

Gamma rays can travel until they expend all their energy in molecular or atomic interactions. In general, these distances are not very great and the exposure pathway would affect only the maximally exposed individual.

Contamination transported via the atmospheric pathway takes the form of contaminated particulates or dust and can provide a

potential dose only when it is inhaled. Doses from radon are intentionally excluded; radon exposure is controlled through compliance with boundary concentration requirements.

Contamination is transported in surface water when runoff from a rainfall event or some other source of overland flow carries contamination from the site to the surface water system. This contamination only poses an exposure problem when the surface water is used to provide potable water or to water livestock and/or to irrigate crops. Contamination is transported via groundwater when contaminants migrate into the groundwater system and there is a potential receptor.

Primary Radionuclides of Concern

The primary radionuclides of concern for these calculations are uranium-238, uranium-235, uranium-234, thorium-230, and radium-226 and their daughter products (excluding radon). For several of the dose conversion factors used in these calculations, the contribution of the daughters with half-lives less than one year are included with the parent radionuclide. Table B-1 lists the pertinent radionuclides, their half-lives, and dose conversion factors for ingestion.

DOSE CALCULATION METHOD

Direct Exposure

As previously indicated, direct exposure is only important in calculating the dose to the hypothetical maximally exposed individual. The dose from direct gamma exposure is determined by using data collected through the TETLD program (described in Section 4.0). These data provide a measure of the amount and energy (in units of mR/yr) of the ionizing radiation at 1.6 m (5 ft) above the ground. For the purposes of this report, it is assumed that the maximally exposed individual works 40 hours per week across McDonnell Boulevard from SLAPS (there are no houses near the site).

The dose to the maximally exposed individual can be determined by assuming that the individual is exposed to a line source located along the fenceline. Because the average exposure rate is known from the TETLD for a distance of 1.6 m (5 ft) from the fenceline, program, the exposure at 50 m (150 ft) from the fenceline can be calculated by using the following equation (Cember 1983).

$$Exposure\ at\ 50\ m = (Exposure\ at\ 1.6\ m)\ x\ \frac{h_1}{h_2}\ x\ \frac{\tan^{-1}\ (L/h_2)}{\tan^{-1}\ (L/h_1)}$$

Where h_1 = TETLD distance from the fenceline [1.6 m (5 ft)]
h_2 = Distance to maximally exposed individual [50 m (150 ft)]
L = Half of the length of the site toward McDonnell Boulevard (500 m (1,500 ft)

The exposure rate at 1.6 m (5 ft) can be calculated by taking the average of the four detectors along this portion of the fenceline (1, 2, 3, and 9). The average exposure rate for these detectors was 556 mR/yr. Using the formula above, the exposure rate at 50 m (150 ft) is approximately 17 mR/yr. Because 1 mR/yr is approximately equal to 1 mrem/yr, the resulting dose would be 17 mrem/yr, assuming 24-h continuous residence. However, this is the dose for the entire year; to calculate the dose to a worker (8 h/day), the following equation must be used:

$$Dose = (Dose\ at\ 50\ m)\ x\ \frac{(40\ h/wk)}{(7\ days/wk\ x\ 24\ h/day)} = 4\ mrem/yr$$

Therefore, the dose from direct gamma radiation to the hypothetical maximally exposed individual is 4 mrem/yr.

This exposure scenario should provide a very conservative estimate of the dose from direct gamma exposure to the hypothetical maximally exposed individual.

TABLE B-1

RADIONUCLIDES OF INTEREST

Radionuclide	Half-life[a]	Dose Conversion Factor[b] for Ingestion (mrem/pCi)
Uranium-238	4.51E+9 years	2.5E-4
Thorium-234	24.1 days	--[c]
Protactinium-234 m	1.17 minutes	--[c]
Protactinium-234	6.75 hours	--[c]
Uranium-234	4.47E+5 years	2.6E-4
Thorium-230	8.0E+4 years	5.3E-4
Radium-226	1602 years	1.1E-3
Uranium-235	7.1E+8 years	2.5E-4
Thorium-231	25.5 hours	--[d]
Protactinium-231	3.25E+4 years	1.1E-2
Actinium-227	21.6 years	1.5E-2
Thorium-227	18.2 days	--[e]
Radium-223	11.43 days	--[e]

[a]Source: Radiological Health Handbook (HEW 1970).

[b]Source: Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation Submersion (EPA-520/1-88-020) and International Dose Conversion Factors for Calculation of Dose to the Public (DOE/EH-0071).

[c]Included in the uranium-238 dose conversion factor.

[d]Included in the uranium-235 dose conversion factor.

[e]Included in the actinium-227 dose conversion factor.

Surface Water

Exposures from contaminants in surface water are important in calculating the dose to both the hypothetical maximally exposed individual and the nearby population. The data used to support the surface water dose calculation consist of measurements of concentrations of contaminants in surface water at the site and of the amount of dilution provided by tributaries or rivers between the site and the intake. Thus, the dose to the maximally exposed individual can be calculated by the following:

$$D_s = \sum_{i=1}^{N} Ci \times (Fs \div Fi) \times Ua \times DCFi$$

Where D_s = Committed effective dose from surface water

Ci = Concentration of the i^{th} radionuclide in surface water at the site

Fs = Average annual flow of surface water at the site

Fi = Average flow of surface water at the intake

Ua = Annual consumption of liquid (approx. 730 L/yr)

DCFi = Dose conversion factor for the i^{th} radionuclide (Table B-1)

To determine the dose to the population, the same equation would be used and the dose would be multiplied by the population group served by the drinking water supply. It is important to note that for the population dose, the intake point is probably not the same as that for the maximally exposed individual.

The approach outlined above should provide a very conservative dose calculation for the surface water pathway because it does not account for radionuclides settling out or for any municipal water treatment.

Groundwater

Exposures from contaminants in groundwater are important in calculating the dose to both the hypothetical maximally exposed individual and the nearby population. The data used to support the groundwater dose calculations consist of measurements of the concentration of the contaminants in groundwater and an estimate of the dilution that occurs between the measurement location and the intake point. The dose for the maximally exposed individual can be calculated by using the following equation:

$$Dgw = \sum_{i=1}^{N} (Ci) \times (D) \times (Ua) \times (DCFi)$$

Where Dgw = Committed effective dose from groundwater
Ci = Concentration of the i^{th} radionuclide in groundwater at the site
D = Estimated dilution factor
Ua = Annual consumption of water (approx. 730 L/yr)
DCFi = Dose conversion factor for the i^{th} radionuclide (Table B-1)

To determine the dose to the population, the same equation would be used and the dose would be multiplied by the population group served by the drinking water supply. It is important to note that the population intake point is usually different from that of the maximally exposed individual.

The approach given above should provide a conservative dose calculation for the groundwater pathway because it does not account for any water treatment.

Atmospheric

The dose to the hypothetical maximally exposed individual from particulate radionuclides transported via the atmospheric pathway is calculated using EPA's computer model AIRDOS, PC mode. Doses to the general public via this pathway are also calculated using AIRDOS. The model provides effective dose equivalents for different distances from the site; these doses are then multiplied by the population between the distance category for this dose and the next.

The release of particulates was calculated using a model for wind erosion because there were no other mechanisms for releasing particulates from the site. The wind erosion model used was taken from the DOE "Remedial Action Priority System Mathematical Formulation." The input into the model consisted of site-specific average soil concentrations, local meteorological data (Section 1.0), and areas of contamination.

The site was modeled as two areas: the interim storage piles and the remainder of the site. Assumptions used in the calculation model were (1) an assumed particle size of 0.05 mm, (2) the pile cover is modeled as the contamination being 99 percent covered by vegetation, and (3) the site had very few mechanical disturbances per month.

APPENDIX C
ENVIRONMENTAL STANDARDS

ENVIRONMENTAL STANDARDS

The DOE long-term radiation protection standard of 100 mrem/yr in excess of background level includes exposure from all pathways except medical treatments and exposures from radon (DOE 1990c). Evaluation of exposure pathways and resulting dose calculations are based on assumptions such as the use of occupancy factors in determining dose due to 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 results in calculated doses that more accurately reflect the exposure potential from site activities.

DERIVED CONCENTRATION GUIDELINES

As referenced in Section 2.0, DOE orders provide the standards for radionuclide emissions from DOE facilities. DOE Order 5400.5, "Radiation Protection of the Public and the Environment," provides the procedures and requirements for radionuclide releases.

Applicable standards are found in Chapter III of DOE Order 5400.5 and are set as derived concentration guidelines (DCGs). A DCG is defined as the concentration of a single radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (e.g., ingestion of water, inhalation), would result in an effective dose equivalent of 100 mrem. The following table provides reference values for conducting radiological environmental protection programs at operational DOE facilities and sites.

Radionuclide	F1 Value[a]	Ingested Water DCG (μCi/ml)[b]	Inhaled Air DCGs[c]		
			D	W	Y
Radium-226	2E-1	1E-7	--	1E-12	--
Thorium-230	2E-4	3E-7	--	4E-14	5E-14
" 232	2E-4	5E-8	--	7E-15	1E-14
Uranium-234	2E-3	5E-6	--	--	9E-14
" 235	2E-3	5E-6	--	--	1E-13
" 238	2E-3	6E-6	--	--	1E-13
Radon-222[d]	3E-9	3E-9	--	--	3E-9
" 220[d]	3E-9	3E-9	--	--	3E-9

[a]F1 is defined as the gastrointestinal tract absorption factor. This measures the uptake fraction of ingestion of a radionuclide into the body.

[b]1E-9 μCi/ml = 0.037 Bq/L.

[c]Inhaled air DCGs are expressed as a function of time. D, W, and Y represent a measure of the time required for contaminants to be removed from the system (D represents 0.5 day; W represents 50 days; and Y represents 500 days).

[d]DOE is reassessing the DCGs for radon. Until review is completed and new values issued, the values given in the chart above will be used for releases from DOE facilities.

SOIL GUIDELINES*

Guidelines established for FUSRAP for residual radioactivity in soil are shown below.

Radionuclide	Soil Concentration (pCi/g) Above Background
Radium-226 Radium-228 Thorium-230 Thorium-232	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer.
Other Radionuclides	Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use.

***Source:** U.S. Department of Energy, "Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Surplus Facilities Management Program Sites," Revision 2, March 1987.

POTENTIAL STATE ARARS

The following Missouri laws and regulations have been identified as potential ARARs for the management of SLAPS. Where differences between state and federal requirements exist, the more restrictive requirements apply.

Potential ARAR	Requirement
Missouri Rules for Radiation Protection, Missouri Code of State Regulations (CSR), Title 19, Department of Health, Division 20, Chapter 10	Contains regulations to protect public health and welfare from the effects of ionizing radiation. Contains requirements for registering nonexempt sources, maximum permissible exposure limits, personnel monitoring and radiation surveys, radiation exposure records and reports, storage of radioactive materials, control of radioactive contamination, and disposal of radioactive wastes.

Missouri Solid Waste Law, Annotated Missouri Statutes (AMS), Title 16, Chapter 260	To protect the public health, safety, and welfare, it is unlawful to deposit any solid waste onto the surface of the ground or into the waters of the state, burn solid wastes, or construct, alter, or operate a solid waste processing or disposal facility or site without a permit.
Missouri Solid Waste Rules, 10 CSR 80, Department of Natural Resources (MoDNR)	Contains requirements for obtaining a solid waste permit (10 CSR 80-2.020 through 2.070) and design and operation of solid waste processing facilities (10 CSR 80-5.010).
Missouri Hazardous Waste Management Law, 16 AMS 260	To provide safe storage, transportation, treatment, and disposal of hazardous wastes; to promote hazardous waste recycling, reuse, or reduction; and to require a permit for construction, alteration, or operation of the hazardous waste treatment, storage, or disposal facility.
Missouri Hazardous Waste Management Rules, 10 CSR 25, MoDNR Hazardous Waste Management Commission	Contains requirements for methods used for identifying hazardous waste (10 CSR 25-4.261); rules applicable to generators of hazardous waste (10 CSR 25-6.262); rules applicable to owners/operators of hazardous waste treatment, storage, and disposal facilities (10 CSR 25-7.264) including interim status standards (10 CSR 25-7.265) and state permit programs (10 CSR 25-7.270); requirements for public participation (10 CSR 25-8.010); requirements for abandoned or uncontrolled hazardous waste disposal sites (10 CSR 25-10.010); hazardous waste fees and taxes (10 CSR 25-12.010); and rules applicable to the management of polychlorinated biphenyl wastes (10 CSR 25-13.010). Text of rules is largely made up of references to federal hazardous waste regulations and are not substantively more restrictive.

Missouri Clean Water Law, 40 AMS 644	State law has intent to protect public health and welfare; protect wildlife, fish, and aquatic life; protect, maintain, and improve water quality for beneficial uses; prevent unpermitted discharges; and control and abate new or existing water pollution.
Missouri Water Pollution Control Regulations, 10 CSR 20, Chapters 1-6, MoDNR Clean Water Commission	Contains requirements for construction and operating permits and includes public participation.
Missouri Water Quality and Effluent Limitations Standards, 10 CSR 20, Chapter 7, MoDNR Clean Water Commission	Contains standards to prevent degradation of surface and groundwater quality including general criteria and specific criteria for classified waters. Prohibits unpermitted discharges to streams.
Missouri Drinking Water Act, AMS 640	State law has intent to maintain a safe quality of water dispensed to the public.
Missouri Drinking Water Regulations, 10 CSR 60, MoDNR Public Drinking Water Program	Contains maximum contaminant levels (MCLs) and monitoring requirements for inorganic chemicals, organic chemicals (including trihalomethane and volatile organic chemicals), turbidity, radionuclides, and secondary contaminants.
Missouri Air Conservation Law, 40 AMS 643	State law has intent to protect air resources and ambient air quality through prevention, abatement, and control of air pollution.
Missouri Air Pollution Control Regulations, 10 CSR 10, MoDNR Air Conservation Commission, Chapters 1-5	Contains requirements for the prevention and restriction of airborne contaminants and includes air quality standards and air pollution control regulations for the St. Louis metropolitan area (Section 5).

Missouri Air Quality Standards, 10 CSR 10, MoDNR Conservation Commission, Chapter 6	Contains ambient air quality pollutant concentration limits and requirements for permitting air pollution sources.

POTENTIAL FEDERAL ARARs

In addition to the federal regulations identified in Section 2.0, the following have been identified as potential ARARs.

Potential ARAR	Requirement
Occupational Safety and Health Administration General Industry Standards, 29 CFR 1910	Health and safety standards are established for hazardous waste operations, including limits for exposure to noise and certain hazardous materials.
Occupational Safety and Health Administration Standards Hazardous Waste Operations and Emergency Response, 29 CFR 1910	General worker protection requirements are established, as are requirements for worker training and the development of an emergency response plan and a safety and health program for employees. Procedures are established for hazardous waste operations, including decontamination of radioactive waste, shipping and transport, and container handling.
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, 40 CFR 192	Contains limited permissible concentrations of radium, thorium, radon, and gamma radiation.
Radiation Protection for Occupational Workers, DOE Order 5480.11	Standards and program requirements are established for worker protection from ionizing radiation, including derived air concentration guides for inhalation and immersion. The basic dose limit of 100 mrem/yr also applies to any member of the public entering a controlled area.

Standards for Protection Against Radiation, 48 FR 20721	The standard for uranium-238 in inhaled air is 3E-12 μCi/ml daily, 1E-12 μCi/ml weekly; the standard for thorium-232 in inhaled air is 4E-15 μCi/ml weekly and 8E-15 μCi/ml yearly; the standard for thorium-230 in inhaled air is 2E-14 μCi/ml yearly; and the standard for radium-226 in inhaled air is 9E-13 μCi/ml weekly.

APPENDIX D

PARAMETERS FOR ANALYSIS

PARAMETERS FOR ANALYSIS AT SLAPS, 1990

Medium	Parameter	Technique
Groundwater	Total uranium	Fluorometric
	Radium-226	Emanation
	Thorium-230	Alpha spectrometry
	Total organic halides (TOX)	Carbonaceous analyzer
	Total organic carbon (TOC)	Coulometric determination
	Specific conductance	Electrometric
	pH	Electrometric
Surface Water	Total uranium	Fluorometric
	Radium-226	Emanation
	Thorium-230	Alpha spectrometry
Sediment	Total uranium	Alpha spectrometry
	Radium-226	Gamma spectrometry
	Thorium-230	Alpha spectrometry
Air	Radon-222	Track-etch
	External gamma radiation	Thermoluminescence

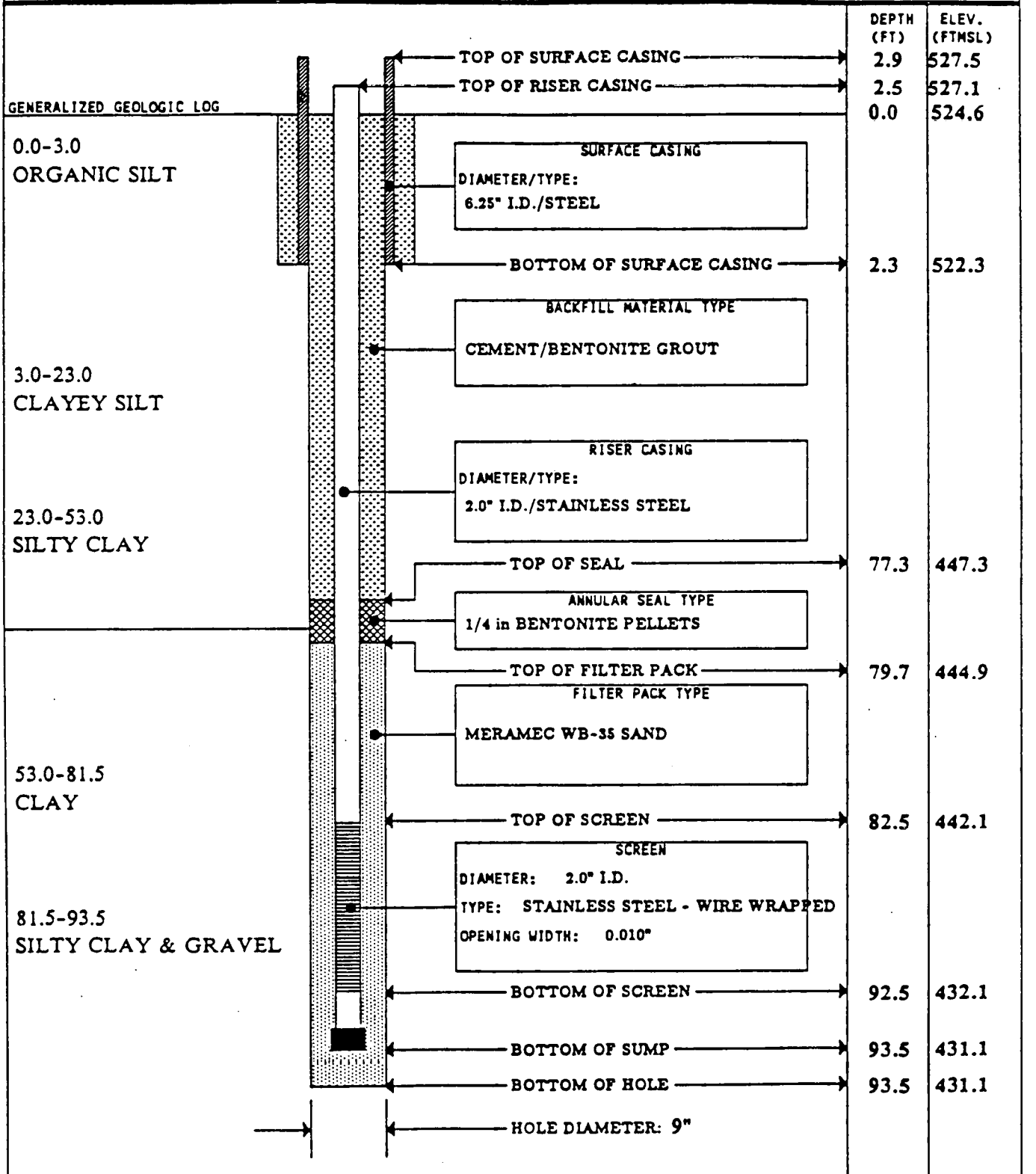
APPENDIX E
SAMPLE OBSERVATION WELL CONSTRUCTION LOGS AND HYDROGRAPHS SHOWING WATER LEVEL ELEVATIONS

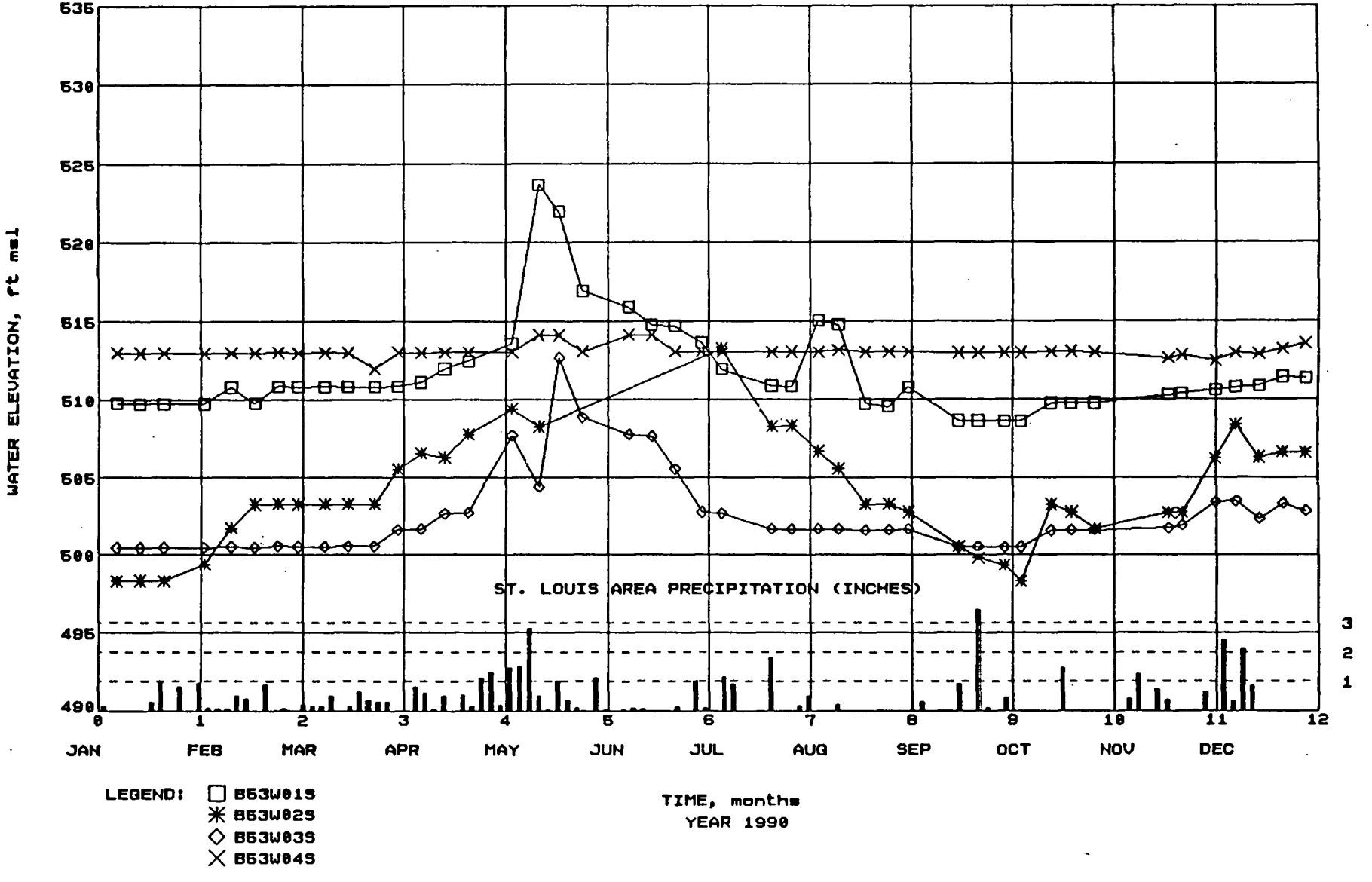
MONITORING WELL

PROJECT	WELL NO.
ST LOUIS AIRPORT SITE	B53W01D

JOB NO.	SITE	COORDINATES
14501	North of Coldwater Creek	N 3198.4 E 1633.8

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
11-18-87	11-19-87	R.C. KISER	TOP OF 2" DIAM. SS RISER

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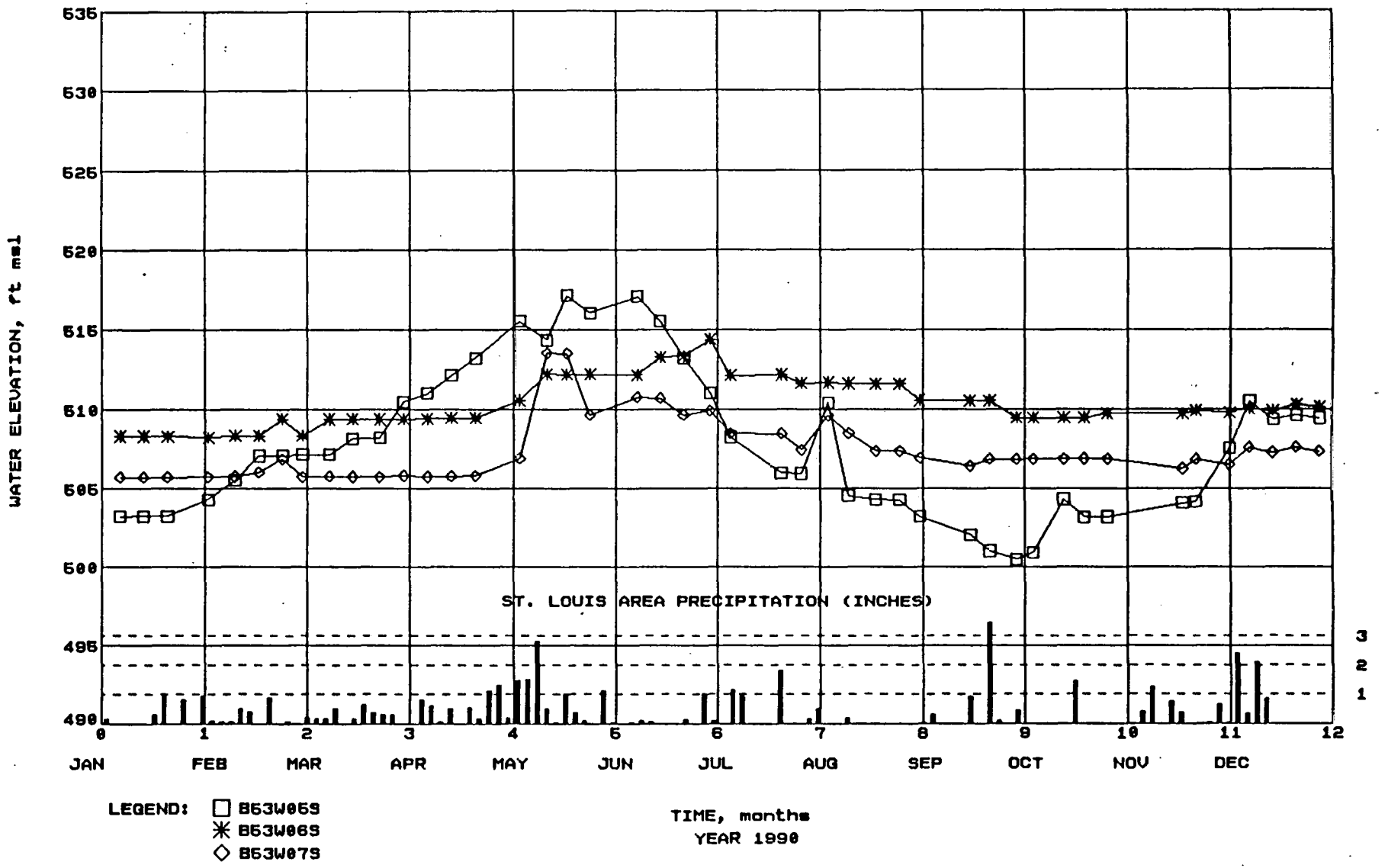
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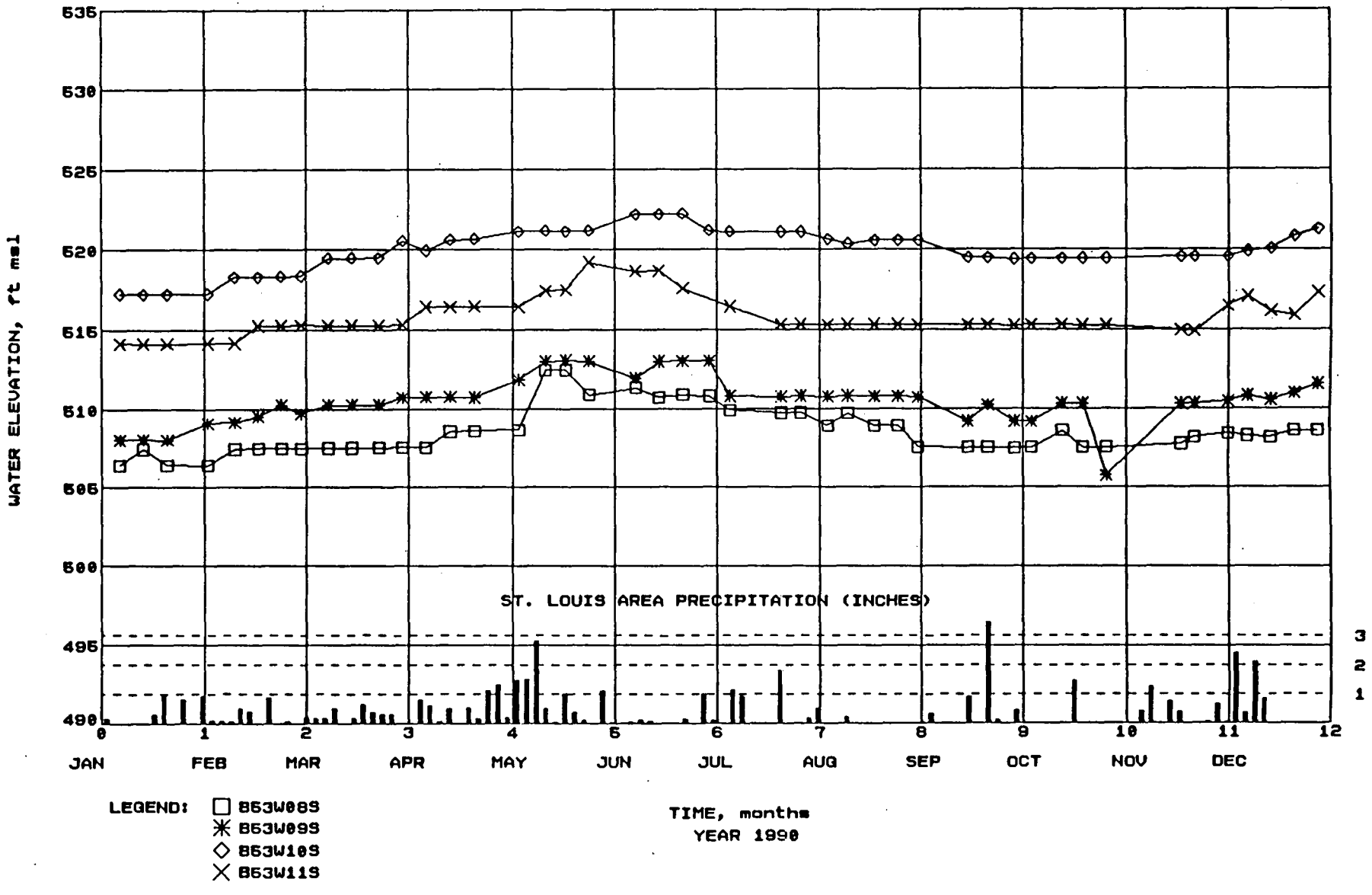
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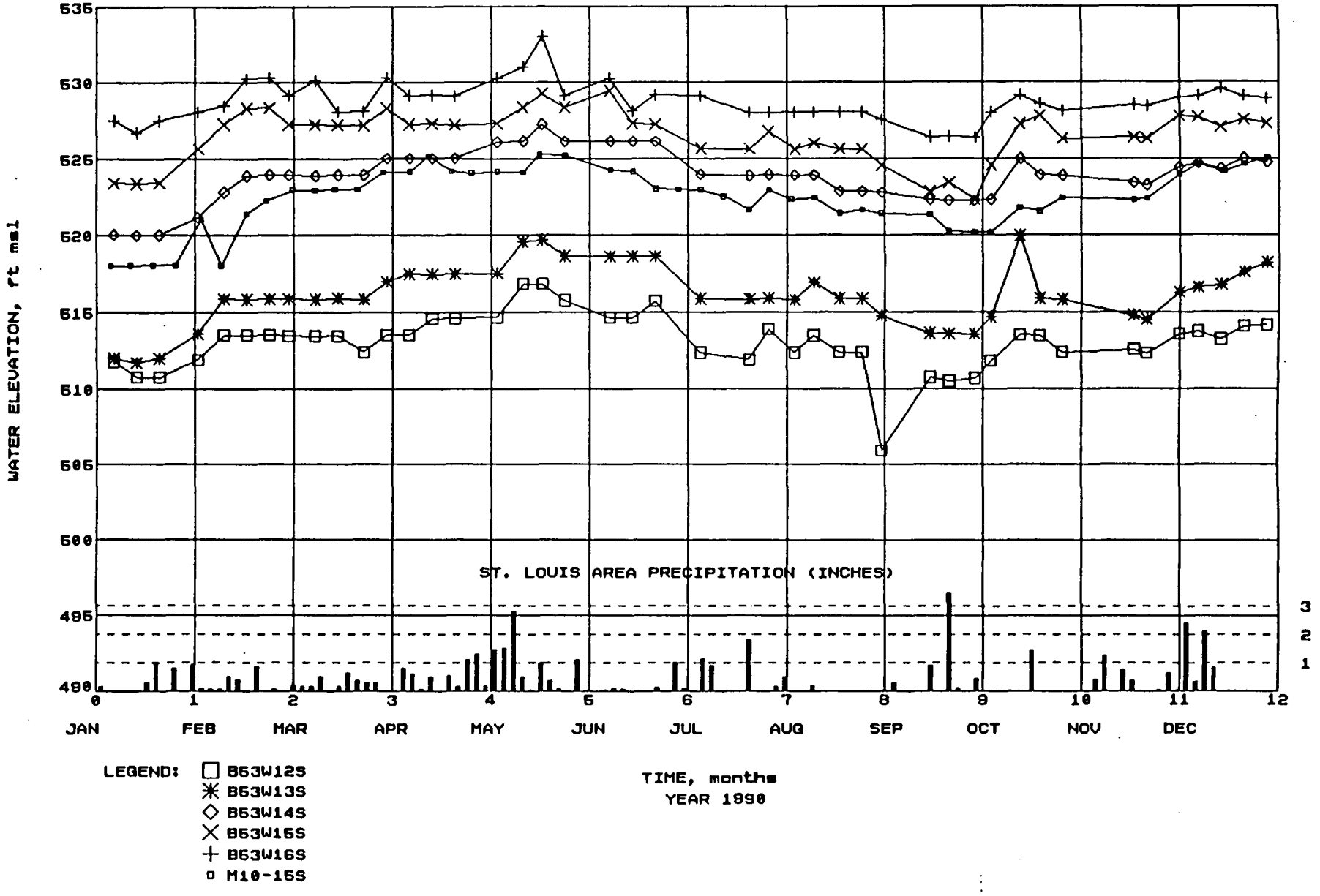
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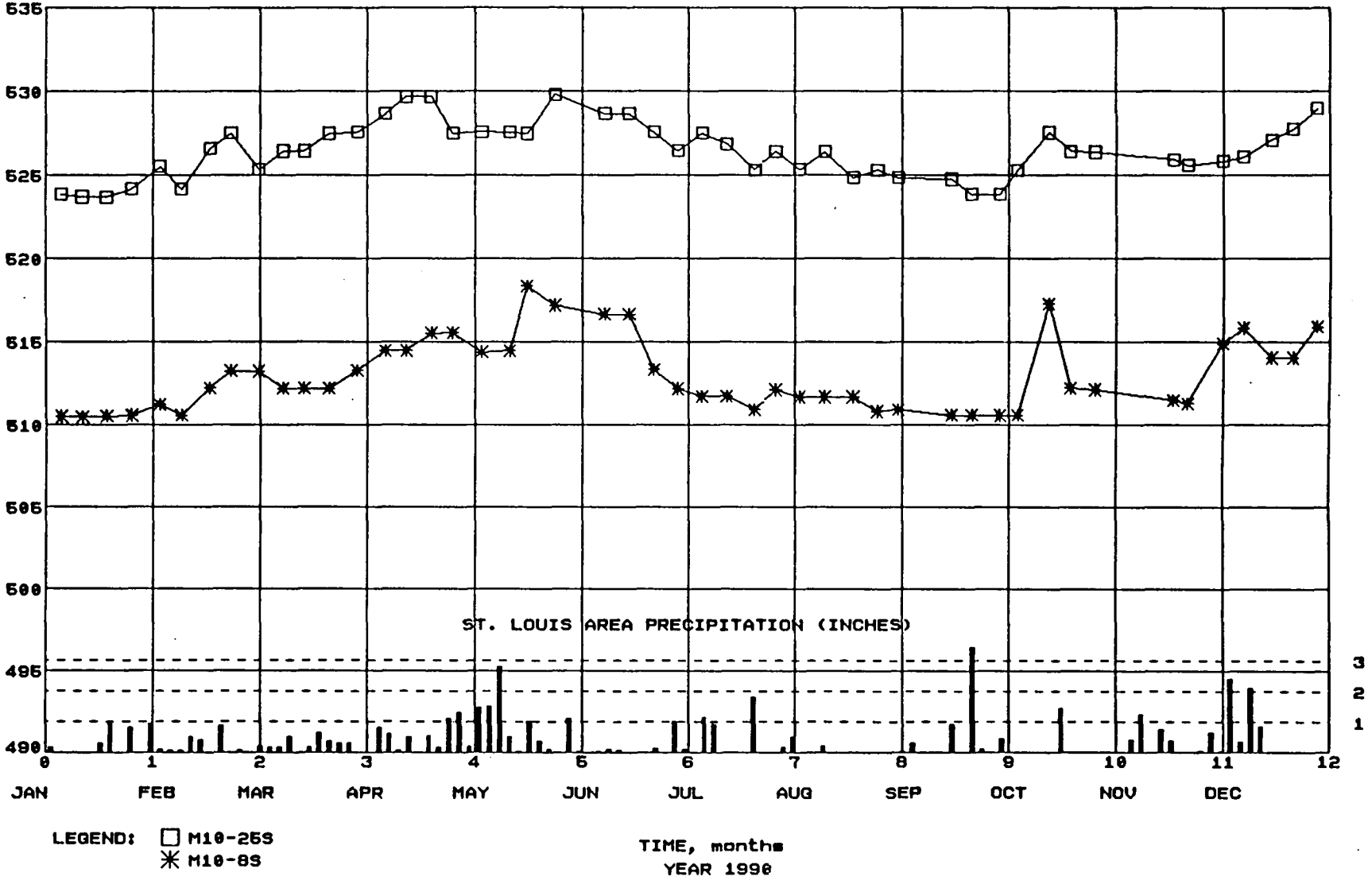
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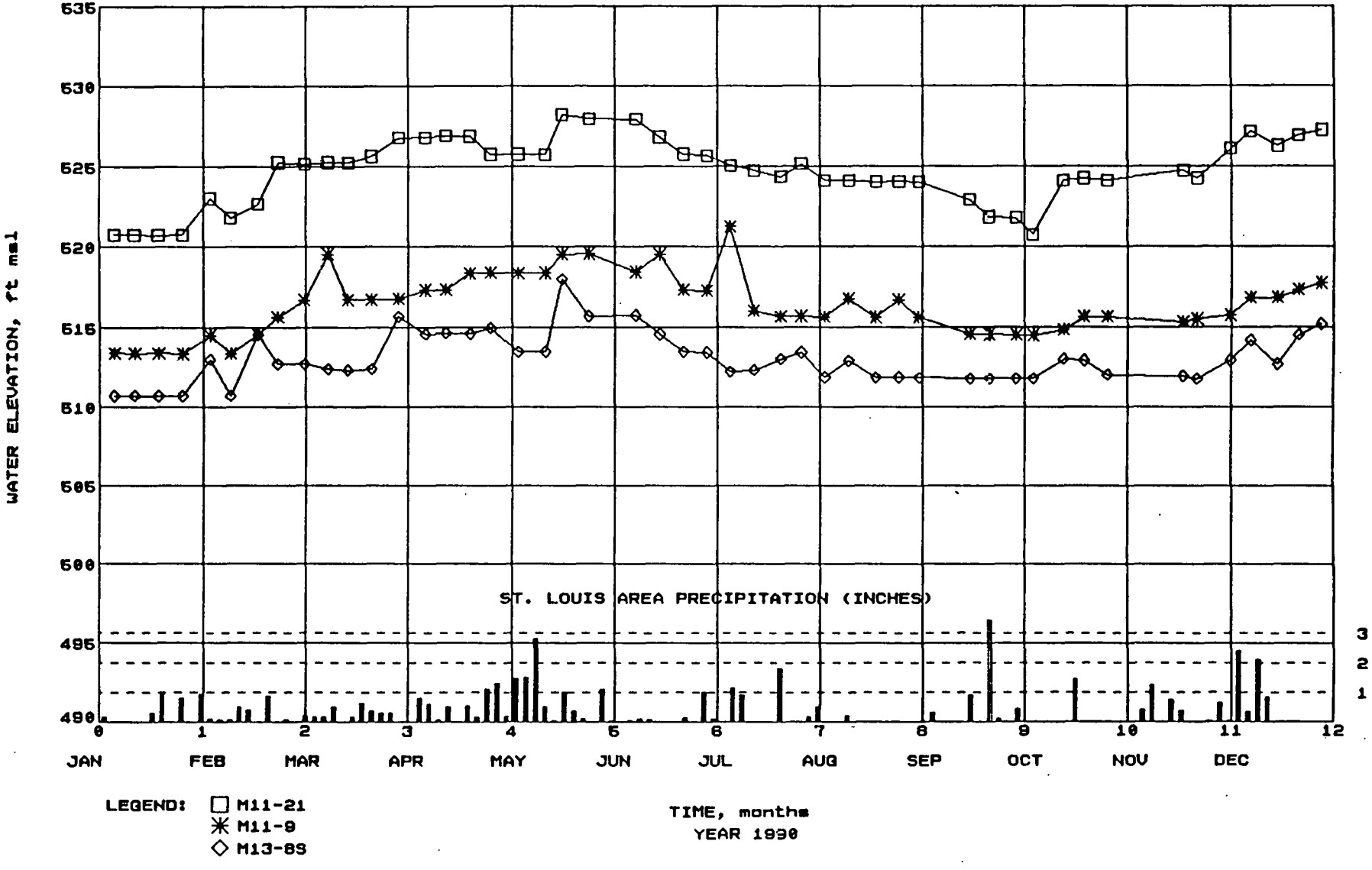
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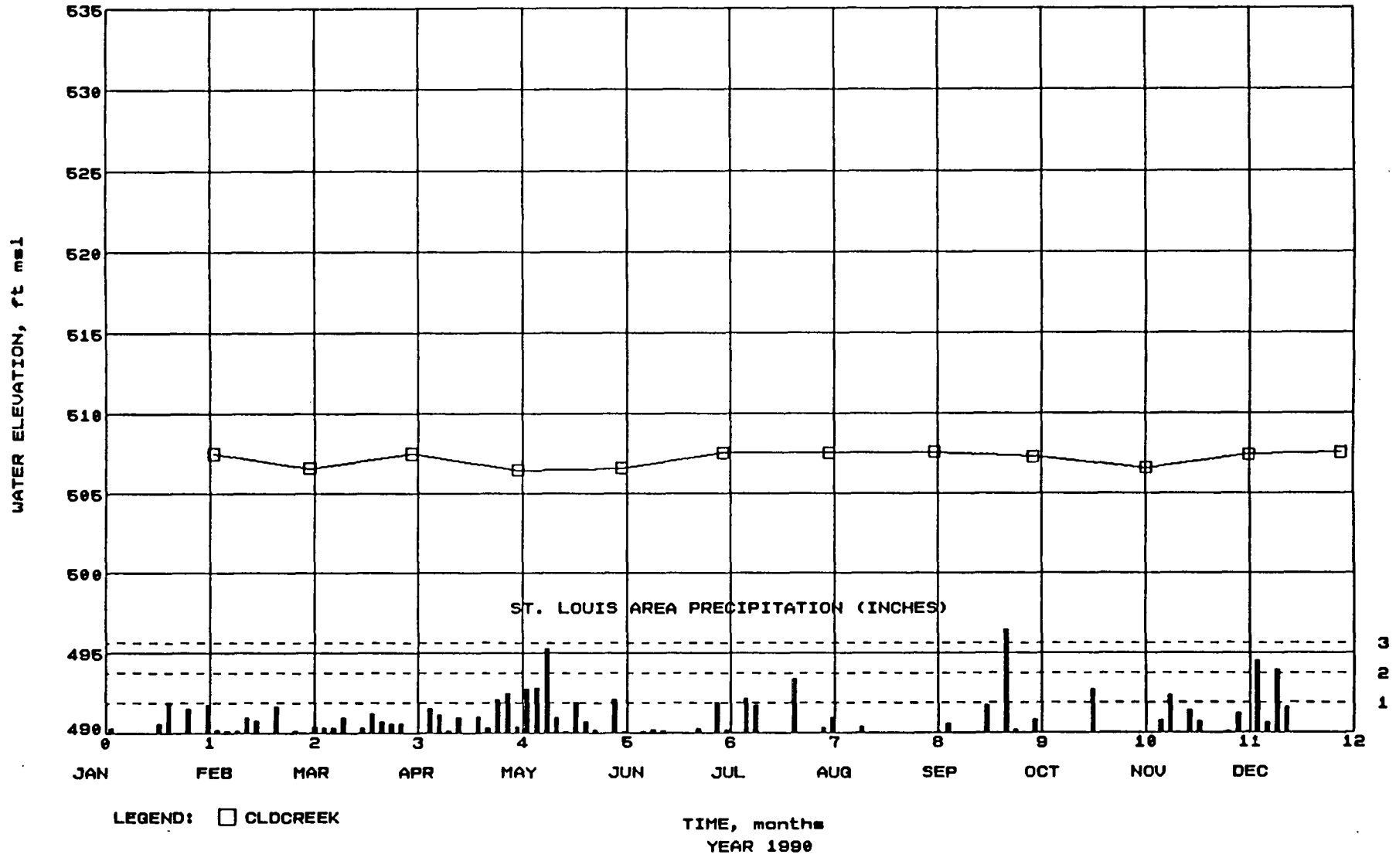
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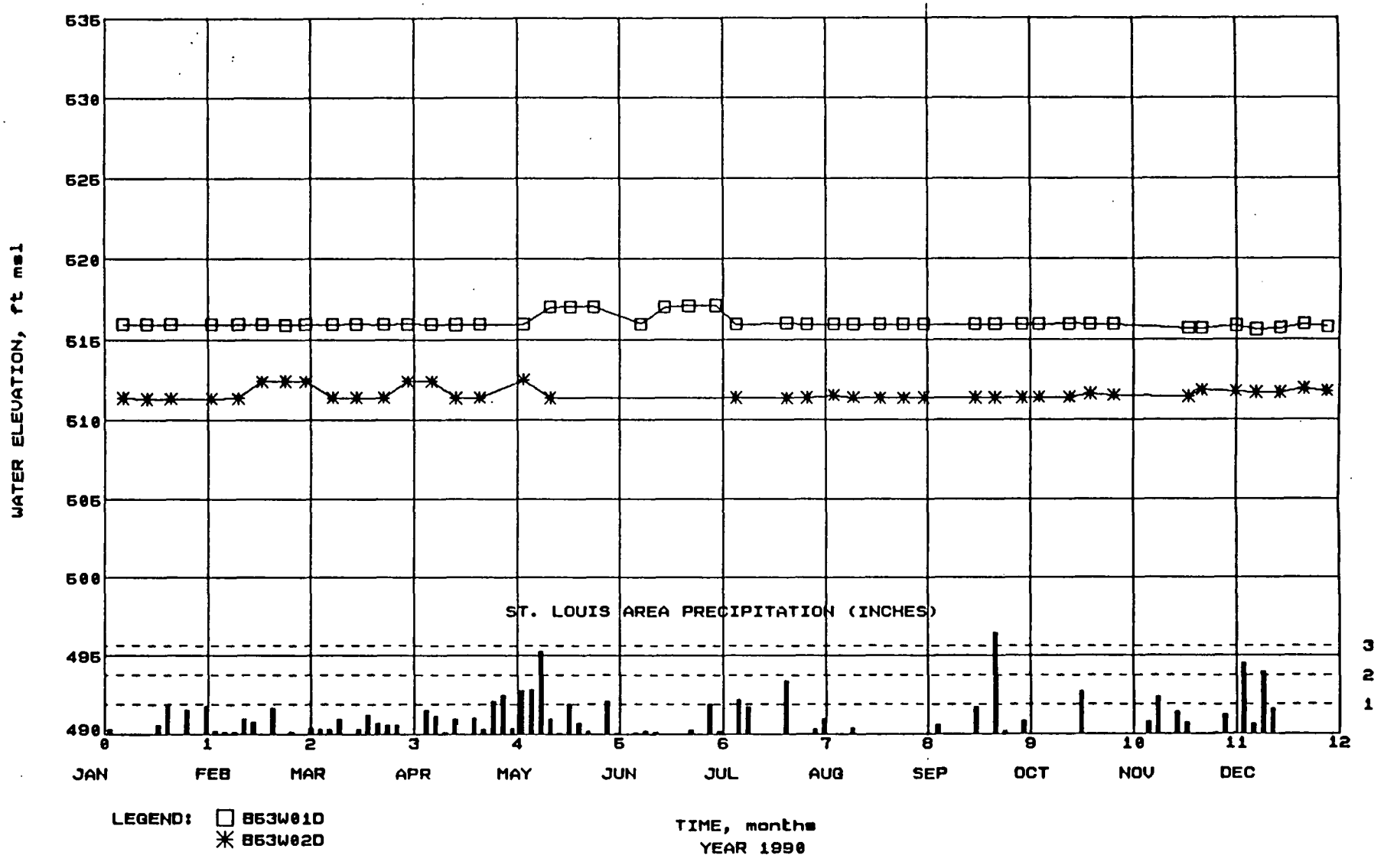
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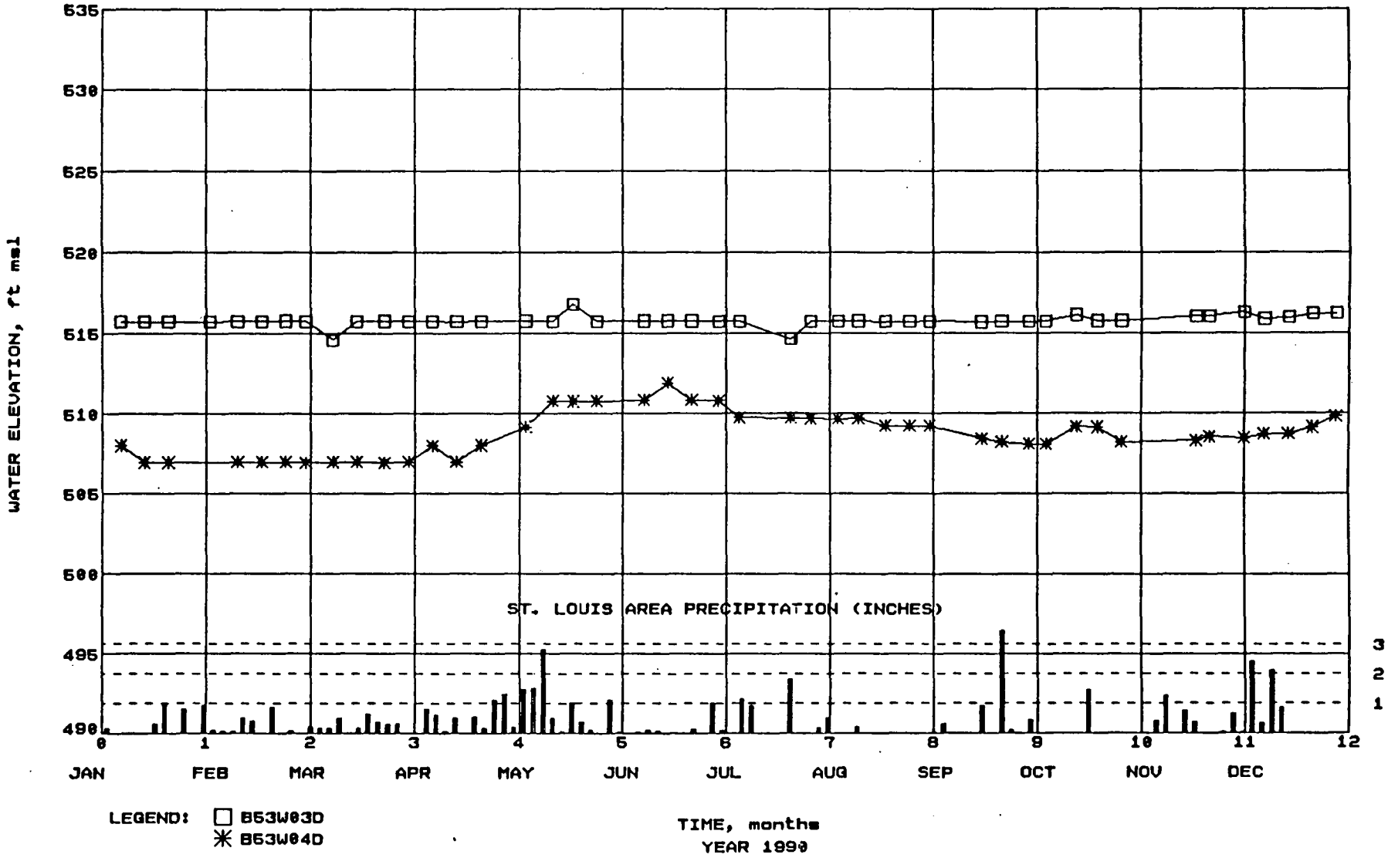
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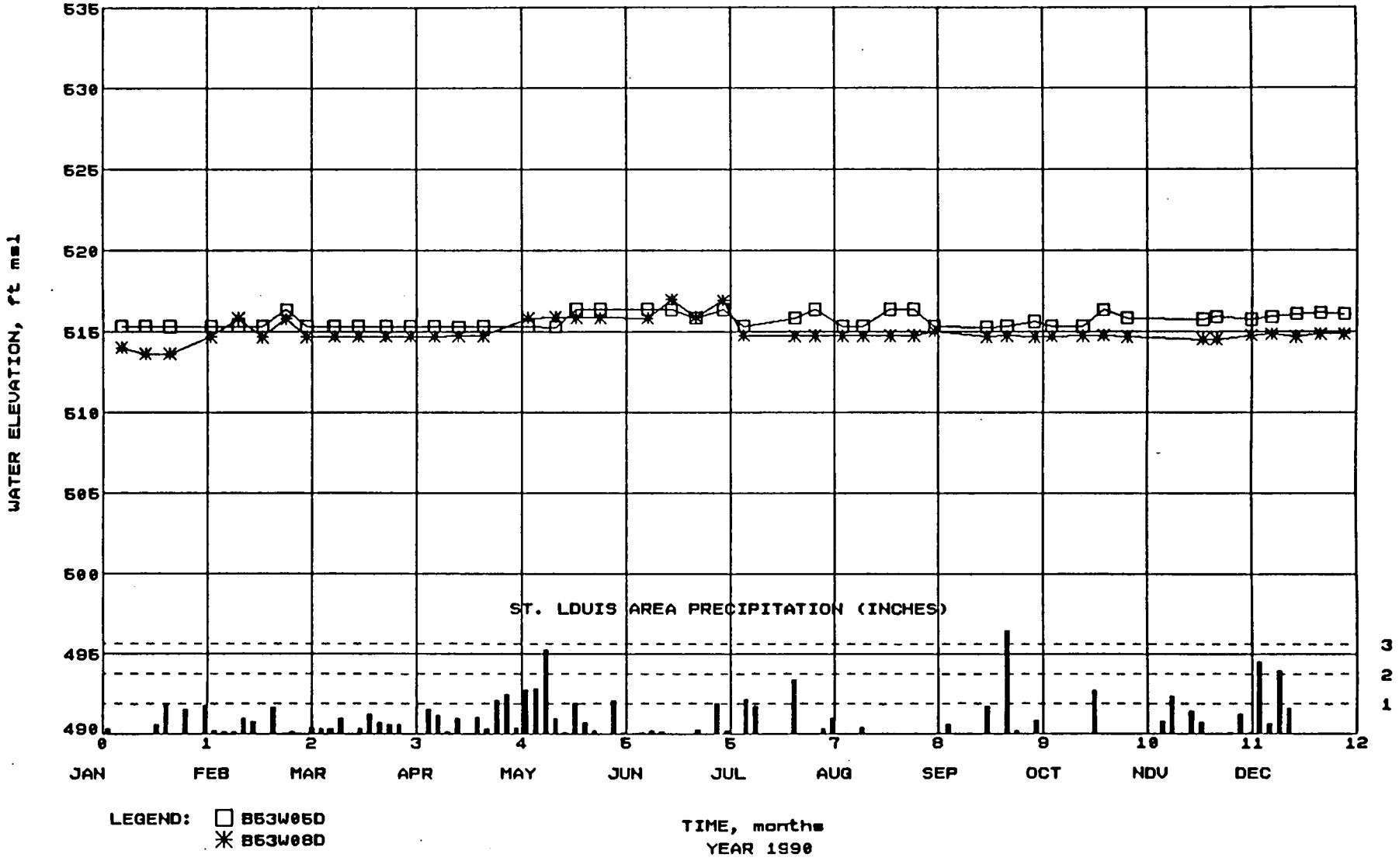
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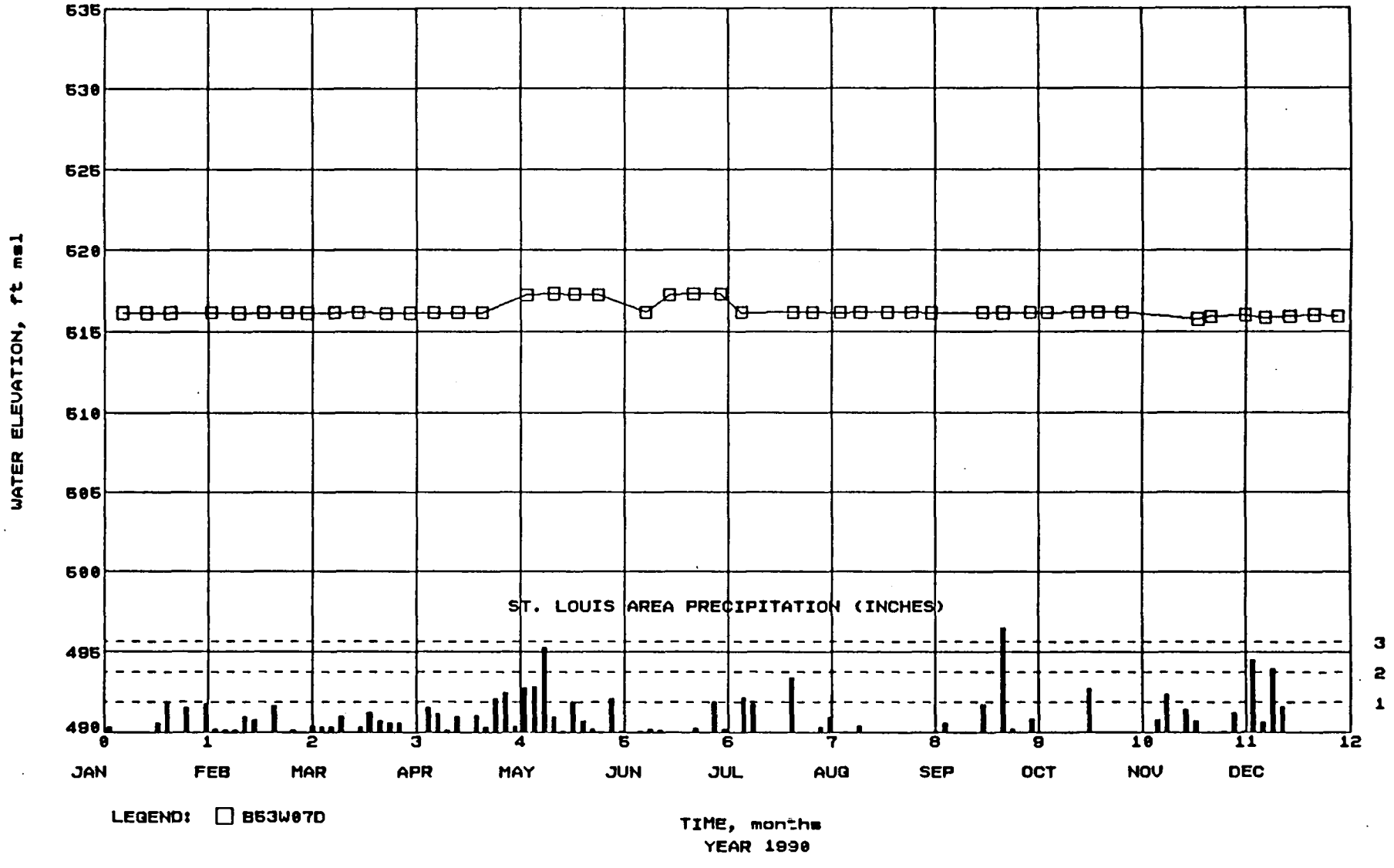
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ST. LOUIS AREA PRECIPITATION (INCHES)
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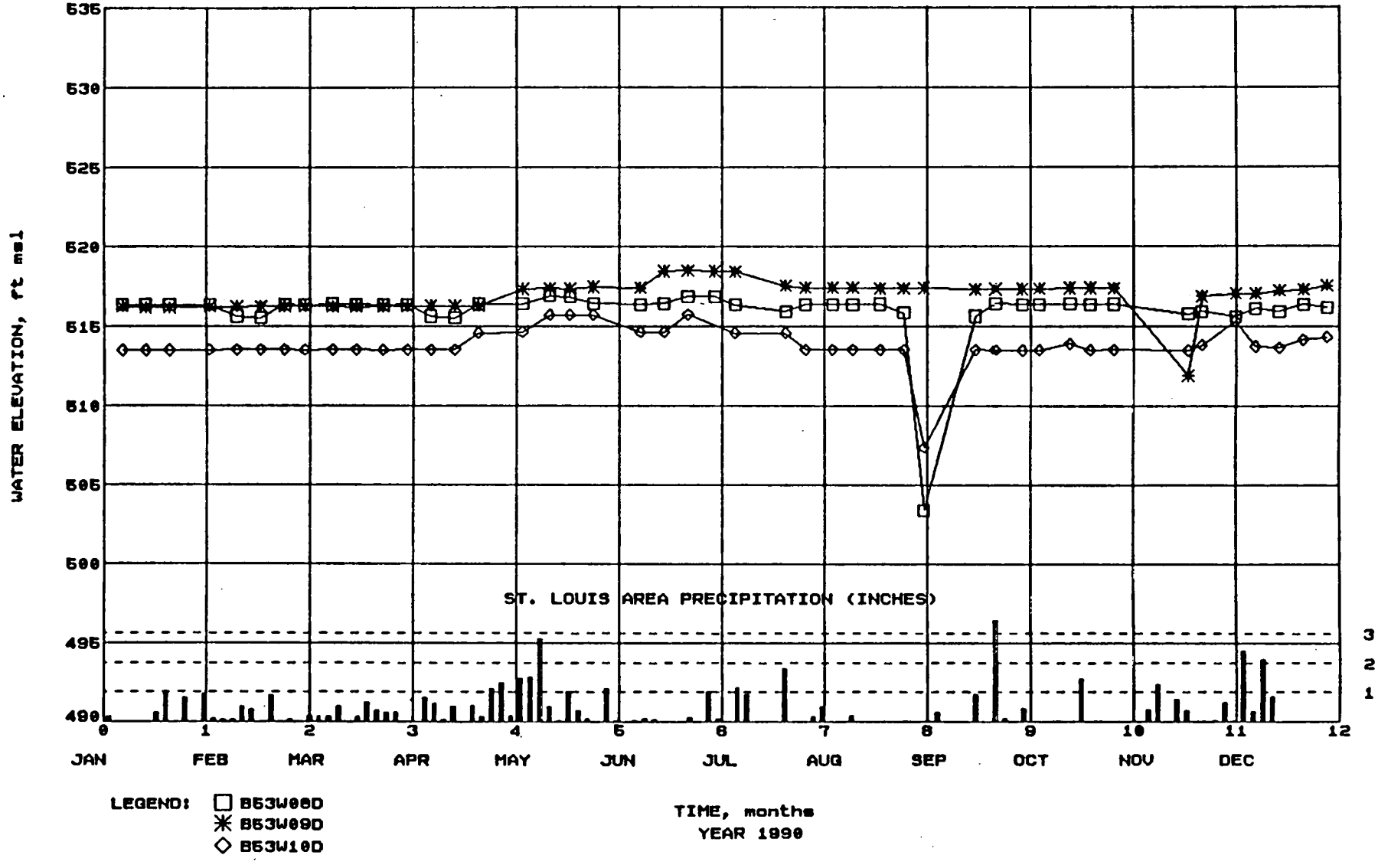
LEGEND: B53W07D
TIME, months
YEAR 1990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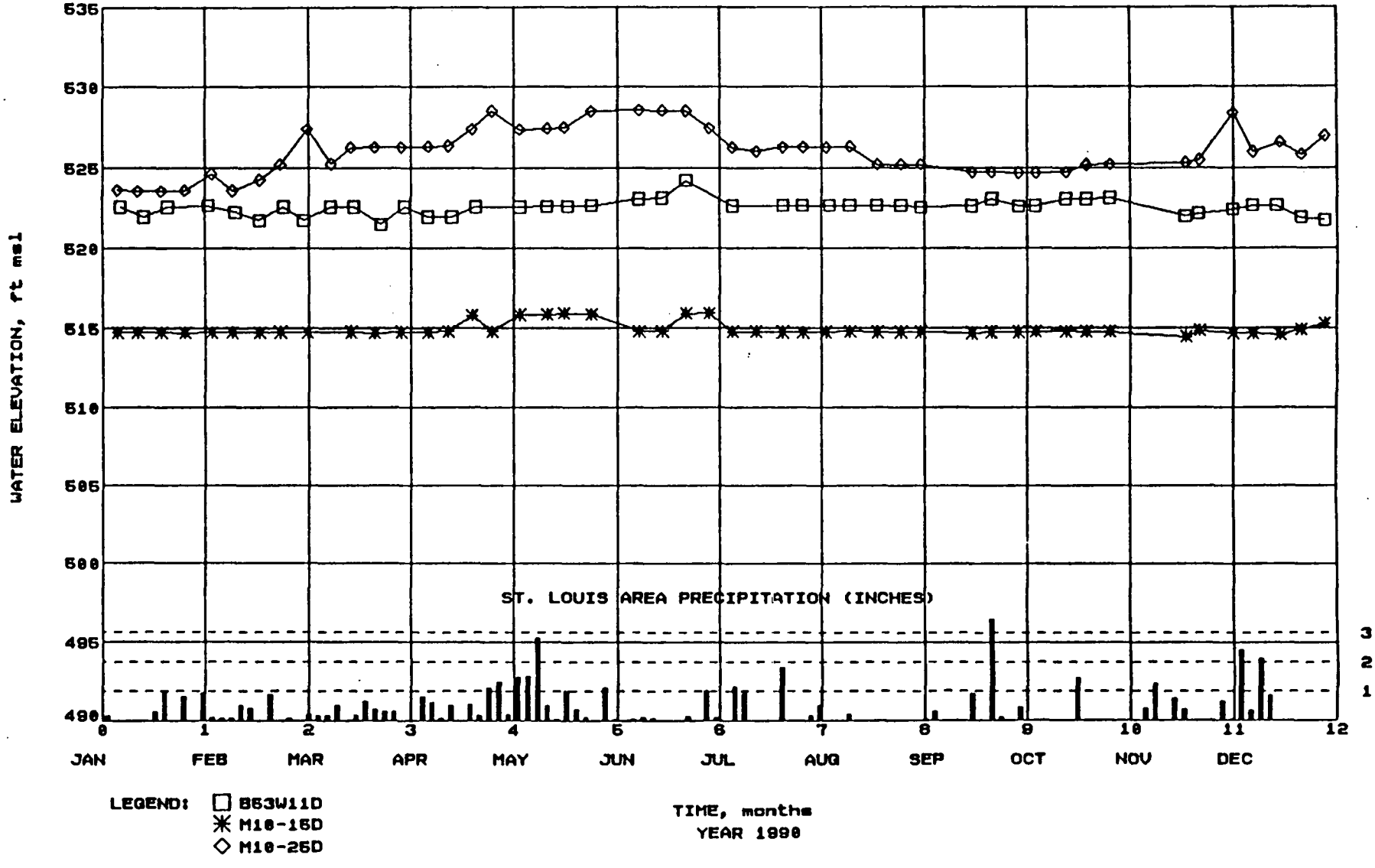
TIME, months
YEAR 1990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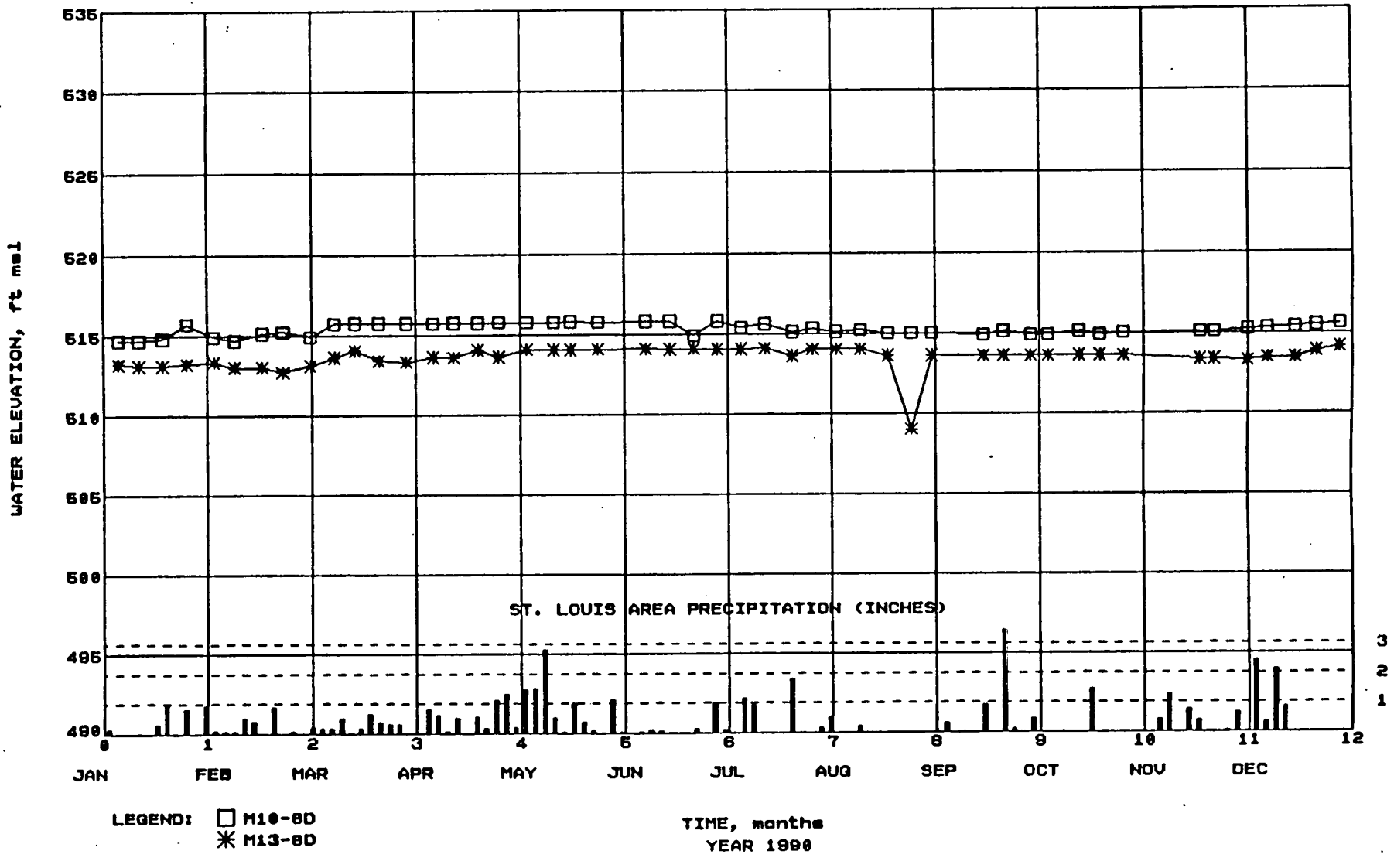
M18-15D
M18-25D
TIME, months
YEAR 1990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WATER ELEVATION, ft msl
ST. LOUIS AREA PRECIPITATION (INCHES)
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LEGEND: M10-8D
M13-8D
TIME, months
YEAR 1990

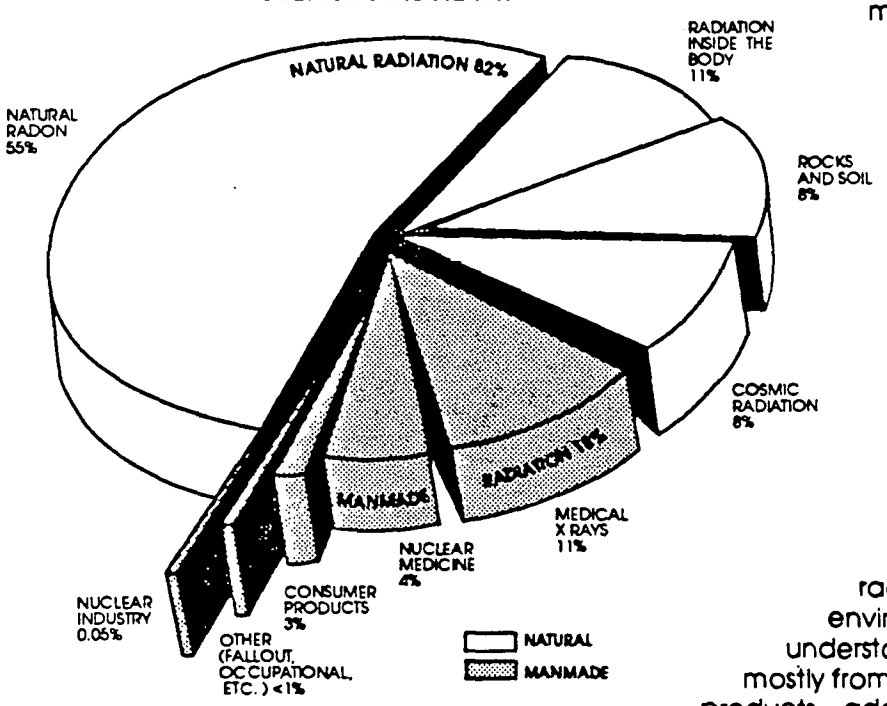
APPENDIX F
RADIATION IN THE ENVIRONMENT

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
McAlpe, 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

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

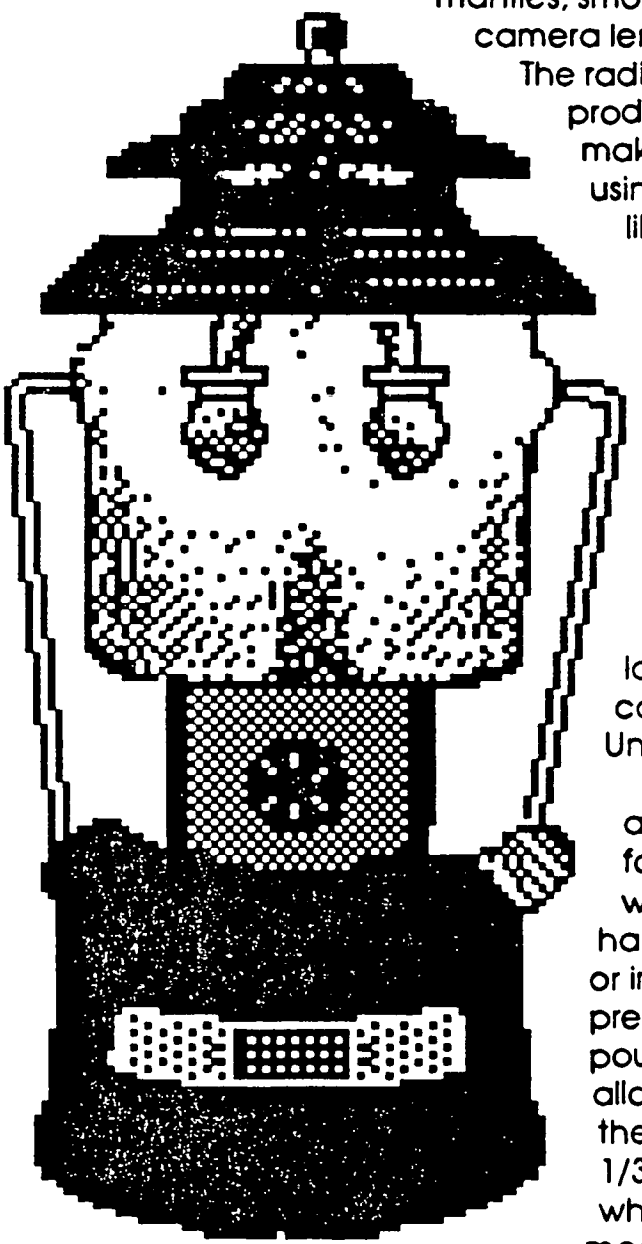
UNIT OF RADIOACTIVITY	SYMBOL	DISINTEGRATIONS PER MINUTE	DOLLAR ANALOGY	EXAMPLES OF RADIOACTIVE MATERIALS
1 Curie	Ci	$2x10^{12}$ or 2 Trillion	2 Times the Annual Federal Budget	Nuclear Medicine Generator
1 Millicurie	mCi	$2x10^{9}$ or 2 Billion	Cost of a New Interstate Highway from Atlanta to San Francisco	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 I 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

SAIC 189

APPENDIX G
CONVERSION FACTORS

TABLE G-1

CONVERSION FACTORS

1 yr	=	8,760 h
1 L	=	1,000 ml
1 μCi	=	1,000,000 pCi
1 pCi	=	0.000001 μCi
0.037 Bq/L	=	10^{-9} μCi/ml = 1 pCi/L
0.037 Bq/L	=	0.000000001 μCi/ml
1 μCi/ml	=	1,000,000,000 pCi/L
$1E^{-6}$ = 1E-6 = 1E-06	=	0.000001 = 1 x 10^{-6}
$1E^{-7}$ = 1E-7 = 1E-07	=	0.0000001 = 1 x 10^{-7}
$1E^{-8}$ = 1E-8 = 1E-08	=	0.00000001 = 1 x 10^{-8}
$1E^{-9}$ = 1E-9 = 1E-09	=	0.000000001 = 1 x 10^{-9}
$1E^{-10}$ = 1E-10	=	0.0000000001 = 1 x 10^{-10}

APPENDIX H

CLEAN AIR ACT COMPLIANCE REPORT

FOR ST. LOUIS AIRPORT SITE

40 CFR Part 61
National Emission Standards
for Hazardous Air Pollutants

CLEAN AIR ACT COMPLIANCE REPORT
(Version 3.0 November 1989)

Facility: SLAPS
Address:
St. Louis , MO. 63042
Annual Assessment for Year: 1990
Date Submitted: 4/ 3/91

Comments: Formerly Utilized Sites Remedial Action Program - U.S. D.O.E.

Prepared By:

Name: Bechtel Natioanl Inc.
Title: FUSRAP
Phone #: (615) 576-1699

Prepared for:
U.S. Environmental Protection Agency
Office of Radiation Programs
Washington, D.C. 20460

CLEAN AIR ACT COMPLIANCE REPORT 4/ 3/91 9:00 AM

Facility: SLAPS
Address: City: St. Louis State: MO
Comments: Formerly Utilized Sites Remedial Action Program - U.S. D.O.E.
Year: 1990

	Dose Equivalent Rates to Nearby Individuals (mrem/year)
Effective Dose Equivalent	0.0470
Highest Organ Dose is to LUNGS	0.3500

----------EMISSION INFORMATION----------

Radio-nuclide	Class	Amad	Area #1 (Ci/y)
U-238	Y	1.0	1.0E-05
RA-226	Y	1.0	8.8E-06
U-234	Y	1.0	1.0E-05
U-235	Y	1.0	4.6E-07
TH-232	Y	1.0	5.7E-07
TH-230	Y	1.0	0.0E-01
Total Area (m**2)			8.8E+04

----------SITE INFORMATION----------

Wind Data	SL_MO.WND	Temperature (C)	14
Food Source	LOCAL	Rainfall (cm/y)	82
Distance to Individuals (m)	300	Lid Height (m)	1000

*NOTE: The results of this computer model are dose estimates. They are only to be used for the purpose of determining compliance and reporting per 40 CFR 61.93 and 40 CFR 61.94.

ORGAN DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL

ORGAN	DOSE EQUIVALENT RATE TO THE ORGAN (mrem/y)
GONADS	8.1E-04
BREAST	8.3E-04
RED MARROW	5.9E-03
LUNGS	3.5E-01
THYROID	8.1E-04
ENDOSTEUM	7.2E-02
REMAINDER	3.6E-03
EFFECTIVE	4.7E-02

DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL
BY PATHWAY FOR ALL RADIONUCLIDES

	EFFECTIVE DOSE EQUIVALENT (mrem/y)	DOSE EQUIVALENT TO THE ORGAN WITH THE HIGHEST DOSE LUNGS (mrem/y)
INGESTION	3.0E-03	3.4E-04
INHALATION	4.3E-02	3.5E-01
AIR IMMERSION	8.8E-10	7.3E-10
GROUND SURFACE	2.6E-05	2.0E-05
TOTAL:	4.7E-02	3.5E-01

SLAPS

DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL
BY RADIONUCLIDE FOR ALL PATHWAYS

RADIONUCLIDE	EFFECTIVE DOSE EQUIVALENT (mrem/y)	DOSE EQUIVALENT TO THE ORGAN WITH THE HIGHEST DOSE LUNGS (mrem/y)
U-238	1.4E-02	1.1E-01
RA-226	1.4E-02	1.1E-01
U-234	1.5E-02	1.2E-01
U-235	6.6E-04	5.1E-03
TH-232	2.3E-03	1.2E-02
TH-230	2.2E-28	8.7E-28
TOTAL :	4.7E-02	3.5E-01

EFFECTIVE DOSE EQUIVALENT AS A FUNCTION OF DISTANCE IN THE DIRECTIONS OF THE MAXIMALLY EXPOSED INDIVIDUAL FOR ALL RADIONUCLIDES AND ALL PATHWAYS

DIRECTION : NORTHWEST

DISTANCE (meters)	EFFECTIVE DOSE EQUIVALENT (mrem/y)
300	4.7E-02
1000	4.7E-03
3000	5.9E-04
10000	6.6E-05
80000	1.8E-06

EFFECTIVE DOSE EQUIVALENT AS A FUNCTION OF ALL DISTANCES AND ALL DIRECTIONS FOR ALL RADIONUCLIDES AND ALL PATHWAYS

DIRECTIONS:	N	NNE	NE	ENE	E	ESE	SE	SSE
DISTANCE (METERS):								
300	3.1E-02	2.4E-02	2.2E-02	3.5E-02	4.4E-02	4.0E-02	2.6E-02	1.7E-02
1000	3.2E-03	1.5E-03	1.8E-03	2.5E-03	4.4E-03	3.5E-03	2.0E-03	1.3E-03
3000	4.4E-04	2.1E-04	2.4E-04	3.3E-04	5.6E-04	4.6E-04	2.7E-04	1.8E-04
10000	6.0E-05	3.0E-05	3.3E-05	4.0E-05	6.3E-05	5.5E-05	3.6E-05	2.4E-05
80000	2.3E-06	1.2E-06	1.3E-06	1.3E-06	1.9E-06	1.9E-06	1.3E-06	9.0E-07

	S	SSW	SW	WSW	W	WNW	NW	NNW
DISTANCE (METERS):								
300	1.7E-02	2.3E-02	2.6E-02	2.7E-02	2.9E-02	4.1E-02	4.7E-02	4.4E-02
1000	1.3E-03	1.8E-03	2.5E-03	1.9E-03	2.3E-03	3.0E-03	4.7E-03	3.3E-03
3000	1.8E-04	2.3E-04	3.1E-04	2.5E-04	2.9E-04	3.9E-04	5.9E-04	4.4E-04
10000	2.3E-05	2.7E-05	3.4E-05	2.7E-05	3.2E-05	4.6E-05	6.6E-05	5.3E-05
80000	8.0E-07	8.2E-07	8.9E-07	7.6E-07	8.5E-07	1.4E-06	1.8E-06	1.7E-06

APPENDIX I

DISTRIBUTION LIST FOR THE ST. LOUIS AIRPORT SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990

DISTRIBUTION LIST FOR ST. LOUIS AIRPORT SITE

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KPLR-TV
4935 Lindell
St. Louis, MO 63108

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KSDK-TV
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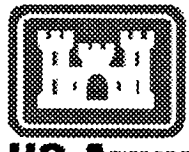

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