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

MAYWOOD INTERIM STORAGE SITE ANNUAL ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1991

Maywood, New Jersey

September 1992

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MAYWOOD INTERIM STORAGE SITE

ANNUAL ENVIRONMENTAL REPORT

FOR CALENDAR YEAR 1991

MAYWOOD, NEW JERSEY

SEPTEMBER 1992

Prepared for

United States Department of Energy

Oak Ridge Field Office

Under Contract No. DE-AC05-91OR21949

By

Bechtel National, Inc.

Oak Ridge, Tennessee

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EXECUTIVE SUMMARY

This document describes the environmental monitoring program at the Maywood Interim Storage Site (MISS) and surrounding area, implementation of the program, and monitoring results for 1991. Environmental monitoring of MISS began in 1984 when Congress added the site to the U.S. Department of Energy's (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP is a DOE program to identify and 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.

The environmental monitoring program at MISS includes sampling networks for radon and thoron concentrations in air; external gamma radiation exposure; and total uranium, radium-226, radium-228, thorium-232, and thorium-230 concentrations in surface water, sediment, and groundwater. Additionally, several nonradiological parameters are measured in surface water, sediment, and groundwater.

Monitoring results are compared with applicable Environmental Protection Agency standards, DOE derived concentration guides (DCGs), dose limits, and other requirements in DOE orders. Environmental standards are established to protect public health and the environment.

Results of environmental monitoring during 1991 indicate that most concentrations of the contaminants of concern were below applicable standards. Concentrations of all radiological and nonradiological parameters, except for thoron were well below applicable guidelines. At one location the annual average thoron concentration exceeded the DCG. The potential radiation dose calculated for a hypothetical maximally exposed individual is 1.2 mrem (milliroentgen equivalent man) per year, which is less than an individual would receive while traveling in an airplane at 12,000 meters (39,000 feet) for three hours.

During 1991, there were no nonroutine releases from the site; MISS was in compliance with applicable regulations for releases from the site based on realistic exposure scenarios, as has been the case since 1984, when the environmental monitoring program began. Site activities were limited to environmental monitoring and routine maintenance.

As part of the ongoing environmental monitoring program at MISS, the adequacy of existing monitoring activities is assessed annually. Results from this assessment are used to identify any necessary changes in the scope of the monitoring program. Such changes may result from changing site conditions, changing regulatory requirements, or newly identified data needs to support the remedy selection process being conducted for the site. Additionally, as monitoring data are accumulated, decisions may be made to adjust monitoring requirements. Future annual site environmental reports will reflect any changes to the routine monitoring program.

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ACRONYMS

AEC	Atomic Energy Commission
BNAE	base/neutral and acid extractable
BNI	Bechtel National, Inc.
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CWA	Clean Water Act
DCG	derived concentration guide
DOE	Department of Energy
DQO	data quality objective
EIS	environmental impact statement
EPA	Environmental Protection Agency
FFA	federal facilities agreement
FUSRAP	Formerly Utilized Sites Remedial Action Program
MCW	Maywood Chemical Works
MISS	Maywood Interim Storage Site
MSD	matrix spike duplicate
MSL	mean sea level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NJDEPE	New Jersey Department of Environmental Protection and Energy
NOAA	National Oceanic and Atmospheric Administration

ACRONYMS
(continued)

NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
PARCC	precision, accuracy, representativeness, comparability, and completeness
PCB	polychlorinated biphenyl
QA	quality assurance
QAPmP	quality assurance program plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation/feasibility study
RPD	relative percent difference
SRM	standard reference material
TCLP	toxicity characteristic leaching procedure
TETLD	tissue-equivalent thermoluminescent dosimeter
TPQ	threshold planning quantity
TSCA	Toxic Substances Control Act

UNITS OF MEASURE

Bq	becquerel
C	Celsius
cm	centimeter
F	Fahrenheit
ft	foot
ft MSL	feet above mean sea level
g	gram
gal	gallon
gpm	gallons per minute
h	hour
ha	hectare
in.	inch
kg	kilogram
km	kilometer
L	liter
m	meter
µCi	microcurie
µg	microgram
mg	milligram
mi	mile
min	minute
ml	milliliter
mm	millimeter
mph	miles per hour
mR	milliroentgen
mrem	millirem
mSv	millisievert
pCi	picocurie
rem	roentgen equivalent man
s	second
Sv	sievert
yd	yard
yr	year

1.0 INTRODUCTION

Environmental monitoring of the U.S. Department of Energy's (DOE) Maywood Interim Storage Site (MISS) and surrounding area began in 1984. This document describes the environmental monitoring program, implementation of the program, monitoring results for 1991, and special occurrences (if any) during 1991 and the first quarter of 1992.

1.1 DOE INVOLVEMENT

MISS 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 remediate.

1.2 SITE DESCRIPTION

MISS occupies approximately 4.73 ha (11.7 acres) in north-central New Jersey in the Borough of Maywood and the Township of Rochelle Park (Bergen County) (Figure 1-1). MISS, the adjacent Stepan Company property, and nearby residential, commercial, and governmental vicinity properties comprise the Maywood Site. The MISS property includes an interim storage pile covered with geotextile material, two railroad spurs, a wooden warehouse, and a circular concrete reservoir (Figure 1-2). A decontamination pad, two trailers, a storage van, and a 5,000-gal water storage tank are inside the controlled area but not on DOE property. The area currently used for storage of approximately 26,700 m^3 (34,900 yd^3) of radioactively contaminated soil is entirely fenced, and access is restricted. Figure 1-3 is an aerial photograph of MISS.

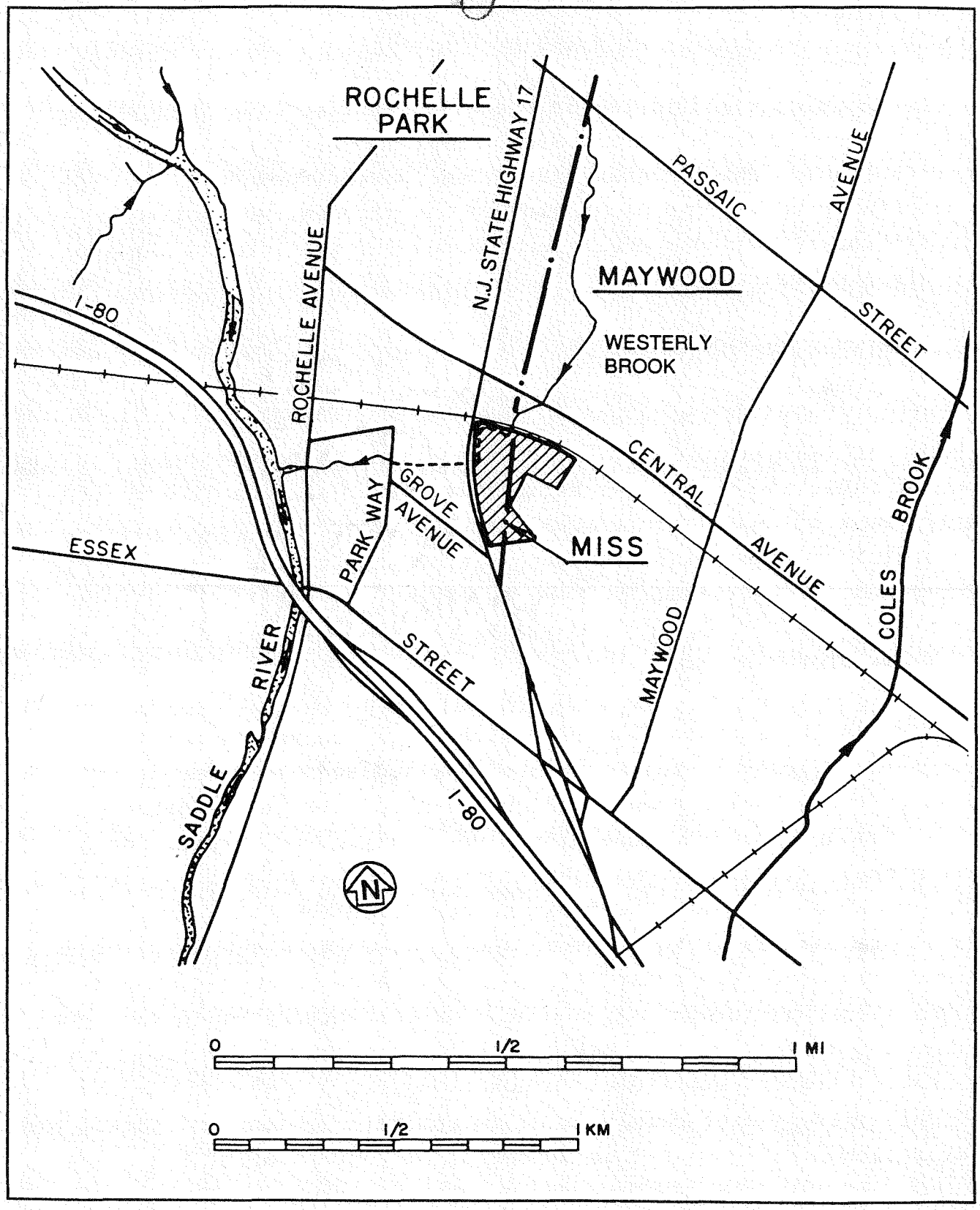
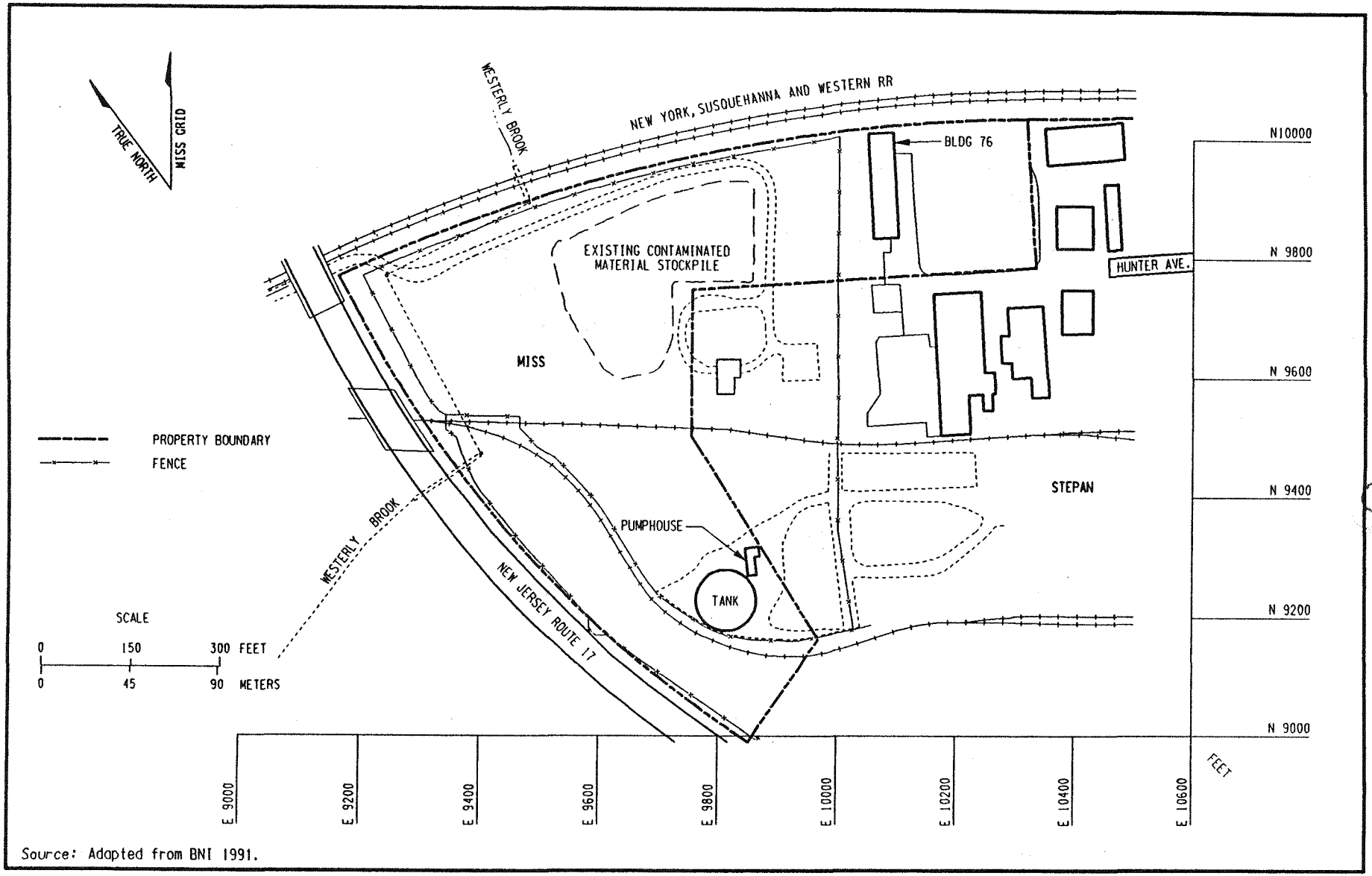


Figure 1-1
Location of MISS



Source: Adapted from BNI 1991.

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Figure 1-2
Plan View of MISS

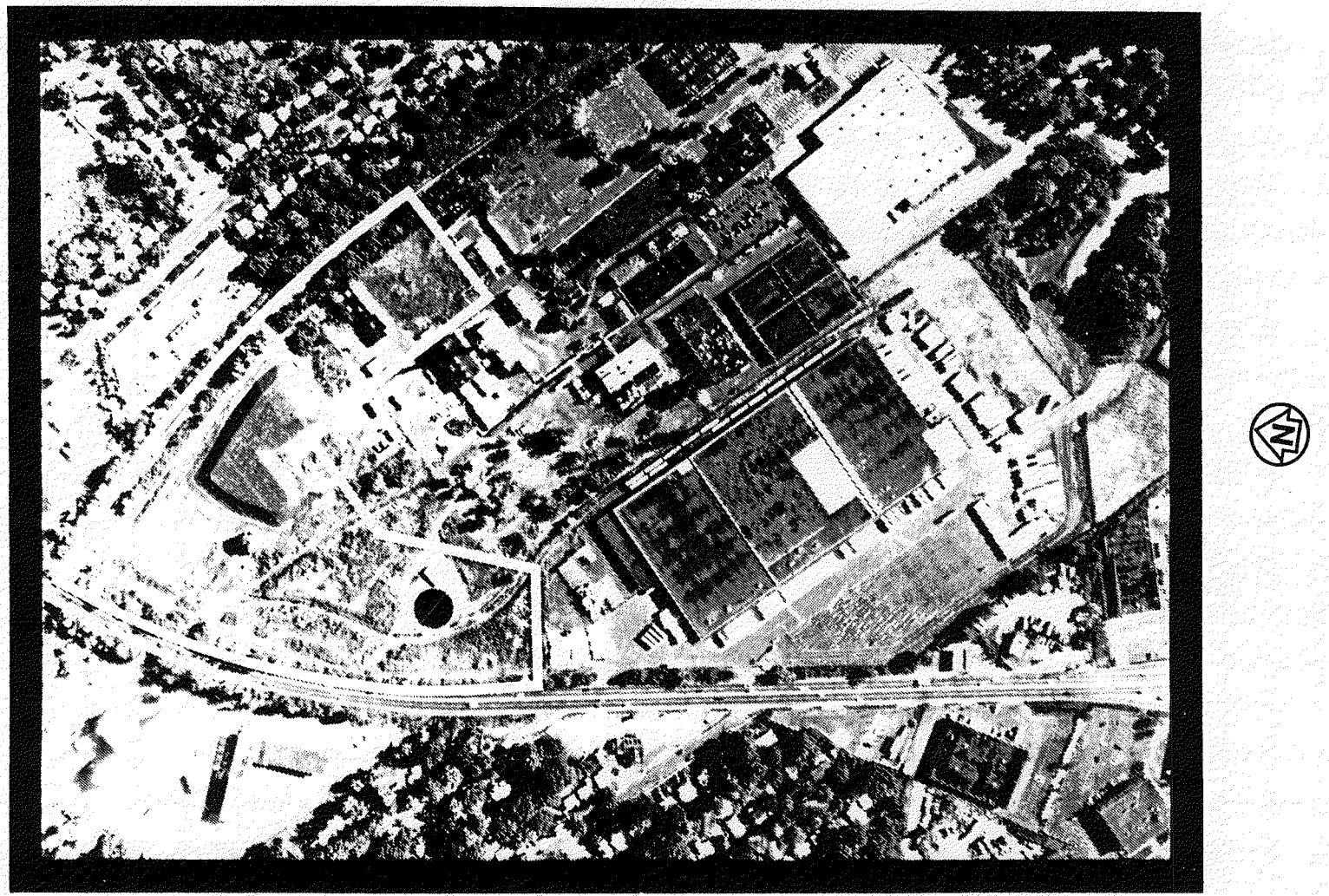


Figure 1-3
Aerial View of MISS and Vicinity

1.3 SITE HISTORY

From 1916 until 1956, Maywood Chemical Works (MCW) extracted thorium from monazite sands (a naturally occurring ore that contains thorium) to make mantles for use in gas lanterns. During this time, a thorium-contaminated slurry produced as a by-product was pumped to diked areas west of the plant. Some of this contaminated material, mixed with tea and coca leaves from other MCW processing operations, was used by local property owners as fill or mulch, and some migrated offsite via natural mechanisms. The company continued to manufacture, process, distribute, and possess radioactive material until the facility was sold to the Stepan Company in 1959.

In 1961, based on an Atomic Energy Commission (AEC) inspection and other information, the Stepan Company was issued an AEC radioactive materials license for storage and remediation of the facility. Actual cleanup began in 1963. From 1966 to 1968, approximately 14,600 m^3 (19,100 yd^3) of contaminated soil was removed from three offsite locations (former settling pond locations) and placed in three onsite disposal areas within the Stepan property boundary.

In 1980 the Nuclear Regulatory Commission was notified of elevated readings near Route 17, on and around the present site, and in 1983 the Environmental Protection Agency (EPA) added the Maywood Site to the National Priorities List (NPL). In 1984, the Maywood Site was assigned to DOE by Congress through the Energy and Water Development Appropriations Act.

In 1985 DOE purchased a 4.7-ha (11.7-acre) portion of the Stepan Company property for use as an interim storage facility for contaminated materials; this area was designated as MISS (Figure 1-2). During 1985 approximately 26,400 m^3 (34,500 yd^3) of contaminated material removed from 18 vicinity properties in Maywood and Rochelle Park and an additional 380 m^3 (500 yd^3) removed from 8 vicinity properties in Lodi and Rochelle Park were placed in the interim storage pile at MISS.

1.4 LAND USE

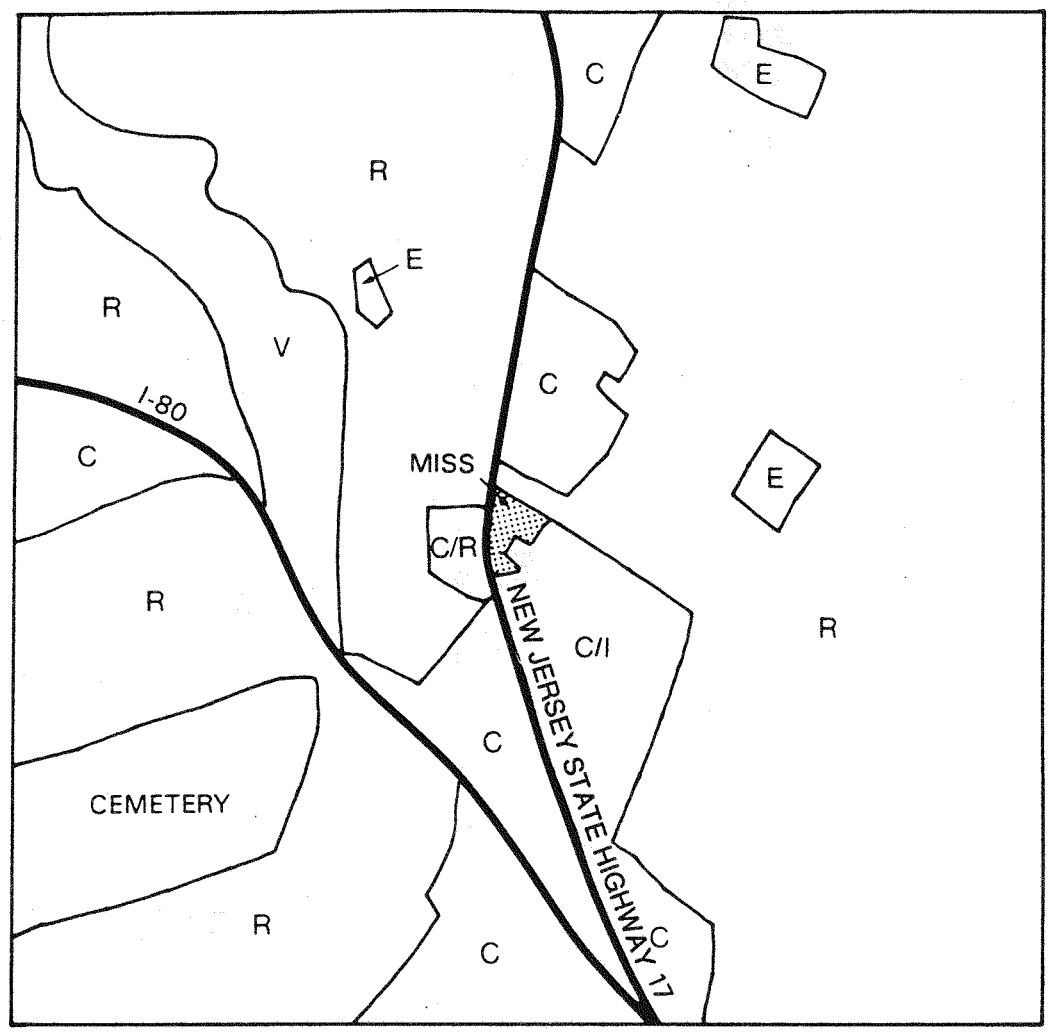
As illustrated in Figure 1-4, land use in the vicinity of MISS is a mixture of residential, commercial, and industrial. The site is bordered by a railroad line to the northeast, commercial and industrial property to the south and east, and New Jersey State Highway 17 to the west.

Westerly Brook, which has been diverted under the northern edge of MISS via a concrete pipe, flows into the Saddle River, a tributary of the Passaic River; these waters are not used as drinking water sources. All drinking water for the communities of Maywood and Rochelle Park is provided by a municipal water system with water supplied by the Oradell, Woodcliff, and Lake Tappan reservoirs, which obtain water from bedrock aquifer wells.

The nearest residential area is approximately 46 m (150 ft) northeast of the site; the residences are a mixture of multiple- and single-family dwellings. The total population of the area within an 80-km (50-mi) radius of MISS is over 10 million.

1.5 CLIMATE

Table 1-1 is a summary of 1991 climatological data from the National Oceanic and Atmospheric Administration (NOAA) for the Newark area [24 km (15 mi) south-southwest of MISS]. Temperature extremes ranged from -13 to 39°C (9 to 102°F). Average monthly wind speeds ranged from 12.9 to 18.0 km/h (8.0 to 11.2 mph), and the predominant resultant wind direction was from the west (NOAA 1992).



BASED ON AERIAL PHOTOGRAPHS, SITE VISITS AND USGS TOPOGRAPHIC MAP 1:24000 SCALE, HACKENSACK, NJ QUADRANGLE (PHOTO REVISED 1981)

R RESIDENTIAL
C COMMERCIAL
C/I MIXED COMMERCIAL/INDUSTRIAL
E EDUCATIONAL
V VACANT
C/R MIXED COMMERCIAL/RESIDENTIAL

0 0.5 MI
0 0.8 KM

N

Figure 1-4
Generalized Land Use in the Vicinity of MISS

Table 1-1
Summary of Climatological Data for the Newark Vicinity, 1991

Month	Temperature (°F) Min	Max	Avg	Total Precip (in.)	Wind Avg Speed (mph)	Resultant Direction
January	9	55	33.6	3.72	9.7	W
February	15	69	38.6	1.81	10.4	W
March	24	77	44.4	5.49	11.2	W
April	34	88	54.8	3.91	10.6	W
May	46	93	68.9	4.80	9.8	NW
June	53	97	74.2	2.95	9.7	NW
July	65	102	77.9	5.21	8.0	W
August	62	96	77.7	5.63	9.1	NW
September	44	95	68.0	3.24	9.0	NW
October	39	82	58.3	1.29	9.2	N
November	27	73	47.6	2.04	9.6	NW
December	14	65	38.8	3.67	10.6	W

Source: NOAA 1992.

2.0 SUMMARY OF ENVIRONMENTAL COMPLIANCE

The primary regulatory guidelines and limits are given in DOE orders and are 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); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); and the National Environmental Policy Act (NEPA).

The following summaries describe compliance requirements as they existed in 1991 and first quarter 1992, as well as anticipated regulatory requirements that may affect the site in the future.

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 1988a)] that establish quantitative limits, derived concentration guides (DCGs), and dose limits for radiological releases from DOE facilities. The applicable guidelines and dose limits are presented in Appendix A. For EPA permitting purposes, DOE orders are treated as legal requirements, and releases of source, special nuclear, or by-product material in compliance with DOE orders at its facilities are considered "federally permitted actions" (54 FR 22524).

A review of environmental monitoring results for calendar year 1991 indicates that, except for boundary concentrations of thoron, MISS was in compliance with applicable radionuclide release standards in DOE orders. Although thoron concentrations were above the 3.0×10^{-9} μCi/ml guideline at one boundary location, measurements taken to calculate the effective dose equivalent for inhabitants 300 m (984 ft) from the site were low (see Subsection 4.3.2). 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. Potential sources of air emissions from MISS are radionuclide emissions from the waste pile and onsite soils. To date, MISS does not require any state or federal air permits, pursuant to the authority of CERCLA Section 121. However, the requirements of Subparts A, H, and Q of the National Emission Standards for Hazardous Air Pollutants (NESHAPs) are potentially applicable (DOE 1990a).

Subpart H has been determined to not apply to MISS because the waste pile is only a diffuse or fugitive emission source, not a point source as defined by the NESHAPs regulation. However, compliance with the non-radon radionuclide standard in Subpart H of NESHAPs has been determined by evaluating the site using the computer model AIRDOS (Version 3.0) approved by EPA. This evaluation was completed, and the information was submitted to EPA pursuant to a draft Memorandum of Understanding between DOE and EPA for compliance with NESHAPs and by agreement with EPA Region II.

A strategy for determining compliance with the radon flux standard in Subpart Q was approved by EPA in July 1990, and compliance with the EPA-approved strategy was maintained in 1991.

NESHAPS Subpart M contains the National Asbestos Emission Standards. One drum of asbestos is in a storage area at MISS; loose asbestos is buried and commingled with soil in a 0.5-m^2 (5-ft^2) area that is marked by warning signs and roped off. When the buried asbestos is excavated, compliance with standards in Subpart M will be required, and applicable state requirements will be identified.

Clean Water Act

Pollutants discharged to waters of the United States are regulated under the federal CWA.

Stormwater is the only discharge from the site to surface water. On November 16, 1990, EPA promulgated its federal program

for the control of stormwater discharges from sites associated with industrial activity, including sites containing waste. New Jersey is an authorized state for implementation of the federal program, and permit applications are due to the New Jersey Department of Environmental Protection and Energy (NJDEPE) Bureau of Industrial Discharge Permits by October 1, 1992. Stormwater sampling is being planned to support submittal of the permit application.

Resource Conservation and Recovery Act

RCRA is the principal federal statute governing the management of hazardous waste. September 25, 1990, was the effective date for implementation of the new toxicity characteristic leaching procedure (TCLP) for determining whether a solid waste exhibits the RCRA characteristic of toxicity. Soil samples taken from the waste pile and onsite soils at MISS have been analyzed for toxicity, and no waste subject to RCRA regulation has been detected. The applicability of RCRA, however, continues to be evaluated while site activities and waste management are conducted.

Toxic Substances Control Act

The most common toxic substances regulated by TSCA are polychlorinated biphenyls (PCBs) and asbestos. Although PCBs were not expected to be present, onsite sampling for PCBs was conducted in late 1990. Analytical results indicate that no PCBs exist onsite. Compliance with the applicable federal and state standards pertaining to asbestos handling and removal will be complied with when the loose asbestos buried onsite is excavated.

Comprehensive Environmental Response, Compensation, and Liability Act

CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) are the primary sources of federal regulatory authority for remedial action activities at MISS.

Because MISS is on the NPL, a federal facilities agreement (FFA) is required for site remedial actions. DOE and EPA Region II signed an FFA on September 17, 1990 (EPA 1990), which became effective on April 22, 1991. Specifically, the parties to the FFA intend that activities covered by the agreement will achieve compliance with CERCLA and will meet or exceed all applicable or relevant and appropriate requirements.

National Environmental Policy Act

Compliance with NEPA has been accomplished through the use of action description memoranda and corresponding memoranda-to-file. Actions taken have been determined to have had no significant impact on the environment. Information on the integrated CERCLA/NEPA process is provided in Subsection 2.3.

Documentation was generated in 1991 to substantiate an NEPA categorical exclusion for the removal of contamination from a MISS vicinity property. This documentation will also be used in support of site environmental monitoring and surveillance activities.

Data collected during 1990 and 1991 remedial investigation activities supported a time-critical removal action conducted at a MISS vicinity property. Documentation of this action was placed in the Administrative Record for the Maywood Site in September 1991. A post-remedial action report documenting the removal action, as required by the hazardous response provisions of the NCP and FUSRAP protocol, is scheduled for publication in July 1992.

Other Major Environmental Statutes and Executive Orders

In addition to these 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 Emergency Planning and Community Right-to-Know-Act; the Safe Drinking Water Act; and the National Historic Preservation Act have all been found to impose no current requirements on MISS. In addition, Executive Orders 11988

("Floodplain Management") and 11990 ("Protection of Wetlands") have been reviewed for applicability and compliance. MISS is in compliance with all applicable environmental statutes, regulations, and executive orders.

2.2 APPLICABLE ENVIRONMENTAL PERMITS

The FFA for MISS provides, in conjunction with DOE policy, that all applicable permit conditions be met even though no permit applications are required. CERCLA Section 121 provides the statutory authority for an exemption to permitting requirements for onsite CERCLA remedial actions.

DOE is preparing to submit a stormwater discharge permit application for MISS to NJDEPE to comply with National Pollutant Discharge Elimination System (NPDES) regulations by the regulatory deadline of October 1, 1992.

2.3 ENVIRONMENTAL IMPACT STATEMENTS AND ENVIRONMENTAL ASSESSMENTS

Preparation of an environmental impact statement (EIS) is required as part of the overall cleanup effort for MISS and vicinity properties. Compliance with NEPA for site remedial actions will be accomplished by incorporating those elements required by an EIS into the format of the CERCLA remedial investigation/feasibility study (RI/FS) to produce an RI/FS-EIS, scheduled for completion in January 1994. All field work to support the RI stage of the RI/FS has been completed, and the results are being documented.

2.4 SUMMARY OF REGULATORY COMPLIANCE IN CALENDAR YEAR 1992 (FIRST QUARTER)

In addition to routine environmental monitoring and site surveillance activities conducted during the first quarter of 1992, the surveillance of residential vicinity properties to ascertain the presence of contamination continued; well development and well performance tests were conducted; a sampling effort is being

planned to support the submission of a stormwater permit to NJDEPE by October 1, 1992; and the investigation of soil contamination at the Stepan Company and vicinity properties commenced in March 1992. All of these activities are being conducted in accordance with applicable federal and state requirements.

On March 29, 1992, a gust of wind tore the corner of the pile cover nearest the access gate from the Stepan Company property. No dust from the open section of the cover was observed, and site health physics technicians reported that the exposed soil was compacted and moist. Corrective emergency measures were immediately instituted.

When the health physics technicians arrived at the site, they began high- and low-volume air sampling for gross alpha activity at five downwind sampling locations, which continued while the cover was being repaired. Wind gusts and the weight of the torn cover prevented the cover from being stretched to completely cover the pile. Therefore, small portions of the exposed soil were temporarily covered with plastic that was extended over the unsealed edges of the torn cover, and concrete blocks were placed on top of the seams. The next day the plastic was removed, the cover was stretched back into place, and the seams were resealed. After the cover repairs were completed, air sampling was discontinued. Data from the sampling indicated negligible readings of airborne radioactivity.

3.0 ENVIRONMENTAL PROGRAM INFORMATION

Routine monitoring for radiation, radioactive materials, and chemical substances at MISS 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 mitigating environmental impacts.

The objectives of this report are to:

- Describe efforts to control stored pollutants until future remediation
- Describe the environmental monitoring program
- Report the radiological and nonradiological conditions of the site and surrounding areas during 1991
- Provide comparison of monitoring results with applicable regulations and DOE orders (see Appendix A)
- Provide trend analyses, where applicable, to indicate increases or decreases in environmental impact

To ensure that the environmental monitoring data are of sufficient quality to meet these objectives, all personnel involved in sampling are trained in site-specific requirements and sampling techniques. This training is conducted before each sampling event begins and is followed up by a "lessons learned" analysis after sampling is completed. The environmental monitoring group supervisor is responsible for ensuring that all Oak Ridge support staff and site support personnel are properly trained.

The primary audience for the environmental monitoring results includes the general public; property owners; community interest groups; news media; 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

Requirements for environmental monitoring of radioactive materials in air, surface water, sediment, and groundwater are found in the DOE orders dealing with radiation protection of the public and the environment. Requirements for environmental monitoring of airborne pollutants (radon and other radionuclides) are found in NESHAPs. Requirements for environmental monitoring of nonradiological parameters are found in DOE Order 5400.1 (DOE 1988b). Nonradiological parameters are monitored to obtain basic information on surface water, sediments, and groundwater.

3.1.2 Monitoring Networks

The environmental monitoring networks at MISS are as follows:

- All radon and gamma radiation exposure rate monitoring stations, except background stations, are onsite and accessible only to employees and authorized visitors. These stations are located on or near the property line to allow determination of exposure at the "fenceline" as required by DOE orders.

- All potential routes for migration of contaminants offsite are routinely monitored.

- Background stations are located offsite in areas known to be uncontaminated. Measured background values are compared with site values to determine compliance with DOE orders.

3.2 SUMMARY OF SPECIAL ENVIRONMENTAL ACTIVITIES

During 1991, the environmental activities at MISS consisted of performing the environmental monitoring described in Section 4.0 and 5.0 and conducting analyses for mobile ions and rare earth elements. These analyses were performed on samples collected during the first three quarters of 1991 for use in the Maywood Site remedial investigation. These analytes were investigated because of their relative abundance in naturally occurring monazite ores used in processing operations at the former MCW.

Analytical results show that concentrations of chlorides, nitrates, phosphates, and sulfates in groundwater, surface water, and sediments are generally low, and onsite and downgradient concentrations are comparable to upgradient concentrations. Therefore, contamination by mobile ions is currently not a concern at MISS.

Several rare earth elements were detected at MISS and the Stepan Company property, but there were few obvious locational groupings, and no rare earth elements were prevalent in either deep or shallow wells. The only obvious association between rare earth elements detected in groundwater and a localized source area at MISS is the fairly consistent appearance of cerium, lanthanum, and neodymium in samples from well B38W18D, which is located immediately downgradient of the former thorium processing area. The same three rare earth elements were consistently detected in soil samples from this area.

No rare earth elements were detected in downstream surface water or sediment samples. Only thulium was detected once at the upstream surface water sampling location. This evidence indicates that rare earth elements are not being transported offsite via the surface water and sediment pathways at MISS.

3.3 SELF-ASSESSMENTS

During April 1991, Bechtel National, Inc. (BNI), the project management contractor for FUSRAP, conducted a self-assessment of the environmental monitoring activities at the site. Findings from this self-assessment focused on monitoring techniques, field documentation of monitoring events, and agreement between sampling practices and stated procedures. As a result of this assessment, corrective actions were developed and implemented.

An action remaining open from the 1990 assessments was the development of environmental monitoring plans [required by DOE Order 5400.5 (DOE 1990b)] to document the rationale for the environmental monitoring networks for FUSRAP sites. These plans were published in November 1991.

Any deficiencies identified in self-assessments are processed through the corrective action process established by BNI. Depending on the nature of the deficiency, a corrective action request, nonconformance report, or observation report is used to document the deficiency and begin the corrective action process. The method of identification, documentation, and final corrective action enables the information to be retained and improvements incorporated into the program.

4.0 RADIOLOGICAL ENVIRONMENTAL PROGRAM

MISS is not an active site; thus, the only "effluents" released from the site would be contaminants that migrate by infiltration into groundwater, surface water runoff, or suspension and dispersion into the air.

Radiological environmental monitoring at MISS in 1991 included sampling for:

- Radon (radon-222) and thoron (radon-220) concentrations in air
- External gamma radiation exposure
- Radium-226, radium-228, thorium-232, thorium-230, and total uranium concentrations in surface water, sediment, and groundwater

The monitoring systems included onsite, fenceline, and offsite stations to provide information on the potential effects of the site on human health and the environment. The analytical methods performed on each matrix are presented in Appendix B.

This section of the report contains the quarterly radiological data for each sampling point, yearly averages, and trend information. Although trends are calculated, the limited number of annual data points, the analytical error, and the natural and site variability restrict the representativeness of the expected range. The methodology for calculating the averages and standard deviations is provided in Appendix C. All quarterly data are reported as received from the laboratory; however, the averages 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). Where appropriate, data are presented using powers of ten (e.g., $0.32 = 3.2 \times 10^{-1}$).

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. For computing annual averages, quarterly values reported as less than a given limit of sensitivity are considered equal to that limit.

The following subsections discuss the radiological monitoring program, results for 1991, and any possible radioactive contaminant migration indicated by the results. Concentration trends are also shown in graphical representations, which include up to six of the highest values for each analyte and matrix sampled during the past five years. The scales for these graphs are set to a percentage of the appropriate guideline based on the values of the samples to ensure maximum resolution. Measured background values are also displayed when appropriate.

4.1 ENVIRONMENTAL MONITORING FOR RADIOACTIVE CONTAMINANTS

4.1.1 Radon and Thoron Monitoring

One potential pathway of radiation exposure from the uranium-238 decay series arises from inhalation of the short-lived radionuclides, radon (radon-222) and radon daughter products. Thoron (radon-220) is the short-lived gaseous decay product of the thorium-232 decay series. Radon and thoron are radioactive (alpha-particle-emitting) gases that are very mobile in air. Radon and thoron monitoring is conducted at MISS to measure their concentrations at the site boundary and to demonstrate compliance with environmental regulations. Radon and thoron detectors are maintained at two onsite, ten fenceline, and three offsite (background) locations, as shown in Figures 4-1 and 4-2. The three offsite (background) locations are not shown in these figures because of their distance from the site.

Data and discussion

The maximum quarterly ambient radon concentration detected was 1.4×10^{-9} μCi/ml (0.052 Bq/L) including background, at locations 5 and 8, and annual average concentrations for the entire site ranged

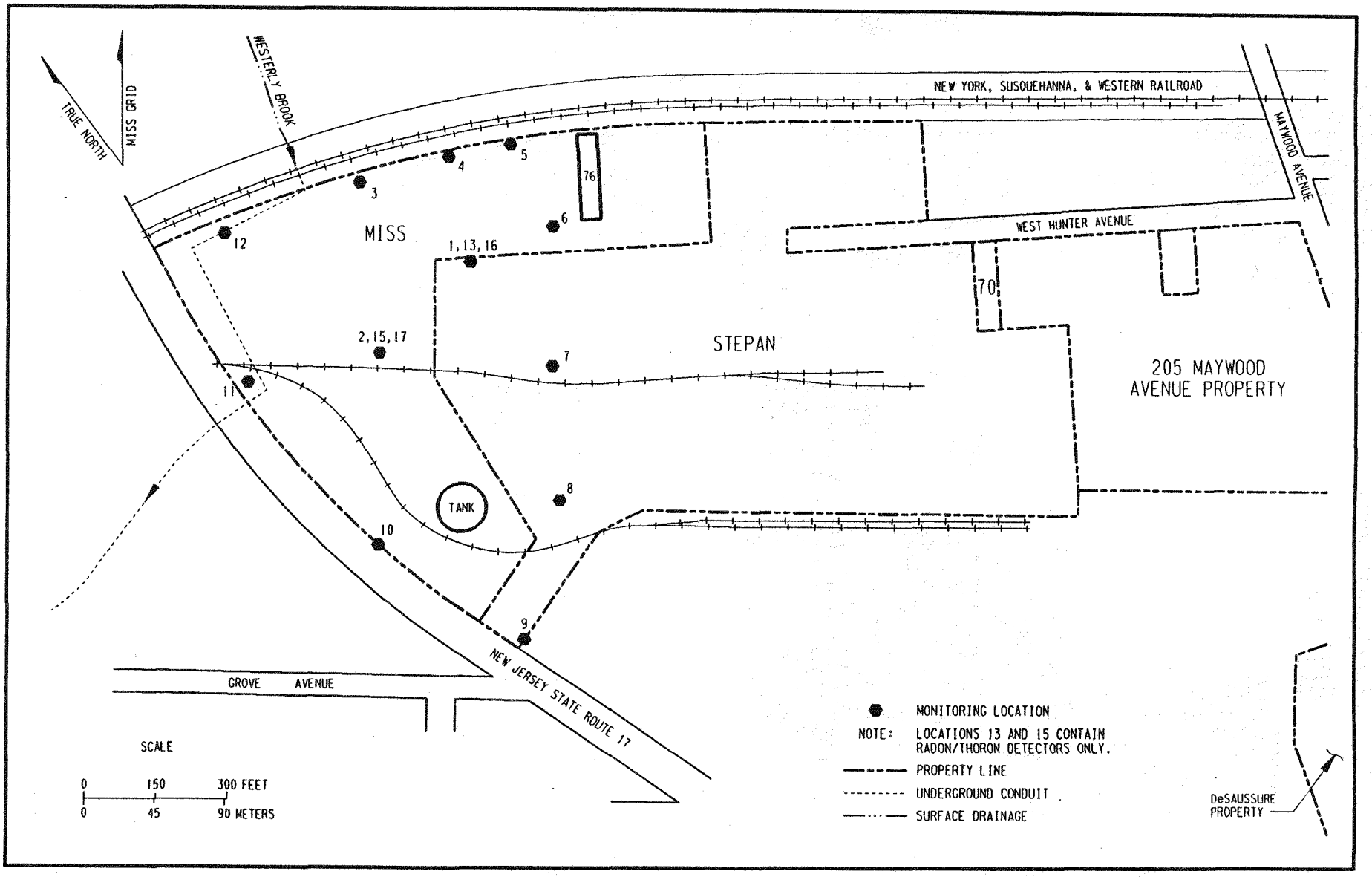


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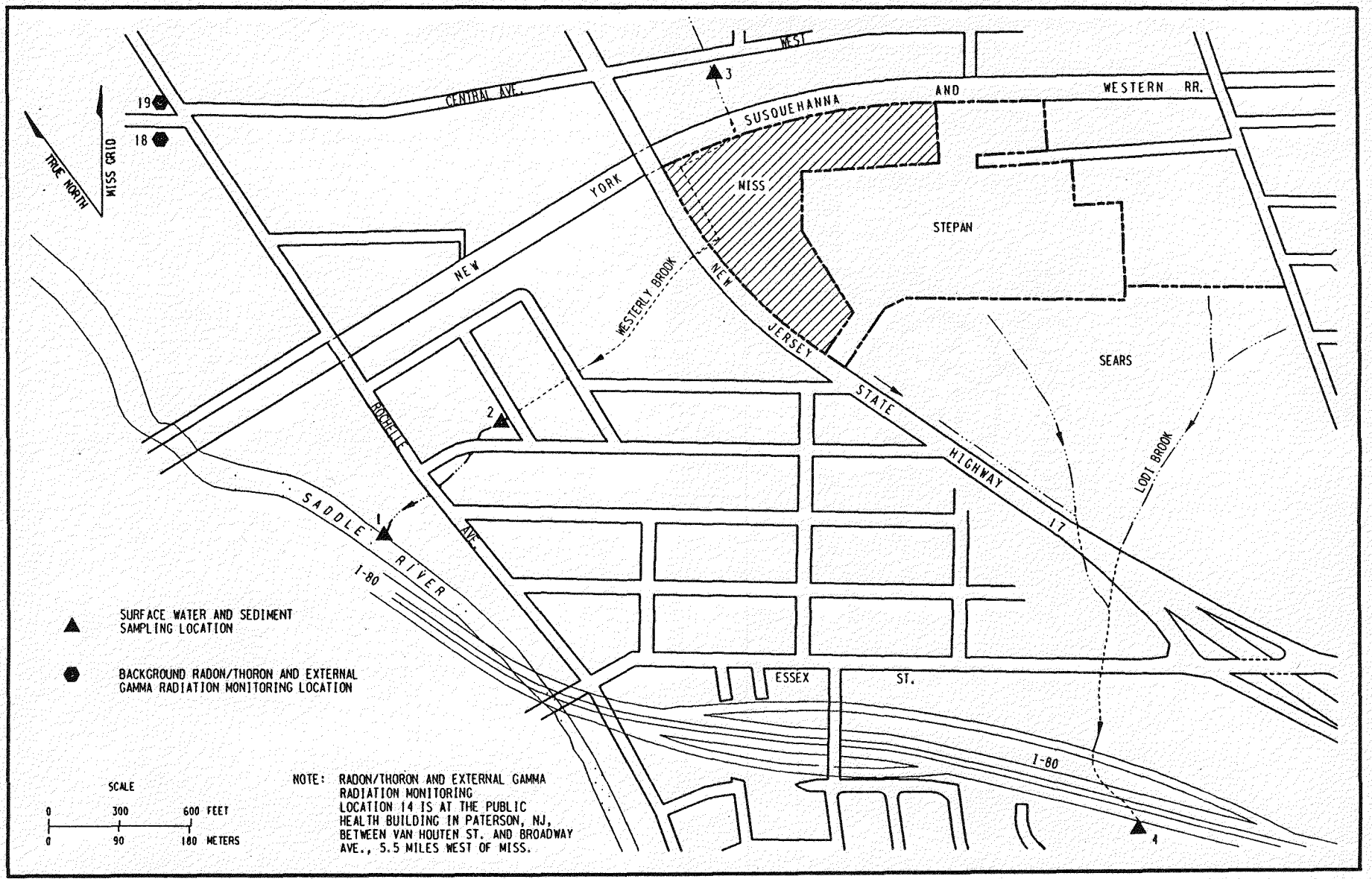
Figure 4-1
Onsite and Fenceline Radon and External Gamma
Radiation Monitoring Locations at MISS



R12F008.DGN

Figure 4-2
Offsite Radon/Thoron, External Gamma Radiation, Surface Water, and Sediment Monitoring Locations in the MISS Area

from 0.4×10^{-9} to 1.2×10^{-9} μCi/ml (0.01 to 0.044 Bq/L) including background (see Table 4-1). No annual average concentration at the fenceline was greater than 40 percent of the DCG of 3.0×10^{-9} μCi/ml (0.11 Bq/L).

The results of radon flux monitoring demonstrate that the MISS pile had an average flux rate of 1.29 pCi/m^2/s (0.047 Bq/m^2/s) with minimum and maximum flux values of less than 0.02 and 36.7 pCi/m^2/s (7×10^{-4} and 1.36 Bq/m^2/s), respectively. The MISS pile is in compliance with the limit of 20 pCi/m^2/s (0.74 Bq/m^2/s) (an averaged value) specified in 40 CFR Part 61, Subpart Q.

The average thoron concentrations detected are presented in Table 4-2. The average thoron concentrations measured around the fenceline ranged from 0.1×10^{-9} to 19.4×10^{-9} μCi/ml (4×10^{-3} to 0.718 Bq/L). DCGs for thoron are being assessed by DOE; until this review has been completed and new guidelines issued, the DCG for radon (3×10^{-9} μCi/ml) can be used for comparison. The average concentration at location 5 exceeded this value by a factor of 6.5, but this does not pose a threat to the public because of the location on the site and the short half-life of thoron.

Trends

Trends in average annual concentrations of radon in air measured from 1986 through 1991 are presented in Table 4-3 and shown in Figure 4-3. All average annual radon concentrations in 1991 fell within expected value ranges. During the past five years, there has been an observable downward trend at locations 5 and 10. The downward trend at location 5 results from additional fill being placed in this area in the fall of 1987. The cause of the downward trend at location 10 is not known. In 1986 and 1987, annual average concentrations at locations 2, 11, and 13 were slightly outside the expected ranges. Since 1988 they have remained within the expected ranges; therefore, they do not appear to be a problem at MISS.

Thoron monitoring was initiated at MISS during 1991 at all previously established radon detector locations; therefore, trend analysis cannot be performed for thoron.

Table 4-1

Average Concentrations[a,b] of Radon at MISS, 1991

Sampling Location[c]	Quarter 1	2	3	4	Avg
	(Concentrations are in 10^{-9} μCi/ml)				
Onsite					
1	<0.9	0.3	<0.3	0.5	0.5
2	<0.9	<0.3	0.5	0.5	0.6
Fenceline					
3	0.9	0.3	0.3	0.5	0.5
4	--[d]	<0.3	0.4	0.8	0.5
5	1.4	0.3	0.8	0.7	0.8
6	<0.9	<0.3	<0.3	0.5	0.5
7	<0.9	0.4	<0.3	0.6	0.6
8	1.4	<0.3	<0.3	0.5	0.6
9	1.1	0.3	<0.4	0.5	0.6
10	1.3	<0.3	<0.3	0.5	0.6
11	<0.9	<0.3	3.0	0.5	1
12	<0.9	<0.3	<0.3	1.4	0.7
Quality Control					
13[e]	<0.9	<0.3	0.5	0.5	0.6
15[f]	<0.9	0.6	<0.3	0.5	0.6
16[e]	<0.9	<0.3	<0.3	0.5	0.5
17[f]	1.1	<0.3	<0.3	0.6	0.6
Background					
14[g]	<0.9	<0.3	--[d]	0.4	0.5
18[h]	<0.9	<0.3	<0.3	0.5	0.5
19[i]	1.1	<0.3	<0.3	0.5	0.6

[a] 1 x 10^{-9} μCi/ml is equivalent to 0.037 Bq/L. The DOE guideline is 3.0 x 10^{-9} μCi/ml.
[b] Measured background has not been subtracted from the fenceline and onsite readings.
[c] Sampling locations are shown in Figures 4-1 and 4-2.
[d] Detector damaged or missing.
[e] Quality control for station 1.
[f] Quality control for station 2.
[g] Located at the Department of Health in Paterson, N.J., approximately 8.8 km (5.5 mi) west of MISS.
[h] Located at the Rochelle Park Fire Station, approximately 0.8 km (0.5 mi) northwest of MISS.
[i] Located at the Rochelle Park Post Office, approximately 0.8 km (0.5 mi) northwest of MISS.

Table 4-2

Average Concentrations[a,b] of Thoron at MISS, 1991

Sampling Location[c]	Quarter 1	2	3	4	Avg
	(Concentrations are in 10^{-9} µCi/ml)				
Onsite					
1	3.15	0	0.6	0.8	1
2	0.94	0.7	1.0	0.8	0.9
Fenceline					
3	0.77	0	0.5	0.2	0.4
4	--[d]	0.8	2.0	1.2	1
5	34.53	6.1	16.8	20.1	19
6	2.19	0.7	2.0	1.4	2
7	0.86	0	1.0	0.1	0.5
8	0.03	0	0.4	0.1	0.1
9	0.30	0.3	0.3	0.6	0.4
10	2.80	0.9	1.6	1.4	2
11	2.16	0.1	0.6	0.9	0.9
12	1.66	0.4	1.9	2.2	2
Quality Control					
13[e]	1.12	0	1.1	0.4	1
15[f]	1.03	0	1.2	1.0	0.8
16[e]	0.59	0.2	0.9	0.6	0.6
17[f]	1.46	0.3	1.1	1.1	1
Background					
14[g]	0	0	--[d]	0	0
18[h]	0.14	0	0	0.2	0.1
19[i]	0	0	0	0.1	0.1

[a] 1 x 10^{-9} µCi/ml is equivalent to 0.037 Bq/L. DCGs for thoron are being assessed by DOE; until this review has been completed and new guidelines are issued, the DCG for radon (3.0 x 10^{-9} µCi/ml) can be used for comparison.

[b] Measured background has not been subtracted from the fenceline and onsite readings.

[c] Sampling locations are shown in Figures 4-1 and 4-2.

[d] Detector damaged or missing.

[e] Quality control for station 1.

[f] Quality control for station 2.

[g] Located at the Department of Health in Paterson, N.J., approximately 8.8 km (5.5 mi) west of MISS.

[h] Located at the Rochelle Park Fire Station, approximately 0.8 km (0.5 mi) northwest of MISS.

[i] Located at the Rochelle Park Post Office, approximately 0.8 km (0.5 mi) northwest of MISS.

Table 4-3

Trend Analysis for Radon Concentrations[a,b] at MISS, 1986-1991

Sampling Location[c]	Average Annual Concentration 1986	1987	1988	1989	1990	Expected Range[d] ($\bar{x} \pm 2s$)	Average Annual Concentration 1991
	(Concentrations are in 10^{-9} μCi/ml)						
Onsite							
1	0.6	0.7	0.6	0.4	0.3	0.1 - 0.9	0.5
2	1.2	1.2	0.9	0.4	0.5	0.2 - 1	0.6
Fenceline							
3	1.2	1.5	0.6	0.4	0.4	0 - 2	0.5
4	1.6	1.1	1.9	0.9	0.6	0 - 2	0.5
5	9.9	9.7	7.4	1.0	2	0 - 10	0.8
6	1.9	2.4	1.4	0.6	0.4	0 - 3	0.5
7	0.9	1.1	0.8	0.6	0.4	0.4 - 1	0.6
8	0.8	1.0	0.4	0.4	0.3	0 - 1	0.6
9	0.9	1.1	0.5	0.5	0.3	0.1 - 1	0.6
10	6.5	4.9	1.0	0.6	0.4	0 - 9	0.6
11	1.3	0.8	0.8	0.5	0.3	0.1 - 1	1
12	2.6	2.3	1.1	0.8	0.3	0 - 3	0.7
Quality Control							
13[e]	1.2	1.1	0.4	0.5	0.5	0.1 - 1	0.6
Background							
14[f]	1.0	0.8	0.3	0.5	0.3	0 - 1	0.5
18[g]	--	--	--	0.4	0.4	0.4 - 0.4	0.5
19[h]	--	--	--	0.4	0.5	0.4 - 0.4	0.6

NOTE: Sources for 1986-1990 data are the annual site environmental reports for those years (BNI 1987, 1988, 1989, 1990a, 1991).

[a] 1×10^{-9} μCi/ml is equivalent to 0.037 Bq/L. The DOE guideline is 3.0×10^{-9} μCi/ml.

Table 4-3

(continued)

[b]Measured background has not been subtracted from fenceline and onsite readings.

[c]Sampling locations are shown in Figures 4-1 and 4-2.

[d]Average value ±2 standard deviations (approximately 95 percent confidence level).

[e]Quality control for station 1.

[f]Located at the Department of Health in Paterson, N.J., approximately 8.8 km (5.5 mi) west of MISS.

[g]Located at the Rochelle Park Fire Station, approximately 0.8 km (0.5 mi) northwest of MISS; established in April 1988.

[h]Located at the Rochelle Park Post Office, approximately 0.8 km (0.5 mi) northwest of MISS; established in April 1988.

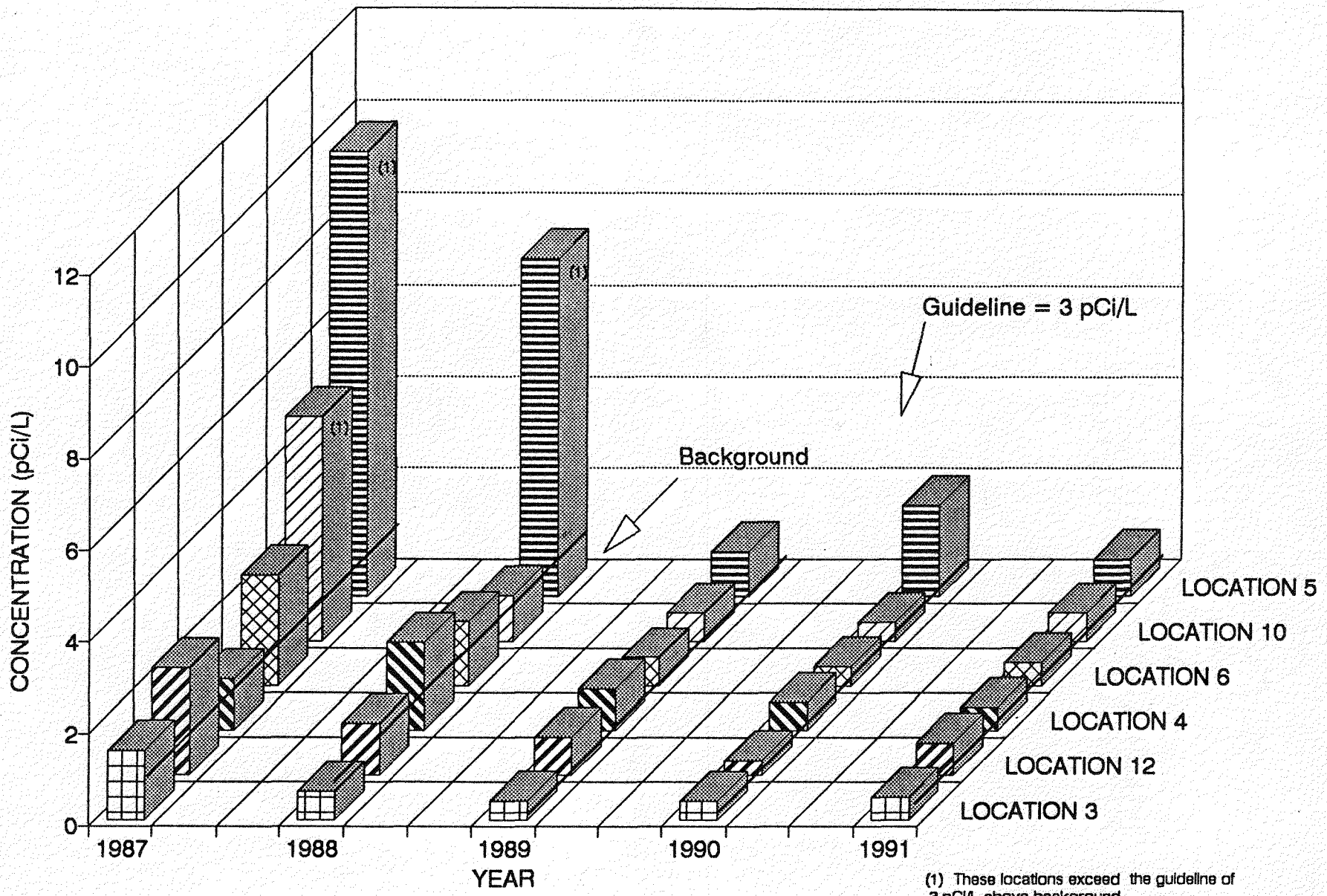


FIGURE 4-3
Average Annual Radon Concentrations at MISS

4.1.2 External Gamma Radiation Exposure Monitoring

External gamma radiation exposure rates are measured as part of the routine environmental monitoring program to confirm compliance with environmental regulations and to determine whether exposure rates are significantly above background. These rates are measured at two onsite, ten fenceline, and three offsite locations, as shown in Figures 4-1 and 4-2. The three offsite background locations are not shown in these figures because of their distance from the site.

Although the tissue-equivalent thermoluminescent dosimeters (TETLDs) used for monitoring are state-of-the-art, the dosimeter accuracy is approximately ±10 percent at exposure rates between 100 and 1,000 mR/yr and ±25 percent at rates between 0 and 70 mR/yr. Therefore, for the low rates that are being monitored at MISS (in the 60 to 120 mR/yr range), there can be seemingly large differences resulting from inaccuracies of detection and the processing system.

The external gamma radiation background value is not constant for a given location or from one location to another, even over a short time, because the value is affected by a combination of both natural terrestrial and cosmic radiation sources and factors such as the location of the dosimeter in relation to surface rock outcrops, stone or concrete structures, or highly mineralized soil. Dosimeters are also influenced by site altitude, annual barometric pressure cycles, and the occurrence and frequency of solar flare activity (Eisenbud 1987). Thus, external gamma radiation exposure rates at the boundary could be less than the background rate measured some distance from the site, and rates onsite could be lower than at the boundary.

Data and discussion

The results of external gamma radiation exposure monitoring are presented in Table 4-4. The annual average exposure rates at MISS in 1991 were 30 mR/yr onsite and 60 mR/yr at the fenceline; these values do not include an average background value of 60 mR/yr. Although the exposure rates at locations 5 and 10 exceeded the

Table 4-4

Average External Gamma Radiation Exposure Rates[a] at MISS, 1991

Sampling Location[b]	Quarter 1	2	3	4	Avg
			(Rates are in mR/yr)		
Onsite (measured background subtracted)[c]					
1	19	24	32	24	25
2	33	0[d]	39	32	30
				Average =	30
Fenceline (measured background subtracted)[c]					
3	23	17	21	23	21
4	98	105	98	70	93
5	130	154	100	101	121
6	33	42	37	39	38
7	4	6	6	8	6
8	8	13	6	14	10
9	8	13	10	16	10
10	167	186	154	104	153
11	35	32	31	27	31
12	78	85	75	53	73
				Average =	60
Quality Control					
13[e]	25	27	24	24	25
15[f]	34	38	33	29	34
16[e]	26	33	19	26	26
17[f]	40	42	36	34	38
				Average =	31
Background					
14[g]	67	70	60	41	60
18[h]	66	75	55	41	59
19[i]	62	70	67	49	62
				Average =	60

[a]The DOE guideline is 100 mrem/yr above background. 1 mrem is approximately equivalent to 1 mR.

[b]Sampling locations are shown in Figures 4-1 and 4-2.

[c]Annual average background has been subtracted from fenceline and onsite readings.

Table 4-4

(continued)

[d]A zero indicates that the measured value was equal to or less than background.

[e]Quality control for station 1.

[f]Quality control for station 2.

[g]Located at the Department of Health in Paterson, N.J., approximately 8.8 km (5.5 mi) west of MISS.

[h]Located at the Rochelle Park Fire Station, approximately 0.8 km (0.5 mi) northwest of MISS.

[i]Located at the Rochelle Park Post Office, approximately 0.8 km (0.5 mi) northwest of MISS.

guideline, they do not pose a threat to the public because the rates are based on the scenario of someone standing at the fence for 24 h/day, 365 days/yr, which is highly unlikely. Information on public exposure can be found in Subsection 4.3.

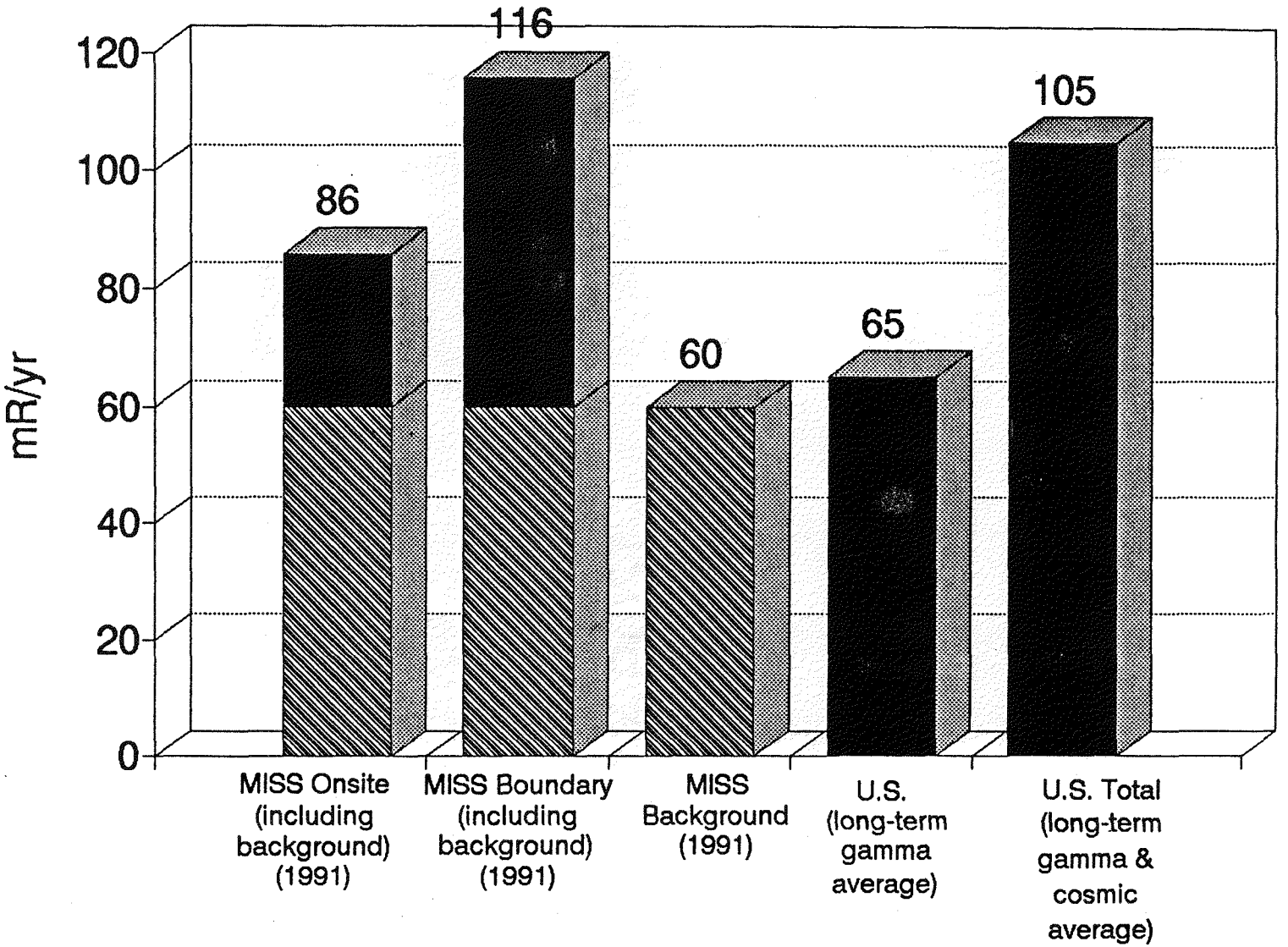
For comparison, Figure 4-4 shows the average annual external gamma radiation exposure rates for locations onsite, at the fenceline, offsite, and across the nation. Based on these data, the radioactive waste stored at MISS does not present a threat to the public from external gamma radiation exposure because the rates are so low and access to the material is restricted.

Trends

Trends in average annual external gamma radiation exposure rates measured from 1986 through 1991 are presented in Table 4-5 and shown in Figure 4-5. 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 an exposure rate at a location consistently falls outside the expected range, then a trend could be present. Although measurements at some locations are consistently higher or lower than others, the only potential trend is in the 1987 to 1989 average annual rates for location 10, which have decreased. Small fluctuations seen from year to year can be attributed to variations in natural background exposure rates and the accuracy of the TETLDs when measuring low exposure rates.

4.1.3 Surface Water Monitoring

Surface water monitoring is conducted to ensure compliance with environmental regulations and to determine whether runoff from MISS contributes to surface water contamination in the area. Sampling locations are shown in Figure 4-2.



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

Source: Martin Marietta Energy Systems, Inc., 1989.

Background

Figure 4-4
External Gamma Radiation Exposure Rates

Table 4-5

Trend Analysis for External Gamma Radiation Exposure Rates[a,b] at MISS, 1986-1991

Sampling Location[c]	Average Annual Rate 1986	1987	1988	1989	1990	Expected Range[d] ($\bar{x} \pm 2s$)	Average Annual Rate 1991
				(Rates are in mR/yr)			
Onsite							
1	41	36	40	28	24	19 - 49	25
2	51	43	52	35	30	23 - 61	26
Fenceline							
3	38	29	21	29	16	10 - 44	21
4	91	69	109	112	80	55 - 129	93
5	172	121	186	154	139	102 - 206	121
6	83	67	85	68	54	45 - 97	38
7	24	36	16	13	9	0 - 41	6
8	18	37	30	9	10	0 - 45	10
9	23	39	32	17	9	0 - 48	12
10	496	521	317	173	150	0 - 679	153
11	50	61	59	35	31	20 - 71	31
12	88	79	106	90	82	68 - 110	73
Quality Control							
13[e]	35	33	39	27	21	17 - 45	25
Background							
14[f]	63	58	78	63	63	50 - 80	60
18[g]	--	--	--	64	64	64 - 64	59
19[h]	--	--	--	56	78	36 - 98	62

NOTE: Sources for 1986-1990 data are the annual site environmental reports for those years (BNI 1987, 1988, 1989, 1990a, 1991).

[a]The DOE guideline is 100 mrem/yr above background. 1 mrem is approximately equivalent to 1 mR.

Table 4-5

(continued)

[b]Average quarterly background has been subtracted from fenceline and onsite readings.

[c]Sampling locations are shown in Figures 4-1 and 4-2.

[d]Average value ±2 standard deviations (approximately 95 percent confidence level).

[e]Quality control for station 1.

[f]Located at the Department of Health in Paterson, N.J., approximately 8.8 km (5.5 mi) west of MISS.

[g]Located at the Rochelle Park Fire Station, approximately 0.8 km (0.5 mi) northwest of MISS; established in April 1988.

[h]Located at the Rochelle Park Post Office, approximately 0.8 km (0.5 mi) northwest of MISS; established in April 1988.

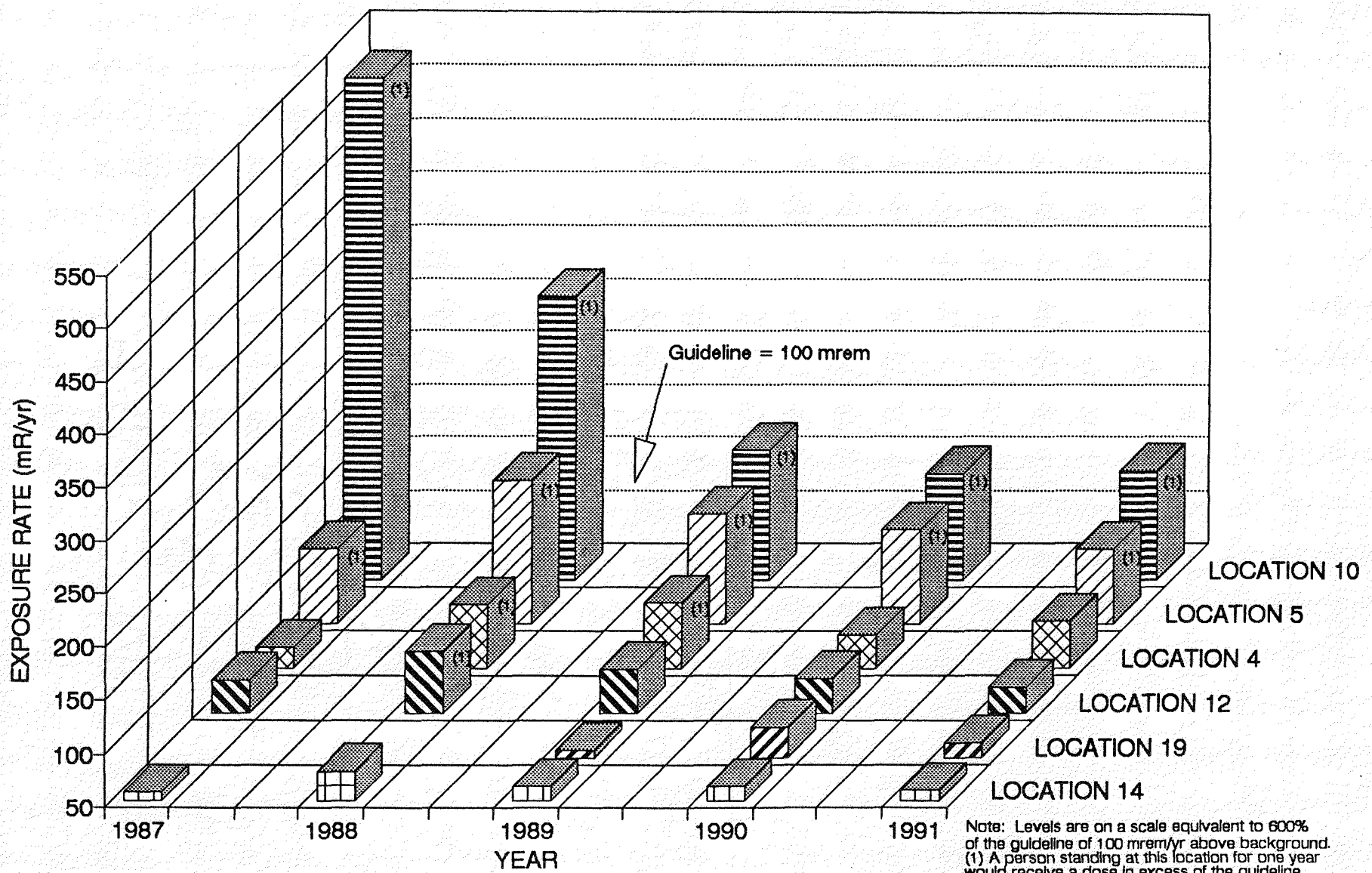


FIGURE 4-5
Average Annual External Gamma Radiation Exposure Rates (above background) at MISS

Data and discussion

Table 4-6 presents 1991 concentrations of total uranium, radium-226, radium-228, thorium-232, and thorium-230 in surface water. The concentrations of these radionuclides approximated natural background levels throughout the year. The site does not appear to be contributing contaminants to offsite areas via the surface water pathway.

Trends

Trends in average annual concentrations of total uranium, radium-226, and thorium-232 measured in surface water from 1986 through 1991 are presented in Table 4-7 and shown in Figures 4-6 through 4-8. Radium-228 and thorium-230 were not analyzed for until 1991. In general, the ranges were fairly consistent among data sets, and quarterly results for 1991 fell within the expected range of values.

4.1.4 Sediment Monitoring

Sediment monitoring is conducted to determine whether contaminants are accumulating in offsite sediment and to ensure compliance with environmental regulations. Sampling locations are shown in Figure 4-2.

Data and discussion

Table 4-8 presents 1991 concentrations of total uranium, radium-226, radium-228, thorium-232, and thorium-230 in sediment. There are no DCGs for radionuclides in sediment; therefore, concentrations of radium-226, radium-228, thorium-230, and thorium-232 in sediment have been compared with FUSRAP soil guidelines, which are listed in Appendix A. No guideline has been established for total uranium.

Radium-226 and radium-228 concentrations remained close to background throughout the year and were below the FUSRAP soil

Table 4-6

Concentrations[a,b] of Total Uranium, Radium-226, Radium-228, Thorium-232, and Thorium-230 in Surface Water at MISS, 1991

Sampling Location[c]	Quarter 1	2	3	4	Avg
	(Concentrations are in 10^{-9} μCi/ml)				
	Total Uranium[d]				
1	1.10	1.33	<3.34	1.04	2
2	1.70	1.28	<3.34	1.41	2
3[e]	0.60	1.77	<3.34	1.08	2
4	--[f]	1.53	<3.34	<1.08	2
	Radium-226				
1	0.30	0.20	0.55	<0.20	0.3
2	0.40	0.16	0.12	0.10	0.19
3[e]	0.40	0.24	0.21	1.60	0.61
4	--[f]	0.18	0.34	0.10	0.21
	Radium-228				
1	<2.4	<1.0	<1.75	<0.5	1
2	<5.0	<1.0	3.94	<0.48	3
3[e]	<12.0	<0.6	<1.26	<4.85	5
4	--[f]	<0.8	5.38	<0.48	2
	Thorium-232				
1	<0.10	<0.20	<0.05	<0.35	0.2
2	<0.10	<0.20	<0.04	0.10	0.1
3[e]	0.10	<0.20	<0.38	0.09	0.2
4	--[f]	<0.10	0.17	0.05	0.1
	Thorium-230				
1	<0.1	<0.1	<0.05	0.95	0.3
2	<0.1	<0.1	<0.04	0.81	0.3
3[e]	0.1	<0.1	<0.38	1.02	0.4
4	--[f]	<0.1	0.12	0.6	0.3

Table 4-6

(continued)

[a]1 x 10^{-9} μCi/ml is equivalent to 0.037 Bq/L. The DOE guidelines for total uranium, radium-226, radium-228, thorium-232, and thorium-230 are 600 x 10^{-9}, 100 x 10^{-9}, 100 x 10^{-9}, 50 x 10^{-9}, and 300 x 10^{-9} μCi/ml, respectively.

[b]Measured background has not been subtracted.

[c]Sampling locations are shown in Figure 4-2.

[d]Total uranium concentrations were determined by using fluorometric analysis during the first three quarters and by kinetic phosphorescence analysis during the fourth quarter.

[e]Upstream background location.

[f]Location dry; no sample taken.

Table 4-7

Trend Analysis for Total Uranium, Radium-226, and Thorium-232 Concentrations[a,b] in Surface Water at MISS, 1986-1991

Sampling Location[c]	Average Annual Concentration 1986	1987	1988	1989	1990	Expected Range[d] ($\bar{x} \pm 2s$)	Average Annual Concentration 1991
	(Concentrations are in 10^{-9} µCi/ml)						
	Total Uranium[e]						
1	<3	<3	3	<5	3	1 - 5	2
2	<3	<3	4.3	<5	4	2 - 6	2
3[f]	<3	<3	3.8	<5	3	2 - 6	2
4[g]	--	--	--	<5	3	--[h]	2
	Radium-226						
1	0.4	0.4	0.4	0.3	0.3	0.3 - 0.5	0.3
2	0.4	0.2	0.3	0.3	0.3	0.2 - 0.4	0.2
3[f]	0.6	0.3	0.3	0.4	0.3	0.1 - 0.7	0.6
4[g]	--	--	--	0.4	0.4	--[h]	0.2
	Thorium-232						
1	<0.1	<0.1	<0.1	0.1	<0.1	0.1 - 0.1	0.2
2	0.1	<0.1	<0.1	<0.1	<0.1	0.1 - 0.1	0.1
3[f]	0.1	<0.1	0.1	<0.1	<0.1	0.1 - 0.1	0.2
4[g]	--	--	--	<0.1	<0.1	--[h]	0.1

NOTE: Sources for 1986-1990 data are the annual site environmental reports for those years (BNI 1987, 1988, 1989, 1990a, 1991).

[a] 1×10^{-9} µCi/ml is equivalent to 0.037 Bq/L. The DOE guidelines for total uranium, radium-226, and thorium-232 are 600×10^{-9}, 100×10^{-9}, and 50×10^{-9} µCi/ml, respectively.

Table 4-7

(continued)

[b]Measured background has not been subtracted.

[c]Sampling locations are shown in Figure 4-2.

[d]Average value ±2 standard deviations (approximately 95 percent confidence level).

[e]Total uranium concentrations were determined by using fluorometric analysis during 1986 through 1990 and the first three quarters of 1991 and by kinetic phosphorescence analysis during the fourth quarter of 1991.

[f]Upstream background location.

[g]Established in July 1989; therefore 1989 value is a result of one sampling effort.

[h]Insufficient data to present meaningful values.

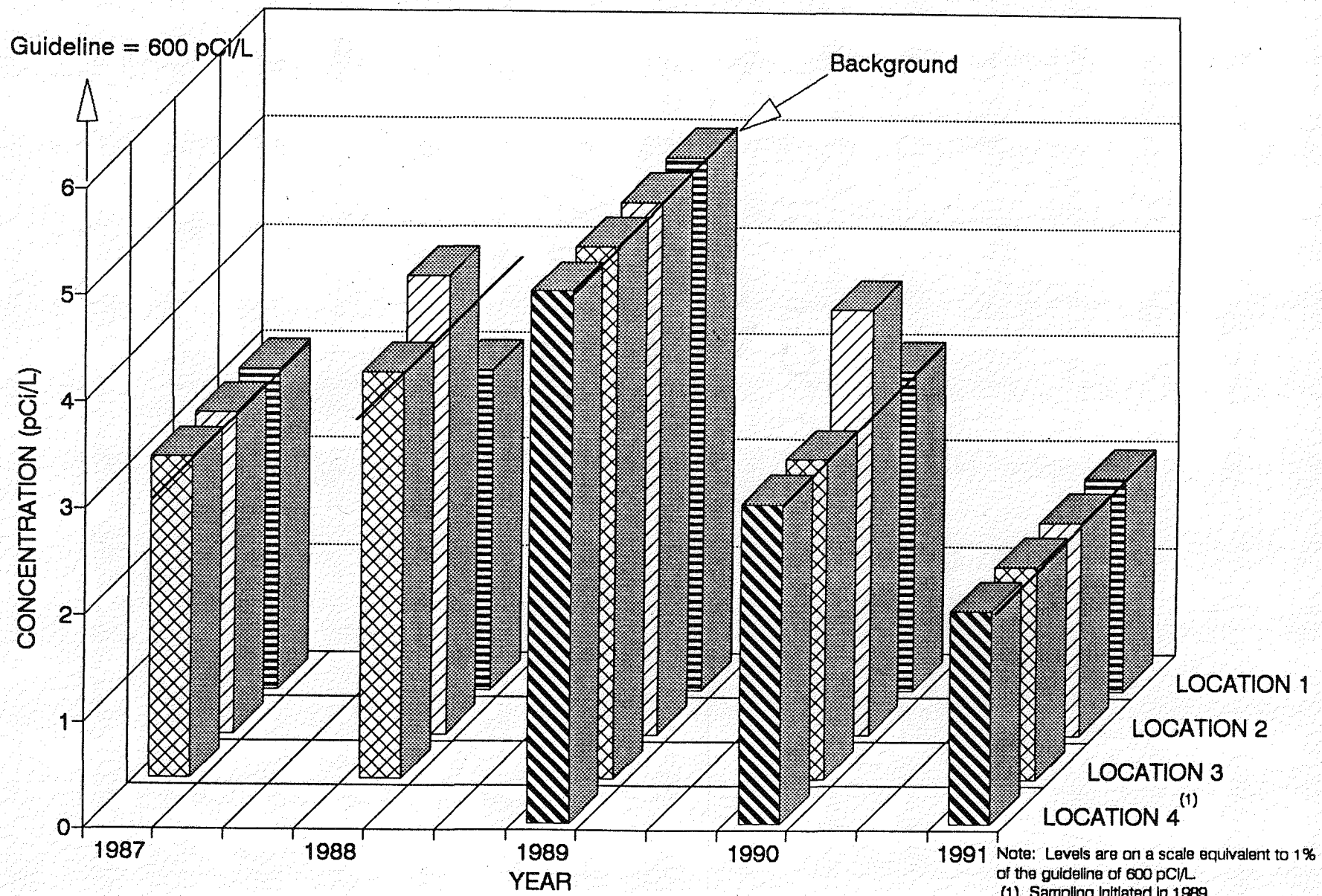
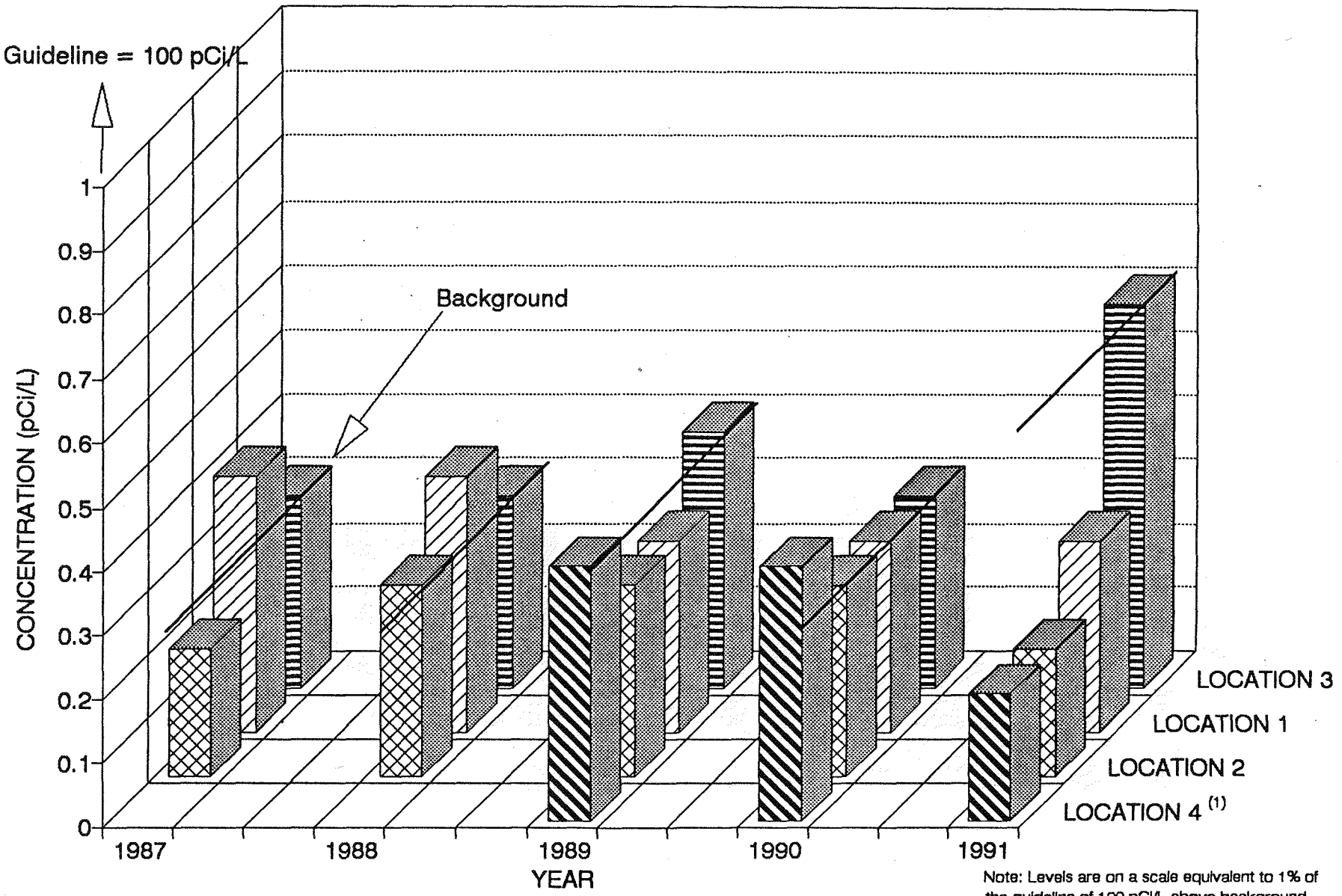


FIGURE 4-6
Average Annual Total Uranium Concentrations in Surface Water at MISS



Note: Levels are on a scale equivalent to 1% of the guideline of 100 pCi/L above background.
(1) Sampling initiated in 1989.

FIGURE 4-7
Average Annual Radium-226 Concentrations in Surface Water at MISS

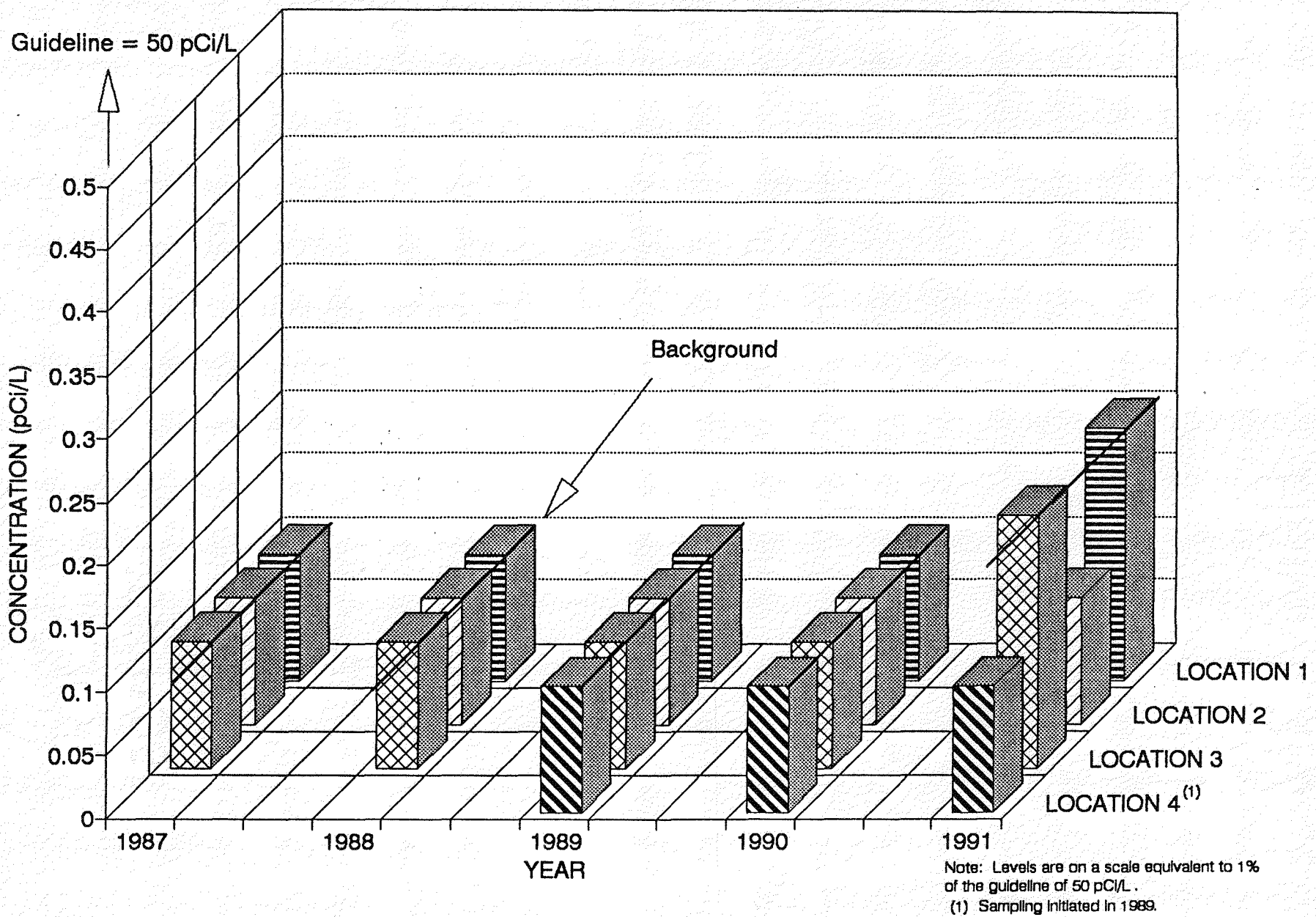


FIGURE 4-8
Average Annual Thorium-232 Concentrations in Surface Water at MISS

Table 4-8

Concentrations[a,b] of Total Uranium, Radium-226, Radium-228, Thorium-232, and Thorium-230 in Sediment at MISS, 1991

Sampling Location[c]	Quarter 1	2	3	4	Avg
(Concentrations are in pCi/g)					
Total Uranium[d]					
1	--[e]	2.10	3.60	3.79	3.2
2	1.0	1.04	1.69	--[f]	1.2
3[g]	--[e]	1.54	2.58	3.33	2.5
4	--[e]	1.33	3.81	5.48	3.5
Radium-226					
1	--[e]	1.20	<0.20	0.86	0.8
2	1.3	0.69	<0.20	--[f]	0.7
3[g]	--[e]	0.80	0.20	0.44	0.5
4	--[e]	0.59	0.20	1.30	0.7
Radium-228					
1	--[e]	4.6	<0.5	1.09	2.1
2	3	<1.1	0.6	--[f]	1.6
3[g]	--[e]	<1.3	<0.5	1.22	1.0
4	--[e]	<1.4	0.5	1.3	1.0
Thorium-232					
1	--[e]	2.30	0.71	1.25	1.4
2	0.8	0.68	0.28	--[f]	0.6
3[g]	--[e]	0.76	0.61	1.11	0.8
4	--[e]	1.21	0.77	11.01	4.3
Thorium-230					
1	--[e]	0.8	<1.1	0.73	0.9
2	0.4	0.4	<0.7	--[f]	0.5
3[g]	--[e]	0.5	<0.9	0.98	0.8
4	--[e]	0.6	1.8	2.64	1.7

Table 4-8

(continued)

[a]1 pCi/g is equivalent to 0.037 Bq/g. The FUSRAP soil concentration guideline for radium-226, radium-228, thorium-232, and thorium-230 is 5 pCi/g. No guideline has been established for total uranium.

[b]Measured background has not been subtracted.

[c]Sampling locations are shown in Figure 4-2.

[d]Total uranium concentrations were determined by using fluorometric analysis during the first three quarters and by kinetic phosphorescence analysis during the fourth quarter.

[e]Sampling location was inaccessible because of ice.

[f]Water level was too high; could not collect sediment sample.

[g]Upstream background location.

guideline of 5 pCi/g. Although some thorium-232 and thorium-230 annual average concentrations exceeded background concentrations, they remained below the FUSRAP soil guideline of 5 pCi/g. In addition, some annual average total uranium concentrations exceeded background concentrations but were below concentrations found in Florida phosphate fertilizers, which range from 6.0 to 58.0 pCi/g. Contaminant migration through sediment transport is not occurring at MISS.

Trends

Trends in average annual radionuclide concentrations measured in sediment from 1986 through 1991 are presented in Table 4-9 and are shown in Figures 4-9 through 4-11. Radium-228 and thorium-230 were not analyzed for until 1991. All average annual concentrations of total uranium, radium-226, and thorium-232 in sediment for 1991 fell within the expected ranges, and concentrations have remained fairly consistent over the past five years.

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.

The groundwater monitoring program is designed to provide sufficient coverage of area groundwater conditions. Two groundwater systems (upper and lower) are monitored in the Maywood area. Wells in the upper groundwater system are identified with an "A" or "S;" those in the lower system are identified with a "B" or "D." Wells B38W01S, B38W02D, and B38W05B are upgradient to establish background conditions; all other wells are downgradient to determine the effect of the site on groundwater in the vicinity (Figure 4-12).

Table 4-9

Trend Analysis for Total Uranium, Radium-226, and Thorium-232 Concentrations[a,b] in Sediment at MISS, 1986-1991

Sampling Location[c]	Average Annual Concentration 1986	1987	1988	1989	1990	Expected Range[d] ($\bar{x} \pm 2s$)	Average Annual Concentration 1991
				(Concentrations are in pCi/g)			
				Total Uranium[e]			
1	1.0	1.2	1.6	1.5	1.0	0.7 - 1.8	3.2
2	1.2	1.1	1.2	0.8	1.0	0.7 - 1.4	1.2
3[f]	0.8	1.1	1.0	1.7	1.0	0.4 - 1.8	2.5
4[g]	--	--	--	1.1	1.0	--[h]	3.5
				Radium-226			
1	0.2	0.4	0.4	0.5	0.4	0.2 - 0.6	0.8
2	0.3	0.3	0.4	0.4	0.5	0.2 - 0.5	0.7
3[f]	0.4	0.4	0.3	0.6	0.5	0.2 - 0.7	0.5
4[g]	--	--	--	0.5	0.5	--[h]	0.7
				Thorium-232			
1	0.7	0.4	0.4	0.3	0.5	0.2 - 0.8	1.4
2	0.7	0.3	0.5	0.3	0.5	0.1 - 0.8	0.6
3[f]	0.4	0.3	0.4	0.3	0.3	0.2 - 0.4	0.8
4[g]	--	--	--	1.5	0.7	--[h]	4.3

NOTE: Sources of 1986-1990 data are the annual site environmental reports for those years (BNI 1987, 1988, 1989, 1990a, 1991).

[a]1 pCi/g is equivalent to 0.037 Bq/g. The FUSRAP soil guideline for radium-226 and thorium-232 is 5 pCi/g. There is no guideline for total uranium.

[b]Measured background has not been subtracted.

Table 4-9

(continued)

[c]Sampling locations are shown in Figure 4-2.

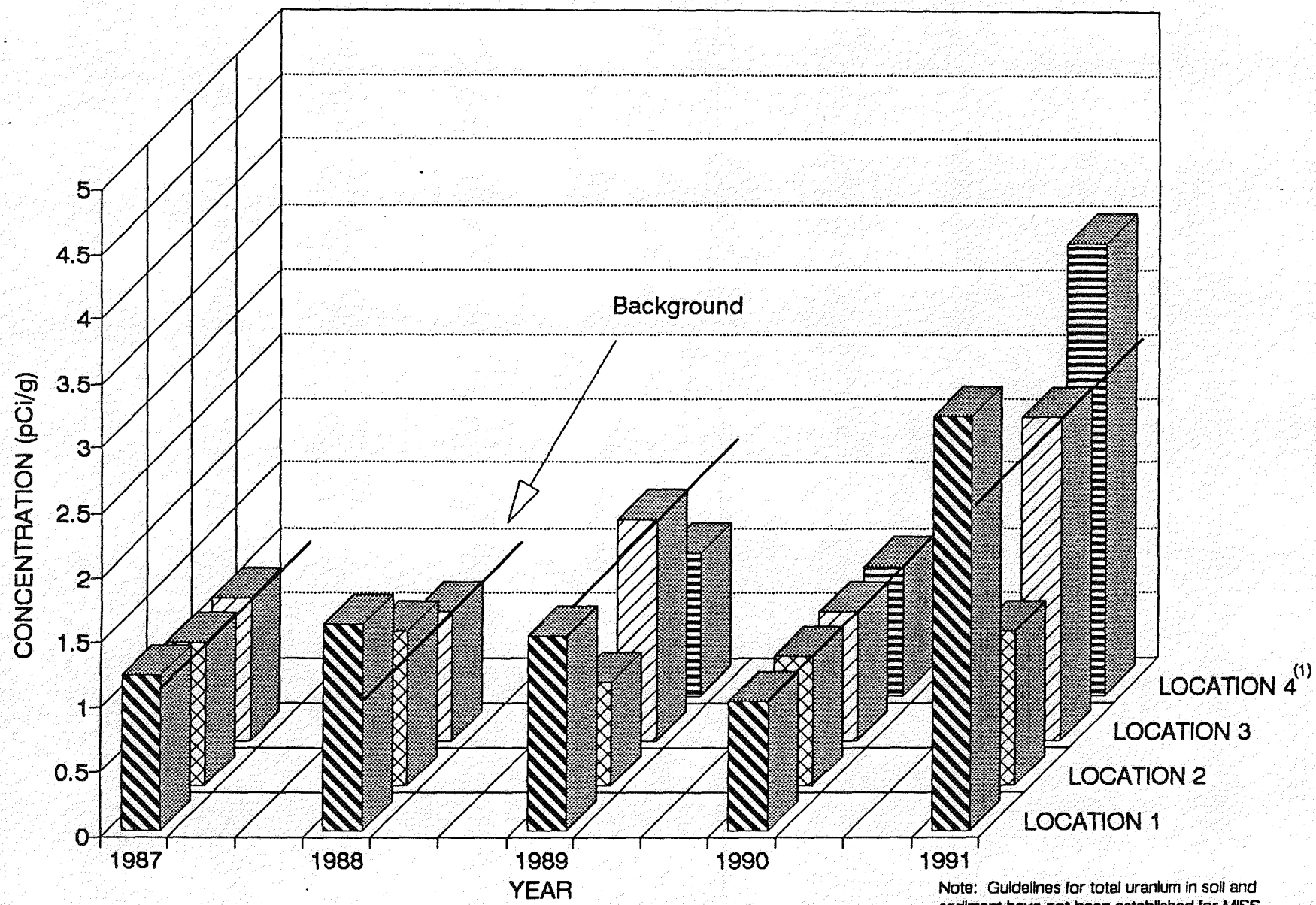
[d]Average value ±2 standard deviations (approximately 95 percent confidence level).

[e]Total uranium concentrations were determined by using fluorometric analysis during 1986 through 1990 and the first three quarters of 1991 and by kinetic phosphorescence analysis during the fourth quarter of 1991.

[f]Upstream background location.

[g]Established in July 1989.

[h]Insufficient data to present meaningful values.



Note: Guidelines for total uranium in soil and sediment have not been established for MISS.
(1) Sampling initiated in 1989.

FIGURE 4-9
Average Annual Total Uranium Concentrations in Sediment at MISS

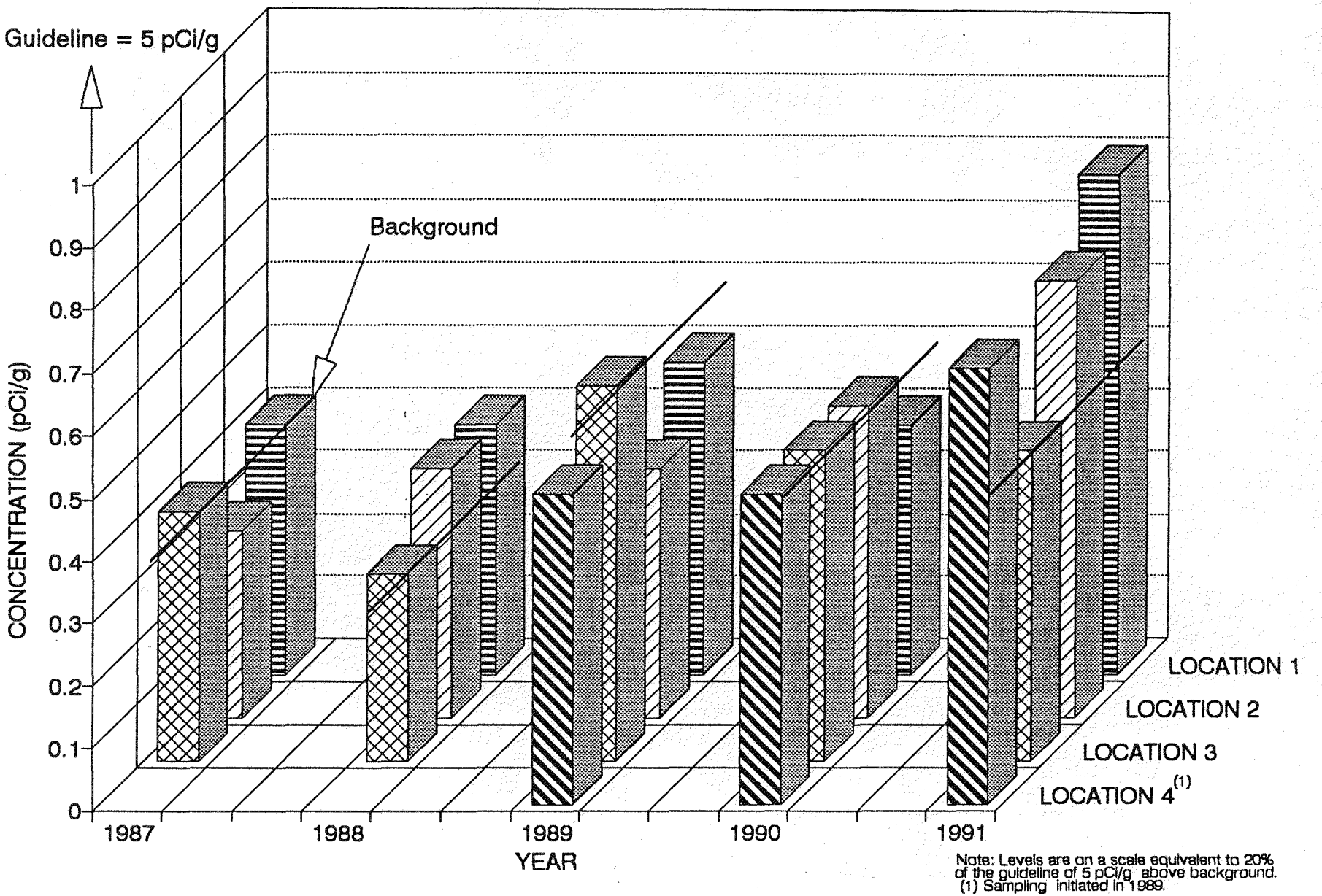
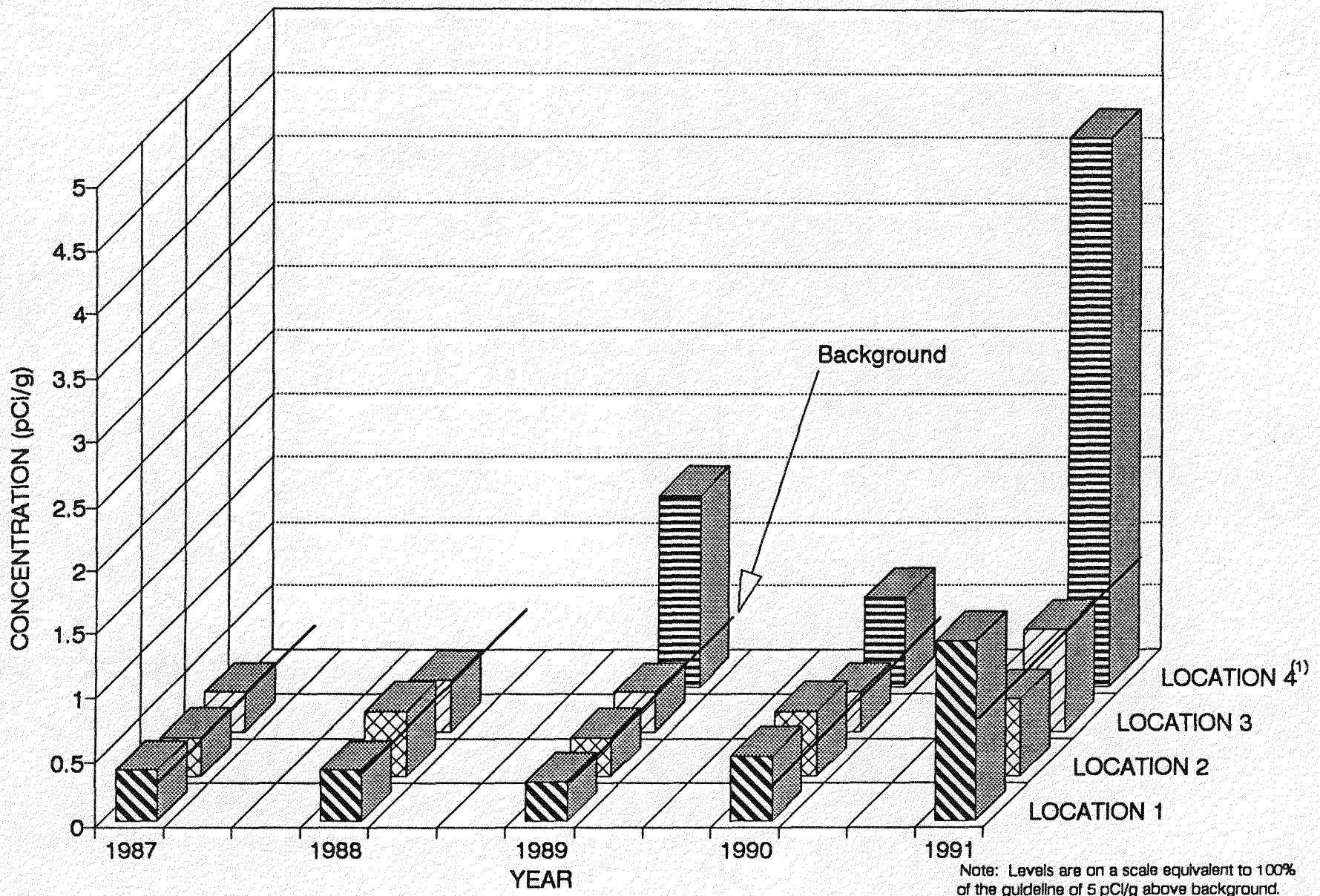


FIGURE 4-10
Average Annual Radium-226 Concentrations in Sediment at MISS



Note: Levels are on a scale equivalent to 100% of the guideline of 5 pCi/g above background.
(1) Sampling initiated in 1989.

FIGURE 4-11
Average Annual Thorium-232 Concentrations in Sediment at MISS

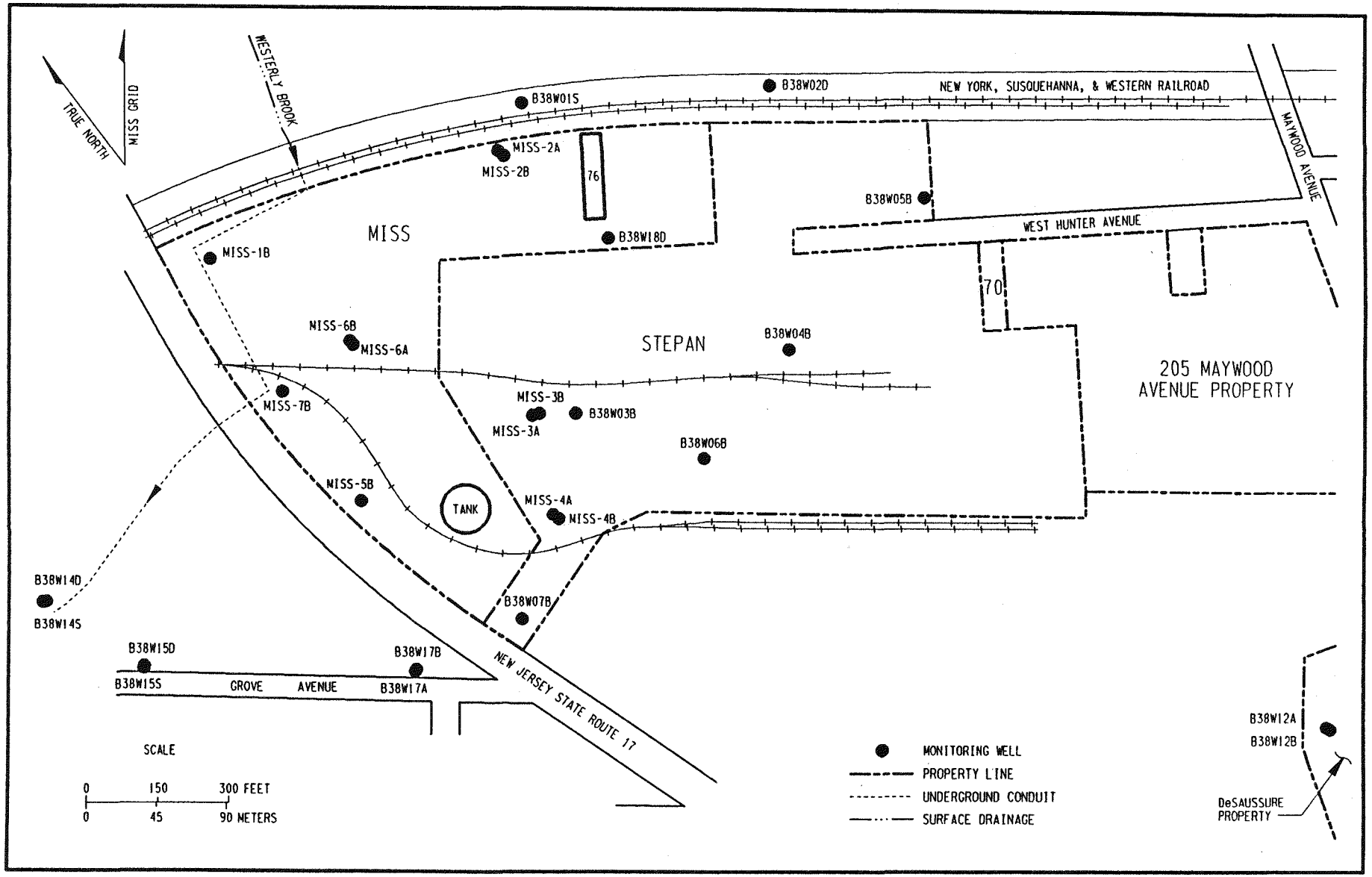


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Figure 4-12
Groundwater Sampling Locations at MISS

Data and Discussion

Table 4-10 presents 1991 concentrations of total uranium, radium-226, radium-228, thorium-232, and thorium-230 in groundwater. Total uranium concentrations were comparable to background levels and well below the DCG of 600 x 10^{-9} μCi/ml (22 Bq/L). Although the average total uranium concentration in well B38W12A was 11.07 x 10^{-9} μCi/ml, it is still well below the DCG of 600 x 10^{-9} μCi/ml. Radium-226 and radium-228 concentrations were comparable to background levels and well below the DCG of 100 x 10^{-9} μCi/ml (3.7 Bq/L). No thorium-230 concentrations exceeded background, and thorium-232 concentrations only slightly exceeded background; all thorium-230 and thorium-232 concentrations were below the DCG of 50 x 10^{-9} μCi/ml (1.9 Bq/L).

Trends

Trends in average annual radionuclide concentrations in groundwater measured from 1986 through 1991 are presented in Table 4-11 and are shown in Figures 4-13 through 4-15. Generally, slightly higher concentrations of uranium, radium, and thorium are found in wells installed in the upper groundwater system within the site boundary, which would be expected for a site such a MISS that is known to contain surface and shallow contamination. Total uranium, radium-226, and thorium-232 concentrations in the deeper wells that are drilled into bedrock have remained relatively constant since monitoring began in 1986.

4.2 UNPLANNED RADIOACTIVE RELEASES

No unplanned radioactive releases occurred at MISS in 1991.

4.3 POTENTIAL DOSE TO THE PUBLIC

This section contains information on exposures to a hypothetical maximally exposed individual and the general public from the radioactive materials at MISS. As expected for a

Table 4-10

Concentrations[a,b] of Total Uranium, Radium-226, Radium-228, Thorium-232, and Thorium-230 in Groundwater at MISS, 1991

Sampling Location[c]	Quarter 1	2	3	4	Avg
(Concentrations are in 10^{-9} µCi/ml)					
Total Uranium[d]					
MISS-1B	<3.39	<3.39	<3.39	1.36	3
MISS-2A	<3.39	<3.39	--[e]	1.79	3
MISS-2B	<3.39	3.72	<3.39	0.31	3
MISS-3A	0.40	--[e]	<3.39	1.16	1
MISS-3B	0.30	<3.39	<3.39	0.74	2
MISS-4A	--[e]	--[e]	--[e]	--[e]	--[e]
MISS-4B	<3.39	<3.39	<3.39	0.08	3
MISS-5B	<3.39	<3.39	<3.39	--[f]	3
MISS-6A	--[e]	--[g]	<3.39	5.93	2
MISS-6B	6.77	<3.39	<3.39	0.50	4
MISS-7B	<3.39	10.16	--[h]	--[f]	5
B38W03B	<3.39	<3.39	<3.39	0.11	3
B38W04B	<3.39	<3.39	--[g]	0.14	2
B38W06B	<3.39	<3.39	6.00	0.07	3
B38W07B	<3.39	5.00	4.06	--[f]	3
B38W12A	12.19	10.70	10.83	10.54	11.07
B38W12B	<3.39	<3.39	<3.39	0.85	3
B38W14S	6.10	3.33	4.06	3.49	4
B38W14D	2.60	7.81	<3.39	2.15	4
B38W15S	<3.39	<3.39	<3.39	1.42	3
B38W15D	<3.39	7.00	6.77	3.90	5
B38W17A	<3.39	4.74	6.77	2.44	4
B38W17B	<3.39	<3.39	<3.39	0.33	3
B38W18D	<3.39	7.79	10.83	7.48	7
Background[i]					
B38W01S	<0.50	--[e]	<3.39	0.87	2
B38W02D	<0.30	0.47	<3.39	0.59	1
B38W05B	<3.39	<3.39	5.42	0.36	3

Table 4-10
(continued)

Sampling Location[c]	Quarter 1	2	3	4	Avg
			Radium-226		
MISS-1B	0.70	0.13	0.43	<0.10	0.3
MISS-2A	0.40	0.23	--[e]	1.90	0.84
MISS-2B	0.10	0.79	<0.07	<0.10	0.3
MISS-3A	1.00	--[e]	3.66	2.80	1.87
MISS-3B	0.10	0.13	0.15	1.20	0.40
MISS-4A	--[e]	--[e]	--[e]	--[e]	--[e]
MISS-4B	0.60	0.39	0.46	0.30	0.44
MISS-5B	0.30	0.21	<0.08	--[f]	0.2
MISS-6A	--[e]	--[g]	0.43	1.50	0.97
MISS-6B	0.80	0.28	0.36	1.20	0.66
MISS-7B	0.30	0.30	--[h]	--[f]	0.20
B38W03B	0.20	0.20	0.15	0.20	0.19
B38W04B	0.60	0.70	--[g]	0.90	0.55
B38W06B	0.30	0.30	0.25	0.70	0.39
B38W07B	0.20	0.10	0.19	--[f]	0.16
B38W12A	1.20	0.12	0.54	0.10	0.49
B38W12B	0.50	0.20	0.15	0.30	0.29
B38W14S	3.40	0.40	0.44	0.10	1.09
B38W14D	0.30	0.20	0.07	<0.10	0.2
B38W15S	0.40	0.24	0.22	<0.10	0.2
B38W15D	0.30	0.27	0.39	<0.20	0.3
B38W17A	1.80	0.50	0.75	4.60	1.9
B38W17B	0.20	0.29	0.38	0.10	0.24
B38W18D	0.20	0.15	0.21	4.90	1.4
Background[i]					
B38W01S	0.60	--[e]	<0.42	2.80	0.96
B38W02D	0.20	0.19	<0.46	3.80	1.2
B38W05B	0.20	0.20	0.43	0.30	0.28
			Radium-228		
MISS-1B	2.0	--[j]	<2.73	0.57	2
MISS-2A	<1.2	<2.8	--[e]	0.23	1
MISS-2B	<1.2	--[j]	<6.16	<0.5	3
MISS-3A	<2.0	--[e]	<3.83	<4.97	4
MISS-3B	<3.0	<4.5	<3.26	<4.8	4
MISS-4A	--[e]	--[e]	--[e]	--[e]	--[e]

Table 4-10
(continued)

Sampling Location[c]	Quarter 1	2	3	4	Avg
			Radium-228 (cont'd)		
MISS-4B	<1.0	<5.4	<3.87	<0.5	3
MISS-5B	<1.0	<29.0	<3.48	--[f]	12[k]
MISS-6A	--[e]	--[e]	--[h]	<0.5	0.5[l]
MISS-6B	1.7	<4.9	<1.22	<0.5	2
MISS-7B	<1.0	<6.5	--[h]	--[f]	4
B38W03B	1.6	--[j]	<3.26	<0.5	2
B38W04B	--[j]	--[j]	--[j]	<0.5	0.5[l]
B38W06B	2.4	--[j]	3.00	<0.5	2
B38W07B	--[j]	--[j]	<2.96	--[f]	3[l]
B38W12A	4.3	--[j]	<7.78	0.51	4
B38W12B	3.3	--[j]	<2.91	0.5	2
B38W14S	2.0	<4.4	--[e]	<0.5	2
B38W14D	<2.0	<5.0	--[e]	<0.5	3
B38W15S	1.8	<2.9	--[e]	<0.5	2
B38W15D	<1.4	<2.8	--[e]	<0.5	2
B38W17A	--[j]	--[j]	<3.0	<0.5	2
B38W17B	--[j]	--[j]	<3.66	<0.5	2
B38W18D	3.1	<9.0	<3.67	0.98	4
Background[i]					
B38W01S	<1.1	--[e]	--[e]	<4.8	3
B38W02D	<2.0	<2.3	--[e]	<4.97	3
B38W05B	2.0	--[j]	3.48	<0.5	2
			Thorium-232		
MISS-1B	<0.10	<0.10	0.04	0.10	0.09
MISS-2A	0.20	0.13	--[e]	0.23	0.19
MISS-2B	<0.10	0.02	<0.07	<0.28	0.12
MISS-3A	1.70	--[e]	0.27	0.46	0.61
MISS-3B	<0.10	<0.04	<0.04	0.61	0.20
MISS-4A	--[e]	--[e]	--[e]	--[e]	--[e]
MISS-4B	<0.10	<0.03	<0.07	<0.25	0.11
MISS-5B	<0.10	<0.08	<0.03	--[f]	0.07
MISS-6A	--[e]	--[g]	0.72	0.26	0.49
MISS-6B	0.70	1.36	0.16	<0.15	0.6
MISS-7B	<0.10	0.24	--[h]	--[f]	0.11
B38W03B	<0.10	<0.04	<0.03	<0.10	0.07
B38W04B	<0.10	<0.09	--[g]	0.10	0.07
B38W06B	<0.10	<0.05	<0.03	<0.20	0.10
B38W07B	0.10	0.24	0.04	--[f]	0.1

Table 4-10
(continued)

Sampling Location[c]	Quarter 1	2	3	4	Avg
		Thorium-232 (cont'd)			
B38W12A	1.40	1.22	0.89	<0.40	1
B38W12B	<0.10	0.13	<0.04	<0.20	0.1
B38W14S	2.00	0.22	0.39	0.19	0.70
B38W14D	<0.10	0.11	0.06	0.13	0.1
B38W15S	0.40	0.18	0.24	0.06	0.2
B38W15D	<0.10	<0.03	0.06	0.35	0.1
B38W17A	1.20	4.18	0.33	2.86	2.1
B38W17B	<0.10	<0.04	<0.11	0.05	0.08
B38W18D	<0.10	0.77	0.16	3.94	1.2
Background[i]					
B38W01S	0.20	--[e]	<0.03	<0.35	0.2
B38W02D	0.10	<0.14	<0.37	0.26	0.2
B38W05B	<0.10	0.08	<0.03	<0.20	0.1
		Thorium-230			
MISS-1B	--[j]	--[j]	0.04	--[j]	0.04[l]
MISS-2A	--[j]	--[j]	--[e]	--[j]	--[l]
MISS-2B	--[j]	--[j]	<0.04	--[j]	0.04[l]
MISS-3A	0.8	--[e]	0.13	0.74	0.6
MISS-3B	<0.1	<0.1	<0.2	0.49	0.2
MISS-4A	--[e]	--[e]	--[e]	--[j]	--[l]
MISS-4B	--[j]	--[j]	<0.03	--[j]	0.03[l]
MISS-5B	--[j]	--[j]	<0.03	--[j]	0.03[l]
MISS-6A	--[e]	--[e]	0.86	--[j]	0.86[l]
MISS-6B	--[j]	--[j]	0.06	--[j]	0.06[l]
MISS-7B	--[j]	--[j]	--[f]	--[f]	--[l]
B38W03B	--[j]	--[j]	<0.03	--[j]	0.03[l]
B38W04B	--[j]	--[j]	--[j]	--[j]	--[l]
B38W06B	--[j]	--[j]	<0.03	--[j]	0.03[l]
B38W07B	--[j]	--[j]	<0.05	--[f]	0.05[l]
B38W12A	--[j]	--[j]	0.26	--[j]	0.26[l]
B38W12B	--[j]	--[j]	<0.03	--[j]	0.03[l]
B38W14S	1.5	0.2	0.43	<0.5	0.7
B38W14D	<0.1	0.2	<0.03	0.33	0.2
B38W15S	--[j]	--[j]	0.22	--[j]	0.22[l]
B38W15D	--[j]	--[j]	0.12	--[j]	0.12[l]
B38W17A	--[j]	--[j]	0.24	--[j]	0.24[l]
B38W17B	--[j]	--[j]	<0.11	--[j]	0.1[l]
B38W18D	--[j]	--[j]	<0.03	--[j]	0.03[l]

Table 4-10

(continued)

Sampling Location[c]	Quarter 1	2	3	4	Avg
Thorium-230 (cont'd)					
Background[i]					
B38W01S	0.2	--[e]	<0.03	4.64	2
B38W02D	0.1	<0.1	<0.18	1.33	0.4
B38W05B	--[j]	--[j]	<0.03	--[j]	0.03[l]

[a]1 x 10^{-9} μCi/ml is equivalent to 0.037 Bq/L. The DOE guidelines for total uranium, radium-226, radium-228, thorium-232, and thorium-230 are 600 x 10^{-9}, 100 x 10^{-9}, 100 x 10^{-9}, 50 x 10^{-9}, and 300 x 10^{-9} μCi/ml, respectively.

[b]Measured background has not been subtracted.

[c]Sampling locations are shown in Figure 4-12.

[d]Total uranium concentrations were determined by using fluorometric analysis during the first three quarters and by kinetic phosphorescence analysis during the fourth quarter.

[e]Dry well or insufficient sample volume for analysis.

[f]Wellhead inaccessible.

[g]Equipment failure during sampling.

[h]Sample lost in processing.

[i]Upgradient wells.

[j]Analysis not requested.

[k]Value is the result of unacceptably high laboratory detection limits.

[l]Insufficient data for meaningful annual average calculation.

Table 4-11

Trend Analysis for Total Uranium, Radium-226, and Thorium-232 Concentrations[a,b] in Groundwater at MISS, 1986-1991

Sampling Location[c]	Average Annual Concentration 1986	1987	1988	1989	1990	Expected Range[d] ($\bar{x} \pm 2s$)	Average Annual Concentration 1991
(Concentrations are in 10^{-9} μCi/ml)							
Total Uranium[e]							
MISS-1B	1.6	3.3	2.4	2.2	3	2 - 4	3
MISS-2A	0.6	2.4	1.4	2.1	3	0 - 4	3
MISS-2B	0.5	2.1	0.8	1.0	3	0 - 3	3
MISS-3A	0.6	2.0	1.5	1.2	3	0 - 4	1
MISS-3B	0.3	3.3	1.3	0.8	2	0 - 4	2
MISS-4A[f]	--	--	3.9	5.5	3	1 - 7	--
MISS-4B	0.5	2.0	0.7	1.0	3	0 - 3	3
MISS-5B	0.3	1.5	0.7	1.5	3	0 - 3	3
MISS-6A	8.4	12.1	8.4	8.0	6	5 - 13	2
MISS-6B	0.8	2.2	1.1	1.2	3	0 - 4	4
MISS-7B	4.7	5.0	6.3	7.0	4	3 - 7	5
B38W04B[g]	--	--	0.8	0.9	3	0 - 4	2
B38W14S[h]	--	--	--	3.2	3	3 - 3	4
B38W14D[h]	--	--	--	4.1	3	2 - 6	4
B38W15S[h]	--	--	--	2.6	3	2 - 4	3
B38W15D[h]	--	--	--	4.8	4	2 - 6	5
B38W18D[h]	--	--	--	4.8	3	1 - 7	7
Background							
B38W01S[h]	--	--	--	2.0	3	1 - 3	2
B38W02D[h]	--	--	--	2.2	3	2 - 4	1

Table 4-11

(continued)

Sampling Location[c]	Average Annual Concentration 1986	1987	1988	1989	1990	Expected Range[d] ($\bar{x} \pm 2s$)	Average Annual Concentration 1991
				Radium-226			
MISS-1B	0.6	0.4	0.9	1.4	0.7	0 - 2	0.3
MISS-2A	0.5	0.4	1.0	1.3	0.9	0 - 2	0.8
MISS-2B	1.5	0.4	0.7	1.0	0.6	0 - 2	0.3
MISS-3A	0.6	0.6	1.2	1.6	1.0	0 - 2	1.9
MISS-3B	0.5	0.3	0.8	1.0	0.5	0 - 2	0.4
MISS-4A[f]	--	--	2.8	3.8	2.0	1 - 5	--
MISS-4B	0.4	0.5	1.4	1.3	0.7	0 - 2	0.4
MISS-5B	0.2	0.3	0.7	1.0	0.6	0 - 2	0.2
MISS-6A	0.4	0.5	2.0	1.3	0.8	0 - 2	1.0
MISS-6B	0.5	0.3	0.7	0.9	0.5	0.5 - 1	0.7
MISS-7B	0.4	0.3	1.5	0.8	0.5	0 - 2	0.2
B38W04B[g]	--	--	1.0	1.2	0.4	0 - 2	0.6
B38W14S[h]	--	--	--	1.0	0.5	0 - 2	1.1
B38W14D[h]	--	--	--	1.0	0.5	0 - 2	0.2
B38W15S[h]	--	--	--	1.2	0.8	0 - 1	0.2
B38W15D[h]	--	--	--	0.7	0.5	0.7 - 1	0.3
B38W18D[h]	--	--	--	0.7	0.5	0.7 - 1	1.4
Background							
B38W01S[h]	--	--	--	1.1	0.7	0 - 2	1.0
B38W02D[h]	--	--	--	0.9	1.0	0.9 - 1	1.2

Table 4-11

(continued)

Sampling Location[c]	Average Annual Concentration 1986	1987	1988	1989	1990	Expected Range[d] ($\bar{x} \pm 2s$)	Average Annual Concentration 1991
				Thorium-232			
MISS-1B	<0.2	<0.3	<0.3	<0.3	0.3	0.2 - 0.4	0.1
MISS-2A	<0.2	<0.1	0.4	0.5	0.3	0 - 0.6	0.2
MISS-2B	<0.2	<0.1	<0.3	0.3	0.2	0 - 0.4	0.1
MISS-3A	<0.2	<0.1	0.7	0.5	0.3	0 - 0.9	0.6
MISS-3B	<0.1	<0.2	<0.3	<0.2	0.1	0 - 0.4	0.2
MISS-4A[f]	--	--	1.6	3.4	2	0 - 4	--
MISS-4B	<0.1	<0.1	<0.2	<0.2	0.2	0.1 - 0.3	0.1
MISS-5B	<0.1	<0.1	<0.2	<0.3	0.1	0 - 0.4	0.1
MISS-6A	0.1	0.3	<0.2	0.5	0.4	0 - 0.6	0.5
MISS-6B	<0.2	<0.1	0.3	<0.2	0.1	0 - 0.4	0.6
MISS-7B	<0.2	<0.1	<0.3	<0.2	0.2	0.1 - 0.3	0.1
B38W04B[g]	--	--	<0.2	<0.2	0.1	0.1 - 0.3	0.1
B38W14S[h]	--	--	--	0.4	0.2	0 - 0.6	0.7
B38W14D[h]	--	--	--	0.3	0.2	0.2 - 0.4	0.1
B38W15S[h]	--	--	--	0.5	0.2	0 - 0.8	0.2
B38W15D[h]	--	--	--	<0.2	0.1	0.1 - 0.3	0.1
B38W18D[h]	--	--	--	0.3	0.1	0 - 0.5	1.2
Background							
B38W01S[h]	--	--	--	0.2	0.2	0.2 - 0.2	0.2
B38W02D[h]	--	--	--	0.3	0.8	0 - 2	0.2

NOTE: Sources for 1986-1990 data are the annual site environmental reports for those years (BNI 1987, 1988, 1989, 1990a, 1991).

[a] 1×10^{-9} μCi/ml is equivalent to 0.037 Bq/L. DOE guidelines for total uranium, radium-226, and thorium-232 are 600×10^{-9}, 100×10^{-9}, and 50×10^{-9}, respectively.

Table 4-11

(continued)

[b]Measured background has not been subtracted.

[c]Sampling locations are shown in Figure 4-12. Well numbers B38W03B, B38W06B, B38W07B, B38W12A, B38W12B, B38W17A, and B38W17B are not included in this trend table because they were not sampled before 1991.

[d]Average value ±2 standard deviations (approximately 95 percent confidence level).

[e]Total uranium concentrations were determined by using fluorometric analysis during 1986 through 1990 and the first three quarters of 1991 and by kinetic phosphorescence analysis during the fourth quarter of 1991.

[f]Shallow well used to monitor groundwater in unconsolidated material; frequently does not contain water.

[g]Installed in April 1988.

[h]Installed in late 1988.

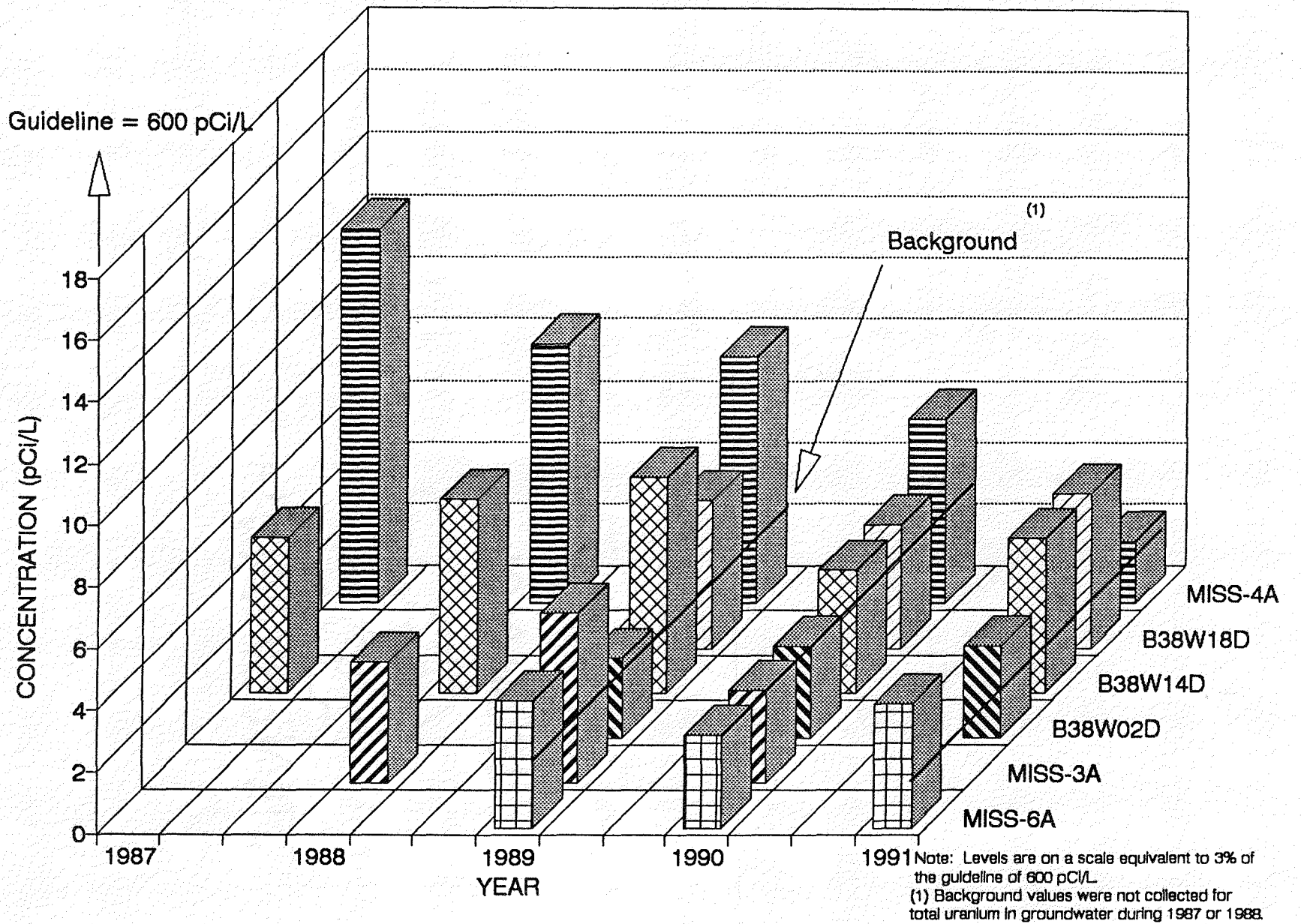

FIGURE 4-13
Average Annual Total Uranium Concentrations in Groundwater at MISS

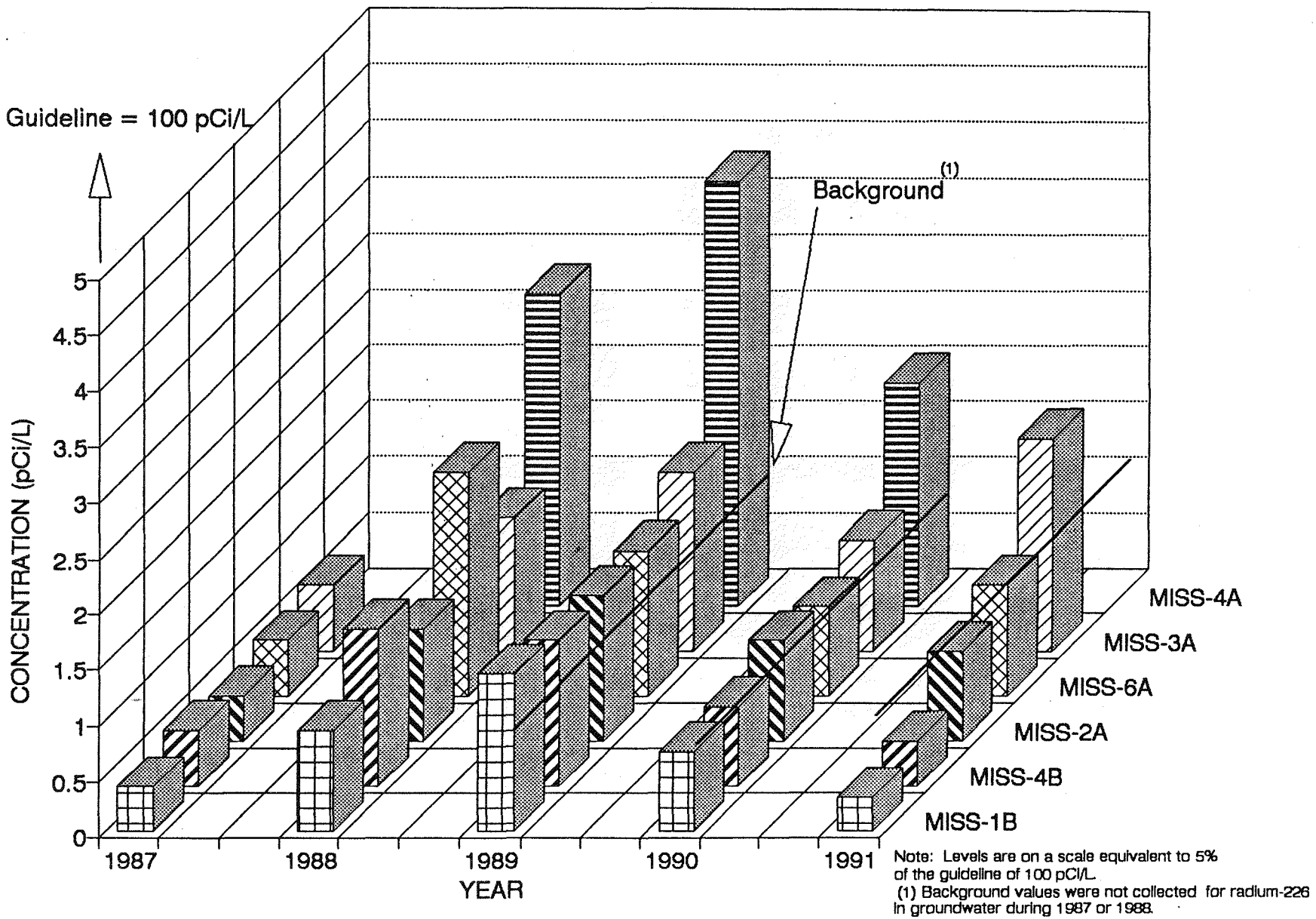

FIGURE 4-14
Average Annual Radium-226 Concentrations in Groundwater at MISS

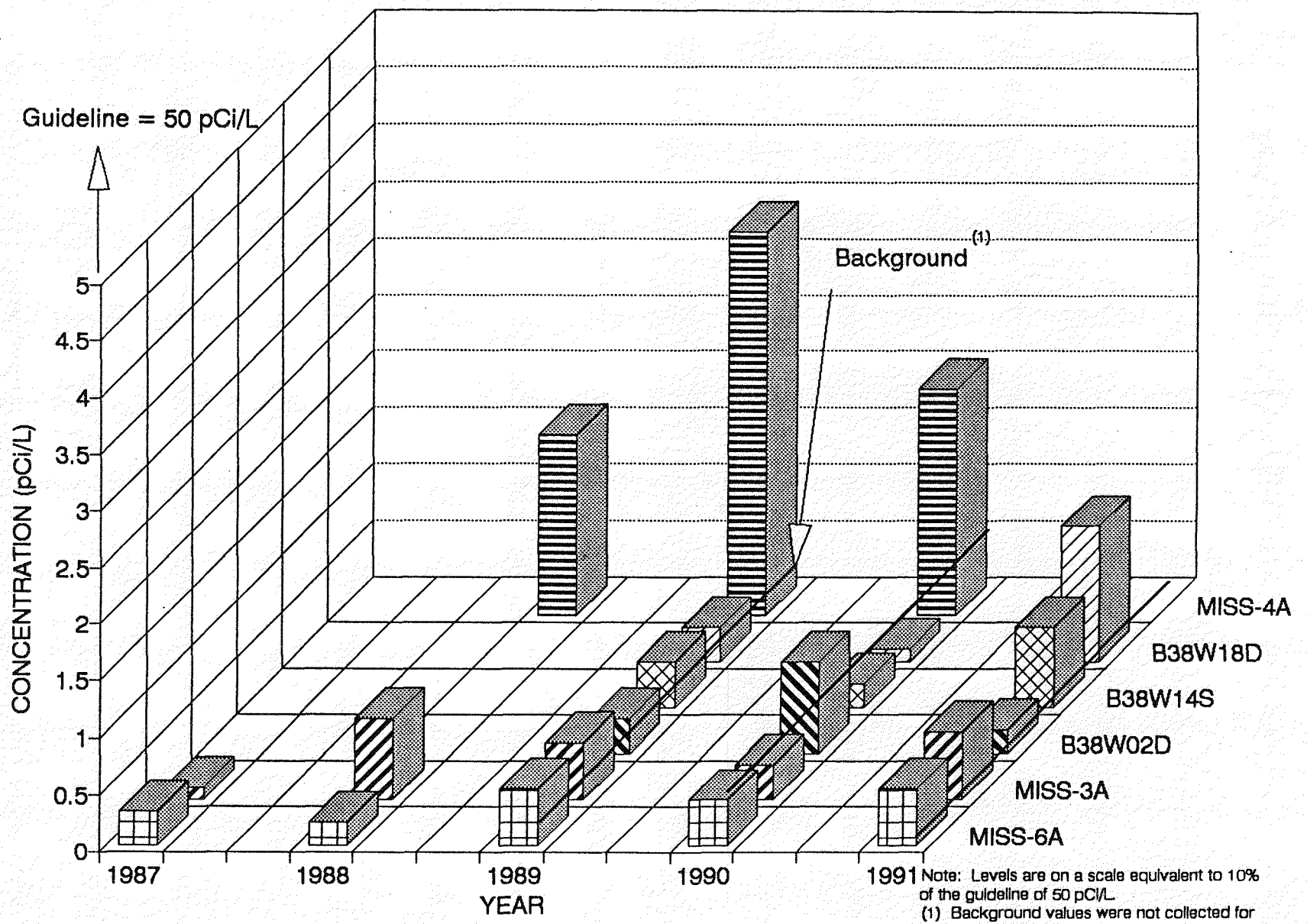

FIGURE 4-15
Average Annual Thorium-232 Concentrations in Groundwater at MISS

relatively stable site such as MISS, all calculated doses were well 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 MISS, 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 pathways considered are surface water, groundwater, air, and direct exposure. All doses presented in this section are estimates and do not represent actual doses. A summary is provided in Table 4-12.

4.2.1 Hypothetical Maximally Exposed Individual

The hypothetical maximally exposed individual is assumed to live 45 m (150 ft) from the northern fenceline of the site. This is an extremely conservative approach because it does not account for any shielding from the building, and it assumes that the individual spends 100 percent of his or her time at the property for an entire year. Using this assumption, the following doses have been calculated.

Direct gamma radiation pathway

The potential annual dose to a hypothetical maximally exposed individual was calculated using the equation given in Appendix D for direct gamma radiation exposure. The calculated dose for this individual is 1.2 mrem/yr (0.012 mSv/yr), well below the DOE guideline of 100 mrem/yr (1 mSv/yr) above background.

Table 4-12

Summary of Calculated Doses[a] at MISS, 1991

Exposure Pathway	Dose to Hypothetical Maximally Exposed Individual (mrem/yr)[b]	Collective Dose for Population Within 80 km of Site (person-rem/yr)[b]
Direct gamma radiation[c]	1.2	--[d]
Drinking water	--[d]	--[d]
Ingestion	--[d]	--[d]
Air immersion	--[d]	--[d]
Inhalation[e]	5.0×10^{-3}	1.6[f]
Total	1.2[g]	1.6
Background[h]	60	6.0×10^{5} [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]Contribution to total dose is negligible.

[e]Calculated using EPA's AIRDOS model (Version 3.0, Appendix E). Based on the AIRDOS PC user manual, the 50-yr effective dose equivalent factors were used to determine the committed effective dose equivalent to various critical organs. Therefore, the "mrem/yr" unit of effective dose equivalent from internal deposition of radionuclides should be interpreted as the "50-yr" committed dose equivalent, based on total radiological particulate intake for a given year.

[f]Derived from Table 4-10.

[g]DOE guideline for total exposure to an individual is 100 mrem/yr (DOE 1990b).

[h]Direct gamma radiation exposure only.

[i]Calculated by the following: (60 mrem/yr) (1.0×10^{7} people).

Drinking water pathway

Only one water pathway, either groundwater or surface water, is used to determine the committed dose to the hypothetical maximally exposed individual. This individual would obtain 100 percent of his or her drinking water from either surface water or groundwater in the vicinity of the site. Because concentrations of total uranium, radium-226, and thorium-232 in surface water and groundwater in the vicinity of MISS are essentially indistinguishable from normal background concentrations, the contribution of these radionuclides to the total dose is negligible.

Air pathway (ingestion, air immersion, inhalation)

Air doses determined using EPA's AIRDOS model were found to be negligible [5.0×10^{-3} mrem/yr (5.0×10^{-5} mSv/yr)], well below the 10 mrem/yr regulatory limit given in 40 CFR Part 61, Subpart E. The 1991 Clean Air Act compliance report is provided in Appendix H; the appendix also gives the calculated amount of each primary radionuclide of concern released to the air in 1991.

Total dose

The total dose for the hypothetical maximally exposed individual is the sum of the 50-yr committed effective dose equivalent and the external effective dose equivalent, based on the total estimated radioactive particulates released in 1991 and the effective dose equivalent due to total external direct gamma radiation measured at the fenceline in 1991. When these doses are added together, the total dose is 1.2 mrem/yr (1.2×10^{-2} mSv/yr). This dose is comparable to the dose an individual would receive from a three-hour flight at 12,000 m (39,000 ft) (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 was also calculated.

Direct gamma radiation pathway

Distance from the site to the nearest residential areas and the presence of intervening structures reduce direct gamma radiation exposure from MISS. Given the previously calculated low doses that the hypothetical maximally exposed individual would receive from direct gamma radiation (approximately 1.2 percent of the DOE exposure limit), the dose to the general public farther from the site would be extremely small.

Drinking water pathway

Because there were no elevated levels of any of the radionuclides of concern detected in either surface water or groundwater, there should be no dose to the general public from either of these pathways.

Air pathway (ingestion, air immersion, inhalation)

The AIRDOS model provides an effective dose equivalent for contaminants transported via the atmospheric pathway at different distances from the site (Table 4-13). Using these effective dose equivalents and the population density, the collective dose for the general population within 80 km (50 mi) of the site was calculated to be 1.6 person-rem/yr (0.016 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 total population dose is the air, the total population dose (Table 4-13) is equal to that for the air pathway

Table 4-13

Maximum Effective Dose to the General Public from MISS, 1991

Distance from the Site (m) (inner radius) (outer radius)	Effective Dose Equivalent (mrem/yr)[a,b]	Population Dose (person-rem/yr)[c,d]
0 - 1,000	5.0×10^{-3} *	0.06
1,000 - 3,000	7.0×10^{-4}	0.07
3,000 - 10,000	1.1×10^{-4}	0.12
10,000 - 80,000	1.7×10^{-5}	1.31
	Total Dose	1.56

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

[b]Values were obtained using AIRDOS (Appendix E). Note: 1 mrem/yr is equivalent to 0.01 mSv/yr.

[c]A population density of 10,000 persons/mi^2 (3,900 persons/km^2) was used in the calculation.

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

*Effective dose equivalent for 300 m.

[1.6 person-rem/yr (0.016 person-Sv/yr)]. The collective population dose is extremely small when compared with the collective population dose due to natural background gamma radiation (Table 4-12) in the area [6.0 x 10^5 person-rem/yr (6.0 x 10^3 person-Sv/yr)] for the same population within 80 km (50 mi) of MISS.

5.0 NONRADIOLOGICAL ENVIRONMENTAL PROGRAM

The environmental monitoring program at MISS includes surface water, sediment, and groundwater monitoring for nonradiological parameters.

Surface water and groundwater samples were analyzed for the indicator parameters total organic carbon, total organic halides, pH, and specific conductivity; mobile ions; organic compounds; and a suite of metals. Sediments were analyzed for metals. The indicator parameters are not addressed in this report because they are only gross indicators of ambient water quality; the parameters indicate that the groundwater and surface water associated with MISS is of a quality that might be expected in an area of mixed residential/commercial establishments.

Nonradiological parameters are monitored as specified by EPA requirements; DOE directives; and federal, state, and local statutes, regulations, and requirements applicable to DOE.

MISS is not an active site; therefore, the only "effluents" from the site would be contaminants that migrate by routes such as infiltration into groundwater, surface water runoff, or suspension and dispersion of airborne contaminants. Based on current site information, very limited nonradiological contamination of the soil exists in localized areas and does not pose a potential threat to human health or the environment.

Tables 5-1 and 5-2 give laboratory detection limits for the metals and volatile and semivolatile organic compound analyses performed on samples from MISS. Several metals identified at the site (e.g., calcium, potassium, sodium, magnesium, and manganese) were not considered because of the variability in their relative abundance in undisturbed soils and their ambient occurrence in the earth's crust.

To determine whether any metals have been released to the environment or are at concentrations potentially harmful to human health and the environment, comparisons were made between downgradient locations and upgradient (background) locations to detect any concentrations significantly (greater than ten times) above known background concentrations. Only the results for

Table 5-1

Laboratory Detection Limits for Metals Analyses of Surface Water, Sediment, and Groundwater at MISS

Analyte	Laboratory Detection Limit for Sediment (mg/kg)	Laboratory Detection Limit for Water (µg/L)
Aluminum	40	200
Antimony	12	60
Arsenic		
(ICPAES[a] scan)	100	500
(Atomic absorption)	2	10
Barium	40	200
Beryllium	1	5
Boron	20	100
Cadmium	1	5
Calcium	1,000	5,000
Chromium	2	10
Cobalt	10	50
Copper	5	25
Iron	20	100
Lead		
(ICPAES scan)	100	500
(Atomic absorption)	1	5
Lithium	20	100
Magnesium	1,000	5,000
Manganese	3	15
Molybdenum	20	100
Nickel	8	40
Potassium	1,000	5,000
Selenium		
(ICPAES scan)	100	500
(Atomic absorption)	1	5
Silver	2	10
Sodium	1,000	5,000
Thallium		
(ICPAES scan)	100	500
(Atomic absorption)	2	10
Vanadium	10	50
Zinc	4	20

[a]ICPAES - Inductively coupled plasma atomic emission spectrophotometry.

Table 5-2
Laboratory Detection Limits for Organic Chemical Analyses of Surface Water and Groundwater at MISS

Compound	Laboratory Detection Limit (µg/L)
Volatile Organic Compounds	
Chloromethane	10
Bromomethane	10
Vinyl chloride	10
Chloroethane	10
Methylene chloride	3
Acetone	10
Carbon disulfide	5
1,1-Dichloroethene	5
1,1-Dichloroethane	5
1,2-Dichloroethene (total)	5
Chloroform	5
1,2-Dichloroethane	5
2-Butanone	10
1,1,1-Trichloroethane	5
Carbon tetrachloride	5
Vinyl acetate	10
Bromodichloromethane	5
1,2-Dichloropropane	5
cis-1,3-Dichloropropene	5
Trichloroethene	5
Dibromochloromethane	5
1,1,2-Trichloroethane	5
Benzene	5
trans-1,3-Dichloropropene	5
Bromoform	5
4-Methyl-1,2-pentanone	10
2-Hexanone	10
Tetrachloroethene	5
1,1,2,2-Tetrachloroethane	5
Toluene	5
Chlorobenzene	5
Ethylbenzene	5
Styrene	5
Xylene (total)	5

Table 5-2

(continued)

Compound	Laboratory Detection Limit (µg/L)
Semivolatile Organic Compounds	
Phenol	10
Bis(2-chloroethyl)ether	10
2-Chlorophenol	10
1,3-Dichlorobenzene	10
1,4-Dichlorobenzene	10
Benzyl alcohol	10
1,2-Dichlorobenzene	10
2-Methylphenol	10
Bis(2-chloroisopropyl)ether	10
4-Methylphenol	10
N-Nitroso-di-n-propylamine	10
Hexachloroethane	10
Nitrobenzene	10
Isophorone	10
2-Nitrophenol	10
2,4-Dimethylphenol	10
Benzoic acid	50
Bis(2-chloroethoxy)methane	10
2,4-Dichlorophenol	10
1,2,4-Trichlorobenzene	10
Naphthalene	10
4-Chloroaniline	10
Hexachlorobutadiene	10
4-Chloro-3-methylphenol	10
2-Methylnaphthalene	10
Hexachlorocyclopentadiene	10
2,4,6-Trichlorophenol	10
2,4,5-Trichlorophenol	50
2-Chloronaphthalene	10
2-Nitroaniline	50
Dimethylphthalate	10
Acenaphthylene	10
2,6-Dinitrotoluene	10
3-Nitroaniline	50
Acenaphthene	10
2,4-Dinitrophenol	50
4-Nitrophenol	50
Dibenzofuran	10
2,4-Dinitrotoluene	10
Diethylphthalate	10
4-Chlorophenyl-phenylether	10
Fluorene	10

Table 5-2

(continued)

Compound	Laboratory Detection Limit (µg/L)
Semivolatile Organic Compounds (cont'd)	
4-Nitroaniline	50
4,6-Dinitro-2-methylphenol	50
N-Nitrosodiphenylamine (1)	10
4-Bromophenyl-phenylether	10
Hexachlorobenzene	10
Pentachlorophenol	50
Phenanthrene	10
Anthracene	10
Di-n-butylphthalate	10
Fluoranthene	10
Pyrene	10
Butylbenzylphthalate	10
3,3'-Dichlorobenzidine	20
Benzo(a)anthracene	10
Chrysene	10
Bis(2-ethylhexyl)phthalate	10
Di-n-octyl phthalate	10
Benzo(b)fluoranthene	10
Benzo(k)fluoranthene	10
Benzo(a)pyrene	10
Indeno(1,2,3-cd)pyrene	10
Dibenzo(a,h)anthracene	10
Benzo(g,h,i)perylene	10

analytes that meet this criterion are included in the tables in this section; all other data are included in Appendix G.

Surface water, sediment, and groundwater samples analyzed for chemical contaminants to date do not comprise a data group sufficient to support a trend analysis.

5.1 SURFACE WATER MONITORING

Analyses of metals show that three of the downstream sampling locations (Figure 4-2) contained lithium, which was not detected in the upstream location. The presence of lithium, a naturally occurring constituent of monazite sands, is attributed to the processing that occurred at the former MCW. Lithium-contaminated soils probably migrated from MISS, extending down to sampling location 1 at the Saddle River. Lithium concentrations are provided in Table 5-3.

Third quarter surface water samples were analyzed for organic compounds; Table 5-4 provides the analytical results. Acetone was detected in three locations, and methylene chloride was detected in all four locations. These compounds were also detected in associated laboratory blanks; therefore, their presence is most likely attributed to laboratory contamination. Chloroform is the only other compound detected in more than two locations, and its concentrations decreased from the upstream location to the downstream locations. This compound is also a common laboratory contaminant and has a volatile nature; therefore, it is unlikely to be persistent in an open stream.

5.2 SEDIMENT MONITORING

Concentrations of metals in downstream sediment samples were comparable to those in upstream samples (see Figure 4-2 for locations); therefore, MISS does not appear to be contributing to metals in sediment.

Table 5-3

Concentrations[a] of Lithium in Surface Water at MISS, 1991

Sampling Location[b]	Quarter 1	2	3	4	Avg
1	227	100[c]	115	438	220
2	305	415	486	709	479
3	100[c]	100[c]	100[c]	100[c]	100
4	--[d]	218	100[c]	100[c]	139

[a]Concentrations are given in units of μg/L.

[b]Location 3 is upstream. Sampling locations are shown in Figure 4-2.

[c]Lithium was analyzed for but not detected above the reported value.

[d]Location dry; no sample taken.

Table 5-4

Concentrations of Organic Contaminants in Surface Water at MISS, 1991 (Third Quarter)

Sampling Location[a]	Analyte	Concentration[b]
1	1,2-dichloroethene (total)	2[c]
	Chloroform	1[c]
	Methylene chloride	2[c,d]
	Tetrachloroethylene	4[c]
2	1,1,1-trichloroethane	1[c]
	1,1-dichloroethane	1[c]
	1,2-dichloroethene (total)	43
	Acetone	3[c,d]
	Chloroform	2[c]
	Methylene chloride	2[c,d]
	Tetrachloroethylene	42
	Trichloroethylene	13
	Vinyl chloride	5[c]
3	Di-n-butylphthalate	1[c]
	Acetone	2[c,d]
	Chloroform	5
	Methylene chloride	7[d]
	Toluene	2[c]
4	Acetone	8[c,d]
	Methylene chloride	3[c,d]

[a]Sampling locations are shown in Figure 4-2.

[b]Concentrations are given in units of µg/L.

[c]An estimated value.

[d]Analyte found in the associated laboratory blank as well as in the sample.

5.3 GROUNDWATER MONITORING

Groundwater monitoring for nonradiological parameters is conducted to provide information on the groundwater quality in the area. Wells B138W01S and B138W02D provide background water quality data for MISS. (Well locations are shown in Figure 4-12.)

Third quarter samples were analyzed for volatile and semivolatile organics; results show some chemical contaminants in both onsite and offsite wells (Table 5-5). Acetone, methylene chloride, di-n-butylphthalate, and bis(2-ethylhexyl)phthalate are the most common compounds detected, but they were also detected in laboratory blanks; therefore, their presence is most likely attributed to laboratory contamination. Vinyl chloride was detected in wells MISS-4B and B38W15S at concentrations of 150 and 190 μg/L, respectively. Most of the organic constituents detected are halogenated solvents used as degreasers, dry cleaning agents, or chemical intermediates. The concentrations of contaminants found in these groundwater samples are typical for an industrial area.

Concentrations of metals that met the criterion of being ten times the background level are presented in Table 5-6. The presence of these metals is sporadic and localized. Aluminum, boron, chromium, iron, lithium, and zinc were detected with regularity; of these metals, only chromium, iron, and lithium were detected at concentrations above the aforementioned criterion. The metals were usually found at similar concentrations in both upgradient and downgradient wells, and no correlation between well location or aquifer sampled and concentration is apparent. Although some metals (notably lead, iron, and copper) were detected in some offsite locations, they do not appear to have originated from MISS.

5.4 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

A permit application to comply with the EPA NPDES requirements will be completed in 1992. Stormwater discharges will be sampled in the third quarter of 1992 to meet the application requirements.

Table 5-5

Concentrations of Volatile and Semivolatile Organic Compounds in Groundwater at MISS, 1991 (Third Quarter)

Sampling Location[a]	Analyte	Concentration[b]
MISS-1B	Di-n-butylphthalate	2[c,d]
	1,2-dichloroethene (total)	2[d]
	Acetone	3[c,d]
	Methylene chloride	2[c,d]
	Tetrachloroethylene	21
	Trichloroethylene	2[d]
MISS-2B	Di-n-butylphthalate	2[c,d]
	Acetone	2[c,d]
	Carbon disulfide	13
	Methylene chloride	1[c,d]
MISS-3A	Bis(2-ethylhexyl)phthalate	8[c,d]
	Di-n-butylphthalate	1[d]
	Phenanthrene	2[d]
	Acetone	5[c,d]
	Methylene chloride	1[c,d]
MISS-3B	Di-n-butylphthalate	2[c,d]
	Acetone	9[c,d]
	Carbon disulfide	7
	Methylene chloride	1[c,d]
MISS-4B	Bis(2-ethylhexyl)phthalate	2[d]
	Di-n-butylphthalate	4[c,d]
	1,2-dichloroethene (total)	41
	Acetone	6[c,d]
	Benzene	23
	Carbon disulfide	6
	Vinyl chloride	150
MISS-5A	Di-n-butylphthalate	2[c,d]
	Methylene chloride	4[d]
MISS-5B	Di-n-butylphthalate	3[c,d]
	Acetone	7[c,d]
	Methylene chloride	4[c,d]
MISS-6A	Endosulfan sulfate	0.14
	Bis(2-ethylhexyl)phthalate	2[d]
	Di-n-butylphthalate	4[c,d]
	Phenol	2[d]
	Acetone	4[c,d]

Table 5-5

(continued)

Sampling Location[a]	Analyte	Concentration[b]
MISS-6B	Di-n-butylphthalate	2[c,d]
	N-nitrosodiphenylamine	4[d]
	Acetone	4[c,d]
	Carbon disulfide	3[d]
MISS-7B	Bis(2-ethylhexyl)phthalate	1[d]
	Di-n-butylphthalate	3[c,d]
	1,1,1-Trichloroethane	1[d]
	1,2-Dichloroethene (Total)	40
	Methylene Chloride	4[c,d]
	Tetrachloroethylene	22
	Trichloroethylene	2[d]
B38W03B	Bis(2-ethylhexyl)phthalate	1[d]
	Di-n-butylphthalate	2[c,d]
	1,2-dichloroethene (total)	2[d]
	Benzene	3[d]
	Methylene Chloride	3[c,d]
	Vinyl Chloride	1[d]
	Xylenes (Total)	3[d]
B38W05B	Alpha Chlordane	0.13[d]
	Dieldrin	0.11
	Gamma Chlordane	0.1[d]
	Bis(2-ethylhexyl)phthalate	2[d]
	Di-n-butylphthalate	3[c,d]
	Methylene Chloride	2[c,d]
B38W06B	Bis(2-ethylhexyl)phthalate	1[d]
	Di-n-butylphthalate	2[c,d]
	Acetone	22
	Benzene	7[d]
	Methylene Chloride	6[d]
B38W07B	Di-n-butylphthalate	2[c,d]
	Acetone	3[c,d]
	Methylene Chloride	5[c]
B38W12A	Bis(2-ethylhexyl)phthalate	3[d]
	Di-n-butylphthalate	1[c,d]
	1,1,1-trichloroethane	1[d]
	Methylene Chloride	12[c]

Table 5-5

(continued)

Sampling Location[a]	Analyte	Concentration[b]
B38W12B	Dieldrin	0.02[d]
	Di-n-butylphthalate	1[c,d]
	Methylene Chloride	5[c]
	Trichloroethylene	4[d]
B38S14D	1,2-dichloroethene (Total)	2[d]
	Acetone	6[c,d]
	Carbon Disulfide	2[d]
	Chloroethane	24
	Tetrachloroethylene	12
	Trichloroethylene	2[d]
B38W14S	Di-n-butylphthalate	1[d]
	Diethylphthalate	2[c,d]
	1,1,1-trichloroethane	5
	1,1-dichloroethane	1[d]
	1,1-dichloroethylene	5
	1,2-dichloroethene (Total)	15
	Acetone	4[c,d]
	Chloroform	2[d]
	Methylene Chloride	1[c,d]
	Tetrachloroethylene	190
	Trichloroethylene	30
	Vinyl Chloride	14
B38S15D	Alpha Chlordane	0.05[d]
	Dieldrin	0.19
	Heptachlor Epoxide	0.02[d]
	1,2-dichloroethene (Total)	4[d]
	Acetone	6[c,d]
	Carbon Disulfide	2[d]
	Chloroform	2[d]
	Methylene Chloride	1[c,d]
	Tetrachloroethylene	4[d]
	Trichloroethylene	1[d]
B38W15S	Di-n-butylphthalate	2[c,d]
	1,1,1-trichloroethane	3[d]
	1,1-dichloroethane	6
	1,2-dichloroethene (Total)	85
	Methylene Chloride	1[c,d]
	Trichloroethylene	1[d]
	Vinyl Chloride	190
B38W17A	Di-n-butylphthalate	2[c,d]
	Methylene Chloride	3[c,d]

Table 5-5

(continued)

Sampling Location[a]	Analyte	Concentration[b]
B38W17B	4,4'-DDD	0.1[e]
	Bis(2-ethylhexyl)phthalate	2[d]
	Di-n-butylphthalate	2[c,d]
	1,2-dichloroethene (Total)	2[d]
	Benzene	6
	Methylene Chloride	2[c,d]
B38W18D	Bis(2-ethylhexyl)phthalate	4[c,d]
	Di-n-butylphthalate	2[d]
	Methylene Chloride	5[c]
Background		
B38W01S	4,4'-DDT	0.01[c,d]
	Gamma-BHC (Lindane)	0.02[d]
	Acetone	15[c]
	Carbon Disulfide	16
	Methylene Chloride	1[c,d]
	Toluene	1[d]
B38W02D	Acetone	3[c,d]
	Methylene Chloride	1[c,d]

[a]Sampling locations are shown in Figure 4-12.

[b]Concentrations are given in units of µg/L.

[c]Compound found in the associated laboratory method blank as well as in the sample.

[d]An estimated value.

[e]Analyte was analyzed for but not detected above the reported value.

Table 5-6

Concentrations[a] of Metals in Groundwater at MISS, 1991

Sampling Location[b]	Metal	Quarter 1	2	3	4	Avg
MISS-2A	Arsenic	5,640	20.0		2,220	1,354.0
	Chromium	22.3	26.1		466	171
	Copper	203	420		171	265
MISS-2B	Lithium	100[c]	12,600	16,700	14,900	11,075
MISS-3B	Iron	8,480	106,000	74,500[d]	21,100	52,520
MISS-6A	Lithium	100[c]	244	12,400	7,210	4,989
B38W04B	Lithium	2,000	2,300		1,670	1,990
B38W06B	Iron	7,820	13,800	12,100	9,020	10,685
B38W12A	Iron	3,740	11,000	24,600	2,770	10,528
B38W14S	Iron	25,300	12,500	510	1,820	10,033
	Lead	62.4[d]	58.0	2.4[d]	14.3	34
B38W15S	Lead	3.0[e]	29.8	49.3[d]	17.1	25
B38W15D	Nickel	8.0[c]	12.3[f]	26.9[d]	40.0[c]	22
B38W17A	Copper	79.3	104	195	91	117
	Iron	31,200	38,500	81,100	34,300	46,275
	Lead		168[d]	100[d]	94	121
B38W17B	Iron	12,200	18,800	9,550[d]	6,080	11,658
B38W18D	Lithium	2,500	307	2,950	2,830	2,147

[a]Concentrations are given in units of µg/L.

[b]Sampling locations are shown in Figure 4-12.

[c]Metal was analyzed for but not detected above the reported value.

[d]An estimated value.

[e]Metal was analyzed for but not detected. The associated value is an estimate and may be inaccurate or imprecise.

[f]The reported value is less than the contract required detection limit but is greater than or equal to the instrument detection limit.

5.5 OTHER EMISSIONS MONITORING

MISS is not an active site; therefore there are no emissions, other than those already discussed, to monitor.

5.6 ENVIRONMENTAL OCCURRENCES

No unplanned releases occurred at MISS in 1991.

5.7 SARA TITLE III REPORTING

No reports under Section 313 of the Emergency Preparedness and Community Right-to-Know Act were filed during 1991. FUSRAP sites were not subject to toxic chemical release reporting provisions under 40 CFR 372.22 in 1991. However, in accordance with the spirit and language of DOE Order 5400.1, FUSRAP evaluates and inventories toxic chemicals used onsite to ensure that no threshold planning quantities (TPQs) are exceeded.

Toxic chemicals, such as nitric acid, are used at FUSRAP sites for sampling and other purposes. However, the quantities of such chemicals stored onsite are well below TPQs. If a TPQ is exceeded at a site, the Toxic Chemical Release Inventory Reporting Form (Form R) under 40 CFR 372.85 will be filed with EPA.

6.0 GROUNDWATER PROTECTION PROGRAM

6.1 HYDROGEOLOGIC CHARACTERISTICS

6.1.1 Site Hydrogeology

General setting

The Maywood Site is located in northeastern New Jersey within the glaciated section of the Piedmont Plateau. The terrain is generally level, with minor relief. Elevations range from 15 to 25 m (45 to 75 ft) above mean sea level (MSL). Surface topography of the Piedmont region slopes gently to the west and is poorly drained (Cole et al. 1981). Drainage around the Maywood area is primarily toward the south via the Saddle, Passaic, and Hackensack rivers, which flow into the Hudson River and ultimately into the Atlantic Ocean.

The site lies within the Newark Basin, a geologic structure that extends from southwest to northeast across central New Jersey. The Newark Basin is underlain by a thick sequence of Late Triassic-age clastic sedimentary rocks known as the Newark Group and by interbedded Triassic basalt. The Newark Group is composed of fluvially deposited conglomerate, sandstone, siltstone, and mudstone, which were derived from erosion of metamorphic and igneous rocks of the New Jersey Highlands, located west of the basin.

The Brunswick Formation, which underlies the Maywood Site, is the youngest unit in the Newark Group, ranging in age from Late Triassic to Early Jurassic. The formation consists primarily of interbedded reddish-brown, fine-grained sandstone, siltstone, mudstone, and shale. The Brunswick Formation is the principal aquifer in the MISS area. Typically, the formation has low primary porosity and hydraulic conductivity. Groundwater flow in the aquifer is controlled by secondary porosity associated with fractures and joints in the formation. Groundwater flow is generally anisotropic (exhibiting directional hydraulic behavior

under pumping conditions), and aquifer properties are highly variable. Well yields depend on the frequency and size of fractures intercepted by the boreholes.

Site setting

Depths to the Brunswick Formation beneath MISS range from 0.3 m (1 ft) in the eastern portion of the site to 7.6 m (25 ft) along the western boundary. The unit is composed of alternating beds of reddish-brown, fine-grained sandstone and siltstone. The uppermost section of the Brunswick Formation is highly weathered with the degree of weathering decreasing with depth. Approximately 0.9 to 7.6 m (3 to 25 ft) of unconsolidated materials overlie competent bedrock (i.e., the Brunswick Formation). These materials include highly weathered bedrock; unconsolidated glacial deposits of clay, silt, sand, and gravel; and urban fill.

The shallow groundwater flow system at MISS is in the unconsolidated sediments and the shallow Brunswick bedrock. Depths to water range from 0.9 to 4.6 m (3 to 15 ft) below ground surface. Water level elevations range from 11.9 to 16.5 m (39 to 54 ft) above MSL. The saturated thickness of the unconsolidated sediments ranges from 1.5 to 4.6 m (5 to 15 ft). Potentiometric levels measured in the bedrock range from 12.2 to 19.5 m (40 to 64 ft) above MSL.

6.1.2 Groundwater Quality and Usage

Groundwater from the Brunswick bedrock aquifer is mineralized and moderately hard to very hard. Groundwater from the unconsolidated deposits is variable in quality but is usually not mineralized. Wells completed in the unconsolidated deposits typically have low yields.

A well inventory of the area within a 4.8-km (3-mi) radius of MISS was conducted in 1987 and 1988. Records were located for 56 wells installed between 1954 and 1987. These wells range in depth from 18 to 210 m (60 to 660 ft) and reportedly yield 38 to 757 L/min (10 to 200 gpm). Most wells are used for domestic

purposes (31 wells) or for irrigation (10 wells). One public water supply well and one industrial well were identified. No information is available for the remaining 14 wells identified. The public water supply well was drilled by the Saddle Brook Board of Education to supply water for the Smith Elementary School. However, the school is currently served by the municipal system, and the well is not in use.

6.2 GROUNDWATER MONITORING

Wells at MISS were monitored for the presence of radioactive and chemical contamination and for hydrogeologic purposes. Sections 4.0 and 5.0 of this report address the results of the radiological and chemical investigations, and this section describes the hydrogeologic results.

6.2.1 Methods

The hydrogeologic interpretations are based on water level measurements from 32 groundwater monitoring wells on and immediately adjacent to MISS. These data were used to determine seasonal fluctuations, groundwater flow directions, and groundwater gradients. The wells were completed in two zones: the unconsolidated sediments and competent bedrock. The depths of wells completed in the unconsolidated sediments and weathered bedrock are generally less than 6.1 m (20 ft), and the depths of wells completed in competent bedrock range from approximately 9.1 to 15.2 m (30 to 50 ft). Monitoring well locations are shown in Figure 6-1, and the well completion data are summarized in Table 6-1. An example of typical well construction details is provided in Appendix H.

Water level measurements in the monitoring wells were taken biweekly and used to prepare two types of graphic exhibits (hydrographs and water level elevation contour maps) that illustrate the hydrogeologic conditions at the site.

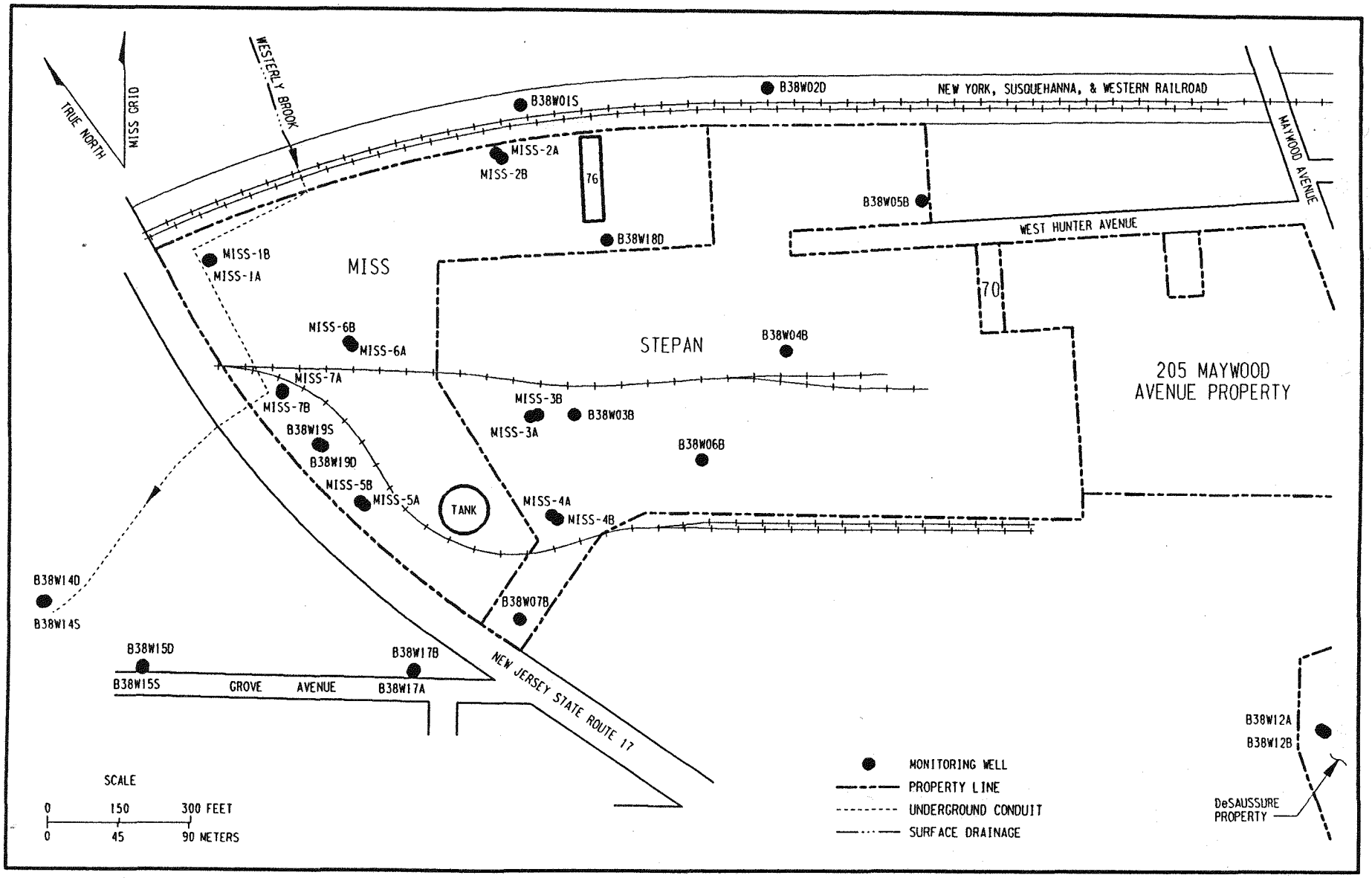

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Figure 6-1
Monitoring Wells Used for Water Level Measurements at MISS

Table 6-1

Monitoring Well Construction Summary for MISS

Well Number[a]	Completion Date	Total Depth [m (ft)]	Screened or Open-Hole Interval Below Ground Surface [m-m (ft-ft)]	Construction Material[b]
MISS-1A	Nov. 1984	3.66 (12.0)	1.6 - 3.47 (5.4 - 11.4)	PVC
MISS-1B	Nov. 1984	16.3 (53.5)	7.01 - 16.3 (23.0 - 53.5)[c]	Steel
MISS-2A	Oct. 1984	6.10 (20.0)	2.1 - 5.2 (6.9 - 16.9)	PVC
MISS-2B	Nov. 1984	17.8 (58.5)	8.7 - 17.8 (28.5 - 58.5)[c]	Steel
MISS-3A	Oct. 1984	4.57 (15.0)	2.0 - 3.6 (6.7 - 11.7)	PVC
MISS-3B	Nov. 1984	15.2 (50.0)	6.10 - 15.2 (20.0 - 50.0)[c]	Steel
MISS-4A	Oct. 1984	3.05 (10.0)	1.4 - 3.0 (4.7 - 9.7)	PVC
MISS-4B	Nov. 1984	14.3 (47.0)	5.19 - 14.3 (17.0 - 47.0)[c]	Steel
MISS-5A	Nov. 1984	4.58 (15.0)	3.2 - 4.5 (10.7 - 14.6)	PVC
MISS-5B	Nov. 1984	16.8 (55.0)	7.6 - 16.8 (25.0 - 55.0)[c]	Steel
MISS-6A	Oct. 1984	4.88 (16.0)	2.2 - 4.02 (7.2 - 13.2)	PVC
MISS-6B	Nov. 1984	16.2 (53.0)	7.02 - 16.2 (23.0 - 53.0)[c]	Steel
MISS-7A	Nov. 1984	3.51 (11.5)	1.4 - 2.9 (4.6 - 9.6)	PVC
MISS-7B	Nov. 1984	15.0 (49.0)	5.79 - 15.0 (19.0 - 49.0)[c]	Steel
B38W01S	Nov. 1988	7.02 (23.0)	5.20 - 6.7 (17.0 - 22.0)	SS
B38W02D	Nov. 1988	13.1 (43.0)	11.3 - 12.8 (37.0 - 42.0)	SS
B38W03B	Aug. 1987	12.3 (40.5)	9.09 - 12.1 (29.8 - 39.5)	SS
B38W04B	Sept. 1987	11.1 (36.3)	6.9 - 8.5 (22.7 - 27.7)	SS
B38W05B	Sept. 1987	13.6 (44.5)	6.92 - 10.1 (22.7 - 33.0)	SS
B38W06B	Sept. 1987	11.1 (36.4)	4.85 - 6.4 (15.9 - 20.9)	SS
B38W07B	Sept. 1987	12.0 (39.2)	5.64 - 8.8 (18.5 - 28.8)	SS
B38W12A	Oct. 1987	4.5 (14.0)	2.1 - 3.78 (7.4 - 12.4)	SS
B38W12B	Oct. 1987	15.3 (50.3)	10.5 - 13.7 (34.5 - 44.9)	SS
B38W14S	Nov. 1988	3.97 (13.0)	2.4 - 3.96 (8.0 - 13.0)	SS
B38W14D	Nov. 1988	15.6 (51.0)	14.0 - 15.4 (46.0 - 50.5)	SS
B38W15S	Oct. 1988	5.03 (16.5)	3.20 - 4.73 (10.5 - 15.5)	SS
B38W15D	Oct. 1988	14.0 (46.0)	12.2 - 13.7 (40.0 - 45.0)	SS
B38W17A	Oct. 1987	4.30 (14.1)	2.4 - 3.87 (7.7 - 12.7)	SS
B38W17B	Oct. 1987	13.5 (44.4)	5.67 - 8.81 (18.6 - 28.9)	SS
B38W18D	Oct. 1988	12.5 (41.0)	10.7 - 12.2 (35.0 - 40.0)	SS
B38W19S	Oct. 1989	4.8 (15.8)	3.9 - 4.5 (12.9 - 14.9)	SS
B38W19D	Oct. 1989	14.6 (47.9)	6.6 - 9.7 (21.7 - 31.9)	SS

[a]Wells installed in the upper groundwater system are designated with an "A" or "S;" wells installed in the bedrock groundwater system are designated with a "B" or "D."

[b]PVC - polyvinyl chloride; SS - stainless steel.

[c]Carbon steel casing extends through overburden and 0.6 m (2 ft) into bedrock; monitored interval is a 7.6-cm- (3.0-in.-) diameter open hole in bedrock.

Note: Water level elevations for wells monitored in 1991 are shown as hydrographs in Appendix H.

6.2.2 Results and Conclusions

Results of water level measurements over the past several years have shown that seasonal fluctuations typically vary by 0.6 to 1.8 m (2 to 6 ft) over the course of a year. Hydrographs showing groundwater levels measured in the unconsolidated sediments and the bedrock during 1991 and in representative wells from 1988 through 1991 are in Appendix H. The hydrographs reflect typical seasonal fluctuations. The maximum range of groundwater fluctuation in the unconsolidated sediments is 1.5 to 1.8 m (5 to 6 ft), which is higher than the maximum range of fluctuation in the bedrock [0.6 to 1.2 m (2 to 4 ft)].

Water levels fluctuate in response to seasonal patterns of precipitation and evapotranspiration. Water levels are generally lowest from May through September, with rising water levels beginning in late November through December (Appendix H). The general trend in groundwater elevations in the wells appears to be the same, and the relationship among the wells is relatively consistent over time.

Water level elevation maps for January 11 and June 26, 1991, are presented in Figures 6-2 through 6-5. These maps reflect both seasonal and long-term general high and low groundwater level conditions. Average hydraulic gradients (change in elevation per unit of horizontal distance) are generally low and indicate groundwater flow to the west toward the Saddle River where shallow groundwater is discharged. Overall, average hydraulic gradients are slightly steeper during periods of seasonally high groundwater conditions than during periods of seasonally low groundwater conditions; however, localized areas develop sharper and steeper gradients during the periods of low groundwater conditions.

Although water table elevations vary with seasonal and yearly variations in natural recharge, the qualitative patterns shown in Figures 6-2 through 6-5 are generally maintained. At the eastern edge of the site, hydraulic gradients are relatively steep, but under most of the site and farther to the west, the contours flatten to a gradient of approximately 0.01. As previously stated, groundwater flow under the site is westward. Near the western

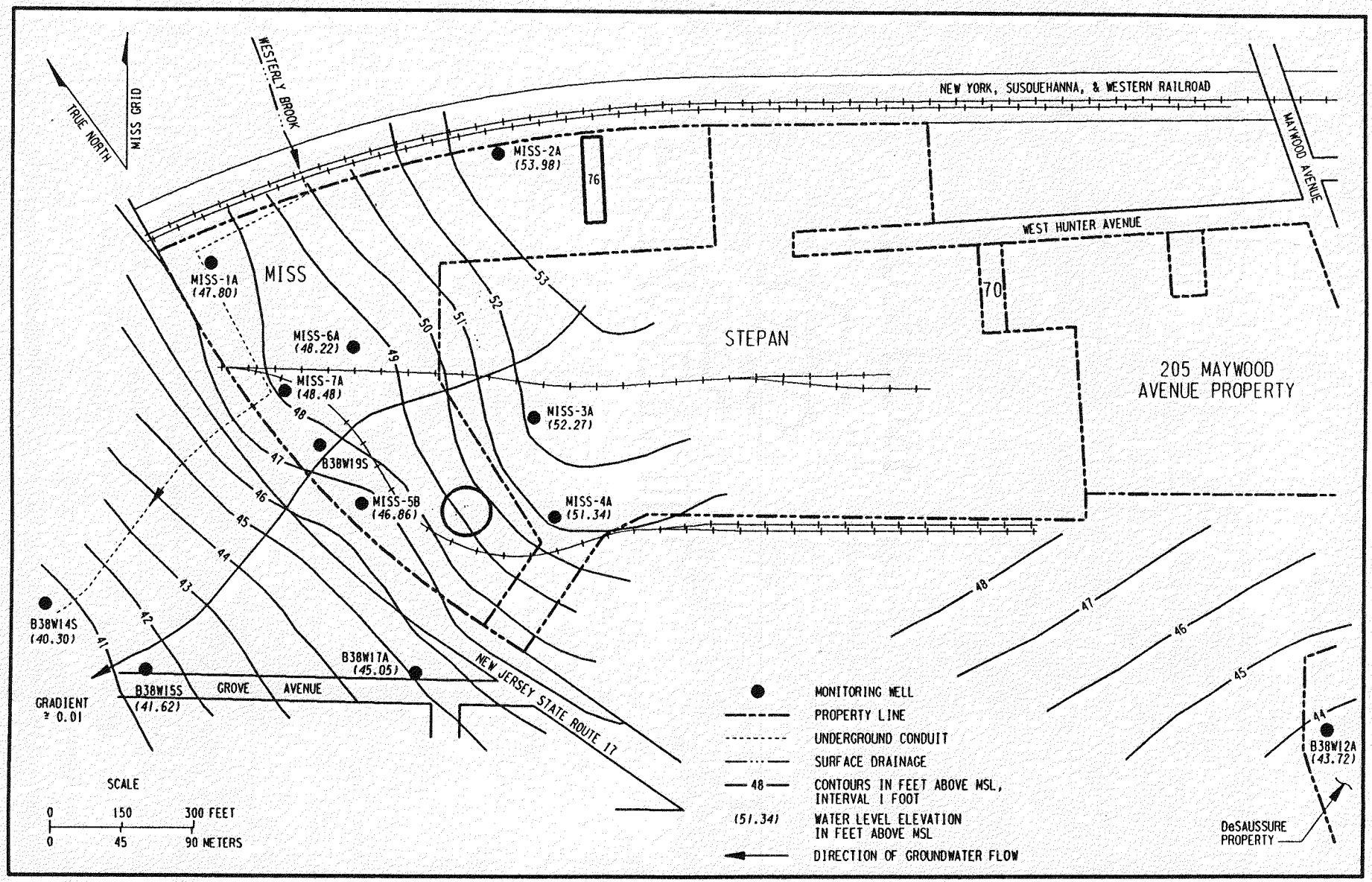

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Figure 6-2
Contour Map Showing Water Level Elevations in Unconsolidated Sediments at MISS (1/11/91)

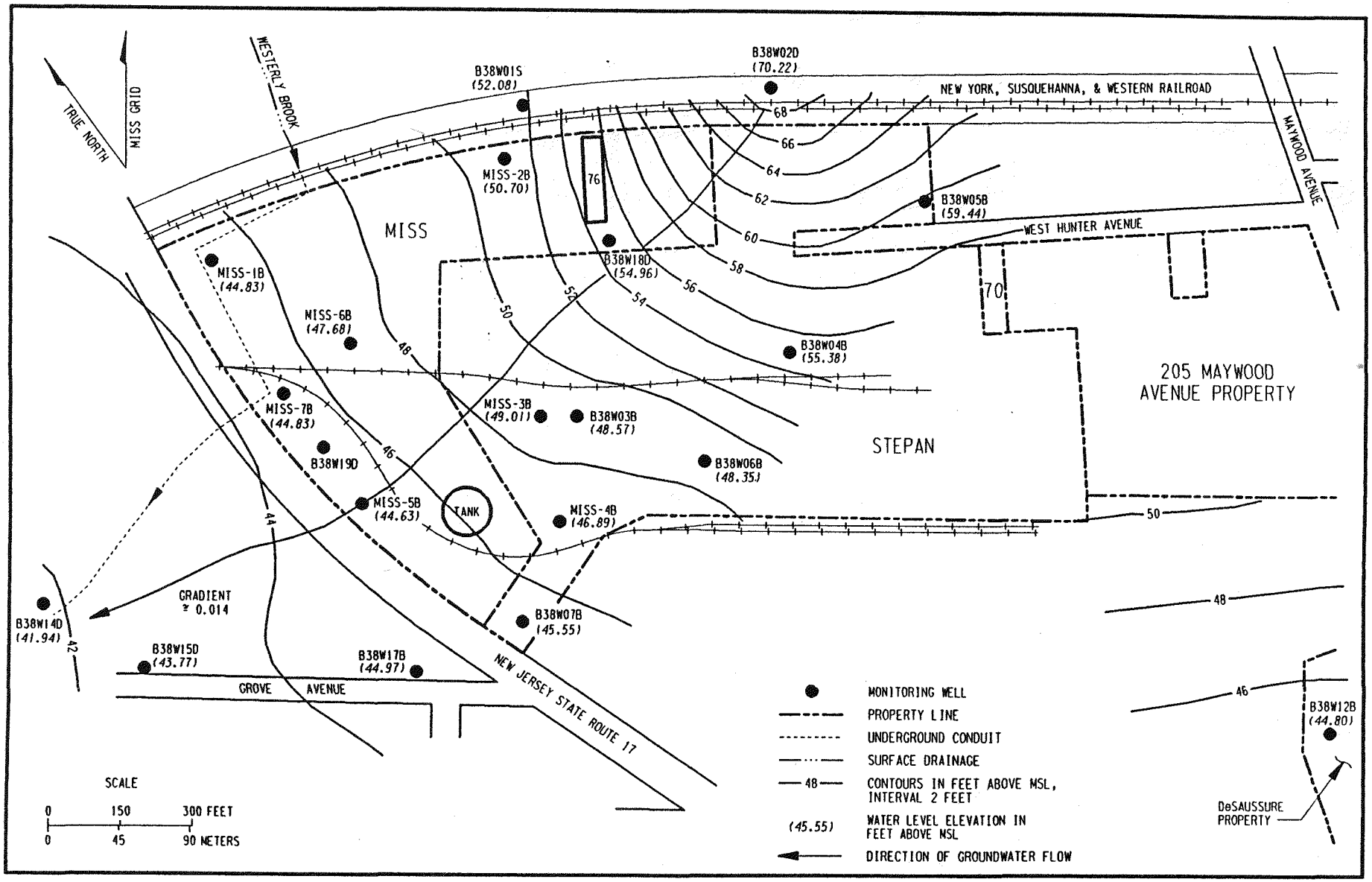

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Figure 6-3
Contour Map Showing Water Level Elevations
in Bedrock at MISS 1/11/91

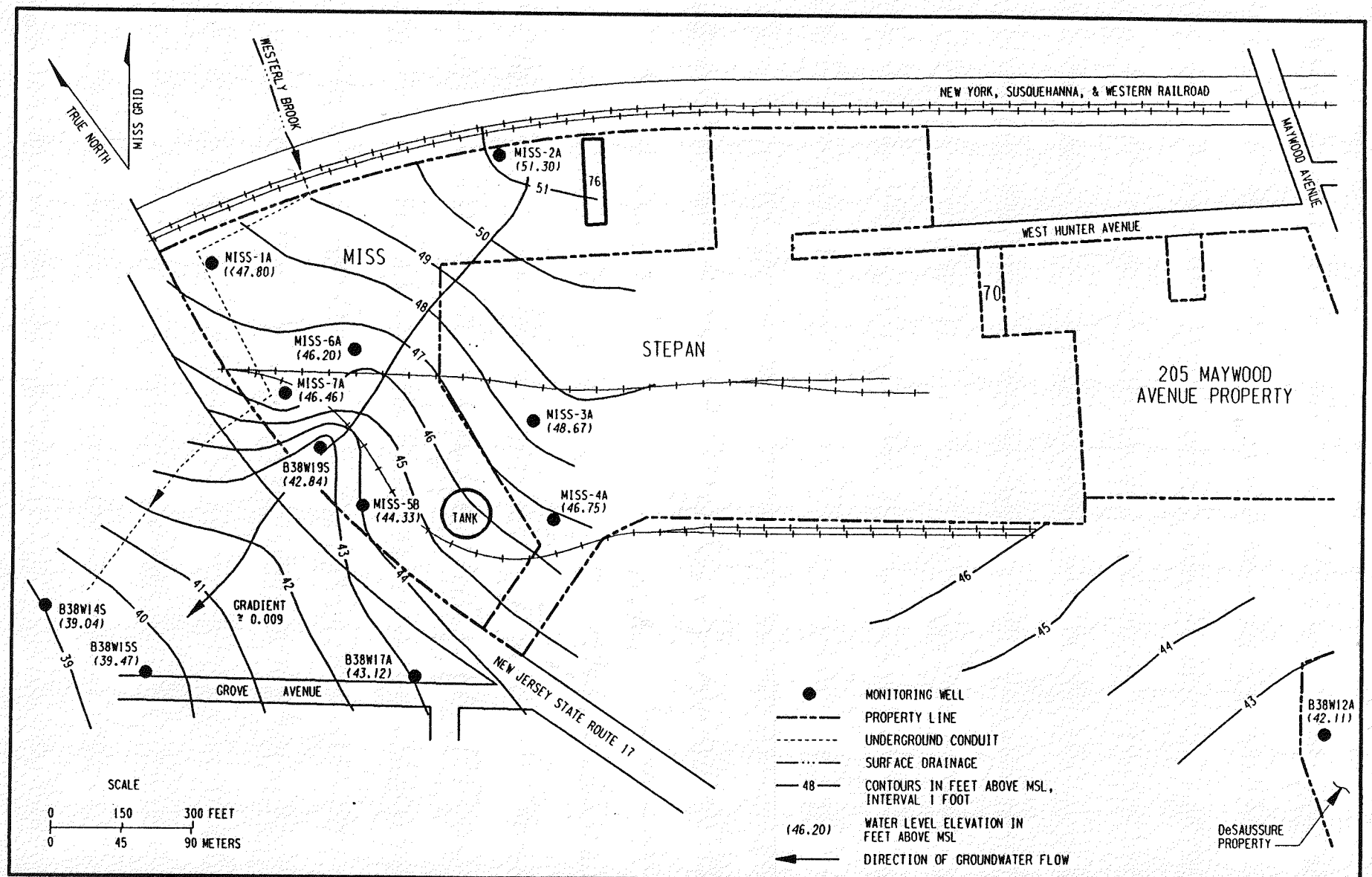

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Figure 6-4
Contour Map Showing Water Level Elevations in Unconsolidated Sediments at MISS (6/26/91)

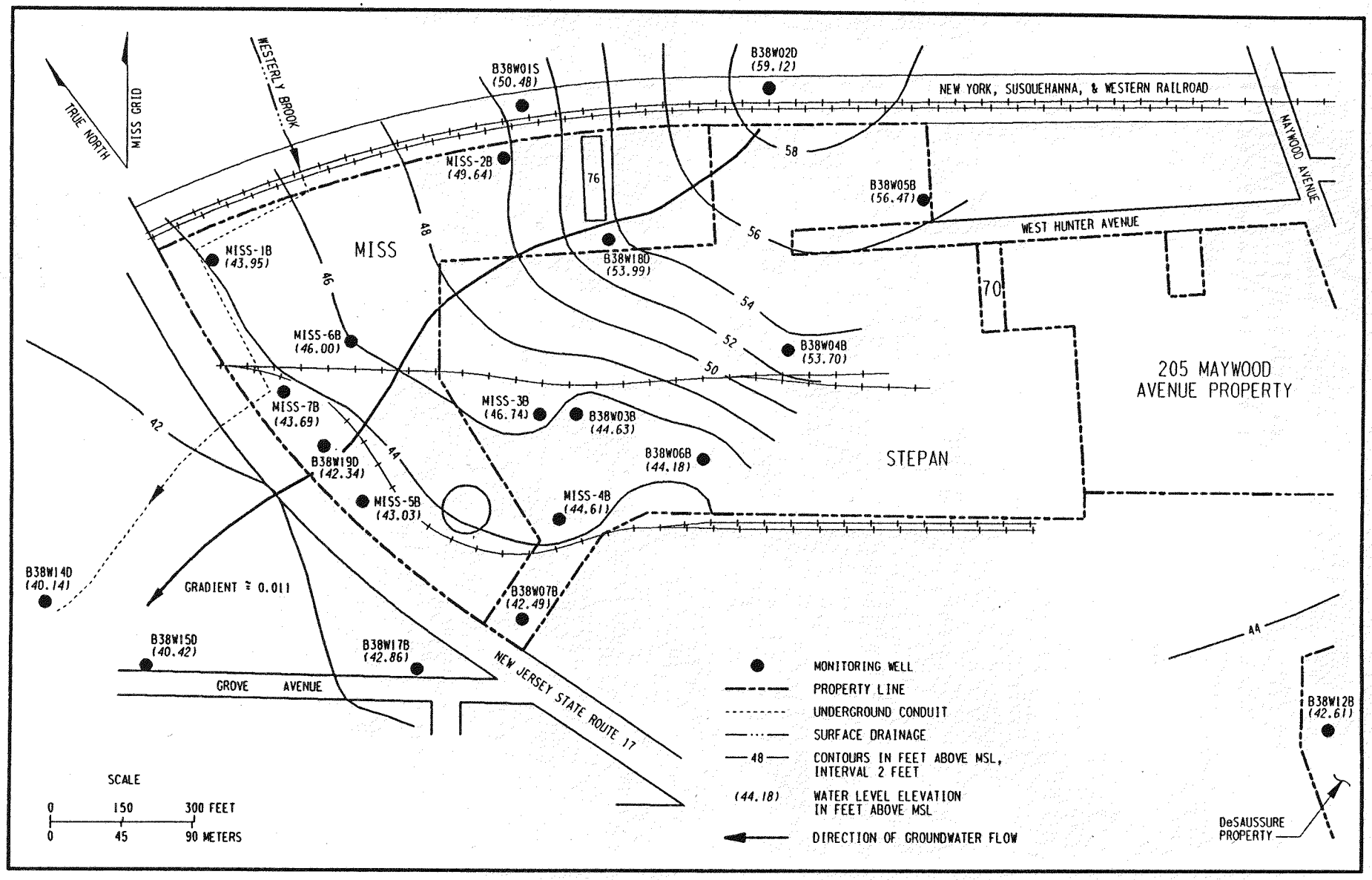

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Figure 6-5
Contour Map Showing Water Level Elevations
in Bedrock at MISS (6/26/91)

fence along Route 17, there is an apparent groundwater depression corresponding to an interpreted erosional channel in the bedrock surface. Results of the investigation of this area are provided in the remedial investigation report for the Maywood Site.

7.0 QUALITY ASSURANCE

7.1 INTRODUCTION

This section summarizes the quality assurance (QA) assessment of the environmental surveillance activities at MISS, which were conducted to ensure that onsite contamination is not posing a threat to human health and the environment. Based on this criterion, the overall data quality objective (DQO) for the environmental monitoring program is to provide data of a sufficient quality to allow reliable detection and quantification of any potential release of contaminated material from MISS.

7.2 PROCEDURES

The Quality Assurance Program Plan for the U.S. DOE FUSRAP (QAPmP) (BNI 1990b) addresses the quality requirements for all work being performed as part of FUSRAP. In addition, all subcontractors adhere to or implement a QA program that is compatible with the QAPmP. The objectives of the QAPmP are to maintain quality through a system of planned work operations and to verify the preservation of quality standards through a system of checks and reviews.

Established QA activities are detailed in project procedures and instructions and an instruction guide and are implemented for all field sampling activities. Sampling methodology and techniques are consistent with the methods detailed in A Compendium of Superfund Field Operations Methods (EPA 1987). Laboratory QA procedures, which have been reviewed by BNI, are implemented to control applicable laboratory activities. In addition, various activities (such as data reviews, calculations, and evaluations) are conducted to monitor the information being generated and to prevent or identify quality problems. Quality control (QC) sample requirements, data use information, and QA/QC procedures are provided in the project's instruction guides.

7.3 QUALITY ASSURANCE SUMMARY

QA/QC activities are an integral part of environmental monitoring activities at MISS. The quality of the data collected for the 1991 monitoring program is considered to be appropriate for these reporting purposes.

The QA/QC program implemented at MISS satisfies the 1991 requirements of DOE Orders 5400.1, 5400.5, and 5700.6B. The programmatic controls in place during the 1991 environmental monitoring program are discussed in the project's instruction guide.

The specific methods and formulas used to evaluate the QA/QC program are described in an internal BNI QA document for annual site environmental reports; the QA document also discusses the requirements of precision, accuracy, representativeness, comparability, and completeness (PARCC). This subsection summarizes the results of the QA/QC program at MISS.

7.3.1 Data Usability

To determine data usability, the analytes of interest for MISS were evaluated for the PARCC parameters; Table 7-1 lists each analyte and indicates whether it meets these and other parameters. The following analytes have been determined to satisfy all elements of the PARCC parameters:

- Metals in groundwater
- Semivolatiles [base/neutral and acid extractable (BNAE) compounds] in groundwater
- Radon in air
- Radium-226 in surface water and sediments
- Radium-228 in surface water and sediments
- Thorium-230 in surface water and sediments
- Total uranium in sediments

Other analytes were also evaluated, and certain elements did not fully meet PARCC requirements or could not be completely evaluated because some QC data were not retrievable. Corrective

Table 7-1

Data Usability Summary

Analyte[1]	Precision	Accuracy	Representativeness	Completeness	Comparability	Quantitative	Qualitative	DQO[2]
Metals	3	YES[4]	YES	YES	YES	YES	YES	YES
Volatile organics	YES	5	5	YES	YES	YES	YES	YES
Semivolatiles (BNAEs)	YES	YES	YES	YES	YES	YES	YES	YES
Pesticides/PCBs	3	YES	YES	YES	6	7	YES	YES
Radium-226	YES	YES	YES	YES	YES	YES	YES	YES
Radium-228	YES	YES	YES	YES	YES	YES	YES	YES
Thoron-230	YES	YES	YES	YES	YES	YES	YES	YES
Thoron-232	YES	YES	8	YES	YES	7	YES	YES
Total uranium	3	YES	YES	YES	YES	YES	YES	YES
Radon-222	YES	YES	YES	YES	YES	YES	YES	YES
Thoron (radon-220)	YES	5	8	YES	6	7	YES	YES
External gamma radiation	YES	YES	8	YES	YES	7	YES	YES

*Further information on any of the above PARCC parameters can be found in corresponding summaries in the text.

[1]BNAE-base/neutral and acid extractable; PCB-polychlorinated biphenyl.

[2]The data quality objective for the environmental monitoring program is to detect and quantify any release from MISS that could be potentially harmful to human health and environment.

[3]Incomplete field duplicate and/or indeterminate laboratory duplicate information was reported for this parameter.

[4]The term "Yes" indicates that data are usable based on the analyses of the indicated PARCC parameters.

[5]Accuracy goal was not met or could not be assessed because of insufficient laboratory standard reference material, blank, or trip blank information.

[6]Comparability factor could not be calculated because precision and/or accuracy information was not reported or was insufficient.

[7]Data do not meet quantitative goals because the amount of variation associated with known sample values could not be adequately assessed.

[8]Representativeness goal was not met or could not be assessed because of insufficient field (rinse) blank and/or insufficient or unreportable laboratory blank information for this parameter.

actions were initiated for all identified data deficiencies and nonconformances. As part of the ongoing FUSRAP QA program, appropriate actions have been implemented including root-cause analyses and procedure development and revision.

Results of the evaluation indicate that the data quality for the following analytes did meet the intended end use. After a thorough review of all site information (including non-QC data), the results were determined to be of sufficient quality to achieve reliable detection and quantification of any potential release of contaminated material from MISS.

- Metals in surface water and sediments
- Volatile organics in groundwater
- Pesticides/PCBs in groundwater
- Radium-226 in groundwater
- Radium-228 in groundwater
- Thorium-230 in groundwater
- Thorium-232 in groundwater, surface water, and sediments
- Total uranium in groundwater and surface water
- Thoron in air
- External gamma radiation in air

7.3.2 Precision

For chemical analyses, the precision goal of 80 percent, as measured by analytical results for matrix spike duplicates (MSDs) and field and laboratory duplicates, was met for metals, volatile organics, and BNAEs in groundwater at MISS. This goal indicates that a minimum of 80 percent of the QC results fell within acceptable ranges. Calculations indicate that minimal variability was introduced by field sampling; however, information for seven of the compounds in groundwater was incomplete, and no field duplicate information was reported for the surface water matrix. (Field duplicates are presently not taken for sediments.)

Results for MSD samples (which are used to measure analytical variability) of groundwater indicate that iron, thallium, aluminum, calcium, chromium, manganese, selenium, arsenic, lead, and silver (in the fourth quarter) exceeded the analytical method's

established criteria for acceptable variation. [The first three quarters of metals data for all matrices were derived from Contract Laboratory Program (CLP) data for Maywood; determining the particular compounds for which analytical variability might exist is not possible.] For the sediment matrix, antimony, arsenic, manganese, silver, and thallium (again, in the fourth quarter) exceeded the method's established criteria for acceptable variation. No fourth quarter MSD data were reported for surface water, which indicates that matrix effects may be present at the site and may interfere with the analytical determination of variation. Evaluation of data usability for the metals, volatile organics, and BNAE analyses indicates that the data met their intended end use.

Analyses for pesticides/PCBs did not meet the precision goal of 80 percent because both original and duplicate field samples had reported values below equipment detection limits; therefore, precision could not be calculated.

The precision goal was met for analyses for radium-226 and thorium-232 in groundwater, surface water, and sediments; radium-228 and thorium-230 in surface water and sediments; total uranium in sediments; radon; thoron; and external gamma radiation. The precision goal was not met for analyses for radium-228 and thorium-230 in groundwater or for total uranium in groundwater and surface water because field duplicate and/or laboratory duplicate information was either unavailable or incomplete. Lack of precision information for these elements does not affect data usability.

Radiological QC data indicate that some degree of variability was present. A high degree of variability was seen in field duplicate results as measured by relative percent differences (RPDs); however, the RPDs were calculated from a very limited data population. (As more data become available, the statistical reliability of these values increases, control limits may become tighter, and data more accurately reflect true site conditions.) The radiological methods used have no defined criteria for RPD values near the method detection limits; therefore, sampling variation cannot be quantitatively separated from laboratory variation. Because the laboratory precision criterion has not been

established, the calculated upper control limit from the field duplicates (the mean plus three standard deviations) was used as the standard of data quality.

Values for radiological sediment analyses are considered qualitative because no field duplicate samples were taken and, consequently, total variability could not be quantified. Qualitative data are useful for estimating the approximate concentration or activity of an analyte, but the amount of variation associated with the data remains unknown.

Data from the FUSRAP radiological laboratory's monthly QC reports indicate that all analytes met the overall laboratory duplicate requirements for precision, and the program's DQOs for precision have been met.

7.3.3 Accuracy

The accuracy goal of 80 percent was met for all chemical analytes of concern at MISS except for volatile organics in groundwater, which did not meet the goal because trip blank information was not reported. This goal indicates that a minimum of 80 percent of the QC results fell within acceptable ranges. Control limits were statistically established from the data population for metals in groundwater. Blank contamination was not detected in any quarter for metals or in the third quarter for the organic analytes. Rinse blanks were not required for either surface water or sediments. Laboratory (method) blank analyses were reported for all metals in groundwater, surface water, and sediments and for organics in groundwater; the accuracy goal was met or exceeded for each parameter.

The accuracy goal was met for radium-226, radium-228, thorium-230, and total uranium in surface water and sediments and for radon and external gamma radiation in air. The 80-percent goal was not met for radium-226, radium-228, thorium-232, and total uranium in groundwater because insufficient rinse blank information was reported. For thoron, accuracy could not be assessed because laboratory blank and standard reference material (SRM) information

was not available. The program has determined that the lack of accuracy information associated with these radiological data did not impact their intended end use.

Evaluation of radiological accuracy was limited because it was based on the total reported results for all FUSRAP sites where environmental monitoring was conducted in 1991. Laboratory QC data were summarized in a monthly report that provided an overall assessment of the laboratory's performance for the period. Because of the summary nature of the reports, MISS QC data may be more accurate than actually reported.

7.3.4 Representativeness

The program's required objective for representativeness was met for all metals, BNAEs, and pesticides/PCBs at MISS. Volatile organics did not meet the representativeness goal because trip blank information was not evaluated for the three quarters of CLP data.

A review of the radiological data indicates that radium-226, radium-228, thorium-230, and total uranium in groundwater did not meet the 80-percent goal because of unreported or incomplete rinse blank information. For thoron and external gamma radiation in air, representativeness could not be assessed because laboratory blank information used in the calculation of representativeness was not reported or is not a laboratory function for the particular analyte. Lack of representativeness information for these analytes does not affect the usability of the data.

7.3.5 Completeness

At MISS, the completeness goal of 80 percent was exceeded for all chemical and radiological groundwater, surface water, and sediment samples. Air monitoring was conducted for external gamma radiation, thoron, and radon, and all required data were collected.

7.3.6 Comparability

All chemical and radiological methodologies satisfy the goals for comparability. In addition, MISS data met the comparability objectives, as calculated from precision and accuracy values, for analyses for metals, volatile organics, and BNAEs in groundwater. Analyses for metals in surface water and sediments and pesticides/PCBs in groundwater did not meet comparability goals because the precision component was not met or could not be calculated from the CLP data.

MISS data met the comparability requirements for radium-226, thorium-230, and total uranium in surface water and sediments and for radon and external gamma radiation in air. The 80-percent goal was not met for the other radiological analytes because precision and/or accuracy requirements were not met or could not be assessed.

7.4 PROGRAMMATIC FACTORS

FUSRAP has established specific requirements for qualifications and training of personnel, data management and recordkeeping, chain-of-custody procedures, audits, performance reporting, independent data verification, and laboratory certification. These topics are covered in more detail in the QA/QC document.

7.5 DOE LABORATORY QUALITY ASSESSMENT PROGRAM FOR RADIOACTIVE MATERIAL

Results of the radiological laboratory's participation in the DOE Environmental Measurements Laboratory Quality Assessment Program are presented in Table 7-2. The range of ratios presented has been determined to satisfy the requirements of the quality assessment program for radioactive materials.

Table 7-2

Results of the Quality Assessment Program, 1991

Sample Type	Analysis	Results TMA/E[a]	Results EML[b]	Units	Ratio TMA/E:EML
Air Filter	Be-7	63.1	53.0	Bq/filter	1.19
Air Filter	Mn-54	5.90	4.80	Bq/filter	1.23
Air Filter	Sr-90	0.914	0.789	Bq/filter	1.16
Air Filter	Cs-137	5.83	4.53	Bq/filter	1.29
Air Filter	Ce-144	67.3	52.2	Bq/filter	1.29
Air Filter	Pu-239	0.146	0.154	Bq/filter	0.948
Air Filter	Am-241	0.0940	0.101	Bq/filter	0.931
Air Filter	U-234	0.0514	0.0350	Bq/filter	1.47
Air Filter	U-238	0.0444	0.0350	Bq/filter	1.27
Soil	K-40	348	374	Bq/kg	0.931
Soil	Cs-137	154	150	Bq/kg	1.03
Soil	Pu-238	10.8	11.5	Bq/kg	0.939
Soil	Pu-239	3.27	3.40	Bq/kg	0.962
Soil	Am-241	1.48	1.76	Bq/kg	0.841
Soil	U-234	26.7	29.4	Bq/kg	0.908
Soil	U-238	23.0	30.0	Bq/kg	0.767
Vegetation	K-40	492	1150	Bq/kg	0.428
Vegetation	Sr-90	151	186	Bq/kg	0.812
Vegetation	Cs-137	74.4	67.6	Bq/kg	1.10
Vegetation	Pu-238	3.50	4.06	Bq/kg	0.862
Vegetation	Pu-239	0.962	1.40	Bq/kg	0.687
Vegetation	Am-241	0.608	0.829	Bq/kg	0.733
Water	H-3	321	361	Bq/L	0.889
Water	Mn-54	194	213	Bq/L	0.911
Water	Co-57	187	230	Bq/L	0.813
Water	Co-60	178	201	Bq/L	0.886
Water	Sr-90	8.53	8.63	Bq/L	0.988
Water	Cs-137	150	169	Bq/L	0.888
Water	Ce-144	33.2	35.1	Bq/L	0.946
Water	Pu-239	0.665	0.773	Bq/L	0.860
Water	Am-241	1.23	1.19	Bq/L	1.03
Water	U-234	0.236	0.219	Bq/L	1.08
Water	U-238	0.275	0.219	Bq/L	1.26
Air Filter	Be-7	74.7	53.8	Bq/filter	1.39
Air Filter	Mn-54	27.1	24.3	Bq/filter	1.12
Air Filter	Co-57	20.0	16.6	Bq/filter	1.20
Air Filter	Co-60	23.6	23.0	Bq/filter	1.03
Air Filter	Sr-90	0.773	0.663	Bq/filter	1.17
Air Filter	Cs-137	31.6	28.0	Bq/filter	1.13
Air Filter	Ce-144	54.5	50.8	Bq/filter	1.07
Air Filter	Pu-239	0.0704	0.0840	Bq/filter	0.838
Air Filter	Am-241	0.0858	0.104	Bq/filter	0.825
Air Filter	U-234	0.0518	0.0395	Bq/filter	1.31
Air Filter	U-238	0.0585	0.0388	Bq/filter	1.51
Soil	K-40	301	430	Bq/kg	0.700
Soil	Cs-137	240	312	Bq/kg	0.769

Table 7-2

(continued)

Sample Type	Analysis	Results TMA/E[a]	Results EML[b]	Units	Ratio TMA/E:EML
Soil	Pu-239	8.25	7.35	Bq/kg	1.12
Soil	Am-241	1.31	1.58	Bq/kg	0.829
Soil	U-234	25.3	28.9	Bq/kg	0.875
Soil	U-238	26.1	28.9	Bq/kg	0.903
Vegetation	K-40	819	992	Bq/kg	0.826
Vegetation	Sr-90	308	439	Bq/kg	0.702
Vegetation	Cs-137	11.7	27.1	Bq/kg	0.432[c]
Vegetation	Pu-239	0.352	0.365	Bq/kg	0.964
Vegetation	Am-241	0.222	0.266	Bq/kg	0.835
Water	H-3	16.6	100	Bq/L	0.166[c]
Water	Mn-54	91.2	103	Bq/L	0.885
Water	Co-57	154	166	Bq/L	0.928
Water	Co-60	261	291	Bq/L	0.897
Water	Sr-90	8.40	10.1	Bq/L	0.832
Water	Cs-137	42.8	46.0	Bq/L	0.930
Water	Ce-144	201	226	Bq/L	0.889
Water	Pu-239	0.519	0.510	Bq/L	1.02
Water	Am-241	0.620	0.570	Bq/L	1.09
Water	U-234	0.426	0.462	Bq/L	0.922
Water	U-238	0.485	0.478	Bq/L	1.01

[a]TMA/E - ThermoAnalytical/Eberline, the radiological analysis subcontractor for FUSRAP.

[b]EML - the DOE Environmental Measurements Laboratory.

[c]Corrective action request has been issued.

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APPENDIX A
ENVIRONMENTAL STANDARDS

ENVIRONMENTAL STANDARDS

The DOE long-term radiation protection standard of 100 mrem/yr (1 mSv/yr) in excess of background level includes exposure from all pathways except medical treatments and exposures from radon (DOE 1990b). 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 use of 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 GUIDES

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 guides (DCGs). A DCG is defined as the concentration of a 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 = 1 pCi/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 for residual radioactivity in soil established for FUSRAP 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.

APPENDIX B
PARAMETERS FOR ANALYSIS

Parameters for Analysis at MISS, 1991[a]

Medium	Parameter	Technique
Groundwater	Total uranium	Fluorometric
	Radium-226	Emanation
	Radium-228	Beta liquid scintillation
	Thorium-232	Gamma spectrometry
	Total organic halides	Carbonaceous analyzer
	Mobile ions	Colorimetric procedure
	Total organic carbon	Coulometric determination
	Total metals: aluminum, antimony, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lanthanides, magnesium, manganese, molybdenum, nickel, potassium, silver, sodium, vanadium, zinc	Inductively coupled plasma atomic emission spectrophotometry (ICPAES)
	arsenic, lead, mercury, selenium, thallium	Atomic absorption (AA) spectrophometry
	Specific conductivity	Electrometric
	pH	Electrometric
	Volatile compounds	Gas chromatography/ mass spectroscopy
	Semivolatile compounds	Gas chromatography/ mass spectroscopy
Surface water	Total uranium	Fluorometric
	Radium-226	Emanation
	Radium-228	Beta liquid scintillation
	Thorium-232	Gamma spectrometry
	Total organic halides	Carbonaceous analyzer
	Mobile Ions	Colorimetric procedure
	Total organic carbon	Coulometric determination
	Total metals: aluminum, antimony, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lanthanides, magnesium, manganese, molybdenum, nickel, potassium, silver, sodium, vanadium, zinc	Inductively coupled plasma atomic emission spectrophotometry (ICPAES)
	arsenic, lead, mercury, selenium, thallium	Atomic absorption (AA) spectrophometry

Parameters for Analysis at MISS, 1991

(continued)

Medium	Parameter	Technique
Surface water (cont'd)	Specific conductivity	Electrometric
	pH	Electrometric
	Volatile compounds	Gas chromatography/ mass spectroscopy
	Semivolatile compounds	Gas chromatography/ mass spectroscopy
Sediment	Total uranium	Alpha spectrometry
	Radium-226	Gamma spectrometry
	Radium-228	Gamma spectrometry
	Thorium-232	Gamma spectrometry
	Total metals: aluminum, antimony, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lanthanides, magnesium, manganese, molybdenum, nickel, potassium, silver, sodium, vanadium, zinc	Inductively coupled plasma atomic emission spectrophotometry (ICPAES)
	arsenic, lead, mercury, selenium, thallium	Atomic absorption (AA) spectrophometry
Air	Radon-222	Track-etch
	Radon-220	Track-etch
	External gamma radiation	Thermoluminescence

[a]Air samples are cumulative; all others are grab samples.

APPENDIX C
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 average values are calculated for all quarters of data.

Thorium-230 Results (pCi/L)

Sampling Location	Quarter			
	1	2	3	4
1	13	7	12	5

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				Average Value
	1	2	3	4	
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. If site conditions do not change, 95 percent of the data points would be expected to fall within this range. An example of these calculations is shown below.

Thorium-230 Results (pCi/L)

Sampling Location	Year					Average Value	Standard Deviation
	1986	1987	1988	1989	1990		
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	2	4
2	5	8	-3	9
3	14	8	6	36
4	8	8	0	0
5	5	8	-3	9

$$\sum (X_i - \bar{x})^2 = 58$$

$$S = \sqrt{\frac{58}{5 - 1}} = \sqrt{\frac{58}{4}} = \sqrt{14.5} = 3.807,$$

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 D
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 in 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 municipal drinking water, 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-232, radium-226, and the daughter products (excluding radon). For several of the dose conversion factors used in these calculations, the contributions of the daughters with half-lives less than one year are included with the parent radionuclide. Table D-1 lists the pertinent radionuclides, their half-lives, and dose conversion factors for ingestion.

DOSE CALCULATION METHOD

Direct Gamma Radiation Pathway

As previously indicated, direct gamma radiation exposure is important in calculating the dose to the hypothetical maximally exposed individual. The dose from direct gamma radiation exposure is determined by using data collected through the tissue-equivalent thermoluminescent dosimeter (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 m (3 ft) above the ground. For the purposes of this report, it is assumed that the hypothetical maximally exposed individual lives 50 m (150 ft) from the site and spends 100 percent of his time at the residence.

Table D-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	2.47E+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]
Thorium-232	1.41E+10 years	2.8E-3
Radium-228	6.7 years	1.2E-3
Actinium-228	6.13 hours	--[f]
Thorium-228	1.91 years	7.5E-4

[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.

[f]Included in the radium-228 dose conversion factor.

The dose to the hypothetical maximally exposed individual can be determined by assuming that the individual is exposed to a line source located along the western fenceline. Because the average exposure rate is known from the TETLD program for a distance of 1 m (3 ft) from the fenceline, the exposure at 50 m (150 ft) from the fenceline can be calculated by using the following equation (Cember 1983).

$$Exposure\ at\ 60\ m = (Exposure\ at\ 1\ m) \times \frac{h_1}{h_2} \times \frac{\tan^{-1}(L/h_2)}{\tan^{-1}(L/h_1)}$$

where: h_1 = TETLD distance from the fenceline [1 m (3 ft)]
h_2 = Hypothetical maximally exposed individual's distance from the fenceline [50 m (150 ft)]
L = Half of the length of the northern fenceline [124 m (407 ft)]

The exposure rate at 1 m (3 ft) can be calculated by taking the average of the results from the four detectors along this portion of the fenceline (3, 4, 5, and 12). The average exposure rate for these detectors was 76 mR/yr above background. Using the formula above, the exposure rate at 50 m (150 ft) is approximately 1.2 mR/yr. Because 1 mR/yr is approximately equal to 1 mrem/yr (1E-2 mSv/yr), the resulting dose would be 1.2 mrem/yr (1.2E-2 mSv/yr) assuming 24-h continuous residence. This exposure scenario assumes continuous exposure and does not account for shielding provided by the structure.

Surface Water Pathway

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 individual can be calculated by the following:

$$D_s = \sum_{i=1}^{N} C_i \times (F_s \div F_i) \times U_a \times DCF_i$$

where: D_s = Committed effective dose from surface water
C_i = Concentration of the i^{th} radionuclide in surface water at the site
F_s = Average annual flow of surface water at the site
F_i = Average flow of surface water at the intake
U_a = Annual consumption of liquid (approx. 730 L/yr)
DCF_i = Dose conversion factor for the i^{th} radionuclide

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 hypothetical maximally exposed individual.

The approach outlined above for the surface water pathway does not account for radionuclides settling out or for any municipal water treatment.

Groundwater Pathway

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 individual can be calculated by using the following equation:

$$D_{gw} = \sum_{i=1}^{N} (C_i) \times (D) \times (U_a) \times (DCF_i)$$

where: D_{gw} = Committed effective dose from groundwater
C_i = Concentration of the i^{th} radionuclide in groundwater at the site
D = Estimated dilution factor
U_a = Annual consumption of water (approx. 730 L/yr)
DCF_i = Dose conversion factor for the i^{th} radionuclide

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 hypothetical maximally exposed individual.

The approach given above for the groundwater pathway does not account for any water treatment.

Air Pathway (ingestion, air immersion, inhalation)

The doses to the hypothetical maximally exposed individual and the general public from particulate radionuclides transported via the air pathway are calculated using EPA's computer model AIRDOS; results are provided in Subsection 4.2.

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 contaminated grass surface on the southwestern portion of the site and a small grass surface behind Building 76.

The average particle size for the soil at MISS is estimated at 0.05 mm for determining the emission factor for windblown material. This greatly overestimates the fraction of the airborne material that is respirable because most particles greater than 0.01 mm in diameter either would not be inhaled or would be quickly removed. Nevertheless, to provide a conservative calculation, all airborne particles were assumed to be respirable with an activity median aerodynamic diameter of 0.001 mm. Because the calculated dose was a small fraction of the NESHAPs standard of 10 mrem/yr, no effort was made to estimate the fraction of the airborne material that would be in the respirable range. Other assumptions used in the model were that the contamination in the pile is 99 percent covered by vegetation and that there are very few mechanical disturbances at the site each month.

APPENDIX E
CLEAN AIR ACT COMPLIANCE REPORT
FOR MAYWOOD INTERIM STORAGE SITE

40 CFR Part 61
National Emission Standards
for Hazardous Air Pollutants

CLEAN AIR ACT COMPLIANCE REPORT
(Version 3.0 November 1989)

Facility: Maywood Interim Storage Site
Address: 100 W. Hunter Avenue
Maywood , NJ. 07607
Annual Assessment for Year: 1991
Date Submitted: 3/12/92

Comments: INPUT DATA IS TAKEN FROM 138-CV-46

Prepared By:

Name: Bechtel National Inc.
Title: FUSRAP
Phone #: (615) 576-4611

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

CLEAN AIR ACT COMPLIANCE REPORT 3/12/92 4:10 PM

Facility: Maywood Interim Storage Site
Address: 100 W. Hunter Avenue City: Maywood State: NJ
Comments: INPUT DATA IS TAKEN FROM 138-CV-46
Year: 1991

	Dose Equivalent Rates to Nearby Individuals (mrem/year)
Effective Dose Equivalent	0.0050
Highest Organ Dose is to ENDOSTEUM	0.0320

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

Radio-nuclide	Class	Amad	Area #1 (Ci/y)	Area #2 (Ci/y)
U-238	Y	1.0	1.1E-07	1.1E-06
U-235	Y	1.0	4.6E-09	4.9E-08
U-234	Y	1.0	1.0E-07	1.1E-06
RA-226	Y	1.0	5.1E-08	5.5E-07
TH-232	Y	1.0	2.2E-07	2.4E-06
Total Area (m**2)			5.4E+03	5.8E+04

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

Wind Data	LEA0435.WND	Temperature (C)	13
Food Source	LOCAL	Rainfall (cm/y)	117
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	3.2E-05
BREAST	3.3E-05
RED MARROW	2.6E-03
LUNGS	3.1E-02
THYROID	3.2E-05
ENDOSTEUM	3.2E-02
REMAINDER	1.6E-04
EFFECTIVE	5.0E-03

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 ENDOSTEUM (mrem/y)
INGESTION	1.5E-04	2.7E-03
INHALATION	4.9E-03	3.0E-02
AIR IMMERSION	2.9E-11	3.6E-11
GROUND SURFACE	1.0E-06	1.1E-06
TOTAL:	5.0E-03	3.2E-02

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 ENDOSTEUM (mrem/y)
U-238	5.7E-04	6.0E-04
U-235	2.6E-05	3.0E-05
U-234	6.2E-04	6.8E-04
RA-226	3.3E-04	5.3E-04
TH-232	3.5E-03	3.1E-02
TOTAL :	5.0E-03	3.2E-02

Maywood Interim Storage Site

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

DIRECTION : NORTH

DISTANCE (meters)	EFFECTIVE DOSE EQUIVALENT (mrem/y)
300	5.0E-03
1000	7.0E-04
3000	1.1E-04
10000	1.7E-05
80000	6.3E-07

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

IRECTIONS:	N	NNE	NE	ENE	E	ESE	SE	SSE
DISTANCE (METERS):								
300	5.0E-03	4.7E-03	4.4E-03	5.0E-03	4.7E-03	3.6E-03	3.2E-03	3.4E-03
1000	7.0E-04	4.1E-04	4.2E-04	5.4E-04	5.2E-04	2.9E-04	3.7E-04	3.0E-04
3000	1.1E-04	6.3E-05	6.5E-05	8.4E-05	8.1E-05	4.6E-05	5.8E-05	4.7E-05
10000	1.7E-05	1.0E-05	1.0E-05	1.3E-05	1.3E-05	7.3E-06	9.3E-06	7.4E-06
80000	6.3E-07	3.9E-07	4.1E-07	5.2E-07	4.8E-07	2.8E-07	3.9E-07	3.0E-07

	S	SSW	SW	WSW	W	WNW	NW	NNW
DISTANCE (METERS):								
300	3.7E-03	3.4E-03	3.4E-03	4.0E-03	3.9E-03	2.8E-03	2.0E-03	3.1E-03
1000	4.6E-04	2.9E-04	3.5E-04	3.9E-04	4.4E-04	2.4E-04	2.0E-04	1.9E-04
3000	7.1E-05	4.5E-05	5.4E-05	6.0E-05	6.7E-05	3.6E-05	3.1E-05	2.9E-05
10000	1.1E-05	7.2E-06	8.5E-06	9.1E-06	1.0E-05	5.4E-06	4.8E-06	4.4E-06
80000	4.5E-07	2.7E-07	3.0E-07	2.7E-07	2.8E-07	1.5E-07	1.6E-07	1.5E-07

METEOROLOGICAL AND PLANT INFORMATION SUPPLIED TO PROGRAM----

AVERAGE VERTICAL TEMPERATURE GRADIENT OF THE AIR (DEG K/METER)

IN STABILITY CLASS E	0.0728
IN STABILITY CLASS F	0.1090
IN STABILITY CLASS G	0.1455

PLUME DEPLETION AND DEPOSITION PARAMETERS

NUCLIDE	GRAVITATIONAL FALL VELOCITY (METERS/SEC)	DEPOSITION VELOCITY (METERS/SEC)	SCAVENGING COEFFICIENT (1/SEC)	EFFECTIVE DECAY CONSTANT IN PLUME (PER DAY)
U-238	0.000	0.00180	0.117E-04	0.000E+00
U-235	0.000	0.00180	0.117E-04	0.000E+00
U-234	0.000	0.00180	0.117E-04	0.000E+00
RA-226	0.000	0.00180	0.117E-04	0.000E+00
TH-232	0.000	0.00180	0.117E-04	0.000E+00

FREQUENCIES OF WIND DIRECTIONS AND TRUE-AVERAGE WIND SPEEDS

WIND TOWARD	FREQUENCY	WIND SPEEDS FOR EACH STABILITY CLASS (METERS/SEC)						
		A	B	C	D	E	F	G
N	0.141	0.00	3.70	5.36	6.19	3.57	1.96	0.00
NNW	0.028	1.67	3.15	5.05	5.13	3.38	1.91	0.00
NW	0.029	0.00	3.15	4.44	5.02	3.17	2.16	0.00
WNW	0.028	0.00	2.54	4.36	5.12	3.12	1.69	0.00
W	0.049	0.00	2.34	3.44	5.33	2.86	1.83	0.00
WSW	0.043	0.00	2.33	3.42	5.14	3.13	1.98	0.00
SW	0.048	1.67	2.62	3.90	5.61	3.49	2.28	0.00
SSW	0.047	0.00	2.78	4.37	5.71	3.96	2.24	0.00
S	0.082	1.67	3.07	4.27	6.44	4.11	2.23	0.00
SSE	0.061	1.67	3.34	4.38	6.90	4.11	1.98	0.00
SE	0.086	0.00	3.45	4.83	7.58	4.18	2.22	0.00
ESE	0.059	0.00	2.83	4.66	7.42	4.11	2.15	0.00
E	0.092	0.00	3.18	4.38	6.99	4.03	2.20	0.00
ENE	0.080	0.00	3.25	4.10	5.52	3.85	2.25	0.00
NE	0.060	0.00	3.30	4.42	5.22	3.63	2.27	0.00
NNE	0.068	0.00	3.24	4.62	6.00	3.71	2.15	0.00

FREQUENCIES OF WIND DIRECTIONS AND RECIPROCAL-AVERAGED WIND SPEEDS

WIND TOWARD	FREQUENCY	WIND SPEEDS FOR EACH STABILITY CLASS (METERS/SEC)						
		A	B	C	D	E	F	G
N	0.141	0.00	3.02	4.73	5.11	3.33	1.43	0.00
NNW	0.028	1.19	1.98	4.42	3.91	3.16	1.39	0.00
NW	0.029	0.00	1.98	3.32	3.96	2.98	1.68	0.00
WNW	0.028	0.00	1.95	3.12	3.72	2.94	1.20	0.00
W	0.049	0.00	1.59	2.44	3.91	2.75	1.31	0.00
WSW	0.043	0.00	1.49	2.76	3.95	2.95	1.46	0.00
SW	0.048	1.19	1.63	3.07	4.48	3.26	1.87	0.00
SSW	0.047	0.00	1.84	3.89	4.94	3.77	1.80	0.00
S	0.082	1.19	2.60	3.87	5.59	3.97	1.78	0.00
SSE	0.061	1.19	2.67	3.97	6.17	3.97	1.46	0.00
SE	0.086	0.00	2.74	4.37	6.81	4.07	1.77	0.00
ESE	0.059	0.00	2.00	3.98	6.73	3.97	1.66	0.00
E	0.092	0.00	2.16	3.69	6.02	3.85	1.74	0.00
ENE	0.080	0.00	2.15	3.81	4.66	3.63	1.81	0.00
NE	0.060	0.00	2.48	3.90	4.32	3.39	1.85	0.00
NNE	0.068	0.00	2.16	3.82	4.92	3.48	1.67	0.00

FREQUENCY OF ATMOSPHERIC STABILITY CLASSES FOR EACH DIRECTION

SECTOR	FRACTION OF TIME IN EACH STABILITY CLASS						
	A	B	C	D	E	F	G
N	0.0000	0.0300	0.2042	0.6347	0.0890	0.0421	0.0000
NNW	0.0051	0.0224	0.1778	0.6169	0.1039	0.0740	0.0000
NW	0.0000	0.0213	0.1184	0.6929	0.0847	0.0826	0.0000
WNW	0.0000	0.0176	0.0765	0.7082	0.0959	0.1017	0.0000
W	0.0000	0.0259	0.0692	0.6788	0.0969	0.1292	0.0000
WSW	0.0000	0.0295	0.0773	0.6385	0.1043	0.1504	0.0000
SW	0.0029	0.0351	0.0774	0.6372	0.1262	0.1211	0.0000
SSW	0.0000	0.0341	0.1081	0.6200	0.1518	0.0859	0.0000
S	0.0017	0.0229	0.0960	0.6580	0.1492	0.0722	0.0000
SSE	0.0023	0.0181	0.0786	0.6961	0.1634	0.0415	0.0000
SE	0.0000	0.0128	0.0532	0.7688	0.1267	0.0384	0.0000
ESE	0.0000	0.0141	0.0433	0.7504	0.1296	0.0625	0.0000
E	0.0000	0.0189	0.0871	0.6810	0.1317	0.0814	0.0000
ENE	0.0000	0.0199	0.1448	0.5329	0.2053	0.0971	0.0000
NE	0.0000	0.0383	0.1512	0.4917	0.2185	0.1003	0.0000
NNE	0.0000	0.0182	0.1230	0.6261	0.1683	0.0644	0.0000

APPENDIX F

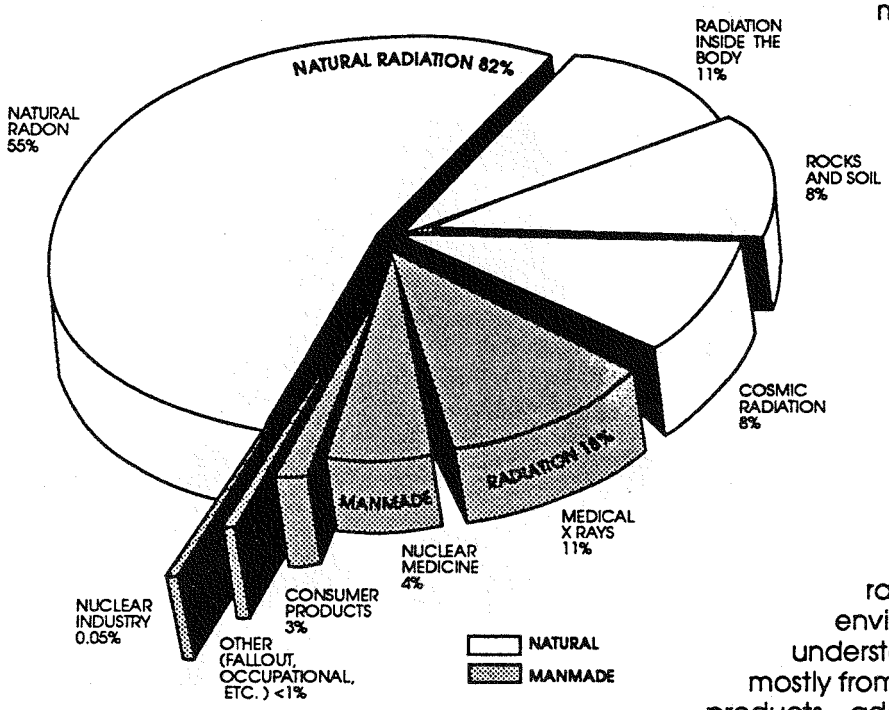
RADIATION IN THE ENVIRONMENT

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
McAipe, Brazil ..... 2,558 mrem/year
Pocos De Caldas, Brazil ..... 7,000 mrem/year

Buildings

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

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

Radon

Radon levels in buildings vary, depending on geographic location, from 0.1 to 200 pCi/liter.

Average Indoor Radon Level ..... 1.5 pCi/liter
Occupational Working Limit ..... 100.0 pCi/liter

RADIATION IN THE ENVIRONMENT

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

mrem = millirem
pCi = picocurie

Food

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

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

Medical Treatment

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

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

Consumer Goods

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

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

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

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

International Nuclear Weapons Test Fallout from pre-1980 atmospheric tests

(average for a U.S. citizen) ..... 1 mrem/year

References

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PERSPECTIVE: How Big is a Picocurie?

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

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

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

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

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

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

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

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

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

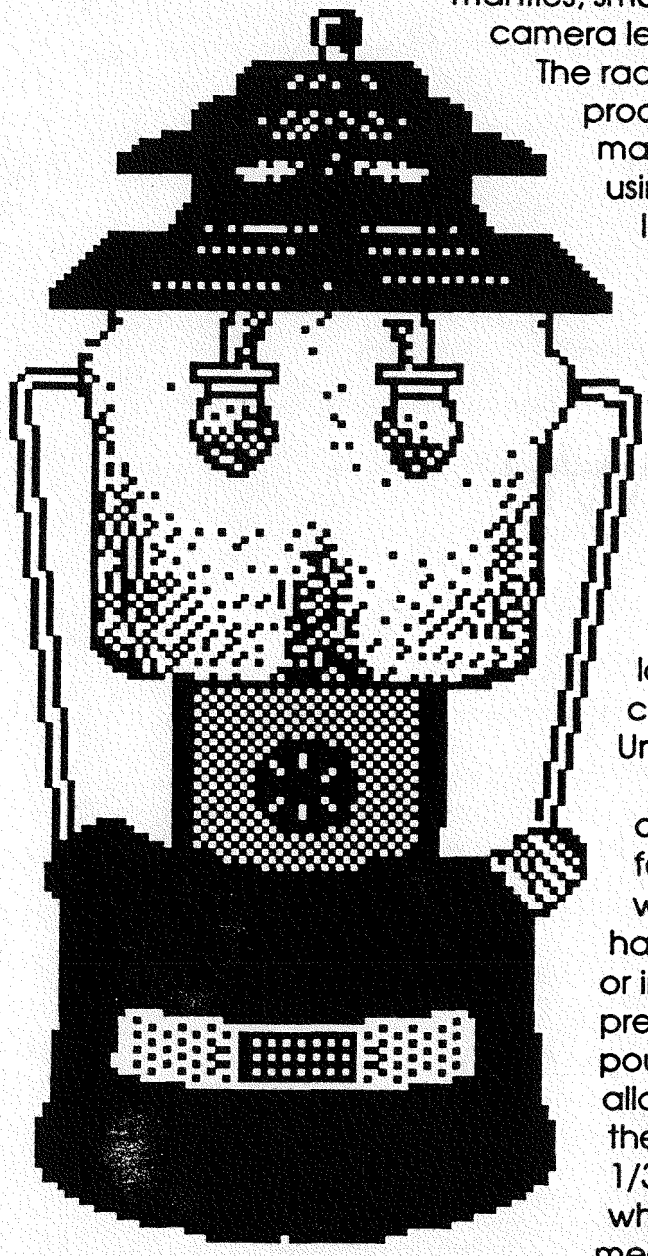
UNIT OF RADIOACTIVITY	SYMBOL	DISINTEGRATIONS PER MINUTE	DOLLAR ANALOGY	EXAMPLES OF RADIOACTIVE MATERIALS
1 Curie	Ci	$2x10^{12}$ or 2 Trillion	2 Times the Annual Federal Budget	Nuclear Medicine Generator
1 Millicurie	mCi	$2x10^{9}$ or 2 Billion	Cost of a New Interstate Highway from Atlanta to San Francisco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

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

PERSPECTIVE: Radioactivity in Gas Lantern Mantles

Around the House

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



Lanterns: In a New Light

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

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

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

APPENDIX G
METALS DATA

Appendix G

Summary of Metal Concentrations[a] in Groundwater at MISS, 1991

Sampling Location[b]	Metal	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Avg
MISS-1B	Aluminum	124	U	77.0	U	116	J	200	U	129.3
	Arsenic	2.0	UJ	2.0	U	2.0	UJ	10.0	U	4.0
	Antimony	20.4	U	19.0	U	55.0	U	60.0	U	38.6
	Barium	17.5	B	42.8	B	75.3	J	200	U	83.9
	Beryllium	0.3	U	1.0	U	1.0	J	1.0	J	0.8
	Boron	100	U	100	U	100	U	100	U	100.0
	Cadmium	3.2	U	4.0	U	4.0	UJ	5.0	U	4.1
	Calcium	12500		31100		63400	J	111000		54500.0
	Chromium	2.9	U	3.0	U	3.0	U	10.0	U	4.7
	Cobalt	4.7	U	4.0	U	8.0	UJ	50.0	U	16.6
	Copper	4.2	U	7.0	U	6.0	UJ	25.0	U	10.6
	Iron	54.8	U	17500		23900	J	6840		12073.7
	Lead	3.0	UJ	2.0	U	2.3	J	3.0	U	2.6
	Lithium	100	U	103		102		125		107.5
	Magnesium	13400		15600		16400	J	22800		17050.0
	Manganese	33.6		284		389	J	356		265.7
	Molybdenum	100	U	100	U	100	U	100	U	100.0
	Nickel	7.7	U	7.0	U	10.0	UJ	40	U	16.2
	Potassium	8770		7420		8940	J	10100		8807.5
	Selenium	2.0	UJ	1.0	U	2.0	UJ	5.0	U	2.5
	Silver	4.5	U	4.0	U	7.0	UJ	10.0	U	6.4
	Sodium	55700		48400		49800	J	57700		52900.0
	Thallium	40.0	UJ	50.0	UJ	20.0	UJ	100	U	52.5
	Vanadium	20.7	B	8.0	U	12.9	J	50.0	U	22.9
	Zinc	5.1	B	3.4		--		20.0	U	4.5
MISS-2A[c]	Aluminum	502		2180				1380		1354.0
	Arsenic	5640	J	20.0	U			2220		2627.7
	Barium	9.5	B	16.7	B			200	U	75.4
	Beryllium	0.40		1.0	U			5.0	U	2.1
	Boron	100	U	874				1920		964.7
	Cadmium	3.2	U	14.0	U			5.0	U	7.4
	Calcium	84500		73200				153000		103566.7
	Chromium	22.3		26.1				466		171.5
	Copper	203		420				171		264.7
	Iron	1660		1340				2150		1716.7
	Lead	10.5	J	25.8				9.6		15.3
	Lithium	100	U	5730				9410		5080.0
	Magnesium	6280		5840				10700		7606.7
	Manganese	193		35.6				108		112.2
	Nickel	9.6	B	15.6	B			40.0	U	21.7
	Potassium	5300		4380	B			11000		6893.3
	Selenium	2.0	UJ	1.0	UJ			5.0	U	2.7
	Silver	4.5	U	4.0	U			10.0	U	6.2
	Sodium	984000		802000				1140000		975333.3
	Thallium	4.0	UJ	5.0	UJ			10.0	U	6.3
	Tin	20.4	U	24.6						22.5
	Vanadium	23.1	B	8.6	B			53.1		28.3
	Zinc	33.6		65.8				22.6		40.7
MISS-2B	Aluminum	124	U	77.0	U	96.0	UJ	200	U	124.3
	Arsenic	20.0	UJ	3.5	B	20.0	UJ	10.0	U	13.4
	Barium	3.9	U	5.0	U	8.0	UJ	200	U	54.2
	Boron	100	U	4030		4280		3400		2952.5
	Cadmium	3.2	U	4.0	U	4.0	UJ	5.0	U	4.1
	Calcium	60500		2078		26300	J	117000		51469.5
	Chromium	13.4		11.8		17.6		11.1		13.5
	Cobalt	4.7	U	4.0	U	8.0	UJ	50.0	U	16.7
	Copper	4.2	U	7.0	U	6.0	UJ	25.0	U	10.6
	Iron	233		14200		22600	J	15200		13058.3

Sampling Location[b]	Metal	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Avg
MISS-2B (cont'd)	Lead	3.0 UJ	2.0 UJ	2.0 UJ	3.0 U	2.5
	Lithium	100 U	12600	16700	14900	11075.0
	Magnesium	44300	36000	38400 J	40200	39725.0
	Manganese	112	96.8	219 J	1090	379.5
	Nickel	7.7 U	10.1 B	17.8 J	40.0 U	18.9
	Potassium	49500	37800	43600 J	47900	44700.0
	Selenium	20.0 UJ	1.0 U	20.0 UJ	50.0 U	22.8
	Silver	4.5 U	4.0 U	7.0 UJ	10.0 U	6.4
	Sodium	1910000	1580000	174000 J	1700000	1338500.0
	Thallium	40.0 UJ	5.0 UJ	2.0 UJ	100 U	36.8
	Vanadium	27.9 B	8.0 U	10.0 UJ	50.0 U	24.0
	Zinc	5.4 B	19.6	208	24.8	64.5
MISS-3A	Aluminum	124 U	2510	15600 J	4000	5558.5
	Arsenic	106 J	252	168 J	226	188.0
	Barium	36.1 B	162 B	335 J	200 U	183.3
	Boron	100 U	100 U	100 U	100 U	100.0
	Cadmium	3.2 U	4.0 U	4.0 UJ	5.0 U	4.1
	Calcium	58100	48600	34900 J	41000	45650.0
	Chromium	2.9 U	3.0 U	37.2 J	10.0 U	13.3
	Cobalt	4.7 U	6.0 B	21.8 J	50.0 U	20.6
	Copper	4.2 U	7.4 B	76.0 J	26.5	28.5
	Iron	69500	111000	99800 J	97800	94525.0
	Lead	3.0 UJ	2.0 UJ	48.9 J	11.0	16.2
	Lithium	100 U	135	119	164	129.5
	Magnesium	6360	5880	6670 J	5370	6070.0
	Manganese	1050	1100	945 J	1050	1036.3
	Mercury	3.0 UJ				
	Nickel	7.7 U	7.0 U	27.2 J	40.0 U	20.5
	Potassium	16700	17500	20300 J	22100	19150
	Selenium	2.0 UJ	1.7 BJ	2.0 UJ	50.0 U	13.9
	Silver	8.0 B	14.3	7.0 UJ	10.0 U	9.8
	Sodium	14100	13900	15400 J	17000	15100.0
	Thallium	40.0 UJ	5.0 UJ	2.0 UJ	10.0 U	14.3
	Tin	20.4 U	19.0 U	55.0 UJ		31.5
	Vanadium	8.1 B	8.0 U	10.0 UJ	50.0 U	19.0
	Zinc	3.5 U	75.7	183 J	127	97.3
MISS-3B	Aluminum	124 U	147 B	187 J	200 U	164.5
	Arsenic	2.0 UJ	10.3 J	5.3 J	10.0 U	6.9
	Barium	4.2 B	16.7 B	11.6 J	200 U	58.1
	Boron	100 U	100 U	100 U	100 U	100.0
	Cadmium	3.2 U	4.0 U	4.0 UJ	5.0 U	4.1
	Calcium	62900	222000	206000 J	92500	145850
	Chromium	2.9 U	3.0 U	6.0 J	10.0 U	5.5
	Cobalt	4.7 U	23.8	36.2 J	50.0 U	28.6
	Copper	4.2 U	7.0 U	6.0 UJ	25.0 U	10.6
	Iron	8480	106000	74500 J	21100	52520.0
	Lead	3.0 UJ	2.0 UJ	2.0 UJ	30.0 U	9.3
	Lithium	100 U	100 U	161	100 U	115.3
	Magnesium	4230 B	9320	10200 J	5000 U	7187.5
	Manganese	1350	8360	7320 J	2410	4860.0
	Nickel	7.7 U	16.9 B	16.7 J	40.0 U	20.3
	Potassium	6860	7740	8260 J	6720	7395.0
	Selenium	2.0 UJ	1.0 UJ	20.0 UJ	5.0 U	7.0

Sampling Location[b]	Metal	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Avg
MISS-3B (cont'd)	Silver	4.5 U	17.7	7.0 UJ	10.0 U	9.8
	Sodium	52800	55700	62200 J	45600	54075.0
	Thallium	4.0 UJ	5.0 UJ	2.0 UJ	10.0 U	5.3
	Vanadium	20.2 B	8.0 U	10.0 UJ	50.0 U	22.1
	Zinc	4.1 B	386	113	42.3	136.4
MISS-4B	Aluminum	124 U	77.0 U	96.0 UJ	200 U	124.3
	Arsenic	2.0 UJ	2.0 UJ	2.0 UJ	10.0 U	4.0
	Barium	32.8 B	356	132 J	200 U	180.2
	Boron	155	146	147	132	145.0
	Cadmium	4.0 U	4.0 U	4.0 UJ	5.0 U	4.3
	Calcium	71800	97000	6760 J	96100	67915.0
	Chromium	3.0 U	3.0 U	8.6 J	10.0 U	6.2
	Copper	5.0 U	7.0 U	7.1 J	25.0 U	11.0
	Iron	55.0 U	29200	37600 J	9600	19113.8
	Lead	3.0 UJ	2.0 U	2.9 J	3.0 U	2.7
	Lithium	100 U	100 U	100 U	100 U	100.0
	Magnesium	14900	16800	1020 J	12400	11280.0
	Manganese	911	2600	2280 J	3190	2245.3
	Nickel	8.0 U	7.0 U	10.0 UJ	40.0 U	16.3
	Potassium	40900	35000	26400 J	24000	31575
	Selenium	2.0 UJ	1.0 UJ	2.0 UJ	5.0 U	2.5
	Silver	5.0 UJ	4.0 U	7.0 UJ	10.0 U	6.5
	Sodium	105000	89700	92100 J	113000	99950.0
	Thallium	4.0 UJ	5.0 UJ	2.0 UJ	10.0 U	5.3
	Vanadium	19.6 B	8.0 U	10.0 UJ	50.0 U	21.9
	Zinc	4.0 UJ	14.3	147	42.7	52.0
MISS-5B[d]	Aluminum	124 U	77.0 U	145 J		115.3
	Arsenic	2.4 J	12.3 J	18.2 J		11.0
	Barium	11.6 B	84.6 B	61.2 J		52.5
	Boron	444	817	650		637.0
	Cadmium	4.0 U	4.0 U	4.0 U		4.0
	Calcium	88400	428000 J	391000		302466.7
	Chromium	3.0 U	3.0 U	7.8 J		4.6
	Copper	5.0 U	7.0 U	6.0 U		6.0
	Iron	55.0 U	8490 J	42900		17148.3
	Lead	3.0 UJ	2.0 UJ	2.0 UJ		2.3
	Lithium	100 U	294	1800		731.3
	Magnesium	23600	78200 J	36300		46033.3
	Manganese	302	3250 J	1580		1710.7
	Nickel	8.0 U	7.0 U	22.5 J		12.5
	Potassium	286000	286000 J	272000		281333.3
	Selenium	2.0 UJ	1.3 J	20.0 UJ		7.8
	Silver	5.0 UJ	4.0 UJ	7.0 U		5.3
	Sodium	136000	438000 J	115000		229666.7
	Thallium	4.0 UJ	50.0 R	2.0 UJ		18.7
	Vanadium	15.6 B	22.1 B	33.2 J		23.6
	Zinc	4.0 UJ	3.6 B	77.7 B		28.4
MISS-6A	Aluminum	124 U	522	4440 J	1140	1556.5
	Arsenic	5.8 J	4.8 B	19.8 J	10.0 U	10.1
	Barium	30.9 B	42.2 B	139 J	200 U	103.0
	Boron	1410	464	2740	1640	1563.5
	Cadmium	4.0 U	4.0 U	4.0 UJ	5.0 U	4.3

Sampling Location[b]	Metal	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Avg
MISS-6A (cont'd)	Calcium	28200	317000 J	212000	247000	201050.0
	Chromium	3.0 U	3.0 U	21.4 J	14.7	10.5
	Copper	6.1 B	79.1	278 J	129	123.1
	Iron	729	3850 J	21400 J	6850	8207.3
	Lead	3.0 UJ	17.1 J	66.1 J	21.4	26.9
	Lithium	100 U	244	12400	7210	4988.5
	Magnesium	4210 B	14800 J	18200 J	14700	12977.5
	Manganese	320	124 J	851 J	517	453.0
	Nickel	8.0 U	8.2 B	17.3 J	40 U	18.4
	Potassium	75000	15700 J	98500 J	65100	63575.0
	Selenium	2.0 UJ	10.2 J	4.5 J	5.0 U	5.4
	Silver	5.0 UJ	4.0 UJ	7.0 UJ	10.0 U	6.5
	Sodium	365000	15000 J	89100 J	55100	131050.0
	Thallium	4.0 UJ	5.0 UJ	2.0 UJ	10.0 U	5.3
	Vanadium	16.9 B	18.8 B	30.8 J	50.0 U	29.1
	Zinc	7.8 B	3520	1860	843.0	1557.7
MISS-6B	Aluminum	124 U	4360 J	2330 J	314	1782.0
	Arsenic	2 UJ	10.6 J	5.9 J	10.0 U	7.1
	Barium	67.3	139 B	92.1 J	200 U	124.6
	Boron	690	1310	1330	1390	1180.0
	Cadmium	4.0 U	4.0 U	4.0 UJ	5.0 U	4.3
	Calcium	500000	91600 J	65000 J	72100	182175.0
	Chromium	3.0 U	3.0 U	7.6 J	10.0 U	5.9
	Cobalt	5.0 U	12.0 B	9.0 J	50.0 U	19.0
	Copper	40.0	12.0 B	21.6 J	25.0 U	24.7
	Iron	55.0 U	34.5	14100 J	7120	5327.4
	Lead	3.0 UJ	31.9 J	12.5 J	13.1	15.1
	Lithium	100 U	1340	14300	12600	7085.0
	Magnesium	20500	10800 J	8770 J	9210	12320
	Manganese	112	2770 J	1790 J	1890	1640.5
	Nickel	13.0 B	18.4 B	10.0 UJ	40.0 U	20.4
	Potassium	23800	106000 J	90800 J	111000	82900.0
	Selenium	11.6	1.0 UJ	2.0 UJ	5.0 U	4.9
	Silver	5.0 UJ	4.0 UJ	7.0 UJ	10.0 U	6.5
	Sodium	27300	303000 J	28100 J	304000	165600.0
	Thallium	4.0 UJ	50.0 UJ	2.0 UJ	10.0 U	16.5
	Vanadium	38.4 B	28.3 B	21.9 J	50.0 U	34.7
	Zinc	3100 J	68.7	105	39.8	828.4
MISS-7B[d]	Aluminum	124 U	77.0 U	96.0 UJ		99.0
	Arsenic	4.6 J	137 J	155 J		98.9
	Barium	4.0 U	36.5 B	34.0 J		24.8
	Boron	593	1490	826		969.7
	Cadmium	4.0 U	4.0 U	4.0 U		4.0
	Calcium	7790	162000 J	56400		75396.7
	Chromium	3.0 U	3.0 U	4.3 J		3.4
	Copper	5.0 U	7.0 U	6.0 U		6.0
	Iron	55.0 U	19600 J	80700		33451.7
	Lead	3.0 UJ	2.0 UJ	2.9 J		2.6
	Lithium	100 U	459	2780		1113.0
	Magnesium	16400	49900 J	26000		30766.7
	Manganese	11.6 B	2390 J	1100		1167.2
	Nickel	8.0 U	7.0 U	10.0 U		8.3

Sampling Location[b]	Metal	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Avg
MISS-7B[d] (cont'd)	Potassium	27400	40400 J	27400 J		31733.3
	Selenium	2.0 UJ	2.0 J	2.0 U		2.0
	Silver	5.0 UJ	4.0 UJ	7.0 U		5.3
	Sodium	827000	960000 J	735000		840666.7
	Thallium	4.0 UJ	50.0 UJ	21.0 J		25.0
	Vanadium	12.4 B	24.6 B	39.7 J		25.6
	Zinc	4.1 J	19.2 B	98.3		40.5
B38W03B	Aluminum	124 U	78.6 B	84.0 U	200 U	121.7
	Arsenic	2.0 UJ	2.0 UJ	2.0 UJ	10.0 U	4.0
	Barium	18.9 B	18.1 B	20.4 J	200 U	64.4
	Beryllium	0.3 U	1.0 U	1.5 J	5.0 U	2.0
	Boron	142	169	108	142	140.3
	Cadmium	3.2 U	4.0 U	2.0 U	5.0 U	3.6
	Calcium	299000	330000	415000	297000	335250.0
	Chromium	2.9 U	3.0 U	6.1 J	10.0 U	5.5
	Cobalt	4.7 U	4.0 U	3.0 U	50.0 U	15.4
	Copper	4.2 U	7.0 U	7.1 J	25.0 U	10.8
	Iron	2940	29700	29500	25700	21960.0
	Lead	3.0 UJ	2.0 UJ	20.0 UJ	3.0 U	7.0
	Lithium	100 U	100 U	100 U	100 U	100.0
	Magnesium	34400 B	43000	68800 J	34300	45125.0
	Manganese	6830	7350	8550 J	6850	7395
	Nickel	7.7 U	7.0 U	6.0 U	40.0 U	15.2
	Potassium	25100	25900	13200	23100	21825.0
	Selenium	2.0 UJ	1.9 BJ	2.1 J	50.0 U	14.0
	Silver	11.4 U	4.0 U	4.0 U	10.0 U	7.4
	Sodium	117000	139000	221000	117000	148500.0
	Thallium	40.0 UJ	5.0 UJ	2.0 UJ	100 U	36.8
	Tin	20.4 U	19.0 U	18.0 UJ		19.1
	Vanadium	15.2 B	16.8 B	38.1 J	50.0 U	30.0
	Zinc	62.1 J	26.4	35.8 U	142	66.6
B38W04B[e]	Aluminum	124 U	77.0 U		200 U	133.7
	Arsenic	2.0 U	2.0 U		10.0 U	4.7
	Barium	309	234		230	257.7
	Beryllium	0.70 J	1.0 U		5.0 U	2.2
	Boron	1120	999		885	1001.3
	Cadmium	3.2 U	4.0 U		5.0 U	4.1
	Calcium	78000	60800		61200	66666.7
	Chromium	2.9 U	3.8 B		10.0 U	5.6
	Cobalt	5.2 B	4.0 U		50.0 U	19.7
	Copper	29.4	7.0 U		25.0 U	20.5
	Iron	45600	11100		8900	21866.7
	Lead	15.0 J	4.2 J		3.7	7.6
	Lithium	2000	2300		1670	1990
	Magnesium	7800 J	6130		6070	6666.7
	Manganese	10200	6820		7110	8043.3
	Nickel	15.9 B	7.0 U		40.0 U	21.0
	Potassium	4710 B	3610 B		5000 U	4440.0
	Selenium	2.0 UJ	1.0 UJ		5.0 U	2.7
	Silver	11.4 UJ	9.5 B		10.0 U	10.3
	Sodium	74200	61100		64000	66433.3

Sampling Location[b]	Metal	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Avg
B38W04B[e]	Thallium	40.0	UJ	5.0	UJ			100	U	48.3
	Tin	20.4	U	25.6	B					23.0
	Vanadium	27.3	J	8.0	U			50.0	U	28.4
	Zinc	72.9		6.6	B			20.0	U	33.2
B38W05B	Aluminum	124	U	711		990		244		517.3
	Arsenic	2.0	UJ	2.2	B	2.2	J	10.0	U	4.1
	Barium	144	B	149		154	J	200	U	161.8
	Boron	100	U	100	U	100	U	137		109.3
	Cadmium	3.2	U	4.0	U	2.0	U	5.0	U	3.6
	Calcium	84200		83700		78300		79300		81375.0
	Chromium	12.0	J	37.0		90.3	J	27.2		41.6
	Copper	8.5	J	14.3	B	13.8	J	25.0	U	15.4
	Iron	376	J	1320		2150		457		1075.8
	Lead	3.0	U	3.3		4.4	J	4.7		3.9
	Lithium	100	U	100	U	100	U	100	U	100.0
	Magnesium	10200		10500		9790		9260		9937.5
	Manganese	24.2		122		140	J	50.6		84.2
	Nickel	7.7	U	21.8	B	48.8	J	40.0	U	29.6
	Potassium	2190	B	1510	B	3885	J	5000	U	3146.3
	Selenium	2.0	UJ	1.0	U	2.0	UJ	5.0	U	2.5
	Silver	11.4	U	4.0	U	4.0	U	10.0	U	7.4
	Sodium	16200		23600		16500		14900		17800.0
	Thallium	4.0	UJ	5.0	UJ	2.0	UJ	10.0	U	5.3
	Vanadium	3.7	U	9.4	B	26.6	J	50.0	U	22.4
	Zinc	25.1		37.7		34.7	B	22.3		30.0
B38W06B	Aluminum	124	U	80.3	B	84.0	U	200	U	122.1
	Arsenic	2.0	UJ	2.0	UJ	2.0	U	10.0	U	4.0
	Barium	151	B	159	B	170	J	200	U	170.0
	Beryllium	0.3	U	1.0	U	1.0	U	5.0	U	1.8
	Boron	133		119		137		132		130.3
	Cadmium	3.2	U	4.0		2.0	U	5.0	U	3.5
	Calcium	130000		154000		136000		116000		134000
	Chromium	3.2	B	7.5	B	5.6	J	10.0	U	6.6
	Cobalt	4.7	U	4.0	U	3.0	U	50.0	U	15.4
	Copper	4.2	U	7.0	U	2.3	J	25.0	U	9.6
	Iron	7820		13800		12100		9020		10685.0
	Lead	3.0	U	2.0	U	2.0	UJ	3.0	U	2.5
	Lithium	100	U	272		839		464		418.8
	Magnesium	10900	B	12100		12200	J	10100		11325.0
	Manganese	2280		2300		2290	J	2170		2260.0
	Nickel	7.7	U	7.0	U	6.0	U	40.0	U	15.2
	Potassium	10900		10700		12800	J	10900		11325.0
	Selenium	2.0	UJ	2.9	BJ	2.0	UJ	5.0	U	3.0
	Silver	11.4	U	7.3	B	4.0	U	10.0	U	8.2
	Sodium	10400		88100		127000		97300		80700.0
	Thallium	40.0	UJ	5.0	UJ	2.0	UJ	10.0	U	14.3
	Vanadium	3.7	U	8.0	U	27.3	J	50.0	U	22.3
	Zinc	11.0	J	8.7	B	9.8	R	35.2		16.2

Sampling Location[b]	Metal	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Avg
B38W07B[d]	Aluminum	62.1 J	1460 J	202 J		574.7
	Arsenic	2.0 U	2.0 U	2.0 UJ		2.0
	Barium	46.2 B	56.7 B	67.5 J		56.8
	Beryllium	0.70 J	1.0 U	1.0 U		0.9
	Boron	118	100 U	100 U		106.0
	Cadmium	3.2 U	4.0 U	4.0 U		3.7
	Calcium	29600	45800 J	85400		53600.0
	Chromium	10.6 J	3.0 U	10.1 J		7.9
	Copper	4.9 B	11.4 B	13.6 J		10.0
	Iron	370	1610 J	488		822.7
	Lead	3.0 UJ	2.6 B	2.2 J		2.6
	Lithium	100 U	100 U	100 U		100.0
	Magnesium	3200	3950 J	6600		4583.3
	Manganese	519	1580 J	3740		1946.3
	Nickel	7.7 U	9.1 B	10.0 UJ		8.9
	Potassium	6490	9970 J	14100 J		10186.7
	Selenium	2.2 J	1.0 UJ	2.0 UJ		1.7
	Silver	11.4 UJ	4.0 UJ	7.0 U		7.5
	Sodium	16200	27600 J	50600		31466.7
	Thallium	4.0 UJ	5.0 UJ	2.0 UJ		3.7
	Vanadium	35.5 J	8.0 U	18.8 B		20.8
	Zinc	10.0 B	32.5	465 J		169.2
B38W12A	Aluminum	124 U	1710	8980	860	2918.5
	Arsenic	2.0 UJ	13.6	30.1	10.0 U	13.9
	Barium	30.9 B	73.3	279	200 U	145.8
	Boron	100 U	100 U	100 U	100 U	100.0
	Cadmium	3.2 U	4.0 U	2.2 UJ	5.0 U	3.6
	Calcium	743000	497000	648000	608000	624000.0
	Chromium	2.9 U	3.0 U	22.2 J	10.0 U	9.5
	Cobalt	7.4 B	4.0 U	11.6 J	50.0 U	18.3
	Copper	5.6 B	7.0 U	27.7	25.0 U	16.3
	Iron	3740	11000	24600	2770	10527.5
	Lead	3.0 UJ	3.0 J	36.6 J	3.9	11.6
	Lithium	100	100 U	100 U	101	100.3
	Magnesium	12500	9940	15200 J	10200	11960.0
	Manganese	1300	1020	2690 J	1880	1722.5
	Nickel	9.1 B	7.0 U	17.9 J	40 U	18.5
	Potassium	2880	1010 U	2689 J	5000 U	2894.8
	Selenium	2.0 UJ	10.0 U	2.0 UJ	50 U	16.0
	Silver	11.4 U	4.0 U	4.0 U	10 U	7.4
	Sodium	29300 J	20800	39600 J	27100	29200.0
	Thallium	40.0 UJ	5.0 UJ	20.0 UJ	100 U	41.3
	Vanadium	25.0 B	28.0 B	80.8 J	50 U	46.0
	Zinc	16.5 J	62.9	67.4 J	64.2	52.8
B38W12B	Aluminum	124 U	77.0 U	84.0 U	200 U	121.3
	Arsenic	2.0 UJ	2.0 U	2.0 U	10.0 U	4.0
	Barium	125 B	80.9	87.7 J	200 U	123.4
	Boron	100 U	100 U	100 U	100 U	100.0
	Cadmium	3.2 U	4.0 U	2.0 U	5.0 U	3.6
	Calcium	136000	89100	99300 J	101000	106350.0
	Chromium	2.9 U	3.0 U	16.0	10.0 U	8.0
	Copper	8.1 J	7.0 U	4.6 J	25.0 U	11.2
	Iron	427 J	598	510	100 U	408.8
	Lead	3.0 U	2.0 U	2.4 J	3.0 U	2.6
	Lithium	100 U	100 U	100 U	100 U	100.0

Sampling Location[b]	Metal	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Avg
B38W12B (cont'd)	Magnesium	30400	19500	22200	21800	23475.0
	Manganese	26.5	32.6	21.7 J	15.0 U	24.0
	Nickel	7.7 U	7.0 U	6.2 J	40 U	15.2
	Potassium	3700 B	1810 B	1958 J	5000 U	3117.0
	Selenium	2.0 UJ	1.0 U	2.5 J	5.0 U	2.6
	Silver	11.4 U	4.0 U	4.0 U	10.0 U	7.4
	Sodium	31600	21000	24200 J	22600	24850.0
	Thallium	40.0 UJ	5.0 UJ	2.0 UJ	10.0 U	14.3
	Vanadium	7.3 B	14.2 B	33.9 J	50.0 U	26.4
	Zinc	23.1	13.6	18.4 B	20.0 U	18.8
B38W14S	Aluminum	7670	4470	1200	443	3445.8
	Arsenic	10.5 J	10.5	8.3 J	10.0 U	9.8
	Barium	326	201	171 J	200 U	224.5
	Boron	100 U	100 U	100 U	100 U	100.0
	Cadmium	4.0 U	4.0 U	2.0 U	5.0 U	3.8
	Calcium	94400	87800	99300 J	86900	92100.0
	Chromium	1050	417	16.0	72.2	388.8
	Cobalt	37.9 B	33.8 B	3.0 U	50.0 U	31.2
	Copper	115	112	4.6 J	25.0 U	64.2
	Iron	25300	12500	510	1820	10032.5
	Lead	62.4 J	58.0	2.4 J	14.3	34.3
	Lithium	100 U	100 U	100 U	100 U	100.0
	Magnesium	28100	25900	22200	24800	25250.0
	Manganese	998	823	21.7 J	106	487.2
	Nickel	312	82.2	6.2 J	43.9	111.1
	Potassium	5980	4830 B	1958 J	5000 U	4442.0
	Selenium	2.0 UJ	1.0 UJ	2.5 J	5.0 U	2.6
	Silver	5.0 UJ	4.0 UJ	4.0 U	10.0 U	5.8
	Sodium	17200	16000	24200 J	15700	18275.0
	Thallium	4.0 UJ	50.0 UJ	2.0 UJ	10.0 U	16.5
	Tin	20.4 U	21.4 B			20.9
	Vanadium	54.2	37.1 B	33.9 J	50.0 U	43.8
	Zinc	81.8 J	66.0 J	18.4 B	48.0	53.6
B38W14D	Aluminum	124 U	1370	344	220	514.5
	Arsenic	2.0 UJ	2.0 UJ	2.0 UJ	10.0 U	4.0
	Barium	33.4 B	72.7 B	65.2 J	200 U	92.8
	Boron	100 U	100 U	100 U	100 U	100.0
	Cadmium	4.0 U	4.0 U	4.0 U	5.0 U	4.3
	Calcium	44300	73300	64200 J	97000	69700.0
	Chromium	3.0 U	9.2 B	5.8 J	10.0 U	7.0
	Copper	22.8 B	81.6	91.3 J	25.0 U	55.2
	Iron	79.0 B	2070	2200 J	421	1192.5
	Lead	3.0 UJ	19.0	26.8 J	3.4	13.1
	Lithium	100 U	100 U	100 U	114	103.5
	Magnesium	9920	19500	16700 J	33500	19905.0
	Manganese	5.6 B	169	161 J	56.9	98.1
	Nickel	8.0 U	30.0 B	27.4 J	40.0 U	26.4
	Potassium	11200	13100	17900 J	5060	11815.0
	Selenium	2.0 UJ	1.9 BJ	2.0 UJ	5.0 U	2.7
	Silver	5.0 UJ	4.0 UJ	7.0 U	10.0 U	6.5
	Sodium	10900	18400	19100 J	31500	19975.0
	Thallium	4.0 UJ	5.0 UJ	2.0 UJ	100 U	27.8
	Tin	21.0 U	24.2 B	55.0		33.4
	Vanadium	18.7 B	14.4 B	15.8 J	50.0 U	24.7
	Zinc	13.9 J	84.4 J	73.6 J	32.7	51.2

Sampling Location[b]	Metal	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Avg
B38W15S	Aluminum	124 U	998	3560	409	1272.8
	Arsenic	6.4 J	2.0 UJ	4.3 J	10.0 U	5.7
	Barium	32.8 B	45.5 B	99.8 J	200 U	94.5
	Boron	463	346	437	433	419.8
	Cadmium	4.0 U	4.0 U	4.0 U	5.0 U	4.3
	Calcium	83700	51800	78100 J	57700	67825.0
	Chromium	3.0 U	7.4 B	20.9	10.0 U	10.3
	Copper	8.0 B	118	154 J	43	80.8
	Iron	70.2 B	3700	6060 J	1250	2770.1
	Lead	3.0 UJ	29.8	49.3 J	17.1	24.8
	Lithium	100 U	1410	1470	1410	1097.5
	Magnesium	321	17800	2460 J	19500	10020.3
	Manganese	910	1350	1760 J	1490	1377.5
	Nickel	8.0 U	9.1 B	22.7 J	40 U	20.0
	Potassium	61500	122000 J	129000	124000	109125.0
	Selenium	2.0 UJ	1.0 UJ	2.0 U	5.0 U	2.5
	Silver	5.0 UJ	4.0 UJ	7.0 U	10.0 U	6.5
	Sodium	321000	180000	182000	171000	213500.0
	Thallium	4.0 UJ	500 UJ	2.0 UJ	10.0 U	129.0
	Vanadium	21.9 B	8.9 B	22.2 J	50.0 U	25.8
	Zinc	48.2 J	41.6 J	64.0 J	58.3	53.0
B38W15D	Aluminum	124 U	415	1700	200 U	609.8
	Arsenic	2.0 UJ	2.2 B	2.0	10.0 U	4.1
	Barium	33.9 B	31.5 B	37.4 J	200 U	75.7
	Boron	374	557	100 U	321	338.0
	Cadmium	4.0 U	4.0 U	4.0 U	5.0 U	4.3
	Calcium	56200	116000	36900 J	57600	66675.0
	Chromium	3.0 U	9.0 B	21.4	10.0 U	10.9
	Copper	5.0 U	29.0	244 J	25.0 U	75.8
	Iron	55.0 U	695	3740 J	305	1198.8
	Lead	3.0 UJ	2.8 B	118 J	3.0 U	31.7
	Lithium	100 U	3350	100 U	1910	1365.0
	Magnesium	20400	42700	2367 J	21600	21766.8
	Manganese	1470	1270	160 J	614	878.5
	Nickel	8.0 U	12.3 B	26.9 J	40.0 U	21.8
	Potassium	143000	66700 J	59000 J	45000	78425.0
	Selenium	2.0 UJ	1.0 UJ	2.0 UJ	5.0 U	2.5
	Silver	5.0 UJ	4.0 UJ	10.0 U	10.0 U	7.3
	Sodium	209000	391000	21800 J	240000	215450.0
	Thallium	4.0 UJ	50.0 UJ	2.0 UJ	100 U	39.0
	Tin	21.0 U	24.7 B			22.9
	Vanadium	18.0 B	14.5 B	13.8 J	50.0 U	24.1
	Zinc	8.0 J	45.2 J	170 J	55.8	69.8

Sampling Location[b]	Metal	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Avg
B38W17A	Aluminum	15600		24000		56400		21900		29475.0
	Arsenic	2.9	B	3.2	BJ	10.5	J	10.0	U	6.7
	Barium	293		412		1290	J	520		628.8
	Beryllium	2.2	J	3.6	B	8.6		5.0	U	4.9
	Boron	113		100		112		133		114.5
	Cadmium	3.2	U	4.0	UJ	3.3	J	5.0	U	3.9
	Calcium	68800		87200		157000		131000		111000.0
	Chromium	1020	J	357		528	J	252		539.3
	Cobalt	31.2	B	33.5	B	81.9		50.0	U	49.2
	Copper	79.3		104		195		91		117.3
	Iron	31200		38500		81100		34300		46275.0
	Lead			168	J	100	J	94		120.7
	Lithium	100		361		551		342		338.5
	Magnesium	11300	J	14500		30800		17100		18425.0
	Manganese	1460		1990		5130	J	2230		2702.5
	Nickel	178		178		2453		220		757.3
	Potassium	22600		23500		36400		29400		27975.0
	Selenium	2.0	UJ	1.0	UJ	20.0	UJ	5.0	U	7.0
	Silver	11.4	UJ	4.6	B	4.0	U	10.0	U	7.5
	Sodium	41000		38700		49000	J	47000		43925.0
	Thallium	40.0	UJ	5.0	UJ	2.0	UJ	100	U	36.8
	Tin	29.3	B	19.0	U					24.2
	Vanadium	71.7	J	46.1	B	125	J	50.6		73.4
	Zinc	149		247		497	J	227		280.0
B38W17B	Aluminum	124	U	77.0	U	90.3	J	200	U	122.8
	Arsenic	3.3	B	6.1	BJ	4.5	J	10.0	U	6.0
	Barium	72.8	B	97.2	B	69.5	J	200	U	109.9
	Beryllium	0.50	B	1.0	U	1.0	U	5.0	U	1.9
	Boron	316		357		344		429		361.5
	Cadmium	3.2	U	4.0	UJ	3.8	J	5.0	U	4.0
	Calcium	22900		277000		236000		224000		189975.0
	Chromium	2.9	U	3.0	U	3.9	J	10.0	U	5.0
	Copper	4.2	U	7.0	U	6.7	J	25.0	U	10.7
	Iron	12200		18800		9550	J	6080		11657.5
	Lead	3.0	UJ	5.6		2.0	UJ	3.0	U	3.4
	Lithium	1040		1030		1300		1910		1320.0
	Magnesium	20800	J	22600		22900	J	24800		22775.0
	Manganese	4250		4540		3760	J	3990		4135.0
	Nickel	7.7	U	7.0	U	6.0	U	40	U	15.2
	Potassium	73200		81700	J	85700	J	95400		84000.0
	Selenium	2.0	UJ	1.0	UJ	2.0	UJ	5.0	U	2.5
	Silver	11.4	UJ	4.0	U	4.0	U	10.0	U	7.4
	Sodium	153000		163000		188000		208000		178000.0
	Thallium	40.0	U	50.0	UJ	2.0	UJ	10.0	U	25.5
	Vanadium	41.7	B	8.4	B	35.9	J	50.0	U	34.0
	Zinc	3.5	U	27.9		366	J	40.8		109.6
B38W18D	Aluminum	124	U	1190		306		7310		2232.5
	Arsenic	2.0	UJ	2.0	U	2.0	UJ	10.0	U	4.0
	Barium	24.8	B	48.1	B	28.2	J	200	U	75.3
	Beryllium	0.70	B	1.4	B	1.6	J	5.0	U	2.2
	Boron	430		421		486		444		445.3
	Cadmium	4.8	B	4.0	U	5.0	U	5.0	U	4.7
	Calcium	125000	J	169000	J	148000		162000		151000.0
	Chromium	2.9	U	265		66.4	J	2370		676.1
	Cobalt	18.2	B	19.0	B	18.4	J	50.0	U	26.4

Sampling Location[b]	Metal	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Avg
B38W18D (cont'd)	Copper	4.2	U	7.0	U	6.0	U	25.0	U	10.6
	Iron	54.8	U	17500	J	16400		21600		13888.7
	Lead	3.0	UJ	2.0	UJ	2.0	UJ	23.9		7.7
	Lithium	2500		307		2950		2830		2146.8
	Magnesium	11400		16100	J	13400		17200		14525.0
	Manganese	2870		4750	J	3500		4730		3962.5
	Nickel	46.5		29.8	B	32.8	J	48.3		39.4
	Potassium	8060		5740	J	6480	J	8120		7100.0
	Selenium	20.0	UJ	1.1	J	2.0	UJ	5.0	U	7.0
	Silver	11.4	U	4.0	UJ	7.0	U	10.0	U	8.1
	Sodium	28400		33700	J	28100		38300		32125.0
	Thallium	4.0	UJ	50.0	UJ	2.0	UJ	100	U	39.0
	Tin	20.7	B	19.0	U					19.9
	Vanadium	6.2	B	10.3	B	21.5	J	50.0	U	22.0
	Zinc	180	J	154		256	J	210		200.0
BACKGROUND										
B38W01S	Aluminum	123	U	2410		1740		1470		1435.8
	Arsenic	2.0	UJ	2.0	UJ	2.5	J	10.0	U	4.1
	Barium	20.4	B	50.6	B	27.1	J	200	U	74.5
	Beryllium	1.8	B	2.7	B	2.6	J	5.0	U	3.0
	Boron	596		589		559		595		584.8
	Cadmium	3.0	U	4.0	U	4.0	U	5.0	U	4.0
	Calcium	371000		413000		445000		433000		415500.0
	Chromium	3.0	U	3.0	U	7.3	J	10.0	U	5.8
	Cobalt	5.0	U	8.4	B	8.0	U	50.0	U	17.9
	Copper	4.0	U	7.0	U	95.1	J	25.0	U	32.8
	Iron	13200		29100		30600		31100		26000.0
	Lead	3.0	UJ	2.6	J	20.0	UJ	30.0	U	13.9
	Lithium	100	U	3550		3290		3200		2535.0
	Magnesium	24500		32700		33000	J	35400		31400.0
	Manganese	1890	J	2590		2770	J	2950		2550.0
	Nickel	8.0	U	15.8	B	13.9	J	40	U	19.4
	Potassium	63300		72700	J	66000	J	64600		66650.0
	Selenium	2.0	UJ	1.0	UJ	2.0	UJ	50.0	U	13.8
	Silver	5.0	U	14.4		7.0	U	10.0	U	9.1
	Sodium	107000		129000		115000		115000		116500.0
	Thallium	40.0	UJ	5.0	UJ	2.0	UJ	100	U	36.8
	Vanadium	13.9	B	9.1	B	10.0	U	50.0	U	20.8
	Zinc	4.4		24.5		40.4	J	60.0		32.3
B38W02D	Aluminum	123	U	958		12200		2630		3977.8
	Arsenic	2.0	UJ	2.0	U	2.0	UJ	10.0	U	4.0
	Barium	253		292		561		364		367.5
	Beryllium	1.3	B	1.0	U	1.0	U	5.0	U	2.1
	Boron	100	U	100	U	100	U	100	U	100.0
	Cadmium	5.7		4.0	U	4.0	U	5.0	U	4.7
	Calcium	98500		104000		122000		96900		105350.0
	Chromium	3.0	U	22.2		26.9		10.0	U	15.5
	Cobalt	5.0	U	4.0	U	16.1	J	50.0	U	18.8
	Copper	4.0	U	11.6	B	26.0	J	25.0	U	16.7
	Iron	55.0	U	1060		13700	J	2520		4333.8
	Lead	3.0	UJ	2.0	U	4.4	J	10.2		4.9
	Lithium	100	U	100	U	100	U	100	U	100.0

Sampling Location[b]	Metal	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Avg
B38W02D (cont'd)	Magnesium	3830 B	4130 B	7770 J	5000 U	5182.5
	Manganese	342 J	360	1380 J	1870	988.0
	Nickel	8.0 U	12.2 B	35.6 J	40.0 U	24.0
	Potassium	815 U	1360 B	4158 J	5000 U	2833.3
	Selenium	2.0 UJ	1.0 BJ	2.0 UJ	5.0 U	2.5
	Silver	5.0 U	10.9	7.0 U	10.0 U	8.2
	Sodium	7440	7670	8060 J	7440	7652.5
	Thallium	4.0 UJ	5.0 UJ	2.0 UJ	10.0 U	5.3
	Tin	20.0 U	23.6 B			21.8
	Vanadium	9.9 B	8.0 U	32.9 J	50.0 U	25.2
	Zinc	19.1	34.1	289 J	66.2	102.1

[a]Concentrations are given in units of μg/L.

[b]Sampling locations are shown in Figure 4-12.

[c]Well was dry during third quarter.

[d]Well was inaccessible during fourth quarter.

[e]Well was bent during third quarter.

APPENDIX H

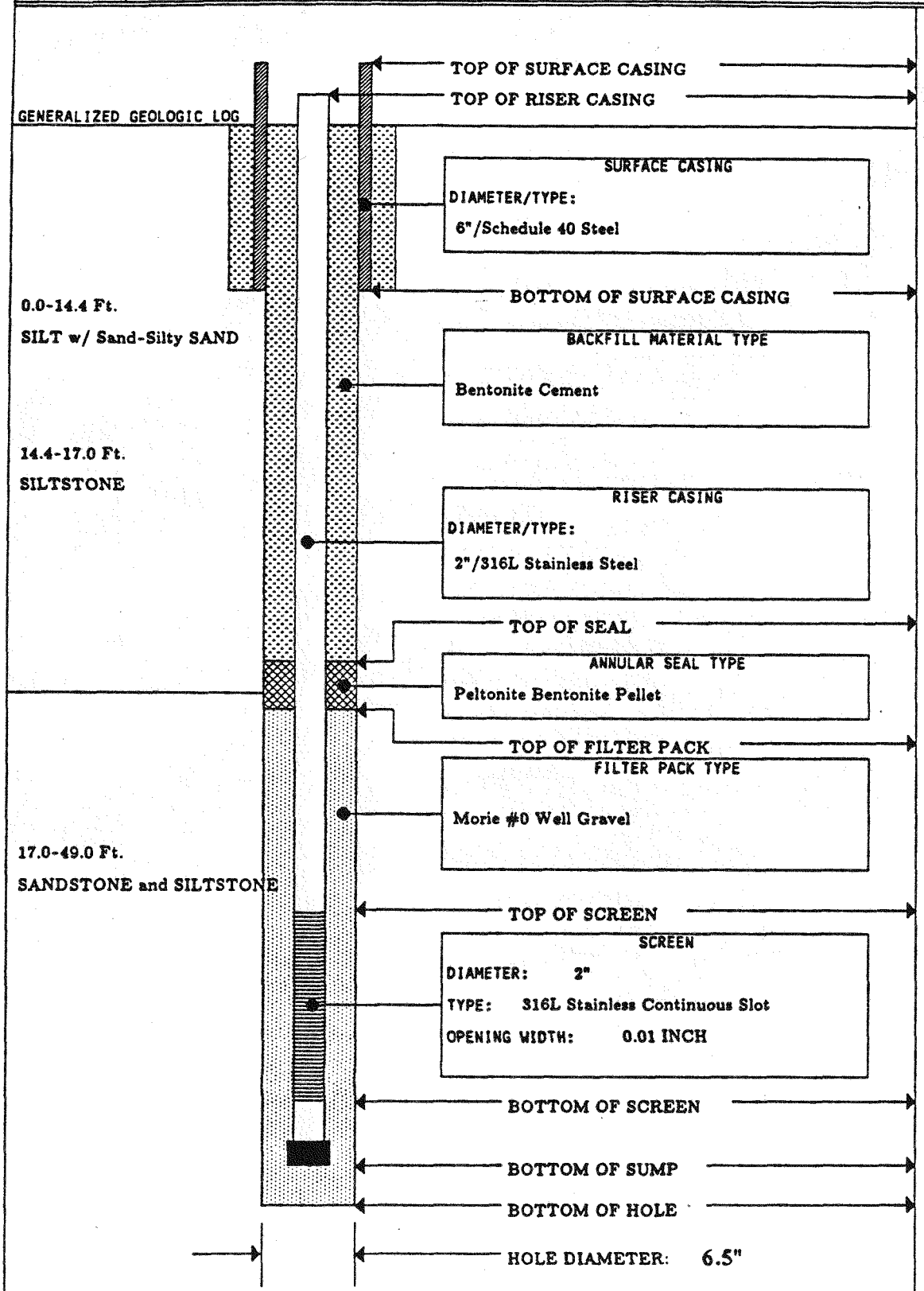
SAMPLE OBSERVATION WELL CONSTRUCTION LOG AND HYDROGRAPHS SHOWING WATER LEVEL ELEVATIONS

MONITORING WELL

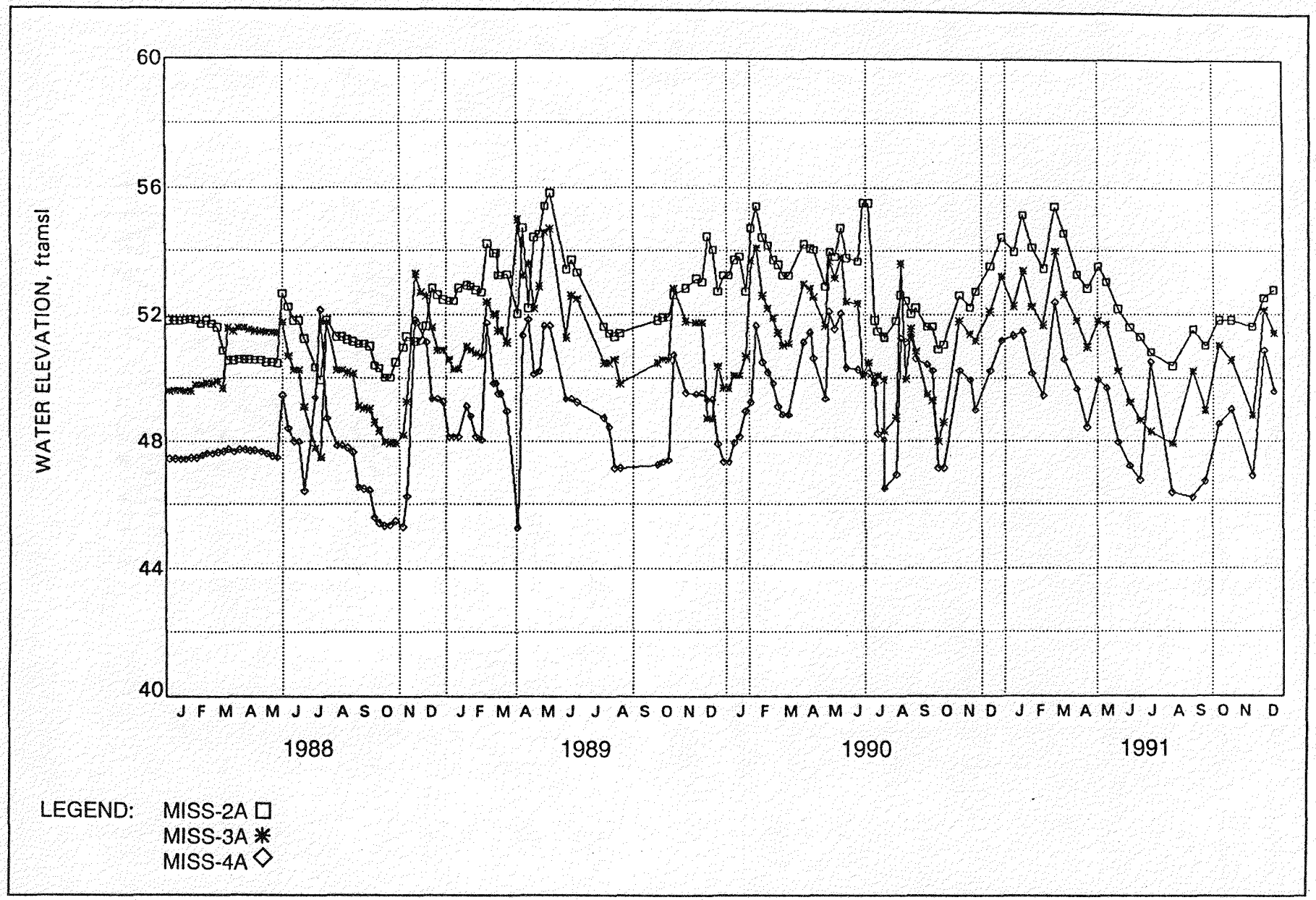
PROJECT	WELL NO.
FUSRAP	B38W5B

JOB NO.	SITE	COORDINATES
14501	MISS	N 9,880.0 E 10,772.0

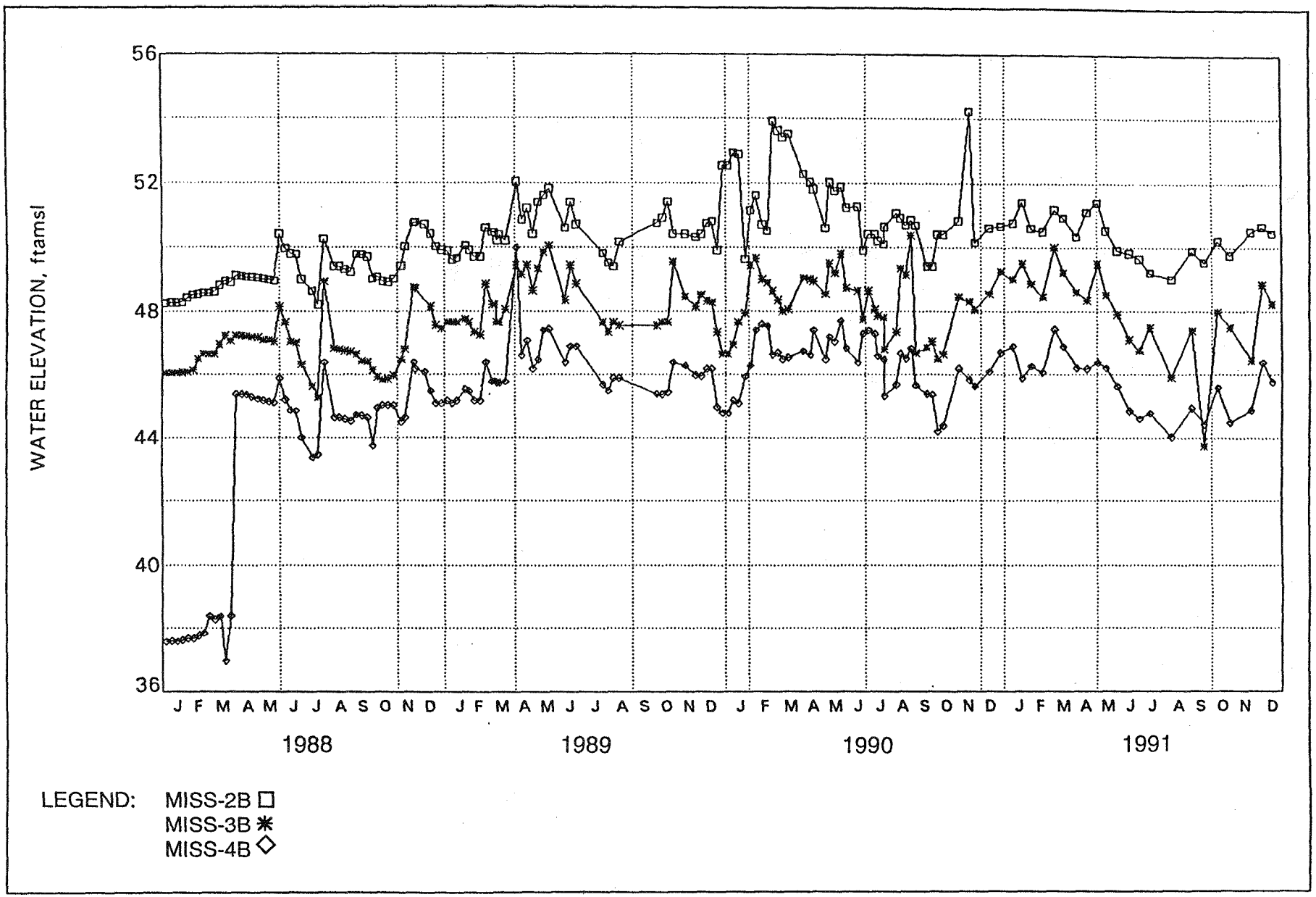
BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
9-16-87	9-21-87	C.A. Clark	Ground surface



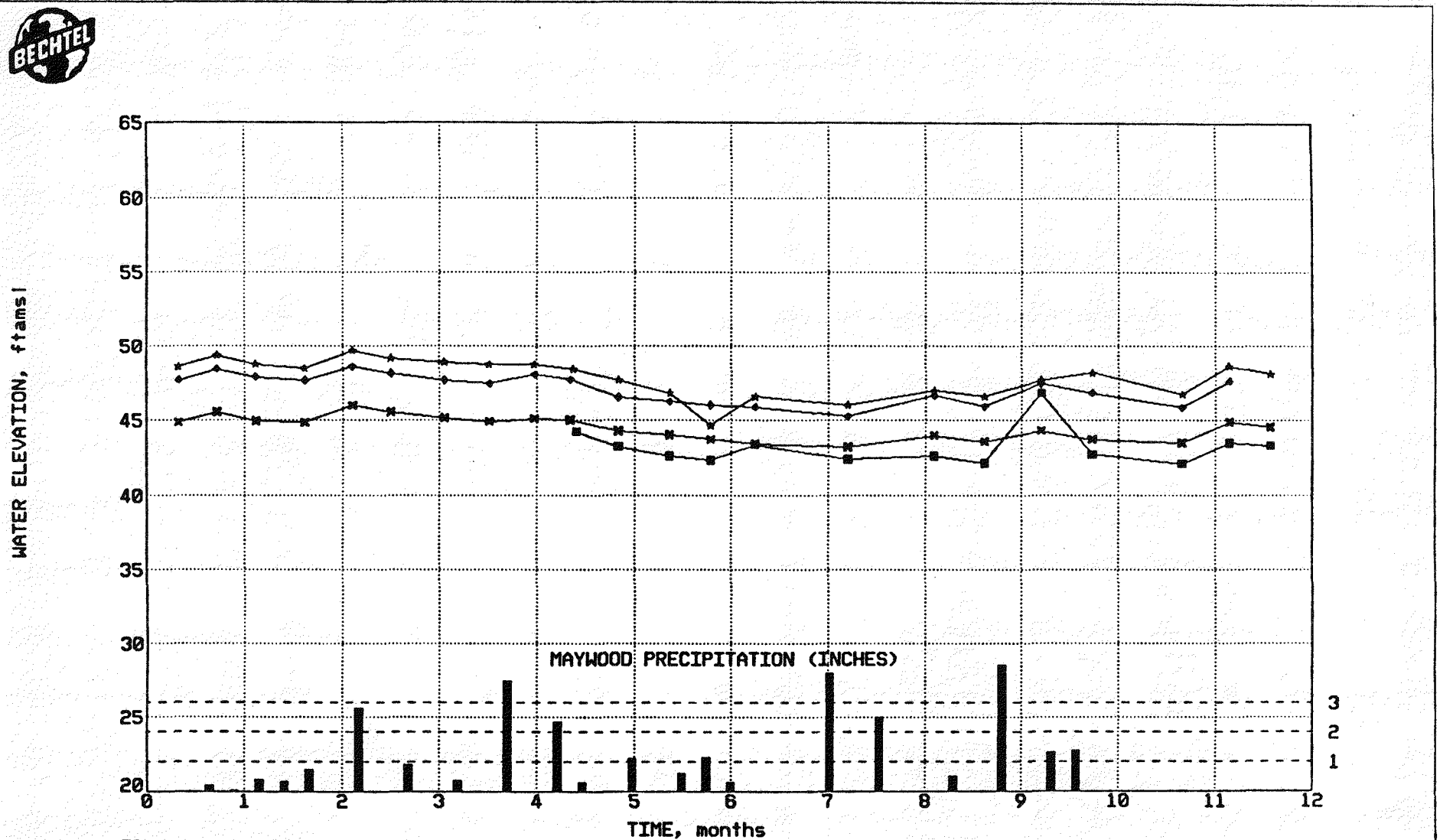
	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	2.9	70.9
TOP OF RISER CASING	0.0	68.1
BOTTOM OF SURFACE CASING	3.0	65.1
TOP OF SEAL	16.5	51.6
TOP OF FILTER PACK	18.5	49.6
TOP OF SCREEN	22.7	45.4
BOTTOM OF SCREEN	33.0	35.1
BOTTOM OF SUMP	44.5	23.6
BOTTOM OF HOLE	44.0	24.1



Hydrographs of Wells MISS – 2A Through MISS – 4A, 1988-1991



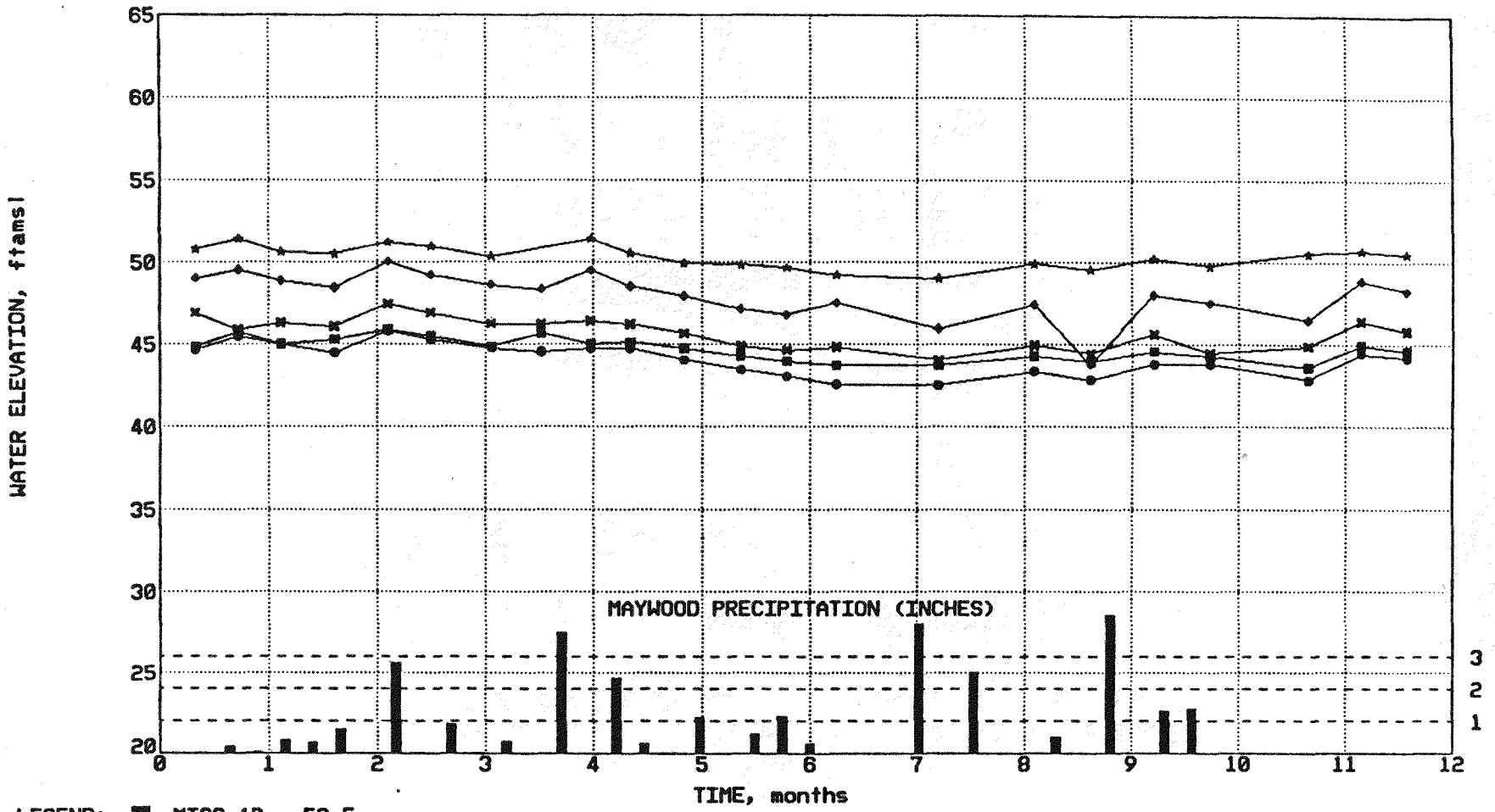
Hydrographs of Wells MISS – 2B Through MISS – 4B, 1988-1991



HYDROGRAPH FOR MISS

Maywood Interim Storage Site PROJECT

BECHTEL JOB 14501-138



LEGEND:
- MISS-1B 53.5
- MISS-2B 58.5
- MISS-3B 50.0
- MISS-4B 47.0
- MISS-5B 55.0

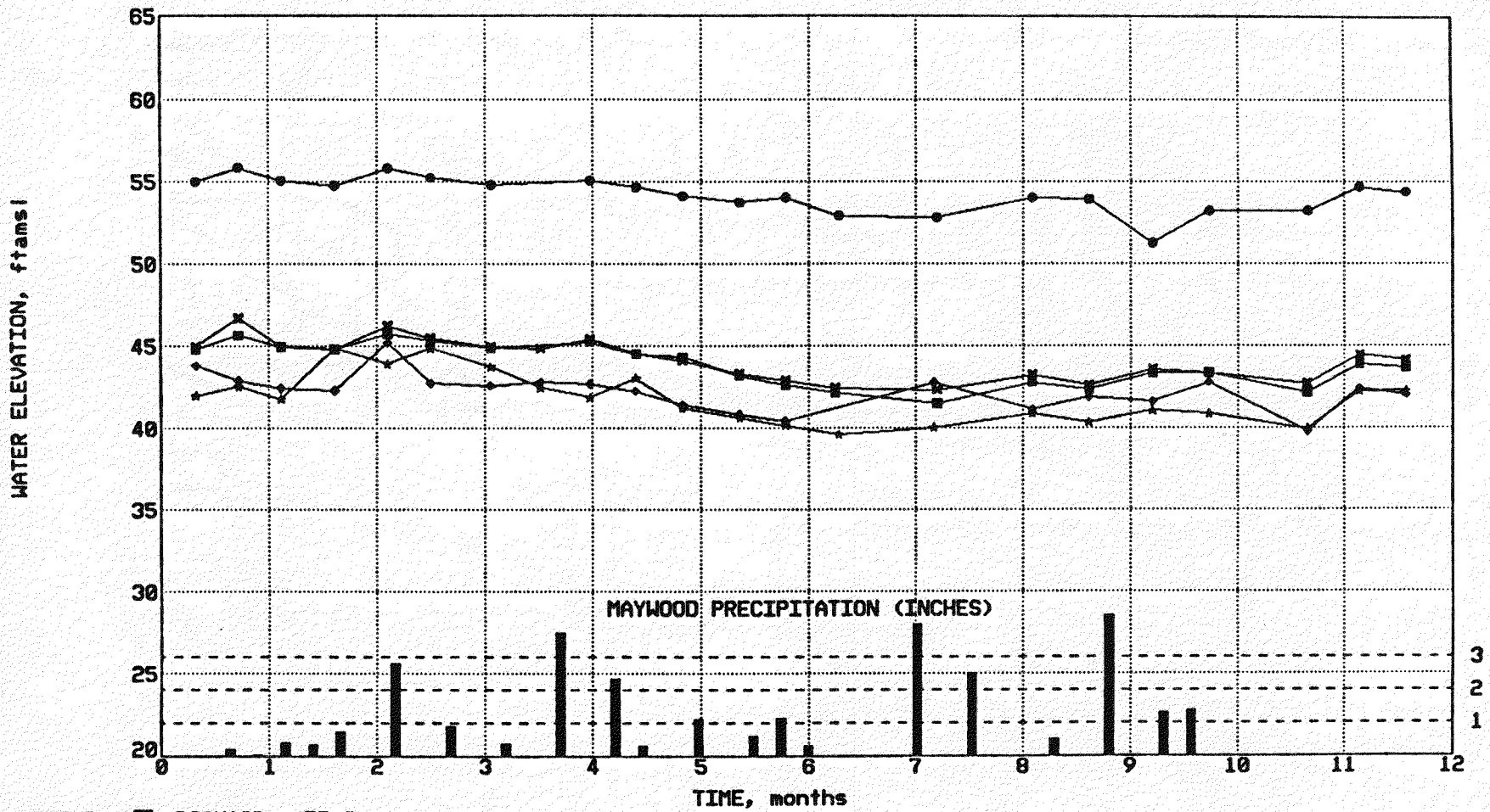
YEAR 1991

Maywood Hydrographs

HYDROGRAPH FOR MISS

Maywood Interim Storage Site PROJECT

BECHTEL JOB 14501-138



LEGEND:

■	B38W12B	55.0
★	B38W14D	52.0
◆	B38W15D	47.5
✖	B38W17B	45.0
●	B38W18D	41.2

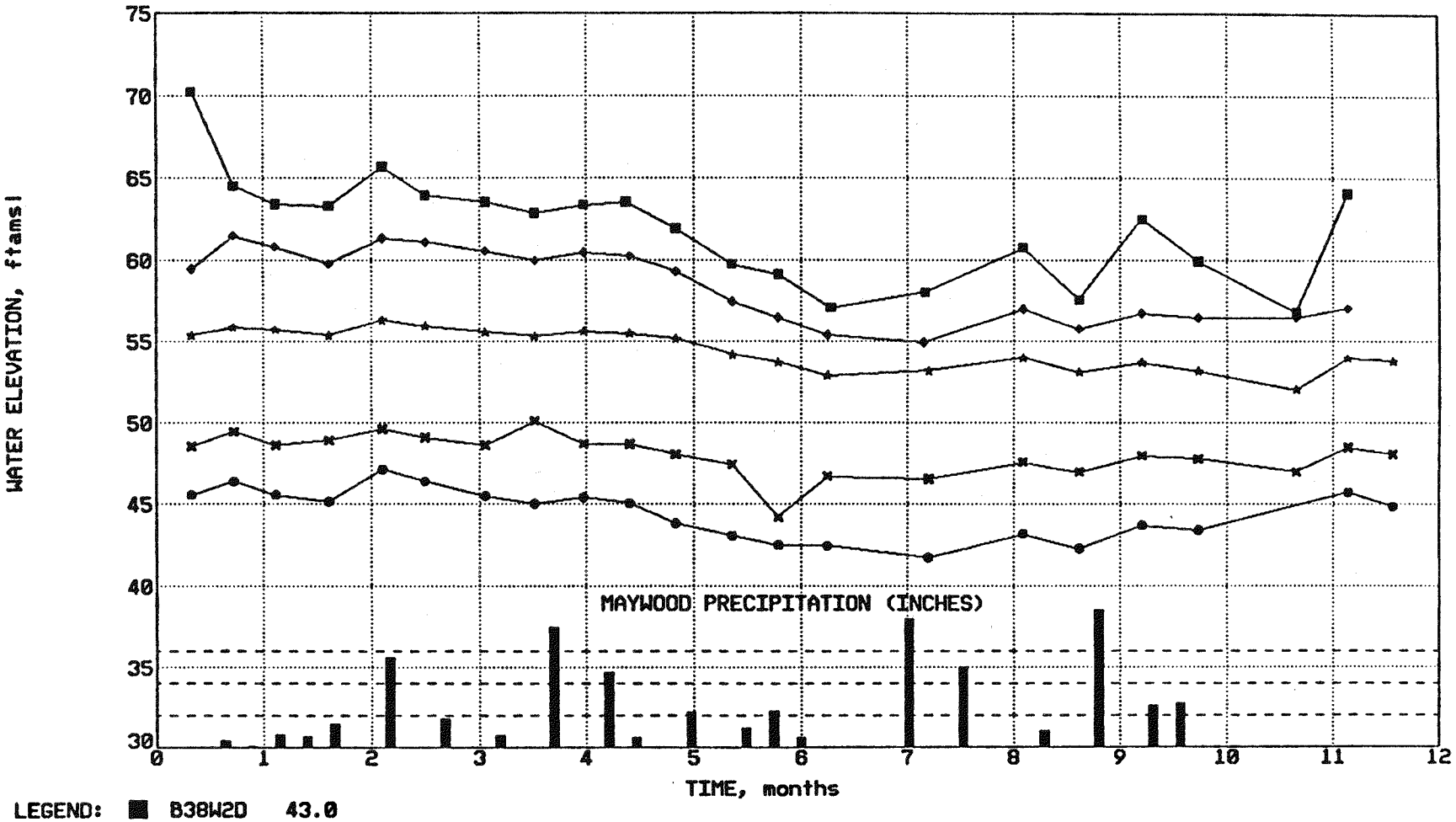
YEAR 1991

Maywood Hydrographs

HYDROGRAPH FOR MISS

. Maywood Interim Storage Site PROJECT

BECHTEL JOB 14501-138



LEGEND:

■	B38W2D	43.0
★	B38W4B	39.7
◆	B38W5B	44.0
✖	B38W6B	36.4
●	B38W7B	43.2

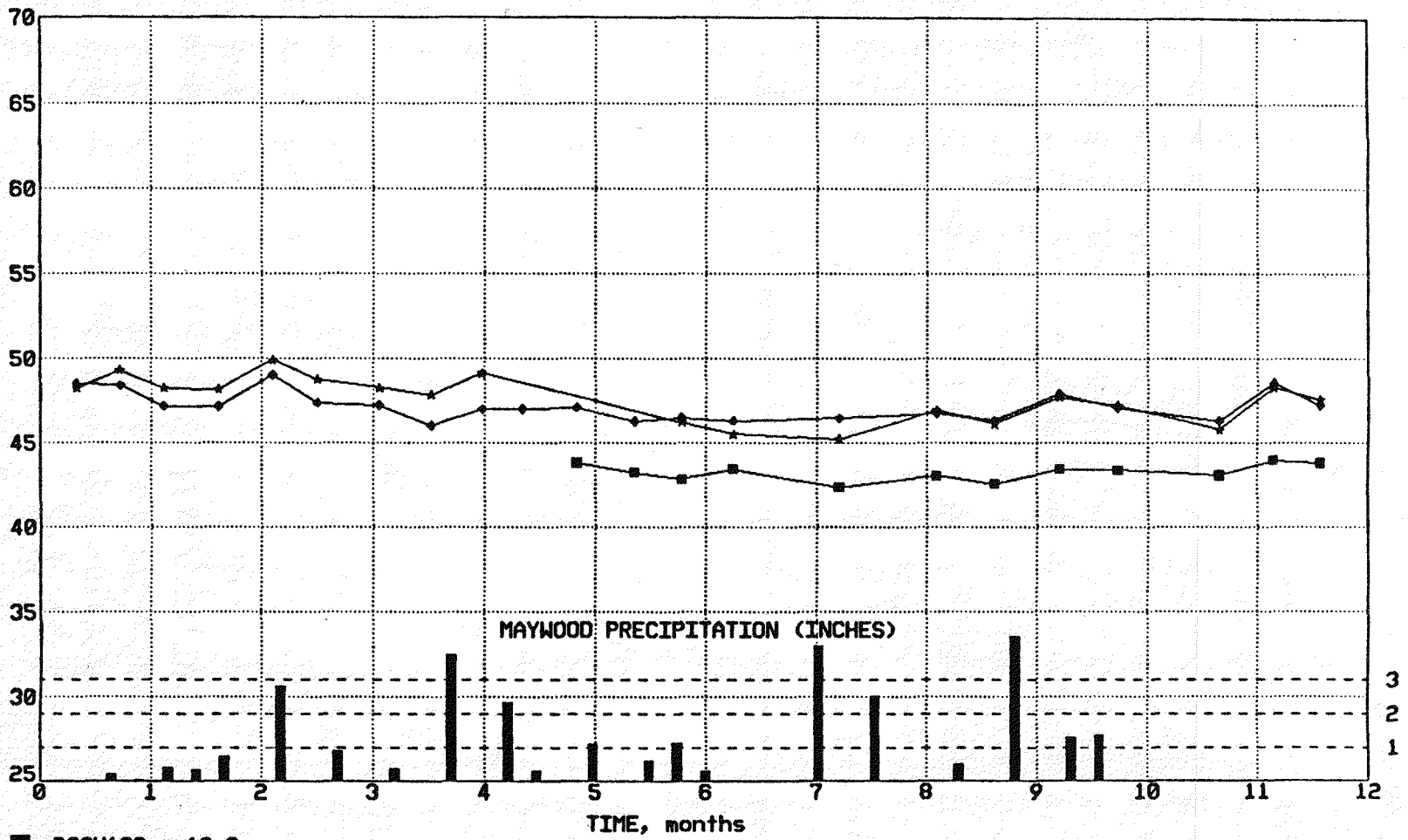
YEAR 1991

Maywood Hydrographs

HYDROGRAPH FOR MISS

Maywood Interim Storage Site PROJECT

BECHTEL JOB 14501-138



LEGEND:
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- ★ MISS-6A 16.0
- ◆ MISS-7A 11.5

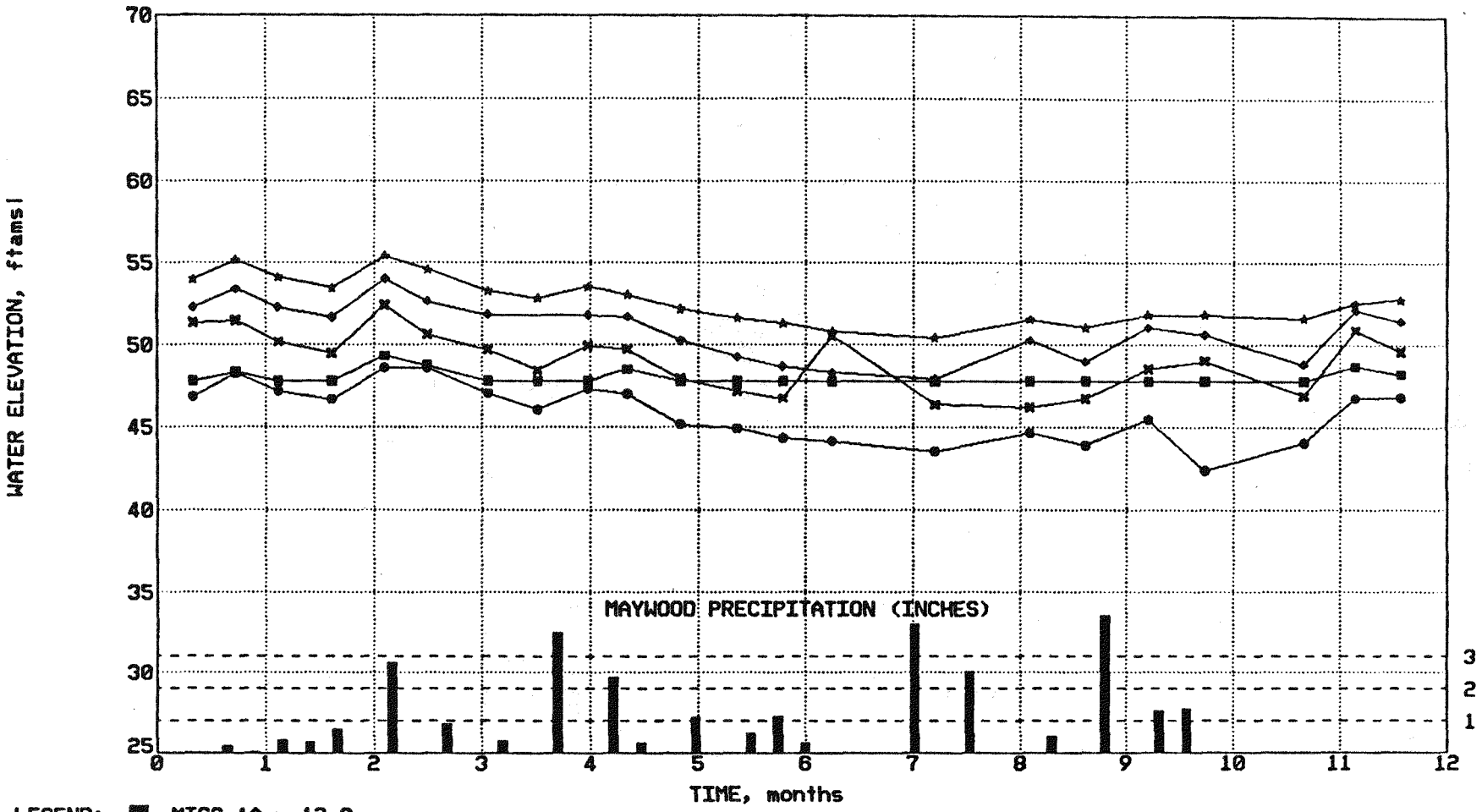
YEAR 1991

Maywood Hydrographs

HYDROGRAPH FOR MISS

Maywood Interim Storage Site PROJECT

BECHTEL JOB 14501-138



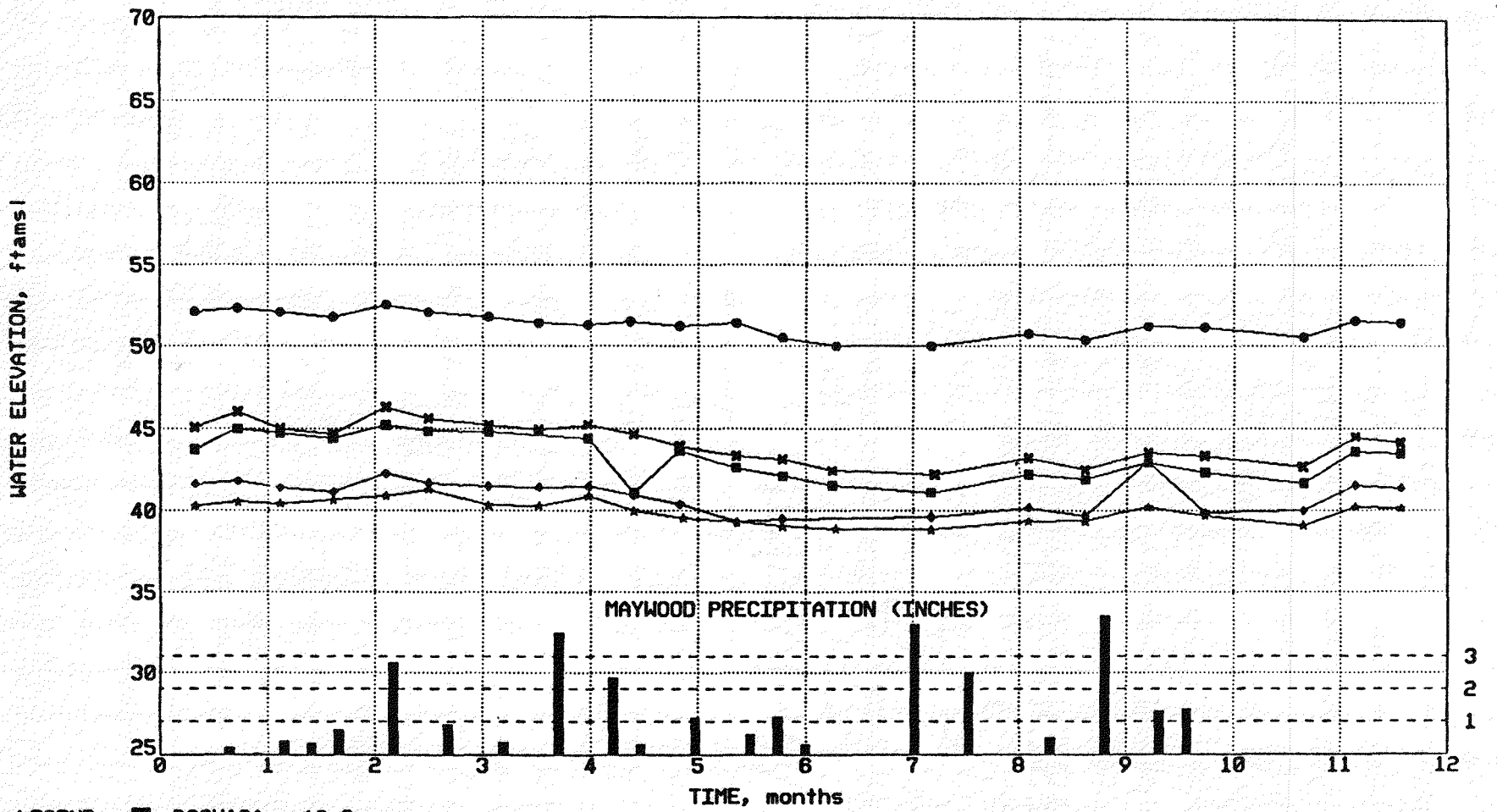
YEAR 1991

Maywood Hydrographs

HYDROGRAPH FOR MISS

Maywood Interim Storage Site PROJECT

BECHTEL JOB 14501-138



LEGEND:
- ■ B38W12A 16.2
- ★ B38W14S 14.0
- ◆ B38W15S 16.5
- ✖ B38W17A 15.0
- ● B38W1S 23.0

YEAR 1991

Maywood Hydrographs

HYDROGRAPH FOR MISS

Maywood Interim Storage Site PROJECT

BECHTEL JOB 14501-138

APPENDIX I
CONVERSION FACTORS

Table I-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 J

DISTRIBUTION LIST FOR MAYWOOD INTERIM STORAGE SITE ANNUAL ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1991

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