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MAYWOOD INTERIM STORAGE SITE
ENVIRONMENTAL REPORT
FOR CALENDAR YEAR 1992

100 WEST HUNTER AVENUE
MAYWOOD, NEW JERSEY

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EXECUTIVE SUMMARY

This report describes the environmental surveillance program at the Maywood Interim Storage Site (MISS) and provides the results for 1992. The site occupies about 4.7 ha (11.7 acres) and is located approximately 20 km (12 mi) north-northwest of New York City and 21 km (13 mi) northeast of Newark, New Jersey.

From 1916 until 1959 Maywood Chemical Works (MCW) extracted thorium from monazite sands (a naturally occurring ore) 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 processing operations, was used by local property owners as fill or mulch, and some migrated offsite by natural mechanisms. The company continued to manufacture, process, distribute, and store radioactive material until the facility was sold in 1959. To date, approximately 41,380 m^3 (54,100 yd^3) of soil contaminated with low levels of radioactivity has been removed from offsite locations and returned to the former processing site for temporary storage or placed in burial pits on the former MCW property. About one-third of the soil was relocated during 1966 to 1968 by the current owner of the chemical company (the Stepan Company), and the remainder was relocated by the U.S. Department of Energy (DOE) in 1984 and 1985.

Environmental monitoring of MISS began in 1984, when the site was assigned to DOE by Congress through the Energy and Water Development Appropriations Act and was placed under DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was established 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. MISS is part of a National Priorities List (NPL) site.

The environmental surveillance program at MISS includes sampling networks for radon and thoron in air; external gamma radiation exposure; and radium-226, radium-228, thorium-232, and total uranium in surface water, sediment, and groundwater. Additionally, chemical analysis includes metals and organic compounds in surface water and groundwater and metals in sediments. This program assists in fulfilling the DOE objective of measuring and monitoring effluents from DOE activities and calculating hypothetical doses to members of the general public.

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

The radiological data for all media sampled support the conclusion that doses to the public are not distinguishable from natural background radiation. Based on a conservative but plausible scenario, an employee in a facility adjacent to the site could receive a hypothetical maximum dose calculated to be about 0.6 mrem/yr (6.0×10^{-3} mSv/yr). This is less than the annual dose one would receive from watching a color television set [less than 1 mrem/yr (1.0×10^{-2} mSv/yr)] or from heating a home and cooking with natural gas [2 mrem/yr (2.0×10^{-2} mSv/yr)]. The radiological dose to the total population is essentially zero.

During 1992, site activities included routine maintenance, environmental monitoring, and onsite sampling in support of future remedial action. No specific releases from the site were detected. Aluminum, arsenic, chromium, iron, lead, manganese, tetrachloroethene, benzene, and chloroform were detected in groundwater samples at concentrations exceeding New Jersey Groundwater Quality Standards (NJGQS) for Class II-A waters and/or Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs). The remedial action alternative selected in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) record of decision (ROD) will address groundwater remediation.

The complete environmental report is distributed to representatives of federal, state, and local agencies and to individuals who have requested copies. The report is also available to the media and is part of the site's administrative record files located at the Maywood public library and the public information office.

COMPLIANCE SUMMARY

The primary regulatory guidelines, limits, and DOE requirements for environmental monitoring originate in the following federal acts: CERCLA; the Clean Air Act (CAA); the Clean Water Act (CWA); the SDWA; the Resource Conservation and Recovery Act (RCRA); the Toxic Substances Control Act (TSCA); the National Environmental Policy Act (NEPA); and the National Historic Preservation Act.

Environmental remediation of MISS is being conducted in accordance with CERCLA, the protocol for remediating low-level radioactive contamination at FUSRAP sites, and applicable DOE requirements authorized by the Atomic Energy Act. The following summaries identify applicable and relevant requirements as they existed in 1992 and the first quarter of 1993, define the status of compliance with the referenced requirements, and forecast the regulatory changes that may affect the site in the near future.

PRIMARY REGULATORY GUIDELINES

DOE Requirements for Radionuclide Releases

DOE requirements are orders that are written directives or verbal communication of written directives issued by DOE. Site releases must comply with specific DOE requirements that establish quantitative limits, DCGs, and dose limits for radiological releases from DOE facilities. A review of environmental monitoring results for 1992 shows that MISS was in compliance with all applicable DOE radionuclide release standards.

Clean Air Act and National Emission Standards for Hazardous Air Pollutants

The primary federal statute governing air emissions is the CAA. The potential source of air emissions from MISS is radionuclide emissions from contaminated soil. MISS is not required to have any state or federal air permits, pursuant to the authority of CERCLA Section 121. Although MISS is a nonoperating DOE facility, Subpart Q ("National Emission Standards for Radon Emissions from Department of Energy Facilities") of the National

Emission Standards for Hazardous Air Pollutants is applicable. Compliance with the EPA-approved strategy for radon monitoring was attained and maintained in 1992.

In 1992 compliance with the emission standard for other radionuclides under Subpart H ("National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities") was evaluated using the EPA Clean Air Act Assessment Package-1988 (CAP-88) PC computer model. An annual report is due to EPA on June 30, 1993, and calculations performed indicated that the site is in compliance with Subpart H.

Clean Water Act

Pollutants discharged to waters of the United States are regulated under the CWA through regulations promulgated and implemented by the State of New Jersey.

Unchannelized stormwater flow is the only potential discharge to surface water. A dye test was performed at MISS on September 3, 1992, to determine the potential for surface water flow to carry contaminants offsite during a stormwater event. The dye test indicated that all of the runoff that occurred during an above-average rainfall event either infiltrated into site soils or drained offsite as diffuse sheet flow. No dye was visible leaving the site in the surface water runoff.

Based on the test results and DOE's knowledge of the site hydrogeology, no point source of surface water runoff is discharging to any receiving surface water. Therefore, after completion of the dye test, a letter was submitted to the New Jersey Department of Environmental Protection and Energy (NJDEPE) concluding that MISS is not within the scope of the stormwater permitting program. No response has been received yet from NJDEPE, but an application for a federal stormwater permit is not planned for MISS at this time.

Safe Drinking Water Act

The SDWA was enacted by Congress in 1974 to regulate drinking water systems, require EPA to set national standards for levels of contaminants in drinking water, and provide for protection of aquifers. Under the 1986 Superfund Amendments and Reauthorization Act, drinking water standards and goals set under the SDWA became groundwater standards for CERCLA cleanups. In addition, NJGQS, which are applicable requirements under CERCLA, became effective in February 1993. These regulations are designed to protect ambient groundwater quality by establishing both radiological and chemical constituent standards for groundwater pollutant discharges and groundwater cleanups.

To determine whether the radionuclide and chemical concentrations in the groundwater at the site met federal and state groundwater quality standards, the 1992 groundwater results were compared with the federal SDWA MCLs, SDWA non-zero maximum contaminant level goals (MCLGs), and the newly enacted NJGWS. During 1992 the NJGQS and/or SDWA MCLs and MCLGs were exceeded in one or more groundwater samples analyzed for aluminum, arsenic, chromium, iron, lead, manganese, tetrachloroethene, benzene, and chloroform. The remaining 1992 groundwater sample results met the standards. Groundwater will be addressed in the environmental documentation being prepared for site remediation.

Resource Conservation and Recovery Act

RCRA is the principal federal statute governing the management of hazardous waste. Results of analyses of soil samples from the waste pile and onsite soils indicate that neither RCRA-regulated wastes nor radioactive wastes containing RCRA-regulated wastes (i.e., mixed wastes) are present at the site.

Toxic Substances Control Act

The most common toxic substances regulated by TSCA are polychlorinated biphenyls and asbestos. Onsite sampling has confirmed that TSCA-regulated waste is not present at the site.

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 exists between DOE and EPA Region II. The agreement defines the roles and responsibilities of the respective agencies and provides a schedule for the completion of a remedial investigation/feasibility study (RI/FS) for the site. A ROD, which documents the remedial action alternative selected for the site, is scheduled for 1994. Data collected during 1990 and 1991 RI 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, was published in March 1993.

It is DOE's policy to integrate NEPA values with the procedural and documentation requirements of CERCLA. DOE integrates CERCLA and NEPA to avoid the duplication of effort and the larger commitment of resources needed to implement both statutes separately. DOE will integrate NEPA values with the RI/FS process developed by EPA for environmental compliance under CERCLA. The resulting document will be the RI/FS-environmental impact statement (EIS).

National Environmental Policy Act

NEPA requires an analysis of potential environmental impacts from proposed federal projects including the cleanup of the Maywood site. This analysis will be contained in an EIS, which will be combined with the FS, as required by CERCLA. During 1992, compliance with NEPA was achieved by the approval of a categorical exclusion (CX) to provide routine maintenance and environmental monitoring activities. A CX is a category of actions, defined in 40 CFR 1508, that does not normally require an environmental assessment or EIS. The site continues to comply with NEPA.

National Historic Preservation Act

Initial contact with the Office of New Jersey Heritage is in progress to identify cultural resources. Any information required by this office will be submitted accordingly. FUSRAP is actively committed to its responsibilities for managing cultural resources that may be affected by environmental restoration activities. The FUSRAP cultural resource management program ensures that the early stages of project planning provide for a thorough consideration of the areas of potential effects of environmental restoration activities on any cultural resources that may be located on FUSRAP sites. Consultation with state historical preservation officers, Native American groups, and local historians is ongoing to identify cultural resources that may be eligible for nomination to the *National Register of Historic Places* in accordance with requirements of Section 106 of the National Historic Preservation Act.

To date, the FUSRAP cultural resource management program has not identified any historic properties, such as districts, sites, buildings, and structures, at any of the FUSRAP sites that are currently undergoing environmental restoration.

Other Major Environmental Statutes and Executive Orders

In addition to DOE requirements and statutes, several other major environmental statutes have been reviewed for applicability. For example, the Federal Insecticide, Fungicide, and Rodenticide Act and the Endangered Species Act have been found to impose no current requirements on MISS. In addition, Executive Orders 11988 ("Floodplain Management") and 11990 ("Protection of Wetlands") and state laws and regulations have been reviewed for applicability. Applicable environmental statutes, regulations, and executive orders are reviewed regularly to maintain continual regulatory compliance at MISS.

APPLICABLE ENVIRONMENTAL PERMITS

Although no permits or permit applications are required for MISS, all substantive permit conditions must be met for onsite response activities. Although CERCLA Section 121 provides the statutory authority for an exemption to permitting requirements for onsite CERCLA remedial actions, the CWA permitting activity under the National Pollutant Discharge Elimination System does not exempt CERCLA offsite remedial actions.

As stated previously, although a stormwater permit is not believed to be required for the site because of the lack of a surface water discharge to a receiving water, a letter was sent to NJDEPE requesting concurrence on DOE's position.

SUMMARY OF REGULATORY COMPLIANCE IN CALENDAR YEAR 1993 (FIRST QUARTER)

During the first quarter of calendar year 1993, environmental monitoring continued, as did review of potentially applicable regulations for their impact on the site. Compliance issues currently being addressed include metals and organics that were detected in excess of SDWA standards and NJGQS.

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ACRONYMS

AEC	Atomic Energy Commission
ANL	Argonne National Laboratory
BNI	Bechtel National, Inc.
CAA	Clean Air Act
CAP88-PC	Clean Air Act Assessment Package-1988
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
CWA	Clean Water Act
CX	categorical exclusion
DCE	dichloroethene
DCG	derived concentration guide
DOE	Department of Energy
DQO	data quality objective
EIS	environmental impact statement
EPA	Environmental Protection Agency
FS	feasibility study
FUSRAP	Formerly Utilized Sites Remedial Action Program
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MCW	Maywood Chemical Works
MISS	Maywood Interim Storage Site
MS	matrix spike
MSD	matrix spike duplicate

ACRONYMS

(continued)

MSL	mean sea level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NJAC	New Jersey Annotated Code
NJDEPE	New Jersey Department of Environmental Protection and Energy
NJGQS	New Jersey Groundwater Quality Standards
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
PARCC	precision, accuracy, representativeness, comparability, and completeness
PCE	tetrachloroethene
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROD	record of decision
RPD	relative percent difference
SDWA	Safe Drinking Water Act
TETLD	tissue-equivalent thermoluminescent dosimeter
TOC	total organic carbon
TOX	total organic halides
TPH	total petroleum hydrocarbon
TSCA	Toxic Substances Control Act

UNITS OF MEASURE

Bq	becquerel
C	Celsius
cm	centimeter
F	Fahrenheit
ft	foot
g	gram
gal	gallon
gpm	gallons per minute
h	hour
ha	hectare
in.	inch
km	kilometer
L	liter
m	meter
μCi	microcurie
μg	microgram
mg	milligram
mi	mile
min	minute
ml	milliliter
mph	miles per hour
mR	milliroentgen
mrem	millirem
mSv	millisievert
pCi	picocurie
ppm	parts per million
rem	roentgen equivalent man
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) began in 1984. This document describes the environmental surveillance program, the results for 1992, and the compliance status of the site.

MISS was assigned to DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP) in 1984. FUSRAP was established 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.

1.1 SITE DESCRIPTION

MISS occupies approximately 4.7 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 compose 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, a pumphouse, and a 5,000-gal water storage tank are inside the controlled area but not on DOE property. The controlled area, currently used for storage of approximately 26,700 m^3 (34,900 yd^3) of radioactively contaminated soil, is entirely fenced to restrict access. The storage pile, which occupies about 0.6 ha (1.5 acres), is about 6 m (20 ft) high and is covered with a heavy, impervious, synthetic fabric. A leachate collection system within the pile and a liner system beneath the pile intercept any seepage that may occur. Figure 1-3 is an aerial photograph of MISS.

From 1916 until 1959, Maywood Chemical Works (MCW) extracted thorium from monazite sands (a naturally occurring ore) 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 by natural mechanisms. The company continued to manufacture, process, distribute, and store natural radioactive material until the facility was sold to the Stepan Company in 1959. The Stepan Company has never processed radioactive material.

In 1961, on the basis of an Atomic Energy Commission (AEC) inspection and other information, the Stepan Company was issued an AEC license for storing radioactive materials and agreed to begin cleanup 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 separated from the site by construction of New Jersey State Highway 17 in 1932) and placed in three onsite burial pits within the Stepan property boundary.

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

So that contaminated material could be removed as quickly as possible from some of the residential and commercial properties in the Maywood area, DOE acquired a portion of the Stepan property to use as a temporary storage site; this area was designated as MISS (Figure 1-2). During 1984 and 1985, approximately 26,400 m^3 (34,500 yd^3) of contaminated material was removed from 18 vicinity properties in Maywood and Rochelle Park, and in 1985 an additional 380 m^3 (500 yd^3) was removed from 8 vicinity properties in Lodi and Rochelle Park. These materials were added to the interim storage pile at MISS.

1.2 REGIONAL DEMOGRAPHY

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 Highway 17 to the west (Figure 1-4).

Westerly Brook, which has been diverted under the northern edge of MISS through 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.

1.3 HYDROGEOLOGIC SETTING

Surface features at MISS include the interim storage pile, two buildings, temporary office trailers, and a concrete reservoir.

1.3.1 Geology

MISS is located in northeastern New Jersey within the glaciated section of the Piedmont Plateau. The terrain is generally level with little 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. In the local area, drainage is to the south through the Passaic, Saddle, and Hackensack rivers.

The site lies within the geologic structure known as the Newark Basin, which extends southwestward from the Hudson River Valley of New York to southeastern Pennsylvania. Sedimentation in the Newark Basin was in the form of clastic (sand, silt, and clay) sediments eroded from the surrounding highlands. These sediments are interstratified with igneous flow basalts. Structurally, the bedrock exhibits monoclinal dip toward the west with shallow open folds. High-angle faults break the bedrock units into tilted blocks that dip to the west and step down toward the coast. Two primary fracture trends within the basin have been identified: a steeply dipping set of joints that parallel the strike of the beds and a nearly vertical set that roughly parallels the dip to the west. Redbeds of the Passaic Formation are exposed as ridges and hills in the Maywood area, but most of the area is mantled by unconsolidated Pleistocene deposits. The surface of the bedrock units underwent considerable change during Pleistocene glacial events. The area was scoured and filled, drainage patterns were altered, and several morainal lakes were created. Wisconsin-age morainal and stratified drift deposits are common in the Maywood area.

The sediments underlying MISS are divided into two stratigraphic units: a bedrock unit composed of interbedded, well-cemented sandstone and siltstone of the Passaic Formation, and an overlying section of unconsolidated clastic sediments of Pleistocene glacial deposits. These units are separated by an erosional unconformity. The surface of the bedrock unit was extensively eroded and weathered by glacial and fluvial processes. The sedimentary section was originally capped by a well-developed deciduous forest soil. Extensive agricultural and later urban development disturbed or destroyed much of the original soil profile. Most of the soil cover in the local area is now classified as urban fill.

Bedrock in the local area consists of alternating beds of dark reddish-brown sandstone and siltstone of the Passaic Formation. The uppermost unit in the site area is a grey to red silica and calcite-cemented quartz sandstone, moderately to highly weathered, having joints and bedding planes oriented horizontally. This sandstone unit is widely distributed throughout the local area. Underlying this unit is a finer-grained siltstone unit, also grey to red but exhibiting more extensive fracturing, jointing, and weathering. Joints in this fine-grained unit are generally horizontal with minor to complete filling with calcite cement.

The bedrock surface in the local area has been extensively weathered. Depth to bedrock varies from 15 cm (6 in.) in the Stepan parking lot northeast of MISS to approximately 9 m (30 ft) near the western boundary of MISS along Highway 17. A prominent high in the bedrock surface extends to the southwest from the high area in the Stepan parking area. This high connects across a saddle to a topographic ridge west of Lodi Brook. This bedrock relief is expressed at the surface and corresponds to a surface water divide. A well-defined low in the bedrock surface, with a northwest-to-southeast orientation, underlies the western edge of MISS and is probably associated with extensive fracturing of the bedrock. Smaller erosional low areas perpendicular to this primary trend are mapped in the central portion of MISS. The configuration of the bedrock surface controlled the type and distribution of the unconsolidated sediments deposited in the local area.

Coarse-grained sediments, including boulders and cobbles of igneous and sedimentary rock, have been described in areas associated with the erosional lows in the bedrock surface. These porous and permeable sediments were deposited by small streams that formed in the area of the bedrock lows. The fractured bedrock and the associated coarse-grained sediments in the unconsolidated section are directly associated and probably form preferential flow pathways in the subsurface.

1.3.2 Surface Water

MISS has an average slope of 1.2 percent and topographically is generally flat, with elevations ranging from approximately 15.2 to 20.4 m (50 to 67 ft) above MSL (not including the waste pile). The mean elevation is 17.5 m (54.7 ft), with highest elevations in the northeastern portion of the site. Most of MISS is grass covered except for the waste storage pile, the unpaved roads, and the railroad spur. Because of the low surface gradient and grass cover, surface water runoff, erosion, and sediment transport from the site are minimal.

1.3.3 Groundwater

The primary groundwater aquifer in the MISS area is the Passaic Formation; groundwater in this formation occurs primarily in a network of interconnected joints and fractures. The intervening unfractured rock has negligible capacity to store and transmit groundwater. In some areas, the upper portion of the bedrock is highly weathered and contributes significantly to the shallow aquifer flow.

The shallow groundwater flow system at MISS is in the unconsolidated sediments and in the uppermost, weathered portion of the Passaic Formation. Groundwater in this shallow aquifer occurs under unconfined to partially confined conditions. No major confining layers have been identified, and saturation is continuous from the water table surface to the maximum depth of site monitoring wells, 18 m (60 ft). Water levels measured in wells completed in bedrock reflect water table conditions toward the northeastern portion of the site and partially confined conditions toward the western and southwestern portions. Depth to water is generally shallow and ranges from approximately 0.6 to 4.6 m (2 to 15 ft) below ground surface. Saturated thicknesses of unconsolidated sediments range from 1.5 to 4.6 m (5 to 15 ft), generally decreasing toward the east where the sediments thin onto a bedrock high. The potentiometric levels in bedrock range from 12 to 20 m (40 to 66 ft) above MSL. Seasonal fluctuations range from 0.46 to 1.8 m (1.5 to 6 ft) during a year. Average hydraulic gradients are generally low and indicate groundwater flow to the west-southwest toward the Saddle River, where groundwater is discharged. Hydrographs are presented in Appendix A.

1.3.4 Water Supply

The major source of water in the Maywood area is surface water from the Hackensack River Basin. One surface water intake is in the Saddle River Basin at Arcola, New Jersey, approximately 4 km (2.5 mi) upstream from MISS.

Groundwater is generally not used for municipal water supply in the lower Saddle River Basin. Some water is pumped from a well field south of MISS during periods of drought or high public demand. A records search was conducted through the New Jersey Department of Environmental Protection and Energy (NJDEPE), and 74 water wells drilled between 1954 and 1982 were identified within a 4.8-km (3-mi) radius of MISS. Depths range from 18 to 201 m (60 to 660 ft), and reported yields range from 38 to 1,324 L/min (10 to 350 gpm). The number and reported uses of the wells are 35 for domestic use, 14 for industrial use, 9 for irrigation, and 1 for public supply. No information was available for the remaining 15 wells. The public supply well, drilled in 1980 by the Saddle Brook Board of Education to supply water for the Smith Elementary School, is 601 m (200 ft) deep with a reported yield of 127 L/min (33.5 gpm). The school is currently served by the municipal water system, and the well is not in use.

1.4 CLIMATE

The climatological data from the National Oceanic and Atmospheric Administration (NOAA 1992, 1993) for the Newark vicinity for 1992 (measured at the Newark Airport) show that temperature extremes ranged from -12° to 36°C (10° to 97°F). Average wind speeds ranged from 14 to 18.4 km/h (8.7 to 11.4 mph), and the predominant wind direction was from the west.

The minimum monthly precipitation [1.85 cm (0.73 in.)] occurred in October 1992, the maximum [12.8 cm (5.02 in.)] occurred in November 1992, and the average for 1992 was 7.77 cm (3.06 in.).

FIGURES FOR SECTION 1.0

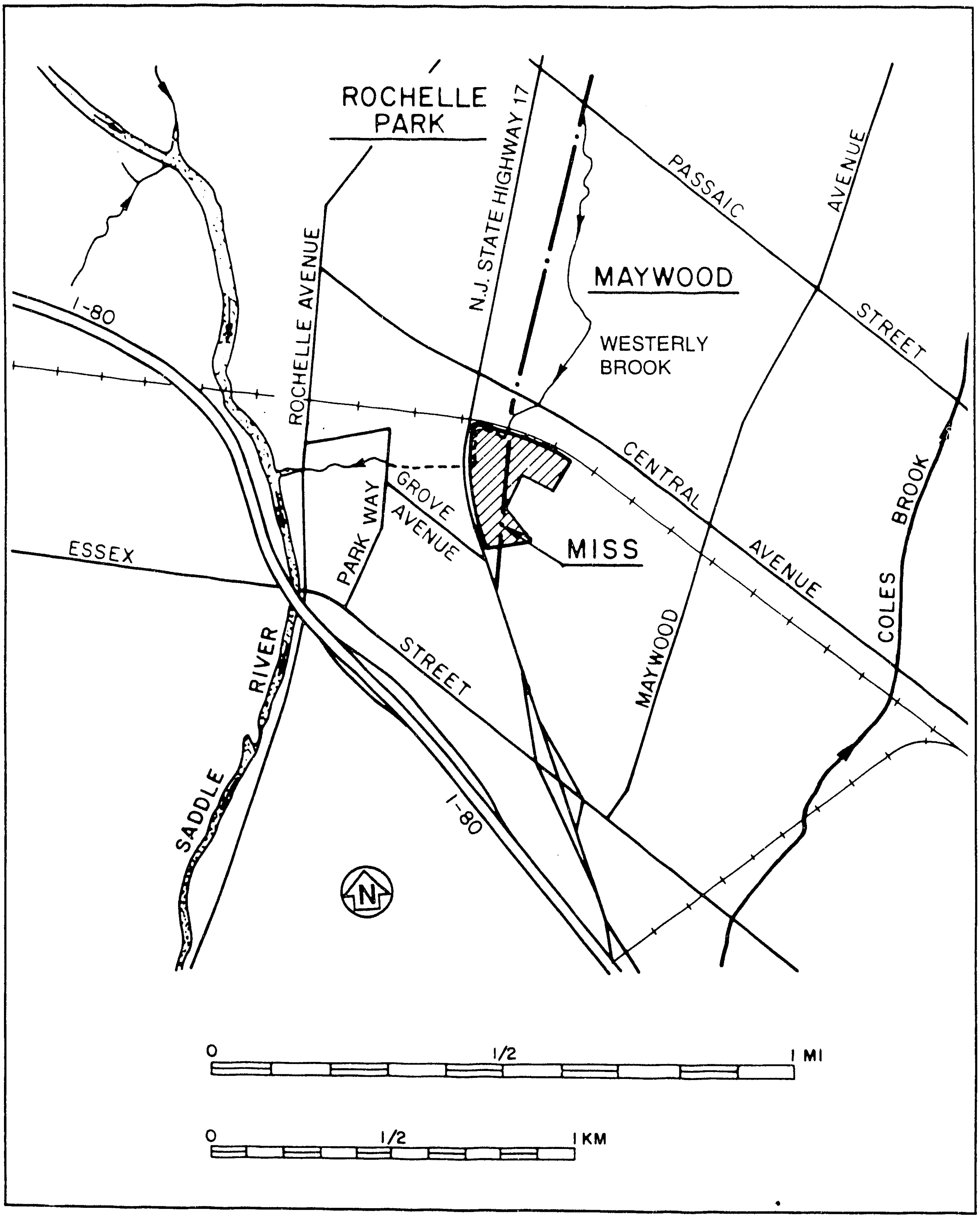
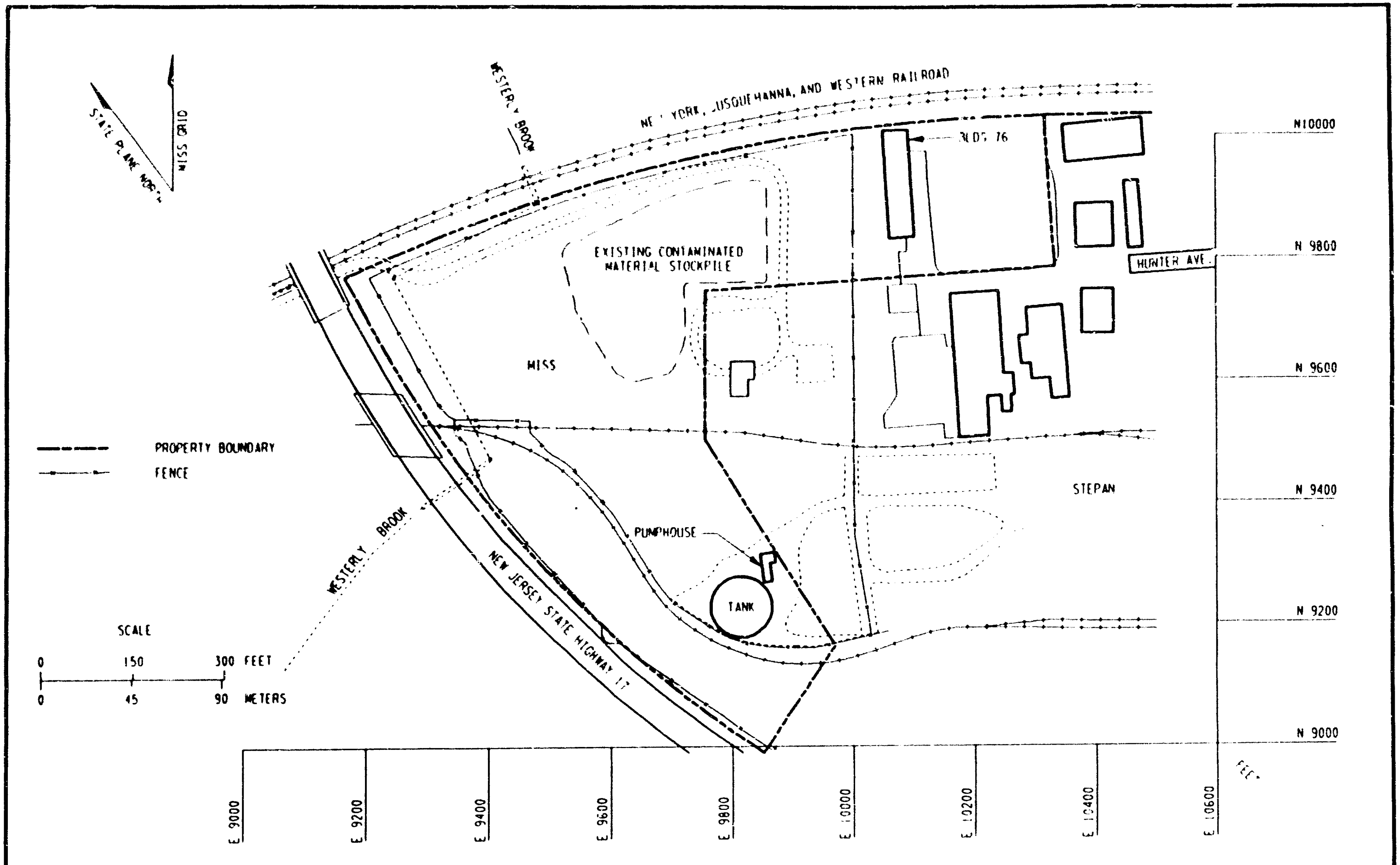


Figure 1-1
Location of MISS



Source: Adapted from BNI 1991a.

R40F004.DGN

Figure 1-2
Plan View of MISS

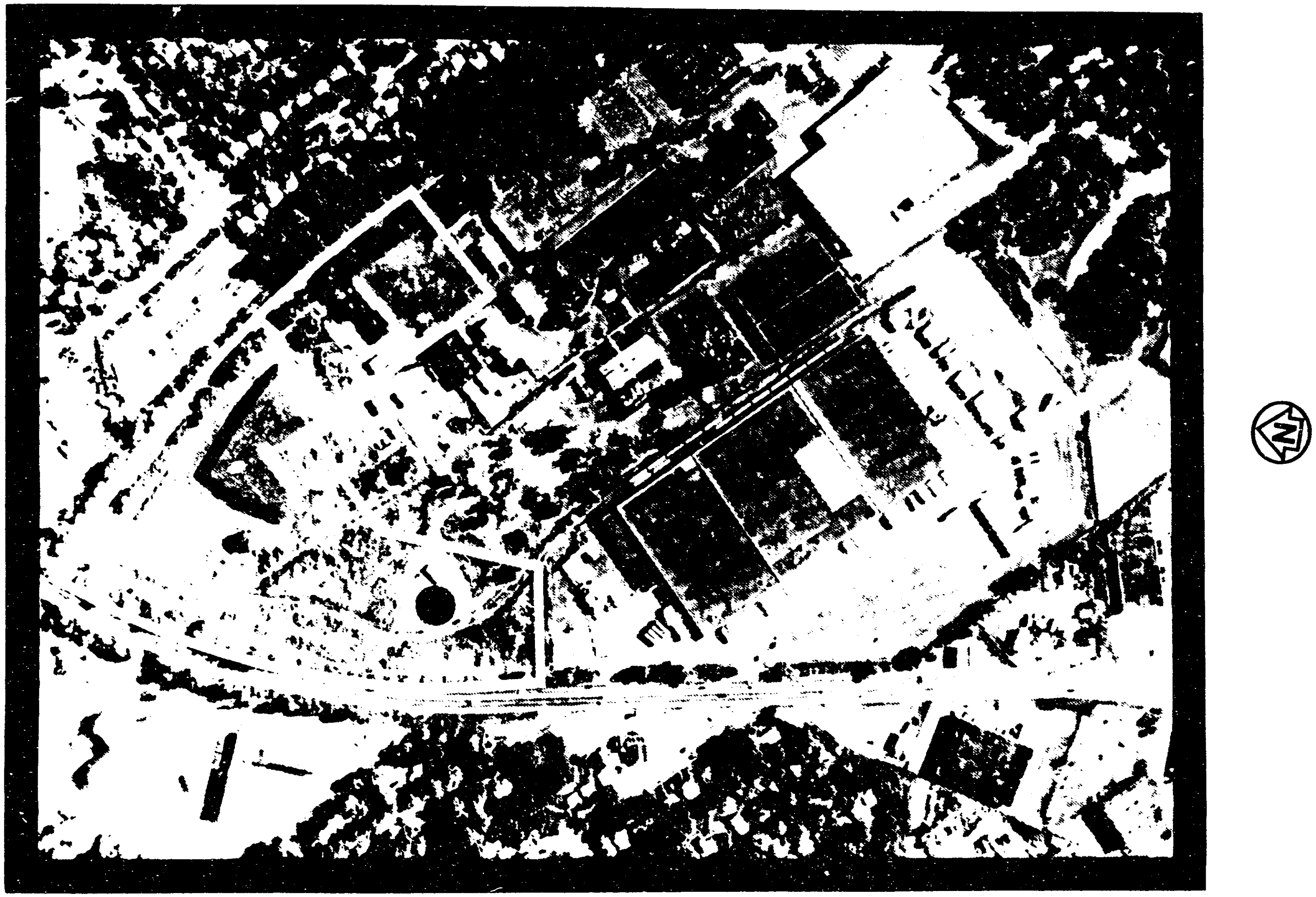
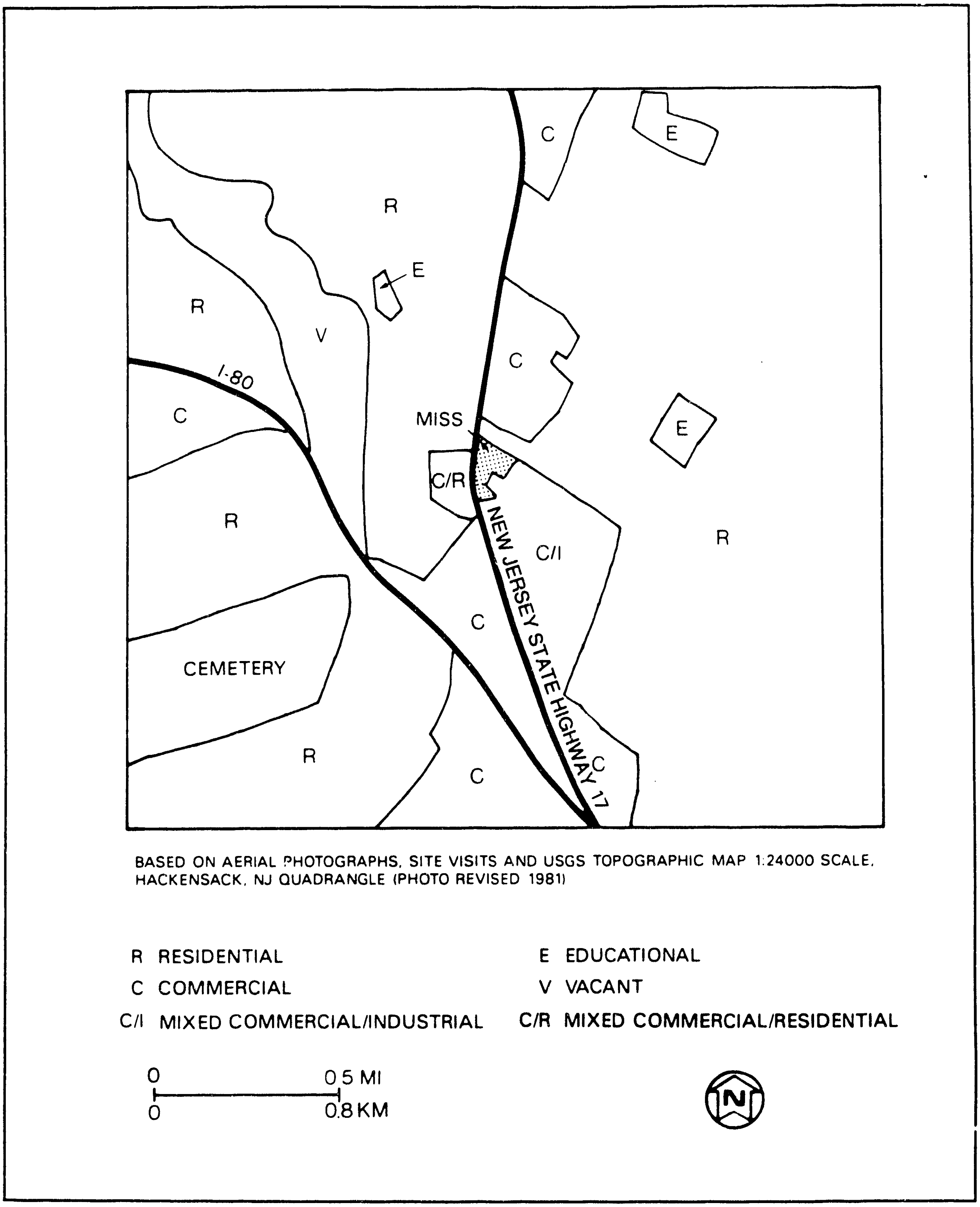


Figure 1-3
Aerial View of MISS and Vicinity



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

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

2.0 ENVIRONMENTAL PROGRAM INFORMATION

This section describes programmatic activities conducted at MISS other than those conducted as part of routine environmental monitoring. Environmental program information discussed in this section includes descriptions of the following:

- Emissions monitoring
- Environmental documentation activities
- Significant environmental activities at the site
- Environmental awareness activities such as employee education programs to help promote waste minimization at the site, site safety inspections, and employee training programs
- Self-assessment activities

Information regarding routine environmental surveillance at the site is provided in Section 3.0.

2.1 PERMIT ACTIVITIES

A dye test was performed at MISS on September 3, 1992, to determine the potential for surface water flow to carry contaminants offsite during a stormwater event. The dye test indicated that all of the runoff that occurred during an above-average rainfall event [2.92 cm (1.15 in.) of rainfall in 2 hours and 45 minutes] either infiltrated into site soils before leaving the site or drained offsite as diffuse sheet flow. No dye was visible leaving the site in the surface water runoff.

Based on the test results and DOE's knowledge of the site hydrogeology, no point source of surface water runoff is discharging to any receiving surface water. Therefore, after completion of the dye test, a letter was submitted to NJDEPE concluding that MISS is not within the scope of the stormwater permitting program. No response has been received to date from NJDEPE.

2.2 EMISSIONS MONITORING

On Sunday, March 29, 1992, a section of the northeastern portion of the MISS pile cover was torn during a period of high-speed winds associated with a severe thunderstorm. The section of the pile cover that was torn measured approximately 15 by 30 m (50 by 100 ft). The soil underneath the cover was damp, and no visible dispersion of the soil appeared to take place.

Contractors were on the premises within 3 to 4 hours to begin cover repairs. They pulled the damaged pile cover back into place, rejoined the seams using 0.6-m- (2-ft-) wide strips of new cover material, and ballasted them with concrete blocks. The soil remained uncovered for approximately 8 hours from the time the tear was noticed until final repairs were complete.

Immediately upon arrival, the contract personnel established temporary particulate air monitoring (high-volume air sampling) to the east of the pile (the predominant wind direction was to the east) to determine whether radioactive material was being released to the environment in the area around the site. The air monitoring results indicated that no release of radioactive material was occurring. Although the event was of limited severity and short duration, an occurrence report was filed, as required by DOE Order 5000.3B. The occurrence report (BNI 1993c) concluded that the pile cover tear was primarily the result of the pile cover material being in poor to very poor condition. Major seam work was recommended for around the base of the pile and around large patches on both sides of the pile. When funding becomes available, the Maywood pile will be recovered with a new geomembrane cover. Until that time, more frequent inspections will prevent another failure until the pile cover can be replaced.

No reports under Section 313 of the Emergency Preparedness and Community Right-to-Know Act were required. FUSRAP sites were not subject to toxic chemical release reporting provisions under 40 CFR 372.22 in 1992. However, FUSRAP evaluates and inventories toxic chemicals used onsite. 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 threshold planning quantities.

2.3 ENVIRONMENTAL DOCUMENTATION

Environmental documentation for the site consists of categorical exclusions under the National Environmental Policy Act for routine site maintenance and environmental monitoring (DOE 1992a,b). The work plan-implementation plan (ANL and BNI 1992), the remedial investigation (RI) report (BNI 1992c), and a post-remedial action report for an emergency removal action at a vicinity property in nearby Lodi, New Jersey (BNI 1993b) were published.

2.4 SIGNIFICANT ENVIRONMENTAL ACTIVITIES

2.4.1 Special Studies

All remaining field work for the MISS RI, with the exception of additional groundwater monitoring wells that will be installed in 1993 (at the request of EPA Region II), was completed, and the final draft of the report was issued in 1992. The feasibility study, baseline risk assessment, and the record of decision are also nearing completion.

2.4.2 Environmental Monitoring Changes

The environmental surveillance programs at FUSRAP sites are periodically evaluated and revised based on the individual site conditions, program objectives, and sampling results. Revisions can consist of the number of sample collection points, frequency of sample collection, and parameters analyzed. This section summarizes changes in the MISS environmental surveillance program from 1991 to 1992 (BNI 1991).

Surface Water and Sediment

The site has remained stable with no apparent increasing or decreasing trend since 1986; the only contaminant release to the environment has been a very low concentration of lithium (approximately 1 ppm); and there are no plans for construction or remedial action during the next year that could disturb the soil surface. Consequently, the sampling frequency was reduced to semiannually for radiological parameters and annually for chemical parameters.

In addition, sampling station 1 (see Section 3.0) will be sampled only if results from the next upstream station indicate migration.

Groundwater

Based on the results from past monitoring activities, the scope of the groundwater monitoring program was reduced in 1992; the revised scope included collection of samples from fewer wells and a reduction in sampling frequency. The 1992 groundwater sampling program included all of the onsite MISS wells (12); two offsite, upgradient (Stepan property) wells; and one offsite, upgradient well (northeast). Groundwater samples were collected once during 1992.

Chemical sampling was changed to an annual cycle for all wells. The time of year when sampling will take place was also changed to coincide with the time of the year when the potentiometric surface is at an intermediate level to obtain the most representative indications of groundwater characteristics.

External Gamma Radiation

Six tissue-equivalent thermoluminescent dosimeter (TETLD) stations (locations 20 through 25) were added to the parameter of the site to enhance evaluation of the gamma radiation exposure rates resulting from radioactively contaminated material at MISS. The need for these additional monitoring locations was made apparent after the evaluation of radiological data obtained during the RI.

Radon/Thoron

Six detectors were also added at locations 20 through 25 to improve evaluation capabilities for radon and thoron. The sampling frequency for all radon/thoron detectors remained quarterly.

2.4.3 Remedial Actions

No remedial actions were conducted during this reporting period.

2.5 ENVIRONMENTAL AWARENESS ACTIVITIES

FUSRAP is committed to minimizing the generation of waste at FUSRAP sites and uses methods for waste minimization including source reduction, material substitution, and recycling. The development of waste minimization goals, waste generation information, and a process for continual evaluation of the program are primary elements of this philosophy.

Pollution prevention awareness is promoted and various waste minimization techniques are implemented as part of continuing employee training and awareness programs to reduce waste and meet the requirements for quality, safety, and environmental compliance. No hazardous waste minimization certifications or waste reduction reports for waste generators were required during this reporting period.

Site workers must complete a 40-h hazardous waste training program before beginning work and an 8-h refresher program annually thereafter to comply with Occupational Safety and Health Administration requirements in 29 CFR 1910.120. During their first three days onsite, workers also attend site-specific training sessions. Additional training includes, but is not limited to, fire extinguisher training, respirator training, self-contained breathing apparatus training, and weekly safety meetings.

Routine safety and security inspections are conducted at the site to ensure that the site is in good repair and is safe for site workers and the public.

2.6 SELF-ASSESSMENTS

A formalized self-assessment approach for all FUSRAP sites was approved on April 22, 1993, specifically addressing self-assessment activities for the program during the remainder of fiscal year 1993 and in fiscal year 1994. No self-assessments were conducted during this reporting period.

3.0 MONITORING NETWORKS AND RESULTS

MISS is not an active site and produces no processing effluents. The only possibility for contamination to be released from the site would be through migration. The adequacy of existing monitoring activities is assessed annually, and the results are used to identify the need for changes in the program. These may result from changing site conditions or regulatory requirements or from newly identified data needs to support the remedy selection process for the site. Additionally, as monitoring data are accumulated, decisions may be made to adjust monitoring requirements. Future site environmental reports will reflect these changes.

Based on knowledge of contaminants historically present at MISS, environmental monitoring in 1992 included sampling and analysis for:

- Radon and thoron concentrations in air
- External gamma radiation exposure
- Selected chemicals and radium-226, radium-228, thorium-232, and total uranium concentrations in surface water, sediment, and groundwater

Readers not familiar with radiation units may benefit from reviewing Appendix B before proceeding.

The monitoring systems included onsite, site boundary, and offsite stations to provide sufficient information on the potential effects of the site on human health and the environment. The analytical methods performed for each parameter in each matrix are provided in Appendix C.

This section of the report contains the results for each sampling point, annual averages, and trend information, where applicable. The methodology for evaluating the data is provided in Appendix D. The results are compared with standards listed in Appendix E.

3.1 AIR MONITORING

3.1.1 Radon/Thoron

One of the potential pathways of radiation exposure from the uranium-238 decay series is the inhalation of the radioactive gas radon-222 and its associated decay products. Radon-222 has a short half-life (3.8 days), which is the time it takes for half of the activity to decay. When the gaseous radon decays, it forms a radioactive particulate (solid) that attaches itself to very small dust particles that can also be inhaled. Similarly, in the thorium-232 decay series, inhalation of the radioactive gas radon-220 (or thoron) and its associated decay products is a potential pathway for radiation exposure. The half-life of thoron is very short (55 seconds), and the associated decay products are also radioactive solids that attach themselves to particles. Both radon and thoron decay by the emission of alpha particles that travel only a very short distance in air (about an inch) before losing their energy and ability to contribute a radiation dose to an individual.

Because radon and thoron are gaseous and subsequently decay to products that attach themselves to very small, easily dispersible particles, they are very mobile in air and are diluted and dissipated very quickly in the environment.

Radon and thoron are monitored quarterly at MISS to evaluate compliance with environmental regulations and to aid in the determination of the potential dose to the maximally exposed member of the general public. The monitoring locations are shown in Figures 3-1 and 3-2.

As shown in Table 3-1, the radon concentrations across the site are essentially the same as background concentrations. The results for thoron monitoring, which was expanded in 1992, are provided in Table 3-2. The levels exceed the DOE guideline of 3×10^{-9} μCi/ml by a factor of about 2.5 on an annual average in the northeastern perimeter area and approach the guideline in two other nearby locations because of gaseous emissions from contaminated soil.

Table 3-3 lists the radon concentrations measured since 1987. The low concentrations for the past five years reflect the lack of disturbance of the contaminated soil and the lower radon emission potential.

Table 3-4 summarizes the thoron concentrations measured at MISS since 1991. These data reflect the predominant thorium contamination in the soil but reveal no particular trend. As with most gases, radon and thoron dissipate quickly and do not affect the offsite population.

3.1.2 External Gamma Radiation

External gamma radiation exposure rates are measured as part of the routine environmental surveillance program to aid in the evaluation of compliance with applicable guidelines.

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 (1 and 10 mSv/yr) and ±25 percent at rates between 0 and 100 mR/yr (0 and 1 mSv/yr).

The external gamma radiation background exposure rate is not constant for a given location or from one location to another, even over a short time. This rate 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 exposure rates measured some distance from the site, and exposure rates onsite could be lower than at the boundary.

External gamma radiation monitoring at MISS consisted of placing TETLDs at the locations shown in Figures 3-1 and 3-2. The dosimeters were removed and analyzed at the middle and end of 1992, yielding the data listed in Table 3-5. The annual average exposure rate was 47 mR/yr (0.47 mSv/yr) onsite and 281 mR/yr (2.81 mSv/yr) at the site boundary, primarily because of the localized subsurface contamination; these values do not include a measured average background exposure rate of 74 mR/yr (0.74 mSv/yr). The highest individual perimeter exposure rates are in the northeastern region and range from 370 to 1,566 mR/yr (3.70 to 15.66 mSv/yr). This region is the location of the former processing activities, and access to this area is currently limited.

The property immediately adjacent to the northeastern corner of MISS is an industrial facility that is occupied by employees 40 hours per week. The facility is located approximately 45 m (150 ft) from the MISS boundary. Because of this, the maximum exposure rates observed at the property boundary would not be possible at the occupied facility, nor would they cause an employee to receive a dose greater than the DOE basic dose limit of 100 mrem/yr. To determine the exposure rates and predict the cumulative exposure that employees at this facility would receive from radioactive material located at MISS, calculations were performed using conservative assumptions to predict the hypothetical maximum exposure to the employees. The hypothetical maximum dose was calculated to be 0.6 mrem/yr (6×10^{-3} mSv/yr). This is a reasonable, expected result based on the fact that the intensity of radiation decreases exponentially as distance from the source is increased (i.e., the farther away one is from the radioactive material, the less the dose is).

Table 3-5 summarizes the external gamma radiation exposure rates measured at MISS for the last six years, as well as at the six new monitoring locations described in Subsection 2.4.2. The exposure rates appear stable at the monitoring locations that have more than one year's data, with no apparent increasing or decreasing trend. Monitoring locations 5 and 10, which have historically yielded exposure rates slightly above measurements at the other detector locations, are in areas of contaminated surface and subsurface soils (former retention pond locations) with radionuclide concentrations significantly higher than those at the other monitoring locations.

For comparison, Table 3-6 shows the annual average external gamma radiation exposure rates at the site boundary, in the vicinity of the site, and across the nation.

3.2 SURFACE WATER AND SEDIMENT MONITORING

3.2.1 Monitoring Network

Currently, surface water and sediment samples are collected at two Westerly Brook and one Lodi Brook locations (Figure 3-3). The sampling frequencies are semiannual for radiological analyses and annual for chemical analyses.

Based on site history, characterization data, and previous monitoring results, the radionuclides of concern in surface water and sediment samples are total uranium, radium-226, radium-228, and thorium-232. Analytical parameters for chemicals in surface water are the metals listed in Appendix C (Table C-1), lithium, total organic halides (TOX), total petroleum hydrocarbons (TPH), and total organic carbon (TOC). Analytical parameters for chemicals in sediment are listed in Appendix C (Table C-1).

3.2.2 Surface Water Results

Westerly Brook begins as a natural channel upstream of MISS and enters an underground culvert before flowing under the site. The underground channel flows for approximately 585 m (1,920 ft) beneath MISS. Groundwater and surface water that has infiltrated through site soils leak into the pipe and are carried beyond the site boundary. After leaving the site, the channel continues underground for another 300 m (1,000 ft) before the brook becomes an above-ground, open-channel flow. Surface water samples are collected at this point downstream of the site.

Radiological results for surface water samples collected in 1992 from Westerly Brook, where it again emerges as an open channel, are essentially the same as background concentrations (Table 3-7), based on a review of data for the previous five years (Table 3-8). The only findings from chemical analysis of these samples that were unusual for an urban location were concentrations of lithium that were slightly above background concentrations. Trace amounts of lithium probably enter the underground channel by infiltrating the groundwater underneath MISS and emerge in surface water downstream. Concentrations of contaminants in surface water samples have remained stable over the last six years, with no apparent increasing or decreasing trend.

3.2.3 Sediment Results

A review of the 1992 radiological data (Table 3-9) and of data for the previous five years (Table 3-10) shows background conditions, and no trends are indicated. The upstream and downstream TPH concentrations were above the detection limit; however, this is not unusual for an urban location that is close to the railroad and Highway 17.

3.3 GROUNDWATER MONITORING

The groundwater monitoring program at MISS was designed to detect potential contaminants, to provide information on potential migration of contaminants through the groundwater system, and to provide sufficient coverage of site groundwater conditions.

3.3.1 Well Network

The groundwater monitoring network consists of 31 wells: 15 were installed in 1984, 16 were installed between 1987 and 1988, and 2 were installed in 1989. The network includes 10 well pairs, a cluster of 3 wells, and 8 single wells. Each well pair consists of a shallow well completed in the unconsolidated sediments (overburden) and a deeper well completed in competent bedrock. Well MISS-1A was replaced with well MISS-1AA during 1992. Depths of wells completed in the overburden are generally less than 6.1 m (20 ft), and depths of wells completed in bedrock range from approximately 9.1 to 15.2 m (30 to 50 ft). Well locations are shown in Figure 3-4.

Seven years of groundwater data (1985–1991) are available from DOE's ongoing environmental surveillance program. The standard analyses for the program from 1985 through 1991 included quarterly analyses for total uranium, radium-226, thorium-232, and screening parameters (TOX, TOC, and TPH); yearly analyses of volatile and semivolatile organic compounds; and, since the second quarter of 1990, analyses for metals. Additional analytical data (including total and dissolved metals) were collected from October 1990 through July 1991 as part of the expanded well sampling and analysis program in support of the remedial investigation being conducted at the site.

Based on the results from past monitoring activities, the scope of the groundwater monitoring program was reduced in 1992; the revised scope included collection of samples from fewer wells and reduction in sampling frequency. The 1992 monitoring plan (BNI 1991a) included collection of groundwater samples from 15 wells: 7 completed in the overburden and 8 completed in bedrock. One well included in the monitoring plan (MISS-7A) was not sampled because of minimal saturated thickness and slow recovery. Figure 3-4 shows the locations of the well network used during 1992. As shown, one well (B38W02D) is offsite and upgradient; two wells are offsite on Stepan property, and the other wells are on MISS property. The samples were analyzed for radionuclides, total metals, volatile and semivolatile organic compounds, pesticides, and polychlorinated biphenyls.

3.3.2 Results

The groundwater radiological and chemical data are interpreted through comparative analysis. Radionuclide concentrations are compared with background concentrations in an upgradient well and with DOE derived concentration guides (DCGs). A DCG is defined as the concentration of a radionuclide in air or water that, under continuous exposure for one year by one exposure mode (e.g., ingestion of water or inhalation), would result in an effective dose equivalent of 100 mrem (1 mSv). Chemical concentrations are compared with background concentrations in the upgradient well, New Jersey Groundwater Quality Standards (NJGQS) (7 NJAC 9-6, 1993), Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs), and SDWA non-zero maximum contaminant level goals (MCLGs) for primary drinking water.

Results for groundwater samples collected from 14 wells during October 1992 are presented in Tables 3-11 through 3-16.

Radiological

Table 3-11 presents the total uranium, radium-226, radium-228, and thorium-232 results reported for 1992. Uranium concentrations in groundwater samples ranged from 0.05×10^{-9} to 22.95×10^{-9} μCi/ml (1.88×10^{-3} to 8.49×10^{-1} Bq/L); radium-226 concentrations ranged from less than 0.03×10^{-9} to 2.4×10^{-9} μCi/ml (1.11×10^{-3} to 8.88×10^{-2} Bq/L); radium-228 concentrations ranged from less than 0.1×10^{-9} to 5.3×10^{-9} μCi/ml (3.7×10^{-3} to 1.96×10^{-1} Bq/L); and thorium-232 concentrations ranged from 0 to 9.58×10^{-9} μCi/ml (3.55×10^{-1} Bq/L). Results for background well B38W02D were 0.44×10^{-9} μCi/ml (1.63×10^{-2} Bq/L) of uranium and an estimated 8.7×10^{-9} μCi/ml (3.22×10^{-1} (3.22×10^{-1} Bq/L) of radium-228. Radium-226 and thorium-232 were not detected in the background well. Several of the radium-228 values are qualified as estimated values on the basis of quality assurance/quality control (QA/QC) determinations and probably reflect slightly elevated estimates of the actual concentrations.

As shown in Table 3-11, radionuclides were detected more frequently and at higher concentrations in samples from wells completed in the overburden than in samples from the bedrock wells. For example, the uranium concentration in overburden well MISS-5A was 23×10^{-9} μCi/ml (8.5×10^{-1} Bq/L), compared with concentrations of less than 6×10^{-9} μCi/ml (2.22×10^{-1} Bq/L) in samples from bedrock wells; concentrations of thorium-232 ranged from less than 0.1 to approximately 10×10^{-9} μCi/ml (3.7×10^{-3} to approximately 3.7×10^{-1} Bq/L) in samples from the overburden wells but were not detected in samples from the bedrock wells. With the exception of the sample results for MISS-2A, radium concentrations were similar in samples from both the overburden and bedrock wells. The sum of the radium-226 and radium-228 concentrations in MISS-2A was 6.2×10^{-9} μCi/ml (2.3×10^{-1} Bq/L). The more frequent detections and the higher concentrations in samples from the overburden wells are not unusual because the site is known to contain contaminated soil.

While some onsite radionuclide concentrations slightly exceeded background conditions, the only current MCL exceeded was by radium in one well [6.2×10^{-9} μCi/ml (2.3×10^{-1} Bq/L) in MISS-2A]; the current MCL is 5×10^{-9} μCi/ml (1.85×10^{-1} Bq/L).

Trends in average annual radionuclide concentrations in groundwater measured from 1987 through 1992 are presented in Table 3-12. As indicated in the table, samples from wells MISS-1AA, MISS-5A, B38W19S, and 19D were not collected before 1992. Results from the other wells were consistent with previous results. Overall, the results indicate little variability in average annual concentrations.

Radiological results from several wells exceed background concentrations; however, all of the results are well below the DCGs of 600×10^{-9} μCi/ml for total uranium, 100×10^{-9} μCi/ml for radium-226, and 50×10^{-9} μCi/ml for thorium-232.

Chemical

Metals detected in the groundwater (Table 3-13) were compared with background concentrations, NJGQS, and SDWA MCLs and non-zero MCLGs.

Aluminum, arsenic, barium, beryllium, boron, chromium, copper, lithium, manganese, nickel, selenium, vanadium, and uranium were identified in the baseline risk assessment (SAIC 1993) as contaminants of concern (COCs) in groundwater both onsite and offsite at MISS. From this list of COCs, aluminum, arsenic, chromium, iron, manganese, lead, tetrachloroethene, chloroform, and benzene in samples collected during 1992 were detected at concentrations above NJGQS and/or existing SDWA MCLs and MCLGs. In addition, concentrations of boron and lithium were significantly above background concentrations; NJGQS and MCLs do not exist for boron and lithium.

These elevated total concentrations are listed in Table 3-14 and summarized as follows:

- Aluminum (greater than 200 μg/L) in samples from most of the overburden wells
- Iron (greater than 300 μg/L) and manganese (greater than 50 μg/L) in all samples
- Arsenic in samples from two overburden wells at concentrations of 304 and 2,780 μg/L, and in samples from three bedrock wells at concentrations from 10 to 42 μg/L
- Chromium in a sample from one overburden well at 654 μg/L

- Lead in samples from two overburden wells at 26.4 and 11.6 μg/L
- Boron (653 to 1,880 μg/L) and lithium (1,190 to 13,900 μg/L) in most samples (both overburden and bedrock wells)

Because of geologic formation types, elevated total concentrations of aluminum in overburden groundwater and iron and manganese in overburden and bedrock groundwater are likely to occur throughout the units. These elevated concentrations are not indicative of contamination from past facility operations.

The elevated total concentrations of arsenic, chromium, and lead in the groundwater are localized and associated with nearby contaminated soils. There appears to be no significant migration of these metals in the groundwater.

Boron and lithium were detected at concentrations above background in most of the groundwater samples (from both the overburden and bedrock wells). The background concentration for boron was 51.7 μg/L; lithium was not detected in the background well. Results for well pairs MISS-1AA/-1B and MISS-3A/B38W03D were comparable to background. Results for the remaining wells ranged from 653 to 1,880 μg/L for boron and from 1,190 to 13,900 μg/L for lithium (Table 3-14). These metals are relatively mobile in solution and migrate with groundwater showing very little retardation.

Samples from three wells were analyzed for sulfate and chloride. Results showed that concentrations from onsite wells were elevated above the background concentrations. Table 3-15 provides these results and other major ion concentrations in groundwater samples. The 1992 sulfate results are consistent with previous results, which have shown that areas with elevated boron and lithium concentrations also have elevated sulfate concentrations.

Organics

Organic compounds detected in the groundwater were compared with NJGQS and SDWA MCLs and MCLGs. These standards, along with the organic compounds detected in groundwater samples, are listed in Table 3-16. Tetrachloroethylene (PCE) and chloroform were detected in well MISS-1B at 15 μg/L each; PCE and 1,2-dichloroethene (DCE) were detected in MISS-7B at 43 μg/L and 10 μg/L, respectively. Trichloroethene, 1,1,1-trichloroethane, 1,1,1-DCE and 1,1-DCE were reported at very low estimated concentrations ranging from 1 to 3 μg/L. Benzene was detected in MISS-5B at 200 μg/L, and toluene was reported at an estimated concentration of 2 μg/L.

Summary

The 1992 results are generally consistent with previous findings.

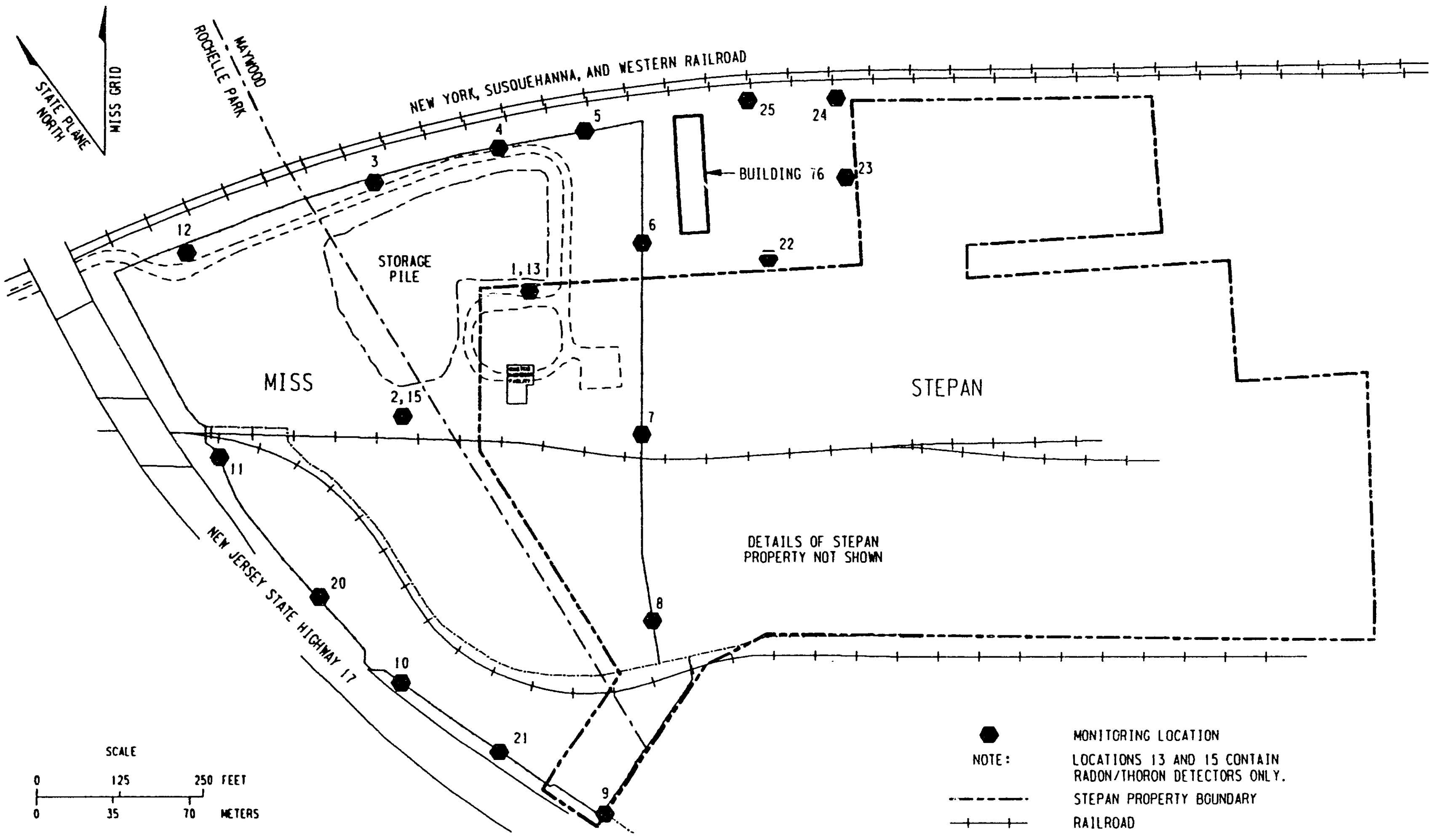
- Radiological results for several wells exceeded background concentrations; however, all of the results are well below DCGs of 600×10^{-9} μCi/ml (22.2 Bq/L) for total uranium, 100×10^{-9} μCi/ml (3.7 Bq/L) for radium-226, and 50×10^{-9} μCi/ml (1.85 Bq/L) for thorium-232. The radium MCL of 5×10^{-9} μCi/ml (1.85×10^{-1} Bq/L) was exceeded in one well (MISS-2A) at a concentration of 6.2×10^{-9} μCi/ml (2.3×10^{-1} Bq/L).

- Elevated concentrations (exceeding NJGQS, SDWA MCLs, MCLGs, and/or background concentrations) of aluminum, arsenic, chromium, iron, lead, and manganese were detected. The presence and concentrations of aluminum, iron, and manganese are not attributed to past facility operations. Total concentrations and the distribution of arsenic, chromium, and lead in the groundwater appear to reflect localized sources associated with contaminated soils.

- Elevated concentrations (exceeding background) of boron, lithium, and sulfate were detected in samples from most of the MISS onsite wells.

- Benzene, chloroform, and tetrachoroethene were detected at concentrations exceeding NJGQS and SDWA MCLs in bedrock wells along the western boundary of MISS.

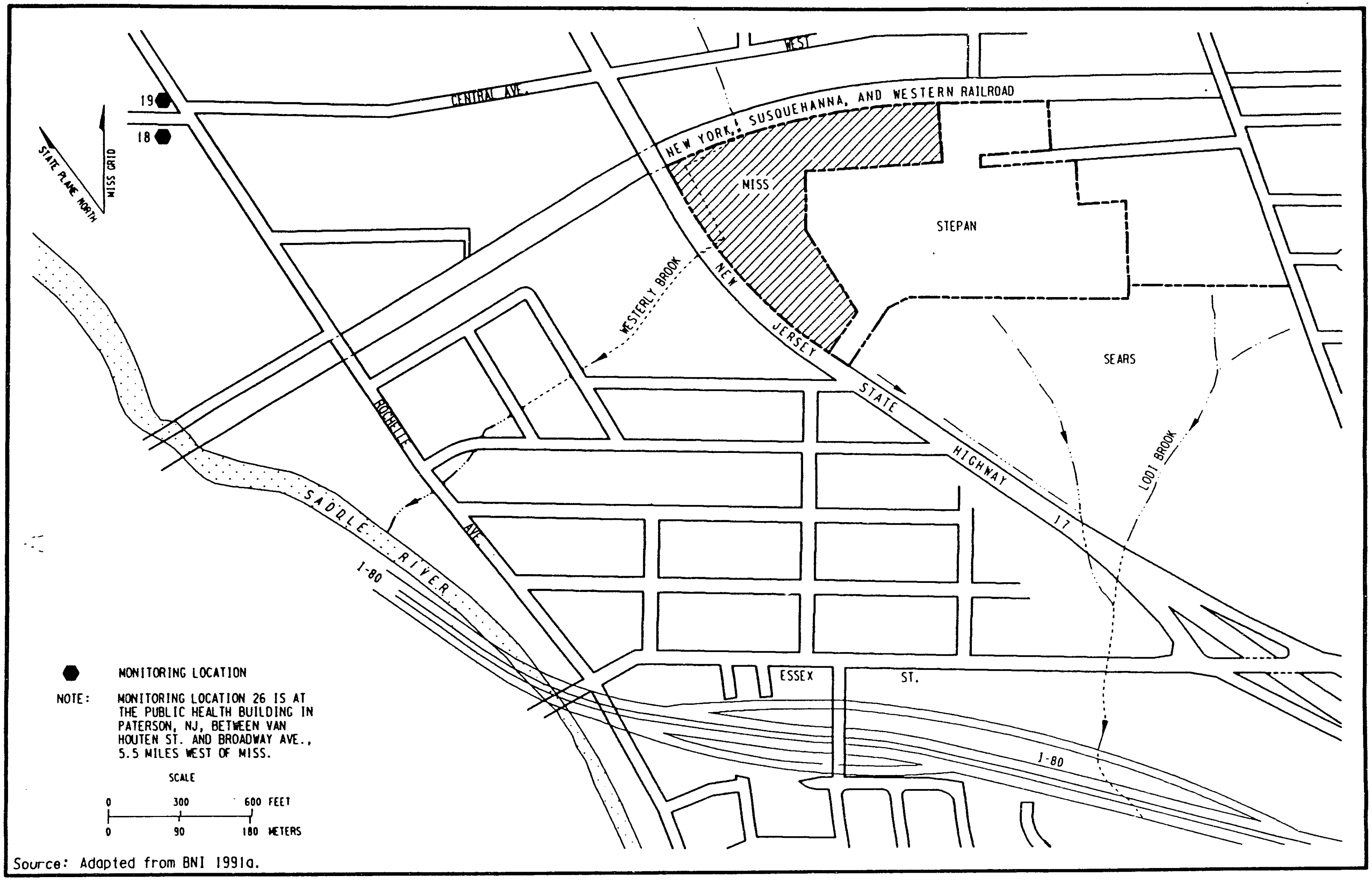
FIGURES FOR SECTION 3.0



Source: Adapted from BNI 1991a.

R40F005.DGN

Figure 3-1
Onsite Radon, Thoron, and External Gamma Radiation Monitoring Locations



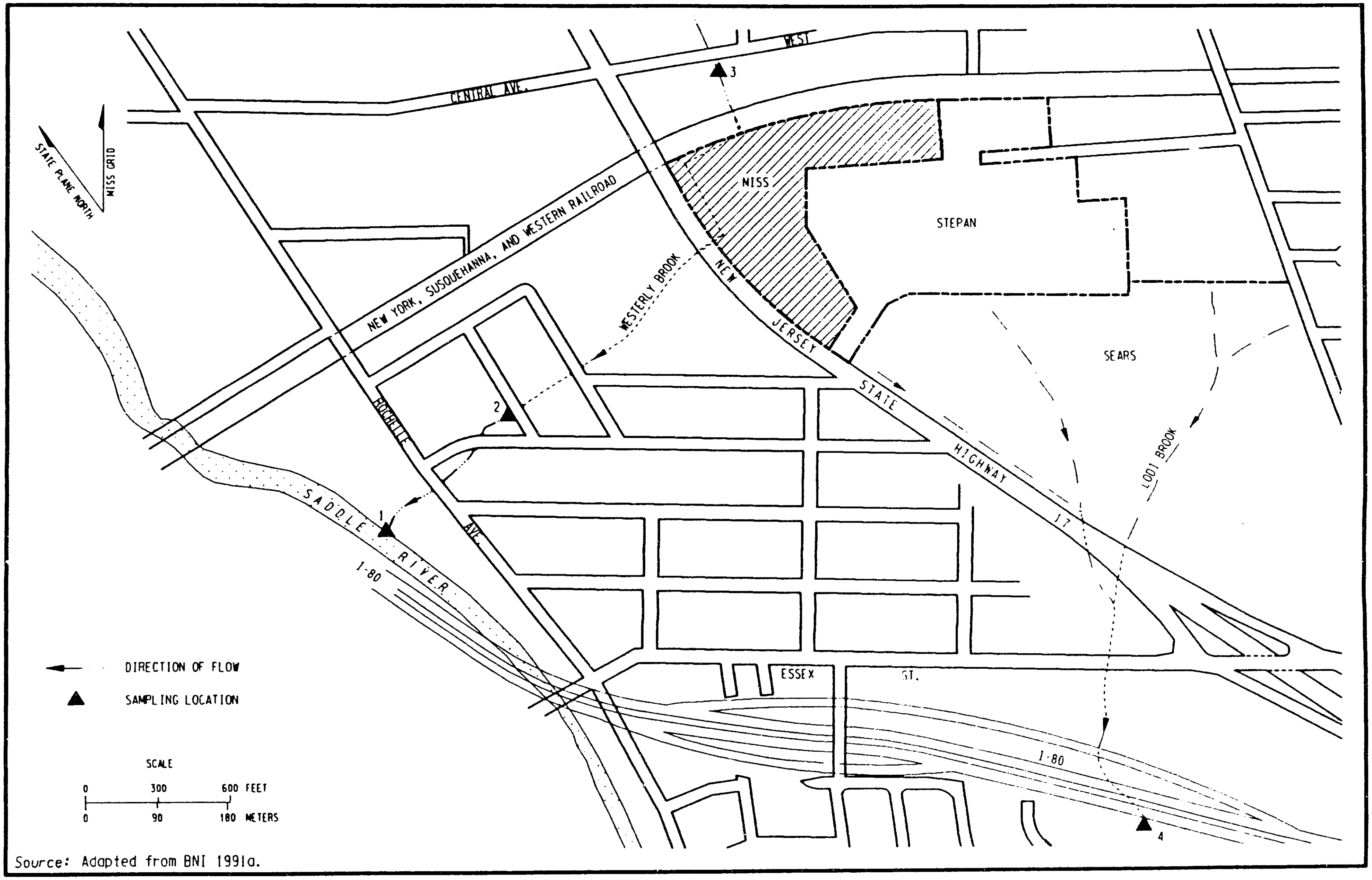
● MONITORING LOCATION

NOTE: MONITORING LOCATION 26 IS AT THE PUBLIC HEALTH BUILDING IN PATERSON, NJ, BETWEEN VAN HOUTEN ST. AND BROADWAY AVE., 5.5 MILES WEST OF MISS.

Source: Adapted from BNI 1991a.

R40F006.DGN

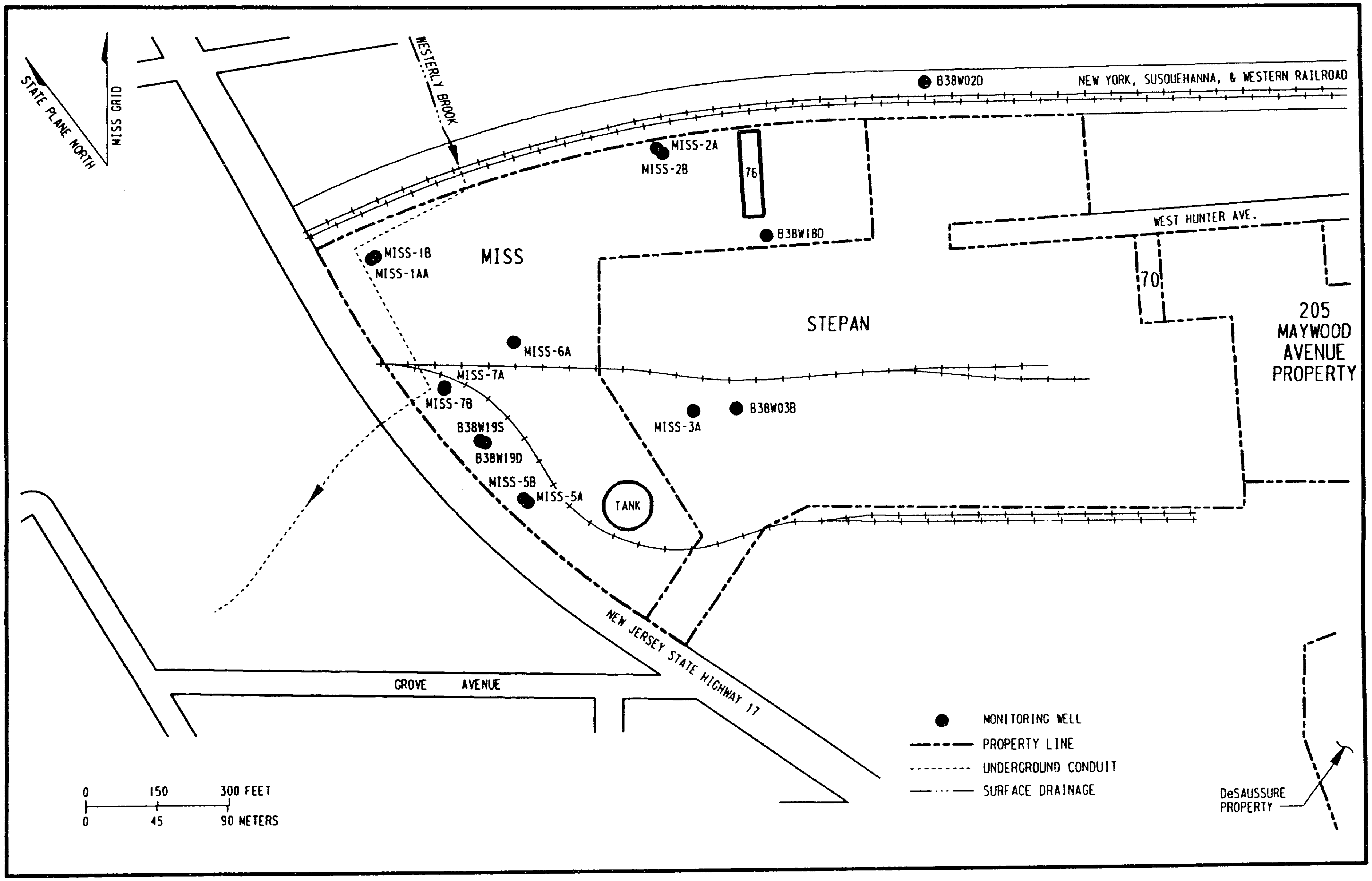
Figure 3-2
Offsite Radon, Thoron, and External Gamma Radiation Monitoring Locations



Source: Adapted from BNI 1991a.

R40F007.DGN

Figure 3-3
Surface Water and Sediment Sampling Locations in the Vicinity of MISS



138 R40F010.DGN

Figure 3-4
Groundwater Monitoring Well Locations

TABLES FOR SECTION 3.0

Table 3-1

Average Concentrations[a,b] of Radon at MISS, 1992

Page 1 of 2

Sampling Location[c]	Quarter 1	2	3	4	Avg
	(Concentrations are in 10^{-9} µCi/ml)				
Onsite					
1	<0.4	<0.3	0.4	<0.3	0.4
2	<0.4	<0.3	<0.3	<0.3	0.3
Fenceline					
3	<0.4	<0.3	0.3	<0.3	0.3
4	<0.4	<0.3	<0.3	<0.3	0.3
5	<0.4	0.4	<0.3	<0.3	0.4
6	<0.4	<0.3	0.6	<0.3	0.4
7	<0.4	<0.3	0.3	<0.3	0.3
8	<0.4	<0.3	<0.3	<0.3	0.3
9	0.4	<0.3	0.3	<0.3	0.3
10	<0.4	<0.3	0.4	<0.3	0.4
11	<0.4	<0.3	0.5	<0.3	0.4
12	<0.4	<0.3	0.4	<0.3	0.4
20	<0.4	<0.3	0.4	0.5	0.4
21	0.4	<0.3	<0.3	<0.3	0.3
22	<0.4	0.9	0.6	<0.3	0.6
23	<0.4	0.6	0.4	<0.3	0.4
24	<0.4	0.5	0.4	<0.3	0.4
25	0.5	<0.3	0.4	<0.3	0.4
Quality Control					
13[d]	<0.4	<0.3	0.4	<0.3	0.4
15[e]	<0.4	0.4	0.4	<0.3	0.4
Background					
18[f]	<0.4	<0.3	0.3	<0.3	0.3
19[g]	<0.4	<0.3	0.4	<0.3	0.4
26[h]	--	--	0.3	<0.3	0.3

Table 3-1

(continued)

---

[a] 1 × 10^{-9} µCi/ml is equivalent to 0.037 Bq/L and 1 pCi/L. The DOE DCG for radon-222 is 3.0 × 10^{-9} µCi/ml.

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

[c] Sampling locations are shown in Figures 3-1 and 3-2.

[d] Quality control for station 1.

[e] Quality control for station 2.

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

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

[h] Located at 100 Fair St., Paterson, N.J., approximately 8 km (0.5 mi) northwest of MISS; established on June 30, 1992.

Table 3-2

Average Concentrations[a,b] of Thoron at MISS, 1992

Page 1 of 2

Sampling Location[c]	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Avg
	(Concentrations are in 10^{-9} μCi/ml)				
Onsite					
1	0.1	0.4	0.4	0	0.2
2	0.5	0.8	0.8	0	0.6
Fenceline					
3	0.2	0.3	0.5	0	0.3
4	0.4	0.6	1.0	0.1	0.5
5	4.6	4.4	3.6	3.5	4.0
6	0.8	1.5	0.7	0.4	0.9
7	0.2	0.5	0.3	0	0.3
8	0	0.3	0.2	0	0.1
9	0.9	0.8	0.7	0.4	0.7
10	0.9	1.7	1.1	0.8	1.1
11	0.6	1.5	1.0	0.2	0.8
12	1.2	0.7	1.9	0.3	0.8
20	0.9	2.8	0.6	0.1	1.1
21	0.9	1.9	2.2	0.9	1.5
22	4.7	10.7	11.2	4.3	7.7
23	2.0	3.0	3.7	1.9	2.7
24	2.3	2.5	4.8	1.2	2.7
25	1.8	2.1	2.2	1.4	1.9
Quality Control					
13[d]	0	0.4	0.4	0	0.2
15[e]	0.8	0.4	0.7	0.1	0.5
Background					
18[f]	0	0	0	0	0
19[g]	0	0	0	0	0
26[h]	--	--	0	0	0

Table 3-2

(continued)

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

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

[c] Sampling locations are shown in Figures 3-1 and 3-2.

[d] Quality control for station 1.

[e] Quality control for station 2.

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

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

[h] Located at 100 Fair St., Paterson, N.J., approximately 8 km (0.5 mi) east of MISS; established on June 30, 1992.

Table 3-3

Trend Analysis for Radon Concentrations[a,b] at MISS, 1987-1992

Page 1 of 2

Sampling Location[c]	Average Annual Concentration 1987	1988	1989	1990	1991	Average Annual Concentration 1992
	(Concentrations are in 10^{-9} μCi/ml)					
Onsite						
1	0.7	0.6	0.4	0.3	0.5	0.4
2	1.2	0.9	0.4	0.5	0.6	0.3
Fenceline						
3	1.5	0.6	0.4	0.4	0.5	0.3
4	1.1	1.9	0.9	0.6	0.5	0.3
5	9.7	7.4	1.0	2	0.8	0.3
6	2.4	1.4	0.6	0.4	0.5	0.4
7	1.1	0.8	0.6	0.4	0.6	0.3
8	1.0	0.4	0.4	0.3	0.6	0.3
9	1.1	0.5	0.5	0.3	0.6	0.3
10	4.9	1.0	0.6	0.4	0.6	0.4
11	0.8	0.8	0.5	0.3	1	0.4
12	2.3	1.1	0.8	0.3	0.7	0.4
20[d]	--	--	--	--	--	0.4
21[d]	--	--	--	--	--	0.3
22[d]	--	--	--	--	--	0.6
23[d]	--	--	--	--	--	0.4
24[d]	--	--	--	--	--	0.4
25[d]	--	--	--	--	--	0.4
Quality Control						
13[e]	1.1	0.4	0.5	0.5	0.6	0.4
15[f]	--	--	--	0.4	0.6	0.4
Background						
14[g]	0.8	0.3	0.5	0.3	0.5	--
18[h]	--	--	0.4	0.4	0.5	0.3
19[i]	--	--	0.4	0.5	0.6	0.4
26[j]	--	--	--	--	--	0.3

Source for 1987-1991 data: BNI 1992a.

Table 3-3

(continued)

---

[a] 1×10^{-9} µCi/ml is equivalent to 0.037 Bq/L and 1 pCi/L. The DOE DCG for radon-222 is 3.0×10^{-9} µCi/ml.

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

[c] Sampling locations are shown in Figures 3-1 and 3-2.

[d] Monitoring location added in 1992.

[e] Quality control for station 1.

[f] Quality control for station 2; established in 1990.

[g] Located at the Department of Health in Paterson, N.J., approximately 8.8 km (5.5 mi) west of MISS; deleted in 1992.

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

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

[j] Located at 100 Fair Street, Paterson, N.J., approximately 8 km (5 mi) east of MISS; established on June 30, 1992.

Table 3-4

Comparison of Thoron Concentrations[a,b] at MISS, 1991 and 1992

Page 1 of 2

Sampling	Average Annual Concentration	
Location	1991	1992
(Concentrations are in 10^{-9} µCi/ml)		
Onsite		
1	1.1	0.2
2	0.9	0.6
Fenceline		
3	0.4	0.3
4	1.3	0.5
5	19.4	4.0
6	1.6	0.9
7	0.5	0.3
8	0.1	0.1
9	0.4	0.7
10	1.7	1.1
11	0.9	0.8
12	1.5	0.8
20[d]	--	1.1
21[d]	--	1.5
22[d]	--	7.7
23[d]	--	2.7
24[d]	--	2.7
25[d]	--	1.9
Quality Control		
13[e]	0.7	0.2
15[f]	0.8	0.5
16[e,g]	0.6	--
17[f,g]	1.0	--
Background		
14[h]	0	--
18[i]	0.1	0
19[j]	0.1	0
26[k]	--	0

Table 3-4

(continued)

Page 2 of 2

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

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

[c] Sampling locations are shown in Figures 3-1 and 3-2.

[d] Monitoring location added in 1992.

[e] Quality control for station 1.

[f] Quality control for station 2.

[g] Monitoring location deleted in 1992.

[h] Located at the Department of Health in Paterson, N.J., approximately 8.8 km (5.5 mi) west of MISS; deleted in 1992.

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

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

[k] Located at 100 Fair St., Paterson, N.J., approximately 8 km (0.5 mi) east of MISS; established on June 30, 1992.

Table 3-5

Trend Analysis for External Gamma Radiation Exposure Rates[a,b] at MISS, 1987-1992

Page 1 of 2

Sampling Location[c]	Average Annual Rates 1987	1988	1989	1990	1991	Average Annual Rates 1992
	(Exposure rates are in mR/yr)					
Onsite						
1	36	40	28	24	25	38
2	43	52	35	30	26	55
Fenceline						
3	29	21	29	16	21	30
4	69	109	112	80	93	97
5	121	186	154	139	121	203
6	67	85	68	54	38	48
7	36	16	13	9	6	12
8	37	30	9	10	10	21
9	39	32	17	9	12	20
10	521	317	173	150	153	178
11	61	59	35	31	31	39
12	79	106	90	82	73	70
20[d]	--	--	--	--	--	33
21[d]	--	--	--	--	--	533
22[d]	--	--	--	--	--	1,566
23[d]	--	--	--	--	--	532
24[d]	--	--	--	--	--	370
25[d]	--	--	--	--	--	741
					Average	281
Background						
14[e]	58	78	63	63	60	--
18[f]	--	--	64	64	59	79
19[g]	--	--	56	78	62	69
25[h]	--	--	--	--	--	109
					Average	74

Source for 1987-1991 data: BNI 1992a.

Table 3-5

(continued)

Page 2 of 2

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

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

[c] Sampling locations are shown in Figures 3-1 and 3-2.

[d] Monitoring location added in 1992.

[e] Located at the Department of Health in Paterson, N.J., approximately 8.8 km (5.5 mi) west of MISS; deleted in 1992.

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

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

[h] Located at 100 Fair Street, Paterson, N.J., approximately 8 km (5 mi) east of MISS; established on June 30, 1992. Because the data were only for six months, they were not used in calculating the average.

Table 3-6
External Gamma Radiation Exposure Rates for Comparison

Location	Average (mR/yr)
Site boundary (1992)	281
Site vicinity (i.e., background in the Maywood area) (1992)	74
U.S. background[a]	103
Grand Central Station (NYC)[b]	525
Statue of Liberty base[b]	325

[a] Shleien 1992.

[b] Appendix B.

Table 3-7

Concentrations[a,b] of Total Uranium, Radium-226, Radium-228, and Thorium-232 in Surface Water at MISS, 1992

Page 1 of 2

Sampling Location[c]	Quarter 2	Quarter 4	Avg
(Concentrations are in 10^{-9} µCi/ml)			
Total Uranium[d]			
2	0.97	0.81	0.9
3[e]	0.10	0.05	0.1
4	0.10	0.05	0.1
Radium-226			
2	0.62	0.47	0.5
3[e]	0.27	0.11	0.2
4	0.47	0.08	0.3
Radium-228			
2	0.90	1.60	1.3
3[e]	0.60	0.80	0.7
4	2.06	1.20	1.6
Thorium-232			
2	0.42	0.00	0.21
3[e]	0.16	0.01	0.08
4	0.18	0.03	0.11

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

Table 3-7

(continued)

Page 2 of 2

[b] Measured background has not been subtracted.

[c] Sampling locations are shown in Figure 3-3.

[d] Total uranium concentrations were determined by kinetic phosphorescence analysis.

[e] Upstream background location.

Table 3-8

Trend Analysis for Total Uranium, Radium-226, and Thorium-232 Concentrations[a,b] in Surface Water at MISS, 1986-1992

Page 1 of 2

Sampling Location[c]	Average Annual Concentration 1986	1987	1988	1989	1990	1991	Average Annual Concentration 1992
			(Concentrations are in 10^{-9} μCi/ml)				
			Total Uranium[d]				
1	<3	<3	3	<5	3	2	
2	<3	<3	4.3	<5	4	2	0.9
3[e]	<3	<3	3.8	<5	3	2	0.1
4[f]	--	--	--	<5	3	2	0.1
			Radium-226				
1	0.4	0.4	0.4	0.3	0.3	0.3	
2	0.4	0.2	0.3	0.3	0.3	0.2	0.5
3[e]	0.6	0.3	0.3	0.4	0.3	0.6	0.2
4[f]	--	--	--	0.4	0.4	0.2	0.3
			Thorium-232				
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	0.21
3[e]	0.1	<0.1	0.1	<0.1	<0.1	0.2	0.08
4[f]	--	--	--	<0.1	<0.1	0.1	0.11

Source for 1986-1991 data: BNI 1992a.

Table 3-8

(continued)

Page 2 of 2

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

[b] Measured background has not been subtracted.

[c] Sampling locations are shown in Figure 3-3.

[d] 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 and in 1992.

[e] Upstream background location.

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

Table 3-9

Concentrations[a,b] of Total Uranium, Radium-226, Radium-228, and Thorium-232 in Sediment at MISS, 1992

Page 1 of 2

Sampling Location[c]	Quarter 2	Quarter 4	Avg
(Concentrations are in pCi/g)			
Total Uranium[d]			
2	2.90	1.42	2.16
3[e]	2.72	2.09	2.41
4	3.08	2.57	2.83
Radium-226			
2	0.55	0.25	0.40
3[e]	0.52	0.45	0.49
4	0.62	0.52	0.57
Radium-228			
2	0.98	0.29	0.64
3[e]	0.74	0.65	0.70
4	1.90	1.60	1.75
Thorium-232			
2	0.80	0.42	0.61
3[e]	0.85	0.65	0.75
4	1.80	1.50	1.65

---

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

Table 3-9

(continued)

Page 2 of 2

[b] Measured background has not been subtracted.

[c] Sampling locations are shown in Figure 3-3.

[d] Total uranium concentrations were determined by kinetic phosphorescence analysis.

[e] Upstream background location.

Table 3-10

Trend Analysis for Total Uranium, Radium-226, and Thorium-232 Concentrations[a,b] in Sediment at MISS, 1986-1992

Page 1 of 2

Sampling Location[c]	Average Annual Concentration 1986	1987	1988	1989	1990	1991	Average Annual Concentration 1992
(Concentrations are in pCi/g)							
Total Uranium[d]							
1	1.0	1.2	1.6	1.5	1.0	3.2	--
2	1.2	1.1	1.2	0.8	1.0	1.2	2.16
3[e]	0.8	1.1	1.0	1.7	1.0	2.5	2.41
4[f]	--	--	--	1.1	1.0	3.5	2.83
Radium-226							
1	0.2	0.4	0.4	0.5	0.4	0.8	
2	0.3	0.3	0.4	0.4	0.5	0.7	0.40
3[e]	0.4	0.4	0.3	0.6	0.5	0.5	0.49
4[f]	--	--	--	0.5	0.5	0.7	0.57
Thorium-232							
1	0.7	0.4	0.4	0.3	0.5	1.4	--
2	0.7	0.3	0.5	0.3	0.5	0.6	0.61
3[e]	0.4	0.3	0.4	0.3	0.3	0.8	0.75
4[f]	--	--	--	1.5	0.7	4.3	1.65

Table 3-10

(continued)

Page 2 of 2

Source for 1986-1990 data: BNI 1992a.

[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.

[c] Sampling locations are shown in Figure 3-3.

[d] 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 and in 1992.

[e] Upstream background location.

[f] Established in July 1989.

Table 3-11

Concentrations[a,b] of Total Uranium, Radium-226, Radium-228, and Thorium-232 in Groundwater at MISS, 1992

Sampling Location[c]	Total Uranium	Radium-226	Radium-228	Thorium-232
	(Concentrations are in 10^{-9} μCi/ml)			
Overburden				
MISS-1AA	3.99	0.99	2.30	9.58
MISS-2A	1.08	2.40	3.80	0.87
MISS-3A	1.22	0.71	2.50	2.46
MISS-5A	22.95	0.39	4.00	6.13
MISS-6A	2.30	0.21 UJ[d,e]	1.30 UJ	0.00 UJ
MISS-7A	NS[f]	NS	NS	NS
B38W19S	0.59	0.08 UJ	1.50	0.09 UJ
Bedrock				
MISS-1B	0.95	0.35	-0.10 UJ	0.04 UJ
MISS-2B	0.26	0.06 UJ	3.30 J	0.00 UJ
B38W03B	0.05	0.03 UJ	3.70 J	0.06 UJ
MISS-5B	0.11	0.15 UJ	4.40 J	-0.01 UJ
MISS-7B	5.35	0.17 UJ	3.90 J	0.10 UJ
B38W18D	3.45	0.31	4.20 J	0.03 UJ
B38W19D	0.24	0.51	5.30 J	0.00 UJ
Background				
B38W02D	0.44	0.02 UJ	8.70 J	0.26 UJ

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

[b] Measured background has not been subtracted.

[c] Sampling locations are shown in Figure 3-4.

[d] U = not detected above detection limit.

[e] J = estimated value.

[f] NS = not sampled.

Table 3-12

Trend Analysis for Concentrations[a,b] of Total Uranium, Radium-226, and Thorium-232 in Groundwater at MISS, 1987-1992

Page 1 of 3

Sampling Location[c]	Average Annual Concentration[d] 1987	1988	1989	1990	1991	Concentration[e] 1992
(Concentrations are in (10^{-9} μCi/ml)						
Total Uranium[f]						
Overburden						
MISS-1AA	NS[g]	NS	NS	NS	NS	3.99
MISS-2A	2.4	1.4	2.1	3	3	1.08
MISS-3A	2.0	1.5	1.2	3	1	1.22
MISS-5A	NS	NS	NS	NS	NS	22.95
MISS-6A	12.1	8.4	8.0	6	2	2.30
MISS-7A	NS	NS	NS	NS	NS	NS
B38W19S	NS	NS	NS	NS	NS	0.59
Bedrock						
MISS-1B	3.3	2.4	2.2	3	3	0.95
MISS-2B	2.1	0.8	1.0	3	3	0.26
B38W03B	NS	NS	NS	NS	3.3 U[h]	0.05
MISS-5B	1.5	0.7	1.5	3	3	0.11
MISS-7B	5.0	6.3	7.0	4	5	5.35
B38W18D	NS	NS	4.8	3	7	3.45
B38W19D	NS	NS	NS	NS	NS	0.24
Background						
B38W02D	NS	NS	2.2	3	1	0.44
Radium-226						
Overburden						
MISS-1AA	NS	NS	NS	NS	NS	0.99
MISS-2A	0.4	1.0	1.3	0.9	0.8	2.40
MISS-3A	0.6	1.2	1.6	1.0	1.9	0.71
MISS-5A	NS	NS	NS	NS	NS	0.39
MISS-6A	0.5	2.0	1.3	0.8	1.0	0.21 UJ[i]
MISS-7A	NS	NS	NS	NS	NS	NS
B38W19S	NS	NS	NS	NS	NS	0.08 UJ

Table 3-12

(continued)

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Sampling Location[c]	Average Annual Concentration[d]					Concentration[e]
	1987	1988	1989	1990	1991	1992
			Radium-226 (cont.)			
Bedrock						
MISS-1B	0.4	0.9	1.4	0.7	0.3	0.35
MISS-2B	0.4	0.7	1.0	0.6	0.3	0.06 UJ
B38W03B	NS	NS	NS	NS	0.14	0.03 UJ
MISS-5B	0.3	0.7	1.0	0.6	0.2	0.15 UJ
MISS-7B	0.3	1.5	0.8	0.5	0.2	0.17 UJ
B38W18D	NS	NS	0.7	0.5	1.4	0.31
B38W19D	NS	NS	NS	NS	NS	0.51
Background						
B38W02D	NS	NS	0.9	1.0	1.2	0.02 UJ
			Thorium-232			
Overburden						
MISS-1AA	NS	NS	NS	NS	NS	9.58
MISS-2A	0.1 U	0.4	0.5	0.3	0.2	0.87
MISS-3A	0.1 U	0.7	0.5	0.3	0.6	2.46
MISS-5A	NS	NS	NS	NS	NS	6.13
MISS-6A	0.3	0.2 U	0.5	0.4	0.5	0.00 UJ
MISS-7A	NS	NS	NS	NS	NS	NS
B38W19S	NS	NS	NS	NS	NS	0.09 UJ
Bedrock						
MISS-1B	0.3 U	0.3 U	0.3 U	0.3	0.1	0.04 UJ
MISS-2B	0.1 U	0.3 U	0.3	0.2	0.1	0.00 UJ
B38W03B	NS	NS	NS	NS	0.04 U	0.06 UJ
MISS-5B	0.1 U	0.2 U	0.3 U	0.1	0.1	-0.01 UJ
MISS-7B	0.1 U	0.3 U	0.2 U	0.2	0.1	0.10 UJ
B38W18D	NS	NS	0.3	0.1	1.2	0.03 UJ
B38W19D	NS	NS	NS	NS	NS	0.00 UJ
Background						
B38W02D	NS	NS	0.3	0.8	0.2	0.26 UJ

Table 3-12

(continued)

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

[b] Measured background has not been subtracted.

[c] Sampling locations are shown in Figure 3-4.

[d] 1987-1991 average annual concentrations based on average of two to four samples per year.

[e] 1992 concentrations based on one sample.

[f] 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 and in 1992.

[g] NS = not sampled.

[h] U = not detected above detection limit.

[i] J = estimated value.

Table 3-13

Concentrations of Total Metals in Groundwater at MISS, 1992

Page 1 of 2

	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron
NJGQS[a]	200	20	8	2000	20	--	4	100	--	1300	300
SDWA MCL[b]	--	6	50	2000	4	--	5	100	--	1300	--
SDWA MCLG[c]	--	6	--	2000	4	--	5	100	--	1300	--
Sampling Location[d]											
					(Concentrations are in μg/L)						
Overburden											
MISS-1AA	4570.0	60.0 U[e]	2.2 J[f]	81.0	1.0 U	124.0	7.0 U	19.4	9.0 U	20.2	3770.0
MISS-2A	691.0	60.0 U	2780.0 J	14.0 U	1.0 U	1690.0	7.0 U	654.0	9.0 U	204.0	1440.0
MISS-3A	15800.0	60.0 U	304.0 J	390.0	1.4	13.0 U	7.0 U	33.5	20.3	66.7	134000.0
MISS-5A	303.0	60.0 U	10.0 U	200.0 U	5.0 U	653.0	5.0 U	10.0 U	50.0 U	25.0 U	9600.0
MISS-6A	746.0 J	60.0 U	5.7	87.2	1.0 U	1520.0	7.0 U	9.0 U	9.0 U	85.7	3530.0 J
MISS-7A	NS[g]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
B38W19S	153.0 J	60.0 U	3.1 J	43.3	1.0 U	1340.0	7.0 U	9.0 U	9.0 U	8.0 U	1170.0
Bedrock											
MISS-1B	49.0 U	60.0 U	2.0 U	82.6	1.0 U	84.8	7.0 U	9.0 U	9.0 U	8.0 U	2420.0
MISS-2B	100.0	60.0 U	2.0 U	14.0 U	1.0 U	1650.0	7.0 U	9.0 U	9.0 U	8.0 U	8460.0
B38W03B	70.4	60.0 U	2.0 U	15.6	1.0 U	131.0	7.0 U	9.0 U	9.0 U	8.0 U	25800.0
MISS-5B	200.0 U	60.0 U	10.0 U	200.0 U	5.0 U	1190.0	5.0 U	10.0 U	50.0 U	25.0 U	3260.0
MISS-7B	200.0 U	60.0 U	25.2 J	200.0 U	5.0 U	1550.0	5.0 U	10.0 U	50.0 U	25.0 U	3710.0
B38W18D	510.0	60.0 U	10.0 J	200.0 U	5.0 U	414.0	5.0 U	38.8	50.0 U	25.0 U	14900.0
B38W19D	200.0 U	60.0 U	41.8 J	200.0 U	5.0 U	1880.0	5.2	10.0 U	50.0 U	25.0 U	3260.0
Background											
B38W02D	2860.0 J	60.0 U	2.0 U	450.0	1.0 U	51.7	7.0 U	9.0 U	9.0 U	8.0 U	2860.0 J

Table 3-13

(continued)

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	Lead	Lithium	Manganese	Molybdenum	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc
NJGQS[a]	10	--	50	--	100	50	--	10	--	5000
SDWA MCL[b]	15	--	--	--	100[h]	50	--	2[h]	--	--
SDWA MCLG[c]	0	--	--	--	100[h]	50	--	0.5[h]	--	--
Sampling Location[d]										
Overburden										
MISS-1AA	2.0 U	358.0	261.0	5.0 U	20.0 U	2.0 U	10.0 U	2.0 UJ	8.0 U	45.6
MISS-2A	4.6 J	8680.0	101.0	5.0 U	20.0 U	2.0 U	10.0 U	2.0 UJ	51.0	29.8 J
MISS-3A	26.4 J	158.0	1330.0	89.2	20.0 U	2.0 U	10.0 U	2.0 UJ	31.4	114.0
MISS-5A	3.0 U	1190.0	824.0	100.0 U	40.0 U	5.0 U	10.0 U	10.0 UJ	50.0 U	22.5
MISS-6A	11.6 J	6290.0	421.0	5.0 U	20.0 U	2.0 U	10.0 U	2.0 UJ	19.0	629.0
MISS-7A	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
B38W19S	2.0 U	2120.0	545.0	5.0 U	20.0 U	2.0 UJ	10.0 UJ	2.0 UJ	43.6	7.0 U
Bedrock										
MISS-1B	2.0 U	104.0	338.0	5.0 U	20.5	2.0 U	10.0 U	2.0 UJ	8.0 U	21.7
MISS-2B	2.0 U	13900.0	5830.0	5.0 U	20.0 U	2.6	10.0 U	2.0 UJ	8.0 U	15.2
B38W03B	2.0 U	52.2	8480.0	16.0	20.0 U	2.0 U	10.0 U	2.0 UJ	8.0 U	18.9
MISS-5B	3.0 U	3210.0	3590.0	100.0 U	40.0 U	5.0 U	10.0 U	10.0 UJ	50.0 U	20.0 U
MISS-7B	3.0 U	4840.0	3060.0	100.0 U	40.0 U	5.0 U	10.0 U	10.0 UJ	50.0 U	20.0 U
B38W18D	3.0 U	2610.0	5120.0	100.0 U	40.0 U	5.0 U	10.0 U	10.0 UJ	50.0 U	114.0
B38W19D	3.0 U	6390.0	2970.0	100.0 U	40.0 U	5.0 U	10.0 U	10.0 UJ	50.0 U	20.0 U
Background										
B38W02D	2.0 U	27.0 U	2530.0	5.0 U	20.0 U	2.0 U	10.0 U	2.0 UJ	12.7	19.0

[a] NJGQS = New Jersey Groundwater Quality Standards (February 1993).
[b] SDWA MCL = Safe Drinking Water Act maximum contaminant level.
[c] SDWA MCLG = Safe Drinking Water Act maximum contaminant level goal.
[d] Sampling locations are shown in Figure 3-4.
[e] U = not detected above detection limit.
[f] J = estimated value.
[g] NS = not sampled.
[h] Effective 1994.

Table 3-14

Summary of Selected Total Metal Concentrations in Groundwater (October 1992 Results)

	Aluminum	Arsenic	Boron	Chromium	Iron	Lead	Lithium	Manganese
NJGQS[a]	200	8	–	100	300	10	–	50
SDWA MCL[b]	–	50	–	100	–	15	–	–
SDWA MCLG[c]	–	–	–	100	–	0	–	–
				(Concentrations are in µg/L)				
Sampling Location[d]								
Overburden								
MISS-1AA	4570.0	–	124.0	–	3770.0	–	358.0	261.0
MISS-2A	691.0	2780.0 J	1690.0	654.0	1440.0	–	8680.0	101.0
MISS-3A	15800.0	304.0 J	–	–	134000.0	26.4 J	158.0	1330.0
MISS-5A	303.0	–	653.0	–	9600.0	–	1190.0	824.0
MISS-6A	746.0 J[e]	–	1520.0	–	3530.0 J	11.6 J	6290.0	421.0
B38W19S	–	–	1340.0	–	1170.0	–	2120.0	545.0
Bedrock								
MISS-1B	–	–	84.8	–	2420.0	–	104.0	338.0
MISS-2B	–	–	1650.0	–	8460.0	–	13900.0	5830.0
B38W03B	–	–	131.0	–	25800.0	–	52.2	8480.0
MISS-5B	–	–	1190.0	–	3260.0	–	3210.0	3590.0
MISS-7B	–	25.2 J	1550.0	–	3710.0	–	4840.0	3060.0
B38W18D	510.0	–	414.0	–	14900.0	–	2610.0	5120.0
B38W19D	–	41.8 J	1880.0	–	3260.0	–	6390.0	2970.0
Background								
B38W02D	2860.0	2.0 U[f]	51.7	9.0 U	2860.0 J	2.0 U	27.0	2530.0

[a] NJGQS = New Jersey Groundwater Quality Standards (February 1993).
[b] SDWA MCL = Safe Drinking Water Act maximum contaminant levels.
[c] SDWA MCLG = Safe Drinking Water Act maximum contaminant level goals.
[d] Sampling locations are shown in Figure 3-4.
[e] J = estimated value.
[f] U = not detected above detection limit.

Table 3-15

Major Ions in Groundwater at MISS, 1992

Sampling Location[a]	Calcium	Magnesium	Potassium	Sodium	Chloride	Sulfate
(Concentrations are in mg/L)						
Overburden						
MISS-1AA	670.00	11.50	4.27	6.63 J[b]	NA[c]	NA
MISS-2A	158.00	9.92	16.00	1590.00 J	NA	NA
MISS-3A	45.60	8.14	29.20	23.50 J	NA	NA
MISS-5A	604.00	91.90	91.60	27.00 J	NA	NA
MISS-6A	184.00	12.00	58.80	52.20	NA	NA
MISS-7A	NS[d]	NS	NS	NS	NS	NS
B38W19S	520.00	76.40	50.10	31.20	NA	NA
Bedrock						
MISS-1B	115.00	22.90	7.77	61.30 J	NA	NA
MISS-2B	358.00	49.70	58.90	1740.00	NA	NA
B38W03B	425.00	61.90	11.20	173.00	NA	NA
MISS-5B	378.00	90.40	290.00	605.00 J	NA	NA
MISS-7B	206.00	70.90	27.60	1550.00 J	124.0	2940.0
B38W18D	174.00	16.00	7.81	37.20 J	NA	NA
B38W19D	248.00	46.90	392.00	533.00 J	211.0	1340.0
Background						
B38W02D	100.00	4.80	1.34 U[e]	8.50	14.6	30.2

[a] Sampling location are shown in Figure 3-4.
[b] J = estimated value.
[c] NA = no analysis requested.
[d] NS = not sampled.
[e] U = not detected above detection limit.

Table 3-16

Organic Compounds Detected in Groundwater at MISS, 1992

				Sampling Locations[d]			
Compound	NJGQS[a]	SDWA MCL[b]	SDWA MCLG[c]	MISS-1B	MISS-2B	MISS-5B	MISS-7B
			(Concentrations are in μg/L)				
Benzene	1	5	0	--	3 J[e]	200	--
Chloroform	6	--	--	15	--	--	--
Tetrachloroethene	1	5	0	15	--	--	43
Trichloroethene	1	5	0	--	--	--	2 J
1,1,1 Trichloroethane	30	200	200	--	--	--	1 J
1,2 Dichloroethene (total)	10/100[f]	70/100[g]	70/100[g]	1 J	--	--	10
1,1 Dichloroethene	2	7	7	--	--	--	2 J
1,1 Dichloroethane	70	--	--	--	--	--	1 J
Toluene	1000	1000	1000	--	--	2 J	--

[a] NJGQS = New Jersey Groundwater Quality Standards (February 1993).

[b] SDWA MCL = Safe Drinking Water Act maximum contaminant level.

[c] SDWA MCLG = Safe Drinking Water Act maximum contaminant level goal.

[d] Sampling locations are shown in Figure 3-4.

[e] J = estimated value.

[f] NJGQS for 1,2 dichloroethene (cis) = 10 μg/L; for 1,2 dichloroethene (trans) = 100 μg/L.

[g] SDWA MCLs and MCLGs for 1,2 dichloroethene (cis) = 70 μg/L; for 1,2 dichloroethene (trans) = 100 μg/L.

4.0 ESTIMATED DOSE

The information in Section 3.0 was evaluated as described in Appendix F to estimate the potential radiation doses to the general public and to a maximally exposed individual from the radioactive material at MISS. This material consists primarily of thorium-contaminated soil resulting from monazite sand processing operations as described in Subsection 1.1.

To assess the potential health effects from the materials stored at MISS, internal and external radiation exposures were considered for the maximally exposed individual and the general public within 80 km (50 mi) of the site.

Doses 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. The distinction is important because external exposures occur only when a person is near the external radiation source, but internal exposures continue as long as the radionuclides reside in the body.

External exposure results from direct gamma radiation exposure from the radioactive materials in the storage pile and in surface and subsurface soils at the site. External exposure is determined by calculations performed on data obtained from the TETLD monitoring program.

To determine internal exposures to the maximally exposed individual and the general population within 80 km (50 mi), realistic and complete pathways by which radioactive materials could enter individuals must be identified. A complete internal exposure pathway must contain each of the following elements:

- A contaminant source and a mechanism by which the contaminant is released into the environment
- An environmental transport mechanism (i.e., a mechanism that disperses the contaminant into the surrounding environment)

- A location where human contact (a human receptor) with the contaminant is possible
- A route of entry that would enable the contaminant to enter the human receptor's body

If any of these four elements are not present, or could not conceivably be present in the future, the exposure pathway is not considered realistic, and no evaluation of exposure from this pathway is performed. Because of the inaccessibility of the contaminated material at the site and the lack of a drinking water well within 1.6 km (1 mi) of the site, the only complete exposure pathways would be from direct gamma radiation and from radon and thoron (and their associated decay products). These pathways would be the only contributors to the potential dose to the maximally exposed individual. All doses presented in this section are estimated and do not represent actual doses. A summary is provided in Table 4-1.

4.1 HYPOTHETICAL MAXIMALLY EXPOSED INDIVIDUAL

4.1.1 Direct Gamma Radiation Pathway

Monitoring data show the highest external gamma radiation levels to be in the northeastern area of the site. The adjacent property is occupied by an industrial facility that is used 40 hours per week and located about 45 m (150 ft) from the site boundary. The maximum exposure rates (in mrem/yr) that employees at the adjacent facility could receive were calculated using conservative assumptions that would tend to overestimate the true exposure rate and the resultant dose. The maximally exposed individual is assumed to work at the facility 40 hours per week.

The calculated yearly dose to this individual was determined by using the average of the annual average exposure rates measured by the TETLDs along this fenceline (locations 23 and 24). Using this average [451 mR/yr (4.51 mSv/yr) above background; see Table 3-5], the hypothetical dose received by the maximally exposed individual from exposure to direct gamma radiation was calculated to be 0.6 mrem/yr (6×10^{-3} mSv/yr), well below the DOE guideline of 100 mrem/yr. This dose was determined using the equation for this pathway given in Appendix F.

4.1.2 Drinking Water Pathway

Only one water pathway, either groundwater or surface water, is used to determine the committed dose to the 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. Concentrations of total uranium, radium-226, radium-228, and thorium-232 in groundwater and in Westerly and Lodi brooks are compared with DOE standards (DCGs). These standards reflect the concentration of a radionuclide in water that if ingested for one year would result in an effective dose equivalent of 100 mrem (1 mSv). All of the radionuclides were well below these standards and comparable with normal background levels. Also, there are no drinking water wells within 1.6 km (1 mi) of the site; therefore, the dose contribution of these radionuclides would be negligible and was not calculated.

4.1.3 Air Pathway (Ingestion, Air Immersion, Inhalation)

To calculate a conservative dose to the maximally exposed individual, the individual was assumed to work within 45 m (150 ft) of the site. Air doses determined using EPA's Clean Air Act Assessment Package-1988 (CAP88) PC computer model were found to be negligible.

4.1.4 Total Dose

The hypothetical total dose for the maximally exposed individual is the sum of the 50-yr committed effective dose equivalent and the external effective dose equivalent, based on the total from all pathways; however, the data demonstrate that the total dose would not be significantly different from natural background.

4.2 GENERAL POPULATION

The collective dose to the general population living within 80 km (50 mi) of the site was considered as described in the following subsections.

4.2.1 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. Because of this additional shielding and the low dose calculated for the maximally exposed individual, it is reasonable to postulate that there is no detectable gamma radiation exposure to the general public above variations in the normal background levels.

4.2.2 Drinking Water Pathway

There are no nearby drinking water wells, radionuclide concentrations in groundwater and surface water are essentially the same as background, and the maximally exposed individual would receive no significant dose commitment from radionuclides in drinking water. Therefore, it is reasonable to conclude that the general public would not receive a committed dose in drinking water.

4.2.3 Air Pathway

The CAP88-PC model provides a hypothetical effective dose equivalent for contaminants transported through the atmospheric pathway at different distances from the site. Based on 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 negligible compared with the dose from natural background.

4.2.4 Total Population Dose

The total population dose is the sum of the doses from all exposure pathways; however, the collective population dose is negligible when compared with the collective population dose from natural background gamma radiation in the area [7.4 × 10^{-5} person-rem/yr (7.4 × 10^{-3} person-Sv/yr)] for the same population within 80 km (50 mi) of MISS.

TABLE FOR SECTION 4.0

Table 4-1

Summary of Calculated Doses[a] for MISS

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]	0.6	--[d]
Drinking water	--[e]	--[e]
Inhalation	2.7×10^{-2}	4.5
Total[f]	--[d]	--[d]
Background[g]	74	7.4×10^{5} [h]

[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 natural background.

[d] Exposures from this pathway are negligible.

[e] No realistic pathway.

[f] The DOE guideline for total exposure to an individual is 100 mrem/yr above background (DOE 1990).

[g] Direct gamma radiation exposure only.

[h] Calculated by the following: (74 mrem/yr) (10×10^{6} people).

5.0 QUALITY ASSURANCE

5.1 INTRODUCTION

This section summarizes the QA assessment of environmental activities, which were conducted to ensure that onsite contamination does not pose a threat to human health or the environment. Using this criterion, the overall project data quality objective (DQO) for the environmental surveillance program is to provide data of sufficient quality to allow reliable detection and quantitation of potential releases of contaminated material from the site. DQO requirements are assessed annually during review of the environmental monitoring plan (BNI 1991) and are updated based on historical information, trends identified, and changes in the environmental regulations.

5.2 PROCEDURES

The *Quality Assurance Program Plan for the U.S. DOE FUSRAP* (BNI 1992b) addresses the quality requirements for work performed under FUSRAP. This plan requires all subcontractors to implement a compatible plan for QA or use the DOE plan. This is done to ensure compatibility with all requirements to maintain protection of human health and the environment.

QA procedures are detailed in project procedures and project instructions and are implemented for all field activities. Sampling techniques are derived from several documents, including *A Compendium of Superfund Field Operations Methods* (EPA 1987) and the EPA Region II QA manual. Laboratory QA procedures are derived from applicable EPA methods to ensure compatibility of the results. Also, activities such as data reviews, calculation checks, and data evaluations have been incorporated in procedures to monitor results and prevent or identify quality problems.

5.3 QUALITY ASSURANCE SUMMARY

QA/QC activities are an integral part of all environmental monitoring activities at the site. The specific methods, definitions, and formulas used to evaluate the QA/QC program are described the *Quality Assurance Document for Site Environmental Reports* (BNI 1993a). This document also discusses in detail the precision, accuracy, representativeness, comparability, and completeness (PARCC) parameters. For informational purposes, brief definitions or explanations will be given throughout this section for terms and processes used during the QA/QC evaluation.

The QA/QC program satisfies the requirements of DOE Orders 5400.1, 5400.5, and 5700.6C (DOE 1988, 1990, 1991). The programmatic controls in place for the environmental surveillance program are discussed in project instruction guides.

5.3.1 Data Usability

To determine data usability, a verification process is used that evaluates items such as holding times, method blanks, spike recoveries, and duplicate results. This information is then used to verify whether the data are of sufficient quality to serve as the basis for making decisions about the site. During this process, two qualifiers are associated with the data if there is any question concerning their usability: "J"—the data result is estimated and should be used with discretion, and "R"—the data result is rejected and should not be used.

The data are then evaluated using the PARCC parameters to determine whether enough information is present to make decisions concerning the site. Any major problems encountered are documented as nonconformances and are tracked to ensure correction.

The results of the PARCC evaluation are presented as a percentage that met requirements. The formula used is:

$$\frac{\text{number of results that met EPA requirements}}{\text{total number of results}} \times 100 = \text{percent acceptable}$$

For Tables 5-1 to 5-5, a generic 80 percent has been used as an acceptable level. Representativeness and comparability cannot have a percentage applied; see Subsections 5.3.4 and 5.3.5 for definitions and discussions about the use of these two parameters.

5.3.2 Precision

Precision is defined as a measurement of the agreement of a set of replicate results among themselves without assumption of any prior information about the true result. Precision is assessed through the use of duplicate results or matrix spike (MS) and matrix spike duplicate (MSD) results. MSs and MSDs are usually used with organic analytes; inorganic analytes are generally run as a true duplicate and a single MS. Field duplicates are also used to assess field precision; results are presented separately from the laboratory duplicate results. Table 5-1 lists the results for laboratory precision. All results met the requirements for acceptability except for TPH and TOX results. Three sets were analyzed, and the first duplicate set failed to meet requirements for both parameters. This failure was assessed during verification for impact on the associated samples.

Table 5-2 provides the results for the field duplicates. All parameters met the precision requirements. Precision for semivolatile and volatile organic compounds and pesticides was not calculated because none were detected in the field duplicates.

Table 5-3 gives the results for the laboratory radiochemical duplicates. Results for thorium-232 failed the generic 80 percent level. EPA does not provide a limit for precision for radionuclides as for chemicals. Because 60 percent of the precision results were acceptable, there should be no major impact on the data. During the verification process, the associated samples were assessed against the poor precision results.

Radiochemical duplicate acceptance criteria have been derived from the *Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* (EPA 1988). The acceptable relative percent difference (RPD) derived from these guidelines is 20 percent for radiochemical precision.

5.3.3 Accuracy

Accuracy is defined as the nearness of a result or the mean of a set of results to the true, known, or reference value. The assessment of accuracy may be determined through standard reference materials, MSs, laboratory control samples, and surrogate spikes.

Table 5-4 gives the results for the chemical spikes. All categories were above the 80 percent level. The radiological spike recovery results listed in Table 5-5 were all within the 75 to 125 percent recovery window.

Radiological spike acceptance criteria have been derived from the *Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* (EPA 1988). The acceptable recovery range derived from these guidelines is 75 to 125 percent recovery for spiked analytes.

5.3.4 Representativeness

Field sampling and laboratory analytical representativeness express the degree to which the data accurately and precisely represent the matrix from which the samples were obtained. Representativeness generally expresses the extent to which the data generated define an environmental condition.

To ensure field sampling representativeness, several controls were used during sampling, including the use of dedicated sampling equipment and trip blanks for volatiles.

The dedicated equipment ensures that there is no cross-contamination between sampling locations. The trip blank for volatiles monitors for contamination from sampling to analysis.

To ensure representativeness in the laboratory, constraints are placed upon analytical methodology. Method blanks are prepared for each parameter analyzed, both organic and inorganic, with an associated frequency of 1 per batch of no more than 20 samples. A method or preparation blank is used to determine whether contaminants are present in the laboratory that could have an impact on the samples associated with that method blank. The presence of contaminants can indicate the possibility for false positive results.

The potential for false negative results can also be reduced through the use of sample preservatives and holding times. All samples were preserved at the time of sampling by adding required chemicals and/or using refrigeration. The use of preservatives limits biological and chemical degradation that would bias sample results.

Tables 5-6 and 5-7 list the contaminants and their concentrations in laboratory blanks and trip blanks. The laboratory contamination was from common laboratory contaminants (acetone, methylene chloride, and di-n-butylphthalate) and metals (boron, calcium, iron, lead, zinc, and uranium). EPA has recognized that certain analytes may be present in the laboratory, and some contamination can be expected. The rules governing these contaminants allow up to 5 times the quantitation limit of these analytes. Results for the common contaminants were below the limits. Contamination by metals was evaluated during verification and found to be insignificant. EPA does not recognize metals as common contaminants.

5.3.5 Comparability

Comparability expresses the confidence with which data are compared with each other, taking into account the use of equivalent instrumentation and methodology. The laboratories follow approved procedures that are consistent with industry-accepted practices, and comparability is maintained.

5.3.6 Completeness

Completeness measures the amount of usable data resulting from the data collection activities compared with the total data possible. For environmental monitoring, all samples were taken as required in the instruction guide. (Subsection 5.3.1 discussed data rejected during the verification process; Table 5-8 summarizes the acceptability rate for all analytes.) All analytes met the completeness goal except the phenolic compounds in the semivolatiles list. The rejections for these compounds appear to result from a combination of poor MS and surrogate recoveries. The overall accuracy result for the semivolatiles produced a 95 percent acceptability rate. The 5 percent failure resulted from incompleteness of results for the phenolic compounds; this impact is shown in Table 5-8.

5.3.7 Interlaboratory Programs

The radiochemistry laboratory participates in the Environmental Measurements Laboratory's Quality Assessment Program, EPA's Cross-Check Program, and the Nuclear Fuel Services' Interlab Quality Control Comparison. The chemical laboratory participates in EPA's water supply and water pollution programs and analyzes quarterly single-blind samples submitted by FUSRAP. Results for these programs are submitted to FUSRAP. Repeated failure of an analyte for consecutive periods results in the suspension of that analyte until corrective actions have been taken. Table 5-9 provides the radiochemistry laboratory results from the DOE Quality Assessment Program. Table 5-10 gives the results from the EPA Intercomparison Program.

TABLES FOR SECTION 5.0

Table 5-1

Results for Laboratory Duplicates

Parameters	Percent Acceptable	Meets Established DQOs
Metals	82	Yes
TOX	66	No
TOC	100	Yes
TPH	66	No
Volatiles	100	Yes
Semivolatiles	94	Yes
Pesticides/ polychlorinated biphenyls	100	Yes

Table 5-2

Results for Field Duplicates[a]

Parameters	Percent Acceptable	Meets Established DQOs
Metals	95	Yes
Semivolatiles	NC[b]	NC
Volatiles	NC	NC
Pesticides	NC	NC
TOC	100	Yes
TOX	100	Yes
TPH	100	Yes
Radium-226	100	Yes
Radium-228	100	Yes
Thorium-232	100	Yes
Total uranium	100	Yes

[a] Acceptability based on a 20 percent RPD for radiological analytes.

[b] NC = not calculated because all duplicate concentrations were nondetectable.

Table 5-3

Results for Laboratory Radiochemical Duplicates[a]

Parameters	Percent Acceptable	Meets Established DQOs
Radium-226	80	Yes
Radium-228	100	Yes
Thorium-232	60	No
Total uranium	100	Yes

[a] Acceptability based on a 20 percent RPD.

Table 5-4

Results for Spike Recoveries

Parameters	Percent Acceptable	Meets Established DQOs
Metals	85	Yes
TOX	100	Yes
TOC	100	Yes
TPH	83	Yes
Volatiles	100	Yes
Semivolatiles	95	Yes
Pesticides/ polychlorinated biphenyls	80	Yes

Table 5-5

Results for Radiological Spike Recoveries[a]

Parameters	Percent Acceptable	Meets Established DQOs
Radium-226	100	Yes
Radium-228	100	Yes
Thorium-232	100	Yes
Total uranium	100	Yes

[a] Acceptability based on a 75 to 125 percent recovery window.

Table 5-6

Results for Laboratory Blanks

Analyte	Concentration
Acetone	8 μg/L
Di-n-butylphthalate	8 μg/L
Methylene chloride	4 μg/L
Boron	13 μg/L
Calcium	67 μg/L
Iron	26 μg/L
Lead	2.8 μg/L
Zinc	8.1 μg/L

Table 5-7

Results for Trip Blanks

Analyte	Concentration
Methylene chloride	7 μg/L

Table 5-8

Usability Rates for Each Analyte

Page 1 of 5

Parameters	Percent Acceptable	Meets Established DQOs
Metals		
Aluminum	100	Yes
Antimony	100	Yes
Arsenic	100	Yes
Barium	100	Yes
Beryllium	100	Yes
Boron	100	Yes
Cadmium	100	Yes
Calcium	100	Yes
Chromium	100	Yes
Cobalt	100	Yes
Copper	100	Yes
Iron	100	Yes
Molybdenum	100	Yes
Lithium	100	Yes
Lead	100	Yes
Magnesium	100	Yes
Manganese	100	Yes
Nickel	100	Yes
Potassium	100	Yes
Selenium	100	Yes
Silver	100	Yes
Sodium	100	Yes
Thallium	100	Yes
Vanadium	100	Yes
Zinc	100	Yes
TOX	100	Yes
TOC	100	Yes
TPH	100	Yes
Volatiles		
Chloromethane	100	Yes
Bromomethane	100	Yes
Vinyl chloride	100	Yes
Chloroethane	100	Yes
Methylene chloride	100	Yes
Acetone	100	Yes

Table 5-8

(continued)

Page 2 of 5

Parameters	Percent Acceptable	Meets Established DQOs
Carbon disulfide	100	Yes
1,1-Dichloroethene	100	Yes
1,1-Dichloroethane	100	Yes
1,2-Dichloroethene (total)	100	Yes
Chloroform	100	Yes
1,2-Dichloroethane	100	Yes
2-Butanone	100	Yes
1,1,1-Trichloroethane	100	Yes
Carbon tetrachloride	100	Yes
Bromodichloromethane	100	Yes
1,2-Dichloropropane	100	Yes
cis-1,3-Dichloropropene	100	Yes
Trichloroethene	100	Yes
Dibromochloromethane	100	Yes
1,1,2-Trichloroethane	100	Yes
Benzene	100	Yes
trans-1,3-Dichloropropene	100	Yes
Bromoform	100	Yes
4-Methyl-2-pentanone	100	Yes
2-Hexanone	100	Yes
Tetrachloroethene	100	Yes
Toluene	100	Yes
1,1,2,2-Tetrachloroethane	100	Yes
Chlorobenzene	100	Yes
Ethyl benzene	100	Yes
Styrene	100	Yes
Xylenes (Total)	100	Yes
2-Chloroethylvinylether	100	Yes
Acrolein	100	Yes
Acrylonitrile	100	Yes
Vinyl acetate	100	Yes
Semivolatiles		
Phenol	62	No
bis(2-Chloroethyl)ether	88	Yes
2-Chlorophenol	62	No
1,3-Dichlorobenzene	88	Yes
1,4-Dichlorobenzene	88	Yes

Table 5-8

(continued)

Parameters	Percent Acceptable	Meets Established DQOs
1,2-Dichlorobenzene	88	Yes
2-Methylphenol	62	No
bis(2-Chloroisopropyl)ether	88	Yes
4-Methylphenol	62	No
N-Nitroso-di-n-propylamine	88	Yes
Hexachloroethane	88	Yes
Nitrobenzene	88	Yes
Isophorone	88	Yes
2-Nitrophenol	62	No
2,4-Dimethylphenol	62	No
bis(2-Chloroethoxy)methane	88	Yes
2,4-Dichlorophenol	62	No
1,2,4-Trichlorobenzene	88	Yes
Naphthalene	88	Yes
4-Chloroaniline	88	Yes
Hexachlorobutadiene	88	Yes
4-Chloro-3-methylphenol	62	No
2-Methylnaphthalene	88	Yes
Hexachlorocyclopentadiene	88	Yes
2,4,6-Trichlorophenol	62	No
2,4,5-Trichlorophenol	62	No
2-Chloronaphthalene	88	Yes
2-Nitroaniline	88	Yes
Dimethylphthalate	88	Yes
Acenaphthylene	88	Yes
2,6-Dinitrotoluene	88	Yes
3-Nitroaniline	88	Yes
Acenaphthene	88	Yes
2,4-Dinitrophenol	62	No
4-Nitrophenol	62	No
Dibenzofuran	88	Yes
2,4-Dinitrotoluene	88	Yes
Diethylphthalate	88	Yes
4-Chlorophenyl-phenyl ether	88	Yes
Fluorene	88	Yes
4-Nitroaniline	88	Yes
4,6-Dinitro-2-methylphenol	62	No
N-nitrosodiphenylamine	88	Yes
4-Bromophenyl-phenyl ether	88	Yes

Table 5-8

(continued)

Page 4 of 5

Parameters	Percent Acceptable	Meets Established DQOs
Hexachlorobenzene	88	Yes
Pentachlorophenol	62	No
Phenanthrene	88	Yes
Anthracene	88	Yes
Butylbenzylphthalate	88	Yes
3,3'-Dichlorobenzidine	88	Yes
Benzo(a)anthracene	88	Yes
Di-n-butylphthalate	88	Yes
Fluoranthene	88	Yes
Pyrene	88	Yes
Chrysene	88	Yes
bis(2-Ethylhexyl)phthalate	88	Yes
Di-n-octylphthalate	88	Yes
Benzo(b)fluoranthene	88	Yes
Benzo(k)fluoranthene	88	Yes
Benzo(a)pyrene	88	Yes
Indeno(1,2,3-cd)pyrene	88	Yes
Dibenz(a,h)anthracene	88	Yes
Benzo(g,h,i)perylene	88	Yes
1,2-Diphenylhydrazine	88	Yes
Benzidine	88	Yes
Benzoic acid	88	Yes
Benzyl alcohol	88	Yes
N-nitrosodimethylamine	88	Yes
Pesticides/Polychlorinated Biphenyls		
Alpha-BHC	100	Yes
Beta-BHC	100	Yes
Delta-BHC	100	Yes
Gamma-BHC (Lindane)	100	Yes
Heptachlor	100	Yes
Aldrin	100	Yes
Heptachlor epoxide	100	Yes
Endosulfan I	100	Yes
Dieldrin	100	Yes
4,4'-DDE	100	Yes
Endrin	100	Yes
Endosulfan II	100	Yes

Table 5-8

(continued)

Page 5 of 5

Parameters	Percent Acceptable	Meets Established DQOs
4,4'-DDD	100	Yes
Endosulfan sulfate	100	Yes
4,4'-DDT	100	Yes
Methoxychlor	100	Yes
Endrin ketone	100	Yes
Endrin aldehyde	100	Yes
Alpha chlordane	100	Yes
Gamma chlordane	100	Yes
Toxaphene	100	Yes
Aroclor 1016	100	Yes
Aroclor 1221	100	Yes
Aroclor 1232	100	Yes
Aroclor 1242	100	Yes
Aroclor 1248	100	Yes
Aroclor 1254	100	Yes
Aroclor 1260	100	Yes
Radiological		
Radium-226	100	Yes
Radium-228	100	Yes
Thorium-232	100	Yes
Total uranium	100	Yes

Table 5-9

Radiochemistry Laboratory Performance on DOE Quality Assessment Program Samples, 1992

Sample Media	Radionuclides	Number of Results Reported	Number Within Control Limits
Air filters	Uranium (mass)	1	1
Soil	Potassium-40 Strontium-90 Cesium-137 Uranium (mass)	4	3
Vegetation	Potassium-40 Strontium-90 Cesium-137	3	3
Water	Tritium Manganese-54 Cobalt-60 Cesium-134 Cesium-137 Cerium-144 Plutonium-238 Plutonium-239 Americium-241 Uranium (mass)	10	9

Table 5-10

Radiochemistry Laboratory Performance on EPA Intercomparison Program Samples, 1992

Sample Media	Radionuclides	Number of Results Reported	Number Within Control Limits
Water	Alpha Beta Zinc-65 Cobalt-60 Ruthenium-106 Cesium-134 Cesium-137 Barium-133	26	24
Water	Radium-226 Radium-228 Plutonium-239 Uranium (natural)	16	16
Water	Strontium-89 Strontium-90	7	6
Water	Tritium	2	2
Air filters	Alpha Beta Strontium-90 Cesium-137	7	5

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APPENDIX A Hydrogeologic Details

HYDROGEOLOGIC DETAILS

Regional

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 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 through the Passaic, Saddle, 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 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 Supergroup and by interbedded Triassic basalt. The Newark Supergroup is composed of fluvially deposited conglomerate, sandstone, siltstone, and mudstone that were derived from erosion of metamorphic and igneous rocks of the New Jersey Highlands, located west of the basin. The Newark Supergroup is composed of ten mappable units. The lowermost formations, Stockton and Lockatong, are Triassic. The remainder of the section is referred to by Lyttle and Epstein (1987) as the Brunswick Group. The lowermost unit of the Brunswick Group, the Passaic Formation, underlies the site and is Late Triassic to Early Jurassic in age. The formation consists primarily of interbedded reddish-brown, fine-grained sandstone, siltstone, mudstone, and shale.

The Passaic 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

The sediments underlying MISS are divided into two stratigraphic units: a bedrock unit composed of interbedded, well-cemented sandstone and siltstone of the Passaic Formation, and an overlying section of unconsolidated clastic sediments of Pleistocene glacial deposits. These units are separated by an erosional unconformity. The surface of the bedrock unit was extensively eroded and weathered by glacial and fluvial processes. The sedimentary section was originally capped by a well-developed deciduous forest soil. Extensive agricultural and later urban development disturbed or destroyed much of the original soil profile. Most of the soil cover in the local area is now classified as urban fill.

Bedrock in the local area consists of alternating beds of dark reddish-brown sandstone and siltstone of the Passaic Formation. The uppermost unit in the site area is a grey to red silica and calcite-cemented quartz sandstone, moderately to highly weathered, having joints and bedding planes oriented horizontally. This sandstone unit is widely distributed throughout the local area. Underlying this unit is a finer-grained siltstone unit, also grey to red, but exhibiting more extensive fracturing, jointing, and weathering. Joints in this fine-grained unit are generally horizontal with minor to complete filling with calcite cement.

The bedrock surface in the local area has been extensively weathered. Depth to bedrock varies from 15 cm (6 in.) in the Stepan parking lot northeast of MISS to approximately 9 m (30 ft) near the western boundary of MISS along State Highway 17. A prominent high in the bedrock surface extends to the southwest from the high area in the Stepan parking area. This high connects across a saddle to a topographic ridge west of Lodi Brook. This bedrock relief is expressed at the surface and corresponds to a surface water divide. A well-defined low in the bedrock surface, with a northwest-to-southeast orientation, underlies the western edge of MISS. This low area is probably associated with extensive fracturing of the bedrock. Smaller erosional low areas perpendicular to this primary trend are mapped in the central portion of MISS. The configuration of the bedrock surface controlled the type and distribution of the unconsolidated sediments that were deposited in the local area.

Coarse-grained sediments, including boulders and cobbles of igneous and sedimentary rock, have been described in areas associated with the erosional lows in the bedrock surface. These porous and permeable sediments were deposited by small streams that formed in the area of the bedrock lows. The fractured bedrock and coarse-grained sediments in the unconsolidated section are directly associated and probably form preferential flow pathways in the subsurface.

The shallow groundwater flow system at MISS is in the unconsolidated sediments and the shallow Passaic Formation bedrock and occurs under unconfined water table and partially confined conditions. Depth to water is shallow and ranges from approximately 0.6 to 4.6 m (2 to 15 ft) below ground surface. Water level elevations range from 12 to 16.5 m (39 to 54 ft) above MSL. 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 to 20 m (40 to 66 ft) above MSL.

Groundwater Monitoring Program

The hydrogeologic interpretations are based on water level measurements from 31 monitoring wells on and immediately adjacent to MISS. These data were used to determine seasonal fluctuations, groundwater flow directions, and groundwater gradients. The groundwater monitoring wells are 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 wells completed in competent bedrock range from approximately 9.1 to 15.2 m (30 to 50 ft) deep. Well locations are shown in Figure A-1. Water level measurements from the monitoring wells were taken biweekly and used to prepare hydrographs and potentiometric surface maps that illustrate the hydrogeologic conditions at the site.

Results of water level measurements over the past several years have shown that seasonal fluctuations typically vary by 0.46 to 1.8 m (1.5 to 6 ft) during a year. Figures A-2 through A-6 are hydrographs showing groundwater levels measured in the unconsolidated sediments and the bedrock from 1989 through 1992. The hydrographs reflect typical seasonal fluctuations. Water levels fluctuate in response to short- and long-term seasonal changes in precipitation and evapotranspiration. Water levels are generally lowest from May through September, rise during late November and December, and peak in February and March.

Water level elevation maps for March 30, 1992, and July 7, 1992, presented in Figures A-7 through A-10, reflect typical seasonal 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 and southwest toward the Saddle River, where shallow groundwater is discharged. Overall average hydraulic gradients are slightly steeper during high groundwater conditions than during low groundwater conditions; however, localized areas develop sharper and steeper gradients during the low groundwater conditions.

Although water table elevations vary with seasonal and annual variations in natural recharge, the qualitative patterns shown in Figures A-7 through A-10 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 fence at Highway 17, there is an apparent groundwater depression corresponding to an interpreted erosional low in the bedrock surface.

FIGURES FOR APPENDIX A

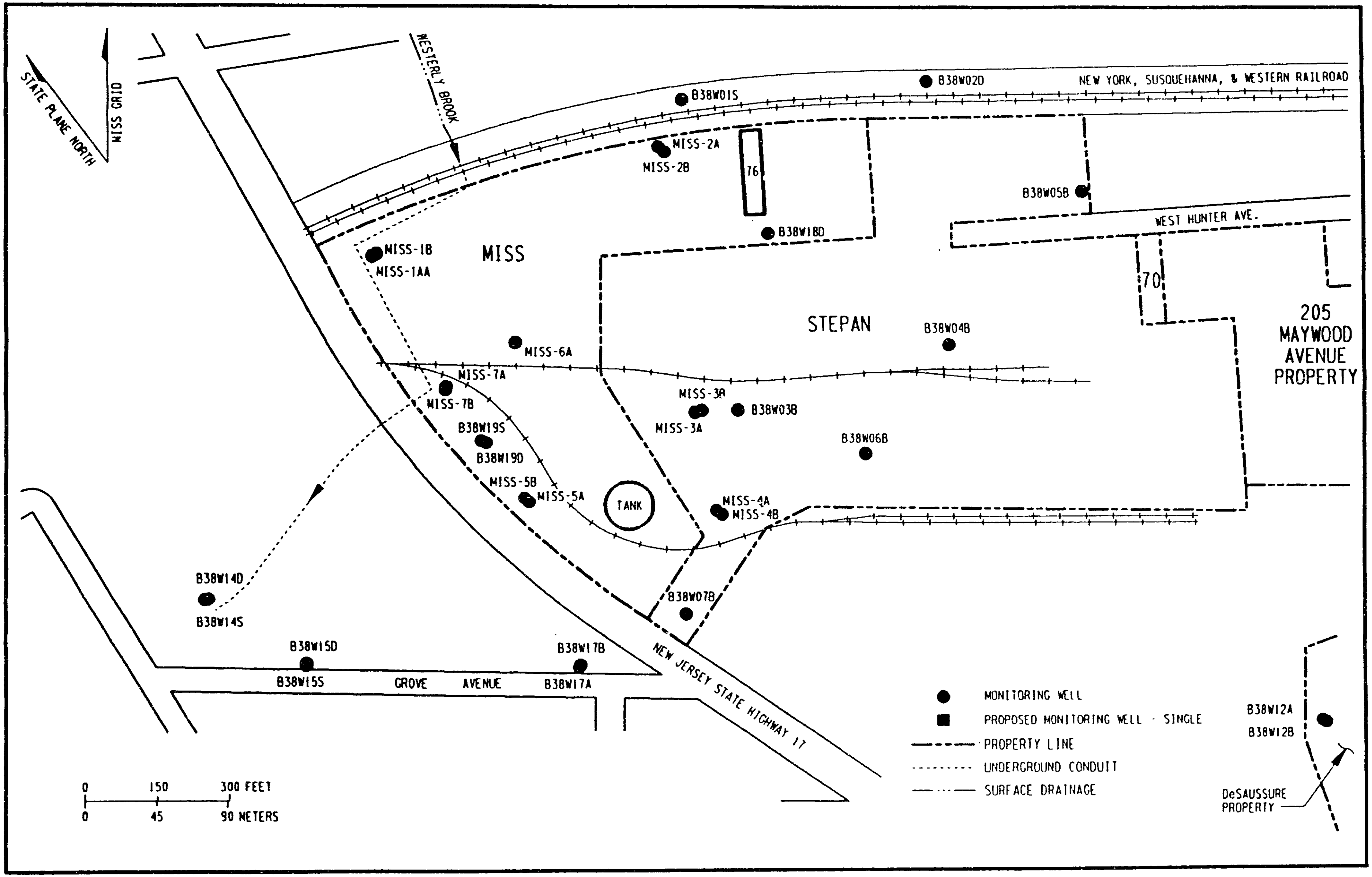

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Figure A-1
Monitoring Well Locations

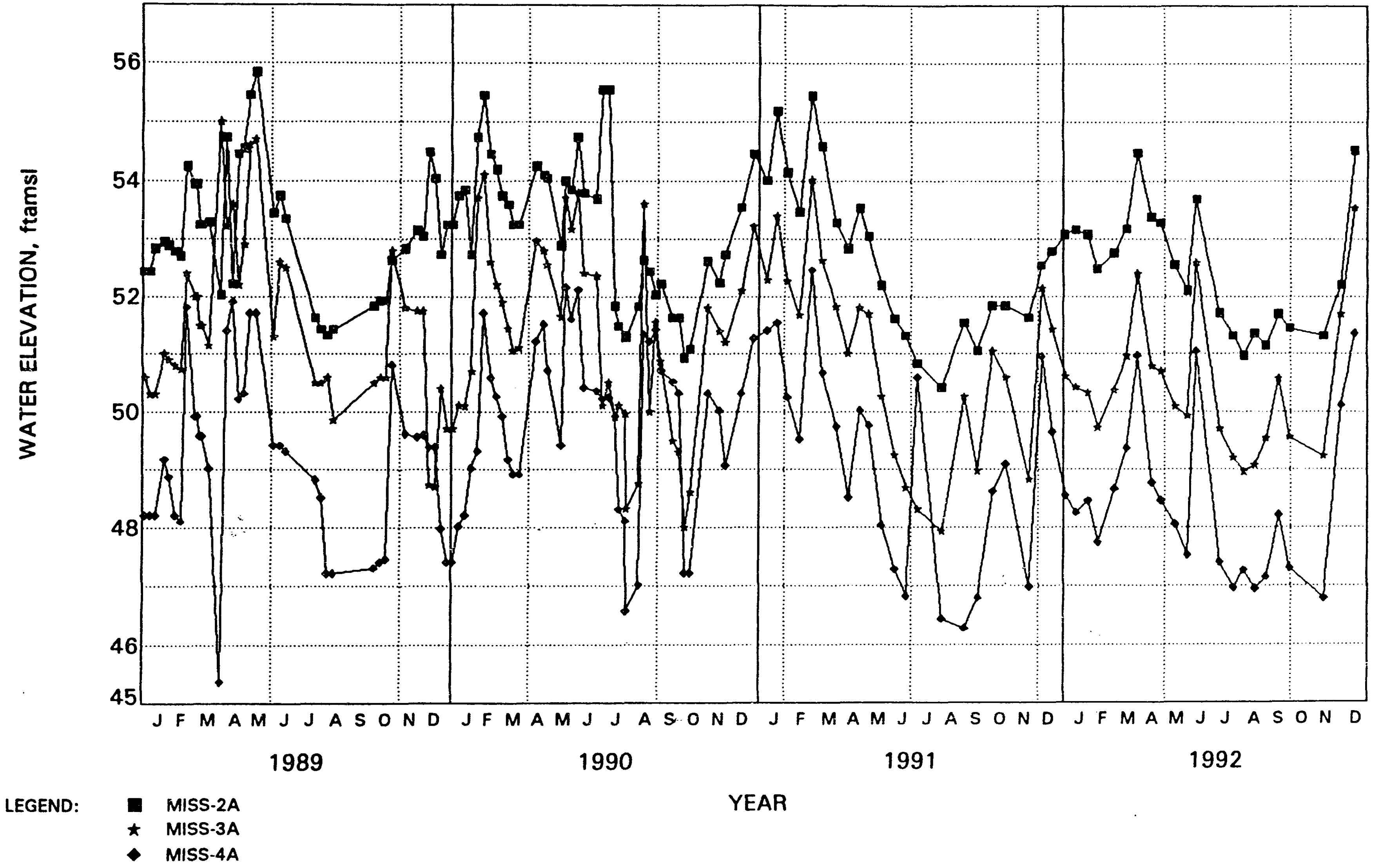


Figure A-2
Hydrographs for Wells MISS-2A, MISS-3A, and MISS-4A

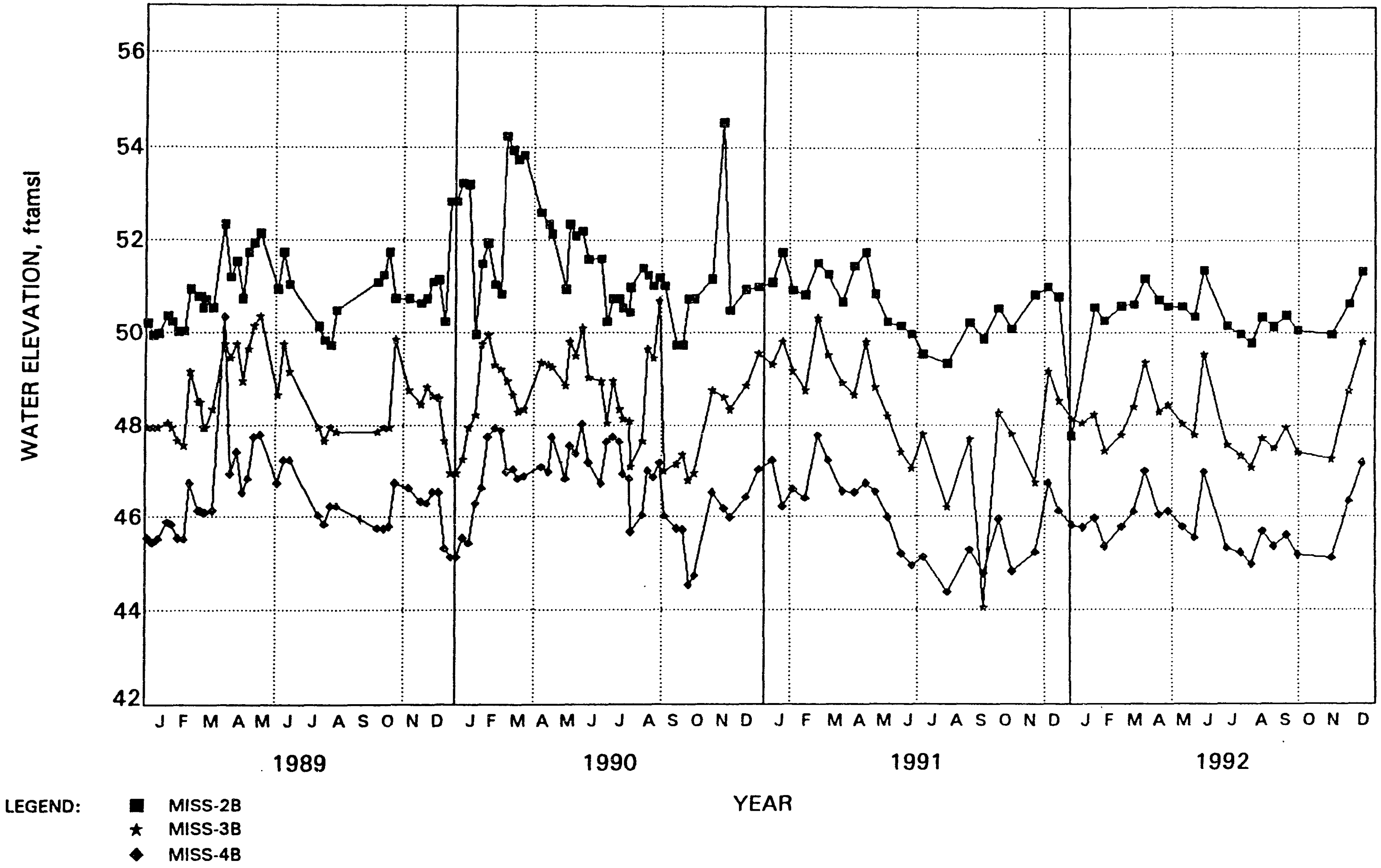


Figure A-3
Hydrographs for Wells MISS-2B, MISS-3B, and MISS-4B

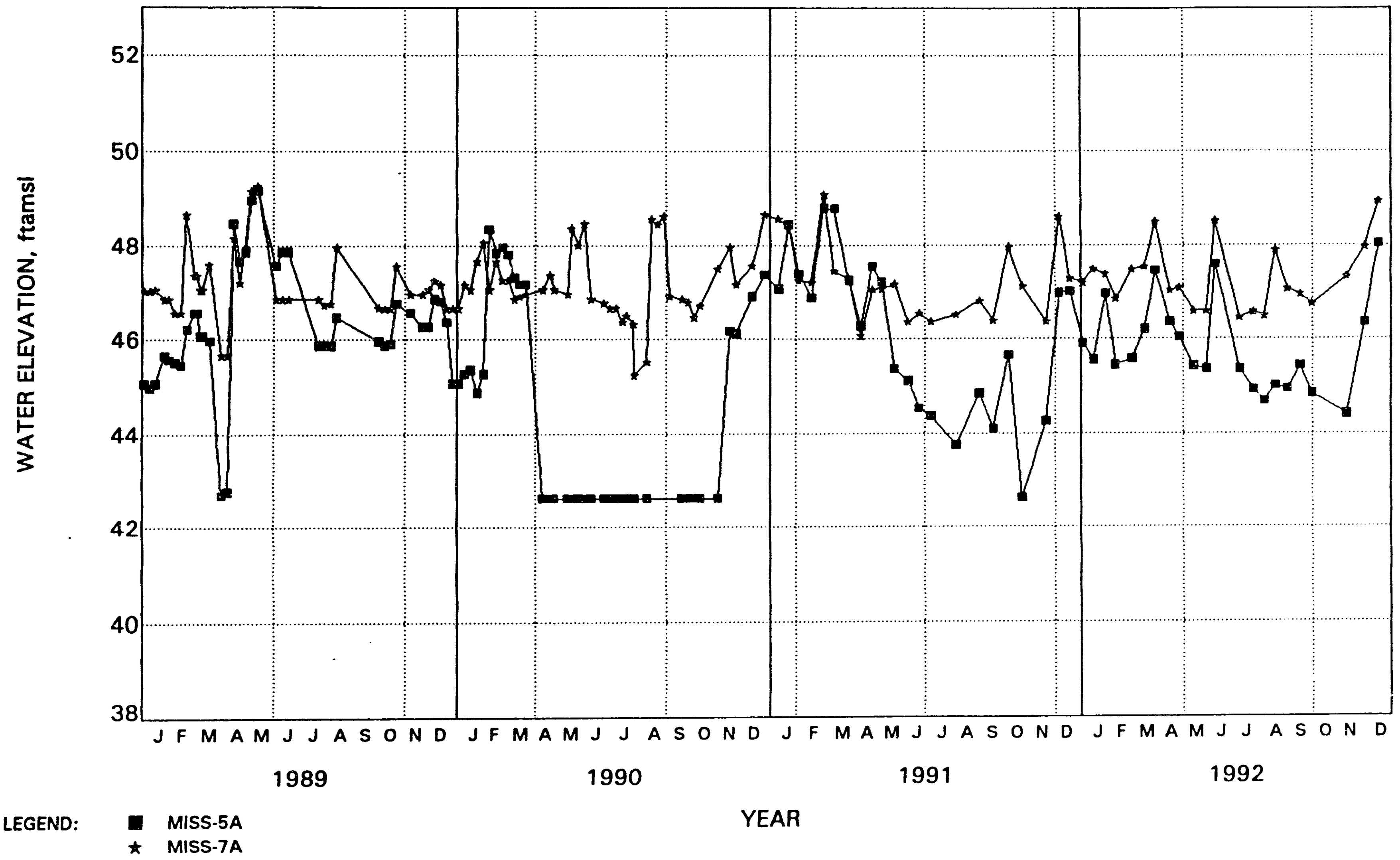


Figure A-4
Hydrographs for Wells MISS-5A aand MISS-7A

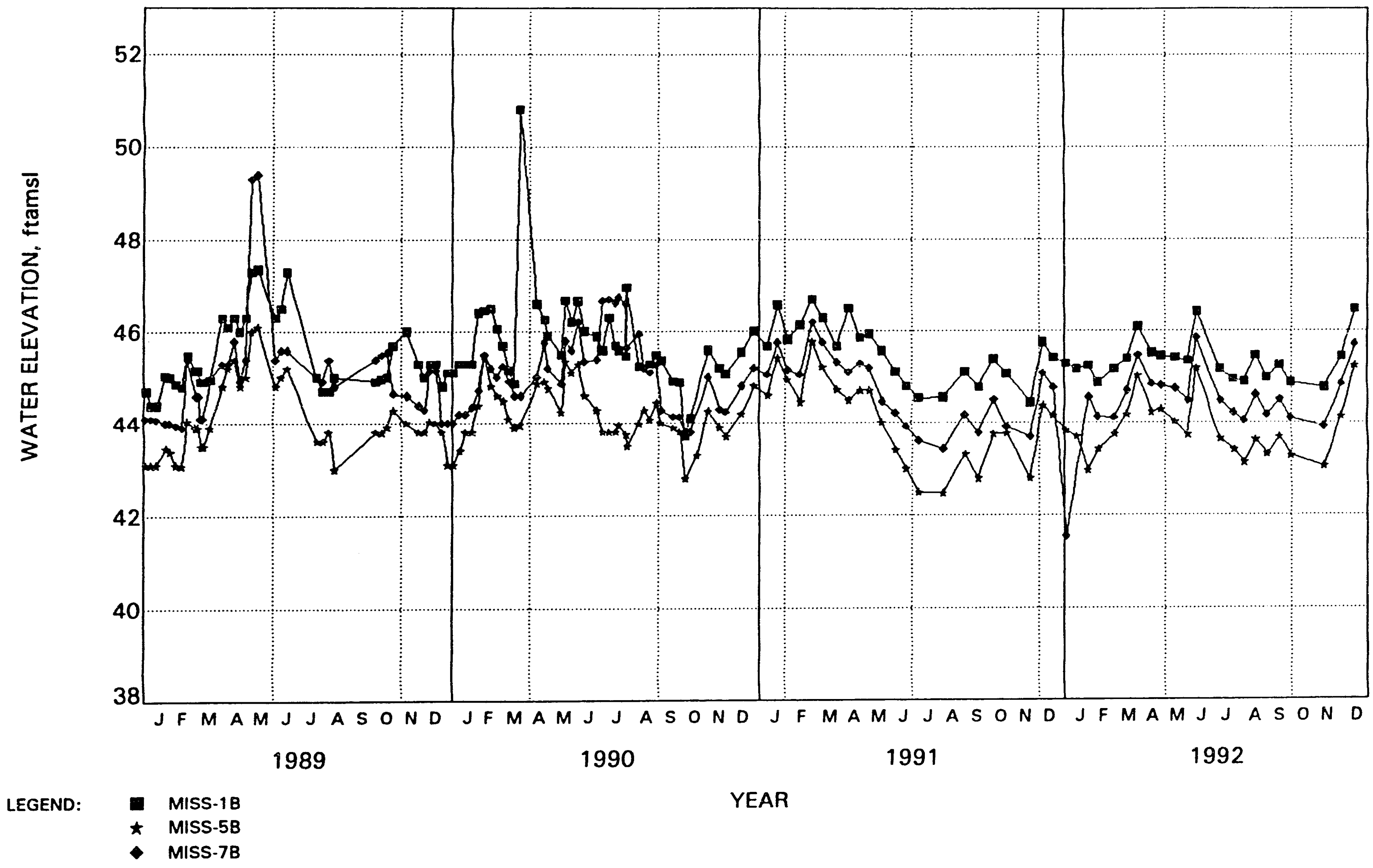


Figure A-5
Hydrographs for Wells MISS-1B, MISS-5B, and MISS-7B

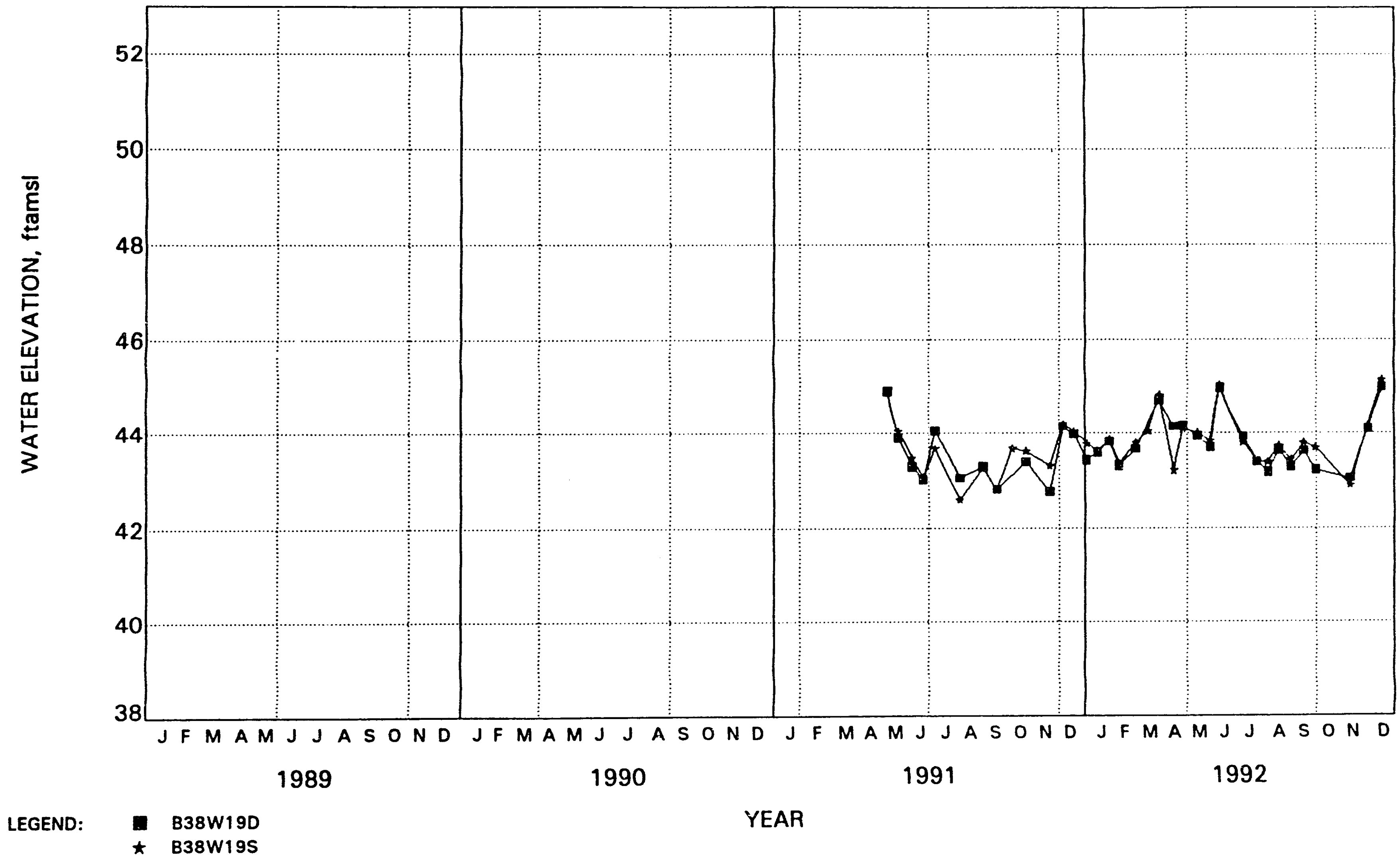
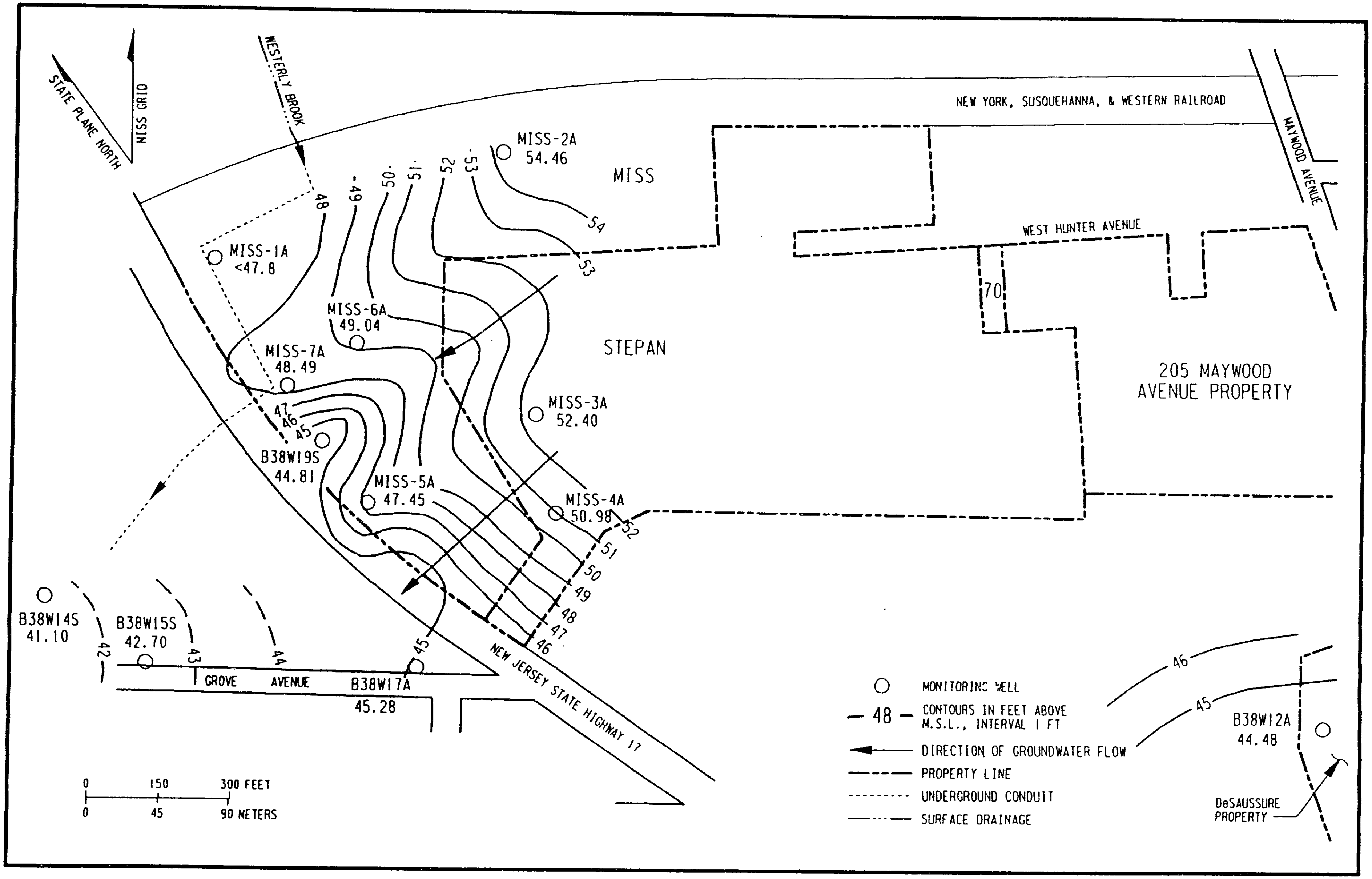
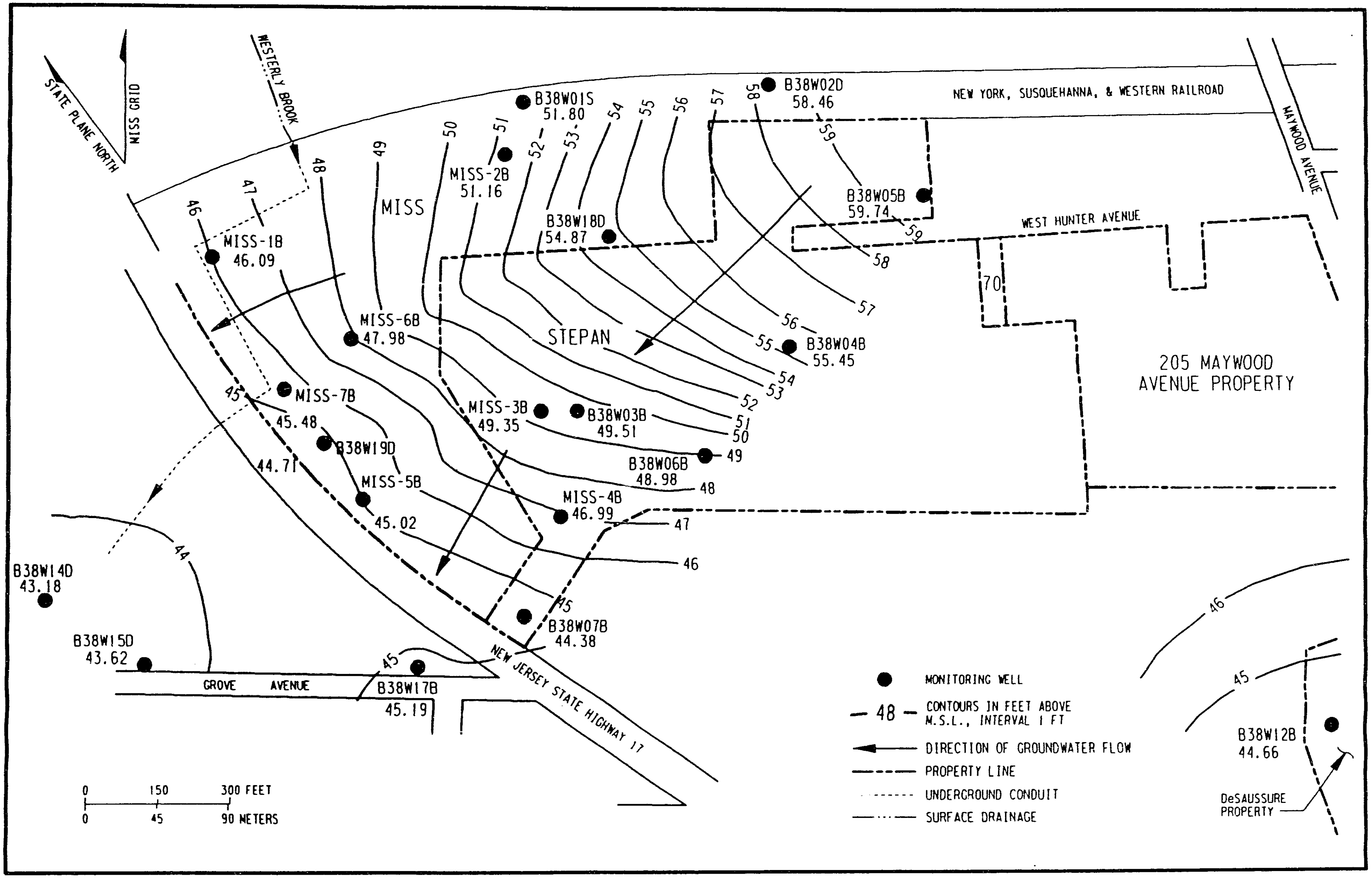


Figure A-6
Hydrographs for Wells B38W19S and B38W19D



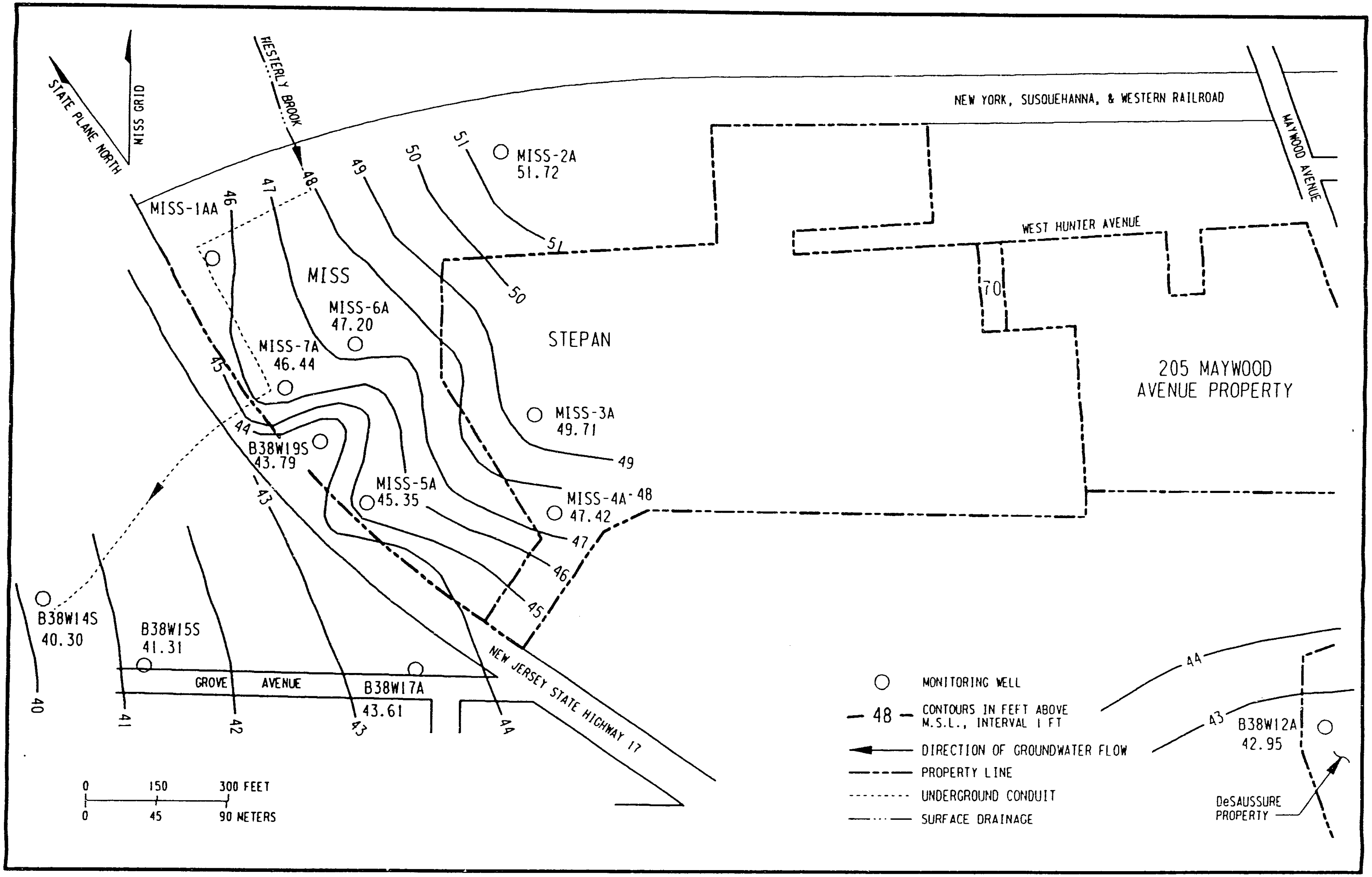
138 R40F001.DGN

Figure A-7
Contour Map Showing Water Level Elevations in Unconsolidated Sediments at MISS, March 30, 1992



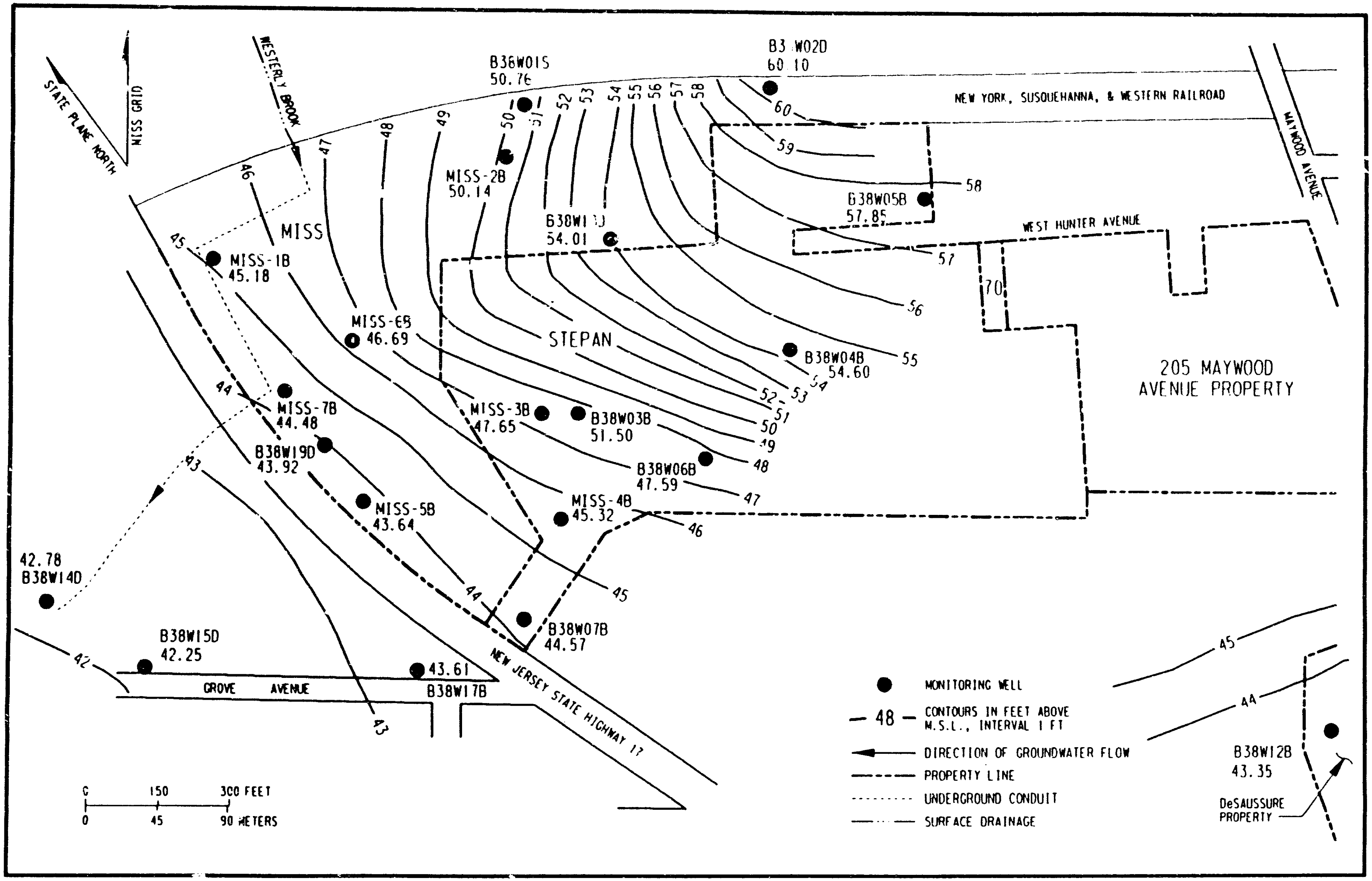
138 R40F003.DGN

Figure A-8
Contour Map Showing Water Level Elevations in Bedrock
at MISS, March 30, 1992



R40F008.DGN

Figure A-9
Contour Map Showing Water Level Elevations in Unconsolidated Sediments at MISS, July 7, 1992



R40F009.DGN

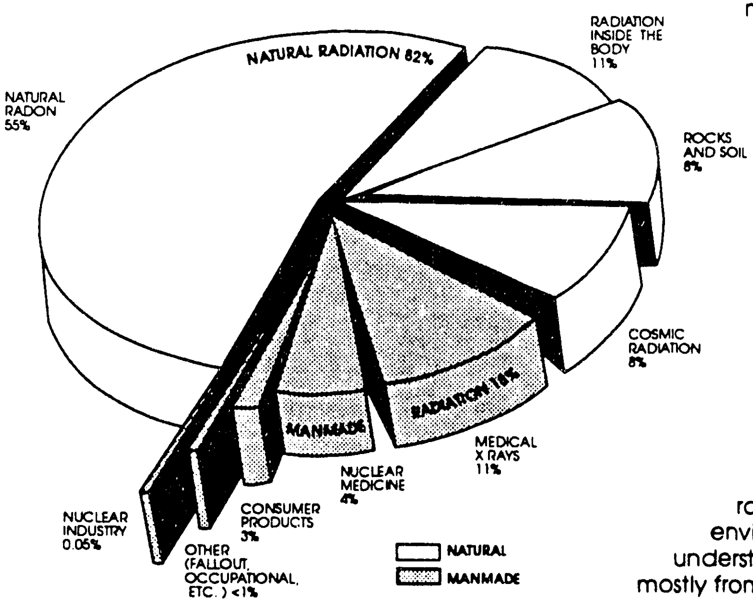
Figure A-10
Contour Map Showing Water Level Elevations in Bedrock
at MISS, July 7, 1992

APPENDIX B 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.

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

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

Cosmic Radiation

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

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

Terrestrial Radiation

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

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

Buildings

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

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

Radon

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

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

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

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Radioactivity in Consumer Products. U.S. Nuclear Regulatory Commission, 1978.

PERSPECTIVE: How Big is a Picocurie?

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

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

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

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

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

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

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

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

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

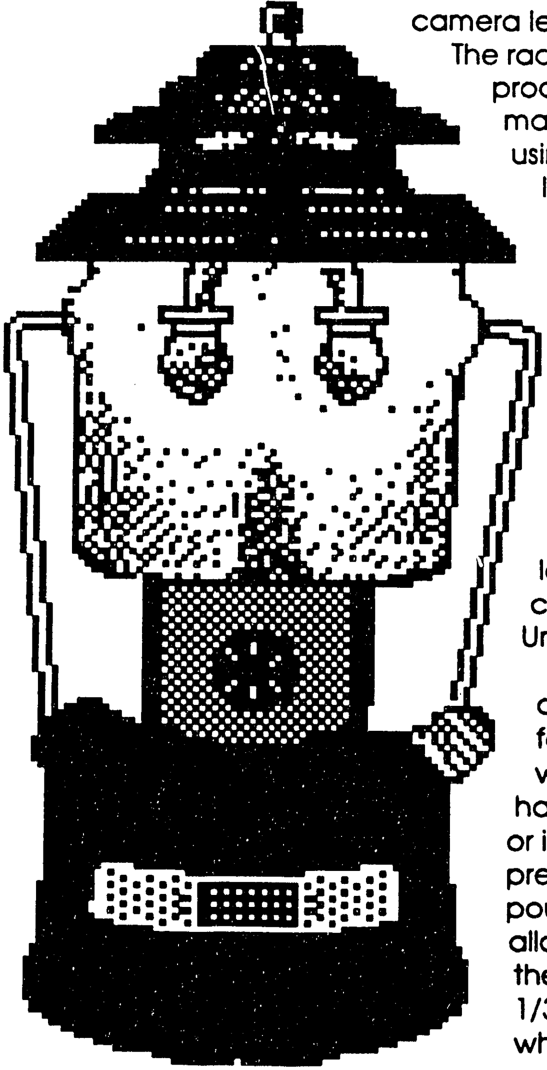
UNIT OF RADIOACTIVITY	SYMBOL	DISINTEGRATIONS PER MINUTE	DOLLAR ANALOGY	EXAMPLES OF RADIOACTIVE MATERIALS
1 Curie	Ci	$2x10^{12}$ or 2 Trillion	2 Times the Annual Federal Budget	Nuclear Medicine Generator
1 Millicurie	mCi	$2x10^{9}$ or 2 Billion	Cost of a New Interstate Highway from Atlanta to San Francisco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

Chart provided by W.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.

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APPENDIX C Parameters for Analysis

Table C-1

Parameters for Analysis at MISS, 1992

Page 1 of 2

Medium	Parameter	Technique
Water	Total uranium	Kinetic phosphorescence analyzer
	Radium-226	Alpha spectrometry
	Radium-228	Beta liquid scintillation
	Thorium-230	Alpha spectrometry
	Thorium-232	Alpha spectrometry
	Total organic halides	Microcoulimetry
	Total organic carbon	Wet ultraviolet-aided persulfate oxidation
	Mobile ions	Colorimetric determination
	Total metals[a]	ICPAES[b]
	arsenic, lead, selenium, thallium	Atomic absorption (AA) spectrophotometry
	Specific conductivity	Electrometric
	pH	Electrometric
	Volatile compounds	Gas chromatography/mass spectrometry
	Semivolatile compounds	Gas chromatography/mass spectrometry
Sediment	Total uranium	Fluorometric
	Radium-226	Gamma spectroscopy
	Radium-228	Beta scintillation
	Isotopic thorium	Alpha spectroscopy
	Metals[a]	ICPAES[b]
	Arsenic	Atomic absorption
	Lead	Atomic absorption

Table C-1

(continued)

Page 2 of 2

Medium	Parameter	Technique
Sediment (cont'd)	Selenium	Atomic absorption
	Thallium	Atomic absorption
	Sulfate	Turbidimetric
	Phosphate	Colorimetric
	Nitrate	Colorimetric
	Chloride	Titrimetric
	Rare earths[c]	ICPAES[b]
Air[d]	Radon-222	Track-etch
	Radon-220	Track-etch
	External gamma radiation	Thermoluminescence

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[a] Includes aluminum, antimony, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lithium, magnesium, manganese, molybdenum, nickel, potassium, silver, sodium, vanadium, zinc, and lanthanides.

[b] Inductively coupled plasma atomic emission spectrophotometry.

[c] Includes cerium, praseodymium, neodymium, tellurium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, lutetium, and lanthanum.

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

Sampling Methods and Detectors for Radon and Thoron

Radon and thoron concentrations are measured using an integrating alpha track-etch detector that contains a piece of alpha-sensitive film enclosed in a small two-piece cup. The radioactive gases diffuse through a membrane of the cup until the concentrations inside the cup are in equilibrium with atmospheric concentrations. Different types of membranes are used to distinguish between radon and thoron; one permits both radon and thoron to diffuse into the cup and one permits only radon to diffuse. Alpha particles from the radioactive decay of radon and thoron and their daughters create tiny tracks when they collide with the film. After they are collected, the films are placed in a caustic etching solution to enlarge the tracks; under strong magnification, the tracks are counted. The number of tracks per unit area is related through calibration to the radon concentration in air. For thoron measurements, both types of detectors are installed at the sampling location. The thoron concentration is then determined by subtracting the concentration measured by the radon detector from the concentration measured by the radon/thoron detector.

Table C-2

Laboratory Detection Limits for Organic Chemical Analyses of Groundwater at MISS During Third Quarter 1992

Page 1 of 4

Compound	Laboratory Detection Limit[a] (μg/L)
Volatile Organic Compounds	
Chloromethane	10
Bromomethane	10
Vinyl chloride	10
Chloroethane	10
Methylene chloride	5
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
Trichloroethylene	5
Dibromochloromethane	5
1,1,2-Trichloroethane	5
Benzene	5
trans-1,3-Dichloropropene	5
2-chloroethylvinylether	10
Bromoform	5
4-Methyl-1,2-pentanone	10
2-Hexanone	10
Tetrachloroethylene	5
1,1,2,2-Tetrachloroethane	5
Toluene	5
Chlorobenzene	5
Ethylbenzene	5

Table C-2

(continued)

Page 2 of 4

Compound	Laboratory Detection Limit[a] (μg/L)
Semivolatile Organic Compounds	
Styrene	5
Xylene (total)	5
Acrolein	10
Acrylonitrile	10
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

Table C-2

(continued)

Page 3 of 4

Compound	Laboratory Detection Limit[a] (μg/L)
Semivolatile Organic Compounds (cont'd)	
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
4-Nitroaniline	50
4,6-Dinitro-2-methylphenol	50
N-Nitrosodiphenylamine	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
N-nitrosodimethylamine	10
Benzidine	50
1,2-Diphenylhydrazine	10

Table C-2

(continued)

Page 4 of 4

Compound	Laboratory Detection Limit[a] (μg/L)
PCBs	
Arochlor 1016	0.50
Arochlor 1221	0.50
Arochlor 1232	0.50
Arochlor 1242	0.50
Arochlor 1248	0.50
Arochlor 1254	1.00
Arochlor 1260	1.00
Pesticides	
Alpha-BHC	0.05
Beta-BHC	0.05
Delta-BHC	0.05
Gamma-BHC (Lindane)	0.05
Heptachlor	0.05
Aldrin	0.05
Heptachlor epoxide	0.05
Endosulfan I	0.05
Dieldrin	0.10
4,4'-DDE	0.10
Endrin	0.10
Endosulfan II	0.10
4,4'-DDD	0.10
Endosulfan sulfate	0.10
4,4'-DDT	0.10
Methoxychlor	0.50
Endrin ketone	0.10
Endrin aldehyde	0.10
Alpha chlordane	0.50
Gamma chlordane	0.50
Toxaphene	1.00

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[a] Detection limits can vary because of dilution ratios.

APPENDIX D Methodology for Statistical Analysis of Data

METHODOLOGY FOR STATISTICAL ANALYSIS OF DATA

Treatment of "Less than Zero" Values

Occasionally a radiological analytical value may be reported as a negative number. This is not a mistake, and the value does not represent "negative radioactivity." Rather it is a result of the radiological measurement process produced by the subtraction of the background radiation measured by the instrument from the radiation measured in the sample. These results are essentially indistinguishable from zero.

Radioactive decay is a random phenomenon that can be described by a normal distribution (i.e., mean and standard deviation). When a sample contains radioactive elements at activities that are near instrument background, a single measurement of the sample can result in a negative value (when the instrument background is subtracted). If many measurements of the sample were taken and used to calculate the mean, this mean would be positive and would approximate the true radioactivity, however small, of the sample. In practice at FUSRAP sites, multiple measurements to calculate the mean activity of a sample near the instrument background are not necessary because the instrument background is typically several orders of magnitude less than any DCGs.

Beginning with the third quarter 1992 environmental monitoring, less-than-zero radiological values have been reported when they occur. This practice will continue for all future environmental monitoring, which will result in more accurate statistical analysis. For 1992 both negative values and values reported as "less than" a detection limit are used in this report. The negative values are used as they were reported in the statistical calculations. For those values reported as less than the detection limit, the detection limit is used in the statistical calculations. The use of the detection limit is a conservative practice because it results in a high bias for the calculated mean.

Treatment of Rounding and Significant Figures

When calculations are made, the result can be no more accurate than the least accurate number in the data (i.e., the number with the least number of significant digits). Regardless of whether a number contains a decimal, the number of significant digits is the total number of digits starting with the left-most, non-zero digit and ending with the right-most digit (even if it is a zero). For example, 231, 230, and 23.0 each have three significant digits, while 0.05 and 5 each have one significant digit. Rounding is performed on final calculation results only, not on interim results.

Treatment of Annual Average Concentrations

Annual average 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.

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

Thorium-230 Results (pCi/L)

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

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 collected and reported. In this example, there were data for all four quarters.

37 ÷ 4 = 9.25

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

APPENDIX E Environmental Standards

ENVIRONMENTAL STANDARDS

The DOE long-term radiation protection standard of 100 mrem/yr (1 mSv/yr) in excess of the background level includes exposure from all pathways except medical treatments and exposures from radon (DOE 1990). Evaluation of exposure pathways and resulting dose calculations are based on assumptions such as the use of occupancy factors in determining dose caused by 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

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 DCGs. A DCG is defined as the concentration of a radionuclide in air or water that, under conditions of continuous exposure to a single isotope 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
Thorium-232	2E-4	5E-8	--	7E-15	1E-14
Uranium-234	2E-3	5E-6	--	--	9E-14
Uranium-235	2E-3	5E-6	--	--	1E-13
Uranium-238	2E-3	6E-6	--	--	1E-13
Radon-222[d]	3E-9	3E-9	--	--	3E-9
Radon-220[d]	3E-9	3E-9	--	--	3E-9

[a] F1 is defined as the gastrointestinal tract absorption factor, which 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.

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: DOE 1987.

APPENDIX F Population Exposure Methodology

POPULATION EXPOSURE METHODOLOGY

DOE Order 5400.5 requires that the impacts of the site on both the 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 the individual and the general population and comparing this dose with DOE guidelines. This appendix describes the methodology used to calculate the doses discussed in Section 4.0.

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 may be 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 numbers 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 by the atmospheric pathway may take the form of contaminated particulates or dust and can potentially lead to a dose only when it is inhaled. Doses from radon are excluded in accordance with DOE Order 5400.5 II, 1.a(3) Application (02/08/90). Radon exposure is controlled through compliance with boundary concentration requirements.

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

Primary Radionuclides of Concern

The primary radionuclides of concern for these calculations at most FUSRAP sites 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 of less than one year are included with the parent radionuclide. Table F-1 lists the pertinent radionuclides common at FUSRAP sites, their half-lives, and dose conversion factors for ingestion.

DOSE CALCULATION METHOD

Direct Gamma Radiation Exposure

As previously indicated, direct gamma radiation exposure is important in calculating the dose to the maximally exposed individual. The dose from direct gamma radiation exposure is determined by using data collected through the tissue-equivalent thermoluminescent dosimeter (TETLD) program. 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, the individual is assumed to work 40 hours per week, 50 weeks per year at a location just opposite the nearest masonry wall of the facility, 45 m (150 ft) from the northwestern fenceline of MISS.

The dose to this individual can be determined by assuming that the individual is exposed to a line source located along a segment of the southeastern fenceline. Because the average exposure rate is known from the TETLD program for a distance of 1 m (3 ft) from

Table F-1

Radionuclides of Interest

Radionuclide	Half-life[a]	Dose Conversion Factor[b] for Ingestion (mrem/pCi)
Uranium-238	4.47E+9 years	2.5E-4
Thorium-234	24.1 days	--[c]
Protactinium-234	1.17 minutes	--[c]
Protactinium-234	6.75 hours	--[c]
Uranium-234	2.45E+5 years	2.6E-4
Thorium-230	7.7E+4 years	5.3E-4
Radium-226	1600 years	1.1E-3
Uranium-235	7.04E+8 years	2.5E-4
Thorium-231	25.52 hours	--[d]
Protactinium-231	3.27E+4 years	1.1E-2
Actinium-227	21.77 years	1.5E-2
Thorium-227	18.718 days	--[e]
Radium-223	11.43 days	--[e]
Thorium-232	1.41E+10 years	2.8E-3
Radium-228	5.75 years	1.2E-3
Actinium-228	6.13 hours	--[f]
Thorium-228	1.91 years	7.5E-4

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[a] Source: Shleien 1992.

[b] Source: *Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentrations and Dose Conversion Factors for Inhalation, Submersion, and Ingestion* (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 fenceline, the exposure at 45 m (150 ft) from the fenceline can be calculated by using the following equation (Cember 1983).

$$\text{Exposure at 45 m} = (\text{Exposure at 1 m}) \times \frac{h_1}{h_2} \times \frac{\tan^{-1}(L/h_2)}{\tan^{-1}(L/h_1)}$$

where: h_1 = TETLD distance from the fenceline [1 m (3 ft)]

h_2 = Maximally exposed individual's distance from the fenceline [45 m (150 ft)]

L = Half the length of the northwestern fenceline between stations 23 and 24 [19 m (62 ft)]

The exposure rate at 1 m (3 ft) can be calculated by taking the average of the results from the two detectors along this portion of the fenceline (stations 23 and 24). The average exposure rate for these detectors was 451 mR/yr above background. Using the formula above, the exposure rate at 45 m (150 ft) is approximately 2.6 mR/yr. Because 1 mR/yr is approximately equal to 1 mrem/yr (1×10^{-2} mSv/yr), the resulting dose would be 0.6 mrem/yr (6×10^{-3} mSv/yr) assuming exposure over a 40-hour week, 50 weeks per year. This exposure scenario does not account for shielding provided by the masonry facility.

Surface Water Pathway

Exposures from contaminants in surface water can be important in calculating the dose to both the maximally exposed individual and the nearby population; however, because no radioactive material is leaving the site in surface water and there is no complete pathway for surface water, it is not a significant contributor to the evaluation of the total dose.

Groundwater Pathway

Exposures from contaminants in groundwater that are part of a drinking water supply are important in calculating the dose to both the maximally exposed individual and the nearby population. The data used to support the groundwater dose calculations consist of measurements of the concentrations of contaminants in groundwater and an estimate of the dilution that occurs between the measurement location and the intake point. However, the onsite shallow wells yield very low or nondetectable levels of radioactivity; therefore, groundwater is not a realistic pathway.

Air Pathway

The doses to the maximally exposed individual and the general public from particulate radionuclides transported via the air pathway are calculated using the EPA computer model CAP88-PC.

The release of particulates is normally calculated using a model for wind erosion because there are no other mechanisms for releasing particulates from the site; however, the storage pile has a sturdy geofabric cover, and the remainder of the site is either vegetated or paved; these mechanisms prevent wind erosion from being a credible pathway.

APPENDIX G Distribution List for Maywood Interim Storage Site Environmental Report for Calendar Year 1992

The Department of Energy distributes this report to local, state, and federal agencies; U.S. Congress; the public; and the media (upon request).

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